Materials for Advanced Ultra-Supercritical (AUSC) Steam Turbines – AUSC Component Demonstration

Phase 1 Final Technical Report

Prepared for: US Department of Energy National Energy Technology Laboratory and the Ohio Coal Development Office

Reporting Period: January 1, 2016 – March 31, 2018

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April 2018

DOE Award Number DE-FE0025064
Ohio Coal Development Office Grant Agreement: OER-CDO-D-15-01

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Acknowledgement

This material is based on work supported by the Department of Energy under Award Number DE-FE0025064 and the Ohio Coal Development Office, Ohio Development Services Agency Grant Agreement Number OER-CDO-D-15-01.

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Acronyms and Abbreviations

AECOM	Architecture, Engineering, Construction, Operating and Maintenance Company
AOD	Argon-Oxygen Decarburization
ASME	American Society of Mechanical Engineers
AUSC	Advanced Ultra-Supercritical
AWT	Average Wall Thickness
B&W	Babcock & Wilcox
CCS	CO_2 Capture & Storage
CHP	Combined Heat & Power
ComTest	Component Test
DOE	Department of Energy
EIO	Energy Industries of Ohio
EPC	Engineering Procurement & Construction
EPRI	Electric Power Research Institute
FEED	Front End Engineering Design
GE	General Electric Company
GMAW	Gas Metal Arc Welding
GTAW	Gas Tungsten Arc Welding
HHV	Higher Heating Value
HP	High Pressure
hp	Horsepower
HRSG	Heat Recovery Steam Generator
IP	Intermediate Pressure
NDT	Non-Destructive Testing
NETL	National Energy Technology Laboratory
OAC	Ohio Administrative Code
OCDO	Ohio Coal Development Office
OD	Outer Diameter
OEM	Original Equipment Manufacturer
ORNL	Oak Ridge National Laboratory
OWT	Oxygenated Water Treatment
PCC	Precision Castparts Corporation
P&ID	Piping & Instrumentation Diagram
PWHT	Post-Weld Heat Treatment
ROM	Rough Order of Magnitude
SC	Supercritical
SEM	Scanning Electron Microscope
SH	Superheater
SMAW	Shielded Metal Arc Welding
SOPO	Statement of Project Objectives
USC	Ultra-Supercritical

VOC	Volatile Organic Compounds

1 Executive Summary

The work by the United States Department of Energy (U.S. DOE)/Ohio Coal Development Office (OCDO) Advanced Ultra-Supercritical (AUSC) Steam Boiler and Turbine Materials Consortia from 2001 through September 2015 was primarily focused on lab scale and pilot scale materials testing. The field testing included air-cooled probes and steam-cooled "loops" that were installed into existing utility boilers to gain exposure of these materials to realistic conditions of high temperature and corrosion due to the constituents in the coal ash. Successful research and development resulted in identification of metallic alloy materials and fabrication processes suited for power generation applications with metal temperatures up to approximately 1472°F (800°C). These materials or alloys have shown, in extensive laboratory tests and shop fabrication studies, to have excellent applicability for high-efficiency low CO_2 transformational power generation technologies.

However, as valuable as these material field tests have been for obtaining information, their scale is significantly below that required to minimize the risk associated with a power company building a multi-billion-dollar AUSC power plant. To decrease the identified risk barriers to full-scale implementation of these advanced materials, the U.S. DOE/OCDO AUSC Steam Boiler and Turbine Materials Consortia identified the key areas of the technology that need to be tested at a larger scale. Based upon the recommendations and outcome of a Consortia-sponsored workshop with the U.S.'s leading utilities, a Component Test (ComTest) Program for AUSC was proposed. The AUSC ComTest program would define materials performance requirements, plan for overall advanced system integration, design critical component tests, fabricate components for testing from advanced materials, and carry out the tests.

A Pre-FEED evaluation of the test facility including the evaluation of three potential sites has been completed and previously reported. This report describes the Front-End Engineering Design (FEED), Detailed Engineering and the Environmental Assessment of the ComTest project.

A significant amount of work was accomplished during Phase 1 to identity the components, as well as the component size, that would be manufactured from advanced alloys such as INCONEL 740H[1] or HAYNES 282[2] alloys. Pathways to supply these components for ComTest have been identified as well as any further development that would be required.

Every project of this nature has challenges and this project was no exception. The greatest challenge has been the project cost. Largely due to the infrastructure and balance of plant equipment upgrades required for Youngstown Thermal, the estimated project cost for the "base case" project was greater than originally budgeted. The project team spent a significant amount of time exploring opportunities for reducing the project cost. These options included:

- Youngstown Thermal was exploring building a Combined Heat and Power (CHP) unit at their facility. The Youngstown Thermal staff, supported by Thermal Engineering Group, worked with the project team to determine whether it was economically desirable to

[1] INCONEL® 740H is a trademark of Special Metals, Huntington, WV, USA
[2] HAYNES® 282® is a trademark of Haynes International, Kokomo, IN, USA

supply ComTest with steam and other utilities, which would be supplied by the CHP project.

- The project team also evaluated opportunities to optimize the project scope to reduce cost, such as reducing project scope by eliminating the Superheater Outlet Header test.
- Southern Company had offered two sites as possible host locations for ComTest. Both sites had infrastructure in place such as steam from an existing unit, natural gas, cooling water and ample electrical power that would be required to be added at the Youngstown Thermal site. Utilizing this existing infrastructure could reduce the project cost.

An additional project challenge was the departure of Babcock and Wilcox from the project in September 2016. This project setback was overcome by GE Power's willingness to assume the design of the ComTest superheater. Since the project could not proceed without the superheater, this was a very positive project development.

The merger of the GE Power and Alstom Power steam turbine divisions created synergies leading to the conclusion that instead of building a small-scale turbine, a more practical and useful endeavor would be to validate the manufacturing technology and supplier readiness for fabricating and machining full scale steam turbine components. Consequently, in March 2017, GE Power decided that a steam turbine test would not be necessary as part of the ComTest demonstration.

Removing the operational testing of the steam turbine from ComTest further reduced the total project cost. Additionally, there was an opportunity to move ComTest from Youngstown Thermal to one of the Southern Company sites and operate ComTest at supercritical steam conditions and test the steam turbine main stop/control valve at a temperature and pressure that would be representative of the conditions of a high pressure steam turbine inlet valve. The steam could also possibly be returned to the host boiler so there would be no economic penalty of using this steam for ComTest. Relocating the project could further reduce the project cost due to the infrastructure already in place, including high pressure natural gas and cooling water, and the potential for heat integration, allowing a reduction of operating costs. Due to these potential cost reductions, it was decided to move the project away from Youngstown Thermal in March 2017.

As integrating ComTest at the Southern Company site was explored, an issue was raised regarding the integration of the ComTest cycle with the plant steam cycle. Steam would be supplied to ComTest at nominally ~3865 psia and 775^{o}F. The steam would be heated with natural gas to 1400^{o}F for the valve test and then cooled to 1000^{o}F so that the steam would be returned to the host boiler at the same conditions as their high pressure steam turbine inlet. However, there were concerns raised that the addition of the energy (natural gas) to the steam could trigger a New Source Review on the unit. Southern Company did not want ComTest to cause this review, so condensing all of the steam exiting ComTest and returning it to the host steam cycle as condensate was explored to insure there would be no implication that ComTest was adding energy to the host plant's steam cycle. Ultimately, Southern Company decided that they wanted to "decouple" ComTest from the operating unit, making ComTest self-supporting, similar to the Youngstown Thermal "base case." Without the steam turbine, the project team reached a consensus that operating the ComTest Superheater and steam turbine valves at the typical pressure of a package boiler (~1000 psig) would not generate enough useful technical information to justify the cost of the test.

Therefore, it was decided in the December 2017 project quarterly meeting to cancel the operational phase of ComTest. Throughout the engineering phase of ComTest, manufacturing and supply chain challenges were identified. When GE Power recommended dropping the steam turbine test from ComTest, they identified many important manufacturing issues that should be evaluated and demonstrated. Other challenges had been raised by the GE Power group designing the superheater as well as those engineering components such as pressure relief and steam turbine bypass valves. In the December 2017 meeting, the project team decided that it was more beneficial to the AUSC technology to pursue these manufacturing and supply chain issues as Phase 2 of the ComTest project.

This report is organized in the following manner:

- Section 2 discusses the ComTest project background and organization.
- Section 3 discussed project management.
- Section 4 discusses the design of the ComTest AUSC components – the Superheater, steam turbine and Superheater Outlet Header.
- Section 5 discusses the implementation of ComTest at Youngstown Thermal and the Southern Company site.
- Section 6 discusses the development of the AUSC Supply Chain
- Section 7 discusses the recommended plan for Phase 2 of ComTest

2 Project Description

2.1 Project Background

From the 1880s through the 1950s advances made in power plant component design and manufacture as well as the introduction of new materials for pressure part components enabled designers to increase the temperature and pressure of steam turbine inlet conditions and offer significant improvements to plant efficiency. But since the early 1960s, further advancement of power plant steam conditions has slowed. There was little motivation to continue lowering heat rates of fossil-fired plants due to the availability in the United States of relatively inexpensive fossil fuels. Meanwhile rising concerns about the environmental impacts of coal combustion led to an increased emphasis on improving emissions control technologies instead. In recent years, however, due to rising fuel cost and climate change concerns, interest in increasing the power plant efficiency has risen.

Increasing power plant efficiency decreases the amount of coal required to generate a fixed power output, which ultimately decreases the power plant fuel cost. High power plant efficiency is especially valued in regions of the world where mining constraints or a lack of local energy resources result in an import-driven energy supply. In these cases, fossil-fired plants desire to extract as many MWh of electricity per ton of coal as possible.

As plant efficiency increases, the emissions per MWh produced are reduced – including CO_2, NO_x, SO_x, particulate, volatile organic compounds (VOC), CO and trace metals. Increasing the thermal efficiency is the most cost-effective way to reduce emissions in fossil fuel power plants. Decreasing the emissions decreases the capital and operating costs associated with the pollution removal and disposal systems. Higher thermal efficiency also decreases water consumption per MWh of power produced which is becoming increasingly important in many parts of the world.

Since 2001, a government/industry program, sponsored by the U.S. DOE and the OCDO and cost shared by industrial and not-for-profit partners, has been evaluating and developing materials that allow the use of advanced steam cycles in power plants. These advanced cycles, with steam temperatures up to 1400°F (760°C), can increase the efficiency of coal-fired boilers from an average of 35% efficiency (current domestic U.S. fleet) up to 47% on a higher heating value (HHV) basis. This program has been performed under prime contracts with Energy Industries of Ohio (EIO) through consortia made up of U.S. boiler and steam turbine manufacturers in conjunction with support provided by NETL's Albany Research Center (NETL-Albany) and ORNL, and technically managed by the Electric Power Research Institute (EPRI). [3]

This program defined the following objectives:

- Identify advanced materials that make it possible to maintain a cost-competitive, environmentally acceptable coal-based electric generation option. High sulfur coals will specifically benefit from the significant reductions in waste generation inherent to increased operational efficiency.

[3] Purgert, R. et al., "Materials for Advanced Ultrasupercritical Steam Turbines", Final Technical Report, DOE Cooperative Agreement: DE-FE0000234, Dec. 2015. http://www.osti.gov/scitech/biblio/1243058

- Increased plant efficiencies associated with this program will reduce the emissions produced per MWh in a pulverized coal unit, decreasing the cost of adding post-combustion environmental control systems.
- Alloys that operate at higher temperatures identified by this program will support future transformational power technologies, including AUSC oxy-combustion, supercritical CO_2 cycles, nuclear power, solar power, and high efficiency natural gas combined cycle power plants.

2.1.1 The Component Test (ComTest) Program

The work by the U.S. DOE/OCDO AUSC Steam Boiler and Turbine Materials Consortia from 2001 through September 2015 was primarily focused on lab scale and pilot scale materials testing. The testing included air-cooled probes and steam-cooled "loops" that were installed into existing utility boilers to gain exposure of these materials to realistic conditions of high temperature and corrosion due to the constituents in the coal ash. Successful research and development resulted in identification of metallic alloy materials and fabrication processes suited for power generation applications with metal temperatures up to approximately 1472°F (800°C). These materials or alloys have shown, in extensive laboratory tests and shop fabrication studies, to have excellent applicability for high-efficiency low CO_2 transformational power generation technologies previously mentioned.

However, as valuable as these material tests inside the boiler have been for obtaining information, their scale is significantly below that required to minimize the risk associated with a power company contemplating building a multi-billion-dollar AUSC power plant. To decrease the identified risk barriers to full-scale implementation of these advanced materials, the U.S. DOE/OCDO AUSC Steam Boiler and Turbine Materials Consortia identified the key areas of the technology that need to be tested at a larger scale. Based upon the recommendations and outcome of a Consortia-sponsored workshop with the U.S.'s leading utilities, the Consortia proposed a Component Test (ComTest) Program for AUSC. The AUSC ComTest program would define materials performance requirements, plan for overall advanced system integration, design critical component tests, fabricate components for testing from advanced materials, and carry out the tests. The key areas, as originally conceived, for expanded testing in the AUSC ComTest or through other testing and demonstration projects included:

- Membrane Wall – The membrane wall of an AUSC PC unit will operate at a higher temperature than conventional USC or supercritical (SC) units and will require higher grade alloys. T23 and T24 have been used in USC units in Europe, US, China, and India and have presented early life challenges. The purpose of this component test will be to use optimized manufacturing technology for T91/92 and other alternative materials to prove manufacturability and operation of a higher temperature AUSC membrane wall and to reduce the risk of the early life issues.
- Superheater – The ComTest Superheater will heat the steam temperature up to 1400°F (760°C) and could be located internal to an existing boiler or external to the boiler.
- High Temperature Pressure Relief Valve – It is important to be able to design and operate pressure relief valve(s) at the temperature and pressures expected during commercial AUSC operation.

- High Temperature, High Pressure Steam Valve Testing – It is important to be able to design and operate the steam turbine stop and control valves at the temperature and pressures expected during commercial AUSC operation. Producing these valves, as well as the other valves needed for an AUSC ComTest, will allow for the qualification of the vendors to produce high quality valves from nickel alloys and determine the performance of the valves at these operating conditions.
- Desuperheater – Steam temperature control will be required for AUSC boilers. Injection of water in the desuperheater will produce a high temperature gradient at the nozzle connection as well as along the length of the device.
- Cycling Header – Most commercial units cycle daily. A thick wall test section, designed to simulate a superheater outlet header with tube penetrations, will be evaluated to understand the mechanical behavior (stress and strain evolution) of these materials, due to cycling temperatures.
- Steam Turbine – The steam turbine for an AUSC power plant will operate at temperatures well above those of current commercial steam cycles, with an inlet temperature of 1400°F (760°C). AUSC ComTest objectives include the selection of materials and manufacturing technologies required for reliable steam turbine operation, evaluation of component life, inspection of any oxidation and/or deposits that develop over the testing period, evaluation of steam path, sealing, and bearing design, and determination of steam turbine performance during AUSC operation.

It was premised that the entire AUSC ComTest program would probably occur at multiple facilities, with the operating pressure and/or size of these components increasing as experience is gained. The proposed first step in the AUSC ComTest program was to test an AUSC IP steam turbine. This test would use steam produced by a natural gas fired boiler at pressures comparable to those expected in the reheat section of a commercial AUSC power plant (i.e., approximately 1015 psia). For this test, a natural gas fired superheater would heat the steam to 1400°F. This steam would then flow through either the steam turbine or the thick-walled cycling superheater header test section.

The proposed AUSC ComTest Project was an expansion and continuation of three previous DOE-funded research and development (R&D) projects that were conducted to close the material technology gap and move AUSC technology towards commercialization (see Table 2-1). The AUSC ComTest Project would include the design, procurement, construction, and testing of a prototype AUSC steam turbine and the prototype scale AUSC components (boiler superheater, boiler tube membrane walls, steam de-superheater, steam headers, main steam piping, and main steam line valves) needed to produce the steam to drive the AUSC steam turbine.

Table 2-1 Prior DOE Materials Technology R&D Projects

Year – DOE Project	Overview
2002 - DE-NT41175	DOE selected this project to develop materials for AUSC boilers. The project resulted in the selection of an alloy for boiler tubing and thick wall steam piping. The project was completed by a consortium consisting of EIO; their subcontractors Babcock & Wilcox, Alstom Power, Foster Wheeler, and Riley Power; the Electric Power Research Institute; and Oak Ridge National Laboratory. The project also received non-DOE funding from the Ohio Coal Development Office.
2006 - DE-NT42442	DOE selected this project to develop the materials for an AUSC steam turbine. This project evaluated a wide spectrum of alloys and coatings for oxidation/erosion resistance and weldability. The project was completed by a consortium consisting of EIO, General Electric, Alstom Power, and Siemens; the Electric Power Research Institute; Oak Ridge National Laboratory; and DOE's NETL.
2010 - DE-FE00000234	DOE selected this project at the end of project DE-NT42442. The project included an in-depth evaluation of the long-term mechanical properties of the alloys; scale-up and validation of casting, forging, and welding technologies needed for large thick wall components; performance of high temperature creep and fatigue tests on component specimens; and performance of a preliminary design and techno-economic analysis of an AUSC steam turbine.

2.1.2 Project Objectives

The technical goal at the beginning of Phase 1 of the project was to perform the Front-End Engineering and Detailed Engineering for a test facility consisting of a prototype R&D scale AUSC steam turbine and the other AUSC plant components that are needed to generate the steam for the turbine. The components that were to be incorporated into this test facility included:

- Membrane wall – Membrane walls would be incorporated into the design of the Superheater. These membrane walls would operate at temperatures expected in a commercial AUSC boiler, but at a lower pressure.
- Superheater – The superheater would be designed to increase the temperature of the steam from approximately 750 to 1400°F. It was to be designed for full commercial operating pressure 4500 psia to demonstrate that the fabrication of a unit with commercial wall thicknesses can be accomplished but it would operate at pressures just below 1015 psia.
- Pressure Relief Valve – Code-compliant pressure relief valve(s) would be designed and fabricated, which would operate at full AUSC temperature (1400°F), but at an operating pressure of 620 psia.
- Steam turbine stop and control valves – the valves would be fabricated which would operate at full AUSC temperature (1400°F), but at an operating pressure of approximately 620 psia.
- Desuperheaters – desuperheaters would be included on the ComTest superheater, the steam turbine bypass line and at the exit of the steam turbine and superheater header test

sections for temperature control. These desuperheaters would operate at temperatures ranging from 650 to 1400°F.

- Superheater Outlet Header – the thick-walled superheater outlet header section would cycle at temperatures between 750 and 1400°F. It would operate at a pressure of 620 psia, but the header would be designed so that the stresses during cycling are typical of what would be seen at commercial superheater operating pressures.
- Steam Turbine – a steam turbine having inlet conditions of 1400 ºF and 620 psia and approximately 100,000 lb/hr of flow would be designed. The inlet temperature and pressure conditions are approximately the same as the inlet conditions expected in the IP steam turbine of a commercial AUSC unit.

During Phase 1 of the project three sites were evaluated as candidate host sites for ComTest:

- Youngstown Thermal (Youngstown, Ohio) is an existing utility site that provides district heating to its customers in the downtown business district. The facility has a combination of coal and natural gas fired units and had much of the utility infrastructure needed to support the project. The "products" of Youngstown Thermal are 165 and 30 psia saturated steam. During operation the ComTest facility would support Youngstown Thermal's steam production.
- Southern Company's Site Plant "A" was also at a large power generating station and included a large supercritical coal fired unit as well as several other units. This site could also provide the high-pressure steam needed for testing steam turbine control valves and other components at the full operating pressure of an AUSC coal fired unit. Early in Phase 1, the area of the plant originally proposed by Southern Company for ComTest became unavailable due to other plant needs and Plant A was no longer considered as a host site.
- Southern Company's Plant "B" was a large electric power generating station consisting of several individual units, including a large supercritical coal fired unit. The supercritical unit could provide high pressure steam needed for testing steam turbine control valves and other components at the full operating pressure of an AUSC coal fired unit.

The expected results from designing, building and operating the test facility were:

- Development of a domestic supply chain for the fabrication of nickel super alloy and other AUSC power plant components.
- Testing of nickel super alloy and other AUSC components for at least 8,000 hours in AUSC steam conditions (temperatures to 1400°F or 760°C)
- Validation by experimentation and metallurgical analysis of the advanced design and life prediction methods for nickel super alloy and other AUSC components exposed to a both steady state and cycling operating modes.
- Validation of the ability to design nickel super alloy and other AUSC components for an operating life of least 30 years
- Validation that an AUSC steam turbine prototype unit can be designed, fabricated and successfully operated in a reliable manner under both steady state and varying load operating conditions.

- Development and validation of fabrication, installation and repair methods for nickel super alloy and other AUSC power plant components.
- Collection of sufficient R&D test and metallurgical analysis data to design an AUSC demonstration power plant with a high probability of technical success. By achieving these results, the risk of an AUSC demonstration should be significantly reduced.

2.2 Scope of Project

The ComTest project began by first performing the FEED analysis needed to develop the design and then selecting the site for the project including performing the National Environmental Policy Act (NEPA) analysis necessary to obtain a positive Record of Decision. The Tasks for the overall project as originally conceived included:

- Task 1.0 – Project Management and Planning
    - Subtask 1.1 – Develop and Maintain the Project Management Plan
    - Subtask 1.2 – Monitor and Report Progress on the Project Management Plan
    - Subtask 1.3 – Develop Plan and Project Organization for Phase 2
- Task 2.0 – Front End Engineering Design (FEED) of the ComTest Facility
    - Subtask 2.1 – Perform FEED Process Engineering on the ComTest Flowsheet
    - Subtask 2.2 – Perform FEED Engineering on the ComTest AUSC Tube Membrane Wall
    - Subtask 2.3 – Perform FEED Engineering on the ComTest AUSC Steam Superheater and the AUSC Pressure Relief Valve.
    - Subtask 2.4 – Perform FEED Engineering on the ComTest AUSC Desuperheater
    - Subtask 2.5 – Perform FEED Engineering on the ComTest AUSC Steam Headers and Steam Piping.
    - Subtask 2.6 – Perform FEED Engineering on the ComTest Steam Turbine; and the Turbine Stop, and Turbine Inlet Control Valves.
    - Subtask 2.7 – Perform FEED Engineering on Miscellaneous ComTest Equipment
    - Subtask 2.8 – Perform ComTest Site Interface Engineering
    - Subtask 2.9 – Complete Assessment of Supply Chain for AUSC Components
    - Subtask 2.10 – Develop preliminary process control system and safety interlock diagrams
    - Subtask 2.11 – Develop FEED Level Cost Estimate, Plan and Schedule for Phase 2
- Task 3.0 – Environmental Assessment for Phase 2
- Review of Task 2.0 and Task 3.0 results with the DOE Project Officer
- Task 4.0 – Detailed Engineering and Environmental Permitting
    - Subtask 4.1 – Finalize Process Engineering Design of the ComTest Facility
    - Subtask 4.2 – Perform Detailed Engineering Design of the ComTest AUSC Membrane Wall.
    - Subtask 4.3 – Perform Detailed Engineering Design of the ComTest AUSC Steam Superheater and the AUSC Pressure Relief Valve
    - Subtask 4.4 – Perform Detailed Engineering Design of the ComTest AUSC Desuperheater

    - Subtask 4.5 – Perform Detailed Engineering Design of the ComTest AUSC Steam Headers and Steam Piping
    - Subtask 4.6 – Perform Detailed Engineering Design of the ComTest AUSC Steam Turbine; and the Turbine Stop and Turbine Inlet Control Valves
    - Subtask 4.7 – Perform Detailed Engineering Design of Miscellaneous ComTest Equipment
    - Subtask 4.8 – Finalize ComTest Site Interface Engineering
- Task 5.0 – Supply Chain Development for AUSC Components
- Task 6.0 – Preparation of Firm Budget, Plan and Schedule for Phase 2
- Task 7.0 – Procurement and Fabrication of ComTest Equipment and Components
- Task 8.0 – Installation and Construction of ComTest Facility
- Task 9.0 – Commissioning and Operation of the ComTest Facility
- Task 10.0 – De-Commissioning of the ComTest Facility, Evaluation of AUSC Components after ComTest Operating Period and Techno=Economics Study of AUSC Power Plant Technology
    - Subtask 10.1 – De-Commissioning of the ComTest Facility
    - Subtask 10.2 – Evaluation of AUSC Components after ComTest Operating Period
    - Subtask 10.3 – Techno-Economics Study of AUSC Power Plant Technology

In Phase 1, Tasks 1-6 were completed. This information will be reviewed by the DOE before proceeding to Phase 2.

2.3 Project Organization

During Phase 1, the project consisted of the following participants:

- AECOM was the Engineering, Procurement and Construction (EPC) contractor.
- The AUSC ComTest Utility Advisory Group is a group of U.S. utilities that have expressed interest in AUSC technology and are providing guidance for the ComTest project. The group currently consists of AEP, Duke Energy, First Energy, Southern Company and Tri-State Generation & Transmission.
- Babcock and Wilcox provided the design of the natural gas fired superheater for the first part of Phase 1, but exited the project in September 2016.
- Electric Power Research Institute provided technical leadership and project oversight.
- Energy Industries of Ohio is the prime contractor for the project and also carried out some of the supply chain development activities.
- GE Power (formerly Alstom Power[4]) provided the design of the thick-wall superheater header test component for thermal cycling as well as the fabrication of the piping between the superheater and the steam turbine. GE Power took over the design of the natural gas fired superheater after Babcock and Wilcox exited the project.
- GE Power provided the design of the steam turbine.

[4] On November 2, 2015 General Electric announced that it had completed the acquisition of Alstom's power and grid business. https://www.gepower.com/about/alstom-acquisition

- Southern Company Services' Research and Environmental Affairs Department provided technical support in evaluating the Southern Company sites. Both sites provided staff during the site evaluations, and were supportive of the project.
- Thermal Engineering Group served as "owner's engineer" for the Youngstown Thermal site. They provided information on interfacing ComTest with the Youngstown Thermal facility.
- Youngstown Thermal provided staff and support during the site evaluations.

2.4 Market Impacts to the Project

Aside from the General Electric/Alstom merger, there were several external market impacts that precipitated actions by the project's participants.

Globally, electricity demand (Figure 2-1) continues to grow as the population continues to increase and the per capita income of individuals in Asia and around the world continues to increase. However, since 2007, electricity generation in the U.S. has slightly declined (Figure 2-2) due, among other things, to the relatively flat economic growth rate and adoption of more energy efficient appliances.

Natural gas prices in the U.S. continue to remain low (Figure 2-3), and this low-cost fuel has caused a significant decrease in coal fired electricity since 2007. As shown in Figure 2-4, coal fired electricity generation has fallen nearly 40% since 2007 and has been replaced by natural gas fired generation and wind power.

Due to the uncertainty surrounding the CO_2 emission goals of the US government as well as the overall market for coal power in the US, several organizations, including Babcock & Wilcox as well as General Electric are prioritizing their research towards projects that support the natural gas market as well as international coal generation and the development of AUSC technology currently has a lower priority. As stated by their managements, this is not a reflection on the viability of AUSC technology in the long term, but the current market in the U.S. does not point to the deployment of greenfield AUSC coal fired power plants.

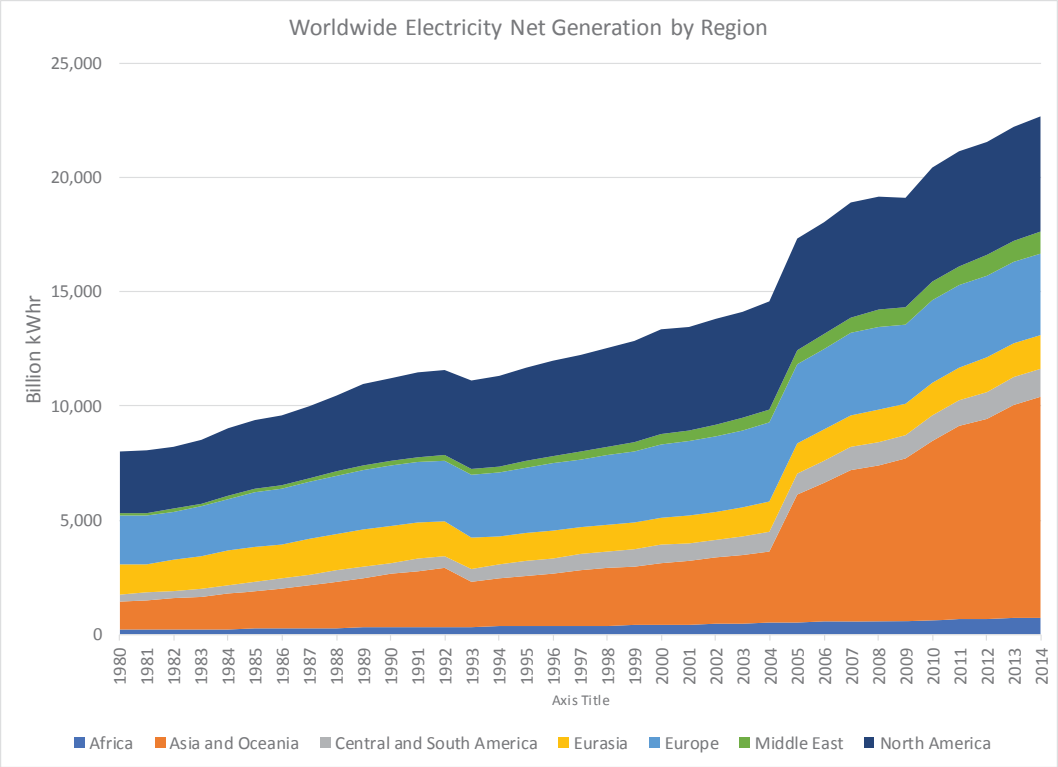


Figure 2-1 Worldwide Electricity Net Generation by Region (EIA)

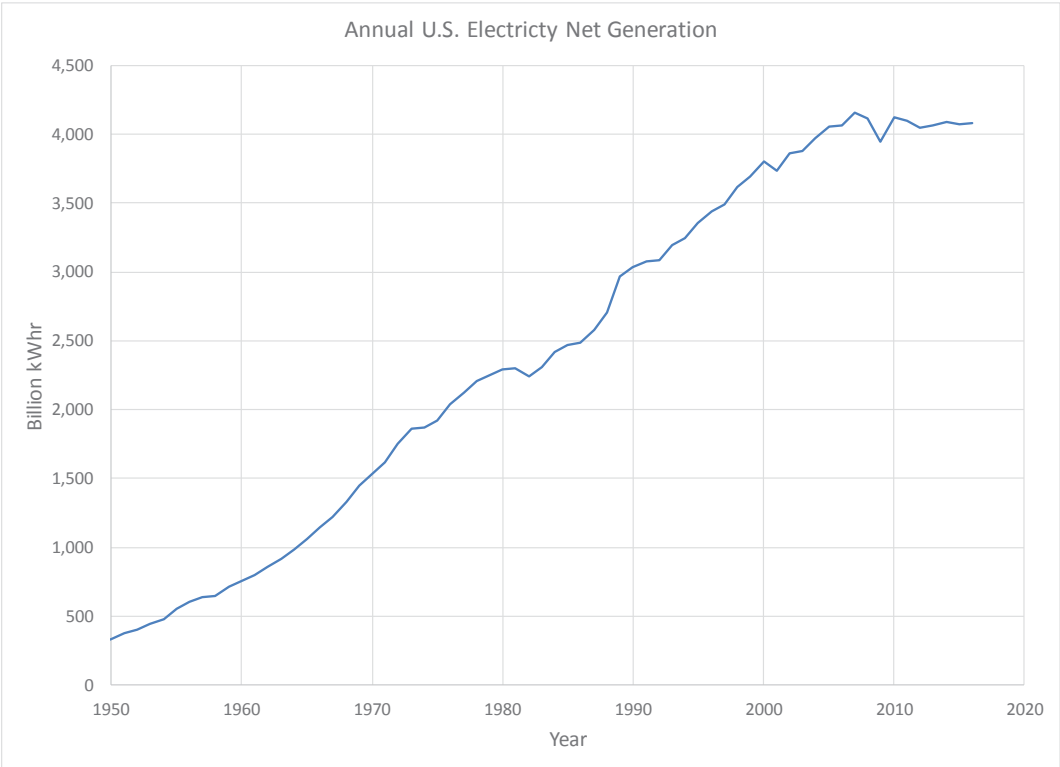


Figure 2-2 Annual U.S. Electricity Net Generation (EIA)

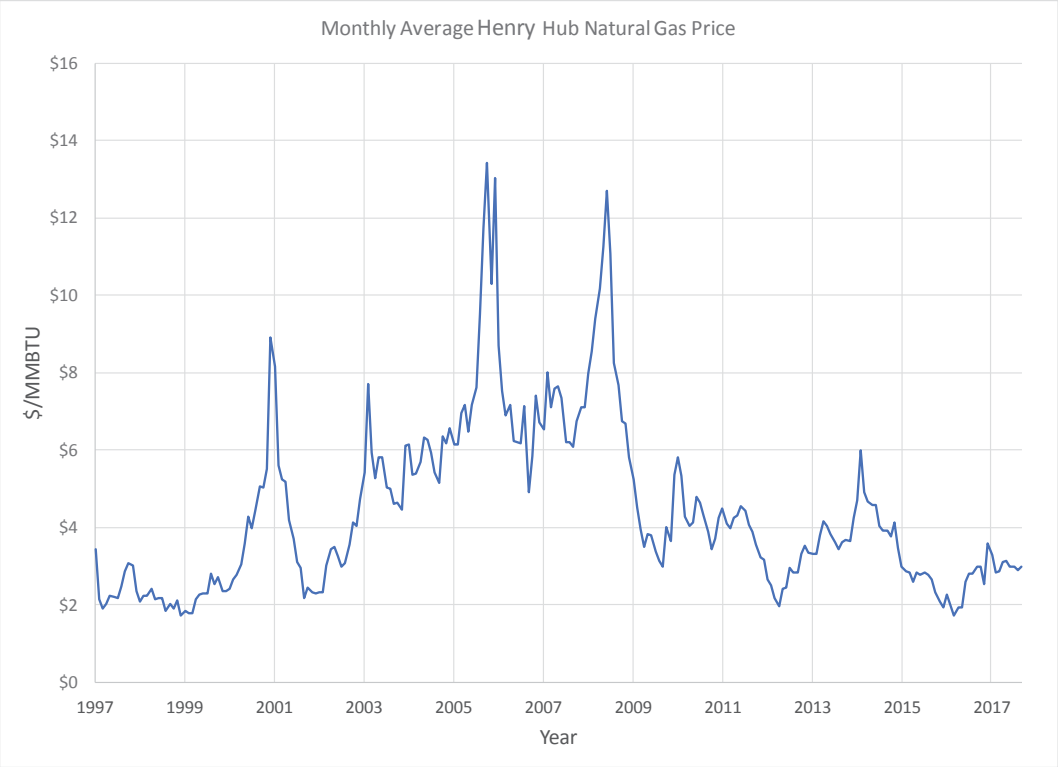


Figure 2-3 Monthly Average Henry Hub Natural Gas Price (EIA)

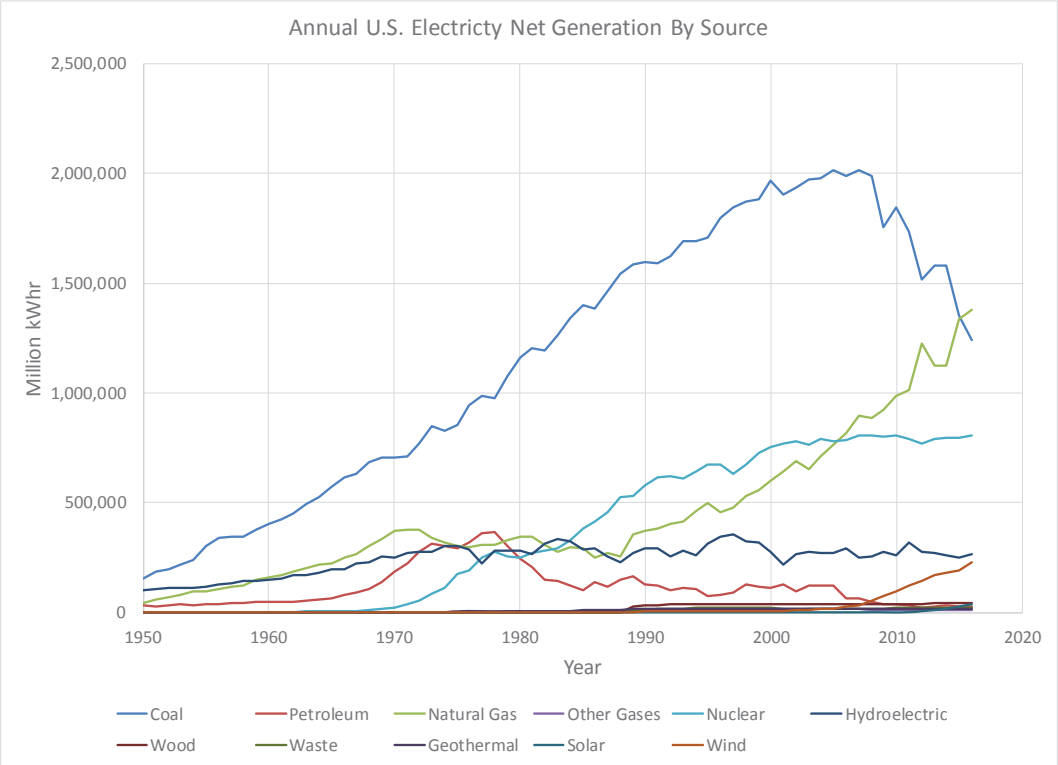


Figure 2-4 Annual U.S. Electricity Net Generation by Fuel Source (EIA)

3 Project Management and Planning

3.1 Project Execution Plan

At the beginning of the Pre-FEED phase of the project, a Project Execution Plan was produced. This execution plan was a “living document” throughout the project that addressed all aspects of the project throughout the life of the project including project organization, execution strategy, communication management, project controls, environmental/health/safety management, quality management, interface management, risk management and closure of the project. The Project Execution Plan is included in the Appendix.

The major topics in the Project Execution Plan table of contents included:

- Project Overview
- Project Charter
- Project Management Approach
- Project Scope
- Baseline Cost Estimate
- Project Organization
- Information Management Plan
- Project Controls
- Environmental, Health and Safety Management
- Quality Management
- Communications Management
- Engineering Plan
- Procurement Management
- Construction Planning
- Commissioning Planning
- Operations Planning
- Project Closeout

3.2 Milestone/Schedule

The major milestones achieved for Phase 1 of the project at Youngstown Thermal included the following:

- Project Initiated - November 1, 2015
- DOE Kickoff Meeting (NETL) – January 21, 2016
- Environmental Assessment (NEPA) of Youngstown Thermal
    - Initial Site Visit & Data Gathering – January 6, 2016
    - Preliminary EA Outline Submitted to DOE – February 25, 2016
    - Cultural Survey – March 1, 2016
    - Environmental Assessment Draft Issued – August 12, 2016
- Civil Site Survey of Youngstown Thermal (Boundary Limits, Topographical Features, Underground Utilities by Ground Penetrating Radar) – January 29, 2016

- Process Hazards Analysis (HAZOP) Review – February 22, 2016
- Geotechnical Evaluation of Youngstown Thermal (Soil Borings & Geotechnical Report) – March 7, 2016
- Preliminary Construction Plan & Schedule (Youngstown Thermal) – March 18, 2016
- Completion of FEED – March 31, 2016
- FEED Design Review (DOE) – April 27, 2016
- Start of Detailed Design – April 18, 2016
- Design Coordination Meeting with YT – May 17, 2016
- YT Cost Proposal Meeting – August 8, 2016
- Review of YT Final Cost Proposal & Site Criteria - January 4, 2017

The major milestones achieved for Phase 1 of the project at the Southern Company sites included the following:

- Environmental Assessment (NEPA)
    - Initial Site Visit & Data Gathering with NEPA Consultant (PHE) – January 25-27, 2016
- Completion of FEED – March 31, 2016
- FEED Design Review (DOE) – April 27, 2016
- Start of Detailed Design – April 18, 2016
- Southern Cost Estimate Site Surveys – October 5 and 6, 2016
- Design Review Meeting at the Southern Company site - December 15, 2016
- Meeting to discuss using the Southern Company site as the potential host site – April 11, 2017
- Meeting to discuss interfaces & tie-ins with the Southern Company site – July 6, 2017
- Final Site Location Approval at the Southern Company site – November 22, 2017

3.3 Project Risk Management

The first Risk Management workshop was held early in the pre-FEED design (October 2015) to begin identifying the major project risks. Risks were identified in the project and a representative list is shown in

Figure 3-1. Risk mitigation strategies were continually discussed and refined during the Phase 1 design as the project evolved.

Figure 3-1 Risk Register

Item	Risk Statement
1	If existing building at Youngstown Thermal is not feasable to house turbine due to cost/schedule constraints, where do we locate turbine
2	Any environmental, regulatory or permitting issues with the sites
3	Turbine not ready to start testing by Oct 2018
4	Effect on schedule if decision to proceed after detailed design
5	Impact of Youngstown Thermal's future commercial development on host site
6	Integrating Youngstown Thermal's plans with ComTest
7	Need to make s selection by 12/23/2015
8	Supply chain uncertainties
9	If terms dictated by host site are not favorable to project (MOU) -all sites
10	If utilities not ready or in place (all sites)
11	Contractual issues within project team
12	NEPA - timely approval & mitigation impacts
13	Unforseen / unknowns with modifying existing building at Youngstown Thermal
14	Security / access of host site
15	Limitations on site size and constructability at Gaston
16	Availabilty of steam (Southern)
17	Disruptions to host operations / production
18	If Southern site selected, effect on Ohio funding
19	Safety - EHS site concerns and inability to mitigate
20	Craft labor & operators - identifying, training and availability
21	Craft labor & operators - workforce rules & requirements
22	Project resources and staffing for each company
23	Transportation & logisitics of equipment
24	Costs of commodities and procurement
25	Transferability / flexibility of design in changing sites / supply chain
26	Site constraints of placing turbine and superheater in close proximity
27	Clearly defined scope boundaries
28	Consortium member withdrawing from project
29	Host site withdrawing from project
30	Availability and disruptions in DOE funding
31	Weather related to host site
32	First of a kind - technology /equipment
33	Information sharing within project team in timely manner
34	Outage schedule at Southern sites
35	Timeline for contract at Southern sites

4 ComTest Components

4.1 **AUSC Superheater**

4.1.1 Babcock & Wilcox Superheater

Under a separate DOE award (DOE-FE0024067) issued in 2014, B&W performed Phase 1 engineering for the ComTest superheater. The superheater was designed to take steam from a conventional package boiler at ~1000 psia and 750°F and deliver the steam to the steam turbine at nominally 620 psia and 1400°F. The superheater was natural gas/air fired and is designed to feed approximately 115,000 ft^3/hr of natural gas.

As shown in Figure 4-1 and Figure 4-2, the superheater would be arranged vertically and supported by a structural steel structure that is approximately 92 feet, 10 inches to the top of steel. Including the adjacent stairwell, the footprint of the structural steel structure would be 34 feet by 33 feet. The exhaust from the stack was expected to be approximately 130 feet above grade.

The steam/water flow through the superheater is best illustrated on the P&ID shown in Figure 4-3. Steam from the package boiler (lower middle of drawing) would flow to the separation bottle before connecting to the inlet headers of the membrane enclosure walls. The steam would flow vertically upward through the walls and then exit through the vertical separator. Once exiting the vertical separator, the steam would flow through the stringer support headers and back downward through the stringer tubes, through the stringer platens, and to the platen outlet header. The steam would then flow through another separator bottle before entering the first stage spray attemperator and then to the primary superheater inlet header. The steam would flow down through the five primary superheater tube banks before exiting and flowing into the second stage spray attemperator. This would desuperheat the steam a second time before entering the secondary Superheater inlet header, through the secondary Superheater tube banks and to the secondary Superheater outlet header. The steam exiting the Superheater outlet header would be at a temperature of 1400°F and pressure of 620 psia with a flowrate of approximately 119,500 lb/hr.

Heat would be supplied to the ComTest superheater by firing of natural gas with air. The hot flue gas would flow vertically upward through the Superheater and heat would be transferred to the steam. Before exiting the Superheater at 675°F, the flue gas would be cooled by two economizers. A portion of the flue gas would be recirculated for NOx control and mixed with ambient air to provide the oxygen for the combustion of the natural gas (see Figure 4-4).

There were two economizers in the superheater (upper and lower). The primary purpose of the lower economizer was to provide the water for the two desuperheaters in the ComTest superheater, which were used for temperature control. High pressure boiler feed water would be supplied to the lower economizer at 255°F and 1015 psia from the deaerator where it would be heated to 495°F. Any excess water not used for desuperheating would be returned to the deaerator.

The upper economizer was primarily for cooling the flue gas exiting the superheater to 675°F before it exhausted out of the stack. Youngstown was to supply water from their low-pressure feedwater system at approximately 265 psia in a separate loop to the upper economizer to cool

the flue gas. After heating, this water would be depressurized to 30 psia and flashed to steam, which could be supplied to Youngstown Thermal's 30 psia steam supply header.

The materials of construction for the various superheater components are shown in Figure 4-5.

In September 2016 B&W decided, due to market conditions, to end their involvement in the AUSC program. As part of their agreement, they agreed to hand off the design information generated for the AUSC superheater and allow another party to build and supply that component to the ComTest project. The boiler division of General Electric agreed to assume responsibility for the design of the AUSC superheater.

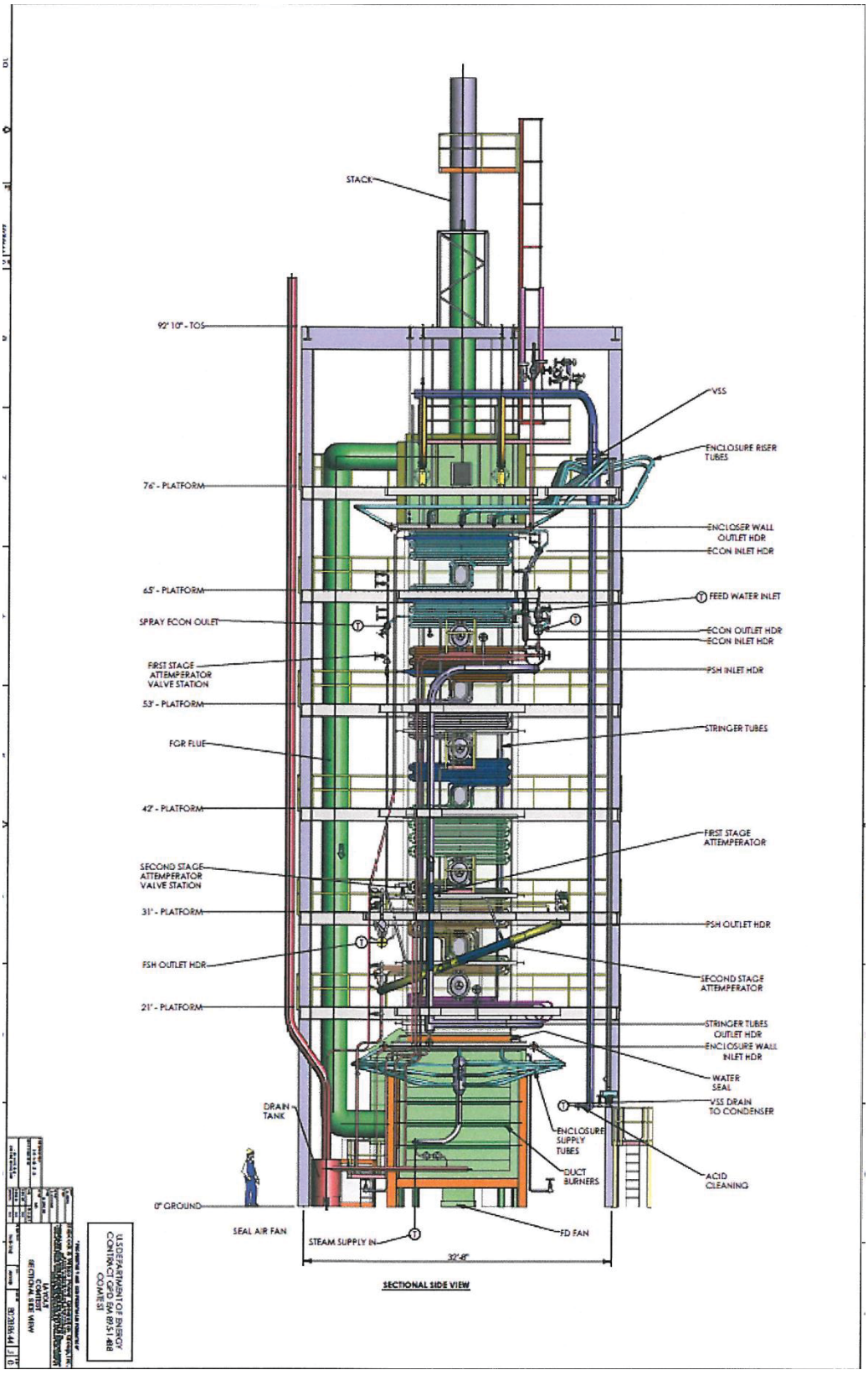


Figure 4-1 B&W ComTest Superheater Side View

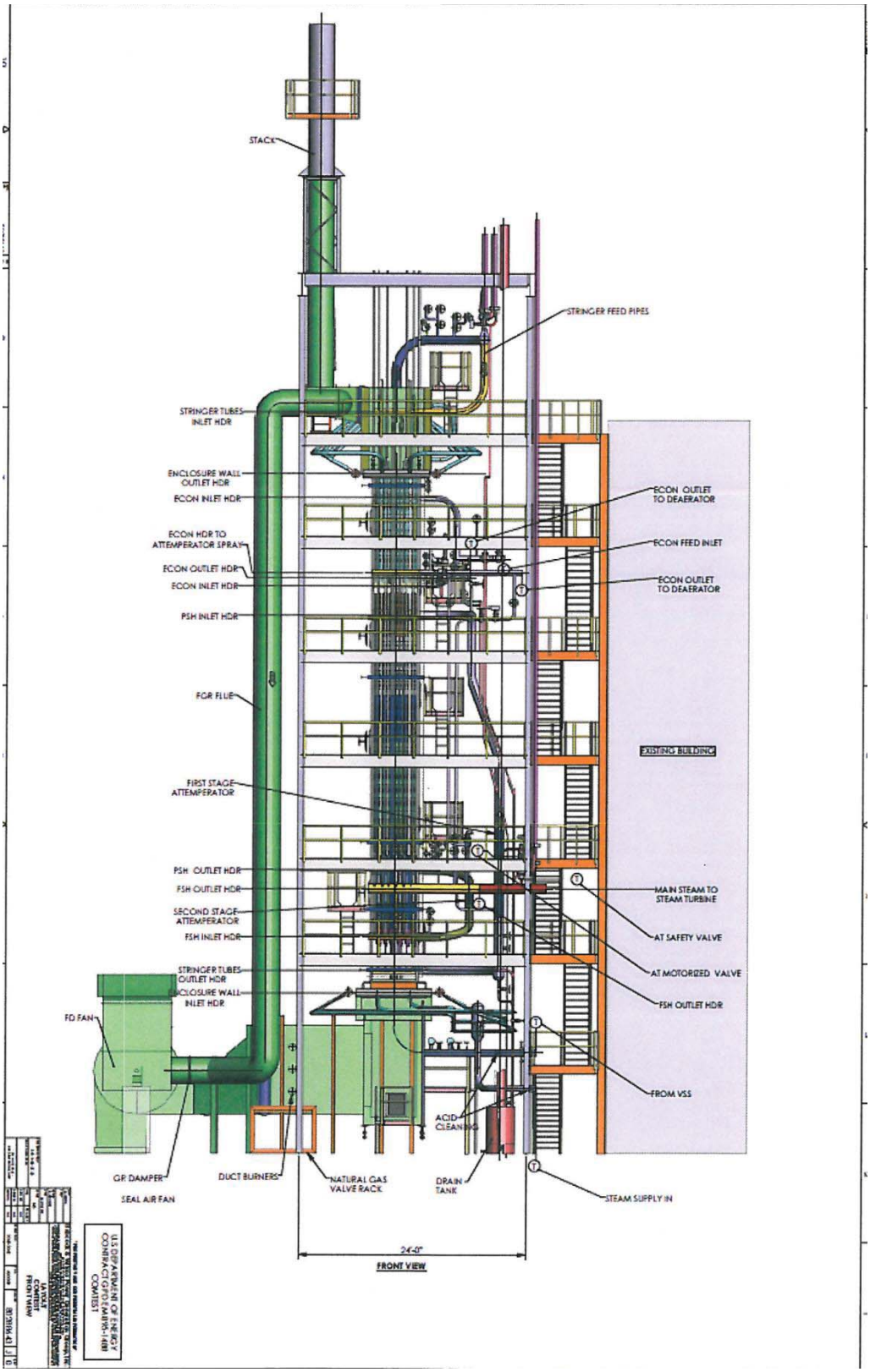


Figure 4-2 B&W ComTest Sectional Front View

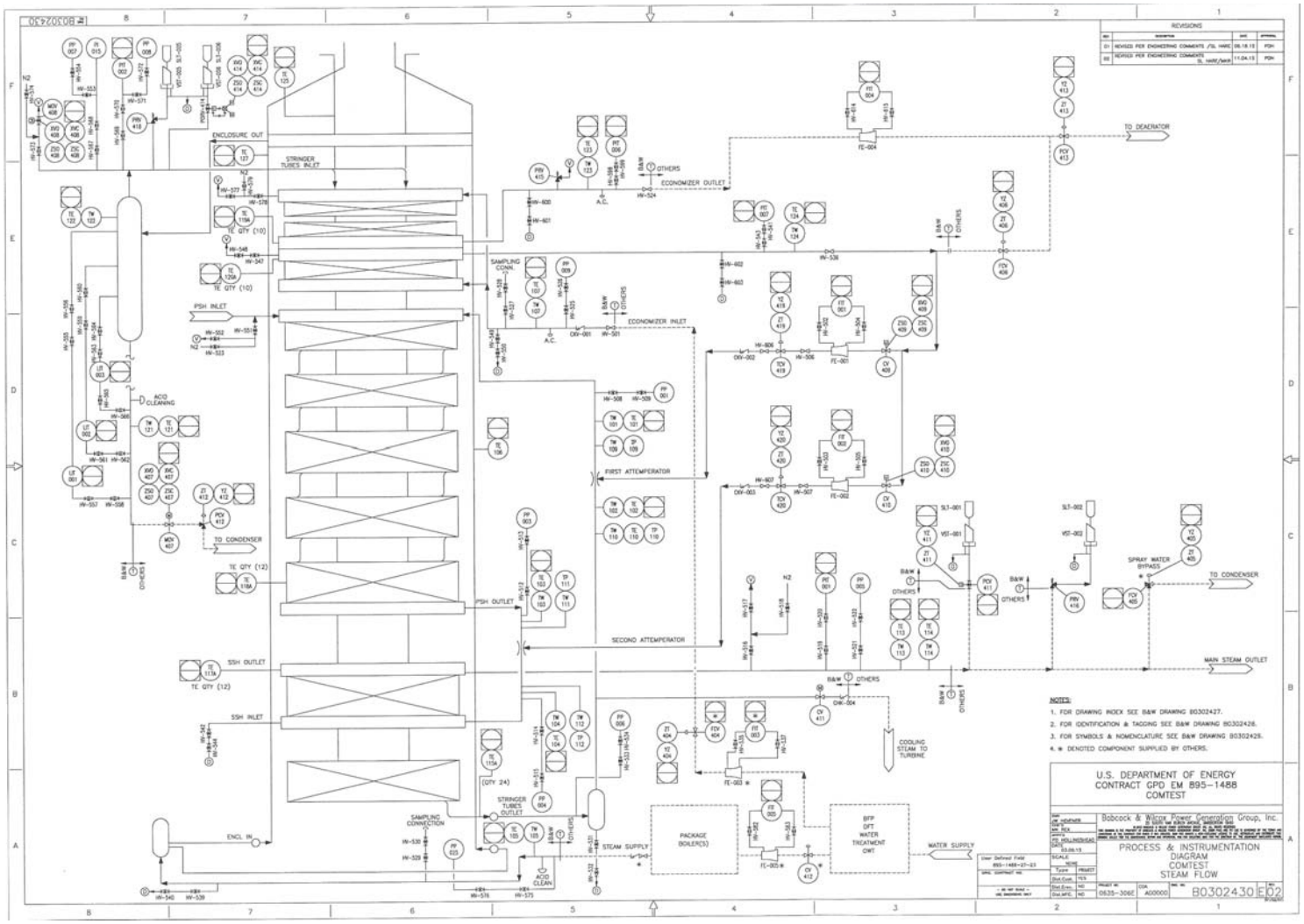


Figure 4-3 B&W ComTest Superheater Steam/Water P&ID

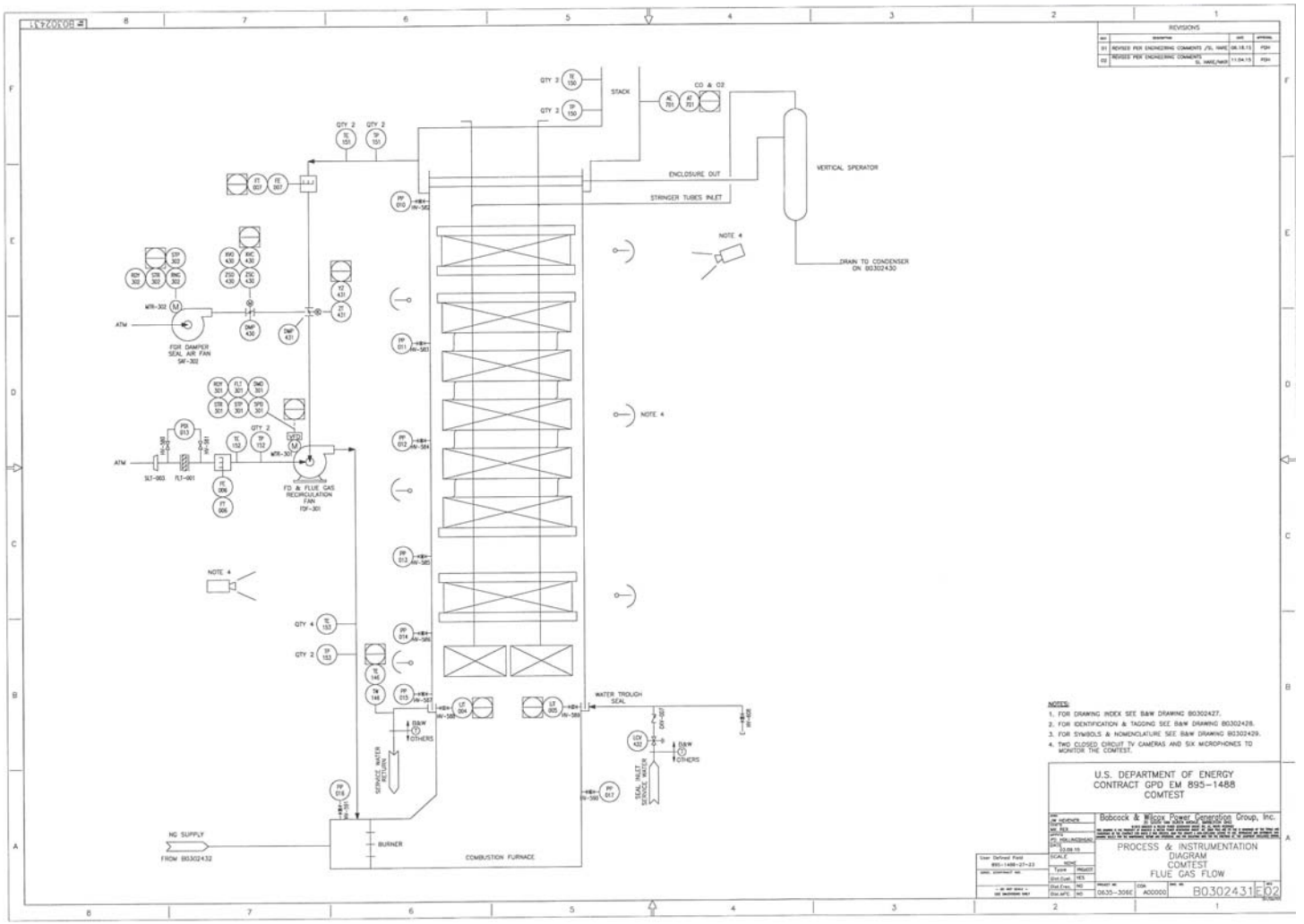
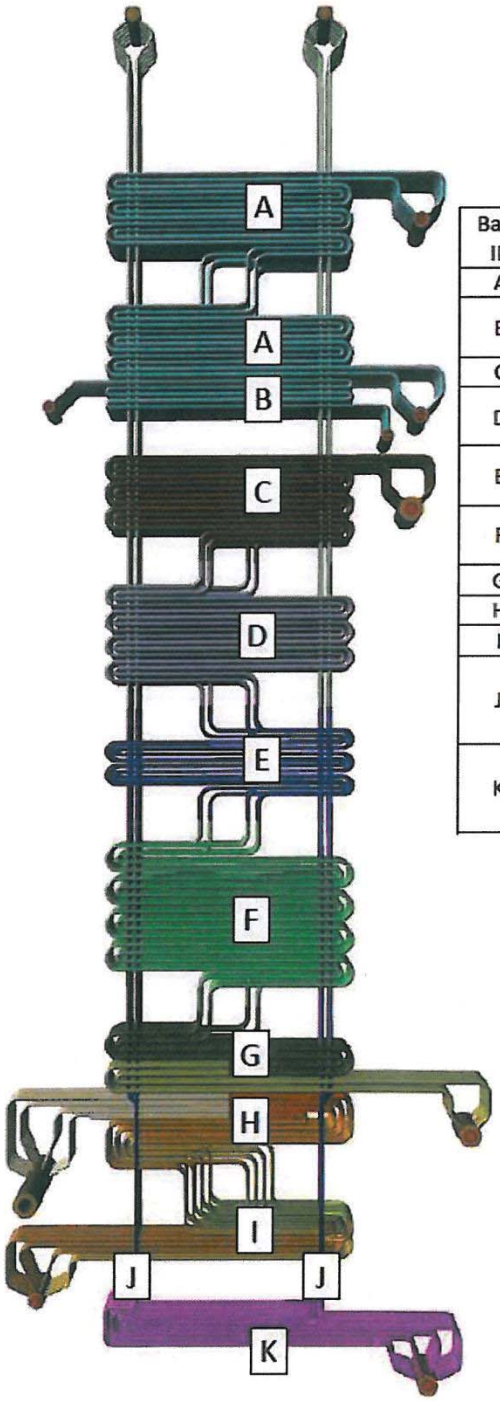


Figure 4-4 B&W ComTest Superheater Flue Gas P&ID



Bank ID	COMPONENT	TUBE OD	TUBE MAT'L	DESIGN PRESS.
A	Economizer	2.50"	SA210A1	1050 psig
B	Economizer for Spray Water	2.50"	SA210A1	1050 psig
C	Pri. SH Inlet	2.50"	SA213T92	4500 psig
D	Pri. SH Intermed.-1	2.50"	SA213TP 310HCbN	4500 psig
E	Pri. SH Intermed.-2	2.25"	SA213TP-310HCbN	4500 psig
F	Pri. SH Intermed.-3	2.25"	IN740H	4500 psig
G	Pri. SH Outlet	2.25"	IN740H	4500 psig
H	Sec. SH Outlet	1.75"	IN740H	4500 psig
I	Sec. SH Inlet	1.75"	IN740H	4500 psig
J	Stringer Tubes	2.00" & 2.25"	SA213T92 & SA213TP-310HCbN	4500 psig
K	Stringer Bank	2.00"	SA213TP-310HCbN & IN740H	4500 psig

Figure 4-5 B&W ComTest Superheater Component Materials of Construction

4.1.2 General Electric Superheater

After B&W withdrew from ComTest, GE Power management approved assumption of the superheater design in August 2016. GE Power started with the conceptual design generated by B&W for the Youngstown Thermal site and modified the unit size and surfacing based on their own detailed design processes. In the fourth quarter of 2016, it was determined that the site location would be moved to a Southern Company site. Southern Company confirmed that the inlet conditions for the superheater design considered for Youngstown Thermal could be maintained. In early 2017, GE Power advised that the scope for the steam turbine would be redefined to a manufacturing study. In addition, Southern Company advised that the addition of the superheater could not have either a negative or positive impact on the power generation of the host unit.

Based on the elimination of the steam turbine and the requirement to return steam to the host unit, GE Power advised that the superheater would need to be redesigned to account for the revised inlet and outlet conditions. The redesigned superheater would take steam from the host unit at 875^{o}F instead of receiving the steam from the package boiler. The superheater would still heat the steam to 1400^{o}F using natural gas and air supplied by a fan. However, the arrangement of the superheater is different than the original design as shown in Figure 4-6 to Figure 4-8. The superheater design also incorporated a higher temperature (1400^{o}F) safety valve.

The flow of steam through the superheater is best described by referencing the P&ID shown in Figure 4-9. Steam from the boiler would enter the superheater at nominally 875^{o}F and 1300 psia. The steam would first flow through the membrane wall superheater SH1, then to SH2 at the exit of the burner. The steam exiting SH2 would then flow to the first desuperheater, and the steam would then be cooled to maintain a certain temperature before it enters SH3. The steam would flow through superheater sections SH3-SH5 before it entered the second desuperheater section. The second desuperheater would be used to control the temperature of the final steam to 1400^{o}F as the steam exited SH7. Exiting the second desuperheater, the steam would flow through SH6 and SH7A/B. The steam leaving SH7 would go through additional stages of desuperheating, reducing the steam temperature to 1000^{o}F before beign returned to the host unit.

The flue gas exiting superheater section SH3 would pass through an economizer section where it would be cooled to 680^{o}F before being released to the atmosphere. The economizer would utilize cooling water to cool the flue gas and then this heat would be rejected to atmosphere.

Views of the three-dimensional model of the superheater are shown in Figure 4-10 to Figure 4-13.

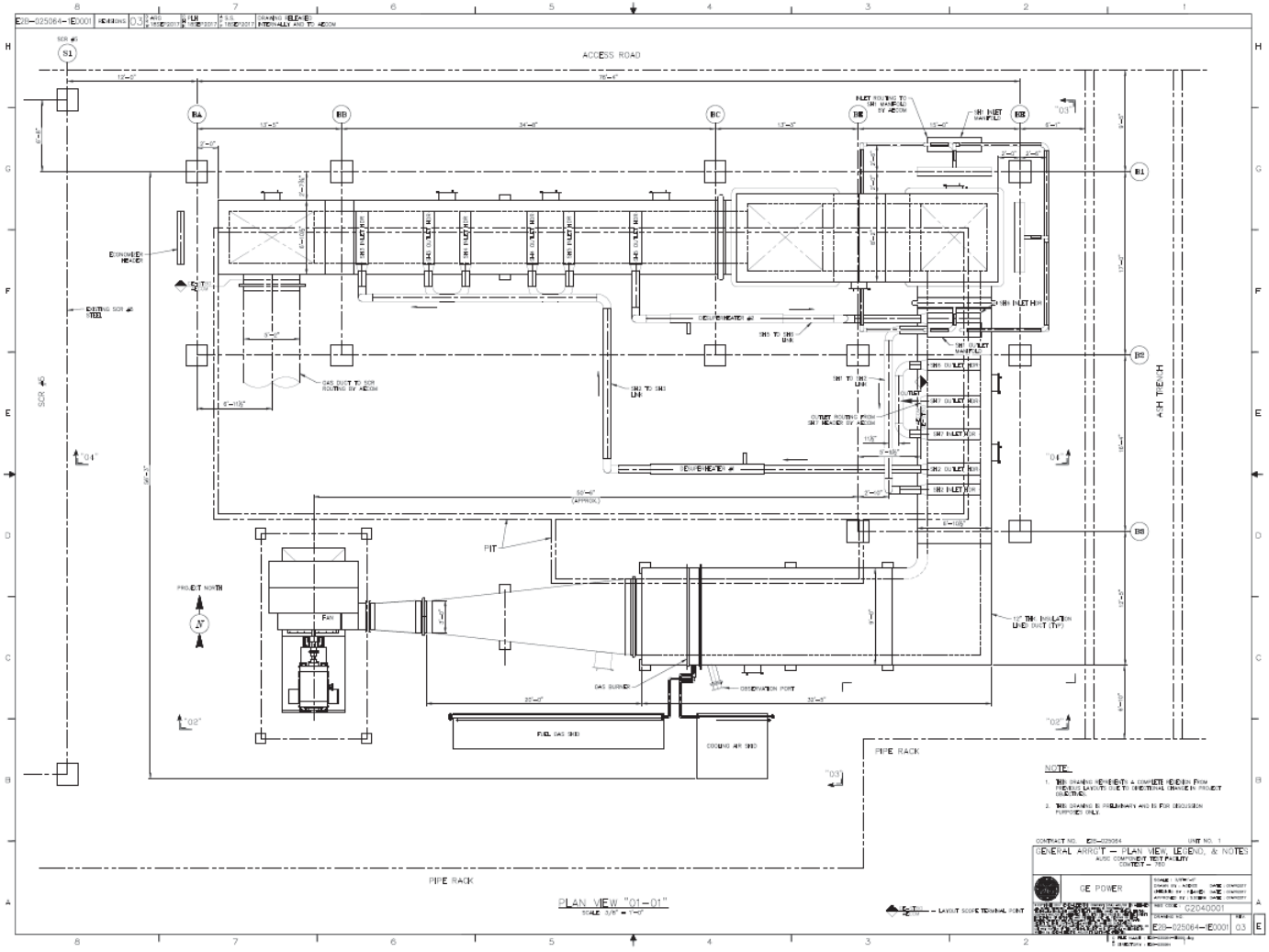


Figure 4-6 GE Superheater - Plan View

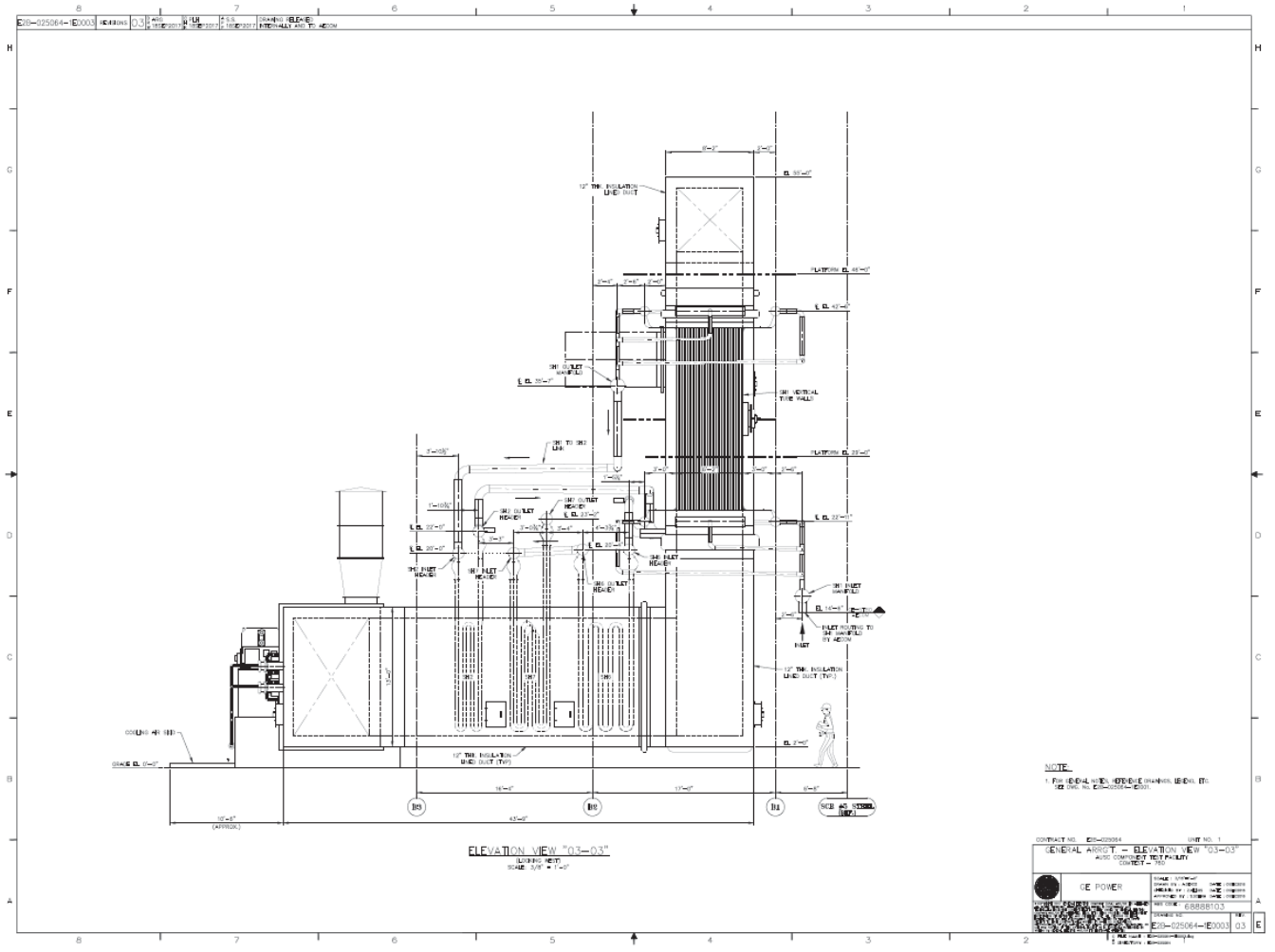


Figure 4-7 GE Superheater - Superheater Inlet from Burner

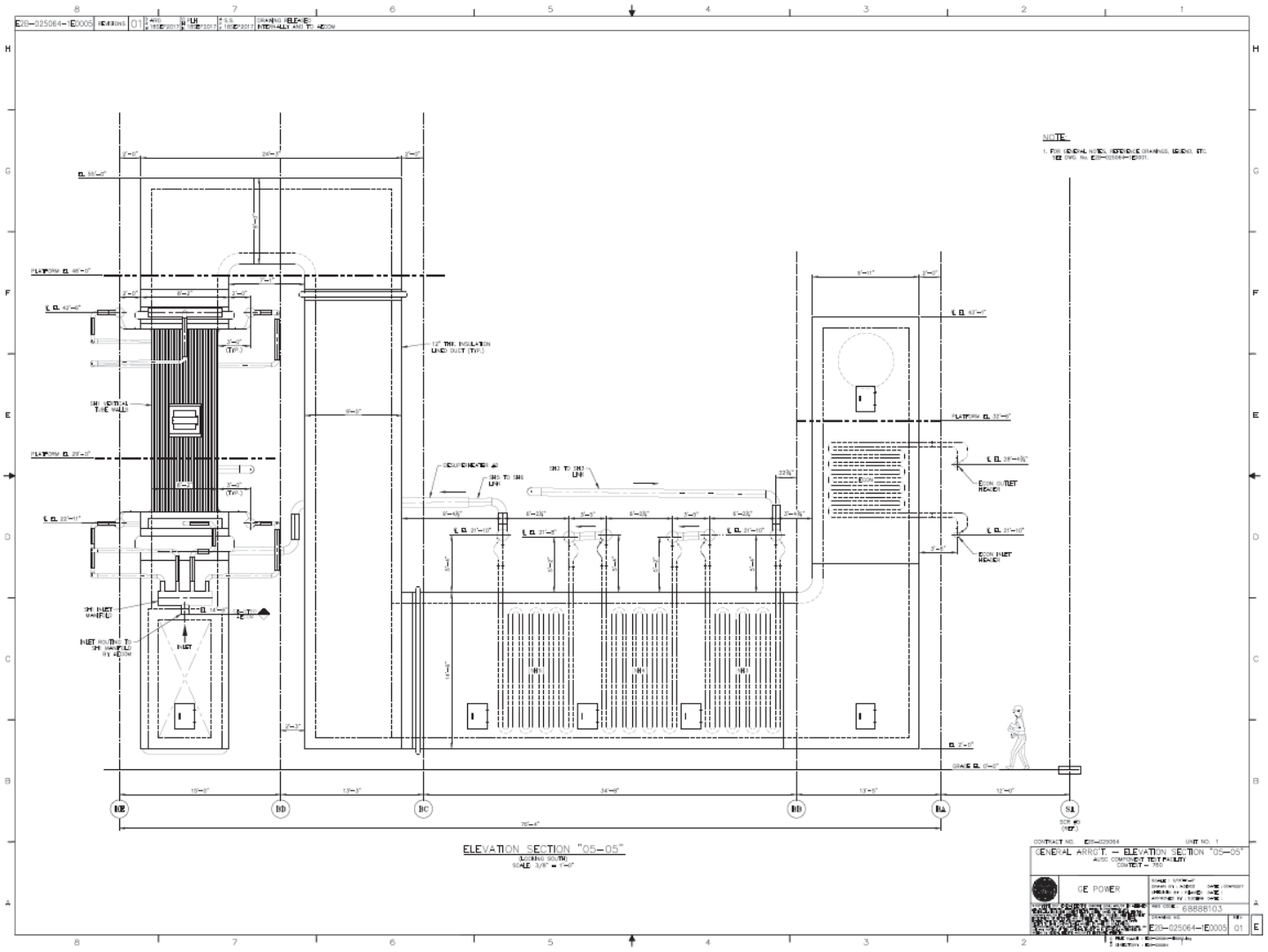


Figure 4-8 GE Superheater Backpass

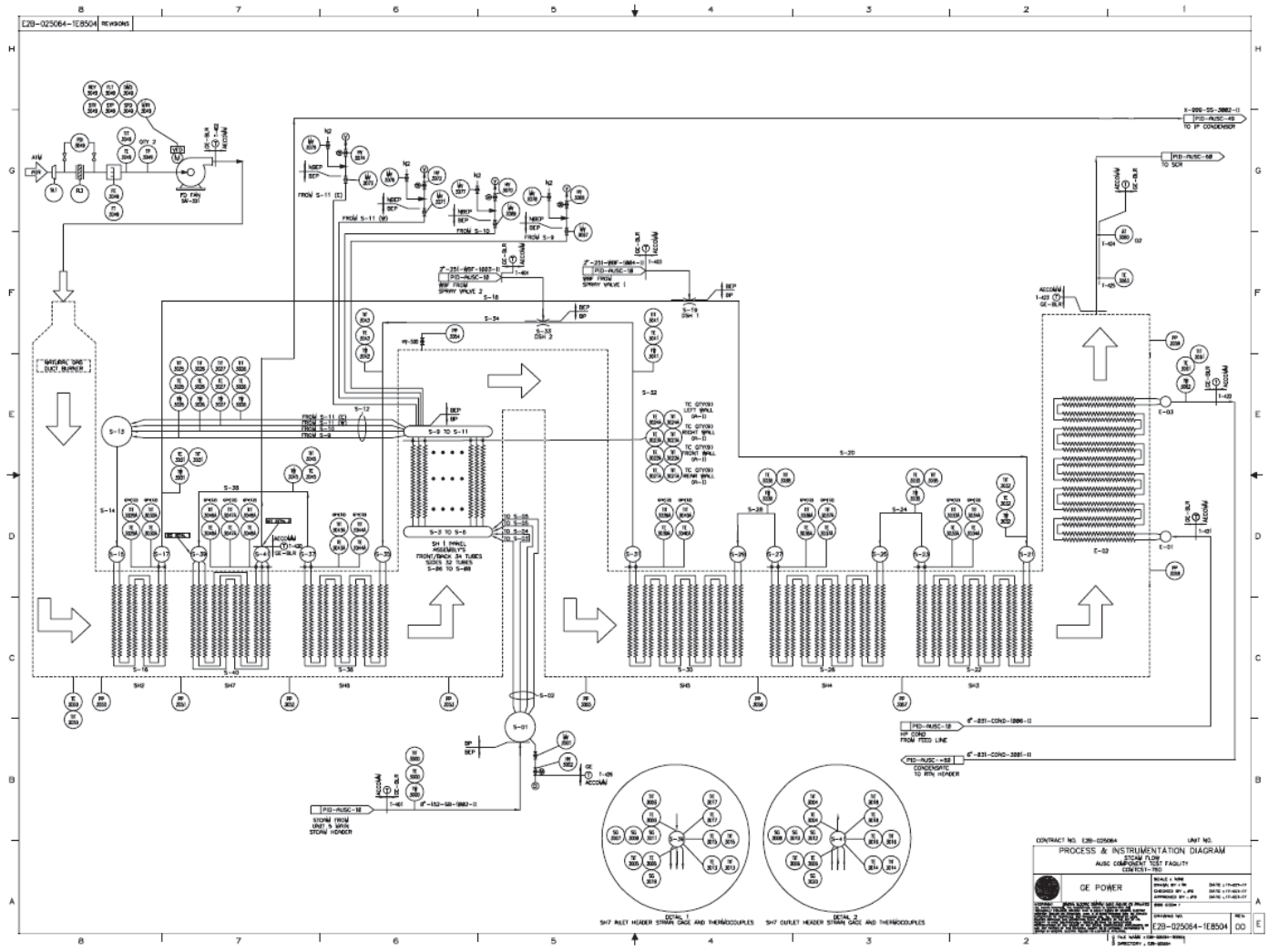


Figure 4-9 GE Superheater Steam Side Piping and Instrumentation Diagram

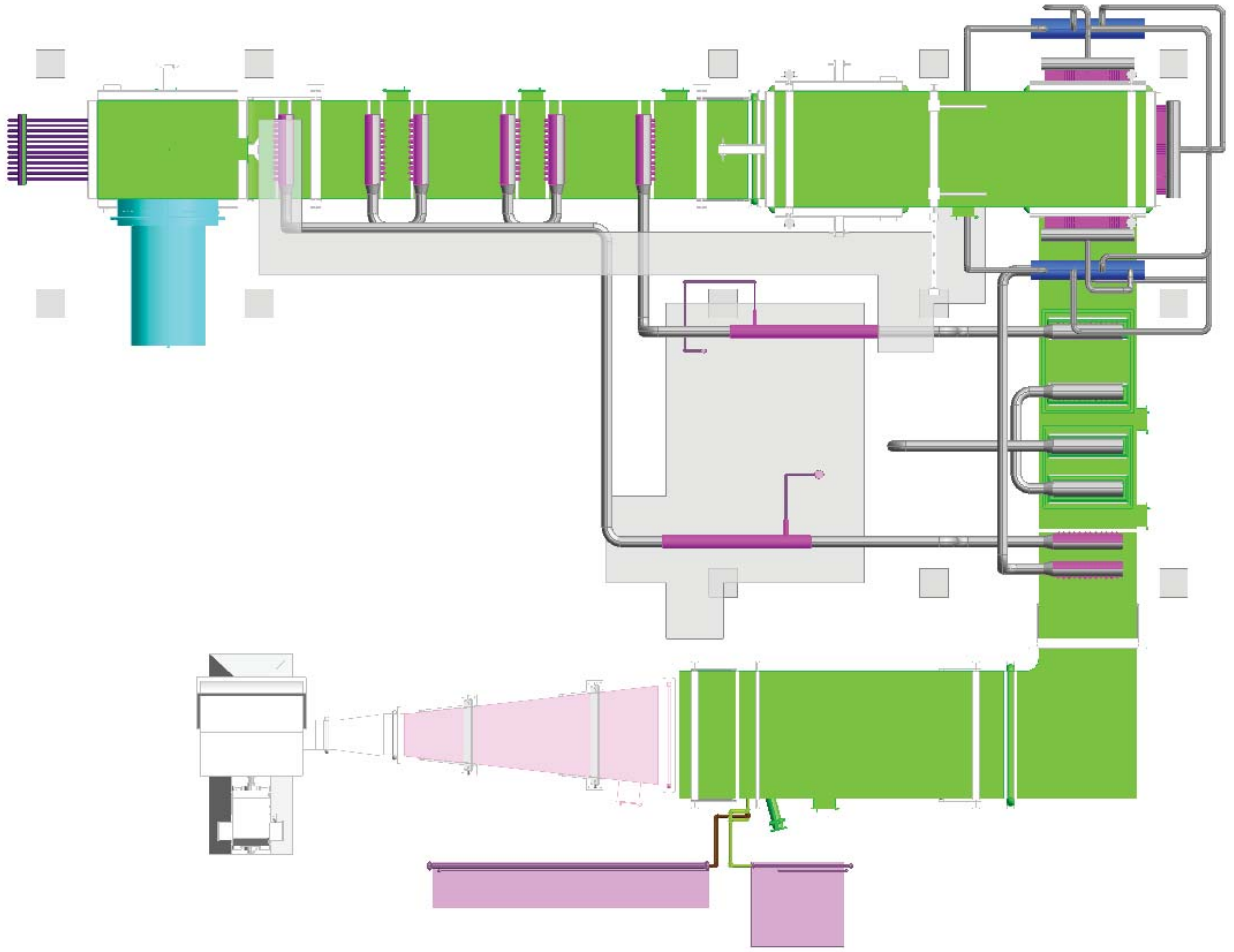


Figure 4-10 GE Superheater - 3D Model Plan View

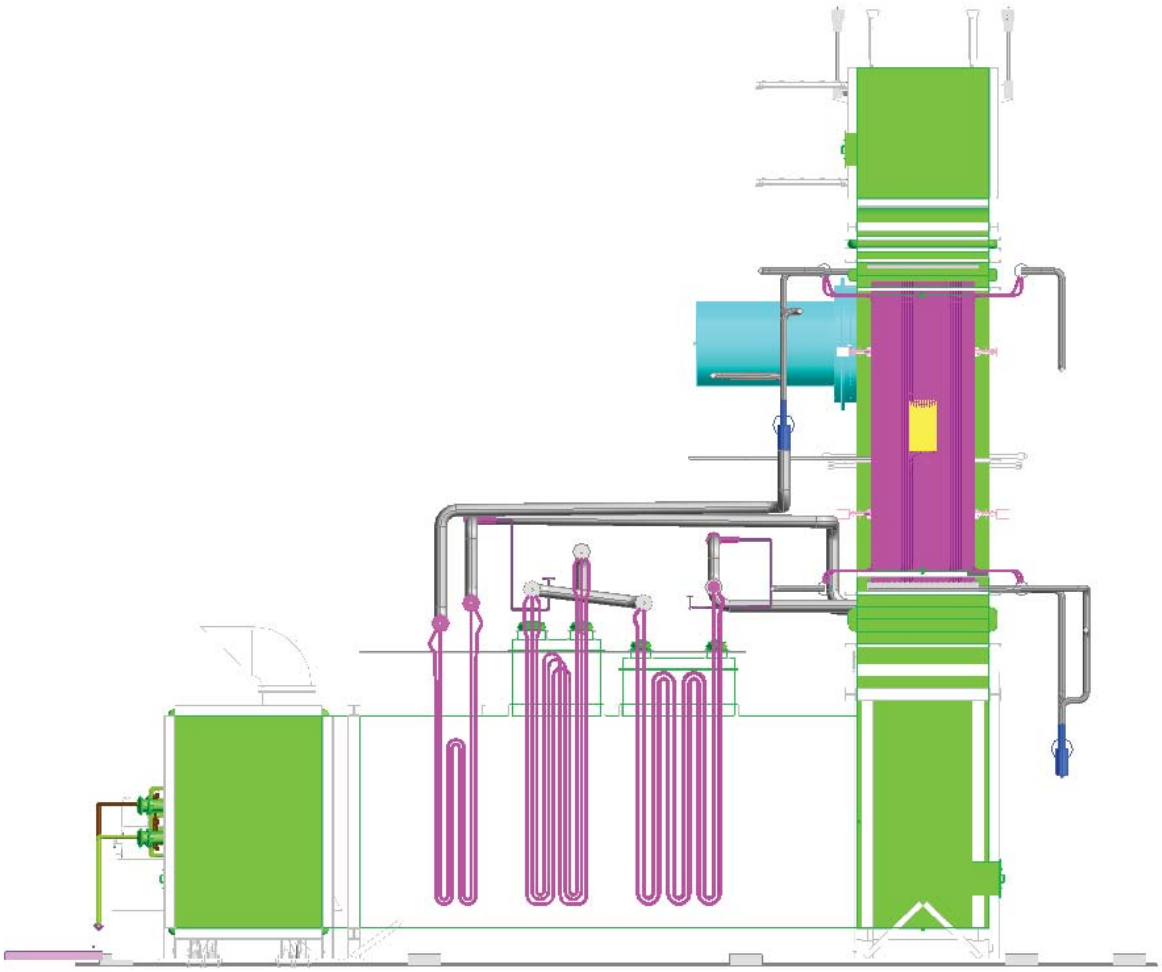


Figure 4-11 GE Superheater - 3D Model Superheater Inlet from Burner

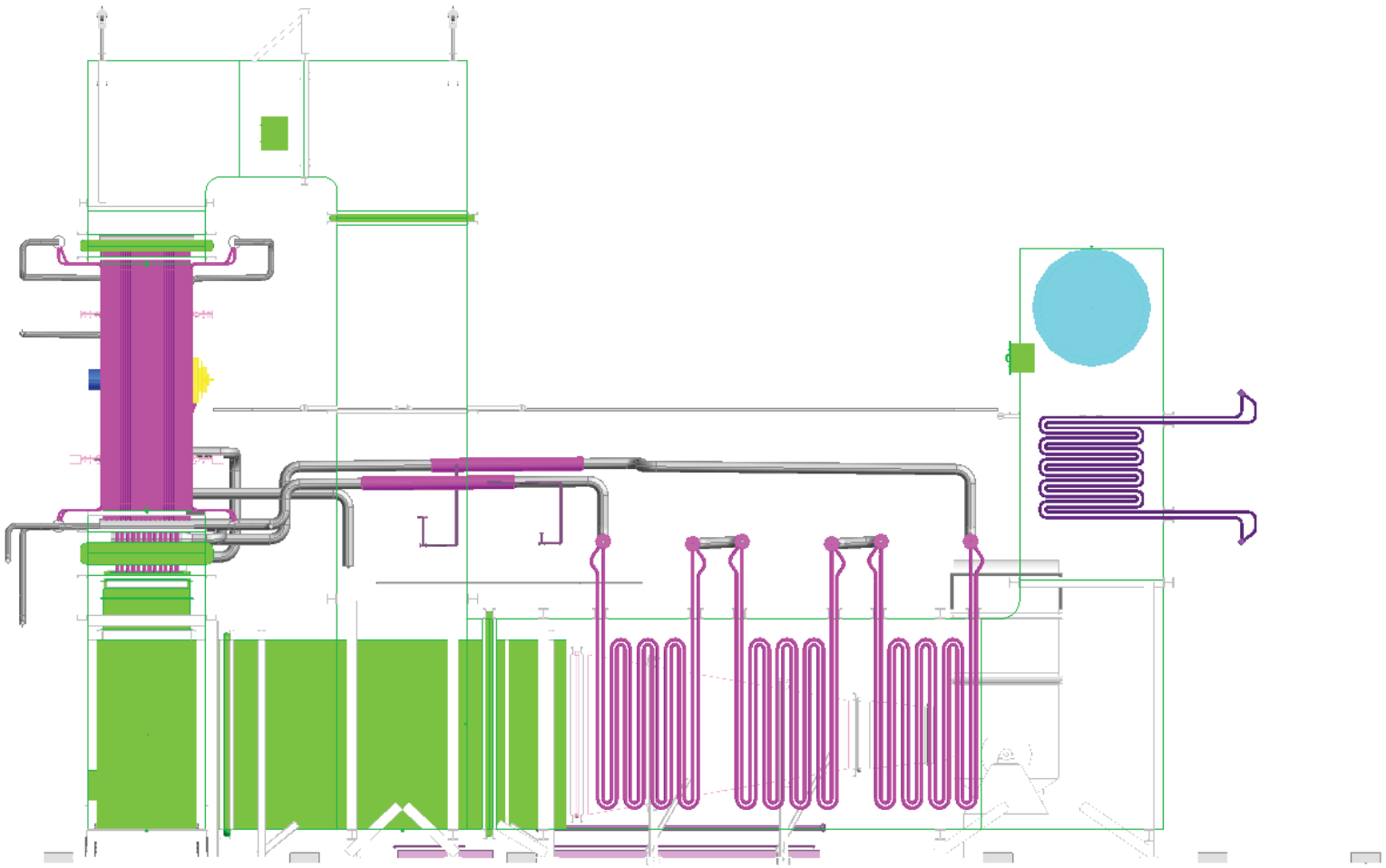


Figure 4-12 GE Superheater - 3D Model GE Superheater Backpass

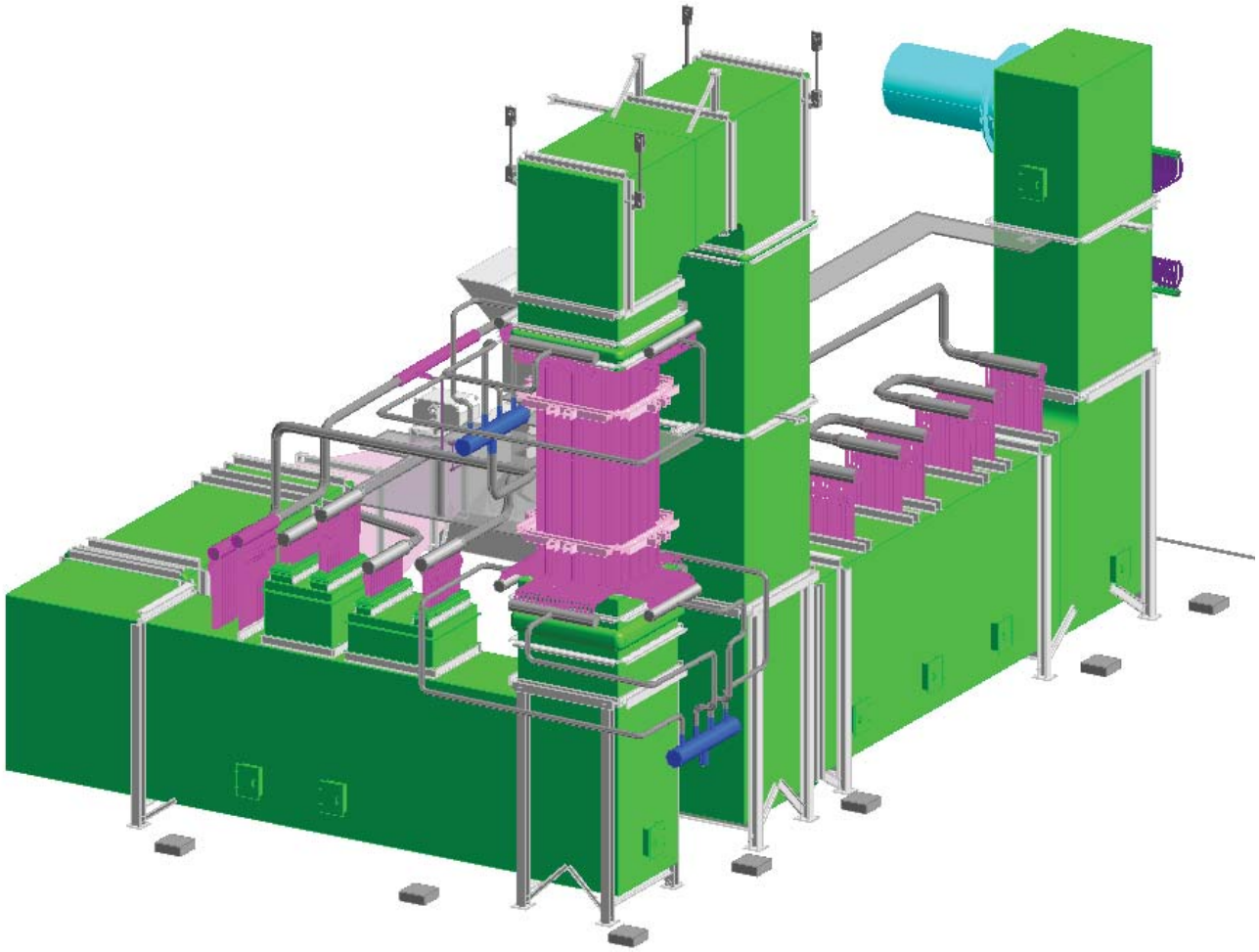


Figure 4-13 GE Superheater - 3D Model

4.2 **AUSC Steam Turbine**

4.2.1 Steam Turbine Configuration

The initial Phase 1 included an engineering evaluation of both impulse and reaction steam path designs for the ComTest steam turbine design as well as a hypothetical, full-scale AUSC application. The objective of the comparative evaluation was to assess performance, cost, and technology barriers for each technology. Based on the pressure and flow constraints provided to General Electric by the project team, as well as basic turbine scaling evaluations, the ComTest turbine options were an eleven-stage, impulse turbine operating at 5,000 RPM with a first stage bucket active length of 24 mm (0.96 in) or a reaction steam turbine design comprised of twenty-seven stages operating at 4,700 RPM with a first stage bucket length of 22 mm (0.85 in). The impulse configuration, shown in Figure 4-14 reflects the concept for a gas-turbine style, through-bolted, stacked disk, rotor configuration. The gas-turbine style, rotor concept was a consequence of limited research and data regarding the weldability of the HAYNES 282 alloy forging and concerns regarding the European, nickel welding, state of art. The comparative evaluation confirmed the feasibility of welding nickel-based alloy material, so that the higher efficiency, reaction design shown in Figure 4-15 could be selected for further development and detailed design.

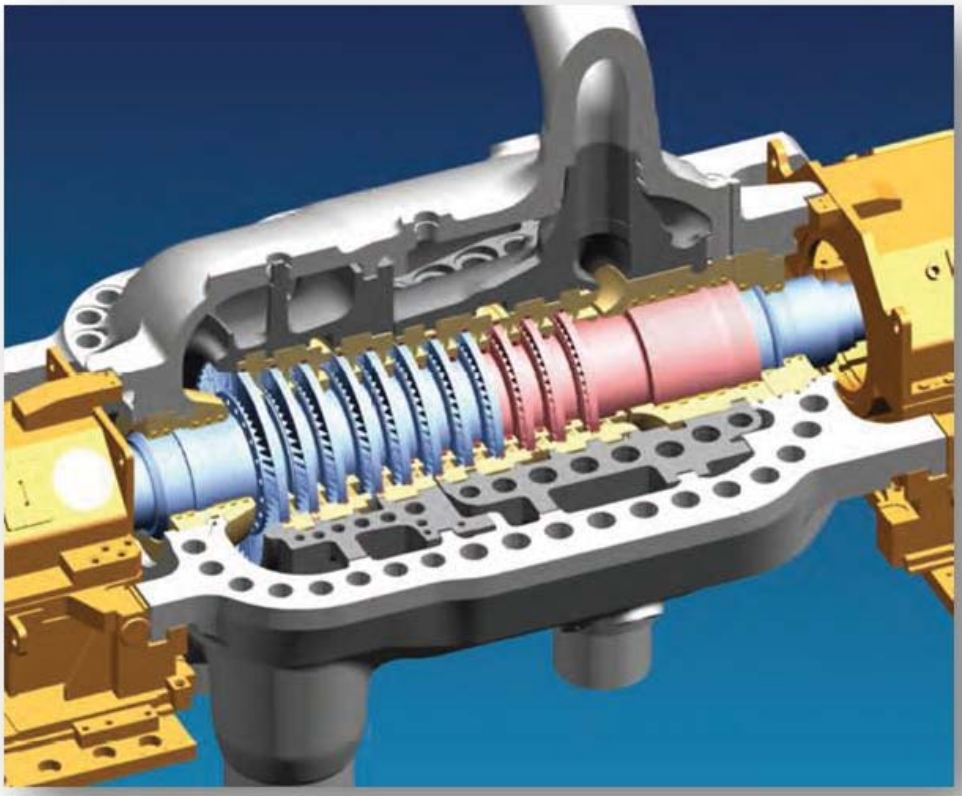


Figure 4-14 Illustration of Eleven Stage, Impulse Turbine

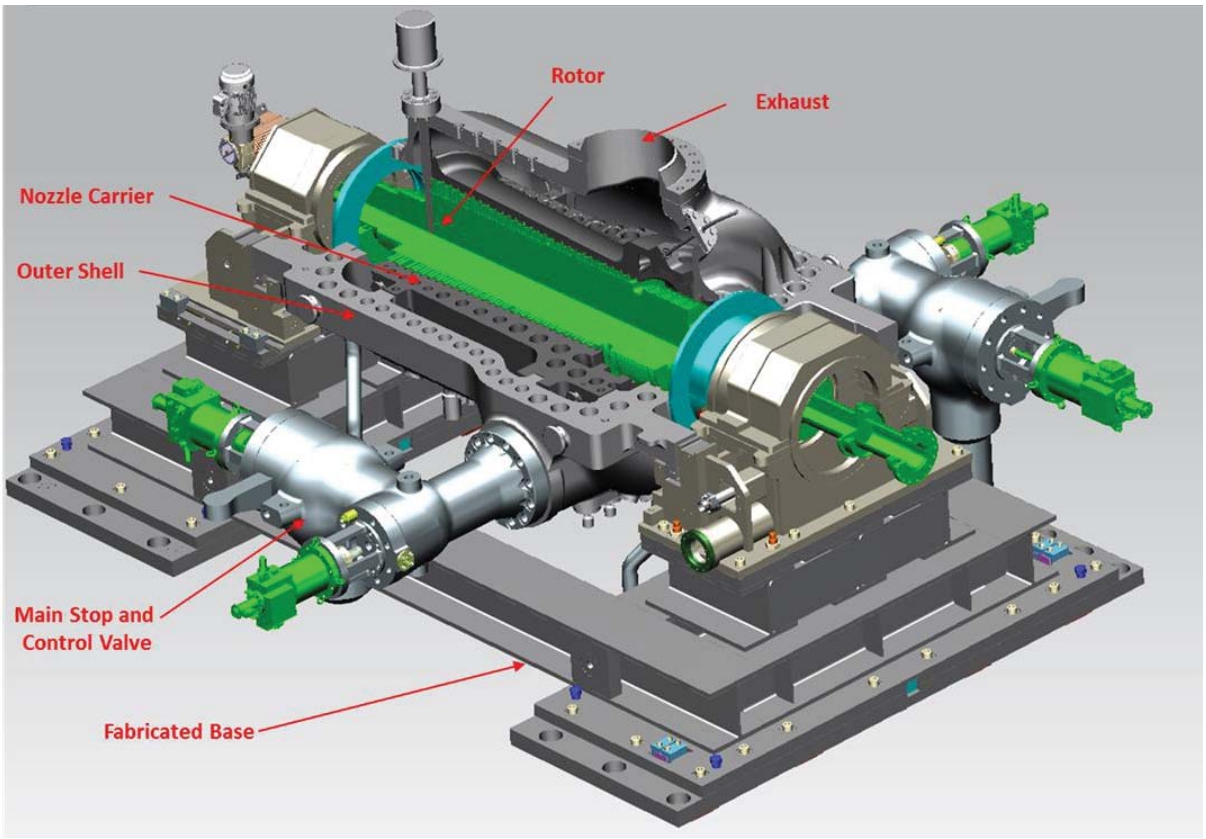


Figure 4-15 Illustration of Twenty-Seven Stage, Reaction Turbine

The operational and economic impacts of turbine exhaust pressure were also investigated during the ComTest FEED study. The initial assumption for the ComTest turbine exhaust pressure was that the turbine exhaust would be tied to a condenser or to the Youngstown Thermal reboilers. For the Youngstown Thermal site, the turbine exhaust pressure was initially increased to 205 psia to enable the host site to generate both the high and low-pressure process steam from the turbine exhaust. While this scenario would be economically favorable, the constant exhaust pressure created multiple issues for the steam turbine design and operation.

GE planned to be able to demonstrate the use of multiple materials, fabrication technologies, and various operational scenarios that are expected in a future full-scale AUSC turbine. The material and fabrication techniques include: 10Cr stainless steel Outer Shells and HAYNES 282[5] alloy to CrMoV welded rotors. The operational scenarios included: Cold Start, Warm Start, Hot Start, Hot Restart, and variable load operation. To demonstrate each of these requirements, the turbine exhaust steam temperature must be held to a level below 1100°F to not exceed the material temperature capabilities of the non-nickel alloys and dis-similar weld regions.

As the exhaust pressure increases, the steam expansion line shortens, resulting in higher exhaust temperatures. The situation becomes increasingly problematic during low load operation where the exhaust steam temperatures were calculated to be more than 1200°F.

[5] HAYNES® 282® is a trademark of Haynes International, Kokomo, IN, USA.

Assuming the inlet steam conditions are held constant, the only way to effectively affect this change across the turbine load spectrum is to increase the expansion line length by decreasing the exhaust pressure.

GE performed a study of exhaust temperature, as a function of exhaust pressure, across the expected operating range of the ComTest steam turbine and determined that a turbine exhaust pressure between 70-80 psia would yield satisfactory exhaust steam temperature conditions and maintain a reasonable steam path design. A comparison of the turbine exhaust steam temperature at varying load levels for the 206 psia and 70 psia cases is shown in Table 4-1.

Table 4-1 Exhaust Temperature as a Function of Load and Exhaust Pressure

	Flange Exhaust Pressure (absolute) 206 psi	**Flange Exhaust Pressure** (absolute) 70 psi
	Exhaust Temp °F	**Exhaust Temp** °F
Baseload	1070	864
75% Part Load	1130	895
50% Part Load	1190	940
25% Part Load	>1250	1020

Based on the results shown above, the thermodynamic design conditions for the ComTest steam turbine are shown in Table 4-2. The steam conditions are representative of the intermediate pressure turbine section of a future AUSC power plant.

Table 4-2 Thermodynamic Design Conditions for the ComTest Steam Turbine

Parameter	**Value**
Throttle Pressure (absolute)	620 psia
Throttle Temperature	1400°F
Throttle Flow	119,510 lb/hr
Exhaust Pressure (absolute)	70.7 psia

4.2.2 Heat Balance

Figure 4-16 illustrates the ComTest steam turbine's heat and mass flow balance at the 100% rated condition corresponding with an output of 10,676 kW at 4700 RPM.

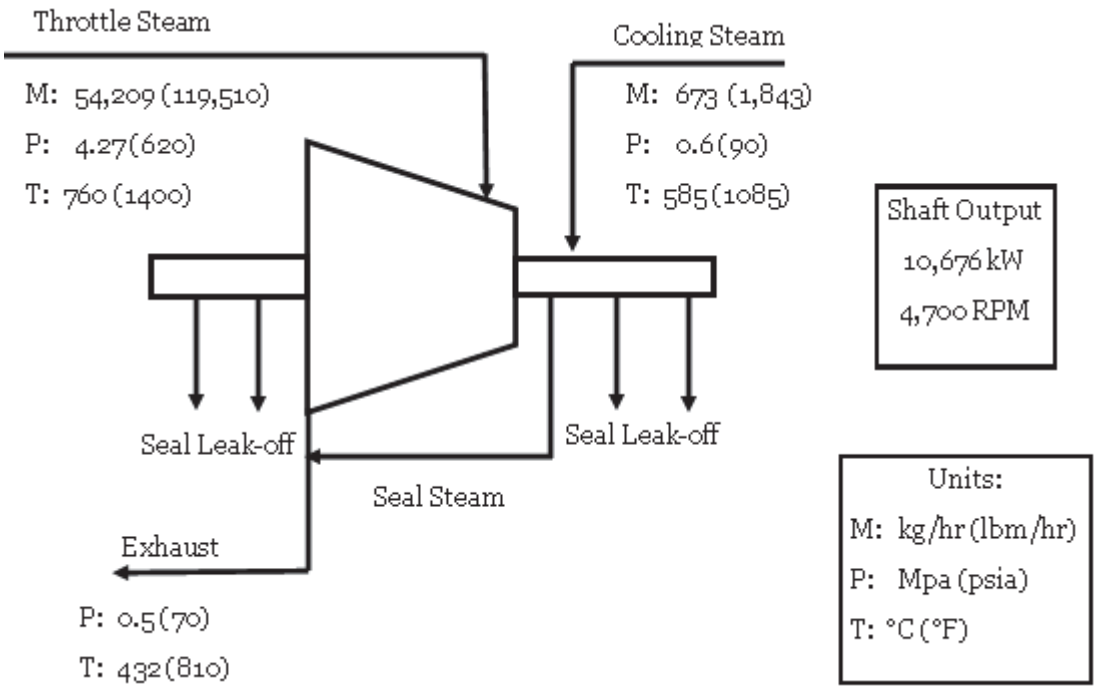


Figure 4-16 Heat Balance Diagram for Turbine Layout

4.2.3 Steam Turbine Overview

Figure 4-17 illustrates an elevation view of the proposed ComTest steam turbine and includes a base mounted, single flow, double shell, steam turbine and two, 100% capacity, on-shell, combined stop and control valve assemblies. The unit would operate in either single or multiple admission modes. Steam from the ComTest Superheater would enter through the combined stop and control valve and be expanded through a twenty-seven stage, reaction type, steam path. After the expansion, the exhaust steam flow would be reversed back toward the inlet end of the turbine and would exit at the top of the outer shell through a 24 in exhaust pipe. The reverse flow configuration provides mass cooling of the inner shell and the inlet region of the outer shell. Figure 4-18 illustrates a plan view of the steam turbine arrangement.

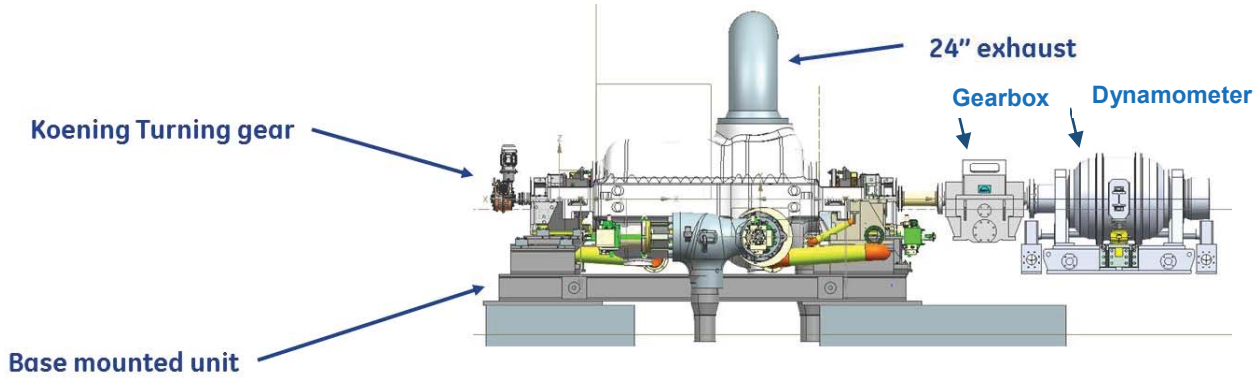


Figure 4-17 Turbine System Arrangement, Elevation View

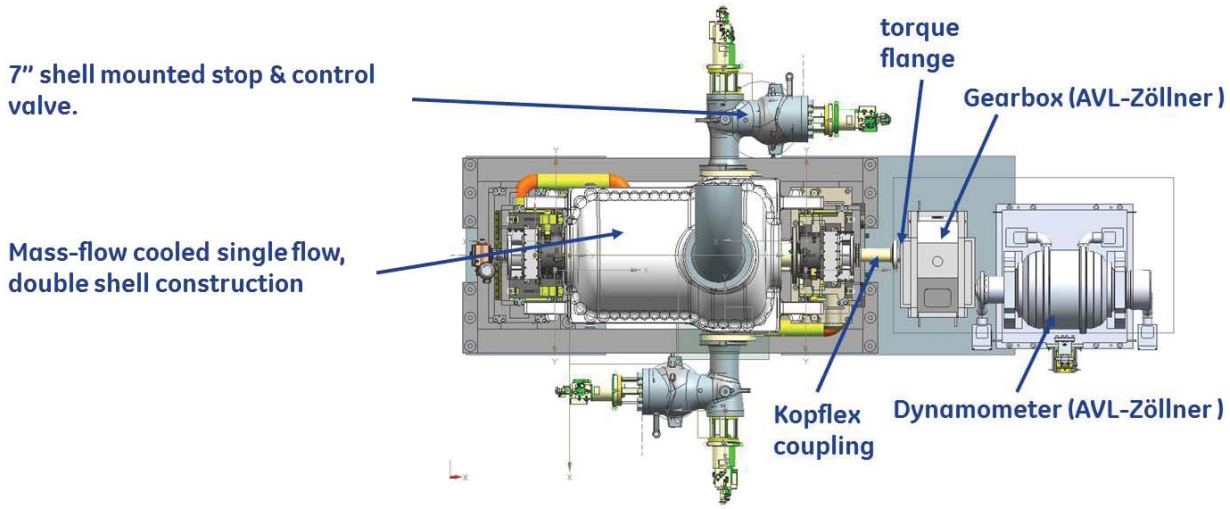


Figure 4-18 Turbine System Arrangement, Plan View

4.2.4 Outer Shell

The steam turbine outer shell would be a two-piece (upper and lower halves) design, cast from existing, i.e. mature, material specification, 10-Cr stainless steel. The outer shell design shared features with full-size designs including: center line supports, horizontal joint bolts, lifting trunnions, drain provisions, and jacking pockets. The outer shell also had provisions for direct mounting of two, combined, stop and control valve assemblies that admit steam to the lower half of the inner shell through sleeves that bridge the outer and inner shell. The outer shell design met all of the GE design criteria for 30-year life including the safety factor requirements for 250,000-hour creep rupture. The shell, shown in Figure 4-19, was well within the weight/production limits and capabilities of GE's current steam turbine shell suppliers.

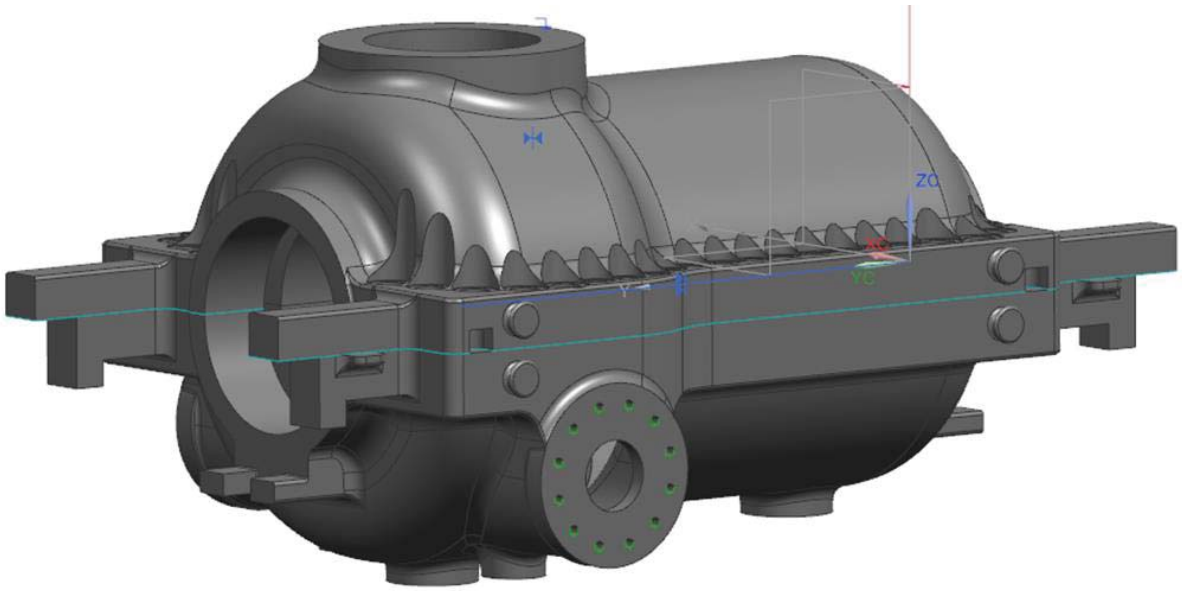


Figure 4-19 Turbine Outer Shell, Upper and Lower Halves

4.2.5 Inner Shell

By comparison, the inner shell was a two-piece (upper and lower halves) design, bolted at the horizontal joint and cast from nickel-based HAYNES 282 alloy material. The design effort originated with a common USC inner shell module that was modified to meet the specific design requirements for the ComTest application. The design strategy for modification of the existing USC inner shell module included:

- Material change to HAYNES 282 alloy;
- Reduction of scale to match demonstration size turbine;
- Geometry change to meet design practice for minimum ligaments and feature size;
- Geometry change for improved castability with HAYNES 282 alloy;
- Aerodynamic redesign of inlet annulus to minimize partial arc response during single control valve operation;
- Additional instrumentation provisions for validation and monitoring.

The inner shell shared the design features of full-size machines including: a toroidal inlet annulus, center line supports, horizontal joint bolts, lifting trunnions, drain provisions, and jacking pockets. Steam would be admitted through the valve transition piece into the inlet annulus in the lower half of the inner shell prior to being directed toward the first-stage, stationary blade. The inner shell also contained the dovetails for the twenty-seven stages of stationary, reaction blades. Figure 4-20 illustrates an external view of the inner shell, while Figure 4-21 illustrates an internal view of the inner shell and the dovetails for the stationary, reaction blades. The inner shell was designed using material properties for large cast HAYNES

282 alloy parts developed under the previous phase[6] of the ComTest materials development program. The inner shell meets all GE design criteria for 30-year life including the safety factor requirements for 250,000-hour creep rupture.

The inner shell had assembled dimensions of 82 in long x 61.75 in wide x 64.5 in high and had an expected finished weight of 15,400 lb. The lower half of the inner shell was the larger of the two halves due to the inlet geometry and the gib key posts with a finished weight of 9,100 lb.

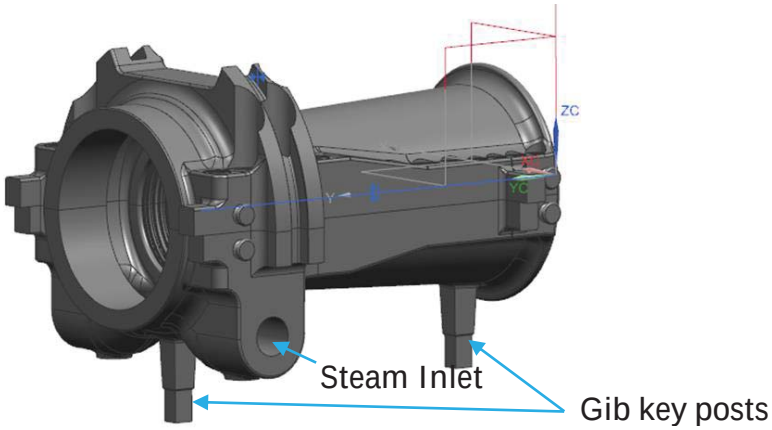


Figure 4-20 Turbine Inner Shell, External View

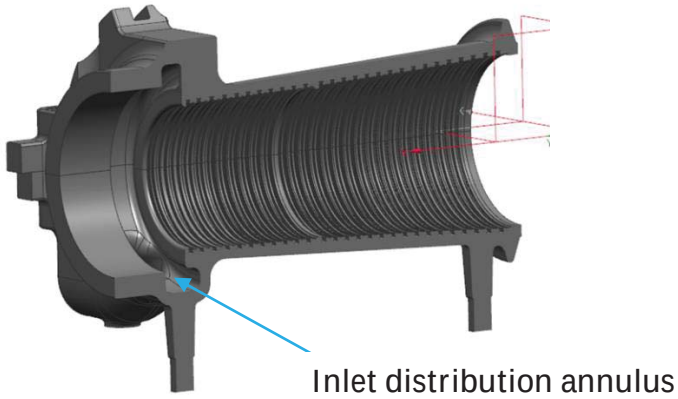


Figure 4-21 Turbine Inner Shell, Internal View

The inner shells required numerous machining operations, including:

- Horizontal joint machining
- Thru-bolt holes
- Internal dovetails for twenty-seven stages of stationary blading
- Seal ring fits for the control valve sleeve

[6] This previous phase was the program under DOE Cooperative Agreement: DE-FE0000234 along with Ohio Coal Development Office Grant Agreement: D-0502(B). That work was awarded and performed prior to the AUSC ComTest Award DE-FE0025046

- Tapped holes for combined stop and control valve flange
- Valve flange face
- Numerous positional fits (vertical and horizontal keys, gib key posts, etc.)

Each of these features required a different machining process not previously performed on cast HAYNES 282 alloy by either GE's own manufacturing facilities nor prospective external vendors. Additional tooling and process development would be warranted prior to receipt of the ComTest inner shell castings to mitigate delivery cycle risk and prevent mis-machining damage to the production casting. Due to the large size of the assembled inner shell, few external vendors have the capacity to perform the required work.

4.2.6 Steam Turbine Rotor

The steam turbine rotor was a four-piece, welded, bi-metallic assembly comprised of a center section made from two HAYNES 282 alloy forgings and outboard ends made of CrMoV, low alloy steel forgings. Figure 4-22 illustrates the rotor design of this configuration. This construction would enable the optimized use of HAYNES 282 alloy, limited to only the highest temperature regions to minimize overall component cost. The cost of the welding process is a fraction of the added cost of a rotor comprised entirely of HAYNES 282 alloy material. The HAYNES 282 alloy cylindrical forgings were each approximately 22 in dia. x 60 in m long, which would require extending the currently demonstrated supplier's capability of 22 in m dia. x 45 in long. The expansion of the supplier's forging capability from 45 in to 60 in was assessed as low risk, after extensive discussions between GE rotor forging engineers and the prospective supplier.

The rotor includes dovetail grooving for the twenty-seven stages of reaction blading. The dovetail designs were a standard, proven GE design which have been successfully used in other steam turbine applications. The rotor was designed using material properties for triple-melt, forged, HAYNES 282 alloy material that was developed under the previous phase[7] of the AUSC materials development program. The rotor meets all GE design criteria for 30-year life including the safety factor requirements for 250,000-hour creep rupture.

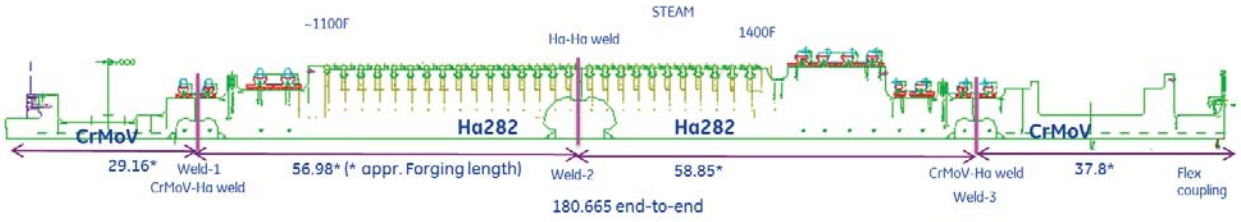


Figure 4-22 Rotor Cross Section

The HAYNES 282 alloy triple-melt process includes vacuum induction melt (VIM), electro slag re-melt (ESR), and vacuum arc re-melt (VAR). The low temperature rotor ends would be manufactured from CrMoV forgings, commonly used in ultra-super critical steam turbine applications, welded to the HAYNES 282 alloy forgings. The use of CrMoV in the outboard ends reduced the total rotor cost, provided a suitable journal surface for hydrodynamic bearings,

[7] This previous phase of the AUSC materials development program DOE Cooperative Agreement: DE-FE0000234 Ohio Coal Development Office Grant Agreement: D-05-02(B)

free from wire-wooling, and would be consistent with future commercial AUSC steam turbine designs.

Transient and steady state thermal and mechanical evaluations were performed to ensure the composite rotor design met all GE design criteria. Detailed heat transfer models of the rotor were developed. These models were used as the foundation of the rotor thermal analyses, which included sensitivity studies for bounding steam seal clearances at both inlet and exhaust ends of the rotor and the effect of variable cooling steam flow.

The location and geometry of the three rotor welds was a critical aspect of the rotor design. The weld locations were selected for regions of the rotor where the temperatures and stresses were acceptable to meet low cycle fatigue (LCF), creep strain, and yield criteria for the base material, weld, and heat affected zone (HAZ). The dis-similar material (HAYNES 282 alloy to CrMoV) welds were placed in the outboard packing region while the HAYNES 282 alloy to HAYNES 282 alloy weld was located on the rotor between the 11^{th} and 12^{th} stage blade roots. The results of the analyses indicated that these locations for the rotor welds would enable meeting all design requirements.

Stresses in the rotor body and dovetail area in the steam path were calculated using standard processes and compared against allowable values considering creep rupture, tensile and yield criteria and standard safety factors. The design met all standard applicable design criteria including bending and torsional stresses.

Transient mechanical analysis (cold start) was performed to check stresses during start up and to confirm adequate low cycle fatigue requirements at rotor fillets and weld cavity areas. Residual stress effects at rotor weld heat affected zone (HAZ) were also included in the analysis to verify the design is acceptable. The rotor geometry was adjusted to meet all design criteria.

4.2.6.1 **Forging and Welding Process Development**

The rotor forging and welding process development was characterized by the following elements:

- Expanding the forging size envelope to 0.75 m (30”) VAR ingot
- Obtaining material properties for forgings in the solution annealed and double aged state
- Develop and demonstrate HAYNES 282 alloy to HAYNES 282 alloy welding
- Develop and demonstrate HAYNES 282 alloy to CrMoV welding
- Obtain material properties for finish welded products
- Develop and demonstrate machining capability for turbine geometry in HAYNES 282 alloy

4.2.6.2 **Forgings**

Currently, HAYNES 282 alloy forging size limitations require the ComTest (and full scale) rotors be weldments. In addition to demonstrating weldability, the ComTest steam turbine program provided an opportunity to challenge forging vendors to produce larger ingots to minimize the number of individual pieces in the weldment. The ComTest steam turbine required two 22-inch dia. x 60-inch long rotor forgings. The AUSC materials development program demonstrated the

ability to manufacture a HAYNES 282 alloy rotor forging made from 24 in VAR[8] ingots, which would yield a 22-inch dia. x 45 to 47-inch long forging. Similarly, a 30-inch VAR ingot would yield the full 22-inch dia. X 115-inch long forging slightly less than the length required to produce a single piece ComTest HAYNES 282 alloy forging. Creating two forgings from 30-inch VAR ingot would demonstrate an expanded forging capability and providing extra material for material property testing in the solution annealed and double aged condition, as well as conducting weld and heat treatment trials.

Post forging and sample removal, the HAYNES 282 alloy would be NDT inspected and solution annealed in preparation for welding.

4.2.6.3 **Rotor Welding**

The formation of the composite rotor forging from the four, individual forgings involved several different operations and processes. First, the two, solution annealed, HAYNES 282 alloy forgings would be welded together using HAYNES 282 alloy weld wire. Then, a layer of INCONEL 617 alloy material would be deposited on the outboard ends of the forgings as a butter layer for the HAYNES 282 alloy to CrMoV dis-similar material weld. This assembly would then be inspected prior to a two-step aging process. Figure 4-23 is a conceptual illustration of the similar metal weld and the deposition layer in preparation for the secondary welding operations.

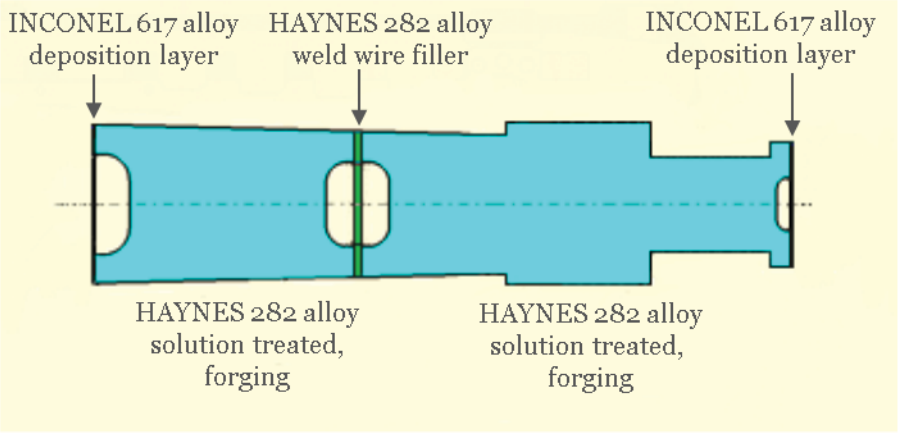


Figure 4-23 Initial Rotor Welding Operations

The CrMoV forgings would also be prepared with a deposition layer of Inconel 617 alloy material. Then, the CrMoV forgings would be welded to the previously prepared and aged HAYNES 282 alloy forgings using INCONEL 617 alloy weld wire. Upon completion of the welding processes, the composite forging would be non-destructively inspected for defects, post-weld heat treated, and prepared for machining operations. Figure 4-24 is a conceptual illustration of these secondary welding operations producing the composite rotor forging.

[8] VAR is an acronym for Vacuum Arc Re-melt which is employed in this case to produce a triple melted HAYNES 282 alloy ingot from which the forging is produced. Triple melting produces a material with improved characteristics compared to the double-melt ingots produced by the alloy supplier.

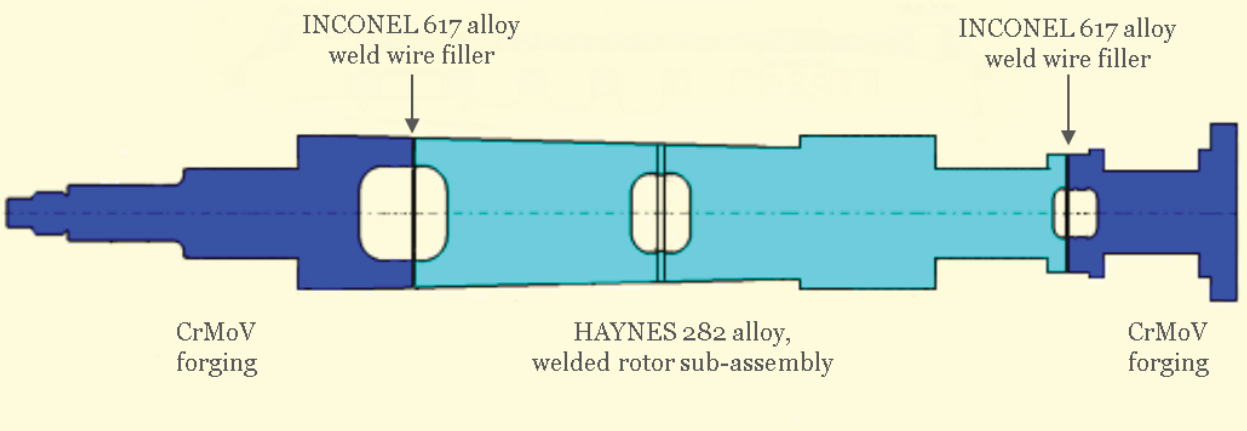


Figure 4-24 Secondary Rotor Welding Operations

Planned welding trials that would be performed in Phase 2 would include:

- INCONEL 617 alloy deposition layer on HAYNES 282 alloy and CrMoV substrates
- Groove weld development using plate stock
  - HAYNES 282 alloy to HAYNES 282 alloy with HAYNES 282 alloy weld wire
  - CrMoV HAYNES 282 alloy with INCONEL 617 alloy deposition layer or "buttering"
- Groove weld development on cylindrical rounds
  - HAYNES 282 alloy forged bar to HAYNES 282 alloy forged bar with HAYNES 282 alloy weld wire
  - CrMoV to HAYNES 282 alloy forgings with INCONEL 617 alloy deposition layer or "buttering"

4.2.6.4 **Rotor Welding Process Development Trials**

In anticipation of producing the welded, composite structure rotor, welding process development trials were completed. The objective of these trials was to determine the weld process parameters, filler materials, weld preparation geometry and evaluate the integrity of the welded joint for specification in the design.

Rotor welding trials were completed with flat plate mock-ups to establish weld parameters for HAYNES 282 to HAYNES 282 alloy welds with two different filler wires: HAYNES 282 alloy and INCONEL 617 alloy. The trials validated the weld preparation geometry and root land thickness necessary to produce satisfactory weld quality results in the mock-ups. The selection of the filler metal would depend on the prevailing stress and duty conditions of rotor design and the weld's location for determining its operating temperature.

The welding trials were completed using 14-inch-diameter, cylindrical, test pieces using both HAYNES 282 alloy and INCONEL 617 alloy filler wire. The size of the test pieces was representative of the ComTest rotor's 22-inch-diameter rotor. While the root pass, root pass tie-in and initial cold wire passes were acceptable and repeatable for both filler wires, the cylindrical test pieces exhibited weld groove distortion and weld groove shrinkage. A hypothesis of the cause of this result related to the weld prep geometry has been made which will require additional welding trials for confirmation.

Dis-similar metal weld trials for the 1.25Cr-1Mo-0.25V (CrMoV) to HAYNES 282 alloy rotor weld was completed using 2-inch-thick, flat plate mockups. An INCONEL 617 alloy deposition layer was applied to both CrMoV and HAYNES 282 alloy test pieces before welding the pieces with an INCONEL 617 alloy filler wire. The INCONEL 617 deposition trials determined that cold wire weld processing produced a better-quality weld deposit than hot wire weld processing, although cold wire did show some evidence of micro fissures. The reason for formation of the micro fissures is not fully understood. Additional evaluation will be required.

Additional weld development work will be necessary whether to produce the ComTest turbine rotor of the Phase 1 design or the prospective full-size, rotor. The full-size rotor would be approximately 33-inch to 43-inch diameter compared to the 22-inch diameter of the ComTest rotor design.

4.2.6.5 **Rotor Machining**

The high temperature portion of the ComTest steam turbine has several design features that must be machined in the HAYNES 282 alloy material, including:

- Internal dovetails for twenty-seven stages of reaction blading
- Integral rotor teeth for sealing
- Grooves for inserted rotor seals
- Balance weight provisions
- High-low packing lands for seals

The internal dovetails for the reaction blading are the most critical in terms of location and geometry tolerance, and surface finish. The ComTest rotating blades and dovetails are a scaled version typical of GE's USC fossil fuel applications. The scaling of the blade decreases the blade neck width, which makes tooling rigidity more challenging, especially when machining nickel-based alloys. GE has limited experience with machining HAYNES 282 alloy material, and recommended machining trials for this material.

The low-temperature CrMoV rotor ends contain design features common to USC steam turbine designs and no special machining or processes are required.

4.2.7 Steam Path and Blading

The ComTest steam turbine's steam path was optimized using a GE proprietary, automated steam path design tool, in combination with historical design criteria, scaled blade and dovetail geometries, and high-temperature material properties. The steam path design consists of twenty-seven stages of conventional, reaction turbine blading appropriately sized for the plant thermodynamic design and expected throttle flow. The speed of the turbine was increased from a 60 Hz standard of 3600 RPM to 4700 RPM to increase the blade lengths to allow the use of conventional manufacturing and assembly processes. The resulting active blade lengths ranged from 0.91 inch to 3.30 inch, which are within normal manufacturing and assembly capabilities for conventional USC steam turbine rotor materials. The high temperature materials required for ComTest create new machining and assembly challenges that were addressed within the design. Figure 4-25 illustrates the first rotating blade and its relationship to the upstream and downstream stationary blades, where the steam flow proceeds from right to left in the figure.

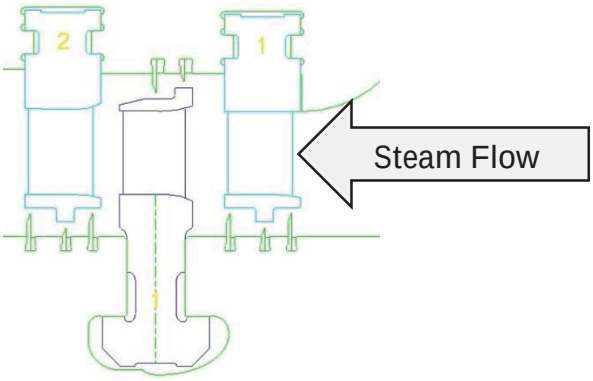


Figure 4-25 Steam Path Detail for First Rotating Blade

The ComTest rotating blade designs were a scale of existing reaction steam turbine rotating blade designs used in other applications. The blade designs were evaluated for centrifugal stresses, steam bending stresses, low-cycle fatigue, creep relaxation, cover contact stresses, and nozzle passing frequency response across the operational spectrum in both steady-state and cyclic transient operational conditions. The blade material was selected on a stage by stage basis to meet GE's design criteria. The most upstream blade stages, being subjected to the highest steam temperatures, would be constructed from NIMONIC 105[9] alloy and INCONEL 625[10] alloy bar stock for high temperature material properties. The later stages of turbine blading would be made using conventional, USC steam turbine materials. The blade designs would meet all GE design criteria, including creep relaxation for a 30-year design life.

Blading was evaluated using traditional design tools, including Finite Element Analysis, against traditional acceptance criteria. Target creep, fatigue and vibration safety factors were met.

4.2.7.1 **Turbine Blade Machining**

The rotating and stationary turbine blades for ComTest were to be manufactured from bar stock using conventional machining methods. GE has limited experience machining turbine blading from NIMONIC 105 alloy bar stock in a production process. The turbine blades have several surfaces that would require precision machining to control profile, position and surface finish including the blade root, vane, and cover. Further machining process development and trials prior to manufacturing release were recommended.

Additional machining would also be required after the bucket assembly. The post-assembly machining of the blade covers would be required to establish final rotating to stationary component clearances. Because of the limited experience with NIMONIC 105, machining trials for these nickel alloy blade covers were also highly recommended to understand manufacturing costs and cycles and the dimensional tolerance and finish capabilities.

Due to the size and weight of the ComTest assembled rotor and inner shell, few external vendors exist with the capability to perform this work.

[9] NIMONIC® 105 is a trademark of Special Metals Wiggin Limited, Hereford, UK
[10] INCONEL® 625 is a trademark of Special Metals Corporation, New Hartford, NY, USA

4.2.8 Pre-warming System

Like most utility steam turbines, the ComTest steam turbine included provisions for pre-warming the turbine prior to admitting main throttle steam. The pre-warming process involved admitting steam into the exhaust pipe through a steam heating pressurization valve while the main throttle valves and the exhaust isolation valves were closed - effectively pressurizing the unit and pre-warming the turbine assembly. The system was designed to bring the turbine metal temperatures up to a minimum temperature of 300°F to control thermal stresses and component life expenditure during cold starts.

4.2.9 Instrumentation

The ComTest turbine contains the full complement of standard instrumentation for turbine control and protection as well as additional instrumentation to be used for validation, monitoring, and diagnostics. All instrumentation would be incorporated in the turbine control system and available for continuous monitoring by GE Engineering through a remote monitoring system.

4.2.10 Turning Gear

The entire power train must be rotated slowly both prior to and after operation to prevent damage from non-uniform thermal gradients including those which if unchecked can result in bowed rotors and damaged bearings. The ComTest steam turbine included an automatic engaging clutch driven turning gear unit that was flange mounted to the turbine front standard. The unit was sized using standard design practice to start the powertrain for zero RPM and maintain constant low speed operation.

4.2.11 Dynamometer

In lieu of a connection to an actual electric grid, a variable load, hydraulic dynamometer was to be supplied to absorb the steam turbine power. The dynamometer was selected through a competitive proposal process. A total of four dynamometer manufacturers prepared proposals for the ComTest application. The selected design consisted of a low-speed, hydraulic dynamometer and a speed reduction gear box. The dynamometer supplier would also provide the control system, lubricating oil system, and the other accessories necessary for the operation of the unit. Figure 4-26 illustrates the arrangement of the dynamometer with the speed reduction gear and associated couplings.

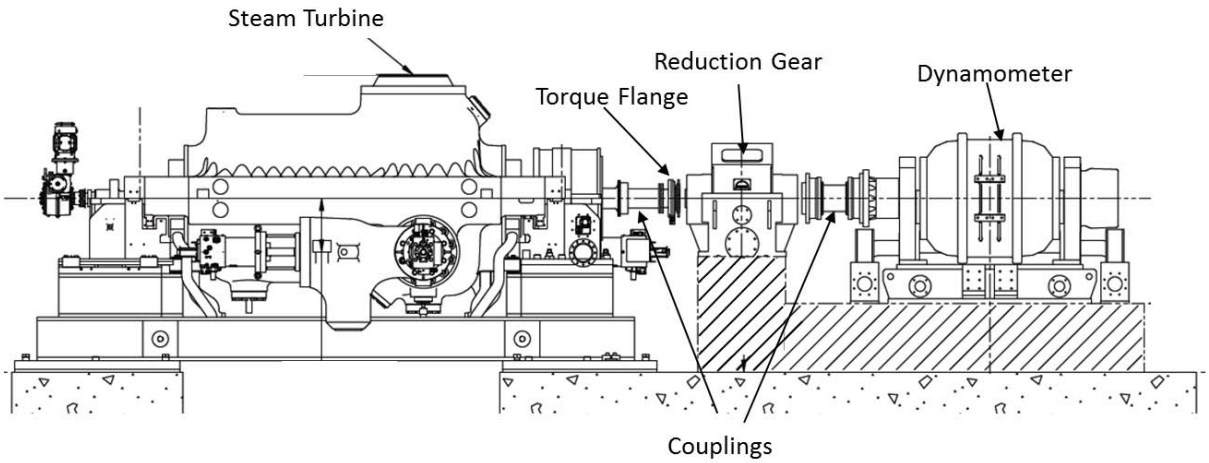


Figure 4-26 Steam Turbine, Reduction Gear and Dynamometer Arrangement

4.2.12 Control System

The ComTest steam turbine control system would consist of a standard Mark VIe[11] control system. The Mark VIe control system is a flexible platform featuring high-speed, networked input/output (I/O) compatible with simplex, dual, and triple redundant systems. Industry standard Ethernet communications would be used for I/O, controllers, and supervisory interface to operator and maintenance stations, as well as third-party systems. The Mark VIe control system would interface with both the steam turbine and the dynamometer, providing turbine speed/load control, system performance monitoring, unit protection, diagnostics and monitoring. The Mark VIe control system would also connect to a remote monitoring and diagnostic platform for continuous, remote monitoring from GE facilities.

4.2.13 Lubricating Oil System

The lubricating requirements for the steam turbine would be furnished by a common forced-feed lubrication system. This lubrication system, complete with oil reservoir, pumps, coolers, filters, valves and various control and protection devices, would provide normal lubrication and absorption of heat rejection load from the turbine bearings. The lubrication system was designed to provide an ample supply of filtered lubricant at the proper temperature and pressure for operation of the turbine.

The oil reservoir for the lubrication system would be fabricated as an integral part of the accessory base. Lube oil pumps would take their suction from the oil tank and discharge into a common header. All lubricant pumped from the lube reservoir to the bearing header flows through the lube fluid heat exchangers to remove excess heat and then through filters providing filtration. After lubricating the bearings, the lubricant flows back through various drain lines to the lube reservoir.

[11] MarkVIe is a trademark of the General Electric Company, Boston, MA, USA

4.2.14 Hydraulic System

The stop and control valve actuators do not require a separate accessory, hydraulic power unit. Each individual actuator would have its own, independent, hydraulic pressure source contained within the unit. The actuators need only be connected to electrical power and the valve specific control signal. Actuators will have redundant trip functions as is customary for all commercial turbines connected to the power grid.

4.2.15 Steam Seal System

A shaft sealing system would be required to seal the turbine casing so that steam does not exhaust into the operating deck, harming personnel, or into bearing housings, contaminating the lubricating oil.

Both “vent” & “seal” end packing leakage steam would exhaust to the gland seal condenser. A desuperheater system would attemperate this combined end packing, leak-off flow prior to entry into the gland seal condenser. This sub-atmospheric steam and air mixture would be drawn out of the end seal packing by a centrifugal blower and condensed within the gland seal condenser. Figure 4-27 shows a schematic of the system.

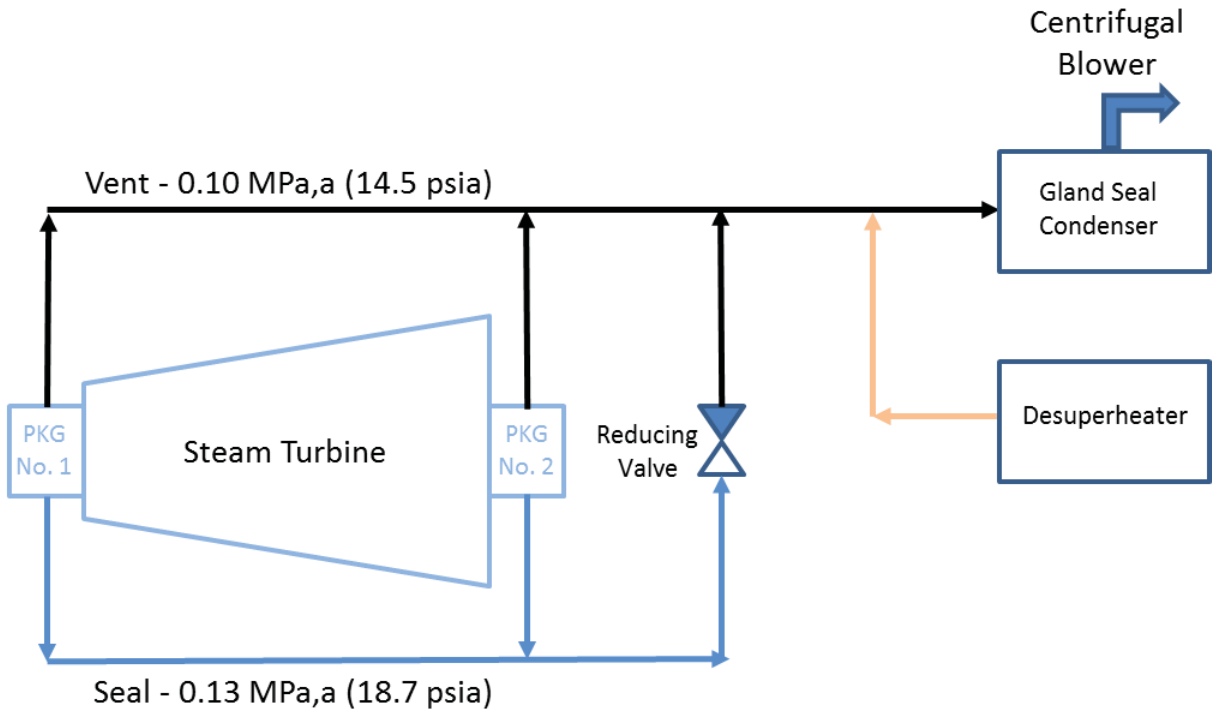


Figure 4-27 Steam Seal System Schematic

4.2.16 Cooling Steam System

Cooling Steam Systems are common on ultra-super critical steam turbines. The ComTest cooling steam system was designed with a simplified version of previous designs used on conventional USC units. The system would provide a controlled flow of steam to the inlet end steam packing region of the turbine to mitigate the risk of localized excess temperature in the

rotor weld and lube oil regions. In this case, the system would provide 90 psia/1085°F cooling steam upstream of the steam seals. The system included an air operated stop valve, an air operated control valve, manual and motor operated drain valves, and associated piping. Figure 4-28 illustrates the rotor end, steam seal design details.

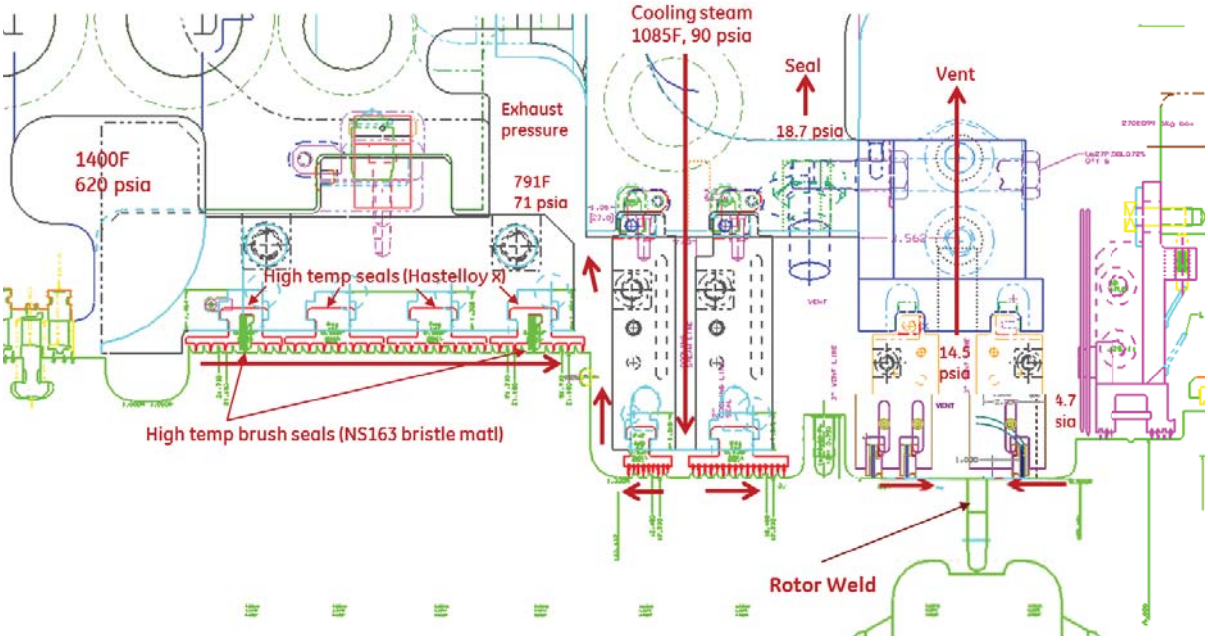


Figure 4-28 Steam Sealing Details

4.2.17 Drain System

The drain system removes excess latent moisture that may accumulate in piping or the turbine shells during start-up, shut-down, and pre-warming operations. The system would have consisted of three drains located on the lower half outer shell, the low point on each steam line and the steam line between valves. The flow from each drain would be controlled by motor operated valves. The ComTest system would be consistent with standard design practice for steam turbines.

4.2.18 Foundation Interface

The AUSC ComTest steam turbine design included a base mounted single turbine section designed for mounting to foundation plates embedded in a reinforced concrete foundation. The turbine base mount design provided for ease of shipment, field installation, and alignment. The base was to be fabricated of structural I-beams and plate to provide a mounting interface to the foundation plates and support the turbine at the two outboard end standards: front and mid-standards. The dynamometer and gearbox would be mounted on a separate base sitting atop an isolated foundation base plate to prevent vibration transmission to the turbine and surrounding equipment. All the supplied components would meet or exceed the structural code and seismic requirements for the ComTest site. Figure 4-29 is an isometric view showing the configuration of the turbine on its base. Figure 4-30 is an elevation view of the turbine, including the speed reduction gearbox and dynamometer as installed on a foundation.

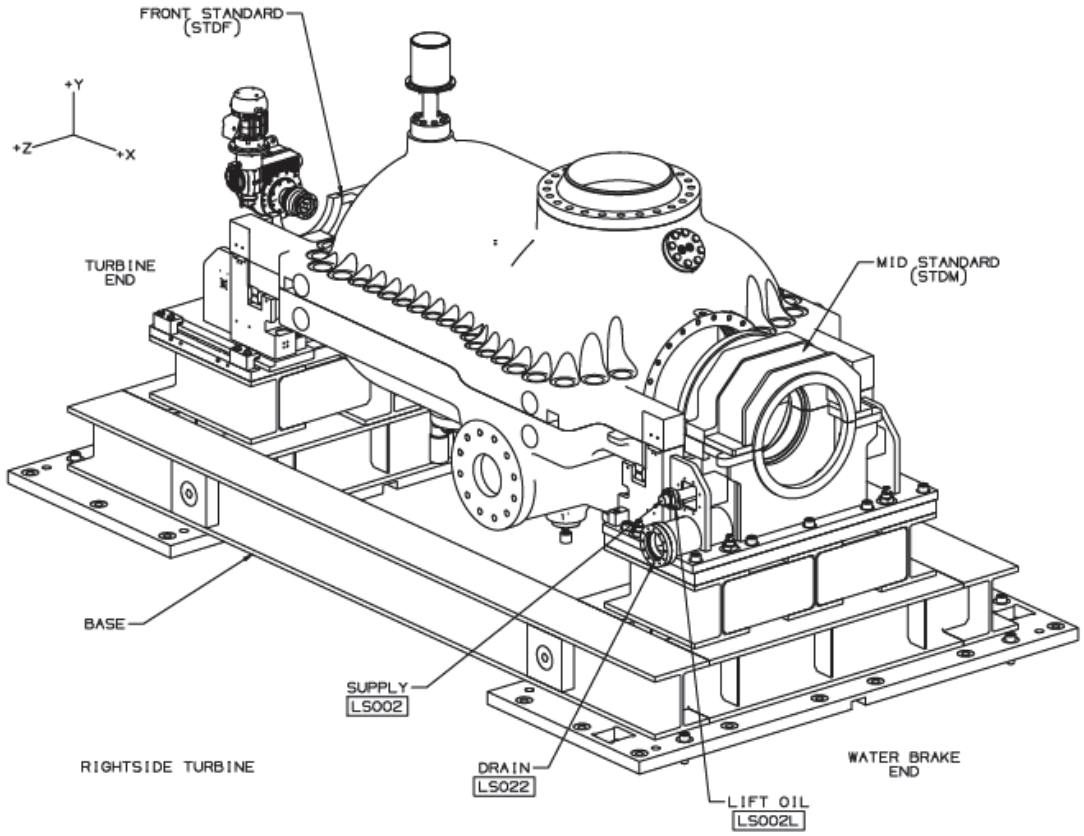


Figure 4-29 Steam Turbine Base and Standard Arrangement

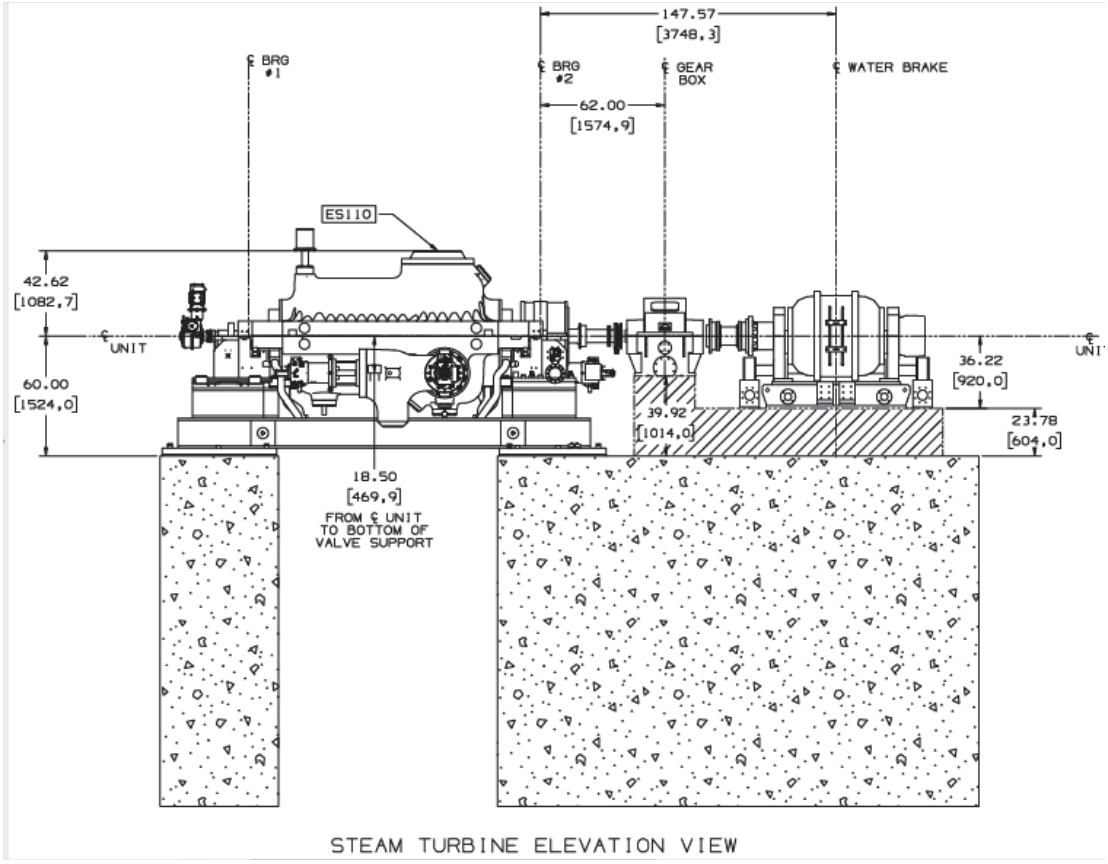


Figure 4-30 Steam Turbine Drive Line and Foundation Configuration

4.2.19 Steam Turbine Starting and Loading

One of the prime concerns of turbine operation is the gradual and uniform heating and cooling of the rotors, shells, and valves. Control of the steam to metal temperature mismatch as well as the rate of metal temperature change (ramp rate) is necessary to ensure that excessive thermal stresses do not occur in any portion of the turbine.

Turbine pre-warming is recommended when the calculated rotor bore metal temperatures are below 300°F. Pre-warming is accomplished through the pressurization of the turbine section. During the pre-warming sequence, the turbine is on turning gear with steam seals applied and steam from an auxiliary steam supply is admitted through the Heating Steam Pressurization Valve. The calculated duration of the pre-warming sequence is 300 minutes from an assumed initial rotor bore temperature of 75°F.

The cold start sequence occurs after an extended shutdown (>5 days) and after the pre-warming sequence, thus the turbine metal temperature is assumed to be at least 300°F. All starting sequences require close adherence to the mismatch between the throttle steam temperature and turbine metal temperatures to avoid either quenching or excessive temperature and the associated stresses. For the ComTest steam turbine, the allowable range of steam to metal temperature mismatch was -100°F to +350°F. Figure 4-31 graphically depicts a cold start, where the assumed metal temperature was 300°F and the throttle pressure is at 100% design condition of 620 psia. In this scenario, the initial throttle steam temperature would be

650°F corresponding to the maximum allowable steam to metal temperature mismatch. The speed, temperature, and load ramp rates shown in Figure 4-31 were established to meet the allowable turbine stresses. The resultant turbine cold start time from initial turbine roll off turning gear to 100% load was approximately 235 minutes.

The warm start sequence is intended to reflect a weekend shutdown over a period of forty-eight hours. During the shutdown, the turbine metal temperature decays over time, but does not drop below the threshold to require pre-warming. The same logic used in the cold start sequence for establishing initial throttle steam temperature and ramp rates was also applied to the other start sequences, including this warm start example. In the example, the warm start curve shown in Figure 4-32 had a turbine metal temperature is 523°F. The initial throttle steam temperature would be set at 850°F. The duration of the resultant turbine warm start from initial turbine roll off turning gear to 100% load would be approximately 181 minutes.

The hot restart sequence is intended to be reflective of a night time shutdown of eight hours. In the example shown in Figure 4-33, the turbine metal temperature decays to 1114°F during the shutdown period. The example assumes that the throttle steam pressure and temperature are both at 100% design conditions. The duration of the turbine hot start from initial roll-off gear to 100% load is approximately fifty-six minutes.

The hot start sequence is intended to be reflective of an unplanned trip event where it may take up to two hours to diagnose and correct the cause of the trip and return to operation. In this scenario, shown in Figure 4-34, very little turbine metal cooling has occurred, and the throttle steam would be at 100% rated temperature and pressure. The turbine can return to 100% load operation in twenty minutes.

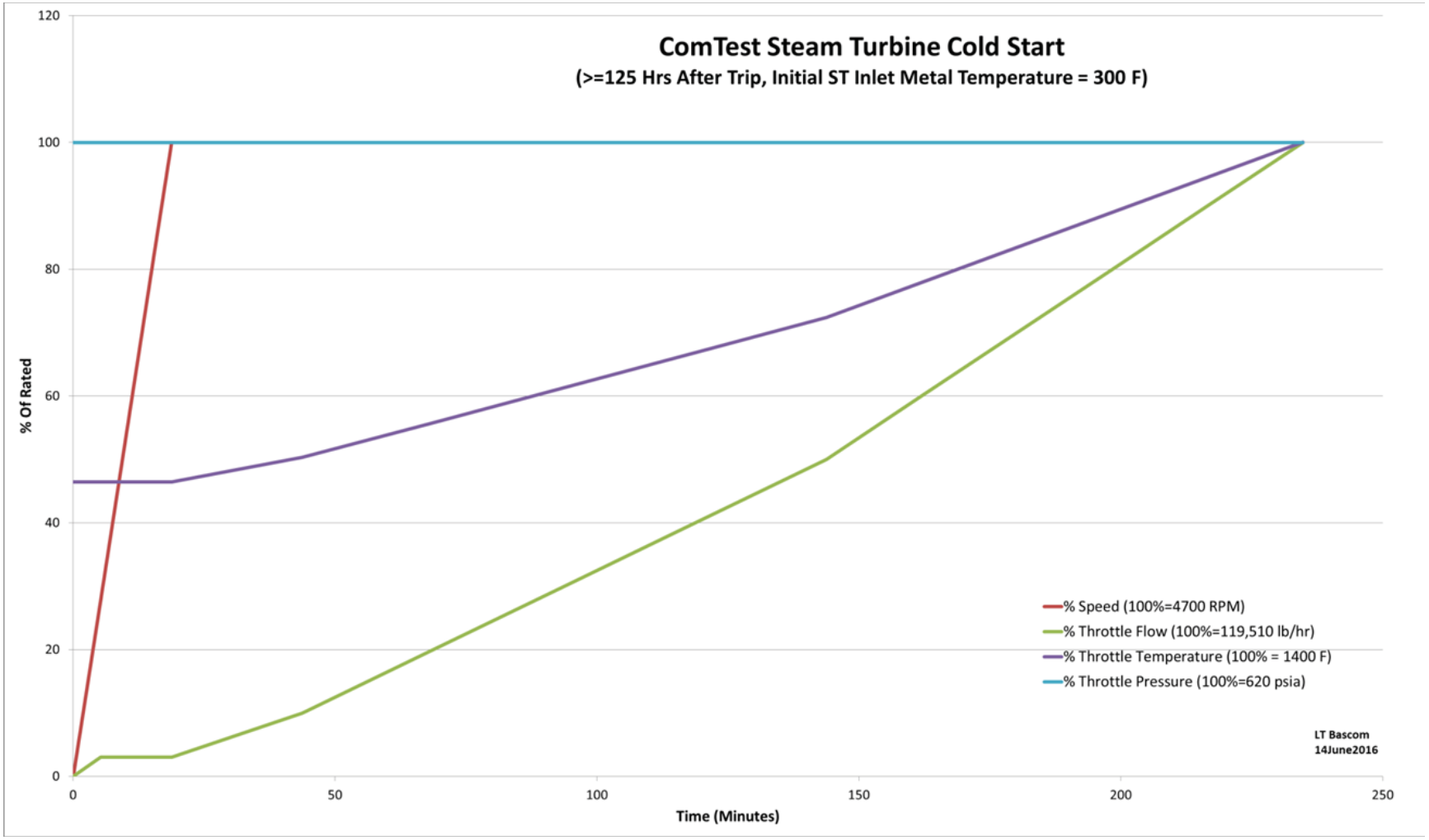


Figure 4-31 **Cold Start Sequence**

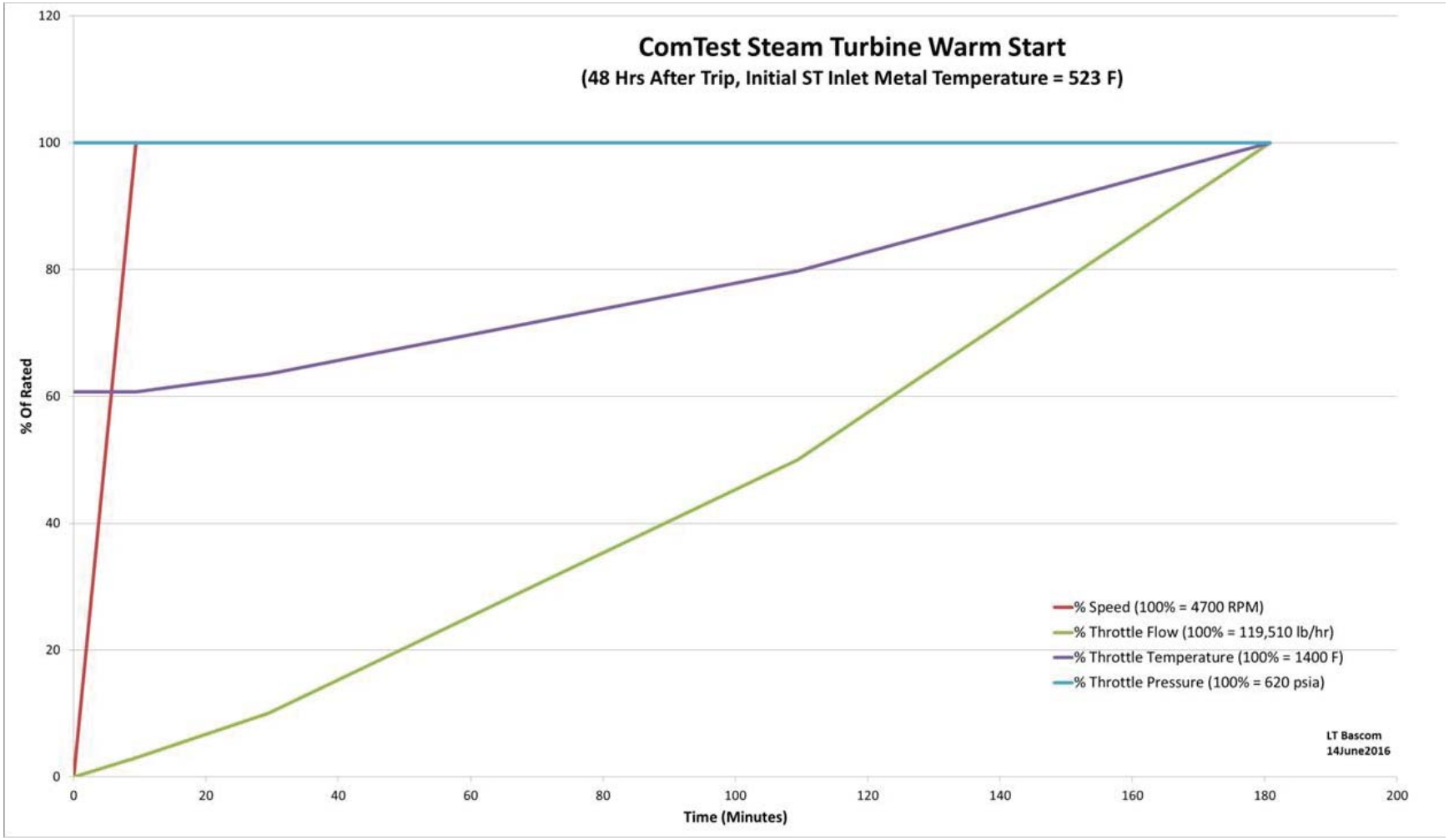


Figure 4-32 Warm Start Sequence

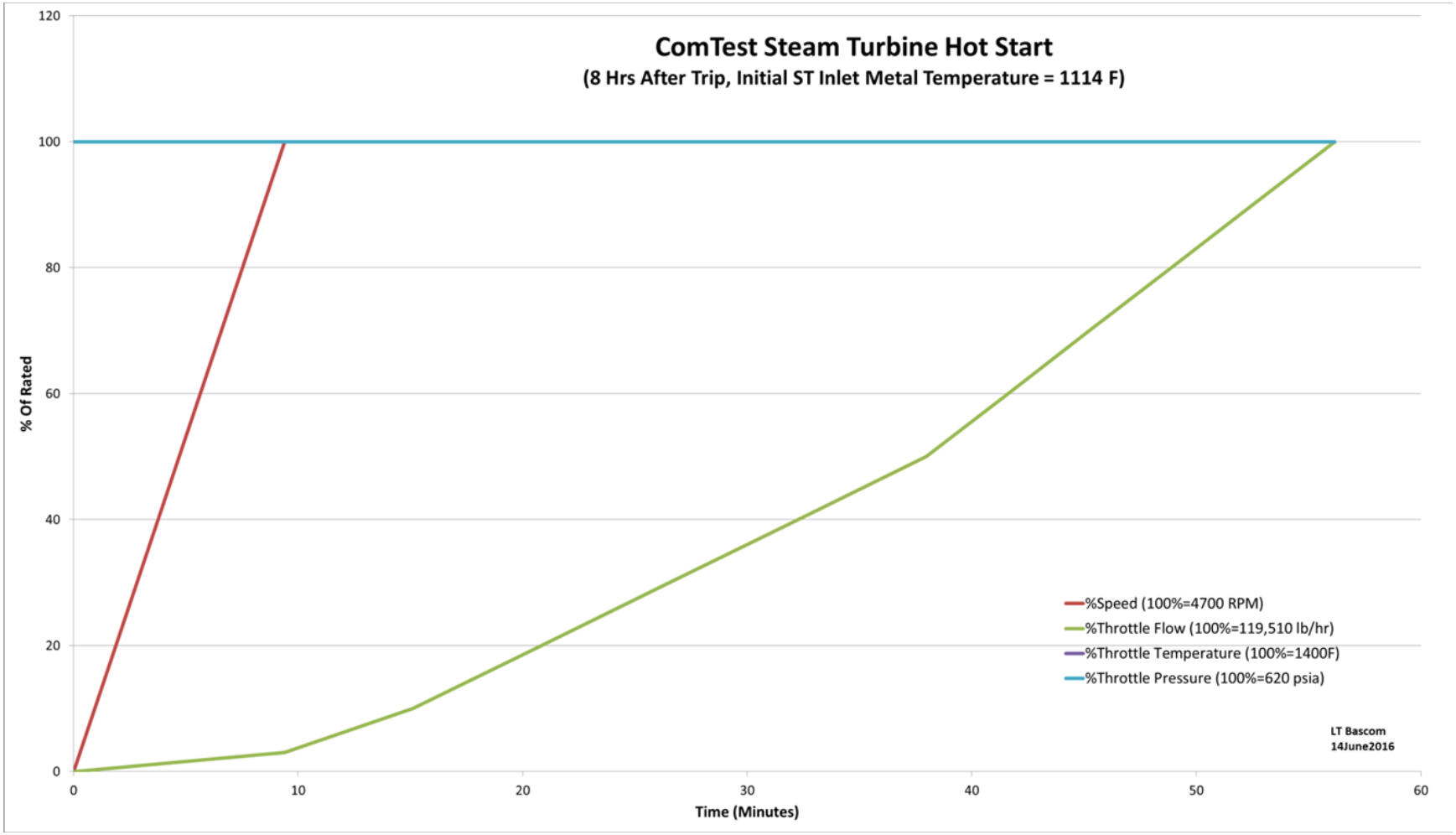


Figure 4-33 Hot Start Sequence

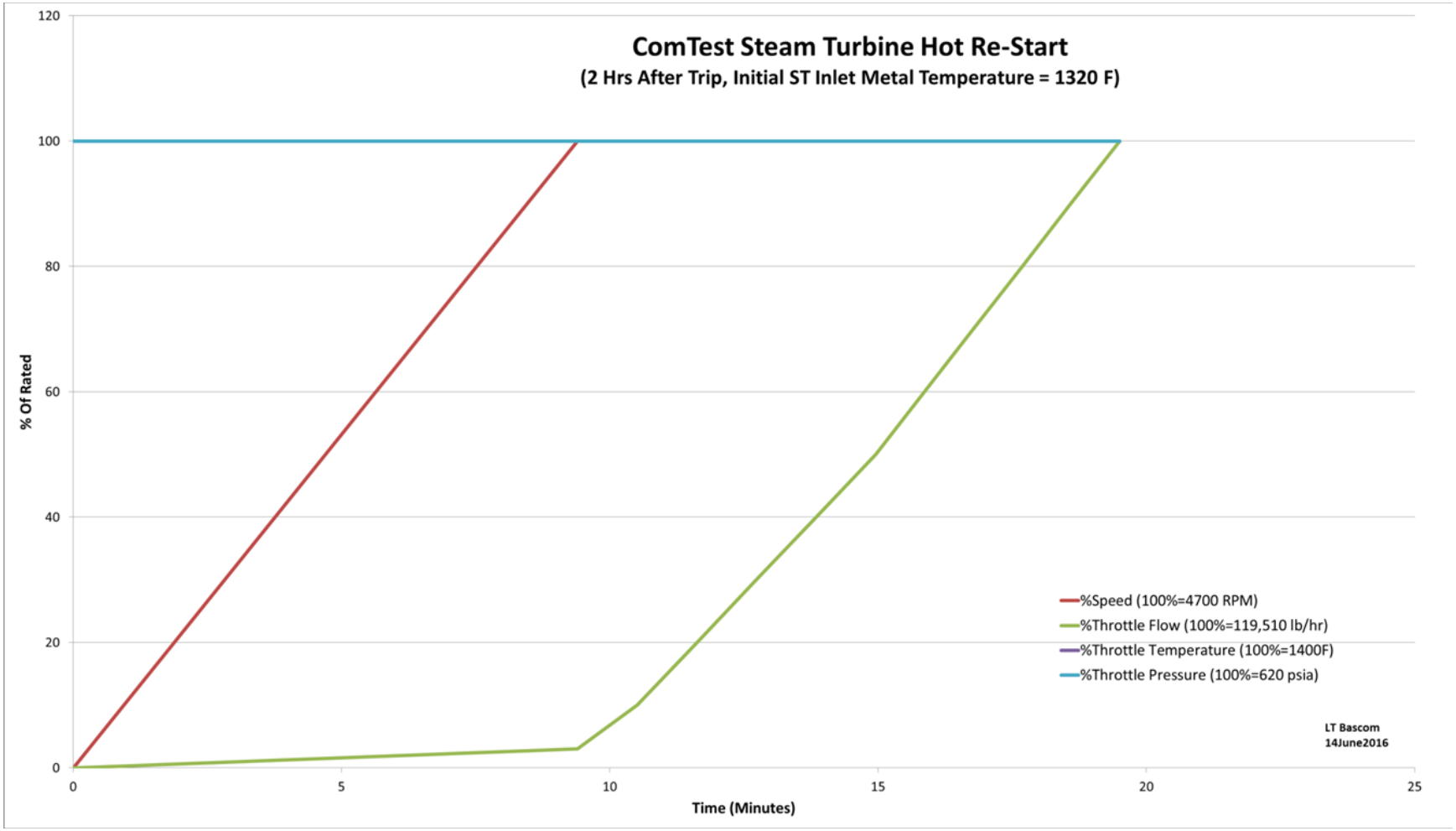


Figure 4-34 Hot Re-Start Sequence

4.3 **Main Steam Stop and Control Valves**

The ComTest turbine included two, shell-mounted, 100% capacity combined stop and control valve assemblies. Each combined valve assembly contained a separate horizontal stop valve and control valve that would be individually operated by a self-contained, single action, hydraulic actuator. The actuators were a fail-closed design through means of mechanical springs. The primary function of the stop valves was to quickly shut off the steam flow to the turbine under emergency over-speed conditions. The primary function of the control valves was to control steam flow to the turbine based on system demands and quickly close under normal overspeed conditions

The objectives for demonstrating these valves in ComTest included:

- Cyclic duty evaluation using two, 100% capacity valves each with different cyclic duties and hours
- Oxidation evaluation
- Throttling and flow stability at various lift points – design a throttling valve and test extensively
- Design, manufacturing, and operation experience with HAYNES 282 alloy and NIMONIC 105 alloy
- Heavy-wall, field weld INCONEL 740H alloy pipe to cast HAYNES 282 alloy valve casing

The design requirements for the valves were:

- Rated Temperature = 760 °C (1400 °F)
- Rated Pressure = 4.3 MPa,a (620 psia)
- Maximum Pressure Capability* = 7.6 MPa,a (1100 psia)
- Max Flow = 58,970 kg/hr (130,000 lbm/hr)
- 30-year design life

*- Increased to 24.1 MPa,a (3500 psia) to allow one valve casting design to be used for both ComTest and DOE's Supercritical Transformational Electric Power[12] (STEP) programs.

The stop valves are hydraulically operated in an open-closed mode either by the turbine over-speed protection system or in response to a turbine trip signal. As in full-size units, periodic testing to ensure reliability is a control function that does not require shutting down or tripping of the unit. The control valves were designed to provide steam shutoff adequate for turbine speed control and provide speed/load control across the turbine output range.

Live steam would be supplied to the valves from the AUSC ComTest Superheater via the main steam header located under the turbine centerline.

[12] The DOE's STEP program's main objective is to build and operate a 10-MWe supercritical CO_2 power cycle test facility for evaluating power cycle and component performance over a range of operating conditions at a relevant scale. The program is funded through DOE Cooperative Agreement No. DE-FE0024007

Like the turbine inner shell, the valve casings and heads would be HAYNES 282 alloy castings. The valves would feature a design pressure rating exceeding 3500 psia and 1400°F to closely simulate a valve design that would be required for utility AUSC applications. In addition to thick wall castability, weldability to INCONEL 740H[13] alloy pipe would be demonstrated. The valve internals were sized for 100% flow passing through one combined valve assembly. Thus, each control valve could be independently stroked to a full-closed position while maintaining a constant unit output and enabling maximum flexibility for throttle duty testing. Figure 4-35 illustrates the stop and control valve with its self-contained actuators. The ComTest valves meet all GE's standard and established design criteria.

During the program, the jurisdiction and relevance of the ASME Boiler and Pressure Vessel Code (Boiler Code) was evaluated to formalize GE's position on the need for the preparation of a code case for the valve at AUSC conditions. All modern GE Steam Turbines, regardless of boiler technology, include both stop and throttle valves deployed in series on all main and reheat steam lines between the boiler and the turbine. The stop and throttle valves each have independent actuators and position indicators and, once assembled, are hydrostatically tested prior to shipment. The throttle valve's functions include: turbine speed/load control and the first line of defense against over speed. The stop valve's function is to provide the second line of defense against turbine over speed. Thus, all applications, including ComTest, would meet the exception of Boiler Code clause PG-58.3.1.

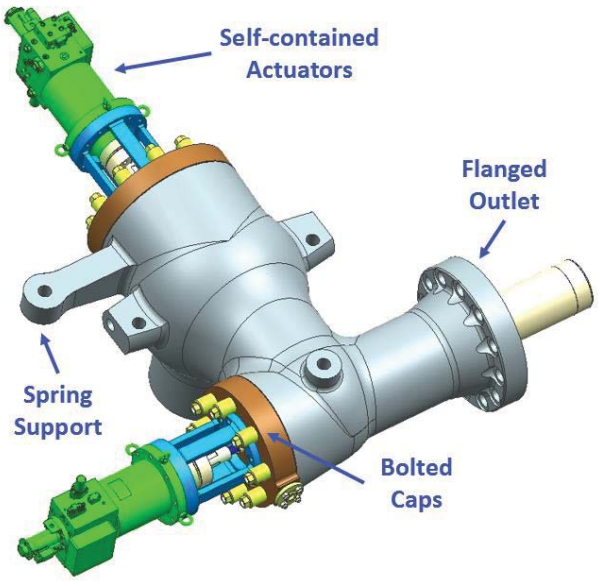


Figure 4-35 Main Stop and Control Valve Assembly, External View

4.3.1 Casing and Heads

The ComTest shell mounted, combined, stop and control valve design originated from existing modules designed for USC fossil-fired steam turbine applications. The valve casing would be mounted to the turbine outer shell by a bolted flange. The steam inlet pipe entered from below

[13] INCONEL® 740H® is a trademark of Special Metals Corporation, New Hartford, NY, USA

and was a dis-similar material welded connection (INCONEL 740H alloy pipe to the HAYNES 282 alloy cast casing). The valve casing would be supported by the combined reaction through the turbine shell and with a spring support attached to the foundation. The valve casing and heads were scaled down to approximately 62% of original and the materials were upgraded to HAYNES 282 alloy material to better match the thermodynamic boundary conditions of the ComTest process design.

The engineering team noted the similarity between the design requirements and thermal boundary conditions for both the ComTest and the STEP programs. The concept of designing one valve casing that could be used for both applications without significant cost implication to either program was investigated. The concept would have identical center sections of the castings, but different flange/pipe connections and internals. The ComTest valve provides a bolted flange for connection to the steam turbine outer shell and a welded connection to the supply steam piping. The STEP valve provides for a GRAYLOC[14] clamp connector seal on the inlet and outlet of the valve. A comparison of the ComTest and STEP valve casings is shown by Figure 4-36 and Figure 4-37, respectively.

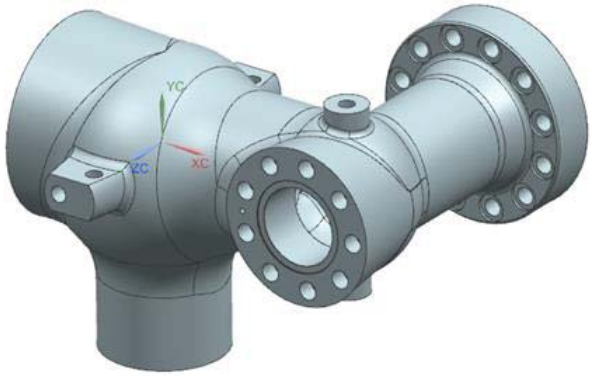


Figure 4-36 ComTest Program Stop and Control Valve Configuration

[14] GRAYLOC® is a trademark of Oceaneering International, Inc. USA, Houston, TX, USA

Figure 4-37 STEP Program Stop and Control Valve Configuration

The pressure capability of the resulting scaled valve casing and head made from HAYNES 282 alloy material exceeded both the ComTest and the STEP design requirements of 1100 psia at 1400 °F and 3650 psia at 1320 °F respectively. The casing wall thickness was later increased to improve the castability of the valve casing design, thus providing significant margin to the design criteria for both the AUSC ComTest and STEP projects.

The AUSC ComTest finish machined valve casing would weigh 4,300 lb., which is within the size envelope of the demonstration valve casting poured during the earlier materials development program, strongly suggesting a high probability of success.

Stress analysis of the valve preliminary casing design was performed to ensure that the fluid was safely contained over the full operational lifetime of the turbine assembly. Linear elastic finite element analysis (FEA) using ANSYS[15] software was used to quantify the stress in the casing at a 1400°F isothermal, steady-state operating condition with 3650 psig internal pressure. Figure 4-38 shows the internal pressure boundary condition and the blow-out pressures applied to the open ends of the casing to simulate loads from components not present in the model.

[15] ANSYS® is a trademark of ANSYS, Inc., Canonsburg, PA, USA

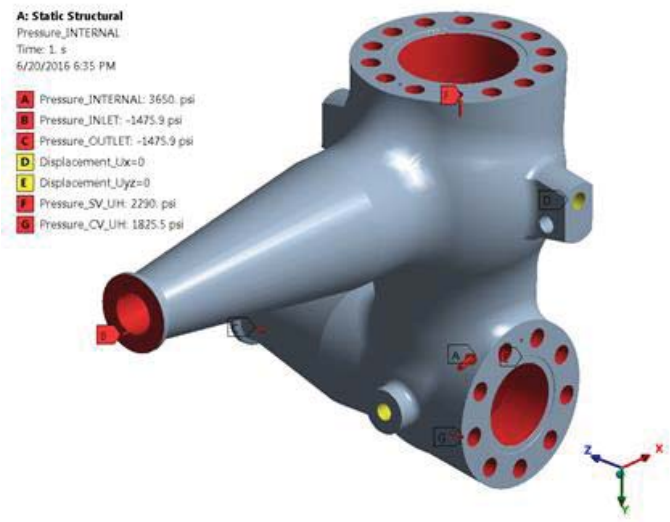


Figure 4-38 Valve Boundary Conditions for Isothermal FEA

4.3.2 Valve Internals

The combined stop and control valve assembly contained a separate horizontal stop valve and control valve assembly, each with separate stem, disk, seat, and self-contained hydraulic actuator. The valve internals, shown in cross-section in Figure 4-39, also included a strainer basket and control valve sleeve (transition piece from the control valve seat to inner shell).

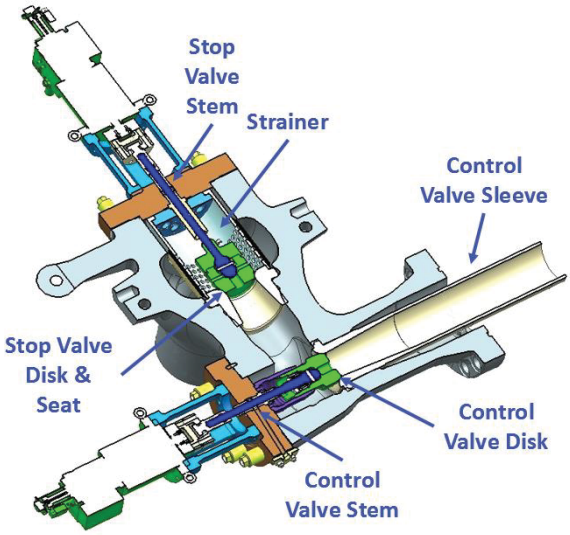


Figure 4-39 Stop and Control Valve Cross Section Showing Internal Elements

The valve internals would share the design features and practices of previous USC fossil steam turbines design but were scaled and redesigned to align with the thermal boundary conditions of ComTest. The valves were designed using standard design practices for valves of this type and consider steam velocity, pressure drop, lift versus flow characteristics, and stresses.

The stop valve design had a 7” seat and the control valve had a 5.5” seat. Both valves were a balanced disk design (internal bypass), thus allowing the valve to open under full design pressure. All internal valve components were HAYNES 282 alloy construction. Unlike typical USC valves that require stem nitriding and nickel alloy weld inlays for the disk and seat contact surfaces, the ComTest valve internals required no additional material processing, coatings, or weld inlays for protection against wear, solid particle erosion, and oxide build-up.

A strainer basket was installed in the stop valve case, upstream of the stop valve disk to prevent large foreign material from entering the valve and the turbine. The strainer would be constructed of HAYNES 282 alloy and meets all design practice requirements.

The resulting valve design exceeds all design requirements for steam turbine valves and had higher design margins than similar valve designs using conventional materials operated at 1,112 °F.

4.3.3 Valve Machining

The valve casing and internal components contained numerous machined features, including:

- Casing to head fits
- Valve seat to body fits
- Threaded stud holes
- Shell fit flange face
- Valve seat contour
- Valve disk contour
- Valve stem and disk pin holes

Machining trials were recommended to confirm that all features could be machined and resulting tolerances meet design requirements. Machining process development data from the shell machining trials would be utilized for similar features. Internal and external supplier quotations were received for performing machining trials.

4.4 **Superheater Outlet Header**

Due to the low price of natural gas and the addition of renewable intermittent loads (e.g. wind and solar) to the grid, fossil unit are frequently being required to cycle load on a daily and weekly basis. Prior SC and USC boilers were designed and operated in less severe thermal cycling conditions with significantly lower ramp rates – on the order of 1.5% per minute load levels. Thermal stress cycles and the associated fatigue usage of the header materials under such transients is significantly lower compared to the newer designs being proposed which will operate with ramp rates as high as 5% per minute contributing to higher fatigue usage and hence life limiting conditions.

Thick-walled super heater outlet headers (SHOH) will also operate at AUSC conditions. Over the design life of such plants, these components are exposed to the most severe fatigue and creep damage accumulation and need to be properly designed for reliable flexible cyclic operation. To validate design guidelines, these components need to first demonstrate that they can achieve a design life of 20 to 30 years with the creep and fatigue conditions required.

4.4.1 Background

To date, no thermal fatigue tests have been conducted on the thick-walled header components fabricated with INCONEL 740H and HAYNES 282. Such tests have been conducted on high strength nickel based alloys HAYNES 617 and HAYNES 263 in the European component tests, ComTes700[16]. These tests exposed the header components to high temperature and accelerated thermal fatigue cycling. However, these tests had somewhat more severe thermal stresses compared to the actual European AUSC concept plant and are intended to be used for material modelling rather than to prove the suitability of the materials for AUSC boiler operating and design conditions. These tests generated useful data on these alloys and helped establish the fatigue strength limits for HAYNES 617 and HAYNES 263 alloys. The European tests did not address the GE AUSC thick-walled header thermal conditions with larger pipe sizes, significantly higher wall thicknesses, severe transient ramp rates and the associated design temperatures and pressures for INCONEL 740H and HAYNES 282 alloys.

European cyclic header tests with HAYNES 617 and HAYNE 263 were completed in 2015 as part of the ComTes700 tests, where a header component was cycled 2,638 times between 750°F and 1340°F. The European concept AUSC plant warm start transient ramp rate is significantly lower than that of the proposed GE concept full scale AUSC (~12°F/min vs. ~23°F/min). The GE AUSC transients are based on simulations and considered to be only conceptual in nature; actual turbine limitations may be more restrictive and control the actual final design transients. The simulated ComTes700 warm start transient is considerably more severe compared to the European concept plant; therefore, the header was exposed to approximately double the design number of cycles. Additionally, only the HAYNES 617 alloy was tested, with its significantly lower creep and fatigue strength properties compared to INCONEL 740H and HAYNES 282 alloys.

Post-test examination of the header component in the ComTes700 tests showed severe thermal cracking in the header boreholes (well beyond the fatigue crack initiation with crack depths as high as 0.5” to ~1”) as well as the header inside surface including the reducer pipe section. Analytical evaluation of the cycling header by MPA of Stuttgart concluded that fatigue life for

[16] Component Test Facility for a 700°C Power Plant (Comtes700), EUR 25921, 2013.

HAYNES 617 and HAYNES 263 alloys observed in the tests was significantly below that estimated using several regulatory standards used in boiler design.

As a part of the DOE Consortium project on advanced boiler materials, a typical thick-walled SHOH with several boreholes was analyzed simulating the most severe thermal transient cycles in a conceptual AUSC boiler design. Warm start transients cycling between 1100°F and 1350°F with a 5% load ramp rate indicated that the thick-walled headers have very high thermal stresses and indeed are life limiting for the component from the fatigue usage point of view. Simulated dynamic cycling transients through APROS simulation program show some overshooting of peak temperatures beyond 1350°F operating temperatures. If the transient operation is properly controlled and these temperature overshoots are minimized and/or avoided, the fatigue usage at the most limiting locations such as SHOH borehole inside corners is below the design curve.

4.4.2 Superheater Outlet Header Test

GE Power was developing the SHOH test component under a separate agreement with the DOE (DE-FE0026183). The purpose of the SHOH test is to build a thick-wall piping component with several tube connections to simulate the boiler headers and piping components in a commercial unit that would operate under AUSC conditions and then vary the temperature of the steam flowing through the test apparatus from ~750ºF to 1400ºF on a cycling basis. The SHOH test apparatus would be designed to look similar to Figure 4-40. Steam would flow into the test apparatus through the bottom, flow through the tubes and then back out through the top header pipe.

The objective of the thick-walled cycling header test is to demonstrate the fatigue life of the component operating at AUSC conditions with flexible dynamic operation. ComTest would validate the suitability of the recently developed high strength nickel-based superalloy materials, namely, INCONEL 740H and HAYNES 282 alloys, for operating life of a full-scale 1000 MWe AUSC boiler thermal fatigue conditions and at AUSC operating temperatures. The proposed test would simulate the most severe thermal fatigue cycling conditions of AUSC warm starts over an expected 30-year design life in an accelerated test by exposing a thick-walled cycling header to 2,000 to 2,500 thermal transient cycles similar to those in Figure 4-41 over a 10-month schedule.

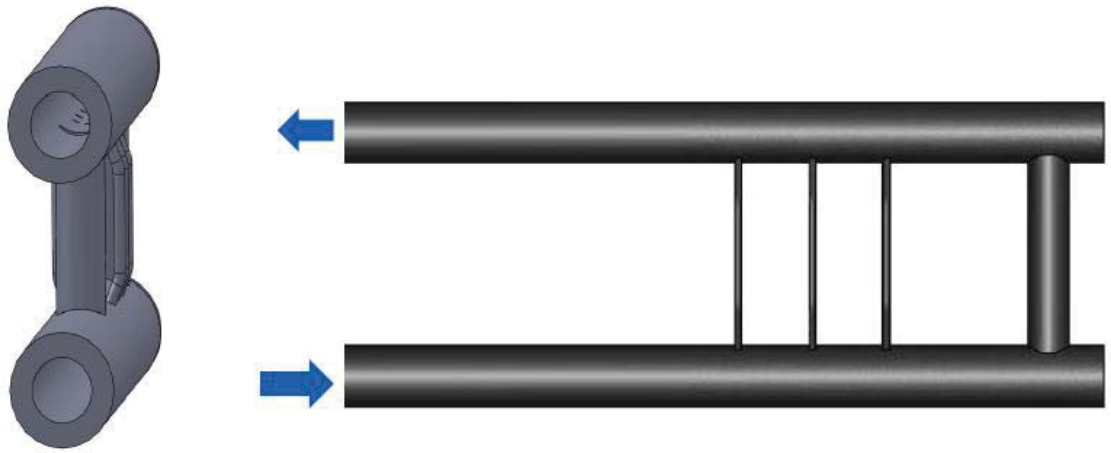


Figure 4-40 Superheater Outlet Header Test Apparatus

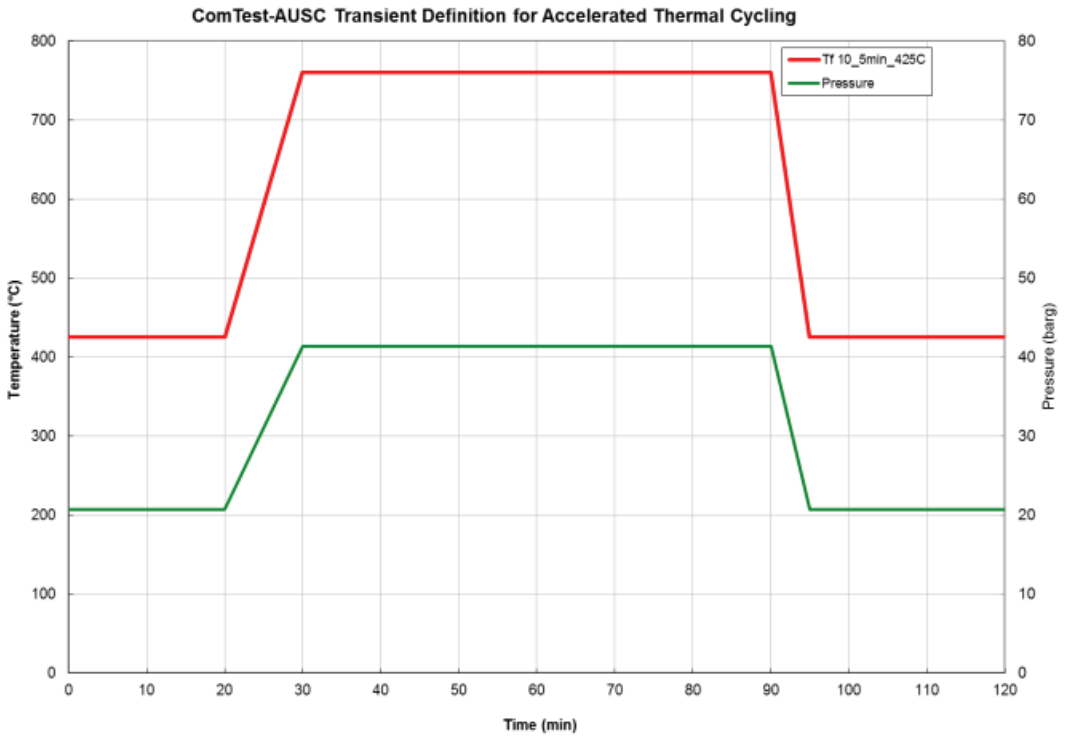


Figure 4-41 ComTest Superheater Thermal Cycle

The cycling operation of the header test is described below:

- Steam at 1400°F would flow through the header test section for approximately one hour (Figure 4-42).

- Using a ramp rate that would be maintained by the control system, the steam exiting the ComTest superheater would begin flowing through the steam turbine bypass line and would be depressurized and desuperheated to approximately 650°F and 205 psia. Simultaneously, the steam flow supplied from the package boiler would increase to ~146,000 lb/hr and the extra 50,000 lb/hr of steam at 935 psig and 750°F would flow through the SHOH test apparatus, decreasing the temperature of the header test section from 1400°F to approximately 750°F. During this time the steam flow through the ComTest superheater would remain constant.
- Steam at 750°F would flow through the SHOH test apparatus for approximately one hour (Figure 4-43).
- The ramping process would be reversed and steam at 1400°F from the ComTest superheater would begin flowing back to the SHOH test apparatus, increasing the inlet temperature. The steam flow from the package boiler to the SHOH would correspondingly decrease. When the header test section inlet temperature reached 1400°F again, the cycle would be complete.

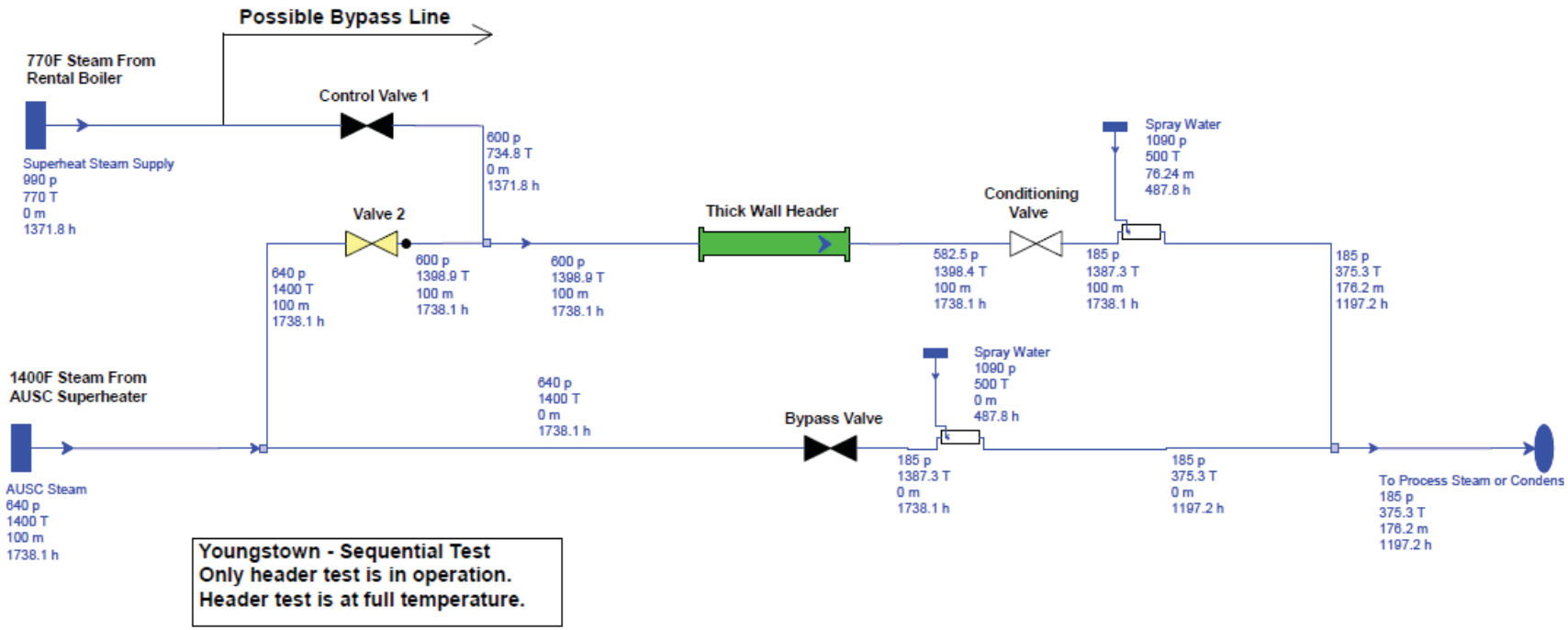


Figure 4-42 Superheater Outlet Header High Temperature Operation

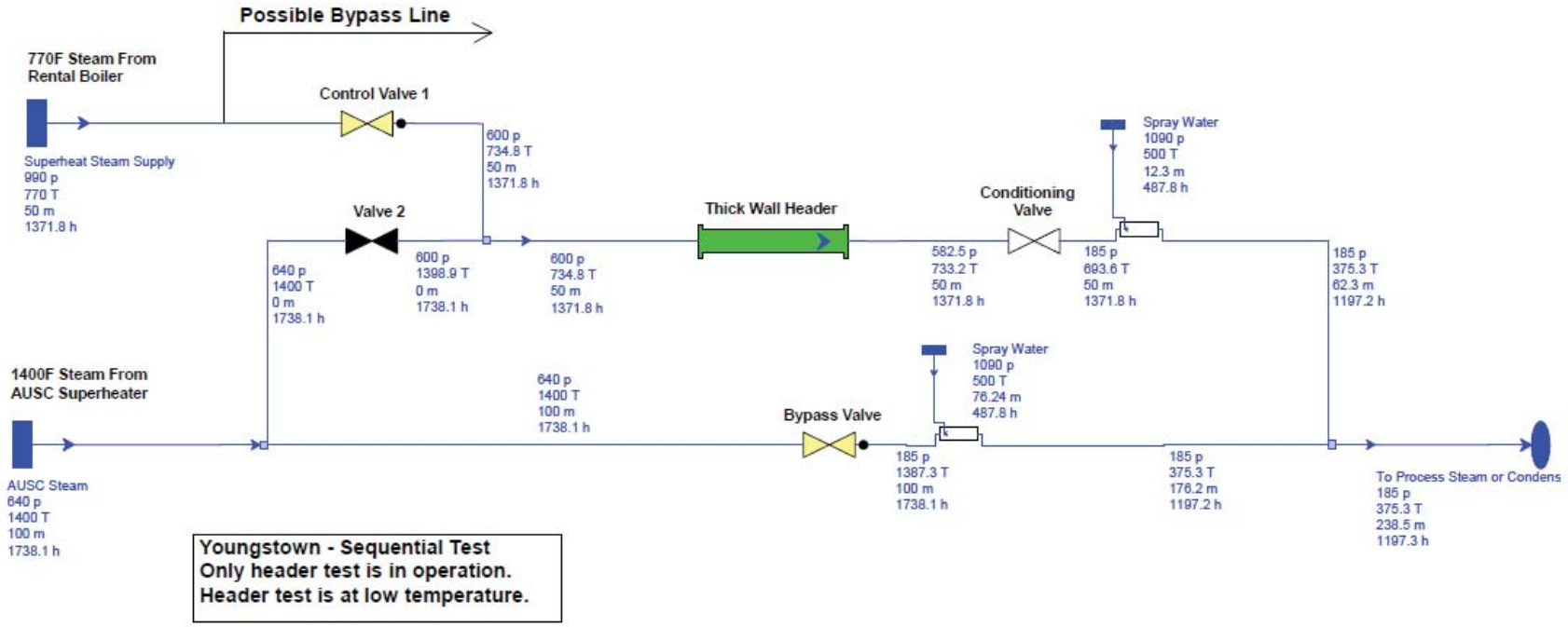


Figure 4-43 Superheater Outlet Header Low Temperature Operation

5 ComTest Configurations

5.1 Youngstown Thermal

The Youngstown Thermal campus located in Mahoning County, Ohio, which includes an existing steam-generating plant, was to serve as a host site for the project (see Figure 5-1 and Figure 5-2). Youngstown Thermal has been in operation since 1895 and operates as a district energy/heating plant. Steam is produced from municipal water and delivered the through underground piping to many of the buildings in the densely populated central business district of Youngstown. The steam is delivered at a pressure of approximately 165 and 30 psia and at saturated temperature for heating, domestic hot water, cooking, laundry, industrial and other uses. The steam plant has historically used a combination of coal- and natural gas-fired units, including three coal-fired boilers (two 100,000 pounds per hour and one 90,000 pounds per hour) and one natural gas-fired boiler (100,000 pounds per hour). However, as of May 2016, Youngstown Thermal began using liquefied wood pulp as their fuel source for their natural gas boiler as part of a renewable fuel oil test project, currently providing approximately 90 percent of their customers' needs.

Figure 5-1 Project Location in Youngstown, Ohio

The climate in Youngstown, Ohio is characterized by warm summers and very cold winters. July is historically the warmest month with an average maximum temperature of 73°F, and January is historically the coldest with an average low temperature of 27°F. Precipitation is

evenly distributed throughout the year with the wettest month being June having an average rainfall of 4.3 inches

Figure 5-2 The Youngstown Thermal District Heating Facility

At the beginning of Phase 1, Youngstown Thermal was in the process of considering the addition of a new, 34 MW combined heat and power (CHP) system for the campus. The new system would include a 10,000 horsepower combustion turbine and a waste heat recovery boiler system operating at 1,000 psig, which would produce approximately 180,000 lb/hr of steam. The new CHP system would produce steam for Youngstown Thermal customers and electricity for internal use, with excess power supplied to the electric distribution grid. The new waste heat recovery boiler would become the primary boiler for Youngstown Thermal, such that the existing natural gas and coal boilers would be used only rarely, such as during maintenance of the new system or during excessive peaks in demand.

The timing of the proposed Youngstown Thermal CHP project created a potential risk to the ComTest. The ComTest project could be delayed and not meet its objectives if it was solely dependent on the development of the CHP project. Because of this, the “base case” for the project was to build a new stand-alone package boiler to supply the steam for ComTest and this configuration will be discussed in Section 5.1.1. If the CHP project proceeded on a schedule that supported ComTest, then the project would use the CHP unit to supply steam. This configuration will be discussed in Section 5.1.2.

The plans for ComTest would have included a two-year operating period (2018-2020), with a goal of 14,000 test hours (6,000 hours for the Superheater Outlet Header and 8,000 hours for

the steam turbine test). Due to the steam load required for each test, the Superheater Outlet Header test and the steam turbine test would never occur concurrently. ComTest would have first conducted the Superheater Outlet Header test, and once complete, would then test the steam turbine. The proposed project would evaluate advanced materials including fabricated nickel super alloy and other AUSC components; test and validate fabrication techniques and the ability to construct, install, and repair ComTest components under both steady-state and cycling operating modes; and provide sufficient research and development test data and metallurgical analysis data to support the development of future commercial-scale technology.

Superheater Outlet Header Test

The boiler (stand alone or CHP unit) would supply steam to the ComTest superheater which would heat the steam to the temperature required for the SHOH test. The superheater, described in Section 4.1, heats the steam from the boiler using natural gas and consists of headers, vertical separator, spray attemperators, superheater tube banks, economizers for flue gas cooling, and desuperheaters for controlling the intermediate and final steam temperatures. The superheater would heat the steam to a temperature of 1400°F at a pressure of 640 psia.

The SHOH test would involve cycling the temperature of the header test section by flowing high-temperature steam (1,400°F) and low-temperature steam (750°F) through the SHOH test component. The cycling between high and low temperatures would occur approximately ten times per day, holding each temperature extreme for approximately one hour before ramping up or down to the other temperature extreme. Steam leaving the superheater header test would flow through the outlet of the header where it would be depressurized and cooled using spray water to meet the outlet conditions required for Youngstown Thermal (650°F and 205 psia). Figure 5-3 depicts a simplified block diagram for the SHOH test.

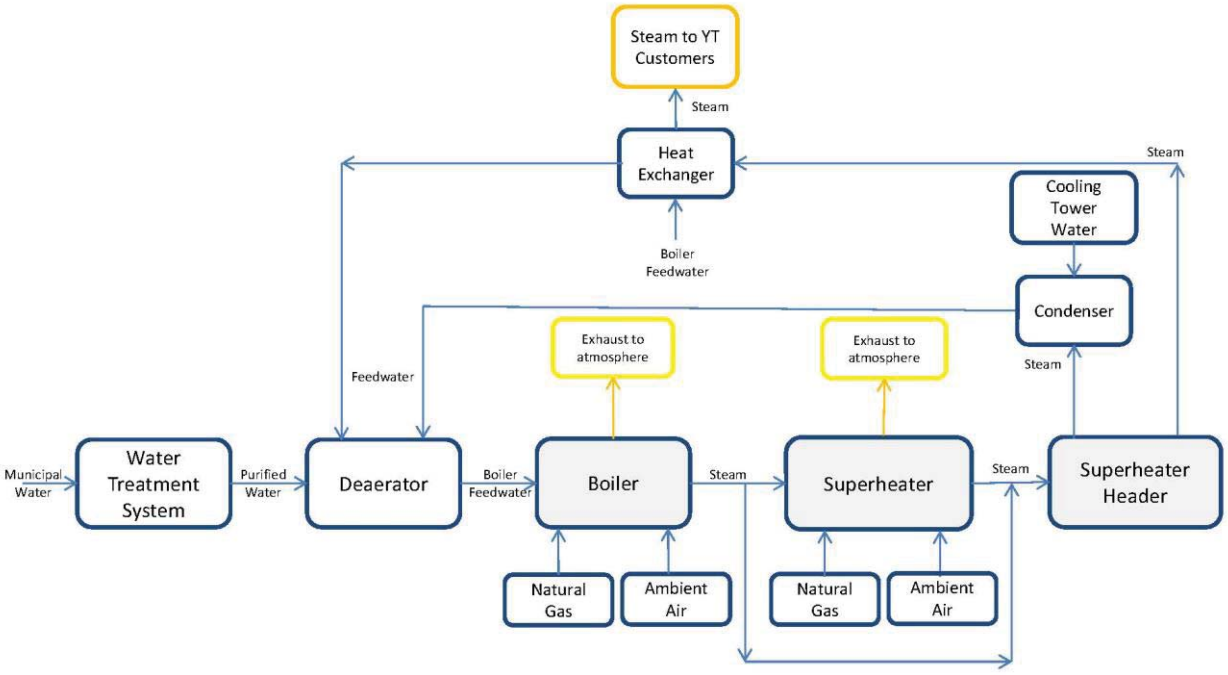


Figure 5-3 Simplified Block Flow Diagram of the AUSC ComTest Project - Superheater Outlet Header Test

Steam Turbine Test

Like the SHOH test, the steam turbine test would involve the package boiler or CHP system supplying steam to the ComTest superheater, which in turn would provide steam to the turbine stop and control valves at a temperature and pressure of 1400°F and 620 psia, before entering the steam turbine. Steam exiting the turbine would then be cooled with spray water before being supplied to Youngstown Thermal for use in generating steam for their customers. The steam turbine would be connected to a water-brake dynamometer to absorb the energy generated by the steam turbine. The dynamometer functions like a water pump and requires cooling water from the cooling tower. Figure 5-4 depicts a simplified block diagram for the steam turbine test.

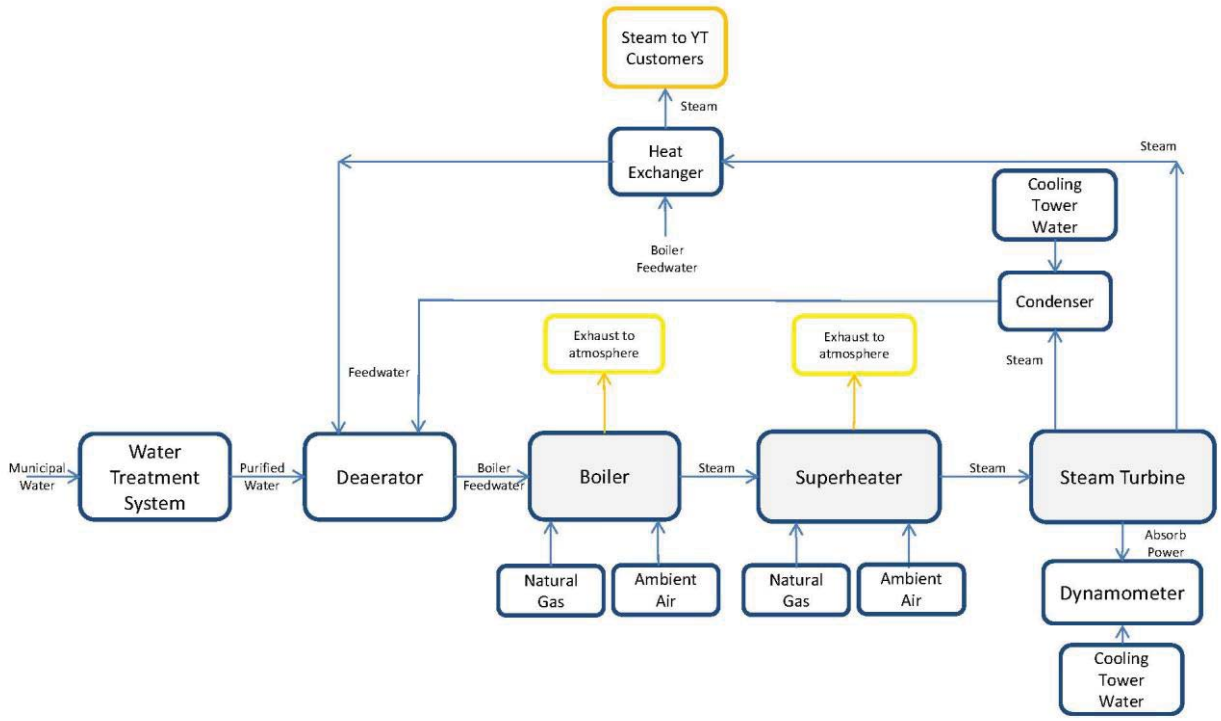


Figure 5-4 Simplified Block Flow Diagram of the AUSC ComTest Project - Steam Turbine Test

5.1.1 Base Case Configuration

The ComTest Project Base Case configuration was designed to be a stand-alone unit that could operate independently of Youngstown Thermal's plant operations. It would consist of a natural gas-fired Superheater and Superheater tower, a natural gas-fired boiler, a cooling tower, and other ancillary equipment. The ComTest Project would also require a new natural gas line to supply the fuel for the project.

5.1.1.1 **Process Configurations**

The flowsheet for the base case configuration with the major stream flows, temperatures and pressures is shown in Figure 5-5. Saturated boiler feedwater (BFW) at pressure of 30 psia and a flowrate of 161,563 lb/hr would exit the deaerator and flow to the HP pump and the water would be discharged at a pressure of 1350 psia. A portion (16,563 lb/hr) of this water would flow to desuperheater 3 (DSH-3) where it would be used as spray water. A second portion (31,000 lb/hr) would flow to the spray water heater where it would be used as spray water in the ComTest superheater. The remaining 114,000 lb/hr of water would enter the natural gas fired boiler.

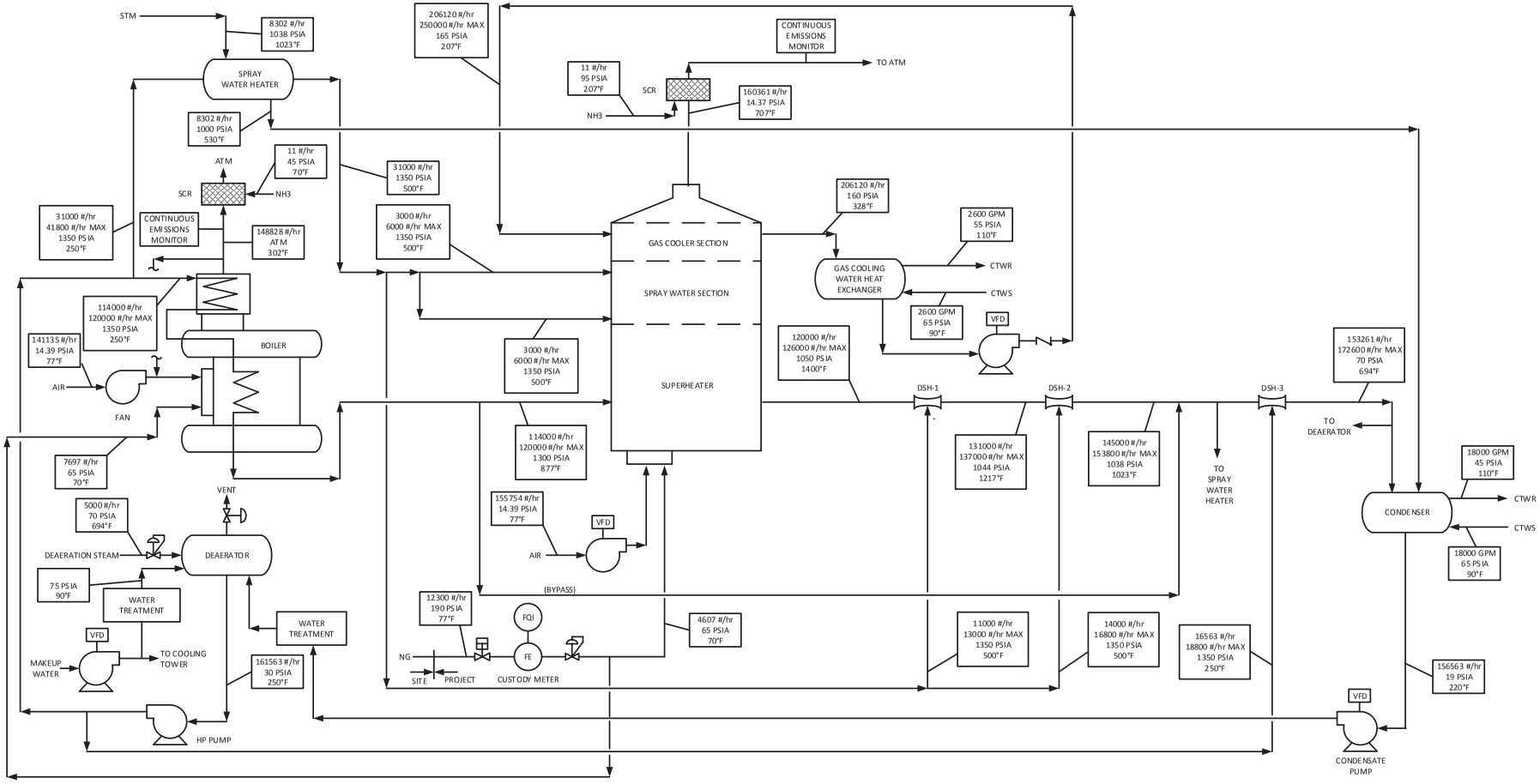


Figure 5-5 Base Case Configuration

The BFW that entered the natural gas boiler would flow through the economizer, boiler and superheater where it would be heated to a temperature of 877°F at a pressure of 1300 psia. The boiler would burn 7,697 lb/hr of natural gas with 141,135 lb/hr of air to generate the steam. Flue gas recirculation would be utilized to minimize NOx, but it was planned that a selective catalytic reduction (SCR) unit would be installed at the outlet of the boiler to control NOx at the required permit limits.

The 31,000 lb/hr of BFW that entered the spray water heater would be heated with 8,302 lb/hr of 1023°F/1038 psia steam from the outlet of the ComTest superheater to a temperature of 500°F. This water would be used as spray water within the ComTest superheater to control the steam temperature (6,000 lb/hr). The remaining water (25,000 lb/hr) would be used in desuperheaters 1 (DSH-1) and 2 (DSH-2) downstream of the ComTest superheater.

The ComTest superheater was designed to heat the steam from the natural gas boiler from a temperature of 877°F to 1400°F. The superheater combustor would burn 4,607 lb/hr of natural gas with 155,754 lb/hr of air. Because of the high steam temperature, the temperature of the flue gas leaving the superheater would still be quite high if it was not first cooled in the gas cooler section. This section would utilize a circulating loop of water (206,120 lb/hr) which would cool the flue gas to approximately 700°F. The circulating loop of water would be at a pressure of ~165 psia and would be heated from 207°F to 328°F in the gas cooler. The gas cooling water heat exchanger would reject the heat to the cooling tower. A separate SCR would be installed at the outlet of the ComTest superheater to control NOx to permitted levels. A steam bypass line around the superheater would be installed and utilized for startup or if there was a trip of the superheater.

The 120,000 lb/hr of superheated steam would flow through a series of desuperheaters before entering a condenser. The desuperheaters would be utilized for the various test components (steam turbine and superheater outlet header) and their function will be described in sequent sections of the report. The cooled steam leaving DSH-3 would be at a temperature of ~695°F. Pressure let down valves (not shown) located just before DSH-3 would decrease the pressure of the steam to 70 psia before it entered the condenser. The steam for the spray water heater would be extracted from this line upstream of the pressure let down valve and the condensate from this heater would be returned to the condenser. Steam for the deaerator (5,000 lb/hr) would be supplied downstream of DSH-3. The remaining steam that entered the condenser would be cooled with water supplied by the cooling tower. The BFW from the condenser would enter the condensate pump where it would flow through a water treatment system before returning to the seaerator and completing the cycle.

The ComTest base system was designed so that it would be able to operate safely and reliably without interfacing with Youngstown Thermal's facility and operate safely if the other ComTest components (steam turbine and SHOH) were out of service. This would allow the unit to be commissioned and started-up without relying on those systems to be in operation. Subsequent sections will describe how the ComTest base system interfaced with the other systems.

Integration of the ComTest Base Case with Youngstown Thermal's Operation

Youngstown Thermal was interested in using the steam being discharged from ComTest to generate the steam that they normally provide to their customers. Youngstown Thermal supplies both 150 psig and 15 psig steam to their municipal customers. Youngstown uses municipal water, treats the water in a water softening system, generates the saturated steam and puts it in an underground pipeline to their customers. The customers use this steam and then release the condensate to their building drains, i.e., it is not a closed system. Due to the high temperature and pressure of the ComTest steam cycle, oxygenated water treatment (OWT) would be required. The cost of purifying the water to OWT specifications would be significantly higher than producing softened water, so it was desirable to produce a closed loop steam generation system. This was accomplished as shown in Figure 5-6. The natural gas boiler and the spray water heater have been removed for clarity in the figure, and the deaerator system has been moved to the right-hand side of the drawing.

The steam from ComTest would flow either into a 150 psig reboiler, a 15 psig reboiler or the previously mentioned condenser. The flowrate to each of the reboilers would be dependent upon the demand of Youngstown Thermal's customers and could vary hourly depending on ambient conditions since most of the steam is used for heating. The ComTest condenser would be designed to accommodate whatever steam was not utilized by the reboilers. If more steam was needed than could be provided by ComTest, Youngstown Thermal would produce the steam utilizing one of their existing boilers.

For this description, it is assumed that the 150 psig reboiler requires 50% of the steam exiting DSH-3, and an additional 25% of the steam is required by the 15 psig reboiler. The remaining steam from DSH-3 flows into the condenser.

The steam flow from ComTest to the 150 psig reboiler is assumed to be 76,631 lb/hr (50% of the total flow) at 205 psia and approximately 708^{o}F. This steam would enter a reboiler and would be condensed to saturated water at 200 psia. This latent heat of the steam would be used to generate 77,799 lb/hr of 165 psia saturated steam using water from the Youngstown Thermal low pressure (LP) feedwater header, which is supplied at 340 psia and 220^{o}F. This steam would then enter Youngstown Thermal's 150 psig steam header and would be supplied to their customers.

The steam flow from ComTest to the 15 psig reboiler is assumed to be 38,315 lb/hr (25% of the total flow) at 70 psia and approximately 694^{o}F (the pressure letdown valve is not shown in Figure 5-6). This steam would enter the reboiler and would be condensed to saturated water at 65 psia. This latent heat would be used to generate 43,627 lb/hr of 30 psia saturated steam using water from the Youngstown Thermal LP feedwater header, which would be supplied at 340 psia and 220^{o}F. This steam would then enter Youngstown Thermal's 15 psig steam header and would be supplied to their customers.

The OWT condensate from the ComTest steam would be collected from the reboilers. Since the collected condensate would be a two-phase mixture at 65 psia, it would flow into a flash drum operating at 50 psia to separate the steam and the water. Approximately, 9,456 lb/hr of steam would be flashed from the condensate which flows to the ComTest condenser. The remaining water would be pumped to the deaerator.

The water from the flash drum, the 38,315 lb/hr of steam which was not utilized by the reboilers and the 8,302 lb/hr of water from the spray water heaters would be combined in the ComTest condenser and cooled using 5,200 gpm of cooling water to 220^{o}F. This water would enter the condensate pump, flow through the water treatment system and then return to the deaerator to complete the cycle as shown in Figure 5-6.

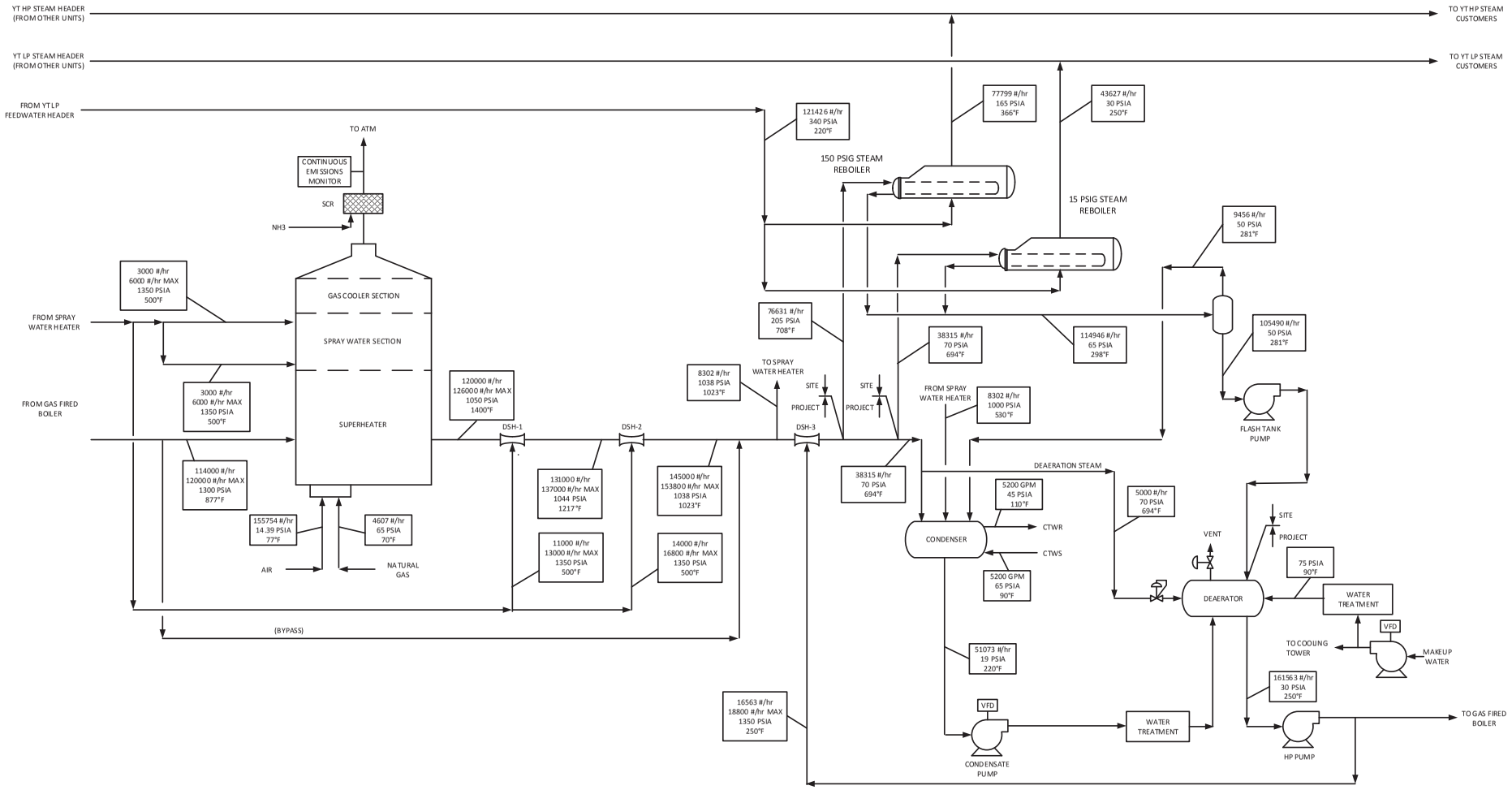


Figure 5-6 Integration of ComTest Base Case with Youngstown Thermal Operation

Operation of the ComTest Base Case with the Superheater Outlet Header

As described in Section 4.4, the purpose of the of the SHOH test was to cycle the temperature of the Superheater Outlet Header component between a minimum temperature and 1400°F numerous times to simulate the cycling a boiler would undergo in its lifetime.

For the SHOH, it would be desirable to operate the ComTest superheater at a steady state, but at a reduced flow of 80,000 lb/hr (see Figure 5-7). When the SHOH was being tested at a high temperature this 80,000 lb/hr of 1400°F steam would flow through the Header component. A desuperheater (DS-3) and pressure letdown valve (not shown) would be located at the outlet of the header, which would reduce the temperature and pressure of the steam to 205 psia and ~675°F.

An additional 40,000 lb/hr of steam from the boiler outlet would bypass the ComTest superheater. This steam would not be used for the high temperature test and would flow through a desuperheater (DS-1) and pressure letdown valve which would also reduce the temperature and pressure of the steam to 205 psia and ~675°F. This steam would combine with the steam exiting the SHOH.

Since this steam would be at 205 psia it would be available for use by Youngstown Thermal in their 150 psig and 15 psig reboilers as shown in Figure 5.6. The reboilers and the flash tank are not shown in Figure 5-7 for clarity, but the flowrates of the steam to the reboilers as well as the deaerator would be the same as shown in the example of Figure 5-6. The steam and condensate returning from the flash drum to the condenser are also assumed to be the same. The steam from the flash tank, the remaining steam from the SHOH and the water from the spray water heater would all combine and be cooled with cooling water in the condenser. The flow leaving the condenser would flow to the deaerator.

When it was time to cycle the temperature of SHOH, the inlet valves would swap, which would allow the cooler steam to enter the Header as shown in Figure 5-8. The 1400°F steam would flow directly to desuperheater/let-down valve DS-2 where the temperature and pressure would be reduced to 205 psia and ~675°F. The cooler steam would be desuperheated by valve DS-3 to the same conditions. The flowrates of steam flowing to the Youngstown Thermal reboilers and to the condenser would be the same after the hot and cooler steam flows swapped.

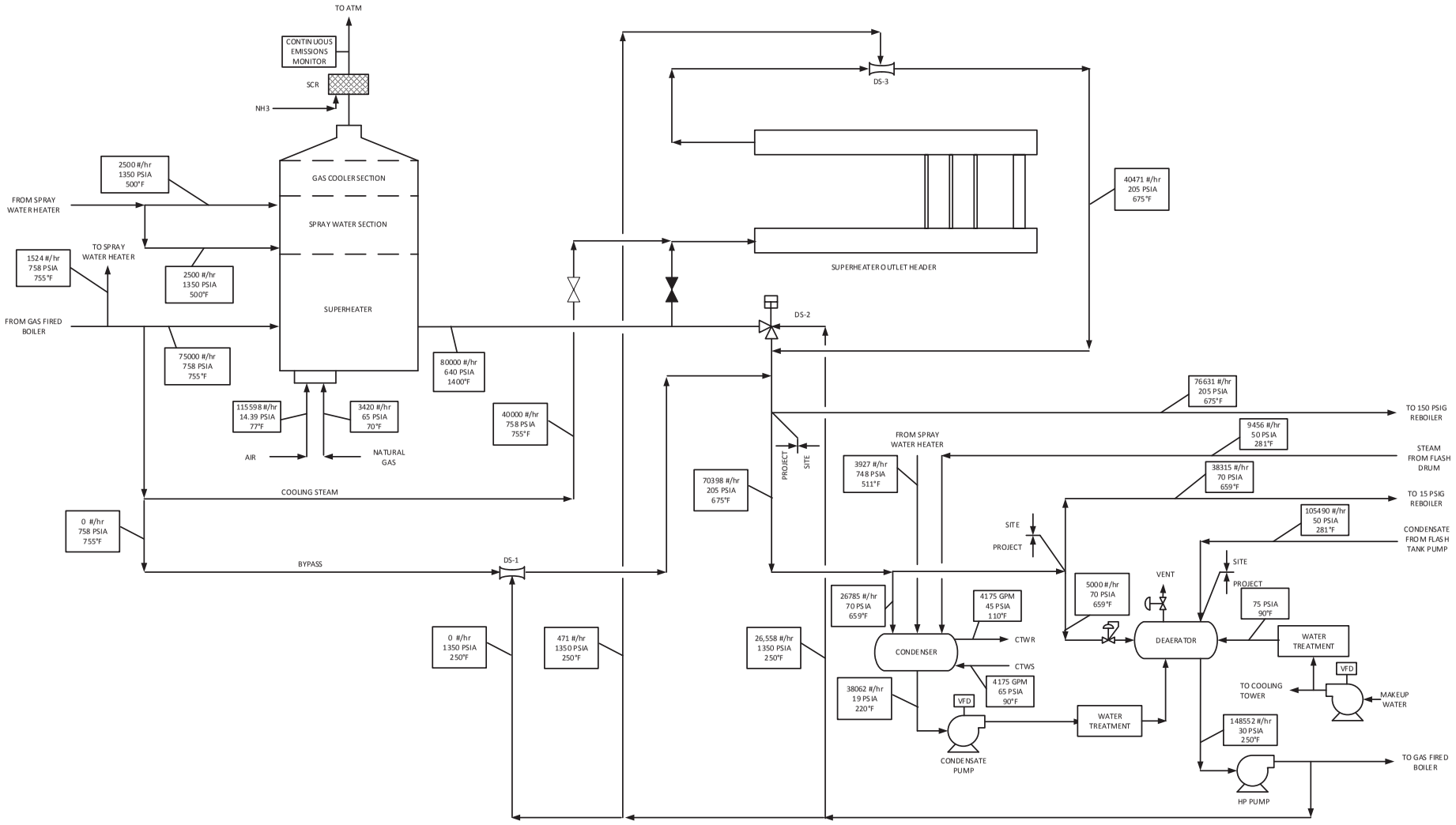


Figure 5-7 ComTest Superheater Outlet Header High Temperature Operation

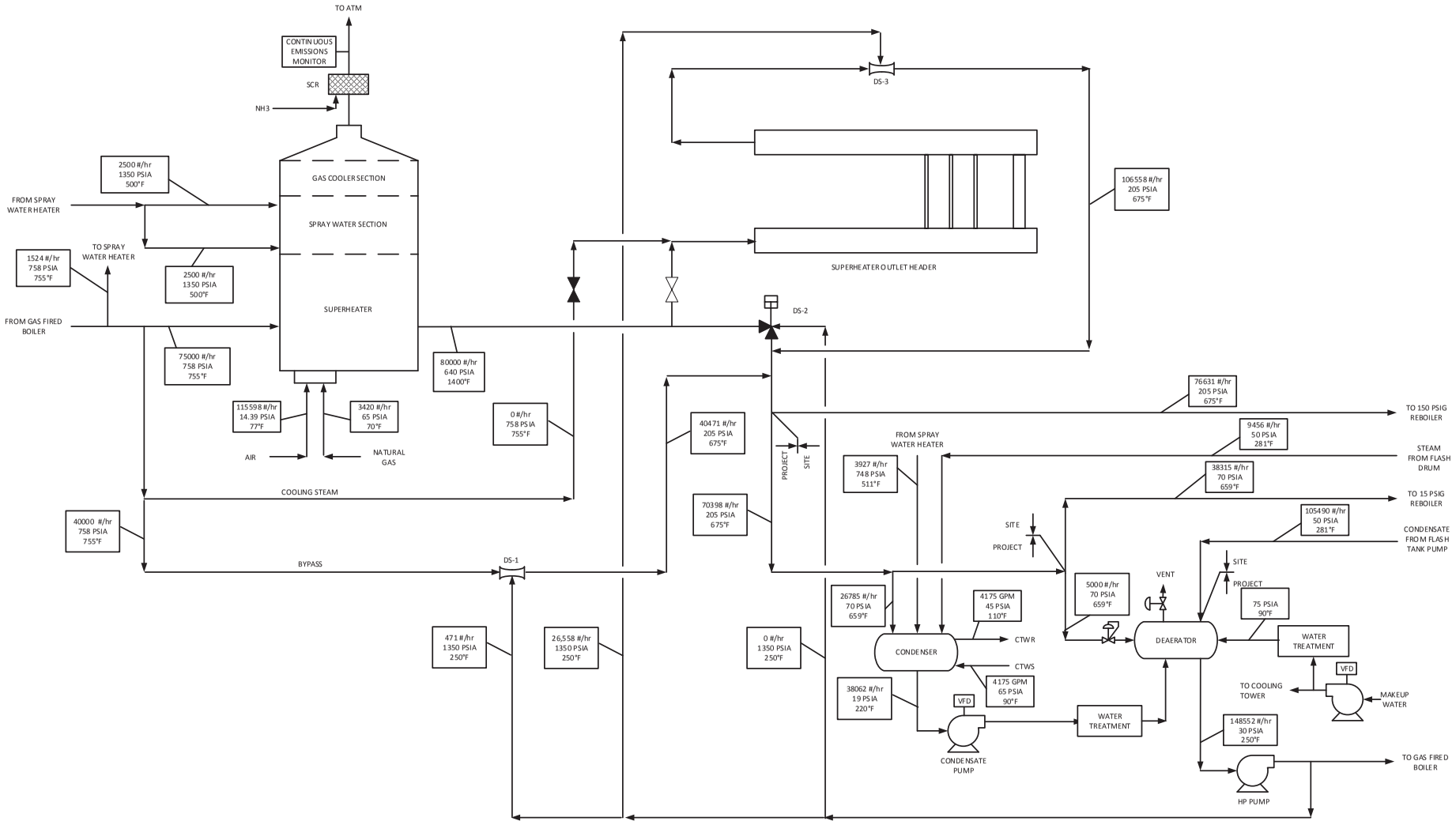


Figure 5-8 ComTest Superheater Outlet Header Low Temperature Operation

Operation of the ComTest Base Case with the Steam Turbine

The operating conditions for the steam turbine were shown in the heat balance diagram of Figure 4-16. The ComTest Superheater was to provide 119,510 lb/hr of steam at 620 psia and 1400ºF as shown in Figure 5-9. In addition to the primary steam flow, the superheater was designed to provide 1,843 lb/hr of steam at 90 psia and 1085ºF which was used for cooling the hottest parts of the turbine as described in Section 4.2.16. During startup, steam was withdrawn from the gas fired boiler to heat the steam turbine before the admission of the high temperature steam.

The ComTest system as shown in Figure 5-5 was designed to superheat the steam provided by a commercially available natural gas fired boiler and the flowrates and pressures shown on the figure are on that basis. The steam turbine was designed for a slightly lower pressure, so the steam pressure exiting the natural gas fired boiler would be decreased before entering the superheater.

Steam would exit the ComTest superheater at 620 psia and 1400ºF. While the turbine was being started, or in the event of a turbine trip, this steam would flow through the turbine bypass line where it would be desuperheated with 53,532 lb/hr of boiler feedwater to 205 psia and 674ºF. This steam would be available for use in Youngstown Thermal's 150 psig and 15 psig reboilers as shown in Figure 5-6 or would flow to the condenser.

When operating, the turbine would exhaust at 70 psia as described in Section 4.2.1. The 116,353 lb/hr of 70 psia steam would be at a temperature of 865ºF. This steam would be desuperheated with 21,534 lb/hr of boiler feedwater to a temperature of 475ºF. Because the steam exhausts from the turbine at 70 psia during normal operation, steam could be only provided for Youngstown Thermal's 15 psig reboilers. Youngstown Thermal would have to provide any required steam for their 150 psig customers from their currently operating boilers. The steam supplied to the 15 psig reboiler would be condensed and flashed to steam at 50 psia. Because the flow to the flash drum does not contain condensate from the 150 psig reboiler, the amount of steam flowing from the flash drum to the condenser is significantly less than shown in Figure 5-6. The condensate from the flash drum would flow to the deaerator.

The shaft output of the steam turbine would be 10.7 MW. However, the project determined that instead of generating electricity with the turbine, the turbine would be connected to a dynamometer as described in Section 4.2.11 to absorb the steam turbine power. The dynamometer acts similar to a water pump and would pump 2,080 gpm of cooling water.

A steam seal system as described in Section 4.2.15 would be required to seal the turbine casing so that steam does not exhaust into operating areas. Steam withdrawn from the steam seals would be desuperheated with cooling water. The cooled steam would be condensed in a gland steam condenser and be discharged to a site drain. Any non-condensibles pulled into the seals would be pulled out of the end seal packing by a centrifugal blower and vented from the gland steam condenser.

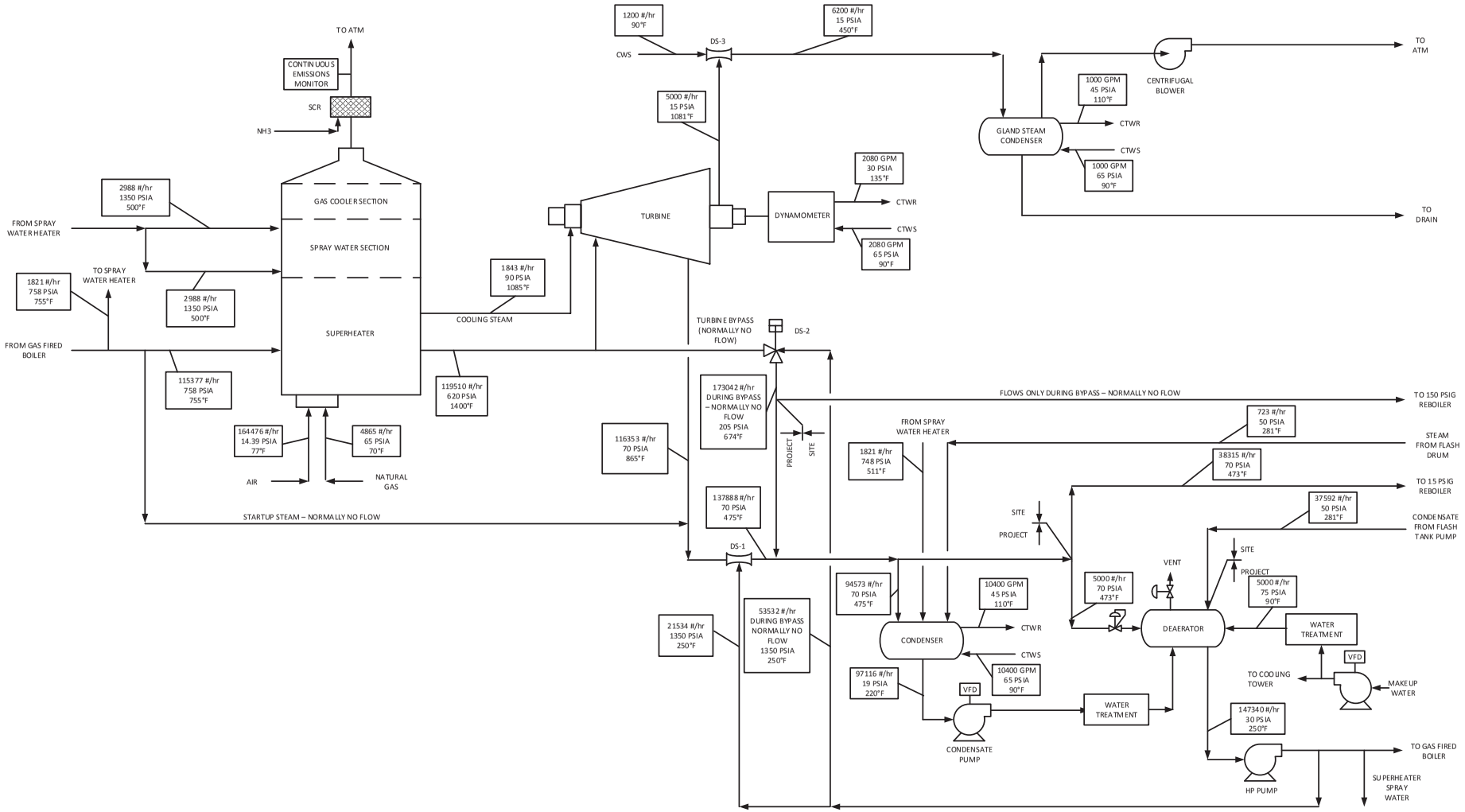


Figure 5-9 ComTest Base Case with Steam Turbine Operation

5.1.1.2 Piping and Instrumentation Diagrams

The Piping and Instrumentation Diagrams for the base case can be found in Appendix B.

5.1.1.3 Site Modifications Required

For ComTest to occur at Youngstown Thermal:

- The AUSC equipment described in Section 4 would be constructed at the Youngstown Site.
- Non-AUSC balance of plant equipment such as the natural gas boiler, cooling tower, and dump condenserwould be required to be added to the Youngstown site.
- Infrastructure changes to the site would also be required. These would include a new natural gas pipeline, electrical upgrades, a new building would be added to house the steam turbine, piping would be added to connect the equipment, civil modifications would be required, etc.

These improvements are summarized in Table 5-1.

Table 5-1 Youngstown Thermal Site Engineering

Component/Equipment	Details
	BUILDINGS
ComTest Turbine Building	A new turbine building would be located adjacent and to the south of the existing boiler building. This building would contain the ComTest steam turbine and its associated equipment. The building would be approximately 70' by 90' and 32' high, having an area of approximately 6,330 ft^2. It would be a single story pre-engineered steel framed building with metal wall panels and roof panels. The building would contain a basement level to support the steam turbine piping and equipment, which would be accessed using stairs. It would have personnel doors as well as coiling steel service doors to provide access to the equipment in the building. The building would also contain the control room for the operation of the ComTest project and a unisex bathroom. The new ComTest Turbine Building would be heated and ventilated. Heating would be provided by gas fired unit heaters located in the basement and at the operating level of the building. Ventilation would be provided by a natural ventilation system consisting of a motor operated ridge vents. The control room would be a temperature-controlled space and would contain a heat pump system to provide cooling. The bath room would be ventilated using a local exhaust fan. A 30-ton capacity, double girder top running crane for performing installation and maintenance of the ComTest turbine would be provided inside the turbine building. Rainwater from the turbine building would be collected in a gutter system and discharged to grade via downspouts. The grade elevation will be modified to route storm water to a local catch basin. Cold and hot water would be provided to the turbine building bath room. Cold water would be provided from the municipal water supply, and hot water would be furnished by a local electric water heater. Sanitary waste piping from the turbine building would tie into the existing sanitary waste system. Process floor drains would be installed as required for the first floor and basement levels. These drains would tie into a pre-fabricated sump and pump which discharges into the process sewer. Process hub drains would be located in the yard area for the Superheater, Cooling Tower, Cooling Tower Water Treatment Skid, Boiler, Dump Condenser/Exchanger, Deaerator and Boiler Water Treatment skids.
Superheater Tower	A new super structure to house the Superheater equipment and components required to increase the steam to AUSC levels would be built on the site. The tower would be 34 feet by 49 feet, 130 feet high, and 1,666 square feet of space. The Superheater would be supported from six still columns resting on a foundation of drilled piers which would extend into the bedrock approximately 30 feet below grade. The drilled piers would be connected with concrete grade beams just below grade and these beams would support a concreate slab. The air fans for the Superheater as well as the other Superheater components would rest on this slab.

SITE IMPROVEMENTS	
Electrical	The operation of the AUSC ComTest Equipment would require significant electrical upgrades to the existing Youngstown Thermal facility. The proposed new electrical improvements would include a new electrical 23 kV sub-transmission service that would be brought to the site from several blocks away (approximately 1,500 feet away from the site on a pole line). This cable would be mostly located on poles with the last 50-100 feet being installed underground to avoid interference with construction activities. In addition, other equipment would be installed including a new 23 kV pad mounted outdoor circuit breaker with metering, two liquid filled transformers installed in the boiler area, a 4160V Motor Control Center (MCC) and a 480V MCC, two uninterruptible power supplies (UPS) and a backup diesel generator. Lighting would be provided to all work areas. Electric heat tracing and instrumentation heaters would be provided to critical instruments. A security system and security cameras would also be provided, and security cameras with microphones would be provided to monitor the superheater during operation. The peak electrical demand for the ComTest facility would be 2,637 kW, with an average annual electricity usage of 18,540 MWh.
Natural Gas Pipeline[a]	A new 12-inch HDPE natural gas service pipeline would provide fuel for the ComTest boiler, superheater, and the unit heaters in the turbine building. The line would extend approximately 1.45 miles from the tie-in point on McGuffey Road to the ComTest project area. The demand would be approximately 6,400 scfm. The line would operate at approximately 85 psig at the tie-in point in the winter and 75 psig at the tie-in point in the summer. A gas meter for this new line would be installed south of the turbine building within a pre-assembled enclosure for weather protection. See Section 5.1.1.7 for more information on the natural gas pipeline
Utility Racks	Steel-framed open utility racks would be provided to support piping and cable trays between the onsite equipment including the ComTest turbine building/control room, superheater tower, and boiler area.
Storm Sewer System	Installation of catch basins and all underground storm sewers would allow drainage towards the southwest corner of the construction site would be included. The new storm sewer piping would tie into the existing sewer system with 12-inch diameter PVC sewer piping. Risers would be installed during the final grading and paving stage. Rainwater from the turbine building would be collected in a gutter system and discharged to grade via downspouts. The grade elevation would be modified to route stormwater to a local catch basin. Process floor drains would be installed as required for the first floor and basement levels. These drains would tie into a pre-fabricated sump and pump that would discharge into the process sewer. Process hub drains would be located in the yard area for the Superheater, Cooling Tower, Cooling Tower Water Treatment Skid, Boiler, Dump Condenser/Exchanger, Deaerator and Boiler Water Treatment skids. Construction would also include installation of underground sanitary sewer piping, and final fixtures would be installed when buildings or structures are completed. Sanitary waste piping from the turbine building (rest room) would tie into the sewer system with 8-inch diameter sewer piping. During construction, it is expected that temporary portable toilets would be provided for workers and sanitary wastewater transported by commercial services for disposal.

Sanitary/Industrial Sewer System	Process floor drains in the ComTest turbine building would tie into a pre-fabricated sump and pump to discharge into the process sewer. Process drains would also be located in the yard area for the superheater, cooling tower and water treatment skid, package boiler and water stream skid. These process flows and sanitary waste from the ComTest turbine building rest room would tie into the existing sanitary/industrial sewer system. The wastewater would be discharged under Youngstown Thermal's current wastewater discharge permit.
Boiler Area	The boiler area will include the foundations for the boiler, water treatment system, transformers, and the "dump" condenser/exchanger.
AUSC Piping	The AUSC steam piping would be fabricated from INCONEL 740H alloy and would connect the ComTest superheater outlet to the steam turbine and the Superheater Header test apparatus. INCONEL 740H alloy would also be used as necessary between the outlet of these components and their corresponding desuperheaters. There would be a superheated steam bypass line from the outlet of the ComTest superheater directly to a desuperheater which would be used to vary the flow through the steam turbine and superheater outlet header test apparatus. This line between the ComTest superheater and the bypass desuperheater would also be INCONEL 740H alloy.
New Plant Piping	New piping and site utility (pipe) racks would be required for the project. Site utility racks would run from the new turbine building to the Superheater Tower and to the areas where the boiler, cooling towers, water treatment and pumps would be located. Piping would traverse the utility racks to connect these various pieces of equipment. Piping would also run through the new turbine building to connect the steam turbine to the appropriate equipment.
Other Site Work	Aside from the foundation work described above, additional site work would be required: • Some demolition of existing underground piping and other equipment. • Finish grading • Installation of gravel surfacing on all work/vehicle traffic areas. • Extension of the existing storm sewer system • Installation of a sanitary/industrial sewer system • Connecting the new storm/sanitary sewers to the existing underground structures.

Source: AECOM 2016b

a. The alternate configuration assumes that Youngstown Thermal would supply the required steam for the AUSC-ComTest Project and thereby purchase, install, and operate some of the equipment required for the project, as discussed in Section 2.4.3.

HDPE = high density polyethelene; HVAC = heating, ventilation, and air conditioning; mmBtu = million British Thermal Units; MW = megawatt; psig = pounds per square inch gage; NO_x = nitrogen oxides; PVC = polyvinyl chloride; scfm = standard cubic feet per minute; V = volt

5.1.1.4 **Equipment List/Description**

The equipment required for the Base Case Configuration at Youngstown Thermal is summarized in Table 5-2.

Table 5-2 Youngstown Thermal Base Case Equipment Descriptions

Equipment	Details
	AUSC COMTEST EQUIPMENT
Superheater	The ComTest Superheater would be an air-blown, natural gas fired steam Superheater approximately 130 feet tall. Steam from the outlet of the boiler would enter the Superheater and the primary steam outlet flow of 119,500 lb/hr will leave the Superheater tower at a temperature of 1400°F. There is a secondary steam flow that would be used by the steam turbine for cooling that will exit the Superheater tower at nominally 1100°F during the steam turbine test. On the gas exit of the Superheater, there would be two economizers. The lower economizer is used to heat high pressure OWT feedwater for use in the two ComTest Superheater desuperheaters. These desuperheaters are used to control the steam temperature within the Superheater. The upper economizer will utilize feedwater from Youngstown Thermal to cool the exiting flue gas. This feedwater will be returned to Youngstown Thermal for use within their processes. The Superheater designed by B&W is described in Section 4.1.1
Steam Turbine/Dynamometer	The ComTest Steam Turbine supplied by GE Power would have throttle conditions of 1400°F and 620 psia, and a throttle flow of 119,500 lb/hr. The steam would discharge at 70 psia. The turbine would operate at a speed of 5400 rpm. Nominally, this turbine would be capable of generating ~10.7 MW. For ComTest, it was not desired to generate electricity with the steam turbine, so a dynamometer would have been mounted on the steam turbine shaft to dissipate the load. The dynamometer would be supplied with water from the cooling tower basin. The Steam Turbine is described in Section 4.2. The Steam Turbine Stop and Control valves are described in Section 4.3.
Superheater Outlet Header	The Superheater Outlet Header test apparatus supplied by GE Power is a piping component that would be used to evaluate the ability of the AUSC materials to operate reliably under conditions of varying boiler loads. By changing the source of the supply of the steam entering the test apparatus, the steam temperature would cycle between 750°F and 1400°F. The Superheater Outlet Header is described in Section 4.4.

Table 5-2 Youngstown Thermal Base Case Equipment Descriptions

Equipment	Details
	BALANCE OF PLANT EQUIPMENT
Package Boiler[a]	A shop assembled, natural gas-fired package boiler rated at 150,000 pounds per hour, 1,100 psig and 850°F for design conditions, and 950 psig and 750°F for operating conditions would be provided. The boiler would be fired with natural gas and the boiler system would include a forced draft fan with a 600 hp motor, low NOx gas fired burner, economizer, interconnecting ducts and stack, access platforms, trim valves, and the burner management control system.
Cooling Tower[a]	Six crossflow cooling tower cells designed for a load of 87 mmBtu per hour to provide the required cooling for the ComTest System would be supplied by the project. Cooling water would be used for the dump condenser and the dynamometer. ComTest proposed using a pre-assembled energy-efficient cooling tower system with low drift rates, and options to integrate additional plume abatement and water conservation technologies. The cooling tower would be supported approximately eight feet above grade by a structural steel framed platform. Each column of the platform would rest on a concrete spread footing foundation. Steel caged ladders would provide access to platforms that are integral with the cooling tower at each end. A separate foundation supports the cooling tower pumps and miscellaneous other equipment.
Water Treatment[a]	Two separate water treatment areas would accommodate the package boiler and the cooling tower. The package boiler would receive feedwater from a deaerator, which would remove oxygen and dissolved gases from the feedwater. The package boiler water treatment system would provide OWT water to the designated users. A cooling tower water treatment system would maintain proper scale, microbiological and corrosion control for the cooling tower water
Deaerator skid and pumps	Vertical inline centrifugal pumps would be used to return condensate from the dump condenser to the deaerator via the water treatment system. One pump would be active the second pump would be a spare. Each pump has a capacity of 350 gpm. A rental unit would provide deaerated feedwater to the boiler and other designated users. The deaerator would operate at 50 psig. The high pressure BFW pumps would discharge the water to the boiler at 1200 psig.

Table 5-2 Youngstown Thermal Base Case Equipment Descriptions

Equipment	Details
Dump Condenser/Exchanger and pumps	The dump condenser would condense the exhaust steam from ComTest that is more than the steam Youngstown Thermal needed to meet their customer's demands. The exchanger would use cooling tower water to cool the steam. It would be a 54-132 TEMA type BEM shell and tube heat exchanger with 304L tubes and shell. It would be mounted horizontally on saddles and concrete piers. The exchanger would designed for a duty of 191 MMBTU/hr. Horizontal split case centrifugal pumps would circulate cooling tower water through the dump condenser/exchanger and back to the cooling tower. Two pumps would be active, one would be stand-by. Each pump would have a capacity of 10,000 gpm.
Desuperheaters	There would be multiple desuperheaters in the process: • An attemperator type desuperheater which would provide attenuated steam to the turbine for startup. • Two desuperheaters would be included in the B&W ComTest superheater for steam temperature control. • A desuperheater would be located on the steam turbine exhaust to cool the steam to meet Youngstown Thermal's temperature specification. • A desuperheater would be located on the bypass line to cool the steam to meet Youngstown Thermal's temperature specifications. • A desuperheater would be located at the outlet of the superheater header test apparatus to cool the steam to meet Youngstown Thermal's temperature specifications.
Hot Well Tank and Pumps	The hot well tank would be in the lower level of the turbine building. The hot well tanks receive circulation water with dissipated heat from the dynamometer located on the upper level. The hot well tanks would be sized for a capacity of 5,500 gallons. Horizontal end suction centrifugal pumps would receive the dynamometer circulation water from the hot well tanks and pump the water to the cooling tower. One pump would be active, the other would stand-by. Each pump would have a capacity of 1,850 gpm.
Air Compressor Package	A skid mounted air compressor package featuring two compressors, a 240 gallon vertical receiver, desiccant dryers and factory mounted pre-wired control panel would be provided as part of the project.

Table 5-2 Youngstown Thermal Base Case Equipment Descriptions

Equipment	Details
Instrumentation and Controls	The control system would consist of a Mark Vie Distributed Control System (DCS) for the ComTest Steam Turbine, which will be supplied by GE. A PACSystems RX3i Programmable Automation Controller (PLC) would be provided for the balance of plant systems. Several of the balance of plant package systems would contain standalone controllers. The ComTest Superheater instrumentation and controls would be supplied by the superheater supplier. Remote I/O cabinets would be located at key areas of the facility to collect signals from the various instrumentation. Instrumentation wiring would be installed in cable trays located on the utility rack and connect to the control room. The control room would house the control system and PLC cabinets, two work stations and a printer. Each workstation human machine interface (HMI) will consist of dual monitors, with a mouse and displays for the ComTest equipment as well as high level information from the standalone package systems.

5.1.1.5 **Hazard and Operability Review**

A Hazard and Operability (HAZOP) Review was held in AECOM's Cleveland, Ohio from February 23 to 25, 2016. Representatives from AECOM, B&W, EPRI and General Electric participated in the review. The HAZOP was facilitated by Bluefield Process Safety. The HAZOP report can be found in the Appendix.

5.1.1.6 **Site Layout**

The Youngstown Thermal steam plant is located on the northern portion of the approximately 3-acre campus that includes the boiler plant, turbine building, management/engineering office, storage building, fly ash silo, coal storage area and pit, coal tower, four 120-foot stacks, and paved surfaces (gravel, asphalt, and concrete). Figure 5-10 shows the existing steam plant buildings and features and the locations of the proposed ComTest Project components on the Youngstown Thermal campus. The ComTest would be integrated into the Youngstown Thermal campus by utilizing a combination of open plant property, relocation of some existing steam plant features, and use of an adjacent property for construction laydown Figure 5-11. Figure 5-12 shows a general arrangement of the base case equipment at the Youngstown Thermal facility. Three-dimensional graphics showing the equipment located on the Youngstown Thermal site are shown in Figure 5-13 and Figure 5-14.

Figure 5-10 Project Site and Youngstown Thermal Campus

Figure 5-11 Proposed Project Area

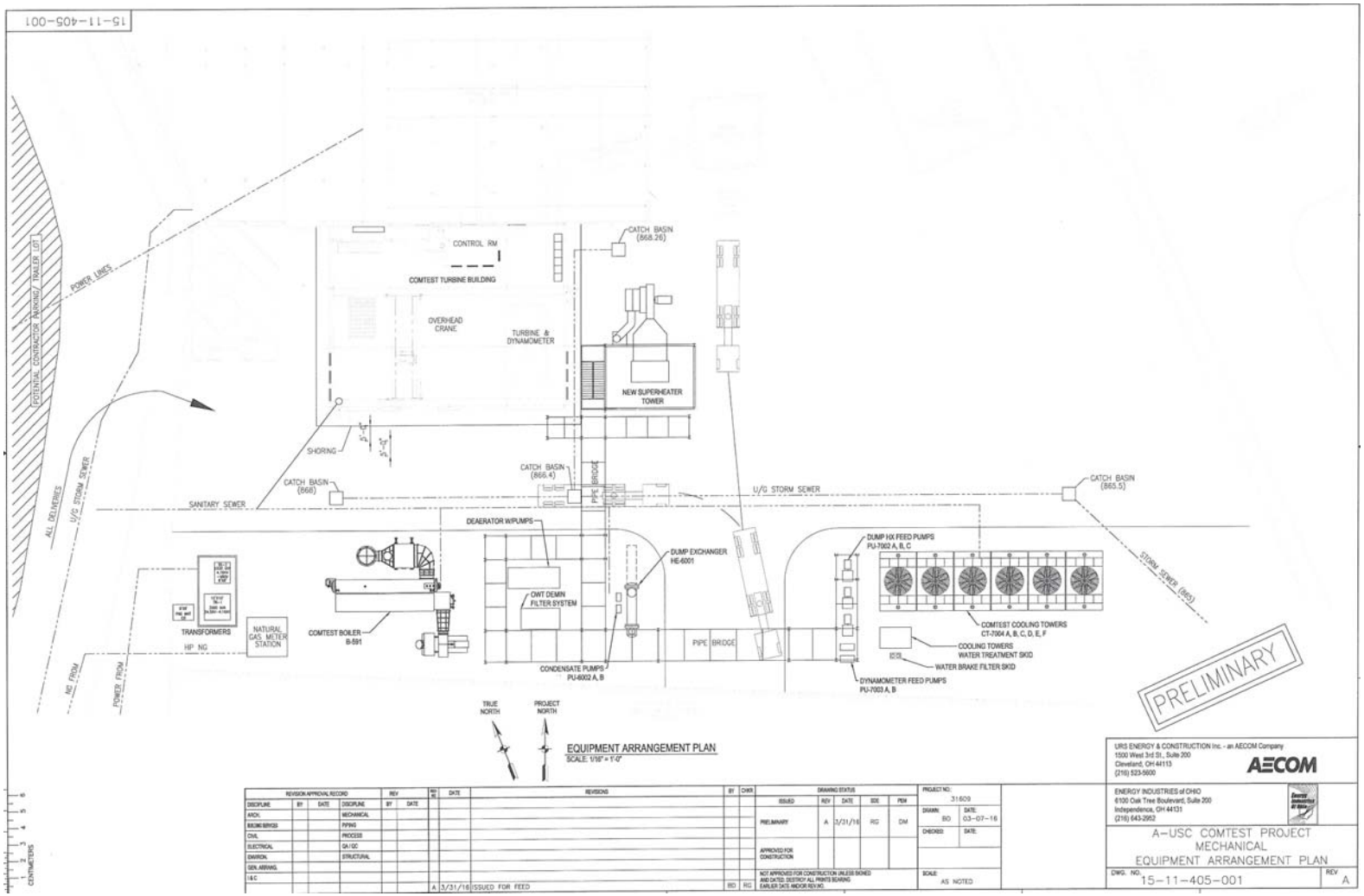


Figure 5-12 AUSC ComTest Mechanical Equipment Arrangement Plan (Base Case)

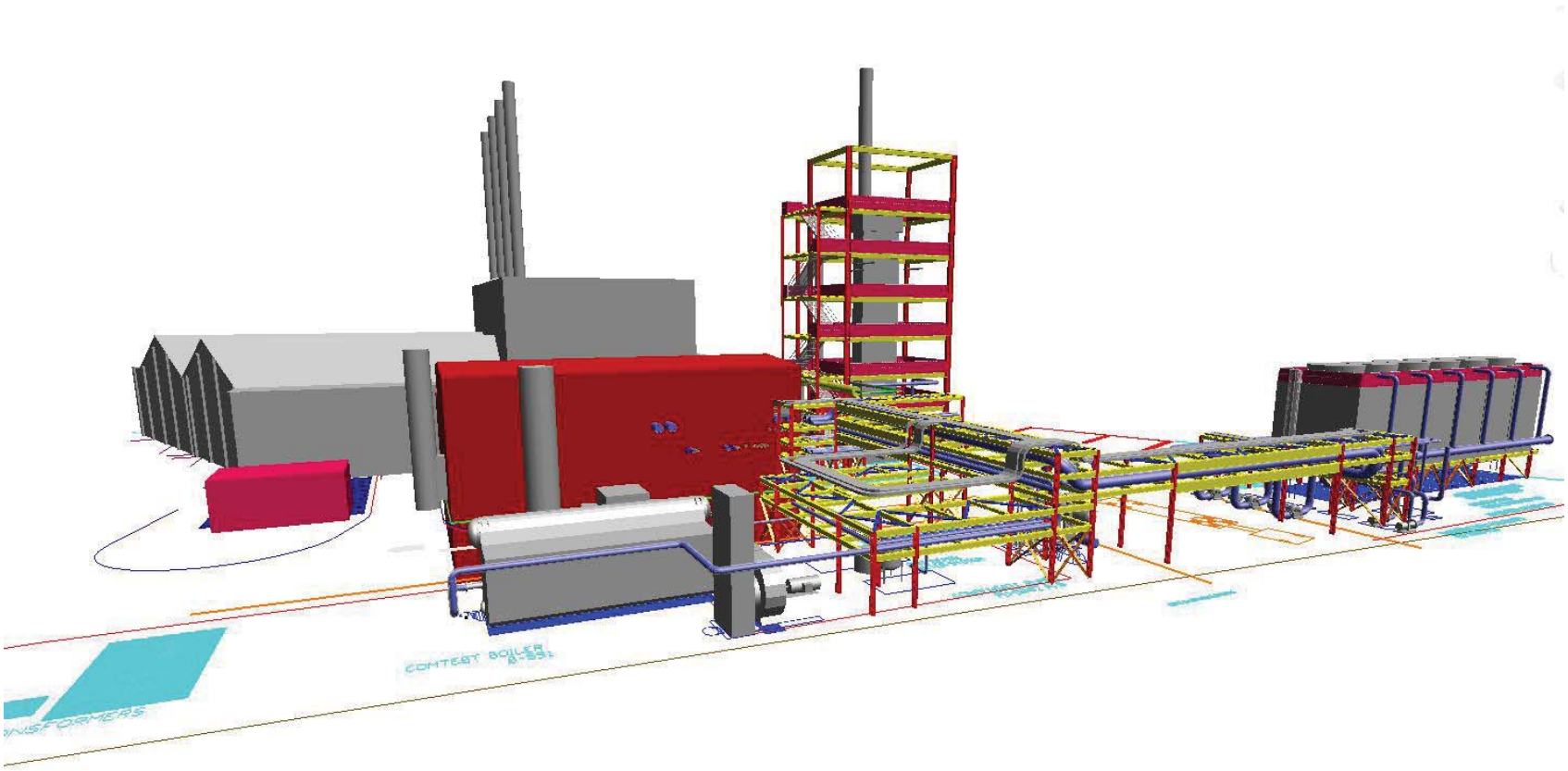


Figure 5-13 The Base Case ComTest Configuration at the Youngstown Thermal Site (looking ~NE)

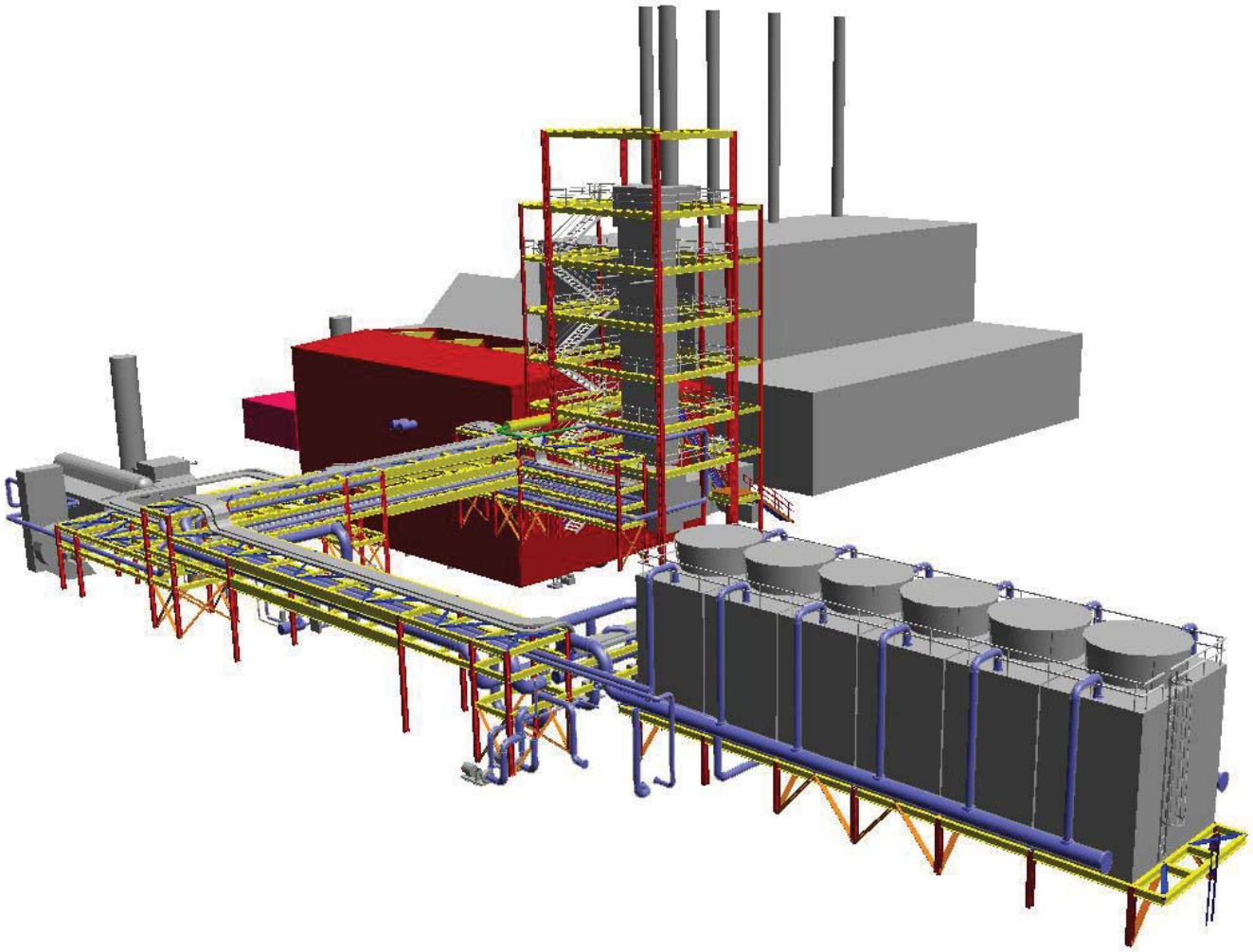


Figure 5-14 The Base Case ComTest Configuration at the Youngstown Thermal Site (looking ~NW)

5.1.1.7 **New Natural Gas Service**

A new natural gas service would be required to service the ComTest boiler and ComTest superheater as well as unit heaters inside the new turbine building. A pipeline would be routed approximately 1.45 miles to the nearest high-pressure service available from the utility.

Dominion East Ohio would construct a new gas line to supply natural gas for the new Youngstown Thermal CHP in the long term and provide natural gas to the AUSC ComTest Project in the short term. Figure 5-15 presents the route of the new natural gas pipeline that Dominion East Ohio proposed as the least disruptive route from their closest tie-in point (on McGuffey Road) to the connection location at Youngstown Thermal (on Belmont Avenue). The route would avoid the downtown area and the Youngstown State University campus. The proposed route is approximately 7,700 feet (1.45 miles) and within the existing road rights-of-way.

The natural gas line would be a 12-inch diameter high-density polyethylene (HDPE) pipe, conforming to ASTM D2513 with a pressure rating of 1,600 psi at 73°F. The anticipated operating pressures during the 2-year project would vary by season, with 85 psig at the tie-in point in winter and 75 psig at the tie-in point in summer. It was anticipated that construction of the gas line would occur from October 2016 to approximately July 2017.

Dominion East Ohio anticipated installing the new line using trenching techniques along the entire distance. The minimum trench width for a 12-inch diameter pipe and stable soil conditions would likely be 24 inches, however, an approximate trench width of 36 inches to account for variations in soil conditions and backfill placement around the pipe was assumed. Anticipated trench depth would be roughly 36 inches, dependent on soil conditions, obstructions along the route, and burial depth required under roadways. The installation contractor would likely use a chain or wheel trencher for most of the route or a conventional excavator if rock is found and would construct using hand excavation in areas of close proximity to existing underground utilities.

The pipeline would supply the natural gas to the package boiler and the superheater, as well as to the gas-fired unit heaters in the ComTest turbine building at a pressure of 75-85 psig. The natural gas flow to the boiler is about 11,000 pounds per hour and to the superheater is 5,200 pounds per hour for a total flow of 16,200 pounds per hour. Using 60°F and 14.7 psia as “standard” conditions, this is a volumetric flow of about 6,400 standard cubic feet per minute, which equates to approximately 3.36 billion standard cubic feet per year.

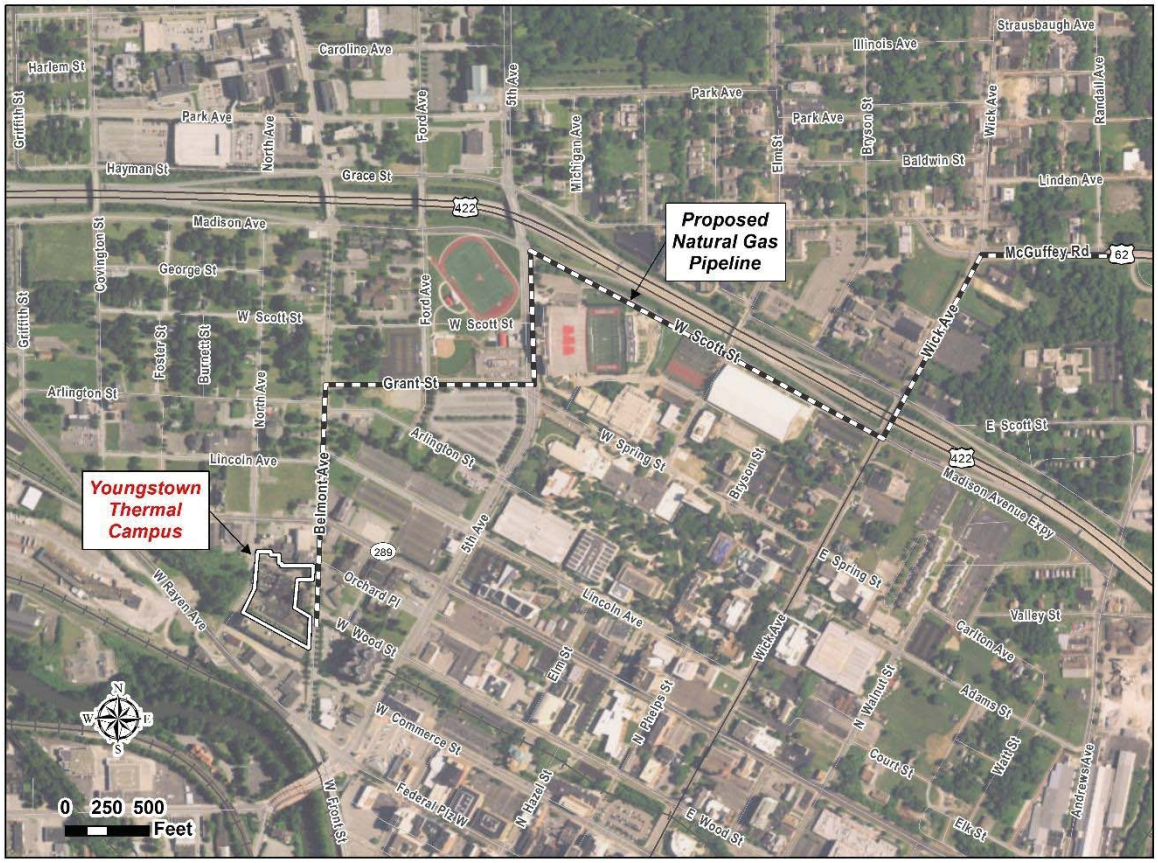


Figure 5-15 Proposed Location of Natural Gas Line

5.1.1.8 **Environmental Performance**

Operation of the AUSC ComTest Project would result in minor impacts to air quality due to emissions from the package boiler, the superheater, and particulate matter from the cooling tower. Both the boiler and the superheater would have their own new emissions stack. The package boiler stack would have a flue gas flow about 341,000 pounds per hour, and the superheater stack would flow about 160,000 pounds per hour. Table 5-3 presents the current emissions from Youngstown Thermal. Table 5-4 presents the estimated performance emissions that could occur from the AUSC ComTest for the base case configuration. The base case configuration assumes the AUSC ComTest operates independent of Youngstown Thermal, and thus uses a package boiler to generate the required steam. The sources of emissions are the natural gas-fired package boiler, the natural gas-fired superheater, and the associated cooling tower.

Table 5-3 Emissions for Youngstown Thermal Plant

Equipment	Annual Emissions (Tons)					
	CO	NO_x	VOC	SO_x	PM[a]	CO_2-eq[b]
YT Current Operations[c]	25.1	41.7	1.0	236.7	29.4	77,754

CO = carbon monoxide; CO_2-eq = carbon dioxide equivalent; NO_x = nitrogen oxide; PM = particulate matter; SO_x = sulfur oxides; VOC = volatile organic compounds

[a.] Includes PM with a diameter of 10 microns or less (PM_{10}) and with a diameter of 2.5 microns or less ($PM_{2.5}$)

[b.] Assumes global warming potential of methane (CH_4) is 21.

[c.] Based on natural gas for Youngstown Thermal boiler B001 and 4,700 tons per year limit for coal in boilers B002, B003, and B004 per current Title V permit (Ohio EPA 2016c).

[d.] Includes Youngstown Thermal proposed combustion turbine, heat recovery steam generator, and cooling tower (assuming particulate emissions at 1200 micromhos and drift at 0.005 percent of circulation).

Table 5-4 Emissions for AUSC ComTest Project

Equipment	Annual Emissions (Tons)					
	CO	NO_x	VOC	SO_x	PM[a]	CO_2-eq[b]
Base Case – AUSC ComTest						
Package Boiler	75.2	75.2	7.2	3.2	14.1	111,863
Superheater	49.7	74.5	2.7	0.3	3.7	58,125
Other[c]					1.4	
TOTAL AUSC ComTest	**124.9**	**149.7**	**9.9**	**3.5**	**19.2**	**169,988**

5.1.1.9 **Project Cost**

As part of Phase 1, AECOM, in cooperation with the other project partners prepared a FEED level cost estimate to project the cost of building and operating ComTest at Youngstown Thermal. The summary level cost estimate is shown in Table 5-5 and Table 5-6.

Table 5-5 Total Project Cost Summary

A-USC ComTest Project Cost Estimates - Overall ($ mm)	
Description	**Youngstown Thermal**
Phase I (Design)	$15.0
Phase II (Build / Operate)	
Buy & Install	$90.7
Operate	$18.7
Decommission & Demo	$3.2
Sub-Totals Phase II	$112.6
Total Project Cost	**$127.6**

Table 5-6 Cost Estimate – Phase 1 Details

A-USC ComTest Project Cost Estimates - Phase II Details ($ mm)	
Description	**Youngstown Thermal**
Buy & Install (B&I)	
OEM Equipment:	
AUSC SuperHeater	$29.0
AUSC Main Steam Piping	$4.0
AUSC Steam Turbine	$24.0
Sub-Totals (OEM)	$57.0
Balance of Plant:	
Turbine Building	$0.7
Steam Generator	$3.1
Cooling Towers	$1.0
BOP Equipment	$4.2
Control System	$2.0
Other Piping	$3.0
NG Pipeline	$4.0
Electrical	$2.8
Misc. (see note 3)	$1.8
Indirect Costs (see note 4)	$11.1
Sub-Totals (BOP)	$33.7
Total B&I Costs	**$90.7**
Operating Costs	
Utilities:	
Steam	$0.0
Natural Gas	$8.2
Electricity	$2.3
Cooling Water	$3.3
Operating:	
Labor & Maintenance	$4.1
Facility Usage Fee	$0.8
Totals Operating Costs	**$18.7**

The DOE award for the project was based on a total budget of approximately $75 million, so the estimated project cost was significantly higher. Throughout the FEED phase of the project, the project team worked with its partners to look at opportunities to optimize the scope of the project to save costs.

5.1.2 Steam Supplied by the Youngstown Thermal Combined Heat and Power Project

As discussed in Section 5.1, Youngstown Thermal had commissioned Thermal Engineering Group to begin the design of a CHP unit for their facility. The timing of the two projects were such that it might be possible to utilize steam from the CHP unit for ComTest. This would save the ComTest project capital cost, but an operating cost would be paid by the project to Youngstown Thermal for steam generation, cooling water, plant labor, etc. if this approach had been taken.

As part of the CHP unit, Youngstown Thermal would also provide the deaerator and boiler feed water treatment equipment, the oxygenated water treatment system, the cooling tower, the cooling tower water treatment system, the cooling tower water supply pumps, and the packaged air compressor. Youngstown Thermal would incorporate these processes into their normal plant operation and supply these "services" to ComTest. In addition, since Youngstown Thermal would need the natural gas line to supply their new CHP system, they would take responsibility for the installation of the new natural gas line.

5.1.2.1 **Process Configuration**

Operation of ComTest utilizing steam from the Youngstown CHP system (Figure 5-16) would be very similar to that with a package boiler since the steam temperature and pressure leaving the Heat Recovery Steam Generator (HRSG) of the CHP unit would be essentially the same as that of the package boiler. Instead of the steam being supplied to the ComTest superheater at nominally 935 psig and 770^{o}F by the package boiler, approximately 180,000 lb/hr of steam at 950 psig and 850^{o}F would be generated in the HRSG and be made available to ComTest.

If ComTest was not operating, this steam would be supplied to a steam turbine owned by Youngstown Thermal. The steam would be expanded through the steam turbine to generate electricity. As the steam was expanded in the steam turbine, a portion of the steam would be extracted at a pressure of 205 psia and a second portion at a pressure of 50 psia. The 205 psia steam would enter a reboiler where it would be condensed. The heat of the condensing steam in the reboiler would be used to raise 165 psia steam using low pressure feedwater. This 165 psia "product" steam would be supplied to Youngstown Thermal's customers for their use. After use, the condensed product steam would be drained into the municipal water supply drain at the customer's facilities. The amount of 205 psia steam extracted from the steam turbine would depend on the demand of the 165 psia steam from Youngstown Thermal's customers.

Similarly, steam would be extracted from the steam turbine at 50 psia and this steam would enter a second reboiler where it would be condensed. The heat of the condensing steam in the second reboiler would be used to raise 30 psia steam also using low pressure feedwater. This low pressure "product" steam would also be supplied to Youngstown Thermal's customers for their use. Like the higher pressure steam the condensed product steam would be drained back to the municipal water supply drain after use at the customer's facilities. The amount of 50 psia steam extracted from the steam turbine would depend on the demand of 30 psia steam from Youngstown Thermal's customers.

The remaining steam would flow through the steam turbine and exhaust into a vacuum condenser to where it would be condensed. The condensate from the condenser would flow through a pump to raise the pressure and is then be returned to the deaerator.

During ComTest's operation, most of the steam generated by the HRSG would flow to the ComTest superheater as described in Section 5.1.1 and the tests described in those sections would be performed. In addition to the steam for the ComTest superheater, Youngstown Thermal would also provide high pressure water for the desuperheaters, natural gas for the ComTest superheater and cooling water. The ComTest equipment would supply steam to the 150 psig and 15 psig reboilers depending on the nature of the testing being performed. Condensate from the ComTest condenser would be pumped to Youngstown Thermal's deaerator.

There would be a few other significant differences between building the "Base Case" and receiving steam from Youngstown Thermal:

- In Section 5.1.1 it was discussed that if ComTest did not provide adequate steam to meet the needs of those the 150 and 15 psig reboilers, the extra steam required would be generated by Youngstown Thermal's existing steam generators. If the CHP unit was providing the steam for ComTest, Youngstown Thermal would first try to supply this extra steam by extracting it from their steam turbine. If that did not meet the demand, then additional steam generators would be operated to meet the needs of their customers.
- The deaerator would be included in Youngstown Thermal's scope and would be integral to their CHP operation. Therefore, the steam supply for the deaerator would be from the flash tank and not from the ComTest steam. This would allow Youngstown Thermal to continue their operations if ComTest was not operating.

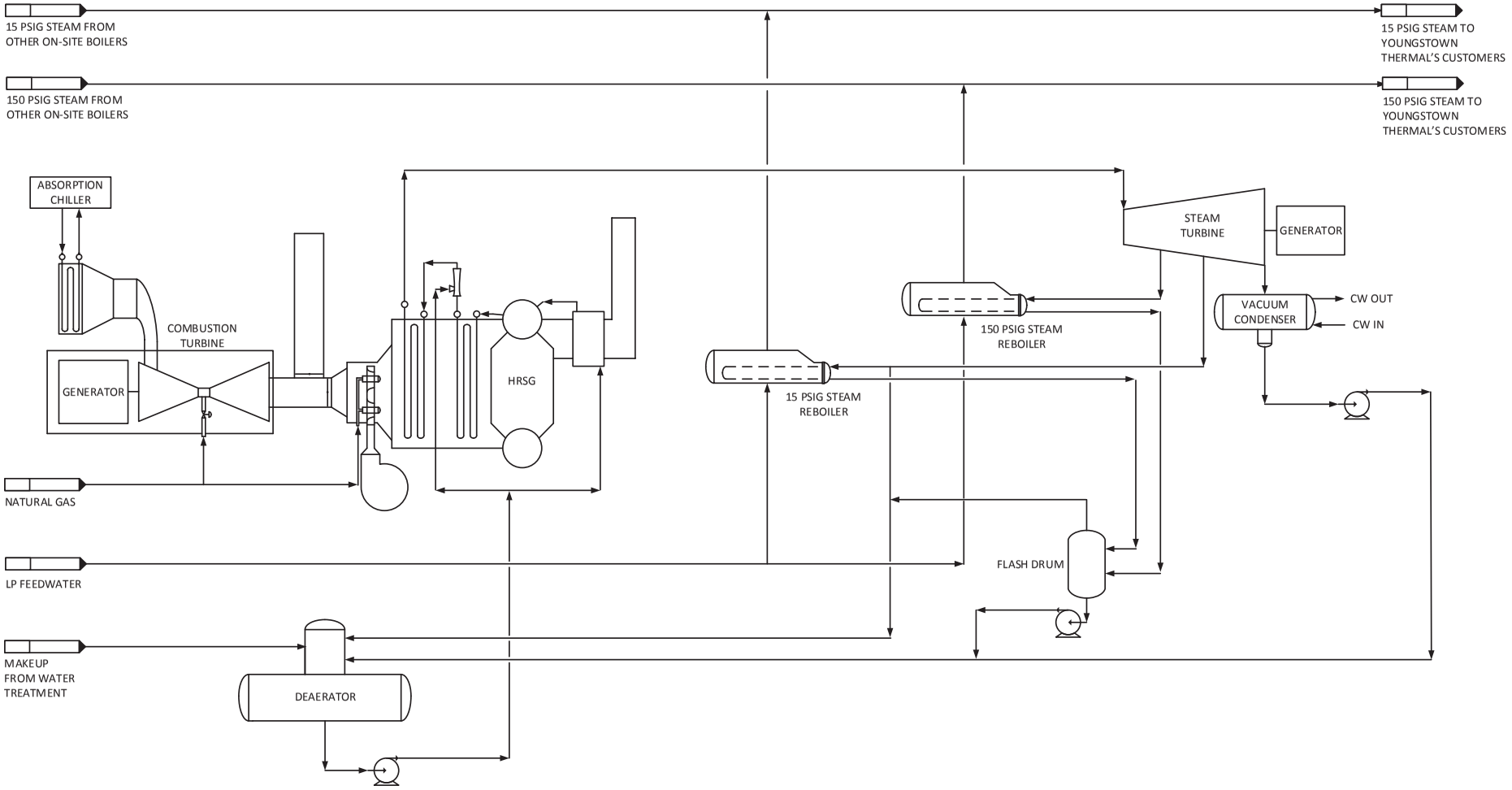


Figure 5-16 Proposed Youngstown Thermal CHP Unit Operation

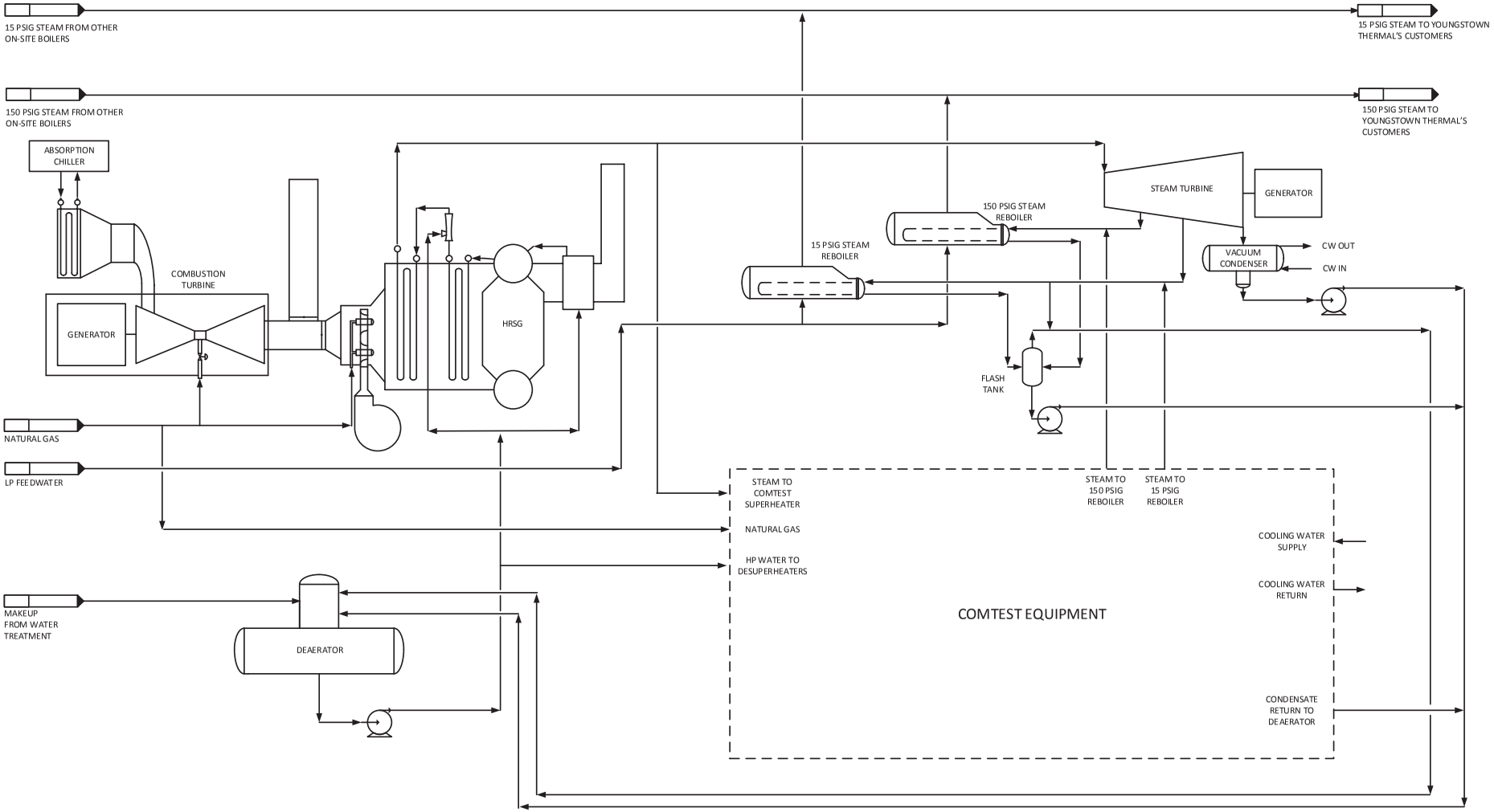


Figure 5-17 ComTest Superheater Header Test with the CHP Unit at Youngstown Thermal

5.1.2.2 **Site Modifications Required**

For ComTest to occur utilizing steam from Youngstown Thermal's CHP unit:

- The AUSC equipment described in Section 4 would be constructed at the Youngstown site.
- The natural gas boiler would not be required. The Deaerator and Cooling Tower would be part of Youngstown Thermal's CHP system and would not be required.
- Some infrastructure changes to the site would still be required such as the electrical upgrades, a new building to house the steam turbine, piping to connect the equipment, and civil modifications. The natural gas pipeline would be installed by Youngstown Thermal as part of their CHP installation.

These improvements are summarized in Table 5-7.

Table 5-7 Site Engineering for Case Where Steam Is Supplied by Youngstown Thermal's CHP Unit

Component/Equipment	Details
	BUILDINGS
ComTest Turbine Building	A new turbine building would be located adjacent and to the south of the existing boiler building. This building would contain the ComTest steam turbine and its associated equipment. The building would be approximately 70' by 90' and 32' high, having an area of approximately 6,330 ft^2. It would be a single story pre-engineered steel framed building with metal wall panels and roof panels. The building would contain a basement level to support the steam turbine piping and equipment, which would be accessed using stairs. It would have personnel doors as well as coiling steel service doors to provide access to the equipment in the building. The building would also contain the control room for the operation of the ComTest project and a unisex bathroom. The new ComTest Turbine Building would be heated and ventilated. Heating would be provided by gas fired unit heaters located in the basement and at the operating level of the building. Ventilation would be provided by a natural ventilation system consisting of a motor operated ridge vents. The control room would be a temperature-controlled space and would contain a heat pump system to provide cooling. The bath room would be ventilated using a local exhaust fan. A 30-ton capacity, double girder top running crane for performing installation and maintenance of the ComTest turbine would be provided inside the turbine building. Rainwater from the turbine building would be collected in a gutter system and discharged to grade via downspouts. The grade elevation will be modified to route storm water to a local catch basin. Cold and hot water would be provided to the turbine building bath room. Cold water would be provided from the municipal water supply, and hot water would be furnished by a local electric water heater. Sanitary waste piping from the turbine building would tie into the existing sanitary waste system. Process floor drains would be installed as required for the first floor and basement levels. These drains would tie into a pre-fabricated sump and pump which discharges into the process sewer. Process hub drains would be located in the yard area for the Superheater, Cooling Tower, Cooling Tower Water Treatment Skid, Boiler, Dump Condenser/Exchanger, Deaerator and Boiler Water Treatment skids.
Superheater Tower	A new super structure to house the Superheater equipment and components required to increase the steam to AUSC levels would be built on the site. The tower would be 34 feet by 49 feet, 130 feet high, and 1,666 square feet of space. The Superheater would be supported from six still columns resting on a foundation of drilled piers which would extend into the bedrock approximately 30 feet below grade. The drilled piers would be connected with concrete grade beams just below grade and these beams would support a concreate slab. The air fans for the Superheater as well as the other Superheater components would rest on this slab.

SITE IMPROVEMENTS	
Electrical	The operation of the AUSC ComTest Equipment would require significant electrical upgrades to the existing Youngstown Thermal facility. The proposed new electrical improvements would include a new electrical 23 kV sub-transmission service that would be brought to the site from several blocks away (approximately 1,500 feet away from the site on a pole line). This cable would be mostly located on poles with the last 50-100 feet being installed underground to avoid interference with construction activities. In addition, other equipment would be installed including a new 23 kV pad mounted outdoor circuit breaker with metering, two liquid filled transformers installed in the boiler area, a 4160V Motor Control Center (MCC) and a 480V MCC, two uninterruptible power supplies (UPS) and a backup diesel generator. Lighting would be provided to all work areas. Electric heat tracing and instrumentation heaters would be provided to critical instruments. A security system and security cameras would also be provided, and security cameras with microphones would be provided to monitor the superheater during operation. The peak electrical demand for the ComTest facility would be 2,637 kW, with an average annual electricity usage of 18,540 MWh.
Utility Racks	Steel-framed open utility racks would be provided to support piping and cable trays between the onsite equipment including the ComTest turbine building/control room, superheater tower, and boiler area.
Storm Sewer System	Installation of catch basins and all underground storm sewers would allow drainage towards the southwest corner of the construction site would be included. The new storm sewer piping would tie into the existing sewer system with 12-inch diameter PVC sewer piping. Risers would be installed during the final grading and paving stage. Rainwater from the turbine building would be collected in a gutter system and discharged to grade via downspouts. The grade elevation would be modified to route stormwater to a local catch basin. Process floor drains would be installed as required for the first floor and basement levels. These drains would tie into a pre-fabricated sump and pump that would discharge into the process sewer. Process hub drains would be located in the yard area for the Superheater, Cooling Tower, Cooling Tower Water Treatment Skid, Boiler, Dump Condenser/Exchanger, Deaerator and Boiler Water Treatment skids. Construction would also include installation of underground sanitary sewer piping, and final fixtures would be installed when buildings or structures are completed. Sanitary waste piping from the turbine building (rest room) would tie into the sewer system with 8-inch diameter sewer piping. During construction, it is expected that temporary portable toilets would be provided for workers and sanitary wastewater transported by commercial services for disposal.
Sanitary/Industrial Sewer System	Process floor drains in the ComTest turbine building would tie into a pre-fabricated sump and pump to discharge into the process sewer. Process drains would also be located in the yard area for the superheater, cooling tower and water treatment skid, package boiler and water stream skid. These process flows and sanitary waste from the ComTest turbine building rest room would tie into the existing sanitary/industrial sewer system. The wastewater would be discharged under Youngstown Thermal's current wastewater discharge permit.

AUSC Piping	The AUSC steam piping would be fabricated from INCONEL 740H alloy and would connect the ComTest superheater outlet to the steam turbine and the Superheater Header test apparatus. INCONEL 740H alloy would also be used as necessary between the outlet of these components and their corresponding desuperheaters. There would be a superheated steam bypass line from the outlet of the ComTest superheater directly to a desuperheater which would be used to vary the flow through the steam turbine and superheater outlet header test apparatus. This line between the ComTest superheater and the bypass desuperheater would also be INCONEL 740H alloy.
New Plant Piping	New piping and site utility (pipe) racks would be required for the project. Site utility racks would run from the new turbine building to the Superheater Tower and to the areas where the CHP system, cooling towers, water treatment and pumps would be located. Piping would traverse the utility racks to connect these various pieces of equipment. Piping would also run through the new turbine building to connect the steam turbine to the appropriate equipment.
Other Site Work	Additional site work would be required as described below: • Foundations for the transformers and the "dump" condenser/exchanger. • Some demolition of existing underground piping and other equipment. • Finish grading • Installation of gravel surfacing on all work/vehicle traffic areas. • Extension of the existing storm sewer system • Installation of a sanitary/industrial sewer system • Connecting the new storm/sanitary sewers to the existing underground structures.

Source: AECOM 2016b

b. The alternate configuration assumes that Youngstown Thermal would supply the required steam for the AUSC-ComTest Project and thereby purchase, install, and operate some of the equipment required for the project, as discussed in Section 2.4.3.

HDPE = high density polyethelene; HVAC = heating, ventilation, and air conditioning; mmBtu = million British Thermal Units; MW = megawatt; psig = pounds per square inch gage; NO_x = nitrogen oxides; PVC = polyvinyl chloride; scfm = standard cubic feet per minute; V = volt

5.1.2.3 **Equipment List/Description**

The equipment required for the configuration where steam was supplied by Youngstown Thermal's CHP unit is summarized in Table 5-8.

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Table 5-8 Equipment for Case Where Steam Is Supplied by Youngstown Thermal's CHP Unit

Equipment	Details
	AUSC COMTEST EQUIPMENT
Superheater	The ComTest Superheater would be an air-blown, natural gas fired steam Superheater approximately 130 feet tall. Steam from the outlet of the boiler would enter the Superheater and the primary steam outlet flow of 119,500 lb/hr will leave the Superheater tower at a temperature of 1400°F. There is a secondary steam flow that would be used by the steam turbine for cooling that will exit the Superheater tower at nominally 1100°F during the steam turbine test. On the gas exit of the Superheater, there would be two economizers. The lower economizer is used to heat high pressure OWT feedwater for use in the two ComTest Superheater desuperheaters. These desuperheaters are used to control the steam temperature within the Superheater. The upper economizer will utilize feedwater from Youngstown Thermal to cool the exiting flue gas. This feedwater will be returned to Youngstown Thermal for use within their processes. The Superheater designed by B&W is described in Section 4.1.1.
Steam Turbine/Dynamometer	The ComTest Steam Turbine supplied by GE Power would have throttle conditions of 1400°F and 620 psia, and a throttle flow of 119,500 lb/hr. The steam would discharge at 70 psia. The turbine would operate at a speed of 5400 rpm. Nominally, this turbine would be capable of generating ~10.7 MW. For ComTest, it was not desired to generate electricity with the steam turbine, so a dynamometer would have been mounted on the steam turbine shaft to dissipate the load. The dynamometer would be supplied with water from the cooling tower basin. The Steam Turbine is described in Section 4.2. The Steam Turbine Stop and Control valves are described in Section 4.3.
Superheater Outlet Header	The Superheater Outlet Header test apparatus supplied by GE Power is a piping component that would be used to evaluate the ability of the AUSC materials to operate reliably under conditions of varying boiler loads. By changing the source of the supply of the steam entering the test apparatus, the steam temperature would cycle between 750°F and 1400°F. The Superheater Outlet Header is described in Section 4.4.

Table 5-8 Equipment for Case Where Steam Is Supplied by Youngstown Thermal's CHP Unit

Equipment	Details
	BALANCE OF PLANT EQUIPMENT
Dump Condenser/Exchanger and pumps	The dump condenser would condense the exhaust steam from ComTest that is more than the steam Youngstown Thermal needed to meet their customer's demands. The exchanger would use cooling tower water to cool the steam. It would be a 54-132 TEMA type BEM shell and tube heat exchanger with 304L tubes and shell. It would be mounted horizontally on saddles and concrete piers. The exchanger would be designed for a duty of 191 MMBTU/hr. Horizontal split case centrifugal pumps would circulate cooling tower water through the dump condenser/exchanger and back to the cooling tower. Two pumps would be active, one would be stand-by. Each pump would have a capacity of 10,000 gpm.
Desuperheaters	There would be multiple desuperheaters in the process: • An attemperator type desuperheater which would provide attenuated steam to the turbine for startup. • Two desuperheaters would be included in the B&W ComTest superheater for steam temperature control. • A desuperheater would be located on the steam turbine exhaust to cool the steam to meet Youngstown Thermal's temperature specification. • A desuperheater would be located on the bypass line to cool the steam to meet Youngstown Thermal's temperature specifications. • A desuperheater would be located at the outlet of the superheater header test apparatus to cool the steam to meet Youngstown Thermal's temperature specifications.
Hot Well Tank and Pumps	The hot well tank would be in the lower level of the turbine building. The hot well tanks receive circulation water with dissipated heat from the dynamometer located on the upper level. The hot well tanks would be sized for a capacity of 5,500 gallons. Horizontal end suction centrifugal pumps would receive the dynamometer circulation water from the hot well tanks and pump the water to the cooling tower. One pump would be active, the other would stand-by. Each pump would have a capacity of 1,850 gpm.

Table 5-8 Equipment for Case Where Steam Is Supplied by Youngstown Thermal's CHP Unit

Equipment	Details
Instrumentation and Controls	The control system would consist of a Mark Vie Distributed Control System (DCS) for the ComTest Steam Turbine, which will be supplied by GE. A PACSystems RX3i Programmable Automation Controller (PLC) would be provided for the balance of plant systems. Several of the balance of plant package systems would contain standalone controllers. The ComTest Superheater instrumentation and controls would be supplied by the superheater supplier. Remote I/O cabinets would be located at key areas of the facility to collect signals from the various instrumentation. Instrumentation wiring would be installed in cable trays located on the utility rack and connect to the control room. The control room would house the control system and PLC cabinets, two work stations and a printer. Each workstation human machine interface (HMI) will consist of dual monitors, with a mouse and displays for the ComTest equipment as well as high level information from the standalone package systems.

5.1.2.4 **Site Layout**

The proposed site layout is shown in Figure 5-18 and Figure 5-19. It was planned that the new CHP unit would be located inside the existing building as shown in the upper right-hand corner of Figure 5-18. The new steam turbine building would be constructed adjacent to the existing building and would house both the CHP steam turbine (upper turbine) and the ComTest steam turbine (lower turbine). Figure 5-19 shows the location proposed by Thermal Engineering for the location of the cooling tower and the electrical equipment necessary to connect the CHP unit to the electrical grid.

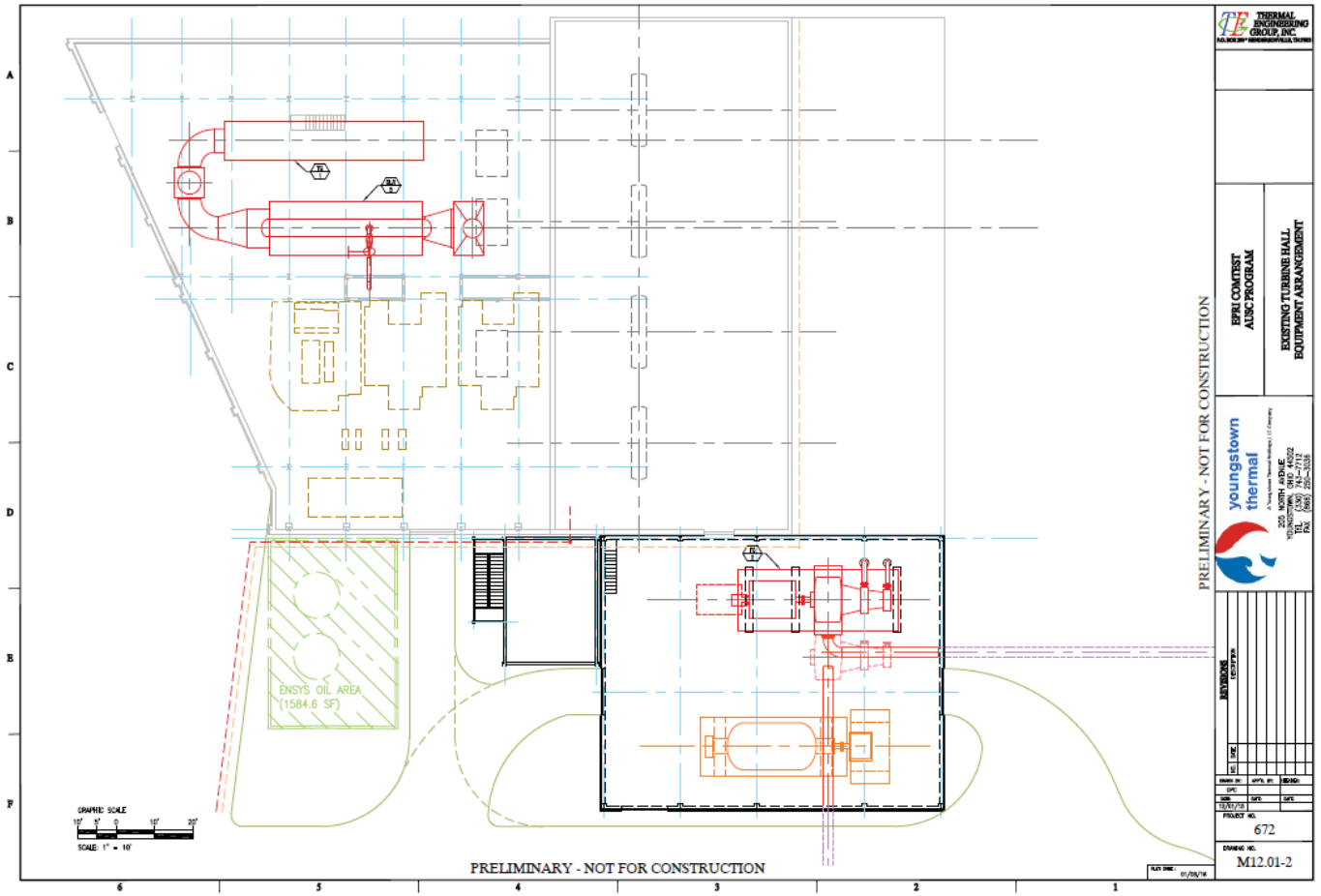

Figure 5-18 Youngstown Thermal Site Showing Combined Heat and Power Unit Location

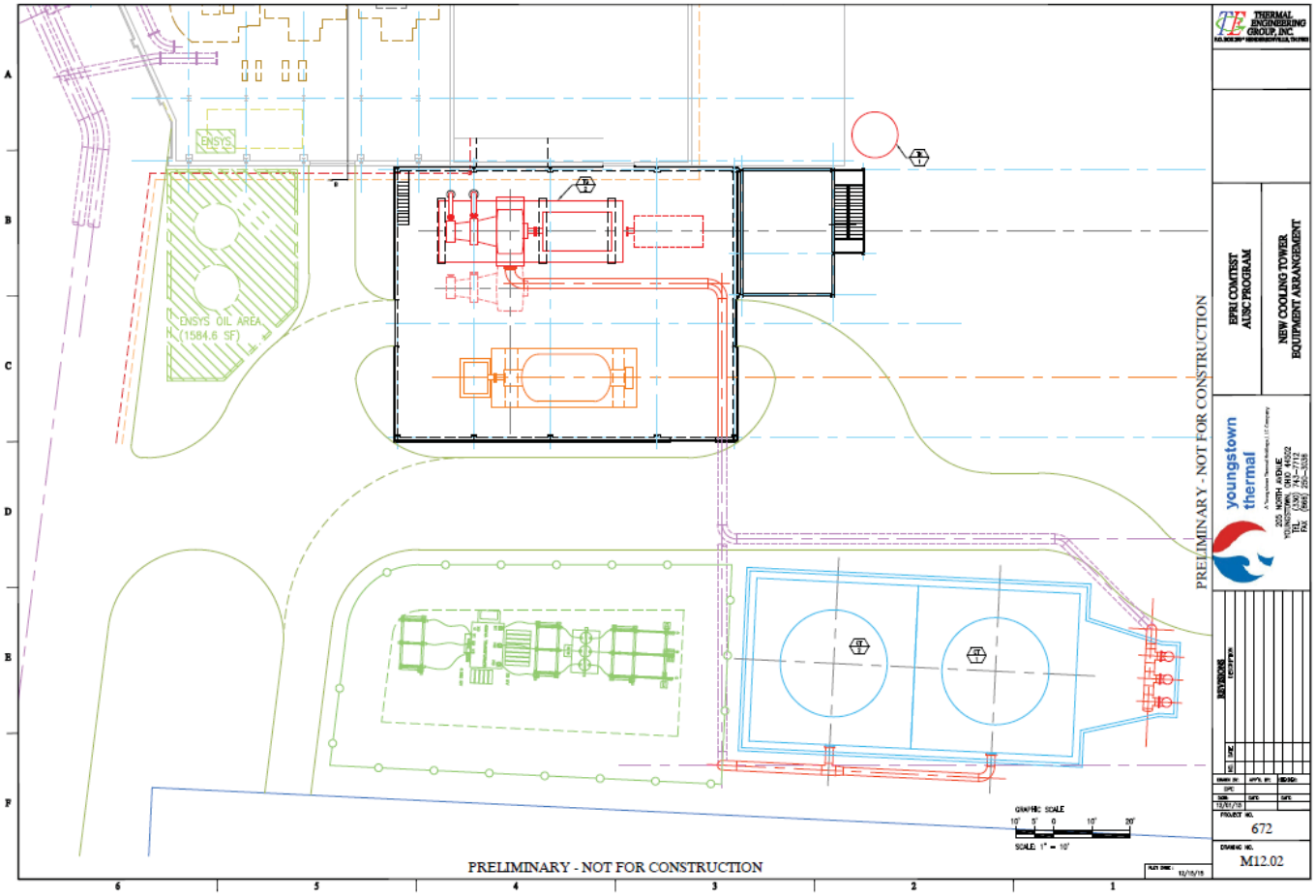

Figure 5-19 Youngstown Thermal Site Showing Combined Heat and Power Unit Location

5.1.2.5 **Environmental Performance**

At the time of the project, Youngstown Thermal was coordinating with the Ohio EPA to apply for modifications to its Title V permit to accommodate the CHP system and to account for the addition of ComTest. These modifications to the permit were expected be in place prior to operations of ComTest. Air emissions that would occur under either AUSC ComTest configuration would not exceed any permit limits or federal or state regulations and would not significantly affect air quality.

Operation of the AUSC ComTest Project would result in additional minor impacts to air quality due to emissions from the superheater emissions stack. The package boiler stack would have a flue gas flow about 341,000 pounds per hour, and the superheater stack would flow about 160,000 pounds per hour. Table 5-9 presents the current emissions from Youngstown Thermal and the estimated emissions from Youngstown Thermal's future operations using its proposed CHP system.

Table 5-10 presents the estimated performance emissions that could occur from the AUSC ComTest Superheater, which would be the incremental change in emissions for the project.

Table 5-9 Emissions for Youngstown Thermal Plant

Equipment	Annual Emissions (Tons)					
	CO	NO_x	VOC	SO_x	PM[a]	CO_2-eq[b]
YT Current Operations[c]	25.1	41.7	1.0	236.7	29.4	77,754
YT Future Operations with CHP System[d]	158.4	161.4	11.8	241.5	51.8	244,867

CO = carbon monoxide; CO_2-eq = carbon dioxide equivalent; NO_x = nitrogen oxide; PM = particulate matter; SO_x = sulfur oxides; VOC = volatile organic compounds

a. Includes PM with a diameter of 10 microns or less (PM_{10}) and with a diameter of 2.5 microns or less ($PM_{2.5}$)

b. Assumes global warming potential of methane (CH_4) is 21.

c. Based on natural gas for Youngstown Thermal boiler B001 and 4,700 tons per year limit for coal in boilers B002, B003, and B004 per current Title V permit (Ohio EPA 2016c).

d. Includes Youngstown Thermal proposed combustion turbine, heat recovery steam generator, and cooling tower (assuming particulate emissions at 1200 micromhos and drift at 0.005 percent of circulation).

Table 5-10 Emissions for AUSC ComTest Project

Equipment	Annual Emissions (Tons)					
	CO	NO_x	VOC	SO_x	PM[a]	CO_2-eq[b]
Utilizing Steam from the Youngstown Thermal CHP Unit						
Superheater	49.7	74.5	2.7	0.3	3.7	
TOTAL AUSC ComTest	**49.7**	**74.5**	**2.7**	**0.3**	**3.7**	

5.1.2.6 **Project Cost**

EIO, AECOM, EPRI, Thermal Engineering Group and Youngstown Thermal worked together to prepare a cost estimate based on Youngstown Thermal supplying steam and other utilities to the ComTest Project. The summary level cost estimate is shown in Table 5-11 and Table 5-12.

Table 5-11 Project Cost Summary for the Youngstown Thermal CHP to Supply the Steam for ComTest

A-USC ComTest	
Project Cost Estimates - Overall ($ mm)	
Description	**YT Proposal**
Phase I (Design)	$15.0
Phase II (Build / Operate)	
Buy & Install	$91.0
Operate	$12.0
Decommission & Demo	$2.5
Sub-Totals Phase II	$105.5
Total Project Cost	**$120.5**

Table 5-12 Project Cost Details for the Youngstown Thermal CHP to Supply the Steam for ComTest

A-USC ComTest	
Project Cost Estimates - Phase II Details ($ mm)	
Description	**YT Proposal**
Buy & Install (B&I)	
OEM Equipment:	
AUSC SuperHeater	$29.0
AUSC Main Steam Piping	$4.0
AUSC Steam Turbine	$24.0
Sub-Totals (OEM)	$57.0
Balance of Plant (AECOM):	
Turbine Building	$0.7
Steam Generator	$0.0
Cooling Towers	$0.0
BOP Equipment	$1.1
Control System	$2.0
Other Piping	$3.0
Nat'l Gas Pipeline	$0.0
Electrical	$1.8
Misc. (see note 4)	$1.8
Indirect Costs (see note 5)	$7.4
Sub-Totals (BOP)	$17.8
Balance of Plant (YT):	
Steam Fixed Charge	$17.5
Cooling Tower Fixed Charge	$2.0
Nat'l Gas Pipeline	$0.0
CHP Credit	($6.00)
G&A	$1.1
Profit	$1.6
Sub-Totals (BOP)	$16.2
Total B&I Costs	**$91.0**
Operating Costs	
Utilities:	
Steam	Included in YT Cost
Natural Gas	$6.4
Electricity	$1.5
Cooling Water	$2.2
Operating:	
Labor & Maintenance	$1.3
Facility Usage Fee	$0.6
Totals Operating Costs	**$12.0**

The summary of costs for the two options at Youngstown Thermal is shown in Table 5-13. Having the Youngstown Thermal CHP unit provide the steam slightly lowered the project's cost, but it was still above the $75 million dollar project budget.

Table 5-13 Comparison of Base Case and Youngstown Thermal CHP Providing Steam for ComTest

A-USC ComTest Project Cost Estimates - Overall ($ mm)		
Description	**YT (AECOM)**	**YT Proposal**
Phase I (Design)	$15.0	$15.0
Phase II (Build / Operate)		
Buy & Install	$90.7	$91.0
Operate	$18.7	$12.0
Decommission & Demo	$3.2	$2.5
Sub-Totals Phase II	$112.6	$105.5
Total Project Cost	**$127.6**	**$120.5**

5.1.3 NEPA

Late in 2015, it was recognized that the project would be required to perform an Environmental Assessment (EA) of the project at Youngstown Thermal to support the National Environmental Policy Act.

AECOM released a competitive solicitation for an outside contractor to perform this work. Based on their experience in this area, Potomac-Hudson Engineering (PHE) was selected by this task. PHE worked closely with the ComTest project team throughout 2016 including participating in multiple site visits.

PHE released the draft of the EA on August 12, 2016. However, this was approximately the same time that the project team was considering moving the project away from Youngstown Thermal and to the Southern Company site, so the EA was not released for public comment and review. The draft EA is included in the Appendix.

5.1.4 Construction

The AUSC ComTest facility would be constructed east of North Avenue on available areas on the Youngstown Thermal campus, just south of the existing steam plant (See Figure 4-42). To support construction staging and laydown, the project would use an adjacent property located immediately west of North Avenue and the campus (see Figure 5-10). In addition, Dominion East Ohio would construct an approximately 1.45-mile natural gas line to supply natural gas needed to operate the AUSC ComTest.

It is anticipated that the construction phase for all facets of the AUSC ComTest Project would have lasted approximately 2 years. Construction was expected to begin in fall 2016 with the offsite construction of the natural gas line and electrical supply infrastructures. In January 2017, the onsite construction would have begun at the Youngstown Thermal campus and adjacent

laydown area, with demolition, clearing, grading, paving, etc. to prepare the site for construction of the foundations, buildings, and infrastructure. It was anticipated that construction would have be completed and the equipment connected and ready for operation by approximately August 2018.

During the construction phase, the project would clear, grade, and utilize the adjacent property directly across North Avenue for a trailer, parking, and laydown area (see Figure 4-43). Space would also be made available on the bottom floor of the five-story brick and concrete building located south of the Youngstown Thermal campus for small parts laydown, and possibly construction office spaces.

During construction, all deliveries would be routed from Martin Luther Blvd onto North Street and into the construction site. There would be available parking for construction workers at various locations near the project site, including within the adjacent lot used for laydown and staging, possibly in the church parking lot on W. Rayen Avenue, or in nearby public garages.

5.2 Southern Company's Site

In late 2015, Southern Company offered the possibility of ComTest being built at two of their operating units. Both units are existing power generating facilities containing multiple coal-fired and natural gas fired units.

Plant A

Plant A (Figure 5-20) consists of five coal fired units – two ~135 MW units, a ~250 MW unit, and a ~360 MW subcritical unit plus a 750 MW supercritical unit. Originally all five units burned coal, but the four smaller units may be converted to natural gas firing in the upcoming years. Not shown in Figure 5-20 are natural gas fired combined cycle units, which are located to the south west of the coal fired units in this photograph. The area proposed by the plant for ComTest was adjacent to the limestone silo which supports the flue gas desulfurization unit.

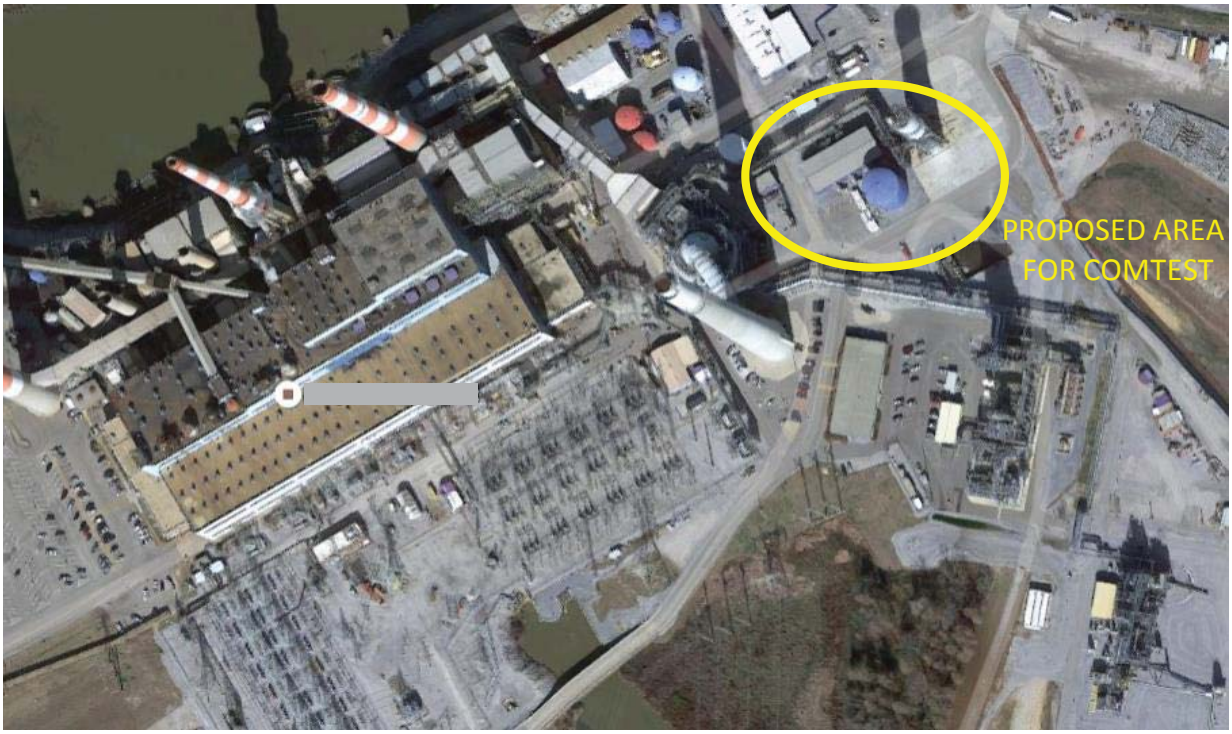

Figure 5-20 Southern Company's Plant A

The area proposed by the plant, as highlighted in Figure 5-20, was basically an open concrete slab adjacent to the main road going through the plant. Therefore, there would be no significant constraints during construction.

At Plant A it was planned that:

- Steam from ComTest would be extracted from the supercritical boiler and supplied to the ComTest superheater. This would eliminate the need for a separate gas fired steam generator.
- Cooling water would be supplied from the plant, eliminating the need for cooling towers.

- Natural gas would be supplied from the header supplying the natural gas combined cycle units, eliminating the long high pressure gas line required at Youngstown Thermal.
- There was ample electrical service available near the location proposed for ComTest which would eliminate the need for the site electrical upgrade at Youngstown Thermal.

Plant B

The power generating facility at Southern Company's Plant B, Figure 5-21, consists of five units – four smaller sub-critical units with a capacity of ~270 MW each and a larger supercritical unit with a capacity of ~950MW. Originally all five units burned coal, but the four smaller units were converted to natural gas fired operation in the 2015/2016 timeframe. The site generates over 2 GW of electricity and with the conversion of Units 1 to 4 to gas fired operation the facility had all the necessary infrastructure to support ComTest. During the project, several locations at the site were discussed as possible locations for ComTest, but the original location shown the Figure was between Units 1-4 and the Coosa River.

Figure 5-21 Southern Company's Plant B

Figure 5-22 shows more detail of the originally proposed area for ComTest. It originally contained the individual stacks for Units 1-4, which have since been dismantled. One of the

challenges of this site was the location of the main coal conveyor which was located between the proposed site and access road.

Figure 5-22 Proposed ComTest Location at Plant B

Like Plant A, it was originally planned that steam from the supercritical unit (Unit 5) would be supplied to ComTest, eliminating the need for the additional natural gas fired steam generator. Additionally, access to cooling water, natural gas and electrical service were in the general vicinity of Unit 5 which should reduce the cost of ComTest at the site relative to Youngstown Thermal.

Several on-site meetings were conducted between Southern Company staff and the ComTest project team in late 2015 and early 2016 to discuss project timing, configuration, interfaces, and environmental impacts, including supplying information to support the NEPA requirements. From this information, AECOM prepared cost estimates at both facilities to evaluate any cost savings that could be gained by utilizing the existing infrastructure at either facility. A high level summary of the estimated costs at both sites is shown in Table 5-14 and a more detailed breakdown of the cost is shown in Table 5-15. From the cost information, it appeared that there was cost savings to be gained by moving the project to one of the Southern sites.

Table 5-14 Initial ComTest Project Cost Summary at the Southern Company Sites

A-USC ComTest Project Cost Estimates - Overall ($ mm)		
Description	**Plant A (AECOM)**	**Plant B (AECOM)**
Phase I (Design)	$15.0	$15.0
Phase II (Build / Operate)		
Buy & Install	$81.8	$78.4
Operate	$14.8	$14.8
Decommission & Demo	$3.7	$3.6
Sub-Totals Phase II	$100.3	$96.8
Total Project Cost	**$115.3**	**$111.8**

Table 5-15 Initial ComTest Project Cost Details at the Southern Company Sites

A-USC ComTest Project Cost Estimates - Phase II Details ($ mm)		
Description	**Plant A**	**Plant B**
Buy & Install (B&I)		
OEM Equipment:		
AUSC SuperHeater	$29.0	$29.0
AUSC Main Steam Piping	$4.0	$4.0
AUSC Steam Turbine	$24.0	$24.0
Sub-Totals (OEM)	$57.0	$57.0
Balance of Plant (AECOM):		
Turbine Building	$0.4	$0.4
Steam Generator	$0.0	$0.0
Cooling Towers	$0.1	$0.1
BOP Equipment	$1.1	$1.3
Control System	$1.7	$1.7
Other Piping	$6.5	$4.6
Nat'l Gas Pipeline	$0.0	$0.0
Electrical	$1.8	$1.8
Misc. (see note 4)	$3.9	$3.2
Indirect Costs (see note 5)	$9.3	$8.3
Sub-Totals (BOP)	$24.8	$21.4
Balance of Plant (YT):		
Steam Fixed Charge		
Cooling Tower Fixed Charge		
Nat'l Gas Pipeline		
CHP Credit		
G&A		
Profit		
Sub-Totals (BOP)		
Total B&I Costs	**$81.8**	**$78.4**
Operating Costs		
Utilities:		
Steam	$4.2	$4.2
Natural Gas	$4.0	$4.0
Electricity	$1.0	$1.0
Cooling Water	$0.0	$0.0
Operating:		
Labor & Maintenance	$5.6	$5.6
Facility Usage Fee	$0.0	$0.0
Totals Operating Costs	**$14.8**	**$14.8**

Despite the advantages of building ComTest at one of the Southern Company sites, there were risks to both the project and the site that had to be taken into consideration:

- Both power plants cycled daily as electrical demand varied, and this could impact the availability of steam to ComTest and the ability to run the test on a continuous basis.
- It was expected that either unit could shut down for planned or unplanned maintenance during the testing period. Without a stand-alone boiler, no testing could occur during this period.
- ComTest's construction would have to be coordinated with the plant's outage schedule.
- The exhaust steam from ComTest was planned to be returned to the host unit's steam cycle. Therefore, failure of components within ComTest could impact the operation of the host unit. This risk was minimized since ComTest was largely external to the power plant and could be shut down and isolated if a component failure occurred.
- ComTest would be required to reimburse Southern Company for the energy equivalent of the steam supplied. Both sites were part of the regulated rate-base, and the fuel supplied to the plants to generate the steam for ComTest would not be used to generate electricity, therefore, the project would have to reimburse Southern Company for this cost, and this was included in the estimate.
- Early in the project, it was decided not to attempt to generate electricity with the ComTest steam turbine due to the cost of adding a generator and tying the generator to the site's electrical distribution system. Therefore, assuming the fuel input to the host steam generator was held constant, the power generated by the plant would decrease. This would increase the plant's heat rate slightly (1-2%) which could impact the dispatch order of the plant and the hours it would operate in a year.
- Since ComTest would add a new emission source (the ComTest Superheater), impacting the site environmental permits was a concern.
- Because the steam entering ComTest was heated with natural gas and ultimately returned to the steam cycle, there could be a perception that a new energy source was being added to the steam cycle, triggering a New Source Review.
- At both sites, river water would be used as the cooling source for ComTest. Both plants had water discharge temperature limits in their permits which could be reached during a hot summer. Since power generation would be the priority at both sites, the operation of ComTest could be curtailed in the summer if the water discharge temperature limit was approached.

Shortly after AECOM performed the cost estimate, Southern Company informed the project team that they had need of the site proposed at Plant A and offered an alternative site which was located to the far right of the area shown in Figure 5-20. This alternate site significantly increased the project cost due to the extension of the pipelines supplying the steam, natural gas, cooling water and the electrical service. Because of that, Plant A was removed from consideration. Therefore, the remainder of this section will focus on ComTest at Plant B.

5.2.1 Steam Supplied by Plant B

5.2.1.1 **Process Configuration**

HIGH PRESSURE CONFIGURATION

During Phase 1, two configurations were considered for testing at Plant B – a high-pressure configuration and a low-pressure configuration. The high-pressure configuration would allow for the testing of steam turbine main stop/control valves with or without the Superheater Outlet Header at an operating pressure and temperature which would be representative of the conditions that would be found at the inlet of a commercial AUSC high pressure steam turbine.

The high-pressure configuration is shown in Figure 5-23. Steam from the supercritical unit waterwall outlet header would be supplied to the ComTest superheater at a pressure of ~3880 psia and 785°F. The steam flow to the superheater would be approximately 76,000 lb/hr. Approximately 4,000 lb/hr of boiler feedwater from the power plant at a pressure of 4230 psia and 500°F would also be supplied to the ComTest superheater for use as desuperheater spray water. High pressure condensate at 480 psia and approximately 208°F would be supplied to the gas cooling section of the superheater at a flowrate of approximately 160,000 lb/hr to cool the flue gas leaving the superheater to ~715°F. The superheater would be fired with 4,858 lb/hr of natural gas which would be burned with 109,950 lb/hr of air.

The 80,000 lb/hr of steam exiting the ComTest superheater at 1400°F and 3660 psia would flow through sets of steam turbine stop and control valve assemblies. Two parallel sets of steam turbine stop valves and control valve assemblies would be installed in the line exiting the ComTest superheater. The control system would continually cycle the valves through the test ensuring that one of the parallel lines was always open.

Downstream of the high pressure, high temperature valves, the steam would flow through the SHOH. The SHOH test would operate very similar to what was described in Section 4.4.2, with the exception that it would be desired to return the steam to the power plant's main steam header at ~3515 psia and 1000°F. The difference in the cycling operation of the header is described below:

- Steam at 1400°F would flow through the header test section for approximately one hour. The steam exiting the SHOH test apparatus would be desuperheated using approximately 22,815 lb/hr of boiler feedwater to a temperature of approximately 1010°F and be returned to the power plant.
- Using a ramp rate that would be maintained by the control system, the steam exiting the ComTest superheater would begin flowing through the bypass line and where it would be desuperheated using ~12,400 lb/hr of boiler feedwater to a temperature of 1155°F. Simultaneously, an additional 40,000 lb/hr of waterwall outlet steam would be extracted from the power plant and the cooler steam would flow through the SHOH as shown in Figure 5-24. Extracting the additional cooler steam from the plant and bypassing the ComTest superheater would allow the superheater and the main stop/control valve to be operated at steady state conditions, simplifying the design.
- Steam at 785°F would flow through the SHOH for approximately one hour. The cooler steam would mix with the bypassed steam and the combined flow of 132,417 lb/hr would be returned to the power plant's main steam header.

- The ramping process would be reversed and steam at 1400^{o}F from the ComTest superheater would begin flowing back to the SHOH test apparatus, increasing the inlet temperature. The steam flow from the superheater through the bypass line would correspondingly decrease. When the header test section inlet temperature reached 1400^{o}F again, the cycle would be complete.

By returning the steam from Comtest to the main steam header at 3500 psia and 1000°F, there would be no “loss of power” penalty to the host facility.

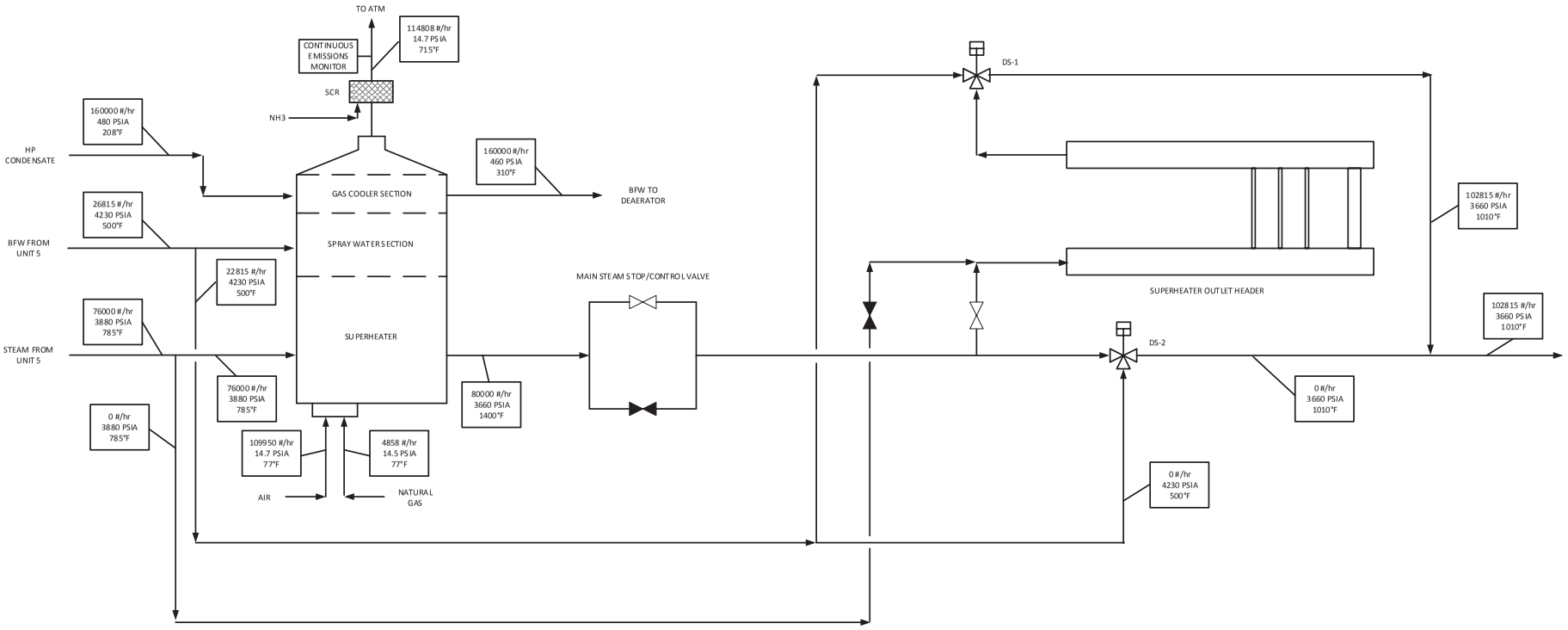

Figure 5-23 Plant B High Pressure Configuration with 1400°F Steam Flowing Through the Superheater Outlet Header

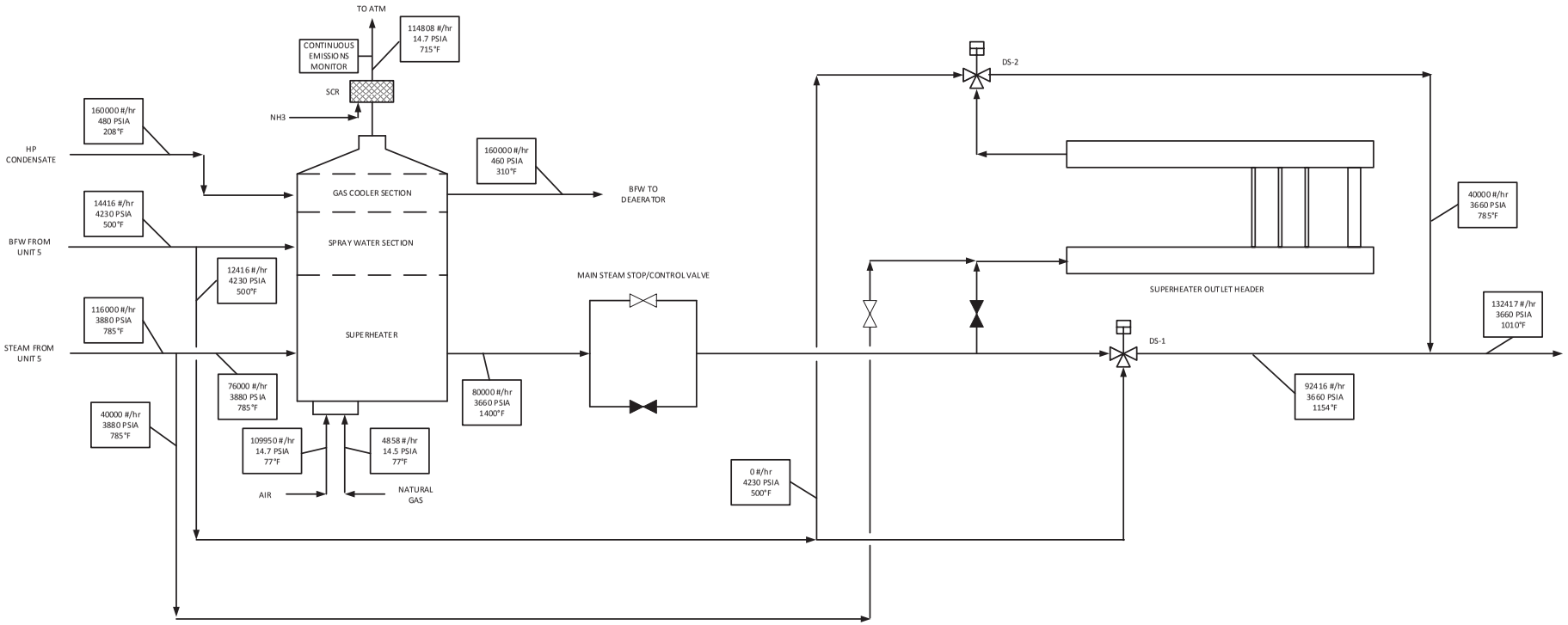

Figure 5-24 Plant B High Pressure Configuration with 785ºF Steam Flowing Through the Superheater Outlet Header

LOW PRESSURE CONFIGURATION

In addition to the high pressure configurations shown in Figure 5-23 and Figure 5-24, a lower pressure configuration was also evaluated for testing the steam turbine at Plant B as shown in Figure 5-25. This configuration was very similar to that for Youngstown Thermal with the exception that the steam for ComTest would be supplied from Unit 5. The cost estimates prepared and previously presented in Table 5-14 and Table 5-15 were based on this Low Pressure Configuration.

The ~3515 psia steam at 1000°F would flow through a pressure letdown system and the pressure reduced to approximately 760 psia. This reduction in pressure would decrease the steam temperature to ~840°F. The steam would flow through the ComTest superheater and be heated to 1400°F. Boiler feedwater from Unit 5 would be used for desuperheating spray water. In addition to the primary steam flow, the superheater would provide the 1,843 lb/hr of steam at 90 psia and 1085°F which would be used for cooling the hottest parts of the turbine as described in Section 4.2.16. During startup, steam directly from Unit 5 would be used to heat the steam turbine before the admission of the high temperature steam.

While the turbine was being started, or in the event of a turbine trip, the steam from the Superheater would flow through the turbine bypass line where it would be desuperheated with boiler feedwater to 70 psia and 475°F before entering the condenser.

When operating, the turbine would exhaust at 70 psia as described in Section 4.2.1. The 116,353 lb/hr of 70 psia steam would be at a temperature of approximately 865°F. This steam would be desuperheated with boiler feedwater to a temperature of 475°F before entering the condenser.

The shaft output of the steam turbine would be 10.7 MW. However, the project determined that instead of generating electricity with the turbine, the turbine would be connected to a dynamometer as described in Section 4.2.11 to absorb the steam turbine power. The dynamometer acts like a water pump and would pump 2,080 gpm of cooling water.

A steam seal system as described in Section 4.2.15 is required to seal the turbine casing so that steam does not exhaust into operating areas. Steam withdrawn from the steam seals would be desuperheated with cooling water. The cooled steam would be condensed in a gland steam condenser and be discharged to a site drain. Any non-condensibles pulled into the seals would be pulled out of the end seal packing by a centrifugal blower and vented from the gland steam condenser.

The condensate exiting the ComTest condenser would flow through a water polishing skid before being returned to the plant's condenser hotwell and reenter the steam cycle.

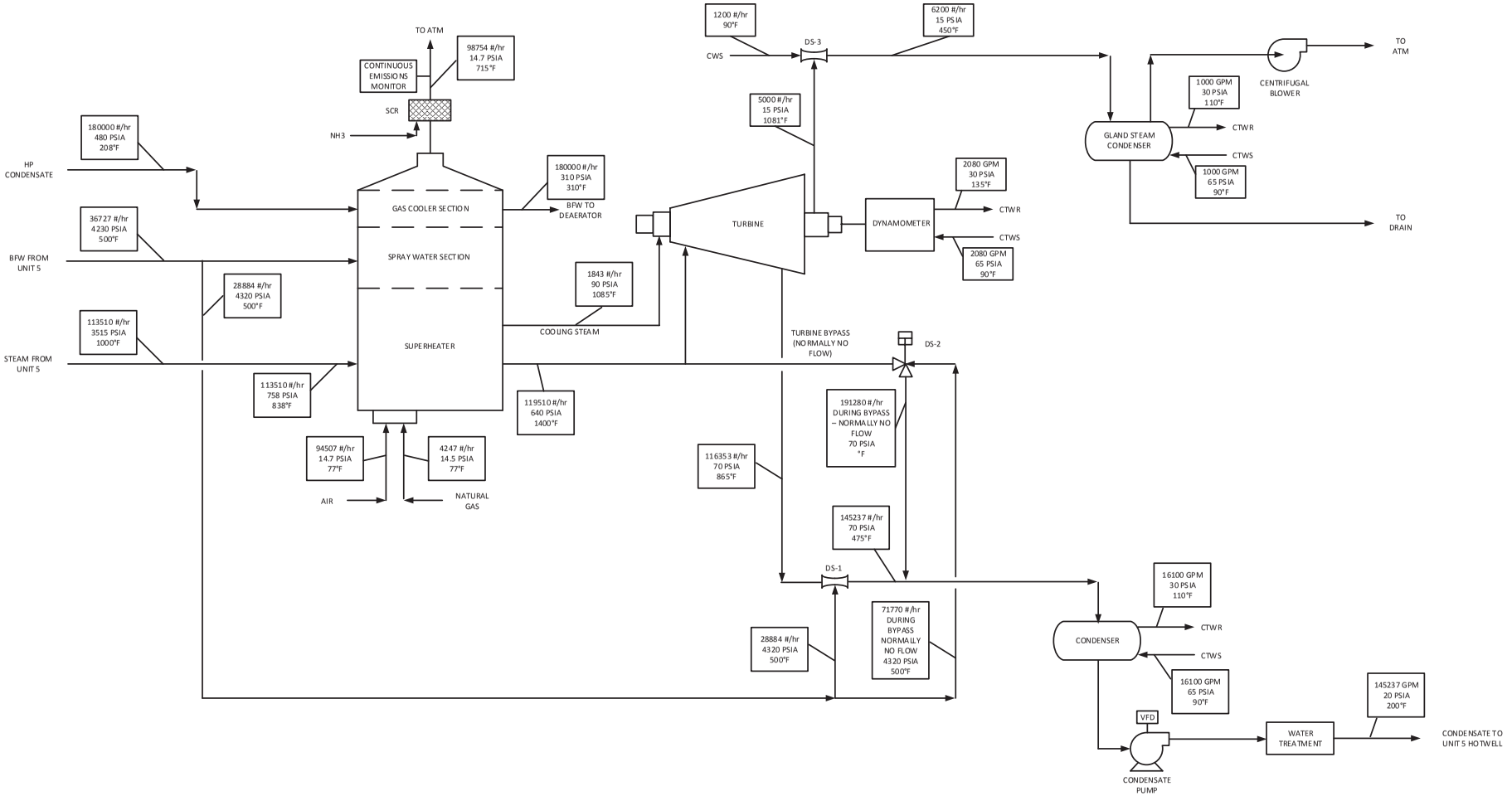

Figure 5-25 Plant B Low Pressure Configuration for Testing the Steam Turbine

Testing the SHOH would be similar to what has been described in previous sections except that the steam pressure entering the ComTest superheater would be increased to 1300 psia. This would allow the steam that would exit the SHOH to be at a high enough pressure to enter the Unit 5 reheat steam header and produce electricity instead of being condensed and flowing to the condenser hotwell.

Approximately 174,000 lb/hr of steam would be extracted from Unit 5 and flow through a pressure letdown system to have the pressure decreased from 3515 psia to 1300 psia. This would decrease the steam temperature to approximately 877°F. Of this steam, 114,000 lb/hr would flow into the ComTest superheater and the temperature would increase to 1400°F. The remaining steam would bypass the superheater. Additionally, approximately 6,000 lb/hr of boiler feedwater would be used in the superheater for desuperheating spray water.

The 1400°F steam would flow through the header test section for approximately one hour as shown in Figure 5-26. The steam exiting the SHOH test apparatus would be desuperheated using approximately 24,905 lb/hr of boiler feedwater to a temperature of approximately 1043°F. This would mix with the 60,000 lb/hr of steam at 877°F that bypassed the ComTest superheater the combined steam flow of 199,314 lb/hr of steam at 1000°F and ~665 psia would be returned to the plant's reheat header.

Using a ramp rate that would be maintained by the control system, the steam exiting the ComTest superheater would begin flowing through the bypass line and where it would be desuperheated using boiler feedwater to a temperature of ~1100°F. The 60,000 lb/hr of steam that had bypassed the ComTest Superheater would flow through the SHOH as shown in Figure 5-27. Having this steam bypass the ComTest superheater would allow the superheater to operate at steady state conditions, simplifying the design.

Steam at 877°F would flow through the SHOH for approximately one hour. The cooler steam would mix with the bypassed steam and the combined flow of 199,314 lb/hr would be returned to the Unit 5 reheat header.

The ramping process would be reversed and steam at 1400°F from the ComTest superheater would begin flowing back to the SHOH test apparatus, increasing the inlet temperature. The steam flow from the superheater through the bypass line would correspondingly decrease. When the header test section inlet temperature reached 1400°F again, the cycle would be complete.

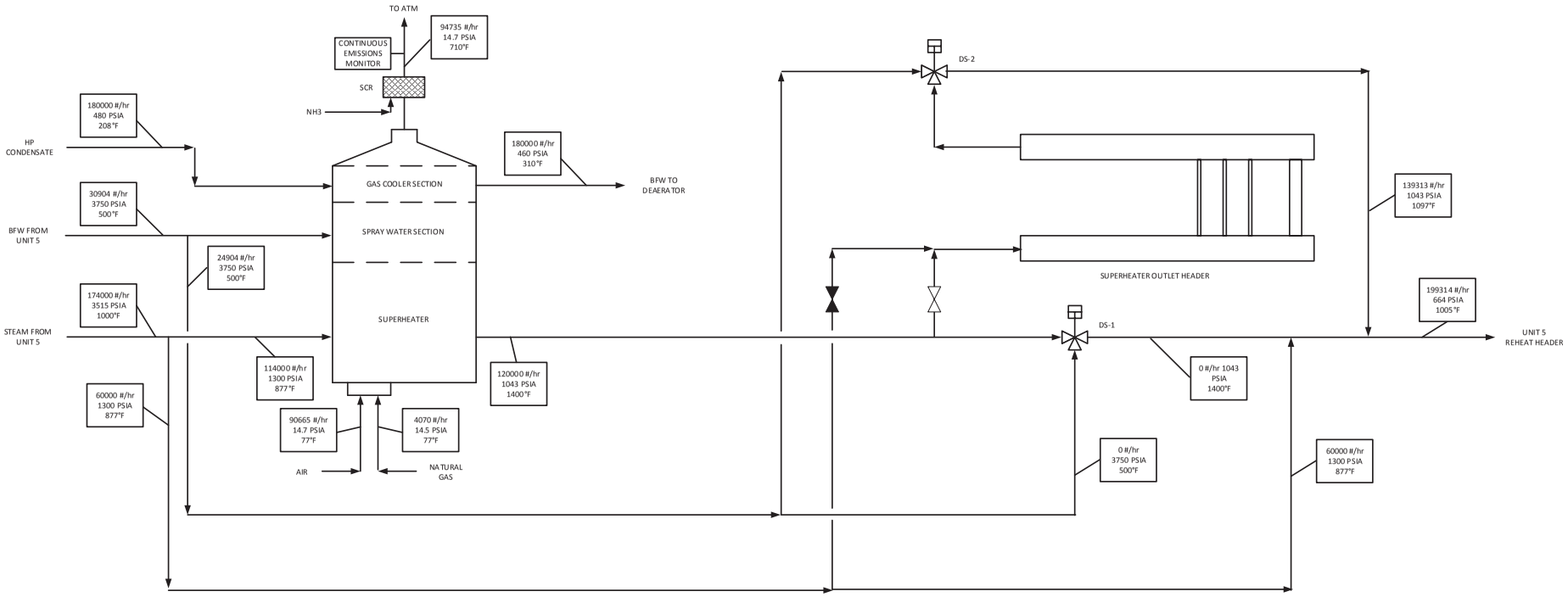

Figure 5-26 Plant B Low Pressure Configuration with 1400°F Steam Flowing Through the Superheater Outlet Header

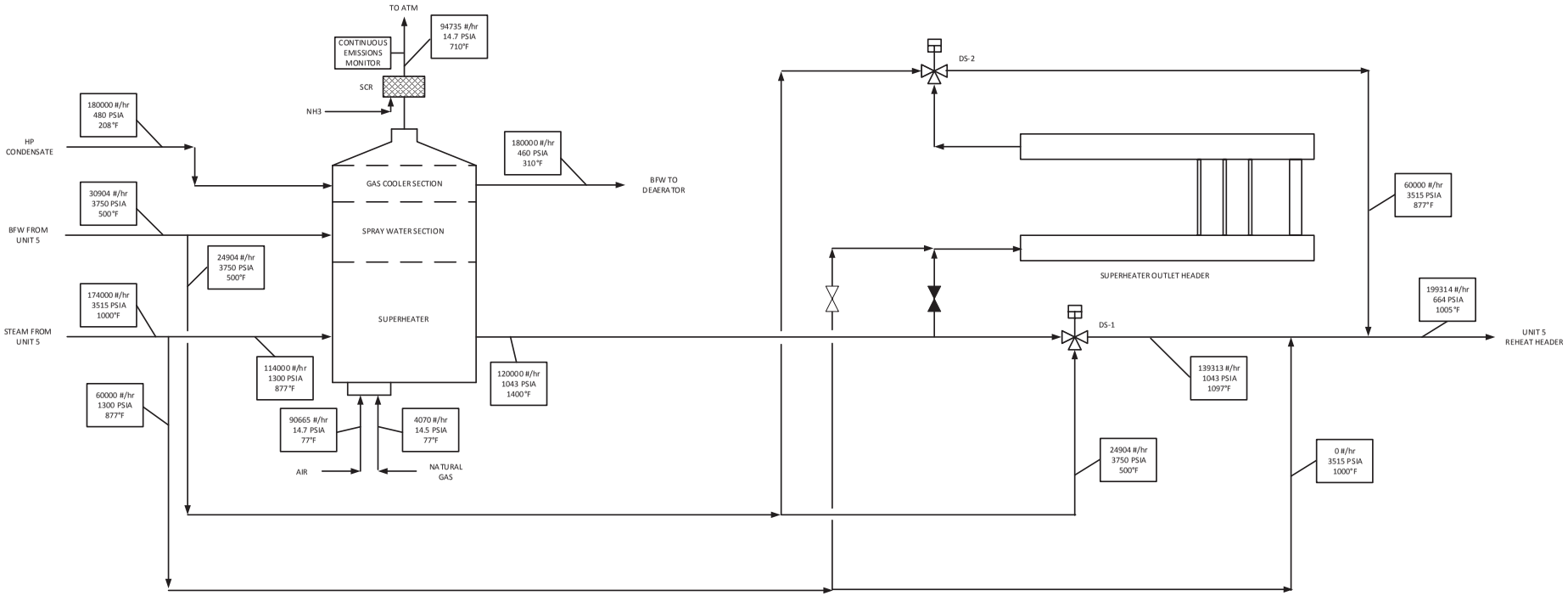

Figure 5-27 Plant B Low Pressure Configuration with 877°F Steam Flowing Through the Superheater Outlet Header

5.2.1.2 Site Modifications Required

Table 5-16 Site Engineering for Plant B Site

Component/Equipment	Details
	BUILDINGS
ComTest Turbine Building	A new turbine enclosure would be located on the site. Due to the difference in the weather between Ohio and Alabama, this would be an unheated building and would be designed primarily to protect the turbine system from rain. It would be a single story pre-engineered steel framed building with metal wall panels and roof panels. The steam turbine would sit on a pedestal with the condenser located below the turbine. Rainwater from the turbine building would be collected in a gutter system and discharged to grade via downspouts. The grade elevation will be modified to route storm water to a local catch basin.
Superheater Tower	A new super structure to house the Superheater equipment and components required to increase the steam to AUSC levels would be built on the site. The Superheater would be supported on a foundation of drilled piers which would extend into the bedrock approximately 30 feet below grade. The drilled piers would be connected with concrete grade beams just below grade and these beams would support a concreate slab. The air fans for the Superheater as well as the other Superheater components would rest on this slab.
	SITE IMPROVEMENTS
Electrical	Electrical service would be taken from local power feeds on the host utility site. The power would be supplied to a new 4160V Motor Control Center (MCC) and a 480V MCC, and two uninterruptible power supplies (UPS). Lighting would be provided to all work areas. Electric heat tracing and instrumentation heaters would be provided to critical instruments as required for freeze protection. A security system and security cameras would also be provided, and security cameras with microphones would be provided to monitor the superheater during operation.
Utility Racks	Steel-framed open utility racks would be provided to support piping and cable trays between the onsite equipment including the ComTest turbine building, superheater tower, and boiler area.
Storm Sewer System	Installation of catch basins and all underground storm sewers would allow drainage into the existing sewer system. Risers would be installed during the final grading and paving stage. Rainwater from the turbine building would be collected in a gutter system and discharged to grade via downspouts. The grade elevation would be modified to route stormwater to a local catch basin

AUSC Piping	The AUSC steam piping would be fabricated from INCONEL 740H alloy and would connect the ComTest superheater outlet to the steam turbine and the Superheater Outlet Header test apparatus. INCONEL 740H alloy would also be used as necessary between the outlet of these components and their corresponding desuperheaters. There would be a superheated steam bypass line from the outlet of the ComTest superheater directly to a desuperheater which would be used to vary the flow through the steam turbine and superheater outlet header test apparatus. This line between the ComTest superheater and the bypass desuperheater would also be INCONEL 740H alloy.
New Plant Piping	New piping and site utility (pipe) racks would be required for the project. Site utility racks would run from the existing plant area to the ComTest facility and would contain steam piping from the existing unit, natural gas, cooling water, and condensate return to the unit. Piping would traverse the utility racks to connect the various pieces of ComTest equipment.
Other Site Work	Additional site work would be required as described below: • Foundations for all equipment added. • Finish grading • Installation of gravel surfacing on all work/vehicle traffic areas. • Extension of the existing storm sewer system Connecting the new storm sewers to the existing underground structures.

5.2.1.3 **Equipment List/Description**

Table 5-17 Equipment for Plant B ComTest

Equipment	Details
	AUSC COMTEST EQUIPMENT
Superheater	The ComTest Superheater would be an air-blown, natural gas fired steam unit. Steam from the outlet of the Southern Company boiler would enter the Superheater and the primary steam outlet flow of 119,500 lb/hr will leave the Superheater tower at a temperature of 1400°F. There is a secondary steam flow that would be used by the steam turbine for cooling that will exit the Superheater tower at nominally 1100°F during the steam turbine test. The Superheater designed by GE Power is described in Section 4.1.224
Steam Turbine/Dynamometer	The ComTest Steam Turbine supplied by GE Power would have throttle conditions of ~1320°F and 620 psia, and a throttle flow of 119,500 lb/hr. The steam would discharge at 70 psia. The turbine would operate at a speed of 5400 rpm. Nominally, this turbine would be capable of generating ~10.2 MW. For ComTest, it was not desired to generate electricity with the steam turbine, so a dynamometer would have been mounted on the steam turbine shaft to dissipate the load. The dynamometer would be supplied with water from the cooling tower basin. The Steam Turbine is described in Section 4.2. The Steam Turbine Stop and Control valves are described in Section 4.3.
Superheater Outlet Header	The Superheater Outlet Header test apparatus supplied by GE Power is a piping component that would be used to evaluate the ability of the AUSC materials to operate reliably under conditions of varying boiler loads. By changing the source of the supply of the steam entering the test apparatus, the steam temperature would cycle between 750°F and 1400°F. The Superheater Outlet Header is described in Section 4.4.
	BALANCE OF PLANT EQUIPMENT
Dump Condenser/Exchanger and pumps	The dump condenser would condense the exhaust steam from ComTest. The exchanger would use cooling tower water to cool the steam. It would be a 54-132 TEMA type BEM shell and tube heat exchanger with 304L tubes and shell. It would be mounted horizontally on saddles and concrete piers. The exchanger would designed for a duty of 191 MMBTU/hr. Horizontal split case centrifugal pumps would circulate cooling tower water through the dump condenser/exchanger and back to the cooling tower. Two pumps would be active, one would be stand-by. Each pump would have a capacity of 10,000 gpm.

Table 5-17 Equipment for Plant B ComTest

Equipment	Details
Desuperheaters	There would be multiple desuperheaters in the process: • An attemperator type desuperheater which would provide attenuated steam to the turbine for startup. • Desuperheaters would be located within ComTest superheater for steam temperature control. • A desuperheater would be located on the steam turbine exhaust to cool the steam before it enters the condenser. • A desuperheater would be located on the bypass line to cool the steam before it enters the condenser. • A desuperheater would be located at the outlet of the Superheater Outlet Header test apparatus to cool the steam before the steam is returned to the Southern Company boiler.
Hot Well Tank and Pumps	The hot well tank would be in the lower level of the turbine building. The hot well tanks receive circulation water with dissipated heat from the dynamometer located on the upper level. The hot well tanks would be sized for a capacity of 5,500 gallons. Horizontal end suction centrifugal pumps would receive the dynamometer circulation water from the hot well tanks and pump the water to the cooling tower. One pump would be active, the other would stand-by. Each pump would have a capacity of 1,850 gpm.
Instrumentation and Controls	The control system would consist of a Mark Vie Distributed Control System (DCS) for the ComTest Steam Turbine, which will be supplied by GE. A PACSystems RX3i Programmable Automation Controller (PLC) would be provided for the balance of plant systems. Several of the balance of plant package systems would contain standalone controllers. The ComTest Superheater instrumentation and controls would be supplied by the superheater supplier. Remote I/O cabinets would be located at key areas of the facility to collect signals from the various instrumentation. Instrumentation wiring would be installed in cable trays located on the utility rack and connect to the control room. The control room would house the control system and PLC cabinets, two work stations and a printer. Each workstation human machine interface (HMI) will consist of dual monitors, with a mouse and displays for the ComTest equipment as well as high level information from the standalone package systems.

5.2.1.4 **Site Layout**

There were four different locations for ComTest at the Plant B site. Figure 5-28 shows the second location, when ComTest was located on the other side of the coal conveyor and across the road from the location shown in Figure 5-22. In this location there was still good access to Unit 5 and the steam lines between ComTest and the unit were relatively short.

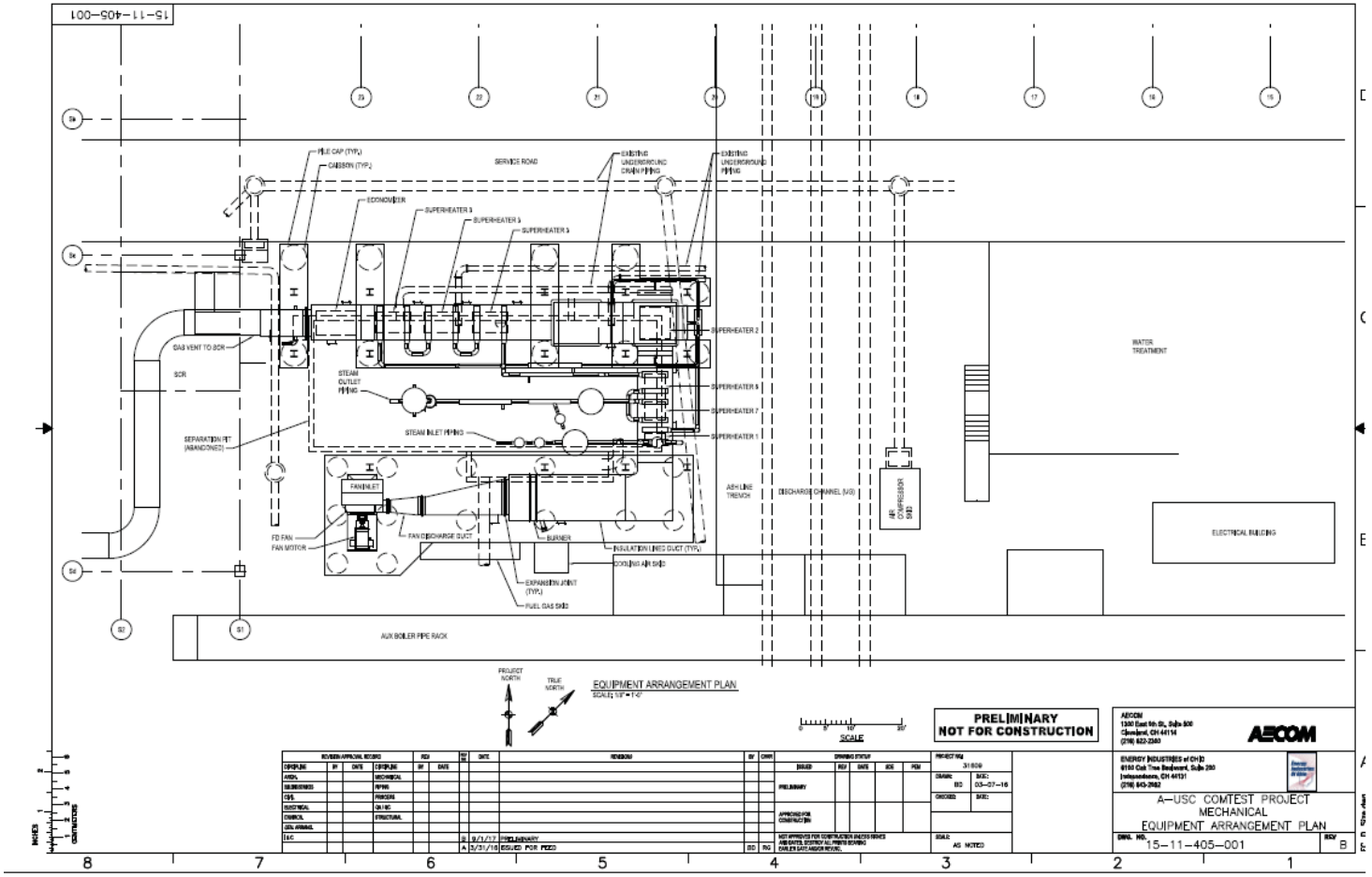

Figure 5-28 Location of ComTest at Plant B Across the Road from the Coal Conveyor

5.2.1.5 Environmental Performance

The emissions associated with ComTest for the cases where steam would be supplied from Unit 5 would be the emissions associated with the ComTest Superheater. These emissions are listed in Table 5-18

Table 5-18 Emissions for AUSC ComTest Project at Plant B

Equipment	Annual Emissions (Tons)					
	CO	NO_x	VOC	SO_x	PM	CO_2-eq
Utilizing Steam from the Host Unit						
Superheater	37.0	38.0	5.0	<0.1	8.0	
TOTAL AUSC ComTest	**37.0**	**38.0**	**5.0**	**<0.1**	**8.0**	

5.2.1.6 Project Cost

The estimated cost for the Low Pressure ComTest configuration at Plant B was shown in Table 5-14 and Table 5-15. In March 2017, GE Power informed the project team that they had decided an AUSC steam turbine test as part of ComTest would not be necessary to mitigate the risk of a commercial AUSC steam turbine. This was largely precipitated by the General Electric and Alstom Power merger in 2015, as described in Section 2.3. Both organizations had steam turbine divisions with varying research backgrounds associated with AUSC technology. Because of this merger, the two former entities integrated their backgrounds and experience and this synergy filled many of the “missing pieces of the puzzle” for the AUSC steam turbine. One of the outcomes of the technology integration was the conclusion that instead of building a small-scale turbine, a more practical and useful endeavor would be to validate the manufacturing technology and supplier readiness for fabricating and machining full scale steam turbine components as will be described in Section 7. Consequently, GE proposed this alternate plan at a quarterly meeting and this plan was approved and accepted by the project team.

This announcement resulted in positive affects to some other aspects of the program as well. The operating pressure of ComTest was set by the “balance” between the steam that was available from a host for the test program and the manufacturability of the steam turbine. To make the test meaningful at a reasonable cost, a minimum steam flowrate of 100,000 to 150,000 lb/hr was selected. Based on this flowrate, the pressure entering the steam turbine needed to be on the order of 600-700 psia to make the steam turbine blade size large enough to be within the normal size of a commercial turbine. This pressure was also typical of reheat turbines so the combination of 1400^{o}F steam entering at a pressure of 600-700 psi was also typical of future commercial AUSC power plants.

With the steam turbine no longer being tested, the lower pressure steam was not required, and the focus of the test could be on testing a high pressure ComTest Superheater and the steam turbine main stop and control valves. There was also the opportunity that ComTest could be configured in such a way that the high-pressure steam could be returned to the host unit so that

there would be no loss in power generation. Additionally, much of the infrastructure that would be required to be added at Youngstown Thermal – including cooling water and natural gas – could possibly be supplied at lower cost at the Southern Company site since these services were existing.

With the steam turbine and its associated equipment as well as the Superheater Outlet Header removed from the project to further reduce the cost, there was a significant decrease in plant cost as shown in Table 5-19 and Table 5-20. This is based on the High Pressure Configuration shown in Figure 5-23 and Figure 5-24. At the time of the estimate there were uncertainties about whether the cost of certain services would be provided by Southern Company or by the project, so a "best" and "worst" case estimate was prepared.

Table 5-19 ComTest Project Cost Summary at Plant B without the Steam Turbine

A-USC ComTest Project Cost Estimate - Overall ($ mm)		
Description	**Plant B (Best Case)**	**Plant B (Worst Case)**
Phase I (Design)	$15.0	$15.0
Phase II (Build / Operate)		
Buy & Install	$38.4	$43.1
Operate	$10.6	$13.8
Decommission & Demo	$1.8	$2.2
Sub-Totals Phase II	$50.8	$59.1
Total Project Cost	**$65.8**	**$74.1**

Table 5-20 ComTest Project Cost Details at Plant B without the Steam Turbine

A-USC ComTest Project Cost Estimate - Phase II Details ($ mm)		
Description	**Plant B (Best Case)**	**Plant B (Worst Case)**
Buy & Install (B&I)		
OEM Equipment:		
AUSC SuperHeater	$20.0	$20.0
AUSC Cycling Header / MS Piping	$0.0	$0.0
AUSC Steam Turbine Valve	$0.0	$0.0
AUSC Steam Turbine Other	$3.0	$3.0
Sub-Totals (OEM)	$23.0	$23.0
Balance of Plant (AECOM):		
Turbine Building	$0.0	$0.0
Steam Generator	$0.0	$0.0
Cooling Towers	$0.0	$0.6
BOP Equipment	$1.0	$2.0
Control System	$1.6	$1.7
Other Piping	$3.8	$4.6
Nat'l Gas Pipeline	$0.0	$0.0
Electrical	$1.2	$1.4
Misc. (see note 3)	$2.8	$3.8
Indirect Costs (see note 4)	$5.0	$6.0
Sub-Totals (BOP)	$15.4	$20.1
Total B&I Costs	**$38.4**	**$43.1**
Operating Costs		
Utilities:		
Steam	$0.0	$3.2
Natural Gas	$4.0	$4.0
Electricity	$1.0	$1.0
Cooling Water	$0.0	$0.0
Operating:		
Labor & Maintenance	$5.6	$5.6
Totals Operating Costs	**$10.6**	**$13.8**

Notice that in the "best case" estimate that there was no cost associated with the steam usage. This was because steam would be removed at high pressure from the water wall header (approximately 3865 psia and 775°F) and returned to the unit at the same conditions as the steam turbine inlet – 3500 psia and 1000°F). Therefore, there would be no loss of power associated with the use of this team by ComTest.

5.2.2 Stand Alone Unit at Plant B

The configuration described in the previous sub-section raised concerns with Southern Company's permitting group. Since steam was being withdrawn from the unit, heated with natural gas, and then returned to the unit it was possible to interpret this modification as a "new source" which could trigger a New Source Review – even though the energy being added to the steam was a very small percentage of the overall energy in the steam. Southern Company did not want ComTest to create a New Source Review of Unit 5. Initially, condensing the steam from ComTest and returning the condensate to the unit's steam cycle was explored so that there would be no energy added to the steam cycle. Ultimately Southern Company decided that ComTest could not be utilize the steam from Unit 5, and ComTest would have to add a package boiler to the scope of the project.

However, the challenge to this configuration was that a package boiler operating at supercritical conditions in this size range isn't available commercially, so this configuration for ComTest would again be operating at lower pressures. It was decided by the project team in the December 2017 quarterly meeting that testing the steam turbine valves alone at this pressure and temperature did not justify the cost of the project. So, the project team decided to "pivot" to validating the manufacturing technology/supplier readiness proposed by GE Power. This will be described in Section 7. This "pivot" basically ended the demonstration phase of ComTest.

5.3 Test Plan Development

5.3.1 Superheater Header Testing

Due to the proposed design and fabrication schedule of the steam turbine, it was planned that ComTest would be initially built with only the superheater and the superheater header and the supporting balance of plant equipment in place. ComTest would be commissioned and testing would begin with these two components. Once the steam turbine arrived on the site and was installed and commissioned, testing would begin on the steam turbine.

Testing of the superheater outlet header section was previously described in Section 4.3.4:

- Steam at 1400°F would flow through the header test section for approximately one hour.
- Using a ramp rate that would be maintained by the control system, the steam exiting the ComTest superheater would begin flowing through the bypass line and would be depressurized and desuperheated to approximately 650F and 205 psia. Simultaneously, the steam flow supplied from the package boiler would increase to ~146,000 lb/hr and the extra 50,000 lb/hr of steam at 935 psig and 750°F would flow through the SHOH test apparatus, decreasing the temperature of the header test section from 1400°F to approximately 750°F. During this time the steam flow through the ComTest superheater would remain constant.
- Steam at 750°F would flow through the SHOH test apparatus for approximately one hour.
- The ramping process would be reversed and steam at 1400°F from the ComTest superheater would begin flowing back to the SHOH test apparatus, increasing the inlet temperature. The steam flow from the package boiler to the SHOH would correspondingly decrease. When the header test section inlet temperature reached 1400°F again, the cycle would be complete.

These cycles would continue during the operation of this phase of the testing to cycle the SHOH as frequently as possible, ideally 2000 to 2500 cycles, during the testing campaign.

5.3.2 Steam Turbine Testing

Once the steam turbine arrived on the site and was installed and commissioned, testing the turbine would be the priority for the remaining time of the project. The goal for the steam turbine was to operate for at least 8,000 hours at AUSC steam conditions under typical operational modes and sequences of a modern, commercial, fossil-fuel-fired, power plant. These sequences included: pre-warming, cold start, warm start, hot start, hot restart, load cycling, and cool down. Pre-warming is recommended after an extended unit shutdown (5 days or more). Cold starts occur after extended unit shut downs including outages and are performed after the pre-warming sequence. Warm starts are representative of weekend shutdowns. A hot start would occur after a night-time shut-down and a hot restart after an unplanned trip event. Load cycling is meant to represent a nightly turn down of unit output to match grid requirements. Cool down occurs after any trip event.

The baseline quantity of ComTest operational sequences were established by General Electric from a commercial product specification and were refined by a cross-discipline engineering team to maximize test learning and reduce the test schedule to fit within the constraints of the

allotted schedule window. The resulting cyclic operation profile including the initial conditions is shown in Table 5-21.

Table 5-21 Operational Test Modes and Sequence Objectives

Sequence	Test Cycles	Initial Condition
Pre-warming		Metal temperature = 24°C (75°F)
Cold Start	10	Metal temp = 150°C (300°F)
Warm Start	30	48 hours post trip
Hot Start	10	8 hours post trip
Hot Restart	10	2 hours post trip
Load Cycles	300	Full-load steady state trip
Cool Down		Full-load steady state trip

Table 5-22 illustrates a simplified test plan for a possible scenario of the sequence of operations that accomplishes the objectives defined in Table 5-21. The test plan assumes no equipment down-time and 100% availability of steam from the primary boiler and superheater. Based on the assumptions, the schedule illustrates how testing might be completed in as few as 66 weeks including fourteen weeks of float for unplanned issues.

Table 5-22 Scenario for Sequence of Operations

| Year | | 2019 | | |

5.4 **Decommissioning**

If the ComTest project had moved into the fired testing phase, at the completion of the 2-year operation period the following activities were planned.

The equipment purchased with government funds would be decommissioned through removal, transfer of ownership, or disposal, depending on the item and negotiated conditions. Upon program completion, EIO would prepare a comprehensive inventory of infrastructure, equipment, materials and residual hardware that was purchased with government funds and submit it to the government plant clearance officer according to government property procedures.

To gain valuable research data on the impacts of the ComTest operation on the materials and equipment, some components would be removed for metallurgical testing and analysis, particularly certain sections and hardware of the turbine device, Superheater, and Superheater Outlet Header. After removal of the test materials, the remaining components would be considered government property and go through a formal disposition process. The process would involve offering the equipment and components to project proponents and contractors and then to the site. If offers are not accepted or tendered, the facility and hardware would be disposed through a structured process that may include equipment sales, evaluation of scrap value, or abandonment in place at the host site.

Government purchased items to be decommissioned include fixed infrastructure improvements and process equipment supporting the project. Infrastructure improvements include the turbine building foundations, steel structure, HVAC system, control room and lighting, and utilities such as power, underground plumbing, natural gas and city water services. It is anticipated that process equipment used for the project would still have a majority of its service life available after the ComTest testing was complete. This equipment includes, but is not limited to, the gas-fired package boiler, water treatment equipment, cooling tower cells, circulation pumps, and heat exchanger. All process equipment would be decommissioned and disposed of in accordance with government plant clearance procedures.

6 Supplier Development Plan

6.1 Goals, Scope, and Approach

The objective of this task was to evaluate the domestic supply chain for power plant components suitable for AUSC power plant design, determine where technical and schedule constraints exist to produce AUSC components, and establish a plan, where necessary, to develop the capability of domestic suppliers to fabricate AUSC components which would meet the required technical specifications and schedule requirement of the AUSC ComTest project. The intent was to gain knowledge on gaps that may exist in the supply chain regarding existing capabilities, experience, and size/shape limitations. Focus was also to be on establishing the status of commodity design sufficiency for the AUSC design conditions for products such as valves. Finally, attention will be given to the status of relevant design codes.

At the onset of the task, the following approach was taken:

A. Review available information on component sizes, shapes, quantities, and materials which includes:
   - Superheater Design
   - Conceptual Turbine Design
   - Site design
B. Develop an initial list of questions and likely constraints
C. Conduct workshops with likely material and component suppliers as part of the ComTest quarterly meeting and present this initial list of questions to the participants. Continue contact with supplier base through participation at quarterly meetings of the consortium.
D. Develop a more detailed list of specific components and supplier development needs
E. Review the information with the consortium and present a plan to address the technical and schedule items

The following sub-sections define the strategy assumed by this task from the earliest scope definition and through subsequent changes. The following sections describe the major milestones with regard to the original and revised scope.

6.2 Assessment from Pre-FEED

This sub-section describes the supply chain issues as identified at the end of the Pre-FEED study.

6.2.1 Superheater

The ComTest superheater had defined Pre-FEED requirements which provided a tentative bill of materials and potential sizes for a Pre-FEED design. Based on these requirements, the conceptual design presented a number of material needs and challenges, the more significant of which follows:

- Tubing sizes chosen for the design were defined, but because of high superheater temperature and pressure, some were outside of the range of typical production, specifically tube wall thicknesses over 0.4” when tube diameter is only 1.75”.
- Tubing quantity (~10,000 lbs) for a ComTest would not be large and was judged as to not be a problem for existing superalloy vendor production.
- INCONEL 740H alloy tubing fabrication:
    - INCONEL 740H alloy post bending local heat-treatment is not allowed by the ASME Code. However, it would be helpful in fabrication if local heat treatment would be allowed. To qualify, some R&D would have to be done by the material manufacturer or program which would support local heat treatment. Some research was performed that was promising, but more data is needed.
    - Being able to leave INCONEL 740H alloy in the as-welded condition would be very helpful for field erection. Some data has been generated by Special Metals that supported as-welded operation as long as the operating temperature was near the aging temperature, but more data is required, and this is not allowed currently by the ASME Code.
- HAYNES 282 alloy material had become available and had been recognized mid-way through the Materials Program as a possible alternate to INCONEL 740H alloy. Plate and tubing had been available from Haynes International (Haynes) and was included in development testing. Piping size is not a limitation.
- Pipe making capability in the domestic industry exists and was judged to be moderate in capability.
- Header size, related to seamless pipe size capability, was somewhat limited but design objectives could still be achieved.
- Lead times were on the order of ~20-24 weeks for piping and tubing (10-12 weeks for ingot, 10-12 weeks for processing), which were acceptable.
- Pipe bends have been made successfully in INCONEL 740H alloy but have not been demonstrated with pipe sizes (diameter and thickness) projected for ComTest.
- The design requires substantial nickel-based alloy field welding, some with limited access. The project would need to train welders and should potentially consider mock-ups earlier on in the process.
- The project would need to address attemperator (desuperheating) design which had been a problem in the European program.
- Real limits were found to exist for the ASME Code required pressure relief valve (PRV), as required by the ASME Code. No 1400^{o}F design pressure relieve valve had ever been demonstrated in the world. It appeared to be a very long-lead time item, with ~1 year of engineering (identified by one vendor) and another ~1 year for manufacturing for an ASME Code approved valve at 1400^{o}F and 4000+psi. Other options potentially existed from an ASME Code and design standpoint, which offered an alternative overpressure protection scheme that did not involve a 1400^{o}F spring-activated PRV, which have been successfully used in Europe. However, this would involve obtaining new ASME Code Case. Valve suppliers desired detailed specifications and will not start development without an official specification document.

    - Forged INCONEL 740H alloy can be used for ASME 760°C (1400°F) valve applications based on recent approval of a Case that permitted INCONEL 740H alloy to these temperatures in ASME B16 due to the program initiative.
    - There was also a need to engage the ASME B31.16 (valve) code to determine options for the consortium to proceed.
- Cast HAYNES 282 alloy material would be a useful addition for cast valve bodies for ComTest in ASME valve piping, but the time needed to run the required amount and type of mechanical tests to support an ASME Code Case was not possible within the ComTest schedule.
- There are other high temperature drains and valves which require better definition during FEED.

6.2.2 Piping System

The ComTest piping system had not been well defined during the Pre-FEED because it would be very site and configuration specific. To assess the supply chain, it was assumed a similar pipe size to the ComTest Superheater outlet piping, to be nominally 100 feet in length, and containing an expansion loop, a bypass valve, and typical piping components, like drains, etc. Based on these requirements, the feedback from the suppliers was as follows:

- The piping findings mirror the Superheater findings for pipe, namely:
    - Procurement of INCONEL 740H alloy piping should not be an issue. It is a 20-24 week delivery item, similar to tubing.
    - Tonnage of piping is not an issue from a supplier standpoint.
    - Pipe bends have been made successfully in INCONEL 740H alloy piping, but not in the sizes (thicknesses) for ComTest.
- Field welding and field repair welding with a shielded metal arc weld (SMAW) fluxed process would be very useful. Currently, code only allows gas metal arc (GMAW) and gas tungsten arc welding (GTAW). A new SMAW alloy Thermanit 263[17] alloy limited production product is now available and being tested by Special Metals. If welds can be successfully made, the consortium members agree it would be very useful to run some testing on the weld to support code incorporation.
- The piping system will likely have multiple desuperheaters. It is unclear what design and manufacturing challenges will be faced by these components.
- A bypass valve is likely. At the time of FEED, no 1400°F bypass valve has been demonstrated. Bypass valve suppliers have since explored what it will take to make this component. More discussion is needed.
- Currently Stellite 6[18], preferred hardfacing material for valve, may not work in valves at 1400F with steam. Valve manufacturers have been researching better alternatives.

[17] Thermanite 263 is a trademark of Voestalpine Bohler, Linz Austria

[18] Stellite 6 is a trademark of Deloro Stellite, Swindon, UK

6.2.3 Superheater Outlet Header

Design of a cycling header had been considered from the preliminary stages. Two designs were considered employing a three-inch-thick pipe of INCONEL 740H alloy or a combination of INCONEL 740H and HAYNES 282 alloys.

- Pipe size for INCONEL 740H alloy was not a problem, and the needed quantity is small.
- No large and thick pipe of HAYNES 282 alloy has yet been manufactured but is planned to be manufactured through Haynes using a European pipe manufacturer.
- High temperature valves will be needed.
- Tubing quantity needed is small and should utilize same sizes as the superheater.

6.2.4 Turbine

Materials allowed for turbine design are not restricted by the ASME Code, thus non-Code materials such as cast, HAYNES 282 alloy are permitted. A combined control and stop valve, sized for 4,000 psi with internals to match the actual conditions, was considered. Feedback from potential suppliers was as follows:

- For HAYNES 282 alloy triple melt forging, a new patent license would be needed between GE, or the forging producer and Haynes to allow for production. Quantity and sizes for the triple melt forging were not an issue but lead time had not been established.
- For the inner shell, MetalTek International (MetalTek) believed centrifugal casting is likely.
- For a combined stop and control valve, MetalTek would use trials on the sand cast half valve body.
- MetalTek or GE would need to obtain a patent license from Haynes to produce re-melt materials for castings.
- MetalTek is concerned about the weight of casting valve body. They feel a 15,000 lb. casting (double the size of the previous casting) is possible, but if the casting is 20,000-25,000 lbs then they will need to go to AOD re-melting which would require development work.
- GE has indicated 50-54 weeks from specification to finished machined casting and nearly 2 years lead time for completed combined steam turbine stop and control valve. Identifying heat-treatment capability and non-destructive evaluation is critical to reducing this timeline.
- Valve internals have yet to be defined but may include both wrought and cast materials.
- The turbine needs flanges and fittings. Special Metals and partners have demonstrated this with small forging houses for INCONEL 740H alloy but Haynes has not for the HAYNES 282 alloy material. Some development would be needed.

6.2.5 Cycling Combined Control and Stop Valve

Same issues as turbine valve (Section 6.2.4)

6.2.6 Valve Code Issues

- At the beginning of the ComTest project, ASME B16.34 (valve code) did not allow any materials for 1300°F service at pressures required for the project.
- The current method for calculating maximum ceiling pressure are highly conservative at AUSC conditions.
- ASME B16.34 does not allow for a design by analysis approach and the design by rule approach it uses makes it difficult to design a valve for the AUSC ComTest.
- From the project standpoint this created a number of issues:
    - If the ComTest were built today it would require a non-ASME compliant valve (there is a European EN standard which could be used) which would require the site State Inspector to sign-off on the project; this is a project risk since the Inspector may or may not allow the non-ASME valve.
    - To modify ASME B16 to include nickel-based alloys, the current rules require that a material has been approved in Section II or has a Section I or B31 Code Case. This limits the potential materials to wrought HAYNES 230, 617, 625 alloys[19], and INCONEL 740H (Code Case 2702). This means that the most preferred consortium option, cast HAYNES 282 alloy, cannot be used in the short-term and that the valve body must be made from a forging.
    - Even with the incorporation of the wrought alloys, an alternative formulation would be required to ensure the nickel-based alloys will have a high enough ceiling pressure.

6.2.7 INCONEL 740H alloy field welding with Thermanit 263 SMAW

- The desire for a fluxed process (Shielded Metal Arc Welding –SMAW) was identified.
- To modify the INCONEL 740H alloy code case to allow this to be used would require:
    - Section IX welding qualification.
    - Microstructure of the weld.
    - Creep test data:
        - ASME requires at least 10,000 hours of creep data.
        - ASME has required 30,000 hours rupture life data to ensure long-term material performance of some complex high temperature alloys.

6.2.8 Inconel Weldment Fracture Toughness Testing

Discussion with welding experts and review of recent literature data on AUSC alloys suggests there was a concern with the Charpy Impact Toughness values obtained in welded joints of INCONEL 740H alloy and other nickel-based alloys. From the standpoint of component behavior and ensuring that field welds in INCONEL 740H alloy will not crack due to hydrostatic testing, it was recommended that fracture toughness (not Charpy Impact) tests be conducted on INCONEL 740H alloy welded joints to estimate the critical flaw size. Such data will be critical for non-destructive Evaluation (NDE) of ComTest components to ensure safety. Testing was planned.

[19] HAYNES® 230®, HAYNES® 617® and HAYNES® 625® are trademarks of Haynes International, Kokomo, IN, USA

6.3 Action Plan to Address Critical Gaps

Based on the Pre-FEED assessment, the following action plan was proposed:

Superheater

- The superheater should avoid use of heavy-wall (0.5”) small diameter (1.75”) tubing, and work with Special Metals to establish easier to produce size range.
- The superheater should explore using HAYNES 282 alloy tubing in addition to INCONEL 740H alloy, recognizing that the material will not be code approved and may not be by that time.

Piping

- There was a need identified to engage a hot induction pipe bender on INCONEL 740H alloy piping, and potentially explore a trial run to ensure project success. This supports both the superheater and piping needs.
- Work with Special Metals to get Thermanit 263 SMAW approved for code use though a focused testing program on weldments provided by Special Metals.

Valves:

- Convene a meeting with the ASME B31.16 committee to explore the best approaches to address long lead time valve issues with the safety relief valve.
- Obtain ASME B16.34 Case approval for high temperature valves using HAYNES 230 and INCONEL 740H alloys.
- Develop the HAYNES 282 alloy database to determine how much data will be needed to get HAYNES 282 alloy forgings (two-step heat-treatment) and cast HAYNES 282 alloy Code approved in ongoing wrought Haynes 282 alloy testing at ORNL. Then develop a plan to obtain State approval to allow this option for ComTest through special exception.
- Once the requirements for bypass valve are defined, begin engaging valve supplier(s) to identify challenges.
- Review hardfacing (non-pressure part) materials issues with valve suppliers and likely solutions or research needed.

Turbine/Turbine Valve

- GE or the forging producer would pursue a license with Haynes to triple melt to reduce procurement cycle time.
- GE would provide more clarity on size of casting needed to MetalTek. If AOD melting is required, a development project with the consortium will be needed rapidly.
- GE, MetalTek, and consortium would need to identify heat-treatment and machining capabilities as soon as possible for castings to reduce timeframe for producing the turbine casing and large valves.
- GE would define flanges and fitting needs, Consortium would work with Haynes and likely small forge shops to do trial components.

General

- Explore pre-purchase of piping and tubing stock, ingots, and/or remelt ingot to reduce overall project lead times and to take advantage of quantity discounts and near historic low nickel-based alloy pricing.

6.4 Task Activity and Accomplishments

It was recognized that close contact and communication with possible material and product suppliers would be necessary to make real progress in understanding the peculiarities and special challenges of supplying materials and services for an AUSC boiler.

A supply chain strategy meeting was held on January 22, 2016 in AECOM's office with participants being: EIO, AECOM, and EPRI to discuss strategy around material procurement. The main discussion for the meeting focused on the potential to move the purchase of the high-temperature materials out of the current scopes of work for the manufacturers to remove the burden of cost-share on materials since the cost of nickel would be a major project cost. Approaches for pre-purchase of ingots or finished product to take advantage of quantity discounts and low nickel prices were also evaluated. Based on the outcome of the meeting, AECOM agreed to produce a schematic of the entire high-temperature systems with pipe sizes, valves configurations, and fittings/bends needed. This would be used to begin discussions with the materials suppliers and potential suppliers.

Major suppliers were invited to the quarterly meeting of the Consortium, and additional visits and follow-on conference calls were held with individual companies to address issues raised in the various meetings.

Follow-on conference calls continued with materials suppliers to keep them abreast of project developments and identify any key concerns or project risks. An outcome of these meetings was to develop a test plan in order to determine the additional welding needs for INCONEL 740H alloy.

6.4.1 Site State Laws and ASME Code Compliance

The initial objective was to site the ComTest facility in the State of Ohio, at the Youngstown Thermal plant site. For that reason, activity was undertaken to obtain State approvals for the site from the Ohio State Chief Boiler Inspector. An initial meeting was held on May 5, 2016 with the Department of Commerce of the State of Ohio to discuss need for an Ohio "State Special" to allow materials and designs not yet approved by ASME in the ComTest plant. Representing the ComTest program was EIO and B&W. The Chief Boiler Inspector resides in the Commerce Department and is believed to have review and final approval of such deviations. It was a very cordial meeting and much information conveyed and exchanged between both parties. The request was also reviewed by the Ohio Power Siting Board. Before we were able to take this effort to completion, the site was changed to Alabama, with separate and different State laws. Activity with the State of Ohio was terminated.

EIO was able to obtain information regarding the applicable Alabama State Law and State Special procedure and supplied that to representatives from the utility. Alabama allows for a site such as ComTest to be considered a research facility, and thus not under their direct

authority, and Southern Company has agreed to this approach. Thus, no further contact with State of Alabama is planned. The program has engaged in discussions with Southern Company regarding their requirements for handling non-ASME Code materials and designs that may be included in ComTest. Details will be included in the Host Site Agreement.

6.4.2 Non-ASME Code High Temperature Valve and Material Issues

Based on contact with potential valve suppliers, a visit was made by EPRI's staff to Flowserve's main power generation valve manufacturing location in Raleigh, NC (January 7, 2016). It was necessary that the program attempt to gain approval of a new ASME Code Case that would define technical requirements for high temperature valves in steam service. Following the meeting, the Flowserve R&D staff and EPRI developed an approach for such a Code Case that would allow moving forward with the ASME B16 Code. Additionally, a list of key items for B16 were constructed and circulated with a wide community of interest including several B16 committee members.

The INCONEL 740H alloy B16.34 Case was developed and was presented to the Code Committee and obtained ASME B16 Committee approval on 9/14/2016. This very significant development allowed for use of high temperature valves made of both INCONEL 740H and HAYNES 230 alloys. The Case was generated by Flowserve, with the support of EPRI. An additional Code Case covering flanged and bolted joints for the same high temperature conditions is being developed by an outside consultant with significant ASME Code experience. There are also two Code Cases going forward in B16.5 and B16.47 that would allow powder metal materials as equivalent to wrought alloys. This could be useful on ComTest, and certainly on future AUSC projects. An issue will be that B16 meets just once a year and the next meeting is March 2018. Concerning the need for a B16 high temperature bolted flange Code Case, both GE and AECOM have concluded that they can design ComTest equipment without flanges, and that a Code Case is not crucial to proceeding. However, the B16 action will continue for future anticipated needs in the future commercial AUSC product.

EIO and GE are working to obtain ASME Code approval for the non-ASME Code pressure relief valve overpressure protection issue. An initial draft of an ASME Code Case was generated by EIO that would permit alternate ways of relieving pressure in the high-temperature superheater steam headers, instead of the mandated method listed in Section I of the ASME Boiler and Pressure Vessel Code. It is the same system that has been approved and used in Europe for USC boiler plants, and for the Comtes 700 test performed in Europe. Presently, the only permitted way to relieve overpressure is with a passive spring-operated pressure relieving valve. However, this sort of valve is still under development in the valve industry for the high temperatures of AUSC technology. The proposed Code Case was submitted to ASME for consideration at their meeting in February 2017. Comments have been received and an updated draft has been discussed and considered at the ASME meetings in 2017. Representatives of EIO and GE Power will be on hand at the ASME meetings to champion the Code Case and work for its approval. Questions and comments continued to be fielded, and it is believed that the outstanding issues will be resolved in the most recent draft which will be acceptable to the Code groups.

In the meantime, Baker Hughes and Flowserve have progressed in their high temperature spring valve development and have reported that an acceptable design is expected to be available by the time ComTest is commissioned, which would negate the need for the Code Case. If an approved Code Case cannot be approved in time, or spring-loaded valve designed, a special one-time exception of the alternate valve system will be solicited to the state board for approval. There would also be an option of locating the spring-loaded valve in the superheater steam piping where temperatures have been mitigated by spray attemperation. This may permit use of existing and proven valve products. Thus, there are several options available to circumvent any potential ASME Code issues with non-ASME Code approved valve use.

The one non-ASME Code material that is still being considered for use in ComTest is alloy HAYNES 282 alloy. Material property testing needed to collect enough data to apply for ASME Code Case approval will not be completed in time for ComTest. The mechanical property data that has been developed to date in the AUSC program was supplied to Haynes early in 2017 and they developed design allowable stresses for the alloy, using established ASME data analysis software that could be used for the State Special application. Their Code expert has analyzed the data and has supplied a draft of design allowable stresses, using procedures required by ASME. These properties have been distributed to the consortium for review. EPRI took the same data population and performed their own ASME analysis procedure and arrived at essentially the same properties as those recommended by Haynes. These have been supplied to GE for use with HAYNES 282 alloy design. The design stresses using ASME prescribed analyses methods are judged by the program to allow for the design and safe operation of the ComTest facility for the two years intended operating time.

EPRI and Oak Ridge National Laboratory have also started an effort to collect all the mechanical property data, especially creep data that has been generated to date on cast Haynes 282 alloy material. This is intended to help ascertain how much mechanical property testing would be required to develop a data base suitable for submission to ASME for a Haynes 282 alloy cast material ASME Code Case.

Haynes Alloys had instructed the program that they will supply a pipe of alloy Haynes 282 alloy. The same pipe made for the first trial will be the one supplied to ComTest. Originally, the only place Haynes 282 alloy was planned for use was in the Superheater Outlet Header, which has been deleted from the project scope. HAYNES 282 alloy pipe was then planned for a short run in the steam line beyond the superheater. Any HAYNES 282 alloy tubing or piping planned would be encased in the Superheater enclosure or placed in a concrete pit, to address potential safety concerns associated with the testing of non-ASME Code approved materials. In the worst case, HAYNES 282 alloy could be excluded from any use in ComTest, thereby removing a potential hurdle to authorization to proceed by the host site.

6.4.3 INCONEL 740H alloy SMAW Electrode Development

Through a collaboration between Oak Ridge National Labs, Special Metals, and EIO, a final test plan was developed to support adding Shielded Metal Arc Welding Electrode Thermanit 263 alloy to the INCONEL 740H alloy ASME Code Case 2702. Special Metals and EPRI had approached Voestalpine Bohler in Europe, developer of the electrode, for any property data that could be added to support the Code Case, but no data was forthcoming, so the US test program will need to supply all ASME required data. Test welds have been made by Special Metals, who

have completed machining creep specimens to be tested by ORNL. Hot tensile tests are being performed by Special Metals. Creep testing started during the last quarter of FY2017. The longest creep tests planned to support a Code Case revision request will be 10,000 hours, which means that the earliest the information will be available to support the Code Case revision will be mid to late 2018. Several tests will be loaded to run up to 20,000 hours, in case the ASME members want to see longer term creep data. After the 10,000 hour creep tests are completed, the ASME Code group will be approached to accept Thermanit 263 SMAW as an acceptable welding process and material in the alloy 740H Code Case 2702. Not knowing the time required to achieve approval of the Case revision, it is possible that Thermanite 263 alloy SMAW may not be available for the fabrication and possibly the construction of ComTest. If necessary, all required welding can be performed using the already approved welding methods of gas tungsten arc (GTAW) and gas metal arc welding (GMAW). In that case, it will be desirable to incorporate Thermanit 263 alloy SMAW welding in weld repair activity later in the run time of ComTest.

In a separate test program intent on fracture toughness testing of piping materials, material was made available from excess B&W weldment test material developed in the Materials Program.

6.5 Major Material Supplier Development Highlights

A list of forging and pipe vendors that have been developing the capability to make INCONEL 740H alloy fittings, forgings, and pipe needed on the project was supplied by Special Metals and distributed to the Consortium. These vendors have been involved in actual manufacturing operations using the alloy due to initiative taken by Special Metals to establish the ability to supply the product forms needed by industry. These vendors possess capabilities suitable for making parts for ComTest.

Induction pipe bending capability has been expanding and has achieved a pipe size that can accommodate all bends required for the superheater and Balance of Plant piping. The latest development is that the vendor has been able to make compound bends in pipe representative of the BOP needs. GE Boiler will solicit material quotations and determine lead times.

Meetings and follow up calls and emails were conducted with Special Metals regarding INCONEL 740H alloy. An agreement was struck in principal to melt INCONEL 740H alloy ingots before the end of Phase 1, provided it benefited the economics of the program. Special Metals was evaluating melting a heat and pouring ingots suitable for ComTest tube and pipe.

Special Metals quoted minimum mill quantity for INCONEL 740H alloy tube as 1000 lbs. They stated that they can manufacture hot isostatically press (HIP) fittings, however, those are not yet ASME Code approved.

Haynes product development has progressed, but they have not yet manufactured a large diameter, thick walled seamless pipe. The first trial is pending at a selected pipe manufacturer in Europe. At the September 2017 Consortium meeting Haynes reported that minimum mill quantity for tube is a few hundred feet; for pipe it is 9000 lbs. The tube lead time is 32 to 35 weeks. Pipe lead times are expected to be shorter.

Information exchange with potential casting suppliers of Haynes 282 alloy for large valve and turbine casings continued as part of the turbine supply side study. MetalTek was established as possible source for Haynes 282 alloy castings.

Efforts to secure a license to permit triple melting of Haynes 282 alloy were initiated between GE, Haynes, and Special Metals.

Key nickel alloy high temperature valve lead time were identified as 48 – 52+ weeks at the September 2017 Consortium meeting in Chicago. An early start on order placement in November or December may be needed to support the ComTest construction.

Flowserve and Velan are working on improved hardfacing alloys for the 1400F design valves. This was included in their reported 48 week lead time. Baker Hughes has a spring activated PRV design and plans testing. The lead time is expected to be 52+ weeks.

The Department of Energy asked that activities regarding alloy Inconel 740H alloy component development be coordinated with ongoing work being done on Supercritical CO_2 power cycle development. The objective of the DOE STEP Program is to build and operate a 10 MWe equivalent sCO_2 Brayton Cycle test facility with operating conditions of 1,300^{o}F and 3,625 psia.

7 End of Phase 1 – Future Plans for ComTest

Section 5 of the report details the efforts put forth by the project team to configure ComTest in such a way that it could be constructed within the budget provided by the DOE Award. Section 6 details the efforts of the team in investigating the availability of the nickel materials and components necessary to construct ComTest. A third major factor in the development of the ComTest project was the merger of General Electric and Alstom Power mentioned in Section 2.3.

In April 2014, GE offered to buy Alstom's power and grid businesses. The acquisition was concluded in November 2015, approximately the same time the ComTest project began. Once the acquisition was completed, GE was able to evaluate Alstom's developments relative to high temperature materials and design philosophy, including nickel-based alloys, for relevance and application to the AUSC ComTest steam turbine program activities. The Alstom developments were the result of its work on both internal and trans-national R&D programs. These programs included:

- Various projects, targeting progressive development of ferritic steels (1995-2010).
- Various steam loops for technology demonstration at temperatures 620°C-720°C (1150°F-1330°F) performed at sites Esbjerg, Westfalen, Amager, Weissweiler in Western Europe (1995-2010).
- AD700 Phase 1 and Phase 2: Plant concept and tests of material/welding/casting (1998-2006).
- Marcko700 & DE : Nickel-based alloy improvement & qualification (2003-2008).
- Comtes700: Test rig built, operation and post-operation inspection (2004-2011).
- NRWPP700: pre-engineering of a 400 MW prototype (2006-2008).
- HTW I+II 725 GKM: Component testing of nickel-based alloys (2008-ongoing).
- MACPLUS: Demonstration of 760°C (1400°F) turbine components (2011-2016).
- Full engineering design of a 1,100 MW steam train at 700°C (1290°F) for full commercial application.

Major programs undertaken by Alstom from 1998 to 2016 included:

- MACPLUS: 2011-2016

  EU Framework Programme 7 project: Component Performance-driven Solutions for Long-Term Efficiency Increase in USC Power Plants

  Work package 5: steam turbine materials for operation at 760°C (1400°F)
  - Nickel-based alloys were the subject of the program
  - Computer modelling of manufacturing processes including casting and forging
  - Demonstration of casting and forging manufacture
  - Demonstration of welding
  - Launch of long term testing
  - Participation by utilities, material suppliers and research institutes.

  The work on forged alloys focused on HAYNES 282 alloy. Haynes International provided a HAYNES 282 alloy billet that was forged by one of the MACPLUS partners in a way designed to simulate the forging and heat treatment of a full-sized forging. The work on

castings focused on a cast version of INCONEL 740H alloy and culminated in the manufacture of a turbine valve chest.

- AD700: 1998-2006

  Technical and commercial feasibility of 700°C/720°C (1290°F/1330°F) coal-fired power plant, including alloy selection and demonstration of manufacture of critical components:

  - Pipes and tubes
  - Rotor forgings
  - Castings
  - Welding processes
  - Long term testing.

- COMTES 700 Turbine Valve: 2004-2011

  The high temperature steam demonstration program in Europe.

  - 2004-05: Manufacture and erection
  - 2005-09: Operation at 705°C (1300°F) with valve stroking
  - 2010-2011: dismantling and investigation
  - The objectives of the validation included:
    - Solutions for pressure containment and bolting
    - Spindles and coatings
    - Valve seats
    - Sealing components

By March 2016, the GE Power steam turbine group decided that several of Alstom Power steam turbine technology elements should be used in the AUSC steam turbine program including a welded-rotor construction in lieu of the originally conceived, bolted-disk arrangement and a reaction turbine aerodynamic design of the steam turbine blading. GE Power continued with the ComTest steam turbine to incorporate these features.

By January 2017, GE concluded that based on information gained from the General Electric/Alstom Power merger, the construction and operation of a sub-scale, AUSC steam turbine was not necessary to confidently design a commercial scale, AUSC steam turbine. Instead, GE recommended alternative work scope elements that would help to satisfy industry risk concerns. The alternatives included full-size manufacturing demonstrations with Haynes 282 alloy for the rotor and nozzle carrier[20] and the design, manufacture and testing of the stop & control valve at full temperature conditions.

The first element would include an assessment of the manufacturing technology and supply chain capabilities based on demonstrations of representative, full-size components that would use HAYNES 282 or NIMONIC 105 alloys. This work would demonstrate commercial readiness. The focus of future work for the ComTest steam turbine should be based upon the proof of full-scale supply chain capability in the United States, and manufacturability, rather on

[20] The component termed “nozzle carrier” has been previously cited as “inner casing” or “inner shell”. The nozzle carrier nomenclature is preferred. It is the same component as the inner casing or inner shell of a double-walled turbine construction.

sub-scale turbine testing. Table 7-1 provides further details of the full-size casting, forging and welding manufacturing demonstrations, non-destructive test (NDT) technique evaluations, and machining trials for rotor, nozzle carrier and blade features. In addition, characterization of microstructure, short-term creep and fatigue properties would be completed to provide confidence that the properties of these components are consistent with the long-term properties being established by the ORNL creep and fatigue testing of the forgings and castings manufactured in the previous phase of the project.

Table 7-1 Manufacturing Technology and Supply Chain Capabilities Recommended by GE Power

Part 1 – Rotor		
Part 1.1 : Rotor Forging Manufacturability		
760°C Turbine Requirements	Demonstrate successful manufacture of forged rotor disks in HAYNES 282 alloy (H282) in a diameter greater than 1 m (39 in). Demonstrate acceptable ultrasonic inspection of forging that can be used on a production basis. Demonstrate compliance with delivery specifications. Demonstrate that at least one supplier is capable of manufacturing rotor disk to support a tender submission for a 760°C (1400°F) turbine project.	
760°C Technology Key Deliverable List (KDL)	Deliverable 1.1.1 <u>Manufacture</u>: Forging	Intent: Demonstrate that large size forgings in H282 are manufacturable. This is to be achieved by manufacturing two rotor disks of 1.1 m (43 in) diameter in H282 material using supplier facilities.
	Deliverable 1.1.2 <u>Confirm</u>: Delivery specification	Intent: Demonstrate satisfactory quality of forgings. This is to be achieved by demonstrating compliance with delivery specification including chemical composition, ultrasonic inspection, grain size, and mechanical tests (e.g. tensile and impact).
Proposed Process	Manufacture of a forged disk of 1.1 m (43 in) diameter Conduct ultrasonic testing at forging facilities to inspect for forging defects using artificially created defect holes as a means of defect detectabililty and sensitivity. Conduct material testing of base material to demonstrate compliance with delivery specification	

Part 1.2 : Rotor Forging Weldability		
760°C Turbine Requirements	Demonstrate the successful ability to weld forged H282 disks with an acceptable level of defects. Demonstrate the successful ability to weld forged H282 disks to forged steel (CrMoV) rings with an acceptable level of defects.	
760°C Technology Key Deliverable List (KDL)	Deliverable 1.2.1 Manufacture: Welded Forging Assembly	Intent: Demonstrate the ability to weld similar metal (H282 to H282) forged disks using representative full-size test pieces. Welding tests to be conducted using existing production weld equipment at GE Power's Schenectady Works. Demonstrate the capability to manufacture required weld-depth by welding up to a maximum weld depth of 200 mm (7.9). H282 test forgings are to be used as the forged material for both disks.
	Deliverable 1.2.2 Manufacture: Welded Forging Assembly	Intent: Demonstrate the ability to dissimilar metal weld (H282 to CrMoV steel) forged disks using representative full-size test pieces. Welding tests to be conducted using existing production weld equipment at GE Power's Schenectady Works. Demonstrate the capability to manufacture required weld-depth by welding up to a maximum weld depth of 200 mm (7.9 in). H282 is to be used as the forged material for nickel-based material disk. St459TS is to be used as the forged material for steel (CrMoV) disk.

	Deliverable 1.2.3 Create: Weld Instruction	Intent: Production weld instruction for Ni-Ni disks. Based on welding trials, define a welding process for optimal welding conditions (control of heat input, wire feed, etc.) for Ni-Ni forgings assemblies. Define welding preparation geometry for weld preparation (e.g. opening angle to ensure no entrapment of weld electrodes, etc.).
	Deliverable 1.2.4 Create: Weld Instruction	Intent: Production weld instruction for Ni-Steel disks. Based on welding trials, define a welding process for optimal welding conditions (control of heat input, wire feed, etc.) for Ni-Steel forgings assemblies. Define welding preparation geometry for weld preparation (e.g. opening angle to ensure no entrapment of weld electrodes, etc.).
Proposed Process	Confirm machining of weld preparation to defined geometry. Perform root weld. Perform NDT (radiographic) inspection of root weld. Perform fill-up weld & ultrasonic inspection (see Part 1.3 below).	

Part 1.3 : Forging Weld Inspectability		
760°C Turbine Requirements	Determine resolution limits of NDT techniques to support Rotor Crack Defect assessment (rotor fracture mechanics analysis). Determine an inspection method of similar metal welds (H282-H282) from outer surface. Determine an inspection method of dissimilar metal welds (H282-Steel) from outer surfaces, inner surfaces and front face (due to higher thermal mismatch). Develop an inspection protocol for in-service inspection including frequency of inspections, operator requirements, estimated durations, costs and capital equipment requirements.	
760°C Technology Key Deliverable List (KDL)	Deliverable 1.3.1 Create: Technical report	Intent: NDT resolution limits for H282-H282 welds. Determine resolution limit based on reference defects for H282-H282 weld using ultrasonic techniques from outer surface. Determine optimum probe arrangement, orientation, and configuration for H282-H282 welds. Input from GE internal NDT inspections program. Comment: this report will generate input for Rotor Mechanical Integrity fracture mechanics calculations.

	Deliverable 1.3.2 Create: Technical report	Intent: NDT resolution limits for H282-CrMoV welds. Determine resolution limit based on reference defects for H282-CrMoV weld using ultrasonic techniques from outer surface, inner surface and front face. Determine and report optimum probe arrangement, orientation, and configuration for H282-CrMoV welds. Comment: this report will give input for Rotor Mechanical Integrity fracture mechanics calculations. The data will be used to generate input for fracture mechanics calculations for commercial designs. These calculations are essential to ensure that the full lifetime of any commercial offerings will be achieved. It is not intended to perform these calculations as part of this project.
	Deliverable 1.3.3 Create: Inspection Procedure	Intent: New manufacture radiographic inspection procedure for root welds. Define radiography technique for the root welds, based on modified standard inspection instruction for specific nickel-based material characteristics.
	Deliverable 1.3.4 Create: Inspection procedure	Intent: New manufacture ultrasonic inspection procedure for fill-up welds. Define an inspection technique for manufacturing, based on optimized inspection conditions. Inspection procedure to be based on findings of investigations reported above. Baseline considered: Ultrasonic inspection of fill-up weld.

	Deliverable 1.3.5 Create: Inspection procedure	Intent: In-service ultrasonic inspection procedure for fill-up welds. Define an inspection procedure for in-service inspection, based on optimized inspection conditions. Inspection procedure to be based on findings of investigations reported above. Baseline considered: Ultrasonic inspection of weld from outer surface Alternative Options (if required, depending on test program results): Ultrasonic inspection of blade roots Isotope inspection from rotor axis
Proposed Process	Prior steps: Manufacture test welds for H282- H282 and H282-CrMoV (according to part 1.2). Introduce reference defects at various locations, sizes and angles. Inspection of reference defects. Correlate inspection results with actual defect sizes (calibration of technique).	

Part 1.4 : Weld Residual Stresses for Mechanical Integrity		
760°C Turbine Requirements	Determine residual stress levels for H282- H282 welds and H282-CrMoV welds (required for rotor lifetime assessment)	
760°C Technology Key Deliverable List (KDL)	Deliverable 1.4.1 Create: Technical report	Report residual stress measurements in H282- H282 welds, and H282-CrMoV welds. Comment: This report provides technical input for Rotor Mechanical Integrity analysis including numerical study of a rotor design, incorporation material data (*e.g.* weld residual stresses) to ensure a rotor design has sufficient life for the full operation of the machine. In addition to the basic rotor design strength, of which the weld is one element, other factors, notably susceptibility to high and low cycle fatigue, are included to provide a comprehensive understanding of the design.
Proposed Process	Instrument rotor welds with strain gauges. Stresses to be measured using trepanning technique. Measure residual stress on rotor welds before and after post-weld heat treatment, for H282- H282 and H282-CrMoV welds.	

Part 2 - Nozzle Carrier		
Part 2.1 : Nozzle Carrier Castability		
760°C Turbine Requirements	Demonstrate that at least one supplier is capable of manufacturing nickel-based alloy components in required size. Demonstrate casting can be produced with 200 mm (7.9 in) wall thickness (with acceptable level of pores, segregation, cracks). Demonstrate satisfactory NDT capability of castings at supplier facilities. Demonstrate that it is possible to achieve quality defined in delivery specification	
760°C Technology Key Deliverable List (KDL)	Deliverable 2.1.1 Manufacture: Castings	Intent: Demonstrate castability of large size castings in nickel-based material. This is to be achieved by: casting a 1.2 m (47 in) diameter ring with 200 mm (7.9 in) wall thickness in H282 material. Identifying foundry with required molding, melting and heat treatment capacity Comment; this casting will be further used for machining trials.
	Deliverable 2.1.2 Manufacture: Casting	Intent: Support welding trails of castings by supplying nickel-based and steel cast pieces. The requirement is for two 600 mm (24 in) diameter x 300 mm (12 in) long x 200 mm (7.9 in) thick cast pipes; 1 x H282 nickel-based material, 1 x CrMoV steel material. Comment: these test pieces will be used for welding tests of H282 to CrMoV material.

	Deliverable 2.1.3 Confirm: Supplier NDT techniques.	Intent: Confirm supplier NDT capability for castings. Demonstrate NDT capability for casting defects by using standard radiographic techniques at casting foundry facilities.
	Deliverable 2.1.4 Confirm: Delivery specification	Intent: Demonstrate satisfactory quality of castings. Demonstrate compliance with delivery specification (chemical composition, radiography, grain size mechanical testing, tensile & impact, etc.).
Proposed Process	Manufacture cast ring of 1.2 m (47 in) diameter with 200 mm wall (7.9 in) thickness Conduct radiographic testing at casting facilities to inspect for casting defects including use of reference wires to demonstrate acceptable resolution. Comment: use standard technique at supplier Conduct material testing at supplier of base material to demonstrate compliance with delivery specification. These tests would be separate and distinct from those describe on Page 5 of this paper and would focus on the characterization of the joint between the nickel-based casting alloy and CrMoV steel components. Such joints are only required as a potential cost reduction measure if the nickel based alloy castings would be welded to CrMoV components e.g in nozzle carrier (inner casing). The test program is not yet fully defined but would include cross-weld rupture testing at the appropriate operating temperature of the joint. Manufacture two pipes from cast H282 & Stg50T (600 mm (24 in) diameter x300 mm (12 in) length x 200 mm (7.9) thick) to support dis-similar metal welding trials	

Part 2.2: Casting Weldability		
760°C Turbine Requirements	**Dissimilar Welds** Demonstrate dis-similar metal welding of H282 to CrMoV is achievable. Demonstrate inspection of welding defects using radiography in dissimilar metal welds. **Similar Welds** Small scale welds: Demonstrate similar metal welding of H282 to H282 for design or repair. Large scale welds: Not currently planned.	
760°C Technology Key Deliverable List (KDL)	Deliverable 2.2.1 <u>Manufacture</u>: Welded Casting	Intent: Demonstrate weldability of H282 to CrMoV. This is achieved by welding test pieces (e.g. pipe specimens) supplied at supplier's facilities. Comment: planned as potential cost reduction for casings or steel flanges to valve bodies.
	Deliverable 2.2.2 <u>Confirm</u>: Supplier NDT techniques	Intent: Determine NDT technique for dis-similar metal welds. Determine satisfactory weld using NDT methods, including radiography and ultrasonic, at supplier facilities of as-welded demonstration article and defect simulating reference holes formed post-welding. Comment: findings of NDT investigations on the nickel-based side of the dis-similar weld, are considered representative of a similar metal (H282-H282) weld.
	Deliverable 2.2.3 <u>Create</u>: NDT specification (similar & dissimilar welds) (supplier scope)	Intent; Define a NDT technique for dissimilar and similar castings welds, based on investigations. Comment; NDT technique for similar weld is read-across from dissimilar weld by analogy.

Proposed Process	H282 pipe to CrMoV pipe, including welding defects. Perform radiographic NDT of weld. Cut-open pipe axially and spark erode reference holes of different sizes and locations. Perform second radiographic NDT of sectioned weld. Cut-ups for Mechanical Testing Program Machine test specimens per test plan. Initiate materials test plan program.

3. Machining Trials		
Part 3.1: Nozzle Carrier Machining Trials		
760°C Turbine Requirements	Determine the optimum machining parameters for H282 nozzle carrier. Determine the machining costs for H282 nozzle carrier. Determine machining tolerances achievable.	
760°C Technology Key Deliverable List (KDL)	Deliverable 3.1.1 Perform; Machining trials Deliverable 3.1.2 Confirm; Design feasibility Deliverable 3.1.3 Confirm; Cost estimates Deliverable 3.1.4 Confirm; lead-times for planning	Milling: Demonstrate that split plane and bolt clamping surface requirements can be achieved, in terms of surface roughness and surface profile. Drilling: Demonstrate feasibility of drilling at diameter of 80 mm (3.1 in) and depth of 270 mm (11 in) with normal supply of cooling. Pre-drill to diameter 74 mm (2.9 mm) is core hole for M80 thread. Thread tapping: demonstrate feasible of thread tapping to a specific thread width or if thread milling is needed (more time-consuming). Turning: This operation should give a calculation reference for turning in the casing.
Proposed Process	Perform machining trials Report results and confirm design feasibility, costs and lead-times	

Part 3.2: Rotor Machining Trials		
760°C Turbine Requirements	Determine the optimal machining parameters for rotor with required geometry and tolerances at acceptable cost (weld prep, blade roots, sealing strip grooves).	
760°C Technology Key Deliverable List (KDL)	Deliverable 3.2.1 Perform; Machining trials Deliverable 3.2.2 Confirm; Cost estimates Deliverable 3.2.3 Confirm; lead-times for planning	Machining test of M24 threaded balancing hole using two H282 test blocks on two axis machines under real conditions to compare machining parameters with CrMoV steel materials. Identify repeatable process Identify machining parameters to achieve tolerances (cutting time, cutting speeds, etc). Thread Tapping: Demonstration of inclined and axial balance plug threads. Test M24 thread size with traditional tools and in review with manufacturer guidence. Turning; Demonstration of weld preparation machining, machining of blade grooves and seal strip grooves.
Proposed Process	Contact with machine tool suppliers. Machining trials on blocks (drilling). Machining of weld preparations.	

Part 3.3: Blade Machining Trials		
760°C Turbine Requirements	Determine the optimal machining parameters for NIMONIC 105 alloy (NIM105) to achieve minimum cost of machining. Determine the machining costs for Nim105 blade geometry.	
760°C Technology Key Deliverable List (KDL)	Deliverable #3.3.1 <u>Perform</u>; Machining trials Deliverable #3.3.2 <u>Confirm</u>; Cost estimates Deliverable #3.3.3 <u>Confirm</u>; lead-times for planning	Determine optimum cutting parameters on stand-alone machine using new cutting tools (various suppliers, macro geometry, coatings, substrate grade, etc.) Demonstrate the process capability using optimal cutting parameters identified in deliverable 3.3.1 in a manufacturing cell Optimization of overall manufacturing costs (by reducing machining times and increasing tool lifetime)
Proposed Process	Machining trial preparation, NC programming of tests, machining trial schedule. Raw material heat treatment to suitable conditions for simulated machining trials. Machining using stand-alone machine. Tool wear analysis for first cost and processing cycle estimation. Integrate milling strategy on manufacturing cell Prove the process capability, optimized cutting parameters, manufacturing cost estimations.	

Environmental Health & Safety (EHS)		
760°C Turbine Requirements	Ensure working procedures comply with EHS standards[21] Identified concern: nickel vapor and dust particles	
760°C Technology Key Deliverable List (KDL)	Deliverable #4.1.1 Create: Technical report (scope of manufacturing)	Check current applicable international standards. Check current manufacturing practice in GE. Welding of nickel-based alloys, e.g. combustion chamber materials Machining of nickel-based alloy components (e.g. blades, combustion chamber components) Perform air quality measurements as required.
	Deliverable #4.1.2 Create: Manufacturing Instruction(scope of manufacturing)	Instructions and procedures to comply with industry requirements. Modify work instructions if necessary to comply with standards.
Proposed Process	Consult cognizant GE individuals (manufacturing): Identify international standards. Summarize air quality measurements. Identify mitigation actions, if required (manufacture in enclosed chamber, air extraction, protective breathing apparatus, etc..). Write manufacturing instructions.	

In addition to the steam turbine development activities listed in Table 7-1, additional manufacturing demonstrations and testing related to the superheater and superheater outlet header were also recommended. It was not believed that a ComTest-like demonstration would be required to commercially guarantee the design of a superheater operating at AUSC

[21] The U.S. Occupational Safety and Health Administration has set the permissible exposure limit for the workplace at 1 mg/m3 per 8-hour workday. The National Institute for Occupational Safety and Health specifies a recommended exposure limit of 0.015 mg/m3 per 8-hour workday.

conditions, but the following development could improve the reliability and manufacturing of a superheater made from AUSC materials.

- Manufacturing demonstration of higher temperature superheater sections:
    - SAVE12AD and HR6W headers and tubing
    - Inconel 740H alloy and Haynes 282 alloy headers and tubing
    - Develop weld procedures for similar and dissimilar metal welds, confirm their fabrication in the shop and evaluate the strength of these welds.
    - Confirm header machining
    - Confirm header girth welds and nipple to header welds.
    - Confirm tube bending practices.
- Development of a high temperature pressure relive valve fabrication or body forging.
- Field erection and repair demonstration of T92 membrane panels
    - Develop weld procedures for T92 panel seam welds and butt welds
    - Simulate field erection for T92 panel seam welds and butt welds.
- Generate additional specimen test data for Inconel 740H alloy and Haynes 282 alloy to support the superheater outlet header development. Continue developing models and test components to simulate the performance of these alloys as the headers cycle under normal boiler operation.

The second major design element would be to complete the design, manufacture and test of a steam turbine main stop/control (MSC) valve. It was considered that the MSC valve design work completed for the sub-scale steam turbine would be leveraged to provide a valve that would be installed and tested in an AUSC ComTest facility that also incorporates the ComTest Superheater and Superheater Outlet Header. This would demonstrate the valve's behavior under cycling duty, evaluate the wear couples within the valve and provide an assessment of oxidation behavior. This test would assess the environmental effects on the valve that are not easily replicated in laboratory testing or numerical simulations and serve as proof-of-concept component validation.

However, it was recognized in 2017 that the demonstration of the valve casting and some of the operational testing objectives would be duplicated by the DOE's Supercritical Transformational Electric Power (STEP) program that is directed at the demonstration of a large scale supercritical CO_2 (sCO_2) power plant. This program would use a valve that is essentially the same as the MSC valve contemplated for ComTest. The manufacture of this valve, specifically casting the large Haynes 282 alloy valve body, and the valve's manufacture and operation would be proven, albeit in a sCO_2 environment.

In the December 2017 quarterly meeting, the AUSC Consortium reached the decision that instead of building the ComTest demonstration facility, it was more prudent that Phase 2 would instead focus on the many manufacturing challenges that were identified as part of the Phase 1 engineering efforts.

8 Summary & Conclusion

The tasks identified for Phase 1 at Youngstown Thermal and at Southern Company have been successfully completed. A test facility to support ComTest has been designed (Task 2) and the Environmental Assessment has been completed (Task 3). Significant progress was made in the design and integration of the individual AUSC components as well as understanding the constraints and challenges of procuring and manufacturing components made from INCONEL 740H and HAYNES 282 alloys.

Every project of this nature has challenges and this project was no exception. The greatest challenge has been the project cost. Largely due to the infrastructure and balance of plant equipment upgrades required, the estimated project cost was greater than budgeted. This delayed the project while options were evaluated including shifting some of the capital cost to Youngstown Thermal as well as optimizing the scope of the project. Four major configurations were explored for the "full" ComTest scope (Superheater, steam turbine and Superheater Outlet Header). Two of these configurations were at Youngstown Thermal – the first was the project's "base case" where a stand-alone plant would be constructed. The second configuration was integrating ComTest with a Combined Heat and Power Plant that was proposed to be added to the Youngstown Thermal facility. Southern Company offered two utility sites as a potential host site for ComTest. The advantages of these sites were that existing infrastructure could possibly be used to reduce the overall project cost. A comparison of these cost estimates can be found in Table 8-1, and all of these configurations were greater than the project budget of ~$75 million.

Table 8-1 ComTest Project Cost Summary

A-USC ComTest Project Cost Estimates - Overall ($ mm)				
Description	**YT (AECOM)**	**Plant A (AECOM)**	**Plant B (AECOM)**	**YT Proposal**
Phase I (Design)	$15.0	$15.0	$15.0	$15.0
Phase II (Build / Operate)				
Buy & Install	$90.7	$81.8	$78.4	$91.0
Operate	$18.7	$14.8	$14.8	$12.0
Decommission & Demo	$3.2	$3.7	$3.6	$2.5
Sub-Totals Phase II	$112.6	$100.3	$96.8	$105.5
Total Project Cost	**$127.6**	**$115.3**	**$111.8**	**$120.5**

An additional challenge was the departure of Babcock and Wilcox from the project in September 2016. This project setback was overcome by GE Power's willingness to assume the design of the ComTest superheater. Since the project could not proceed without the superheater, this was a very positive project development.

The merger of the General Electric and the Alstom Power steam turbine division created synergies which lead them to reach the conclusion that instead of building a small-scale turbine, a more practical and useful endeavor would be to validate the manufacturing technology and supplier readiness for fabricating and machining full scale steam turbine components. Consequently, GE proposed this alternate plan at the March 2017 quarterly meeting which was agreed to by the project team. The decision to delete operational testing of the steam turbine, in favor of fabrication development activities, significantly reduced the project cost. Additionally,

the project could be moved to an alternate site, containing a supercritical steam utility boiler, operated by Southern Company which would allow for testing of the main steam turbine stop and control valves at a temperature and pressure that would be similar to the conditions found at the inlet of the high-pressure steam turbine on a commercial AUSC power plant. Moving ComTest from Youngstown Thermal to a Southern Company site could further reduce the project cost due to the infrastructure already in place at the site. Due to these potential cost reductions, it was decided to move the project away from Youngstown Thermal in March 2017.

AECOM generated an estimate based on the reduced scope at Plant B. Some of the cost assumptions were under discussion with Southern Company at the time of the estimate, so a "best" and "worst" case estimate was prepared and presented below:

Table 8-2 ComTest Reduced Scope at Plant B

A-USC ComTest Project Cost Estimate - Overall ($ mm)		
Description	**Plant B (Best Case)**	**Plant B (Worst Case)**
Phase I (Design)	$15.0	$15.0
Phase II (Build / Operate)		
Buy & Install	$38.4	$43.1
Operate	$10.6	$13.8
Decommission & Demo	$1.8	$2.2
Sub-Totals Phase II	$50.8	$59.1
Total Project Cost	**$65.8**	**$74.1**

In the "best case" estimate it was assumed that there was no cost associated with the steam received from Plant B. This was because steam would be removed at high pressure from the water wall header (approximately 3865 psia and 775°F) and returned to the unit at the same conditions as the steam turbine inlet – 3515 psia and 1000°F). Therefore, there would be no loss of power associated with the use of this team by ComTest.

Unfortunately, the configuration raised concerns with Southern Company's environmental permitting group. Since steam was being withdrawn from the unit, heated with natural gas, and then returned to the unit it was possible to interpret this modification as a "new source" which could trigger a New Source Review – even though the energy being added to the steam was a very small percentage of the overall energy in the steam. Southern Company did not want ComTest to create a New Source Review of Unit 5. So initially the project team considered condensing the steam from ComTest and returning the condensate to the unit's steam system so that there would be no energy added to the steam cycle. Ultimately Southern Company decided that ComTest could not be utilize the steam from Unit 5, and ComTest would have to add a package boiler to the scope of the project.

The challenge of this configuration was that a package boiler operating at supercritical pressures in this size range isn't available commercially, so ComTest would operate at lower

pressures (<1000 psia). Because of this, it was decided by the project team in the December 2017 quarterly meeting that testing the steam turbine valves alone at this pressure and temperature did not justify the cost of the project. So, the project team decided to “pivot” to validating the manufacturing technology/supplier readiness proposed by GE Power as described in Section 7. This “pivot” basically ended the phase of the project where ComTest would be an operating power system and Phase 2 of ComTest would focus on manufacturing components to validate the readiness of US suppliers to provide commercial-scale piping, tube assemblies and components for future AUSC power plants.

9 Bibliography

1. Information regarding the Babcock and Wilcox Superheater was obtained from the following reports:

   Component Test Facility (ComTest) Phase I Engineering for 760°C (1400°F) Advanced UltraSupercritical (A-USC) Steam Generator Development Research Topical Reports (DOE Contract Number – DOE-FE0024067)

   - Task 2.0 Scope Interface Engineering
   - Task 3.1 Product Pre-Front End Engineering Design Studies
   - Task 3.2 Preliminary Commissioning and Testing Plans
   - Task 4.0 Mechanical Engineering

Appendix

AECOM Project Execution Plan

Advanced Ultra-Supercritical Component Test

Project Execution Plan (PEP)

Revision History				
Revision	Issue Date	Description	Approval	Approval Date
A	01-21-16	Issue for Review		

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1.0 - Project Execution Plan Overview

The technical goal of this project is to bring AUSC technology to a commercial scale demonstration level of technology readiness by designing, procuring, constructing and operating a Component Test (ComTest) facility that consists of a prototype R&D scale (approximately 134,000 lbs/hr steam flowrate) AUSC steam turbine and the other AUSC plant components that are needed to generate the steam to run the prototype steam turbine.

The expected results of the project will be:

- Development of a domestic supply chain for the fabrication of nickel super-alloy and other AUSC power plant components.
- Testing of nickel super-alloy and other AUSC components for at least 8,000 hours in AUSC steam conditions (temperatures over 1300°F (700°C)).
- Validation by experimentation and metallurgical analysis of advanced design and life prediction methods for nickel super-alloy and other AUSC components exposed to a both steady state and cycling operating modes.
- Validation that a prototype AUSC steam turbine can be designed, built and operated in a reliable manner under both steady state and varying load operating conditions.
- Develop and validate the fabrication, installation and repair methods for nickel super-alloy and other AUSC power plant components.
- Obtain sufficient R&D test and metallurgical analysis data to design an AUSC demonstration plant with a high probability of technical success.

The duration of this project will be 78 months, including the pre-FEED Phase of the project.

There are three sites under consideration to host ComTest:

- Youngstown Thermal (Youngstown, Ohio) – Youngstown Thermal is a district heating facility which supplies steam to its customers. Implemented at Youngstown, the ComTest will include adding a water treatment system and package boilers to produce approximately 600 psig steam at 750°F. The steam will be superheated to 1400°F in a gas fired unit designed by B&W before flowing through a steam turbine provided by General Electric.
- Southern Company's Plant A – Plant A consists of 5 operating units. Unit 5 is a supercritical unit which is being offered by Southern Company as a host for ComTest. The ComTest at Southern Company would include the high pressure components (valves, membrane walls, superheater header) and could potentially host the steam turbine test if circumstances warrant.
- Southern Company's Plant B – Plant B consists of 5 operating units. Unit 5 is a supercritical unit which is being offered by Southern Company as a host for ComTest. The ComTest at Southern Company would include the high pressure components (valves, membrane walls, superheater header) and could potentially host the steam turbine test if circumstances warrant.

The project is divided into two major components – a pre-FEED task and then the overall project execution.

The objective of the pre-FEED task will be to narrow down the site selection, generate flowsheets at each site based on the customer's requirements and collect the necessary financial and environmental information that could provide a choice for the site selection. Initially it will be assumed that the steam turbine test will be at Youngstown Thermal with the high pressure components at the two Southern sites. After evaluating these configurations and choosing one of the Southern sites for the HP test, the evaluation of the cost of implementing the steam turbine at the Southern site(s) will be evaluated and compared to the cost of implementing the test at Youngstown Thermal. This will allow for a final site selection.

The goals of the overall project will be achieved by first performing the Front End Engineering Design (FEED) and Detailed Engineering (DE) design studies based on the selected sites for the AUSC components and other ancillary equipment such as the boiler feedwater heater, the steam generator, and the process control system needed, The scope of work in Phase I includes the Front End Engineering Design and the environmental permitting work for NEPA, the construction and the operation phase.

There will be nine (9) major technical tasks of this project in addition to Project Management and Planning (Task 1). Technical Tasks 2 through 6 will be conducted in Phase I of the project. Tasks 7 through 10 will be conducted in Phase II of the project.

- Task 1 is the Project Management and Planning Phase
- Task 2 will perform the Front End Engineering Design work to define the technical and engineering requirements for detail engineering design of the ComTest facilities.
- Task 3 will perform the environmental assessment to support DOE's National Environmental Policy Act (NEPA) for the ComTest facilities and determine what environmental permits and controls are required to build and operate the facilities.
- Task 4 will perform the detail engineering design and environmental permitting of the ComTest facilities.
- Task 5 will develop manufacturing sources (supply chain) based in the United States for the ComTest facility equipment, and also for commercial scale AUSC components.
- Task 6 will prepare a detailed plan, budget and schedule for Phase II of this project – procurement, construction, start-up, testing and de-commissioning of the ComTest facilities.
- Task 7 will procure the AUSC components and other ancillary equipment and systems needed for the ComTest facilities.
- Task 8 will construct the ComTest facilities; prepare start-up, operating and testing plans; train operators and maintenance personnel and complete other pre-commissioning activities
- Task 9 will commission and operate the ComTest facilities

- Task 10 will de-commission the ComTest facilities, conduct post shutdown metallurgical analyses of AUSC components, and prepare comprehensive reports on the data and results obtained from the operation of the ComTest facilities.

This Project Execution Plan (PEP) includes information relating to the project organization, execution strategy, communication management, project controls (i.e. change control, scope management, schedule management, and cost control), environmental, health, and safety (EHS) management, quality management, interface management, engineering management, procurement management, construction management, operating management, risk management, and closure management.

In addition, information pertinent to the project but either too large to include in the text or sufficiently self-contained to be a stand-alone document will also be presented as appendices.

The PEP is governed by the change control process described in Section 8. Any changes to this document must be made in accordance with these procedures.

Adherence to the PEP will be critical to achieve the ComTest program goals. Failure to execute the plan will delay project schedule, result in budget overruns, and compromise project safety and quality. Therefore, it is incumbent upon each project stakeholder to ensure that their participating project team members are conversant with and execute their work in accordance with this PEP.

Finally, the PEP is a living document that will be updated with more granular details as the project matures. Updates to the PEP will communicated to the project team, so that any changes in scope or expectations are fully understood.

2.0 - Project Charter

The ComTest Project Team's charter is to design, build, and operate a test facility for the purpose of demonstrating components operating at AUSC conditions. It is the intention of the project to demonstrate multiple components at the applicable temperatures including:

- Membrane wall
- Superheater
- Thick wall superheater header section
- Steam turbine stop and control valves
- Steam turbine

These components could be tested at either Youngstown Thermal, Plant A, or Plant B.

The specific objectives for this project include:

- The pre-FEED for the project is primarily focused on defining the flowsheet at each facility – deciding what AUSC technology will be evaluated at each facility.
- The Process Design Package will be developed during the FEED process including the process flow diagrams, heat and material balance, equipment specifications, equipment layout, Piping and Instrumentation Diagrams, Hazardous Operations review, and the cost estimate.
- Develop the Environmental Assessment(s) necessary to support the DOE's National Environmental Policy Act (NEPA) process. Work towards a successful Record of Decision (ROD) for each selected facility.
- Execute Detailed Engineering including
  - Finalize process calculations
  - Design of all foundations, structural steel, piping racks, site modifications, etc.
  - Design of all equipment necessary for the project.
  - Design and analysis of all piping required for the project.
  - Development of the electrical power system.
  - Development of the instrumentation and control system including the control strategy and process interlocks.
  - Develop commissioning, startup and construction plans.
  - Generate and issue requests for quotations of all equipment.
  - Finalize the project cost estimate.
- Develop the supply chain relationships necessary to procure the equipment required for the facility.
- Procure the equipment and bulk materials such as pipe, concrete, steel, instrumentation, electrical, insulation, etc.
- Construct the facility.
- Commissioning, startup and operation of the facility
- Report progress to DOE and all stakeholders.

In order to accomplish this Charter, the following milestones have been identified:

- Obtain all environmental permits
  - All necessary air and water permits required for construction
  - Environmental Assessment – Required for DOE Record of Decision.
- Complete the FEED Project Development Package
- Complete the Detailed Engineering
- Procurement of all necessary materials.
- Construct the facility and achieve mechanical completion
- Complete all commissioning and startup activities.
- Operate the facility to achieve the test objectives.

In addition to project execution goals, it is necessary that the project meet the expectations of the project's stakeholders. Major stakeholders identified for this project include:

- The Department of Energy
- Ohio Coal Development Office
- Energy Industries of Ohio
- The electrical utility industry
- The AUSC Consortium members
- Youngstown Thermal
- Southern Company
- AECOM

3.0 - Project Management Approach

The objective of the Project Execution Plan is to implement clear directions and priorities to successfully achieve the requirements and goals outlined in Section 2 above. The goals and priorities outlined in this plan apply to all members of the ComTest Project team, fabricators, suppliers, construction firms, and commissioning and operation team. The priorities of the project are listed in order of importance to this project:

1. Safety
2. Cost
3. Quality
4. Schedule

The project approach begins with a clear definition of the project scope (see Section 4). From the scope statement, a baseline cost estimate, schedule, and cash-flow will ultimately be developed in order to accurately track the project. Activities within the schedule will be associated with a work breakdown structure (WBS) code. In order to control both cost and schedule, each WBS element will be subject to change control to ensure that changes are evaluated and implemented in a controlled fashion.

The project will implement a staged gate process by which the documentation associated with the major milestones will be formally evaluated and approved. Approval will allow the project team to advance to the next gate and begin a new series of project activities as defined by the project schedule. The milestones are defined in Section 6.

The PEP is comprised of subsidiary plans established to address items critical to the success of the project. They will be directed by the appropriate party for Project Controls, Contract Management, Communications Management, Document Management, Engineering, Procurement, Construction, Quality, Commissioning, Operations, and Risk. The details for the different plans are outlined in the remaining sections of the PEP.

4.0 - Project Scope

The overall objective of this project is to successfully develop test facilities for the demonstration of AUSC component technologies and then demonstrate these components for approximately 8,000 hours of operation at temperatures of over 1300ºF. Therefore, the project scope will include the project oversight, design, procurement, construction, commissioning, operation, and permitting of these test facilities.

The Project consists of a Pre-FEED phase and then the main project. For the Pre-FEED phase the scope activities include:

- Task 1 – Project Management Planning - This task includes all work elements required to maintain and revise the Project Management Plan, and to manage and report on activities in accordance with the plan. It shall also include the necessary activities to ensure coordination and planning of the project with OCDO, DOE, and other project participants.
- Task 2 – Project Definition – In Task 2, a host site will be finalized for the high-pressure boiler portion of ComTest. Two candidate sites have been identified and the team will review these sites to determine the best option, then work to get a memorandum of understanding in place with the site owner. Preliminary information from the site will be collected that will support the FEED effort.

  The project team will also work with Youngstown Thermal to assess the current site and identify the modifications required to install the equipment and any possible site constraints. This includes evaluating the current environmental permits, existing utilities (natural gas, cooling water, and electrical power), the site layout and available room to locate the equipment, and how the project would interface into the existing facility.

  Subtasks include:

  - Perform pre-FEED Process Engineering of the overall ComTest facility
  - Perform pre-FEED Design Engineering of the ComTest Steam Turbine
  - Perform pre-FEED Design Engineering of the ComTest AUSC Steam Superheater and Piping Components
  - Perform pre-FEED Site Engineering.

- Task 3 – Supply Chain Assessment for AUSC Components - Task 3 involves developing a list of materials suppliers and fabricators in the USA who are most likely to have the manufacturing equipment, skill, and quality assurance systems needed to provide nickel super-alloy AUSC components and other AUSC components that are made from special creep resistant ferritic and ferro-nickel alloys.
- Task 4 – Identify the Host Site for the High Pressure Testing of the AUSC Steam Generation and Piping Components.

Once the pre-FEED is essentially complete, the project will move into the next Phase. This part of the project has also been divided into several Tasks:

- Task 1 - Project Management and Planning - This task includes all work elements required to maintain and revise the Project Management Plan (PMP) and to report on activities in accordance with the plan. It shall also include the necessary activities to ensure coordination and planning of the project with the Ohio Coal Development Office, other project participants and elected officials necessary to maintain visibility of the program. The project team will execute the project in accordance with the approved PMP. The project's management team will manage and control project activities in accordance with their established processes and procedures to ensure subtasks and tasks are completed within the schedule and budget constraints defined by the PMP. This Task includes tracking and reporting progress and project risks to the (DOE) and other stakeholders.
- Task 2 – Front End Engineering Design (FEED) of the ComTest Facility(ies) – Perform the FEED activities to define the process engineering design basis and the technical and engineering specifications for the equipment and process control systems that will be installed in each ComTest facility. The project team will conduct sufficient plant, structural, electrical and civil engineering design work to perform a FEED level cost estimate. The FEED design applies to the facility as a whole as well as the AUSC equipment (membrane wall, superheater, desuperheaters, steam headers/piping, steam turbine, steam turbine stop and control valves).

  Typical FEED deliverables include:

  - Process Flow Diagrams
  - Heat and Material Balance
  - Equipment List
  - Utility Summary
  - Emission Profile
  - Influent/Effluent Summary
  - Piping and Instrumentation Diagram
  - General Arrangement
  - Process Narratives
  - Control Logic Narratives
  - Basis of Design
  - Site Specification Document
  - Hazardous Operations Review (HAZOP)
  - Preliminary Process Control and Safety Interlock Diagrams.
  - FEED Cost Estimate (+/- 20%)

- Task 3 – Permit/Regulatory/Legal – during this Task, which will run in parallel with Task 2, all the required permits necessary for constructing and operating the facility(ies) will

be initiated and completed. The project team will determine site environmental requirements including the potential impact on existing permits and evaluate requirements for permit modification or submission of new environmental permit applications.

The project team will determine what environmental emissions control equipment and systems are required (if any) and develop the engineering data and specifications for that equipment.

The project team will develop the plan and schedule for an Environmental Assessment (EA).to satisfy the requirements of the National Environmental Policy Act (NEPA). The project team will work with the NEPA office at the National Energy Technology Laboratory (NETL) to prepare and submit to the DOE the documents needed to obtain a positive Record of Decision within a timeframe that is consistent with other key milestone dates of the project.

The project team will work with the host site(s) to obtain all permits necessary for construction and operation of the facility.

- Task 4 – Detailed Engineering – The project team will perform the following Detail Engineering design activities that are needed for the procurement, installation and operation of the ComTest facility.

  - Finalize process engineering calculations including the heat & mass balances, process flow diagrams, piping and instrumentation diagram, equipment list, motor & utilities list, final layout and general arrangement drawings, final electrical single line diagrams, and facility process control strategy.
  - Design all foundations, structural steel, piping racks, site modifications and modifications to the existing building and other structures.
  - Design and specify all of the equipment necessary for the project.
  - Design all piping required for the project. Generate the piping isometrics required for the fabrication of all piping system components.
  - Develop an electrical power plan to Electrical Code and National Fire Protection Association (NFPA) standards including the single line diagram, conduit and cable schedules, design of any necessary motor control equipment, heat tracing, and other ancillary electrical items.
  - Develop the instrumentation and control system per Electrical Code and NFPA standards for the project including the instrument loop and wiring diagrams; the specification of the control system, data historian architecture and communication system; and all instrumentation and valves.
  - Finalize process control and safety interlock diagrams.
  - Conduct and document a ComTest operability meeting with all project participants to discuss safety, commissioning planning, startup of the system, and test plan development.

- Implement findings from HAZOP review conducted during Task 2 and conduct the final HAZOP reviews.
- Finalize the construction strategy and obtain all required construction approvals, permits and licenses.
- Generate and issue Requests for Quotations (RFQ's) for all equipment items required to build the ComTest facility. Obtain and evaluate all bids, and select a preferred supplier for each equipment item.

Subtasks for Detailed Engineering include:

- Subtask 4.1: Finalize Process Engineering Design of the ComTest Facility.
- Subtask 4.2 Perform Detail Engineering Design of the ComTest AUSC Tube Membrane Wall
- Subtask 4.3 Perform Detail Engineering Design of the ComTest AUSC Steam Superheater and the AUSC Pressure Relief Valve.
- Subtask 4.4 Perform Detail Engineering on the ComTest AUSC Desuperheater
- Subtask 4.5 Perform Detail Engineering Design of the ComTest AUSC Steam Headers and Steam Piping. This will include a turbine bypass conditioning valve with temperature control. The design will include pipe support locations, forces and moments, and expansions.
- Subtask 4.6 Perform Design Engineering Design of the ComTest Steam Turbine; and the Turbine Stop and Turbine Inlet Control Valves – Produce a detailed engineering design for the AUSC steam turbine and the associated valves. The detailed engineering design of the steam turbine and turbine inlet stop and control valves will include all necessary design activities and calculations, a cross-section of the steam turbine and the inlet stop and control valves.
- Subtask 4.7 Perform Detail Engineering Design of Miscellaneous ComTest Equipment
- Subtask 4.8 Finalize ComTest Site Interface Engineering – Produce a detailed design which defines all of the interfaces between the ComTest facility and the existing facilities of the site host(s). This will include all connections to utilities such as cooling water, fuel, and instrument air. Any temporary equipment or sub-systems which will be leased to support the operation the ComTest facility will be defined in sufficient detail to allow competitive leasing contracts to be solicited.

- Task 5 – Supply Chain Development for AUSC Components – This task will begin during the pre-FEED phase of the project and run in parallel with all other tasks. The intention it to develop a list of materials suppliers and fabricators in the USA who are most likely to have the manufacturing equipment, skill, and quality assurance systems needed to provide nickel super-alloy AUSC components and other AUSC components that are made from special creep resistant ferritic and ferro-nickel alloys.

  The project team will then finalize lists of potential suppliers who has been determined to possess adequate quality and process control systems, the necessary equipment

workforce, or who can acquire the required skills and equipment in a timeframe consistent with the Phase II schedule requirements. The project team will insure that all potential suppliers on the final bidders list will have adequate traceability of materials and processes with formal "routers" or job tracking software, control of material lots from time of receipt through delivered product, traceability of calibration of inspection instruments, and radiographic certification and other appropriate certifications or licenses of inspection personnel.

- Task 6.0 – Preparation of Firm Budget, Plan and Schedule for Phase II - The project team will prepare a budget, schedule, and implementation plan for Phase II in accordance with the requirements of Tasks 7.0 through 10.0. The implementation plan will include a detailed procurement plan for Task 7.0, detailed construction plan for Task 8.0, an environmental health and safety (EHS) plan for Task 8.0, a construction quality assurance and inspection plan for Task 8.0, a preliminary operating and testing plan for Task 9.0, a preliminary EHS plan for Task 9.0, a preliminary facility decommissioning plan for Task 10.0, a preliminary plan for the analysis of operating data obtained on the AUSC components, and a preliminary plan for the metallurgical analysis of the condition of the AUSC components after decommissioning of the ComTest facility.

- Task 7.0 – Procurement and Fabrication of ComTest Equipment and Components - Using the results of Tasks 2.0 and 5.0 the project team will conduct negotiations with the selected bidders and award the equipment or materials supply contracts. After issuance of the supply contracts, the project team will conduct follow up, expediting, and plant visits to insure compliance with planned schedules and to address any problems encountered so that rapid coordination and impact to the schedule can be assessed and mitigated. The project team will also observe and participate in final inspections either at the supplier's facilities or at the ComTest site before acceptance of the procured equipment or materials, and before final approval of invoice for payment. The project team will develop special procedures as needed to monitor and control the fabrication of nickel superalloy and other AUSC components.

- Task 8.0 – Installation and Construction of ComTest Facility - The project team will install, construct and complete pre-commission activities on all components and systems of the ComTest facility in accordance with the detailed design completed in Task 4.0, the procurement and construction plans completed in Task 6.0, and the procurement and fabrication work completed in Task 7.0. Following industry practice, each system and subsystem will be verified and/or tested and certified to have been constructed per construction documents, and that the equipment (or system) has all the mechanical, process control, instrumentation and electrical interconnections to function as designed.

  The project team will develop Operation and Maintenance (O&M) procedures for the process equipment components that comprise the ComTest facility in parallel with Tasks 2, 4, 6 and 7. Operating procedures will include but are not limited to instructions for startup, normal operations, normal shut-down and emergency shut-down operations of

components and the integrated system. The subsystem manuals provided by component vendors will be incorporated into the overall plant operations and maintenance procedures, as appropriate. The project team will identify and begin training the qualified supervisors, plant engineers, equipment operators and maintenance personnel for the ComTest facility.

- Task 9.0 – Commissioning and Operation of the ComTest Facility - The project team will commission, start-up and operate the ComTest facility in accordance with the plan developed in Task 8.0. The project team will complete the training of the qualified operators and maintenance personnel for the ComTest commissioning and operating phase. The project team will complete and document specific and detailed start-up, operating, and shutdown procedures for all equipment items in the ComTest facility. The team will also develop, document and implement detailed testing and data gathering protocols for all the AUSC components. Before starting ComTest operations, the project team will review the testing and data gathering protocols with the DOE Project Officer and the AUSC Utility Advisory Committee to insure that the testing protocols will provide the data needed for design of commercial scale AUSC power plants. The project team will then implement the ComTest facility operating and testing plan.

- Task 10.0 – De-Commissioning of the ComTest Facility, Evaluation of AUSC Components after ComTest Operating Period, and Techno-Economics Study of AUSC Power Plant Technology. This Task consist of three subtasks:

  - Subtask 10.1: De-Commission the ComTest Facility - The project team will finalize and implement a final shutdown and de-commissioning plan that is consistent with the DOE's requirements for disposal of the ComTest facility equipment at the end of the project performance period.

  - Subtask 10.2: Evaluation of AUSC Components after ComTest Operating Period - The project team will finalize the plans for the analysis of operating data obtained on the AUSC components, and for the metallurgical analysis of the condition of the AUSC components after decommissioning of the ComTest facility.

    After Task 9.0 has been completed, the project team will obtain samples for metallurgical testing and analysis from each of the AUSC components in the ComTest facility. Material samples will be obtained from the components and subjected to metallurgical testing and analysis. The project team will review the operating data and metallurgical analyses on each of the AUSC components and determine the metallurgical and structural condition of each of the AUSC components. In the final scientific/technical report, the project team will provide all relevant operating data, metallurgical test data, and results of the condition assessment of each of the AUSC components in the ComTest facility.

- Subtask 10.3: Techno-Economics Study of AUSC Power Plant Technology - The project team will perform a techno-economic study on a pulverized coal power plant that operates at AUSC steam conditions utilizing the procurement and construction cost data from Tasks 7.0 and 8.0, the ComTest facility operating data from Task 9.0, and the AUSC component condition data from Subtask 10.2 to perform the techno-economic study. The project team will select an appropriate power plant size and design conditions which will include such factors as coal type and environmental emission control requirements. The project team may use the results of previous AUSC techno-economic studies as the starting point for Subtask 10.3 and will include the techno-economic study in the final scientific/technical report.

5.0 - Baseline Cost Estimate

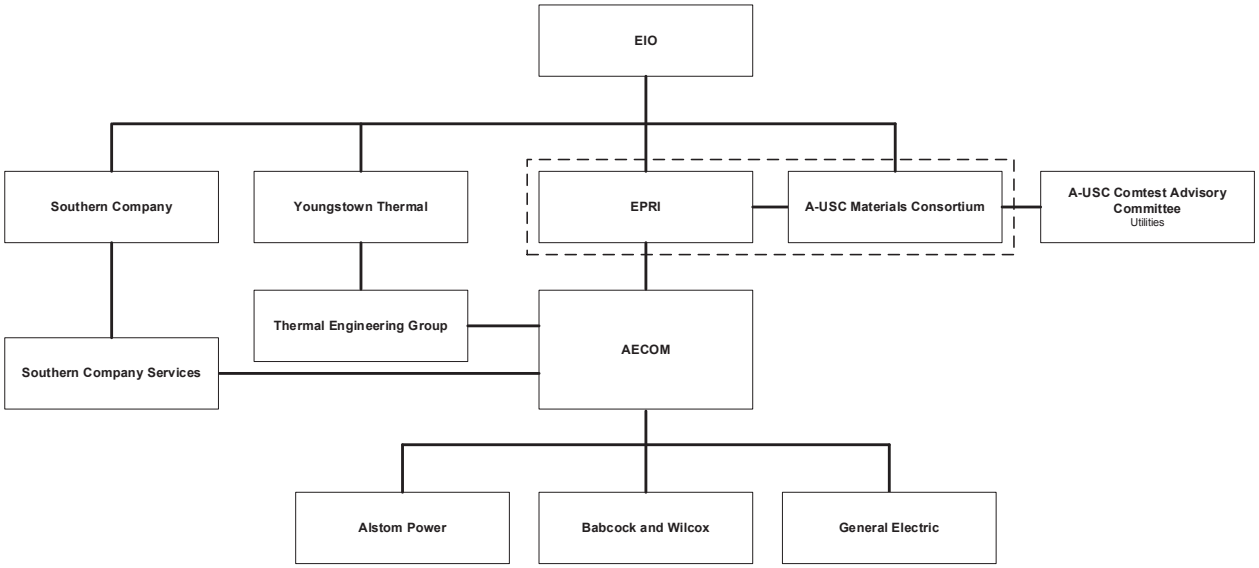
The cost estimate performed at the end of FEED will be based on the following engineering documents:

- Process Flow Diagrams
- Heat and Material Balance
- Equipment List
- Utility Summary
- Influent/Effluent Summary
- Piping and Instrumentation Diagram
- General Arrangement
- Basis of Design
- Site Specification Document
- Quotations on all major equipment including sub-components supplied by Alstom, B&W and General Electric.

And will include the facility costs categories associated with each facility including:

- Earthwork/Drainage/Pavement
- Equipment costs
- Piping
- Architecture (if required)
- Civil
- Structural
- Instrumentation and Controls
- Electrical
- Insulation
- Paint
- Engineering
- Permitting
- Construction Management
- Home office support
- Insurance
- Escalation
- Spares
- Commissioning
- Operation, including the costs required by the host facility.
- De-commissioning/demolition/restoration

6.0 - Project Organization



EIO is the overall project manager for the project. They also have the responsibility of maintaining the primary contract with DOE and all reporting. EIO is the administrative, financial, and contractual lead organization. EIO will be the primary contact with Youngstown Thermal and Southern Company. EIO will have the responsibility for developing all contracts with the host, coordinating meetings, press releases, etc. EIO will also continue in its role of being the project manager for the A-USC Materials Consortium, which is the primary technical group supporting ComTest.

The A-USC ComTest Consortium will be providing the primary support for the ComTest project. The Consortium consists of Alstom Power, B&W, GE, and EPRI who are providing cost sharing in addition to the public funding sources.

Youngstown Thermal (Youngstown, Ohio) is providing a test site for ComTest.

Southern Company has provided two potential test sites for ComTest.

The A-USC ComTest Advisory Committee is a group of utilities which will be providing technical oversight to the ComTest project. They will work directly with the A-USC Materials Consortium. Currently the Advisory Committee includes representatives from AEP, Duke, First Energy, Southern Company and Tri-State.

EPRI will be the technical project manager for ComTest and the primary point of contact for AECOM. EPRI will receive project direction from the A-USC Materials Consortium. EPRI will have the primary reporting responsibilities on the project and will supply the necessary reports to EIO as required by the DOE contract. Alstom Power, B&W and GE will communicate directly with AECOM on technical/equipment information in their scope so that EPRI does not become a “bottleneck” on the project.

AECOM is the EPC on this project. They will provide many engineering services on the project including site evaluation, piping design, electrical design, instrumentation/controls, foundations, structural, architectural, construction, estimating, etc.

Alstom Power – Alstom will supply the components for the A-USC thick-wall test component as well as a membrane wall for the superheater. They will also construct the nickel piping between the superheater and the steam turbine as well as the steam turbine bypass piping and conditioning valve. They will work directly with AECOM on the equipment within their scope.

B&W – B&W will supply the superheater/economizer to the project. They will work directly with AECOM on the equipment within their scope.

GE – GE will supply the steam turbine to the project. They will also work directly with AECOM on the equipment within their scope.

Thermal Engineering Group is the “owner’s engineer” for Youngstown Thermal. They will work directly with AECOM.

Southern Company Services is the engineering group for the Southern Company facilities and will function as the “owner’s engineer for the two proposed power plants.

AECOM, Southern Company, and Youngstown Thermal are support organizations and do not have any vested ownership or rights to the data or the outcome of the project.

7.0 – Information Management Plan (Provided by AECOM)

7.1 Purpose

The purpose of this Information Management Plan is to outline Information Management responsibilities and requirements on the AUSC ComTest Project.

7.2 Scope and Applicability

The Information Management Plan reflects AECOM requirements for compliance with the AUSC ComTest PEP, and covers (but is not limited to) the following:

- Training
- Document Numbering
- Master Document Register
- Document Distribution Matrix
- Electronic Data Interchange
- Forms
- Transmittals
- Supplier / Subcontractor documentation
- Reporting
- Handover
- Records Retention

7.3 References

AECOM Project Execution Procedures and Standards

PEP 316	Record Filing, Retention, Retrieval, and Destruction of Document
316-01(MM)	Standard Project File Index and Retention Schedule
PEP 317	Document Control and Distribution
PEP 319	Project Communications
PEP 353	Design Document Numbering System
PEP 404	Supplier Drawings & Data Identification & Review
FS-DC-002	Document Action Request Form
FS-DC-004	Document Distribution Matrix
FS-DC-007	Non-Engineering Technical Document Numbering
FS-DC-009	Aconex Meta-Data Entry Protocol
FS-DC-010	Aconex Document Types and Meta-Data
FS-DC-014	Engineering Working Document Filing Structure

7.4 Definitions

Term	Definition
Aconex	Aconex provides online project document management for construction and engineering projects, and is the electronic document management and communication application for delivering AECOM EC projects. This application is internet based and provides extensive access control and search capabilities and supports multiple versions and revisions of a document. It includes a workflow component that routes documents to specific people and organizations according to a defined set of rules. This application also can be used to generate lists, reports and transmittals.
SharePoint	

7.5 Roles & Responsibilities

Role	Responsibilities
AECOM Project Information Management Supervisor / Lead	• Oversee AUSC ComTest Project Information Management staff • Ensures that all AUSC ComTest Project documents are managed and controlled in accordance with this plan and all AECOM Project Execution Procedures and Standards for Document Management • Reports to Project Director • Ensures project information will be managed using integrated processes and effective technology so that it is accurately maintained, reliable, and accessible in a timely manner • Responsible for ensuring that all Document Management personnel are properly trained in accordance with AECOM standards, procedures, and systems • Manages and audits document deliverables and confirms adherence to AECOM standards and procedures when delivering data and documents. • Responsible for overall aspects of document management and technical business execution. • Quality assurance of data and documents • Generates advanced data queries as required. • Provides required feedback during various project reviews.

AECOM Project Information Management Specialist	• Ensures that all project documents are managed and controlled in accordance with execution plan and all AECOM Project Execution procedures and standards for Information Management. • Acts as interface between AECOM and all suppliers and subcontractors in matters related to document management • Ensures that document flow between home office and site is managed and controlled • Reports to Project Information Supervisor / Lead

7.6 Plan

7.6.1 Project Aconex Document Types

Project documents are classified in the Aconex Electronic Document Management System (EDMS) according to the list below and AECOM Document Control Standards **FSA-DC-009 Aconex Meta-Data Protocol and FSA-DC-010 Aconex Document Types and Meta-Data**

Document Type	Description	Examples
Construction	Typically a project document that has been created from a field office or pertains to field work.	FCR (Field Change Request), RFI (Request For Information), Construction Execution Plan, Construction Reports, Construction Schedule, and Progress Photos
Engineering	Any project document issued by the company, such as drawings, calculations, specifications, and data sheets	Drawings, Specifications, Reports/Studies, Lists, Data Sheets, Site Data, Surveys, Tests, Work Plans, Field Plans, Calculations, ECI (Engineering Change Instruction), Design Basis/Design Criteria documents, and other Engineering documents
Print	Document submittals (such as drawings, catalogs, specifications, manuals) originating from a Subcontractor, or Supplier	All Documents / Data from Suppliers and Subcontractors
Procurement	Includes requisitions, purchase orders & change orders, subcontracts, as well as all other documents generated by the Company	Bid and Purchasing Requisitions, Subcontract Requisitions, Bid Documents and Service Contracts
Project Document	Contract documents, project controls documents, project execution plans, project management, quality documents, reference documents, etc. created by the Company	Contracts, Project Controls, Financial, Environmental, Health, Safety, Quality, Startup, Procedures, Reference documents, Project Management, Client Non-Engineering Documents

7.6.2 Project Document Numbering

AECOM Project Documents are numbered according to the references below:

Technical documents shall be numbered in accordance with **PEP–353 Design Document Numbering System**

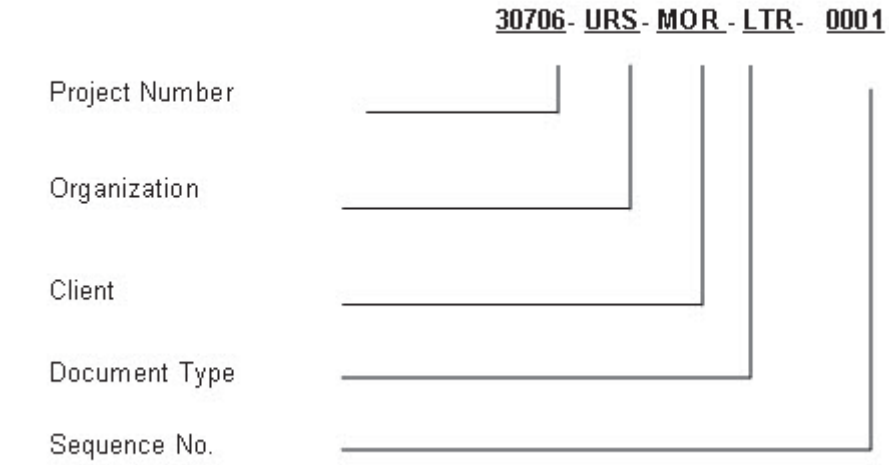
Non-Engineering documents shall be numbered in accordance with AECOM Document Control Standard Guideline **FS-DC-007 Non-Engineering Project Document Numbering**

7.6.3 Outgoing Correspondence Identification Number

Each correspondence shall include a unique identification number. The initiator shall obtain this number from Document Control. The format of the identification number shall be:

Correspondence Numbering Format

Outgoing Client Correspondence Numbering Scheme Example:



7.6.4 Document Formats

If the project chooses, Project Information Management will maintain native files / drawings in Aconex along with issued technical documents in Adobe PDF format. If the project chooses to retain native file formats, the native files shall be submitted to Project Information Management at the same time as the Adobe PDF record document.

If Project Information Management is maintaining native files, Project Information Management will reject documents if native file is not submitted with the record (PDF) document.

7.6.5 Document Distribution Matrix (DDM)

The document distribution matrix is used by the Project Information Management staff to define the distribution requirements for documents on the AUSC ComTest Project per

Document Control Standard **FS-DC-004 – Document Distribution Matrix.**

7.6.5.1 Responsibilities

- AECOM project management, discipline leads and EPRI will determine distribution requirements.
- Project Information Management is responsible for the maintenance, implementation, administration and distribution of the DDM
- Project Information Management will upload DDM distribution into the Distribution module in Aconex for quick and consistent notifications of issue

7.6.5.2 The following designations are noted in the DDM:

E=Electronic *(Enterprise Engineer)* notification
C=Hard copy of document
H=Half size drawings *(11x17)*
R=Reviewer
F=Full size drawings (when available)
O=Only when originator

Any changes to distribution or personnel must be requested to Project Information Management

See Exhibit A for DDM example

7.6.6 Document Action Request (DAR) Form

The Document Action Request (DAR) is a project specific form utilized by the project team with predefined document attributes used by the project team to provide direction to the Project Information Management staff for receiving, identifying status, issuing or distributing project documents. DAR directions include a listing of project documents attached / affected, distribution, issuance status, and / or filing instructions.

Note: There is no distribution required for the DAR. It is to be used to provide instructions to the Project Information Management staff only. Once the transmittal has been issued, the DAR should be filed in Aconex as a record of instructions.

See AECOM Document Control Standard **FS-DC-002 Document Action Request (DAR)** Form for instructions.

7.6.7 Electronic Document Management System (EDMS)

7.6.7.1 Aconex

AECOM utilizes Aconex, an electronic document management system, to manage, classify, distribute, and transmit issued project information in a secure Web-accessible environment. Aconex is considered the AECOM official project document repository on the. AUSC ComTest Project

The AECOM team is required to access the most current document versions/revisions via Aconex. Documents printed from Aconex are considered Uncontrolled.

Aconex will:

- Provide a central meta-data structured database for released engineering, procurement, supplier and procurement documents, QA/QC records, and related project correspondence
- Provide version and revision control and maintain version history for released engineering documents and supplier documents
- Provide standard information status reporting/queries for correspondence, transmittals, engineering, and supplier documents
- Allow security access level controls and permissions based on the needs of the AUSC ComTest Project Project

7.6.7.2 Email (Aconex Mail)

It is the responsibility of all project team members to ensure that project related e-mail is captured using the Aconex Mail Module.

- Email Archive Process
  - The Aconex Mail module will be utilized for all project related e-mail. It is the responsibility of the AUSC ComTest Project team to utilize the Mail Module within Aconex for all project related mail communication. Aconex will retain the correspondence and the associated correspondence threads.
  - The following is the procedure for Mail in Aconex:
    - The Aconex Mail Type is General Correspondence.
    - Each Aconex Mail **MUST** contain, at a minimum, the mandatory attributes below. These attributes must be added to the Aconex mail at the time it is created.

Aconex Attributes:	**Example**
Attribute 1	AECOM Internal Correspondence

Discipline	Civil
Subject	Design Review Notes

Each Project Mail should contain, at a minimum, these attributes. These attributes should be added to the Aconex Mail at the time it is forwarded and may appear either in the subject line or the body of the email. Aconex Mail missing either of these attributes may be returned to forwarder for correction.

7.6.8 Project Network Drive

The AUSC ComTest Project Network Drive, commonly referred to as "F:Drive", is a network storage location utilized by the program team to facilitate all work-in-progress data. The network drive is organized with a consistent file directory structure for each discipline. The organization of data under these consistent structures is the responsibility of the disciplines.

Engineering work-in progress documents are stored on the network drive per AECOM Document Control Standard **FS-DC-014 Engineering Working File Structure**.

These directories are secured by controlled access groups (ACLs) and managed by the designated IT administrator. All data is managed for fault tolerance and disaster recovery.

7.6.9 Information Security

7.6.9.1 Access Control

For security purposes, access to AECOM systems, programs, shared folders, etc., is strictly controlled. Access request forms are required for all staff requiring project folder or system access, and must be approved by AECOM IT and/or Legal (if required). Non-US citizens must provide "green card" documentation to be granted folder / system access.

The Project Information Management staff shall provide guidance on this process during the required Aconex training.

Aconex application passwords will expire every 90 days. Notifications and instructions for changing passwords will be launched in Aconex as a system notification.

The Aconex log-in screen includes a link to requesting a new password.

7.6.9.2 Project Network Drive Access Controls

The Project Network Drive for the Project is secured by controlled access groups (ACLs) and managed by the designated IT administrator. Access is granted separately by the designated IT administrator, where team members are assigned to a specific permissions group, determined by their discipline or specific role on the project.

7.6.9.3 Aconex Access Controls

Aconex security contains several layers of secure access to project documents within the Aconex environment. The assigned Access permissions dictate the ability for project team members to view information and perform tasks in Aconex.

User Roles

User Roles are predefined groups of Access Controls. Assigned User Roles determine the ability of the assigned user to perform Access Controls tasks within Aconex

The types of User Roles and permissions are:

Aconex User Roles	Permissions
Read Only	provides read only access
Standard User	allows a user to create, view and manage mail, search the document register and participate in workflows
Manager/Lead	can do all the things a standard user can do as well as initiate workflows and consolidate comments on workflows
Doc Control	user must belong to the PIM Department. In addition to Standard user and manager / lead rights this user can create confidential documents, transmit updated documents, upload single documents and create and generate bulk processing jobs
PIM Super User	Assigned only on approval from the Aconex implementation team. User can create projects, maintain metadata tables and perform all the functions that a standard user can but does not have Doc Control privileges
Coordinator	Create Cabinets, Workflows, Virtual Documents

NOTE: On AECOM Aconex, only Project Information Management staff is assigned the “Doc Control” role. All other team members will be assigned to the “Standard” or “Manager / Lead” User Role.

7.6.10 Transmittals

All project documents distributed on the Project will be accompanied by a AECOM transmittal. The transmittal will include primary distribution, AECOM internal distribution, document statuses, reason for issue, and appropriate file index codes.

Transmittals are generated automatically from Aconex at the time of document issue by Project Information Management.

Aconex guarantees delivery of transmittals and attachments and records the receipt acknowledgement(s) in the document event logs.

All AECOM Transmittals and Documents shall be submitted to the ?? Sharepoint Site immediately after generating a transmittal from Aconex.

7.6.11 Hard Copy Distribution

7.6.11.1 Hard Copy Documents

The following types of documents are filed in hard copy:

- Contract documents and documents containing original signature(s).
- Procurement/Subcontract Documents

The Procurement group shall retain the official procurement/subcontract documents until project closeout. Project Information Management maintains electronic copies of Requisitions, Requests for Proposals (RFPs), Proposals, Bid Evaluations, Purchase Orders, Subcontracts, Change Orders, correspondence, vendor data and other documents pertaining to subcontracting or purchasing on this project.

7.6.11.2 Documents Not Requiring Hard Copies

The following are types of documents that do not require that hard copies be maintained.

- Correspondence - TO/FROM client and third parties.

  These will be scanned as required and maintained in Aconex

- Logs and lists

  Purchase order (PO) and subcontract logs, equipment lists, instrument lists, drawing and spec lists. These types of documents are frequently being modified and will be maintained in Aconex

- Weekly reports and schedule updates. Weekly reports and schedule updates are maintained in Aconex

- AEA generated signed, issued Engineering documents

  These will be scanned as required and maintained in Aconex

- Supplier and subcontractor documents

- AEA reviewed, signed off electronically or manually and then scanned

7.6.12 Supplier / Subcontractor Submittals

Supplier and subcontractors shall upload their submittals with correct attributes to Aconex for review by AECOM and/or EPRI. Submittals will be reviewed per AECOM Project Execution Procedure (PEP) 404

Supplier submittal review cycle: TBD

7.6.13 Reporting

AECOM will provide document status reports per Client's request. Searches / queries in Aconex may be generated and saved at the user level.

The Master Document Register (MDR) is a listing of all officially-issued controlled project documents, generated from Aconex. The MDR reflects all project documents, drawings, reports and their associated statuses and revisions. The MDR is updated and maintained inherently, reflecting changes to the documents within the EDMS. The MDR is customizable, allowing specific queries/reports to reflect project reporting requirements.

7.7 Training

7.7.1 Training

Training for Aconex will be provided by AECOM Project Information Management and the Aconex vendor prior to use of these applications. Generally training will address;

7.7.1.1 Methods and Technology

In addition to training required in the Project Training Matrix all AECOM AUSC ComTest Project project staff members should have completed training prior to performing tasks in the AECOM information management systems. Required training, based on role, is reflected in table below.

Role	System	Training Required
End User (includes client, engineering staff, suppliers, etc.)	Aconex	End User Training (1-2 hours training class classroom)
Project Information Management (PIM) Staff		Document Controller training (2 days classroom)

AECOM Project Information Management Staff	SharePoint	Classroom training (1 Day)

7.8 Record Retention

All project documents will be retained in accordance with AECOM EC retention requirements, and PEP 316, form 316-01 (MM).

Documents will be classified and retained electronically in accordance with the Project File Index (See Attachment A).

7.9 Forms and Exhibits

Exhibit A - AUSC ComTest Project Document Distribution Matrix (DDM)

Morenci Tailing Storage Expansion Project/ Design Engineering/ Distribution Matrix

	Discipline	Type	Title	URS-Project Director Dave Eichelberger	URS-PMPEM Joe Butkovich	URS-Asst PMPEM Daniel Landers	URS Construction-CM JJ Johnson	Project Engineer Mike Seidl	Estimating Kim Bissell	URS H & S Sally Miller	URS - Q.A. Mgr Kevin Sagez	URS-Civil SDE Jason Mann	URS-Struct SDE Larry Bennett	URS-Elect SDE Bill Privratsky
12	**Civil - Jason Mann**													
		Spec.	Specifications (Surveying, Pond Liner, Railroad)					ECH			R			
		DWG	Plot Plan / Civil Site Plan					ECH			R			
		DWG	Site Preparation					ECH			R			
		DWG	Site Grading and Drainage					ECH			R			
		DWG	Fencing					ECH			R			
		DWG	Misc Site Work Details					ECH			R			
		Estimate	MTO					E						
		Model	3D Modeling Plant Layout					E						
		Calc	Drainage, Sanitary Sewer and Pavement Thickness					E						
		DWG	Vendor Data					ECH			R			
13	**Structural - Larry Bennett**													
		Spec.	Specifications		R		R	ECH			R	R	F	
		DWG	Structural Steel		R	R	R	ECH			R	R	FH	R
		DWG	Concrete		R	R	R	ECH			R	R	FH	R
		Calc	Structural Steel Calculations										F	
		Calc	Structural Concrete Calculations										F	
		DWG	Structural Steel Shop Drawings (Vendor)								R		FR	
		DWG	Rebar & Embed Shop Drawings (Vendor)								R		FR	
		Study	Geotechnical Investigation Report (Vendor Supplied)									R	FR	
		DWG	Vendor Data											
15	**Mechanical - Bob Cahill**													
		Spec.	Specification - Mechanical Equipment/Technical					E			R		R	R
		List	Mechanical Equipment List								R		CH	RCH
		Datasheet	Mechanical Equipment Datasheets								R		CH	RCH
		DWG	Mechanical Equipment Arrangement (MEA) - Preliminary Vendor Dwgs		CH						R		CH	RCH
		MRQ	Material Requisition for Quotation (MRQ)		RCH	RCH					R			CH
		Bid	Vendor Proposals (Only if we do Procurement)								R			
		TBAS	Technical Bid Analysis Summaries - (Only if we do Procurement)		CH						R			

Page

8.0 - Project Controls

8.1 Project Controls Overview

The AUSC ComTest Project Project Controls team is responsible for providing cost/schedule progress and performance data, analysis and reporting to the Project Management team in accordance with the established project control baselines. Project Control responsibilities are defined by AECOM Energy & Construction Project Execution Procedures (PEP's) and span the project life cycle as defined by the Scope of Work and Contract. Project Controls responsibilities include:

- Work Breakdown Structure (WBS) Development and Maintenance
- Planning and Scheduling
- Progress and Performance Measurement
- Cost Analysis and Forecasting
- Change Management
- Internal and Client Reporting

8.1.1 Applicable Procedures and Standards

The following AECOM procedures will be utilized on the project.

- AECOM PEPM 300 - Work Breakdown Structure
- AECOM PEPM 301 - Estimating
- AECOM PEPM 302 - Planning & Scheduling
- AECOM PEPM 305 - Progress and Performance Measurement Progress Measurement
- AECOM PEPM 307 & 308 - Internal Project Status Reporting Client Status Reporting
- AECOM PEPM 312 - Cost Analysis and Forecasting
- AECOM PEPM 314 – Change Control

8.2 Project Controls Systems

The following web-based systems will be utilized to support the Project Control functions on the

Table 8.2-1-Project Control Tools

System Name	Purpose	IT Environment
PRISM	Integrated project management software applications designed to provide project information, and Earned Value reporting. PRISM integrates project planning data with Primavera, and provides a single source data entry and data integrity. It also integrates actual and committed financial /accounting data with project budget data for forecasting and reporting. Physical Progress Measurement (%), Progress Curves	AECOM CITRIX
Primavera 6	Project Scheduling	AECOM Citrix
CAES, Excel	Estimating	AECOM
Oracle	Project Accounting	AECOM
Deltek	Personnel Time Collection (NON-CRAFT)	AECOM
Oracle	Project Accounting	AECOM

8.3 Work Breakdown Structure

The Work Breakdown Structure (WBS) for the project is included in Attachment A.
WBS Structure will differentiate by discipline between:

- Pre-FEED/FEED
- Detailed Design
- Construction
- Startup Activities

The AECOM-EC Corporate Standard Code of Cost Accounts will be utilized on the AUSC ComTest Project.

8.4 Planning and Scheduling

8.4.1 Schedule Levels and Development

AECOM project team in close coordination with Client team would develop the following schedules for the AUSC ComTest Project.

- Project Milestone Schedule (Level I) - A list of the major milestones of a project with their corresponding scheduled dates (refer to exhibit B). This is normally illustrated in Bar Chart format.

- A list of the major milestones of a project with their corresponding scheduled dates. This is normally illustrated in Bar Chart format.

- Project Summary Schedule (Level II) - A Summary Project Schedule that identifies the major activities, interface points, and duration estimates for the completion of the project. - A Summary Project Schedule that identifies the major activities, interface points, and duration estimates for the completion of the project.
- Project Master Schedule (Level III) - A Detailed Project Schedule that expands the Level II schedule to specifically identify project activities and their associated logic ties (refer to PEP 302, Form 302-03 (S)) - A Detailed Project Schedule that expands the Level II schedule to specifically identify project activities and their associated logic ties (refer to PEPM 302 .)
- Working Schedule (Level IV) - An expansion of the Level III schedule that represents detail at the deliverable level. - An expansion of the Level III schedule that represents detail at the deliverable level.

8.4.2 Scheduling Procedure and Processes

TBD

8.5 Budgeting and Forecasting

8.5.1 Budgeting and Forecasting

The project cost control baseline will be established in PRISM.

Key elements of the cost monitoring process include the following:

- Overall project cost will be reported / forecasted on a monthly basis.
- AECOM Direct & Cost analysis and forecasting responsibilities will include the following:
- Project Controls Lead will establish an agreed upon Performance Measurement Breakdown into manageable elements per the WBS and Cost Code.
- Project controls lead (or designee) will input original approved budget into PRISM.
- Project controls lead (or designee) will collect all monthly project cost data, actual costs, commitments, and estimated invoices (accruals), as required.
- Project controls will review and cost-code all source documents, such as purchase orders, time cards, subcontract pay estimates, approved change orders, and internal change orders.
- Project controls will incorporate approved change orders into performance baseline for inclusion in the monthly analysis.
- Project controls will prepare the monthly project cost report and submit it to project management for review.
- Project controls will perform periodic forecast updates. After review and approval by project management, the revised forecast will be incorporated into the project cost report.

8.5.2 Progress & Performance

Project performance will be measured by dividing the Scope of Work into controllable elements that will allow adequate performance visibility to effectively manage the project. For the AUSC ComTest Project this includes controlling the major elements of scope.

Performance measurement data (actual and forecast deliverables/quantities and work is transferred to the Project Cost Report for use in additional project status analysis and reporting on a monthly basis.

8.5.2 Change Management Procedure

Any change in scope after establishing the Control Budgets and Schedules will be processed by in accordance to AECOM's PEPM 314. All Field Potential Deviations (314-02 (M)), Change Notices (314-03 (M)), and Change Orders (314-04 (M)) will follow PEPM 314.

8.5.3 Master Change Management Log

The Master Change Management Log (314-11 (S)) is a spreadsheet that identifies, tracks, and reports the status of all project deviations and change categories. The log includes man-hour impact for labor and cost impacts due to material or other costs resulting from changes.

8.5.4 Change Control Meeting (CCM)

Change Control Meetings will be scheduled and led by either the Site Manger and/or the Project Controls lead. Change Control meetings for the AUSC ComTest Project will be held weekly.

9.0 - Environmental, Health and Safety Management

The project leadership has adopted a zero incident target for this project – zero recordable and lost time safety incidents and zero environmental incidents. Safety is the responsibility of all team members. Achieving this target will involve considerable management attention to safety. The purpose of the Environmental, Health and Safety Plan is to ensure that the safety and health of plant personnel, contractor personnel and visitors is of primary importance through the establishment of safe procedures. The plan will include all the health, safety, and environmental programs and procedures required for project execution. The plan will incorporate a behavioral based safety program with elements of continuous improvement. An equally important element of the EHS management is Process Safety; that is to guide and ensure the safe development of the process during the design phase. This is accomplished by adopting safe design practices and adherence to process safety standards.

9.1 SH&E Plan

A site specific Environmental, Safety and Health Plan will be developed and maintained by the Safety Manager incorporating the client's requirements and the applicable regulatory requirements. The ES&H Plan will be reviewed and approved by the client. The Safety Plan will be maintained in the project files under file code 18.001 F. Any changes to the Plan will be communicated to the Company and subcontract employees.

9.2 Substance Abuse Program

The [Safety Manager or client] will establish a substance abuse program for all Company and subcontractor employees working on the project. The [Safety Manager or client] will maintain a log of all persons having undergone substance abuse testing. The substance abuse testing will be performed by [Supplier Name].

9.3 Safety Incentive Program

A project safety reward and incentive program will be established by the Safety Manager. [Describe the program either below or as a reference to the ES&H Plan]

9.4 Training

An ES&H Training program will be established for the project. The training will include [safety orientation, hazards communication, task specific training, tool box training and competent and qualified persons training]

9.5 Monitoring

The Safety Manager will monitor project activities undertaken by Company and subcontractor employees to ensure compliance with the ES&H Plan and will direct corrective and preventive actions to ensure a safe work environment.

9.6 Reporting

The Safety Manager will generate and maintain reports and records for the following: [daily safety log, weekly and monthly safety reports, lockout/tag out, Incident investigations, OSHA monthly safety report, safety meetings safety inspections, others]

9.7 Incident Investigations

The Safety Manager along with appropriate others will conduct an incident investigation when required and issue a report of the findings to the project team. The Project Manager and Safety Manager will verify the implementation of all corrective and preventive actions taken as a result of the investigation.

9.8 Safety Audits

The Safety Manger will conduct or coordinate the conduct of ES&H audits both internal and from sources outside the project.

10.0 - Quality Management

The purpose of the Quality Management Plan is to ensure that structures, systems, and components delivered are safe, reliable, operable, and well documented. Quality is an overarching function affecting Engineering, Procurement, Fabrication, Construction, and Commissioning. The project team's goals include the evaluation of performance as it relates to quality and the identification and correction of problems throughout the project-lifecycle.

10.1 QA/QC Plan

A Quality Assurance/Control Plan (File Code 17.001 F) will be developed and maintained by the [Project Quality Manager]. The plan is intended to define all of the activities conducted under the leadership of the [Project Quality Manager] and will be developed in alignment with [Form 480-01 (S)]. This includes all of the following as required by the Company Quality Manual, contract requirements and services provided:

10.2 Supplier/Subcontractor QA/QC Plans

All subcontractors and suppliers will be required to submit a QA/QC Plan, which will be reviewed and approved by the [Quality Manager and Construction Engineer or Design Engineer as applicable]

10.3 Equipment and Material Criticality Review

The Quality Manager along with design personnel and procurement personnel will review the project engineered equipment and materials to determine the criticality of the item and establish the level of surveillance required.

10.4 Audits and Surveillances

Internal audits will be conducted to verify the project team's compliance with the Project Execution Plan and Project QA/QC Plan.

Audits will be conducted on suppliers and subcontractors to confirm compliance to their approved QA/QC Plans.

Based on the criticality review, surveillances of suppliers and subcontractors will be conducted.

All planned audits and surveillances will be identified in the Project Audit and Surveillance Plan. The Plan will be maintained and updated with the current status on a monthly basis in the project files under file code 17.020 F.

10.5 Personnel Qualifications and Certifications

The Quality Manager will maintain qualification, certification and training records of personnel engaged in audits, surveillances, inspections and welding or other special processes as required by [the contract].

10.6 Measuring and Test Equipment Calibration

A log of all measuring and testing equipment used by the Company will be maintained by the [Quality Manager or Construction Engineer]. The log shall be maintained in the project file under file code 17.020 F.

10.7 Inspection and Test Plan

An Inspection and Test Plan will be developed from the project specifications and code requirements identifying all required inspections and tests. The Plan will be updated on a monthly basis to reflect the current status of all required inspections and test. All inspection and test documentation will be maintained in the project file system by the Quality Manager by equipment number.

10.8 Quality Checklists

All Company inspections and tests will be documented using Company appropriate standard quality checklists for the system or type of equipment inspected. All inspection and test documentation will be signed off by the [Quality Manager, Field Supervisor, and client representative].

10.9 Non-Conformance Reporting

Non- conformances to design documents will be documented in a Non-Conformance (NCR) report. The report will identify the non-conformance and require the responsible party to develop a corrective action plan so cost can be accumulated in a structured manner. The Quality Manager will maintain all NCR documentation and develop and maintain a NCR log to track the status of each. The NCRs and log will be maintained in the project file under file code 17.051 F.

10.10 Quality Trending and Status Reports

On a monthly basis the Quality Manager will produce the following quality trending and status reports: [List the reports that will be generated]

[weld reject rates; NCRs; inspection and test status, audit and surveillance results]

11.0 - Communications Management

11.1 Project Kickoff Meeting(s)

A project kickoff meeting will be conducted during the FEED phase of the project. The kickoff meeting will include discussions on the scope of work, key contract requirements, the execution strategy, milestone schedule, budget and charge code structure. The meeting will be chaired by the Project Engineering Manager and attendees will include all key project team members and the client.

11.2 Project Execution Plan

The project execution plan (PXP) will be reviewed by the project team and commented on during the FEED phase.

11.3 Risk and Opportunity Assessment

Key project team members will review the risks identified during the Pre-FEED/ FEED phase and evaluate other potential risks and opportunities. Risk and Opportunities will be captured in a project risk plan. The Project Manager and key team members will revisit the Risk Plan on a monthly basis to ascertain the status of previously identified risks and identify any new risks or opportunities.

11.4 Bi-Weekly Schedule Review/Coordination Meeting

A bi-weekly schedule review/coordination meeting will be conducted with the Project Control Manager and other key team functions to discuss the status of activities and issues impacting the status. The meeting will be chaired by AECOM. Meeting minutes with identified action items (including responsibility and target completion date) will be prepared, distributed to the team as appropriate and retained in the project records.

11.5 Monthly Project Review Meeting

A monthly project review meeting will be conducted with key team members as appropriate. The purpose of the meeting is to inform the client of the status of the project and any issues having an impact on the achievement of defined project goals.

11.6 Internal and External Communications

Project communications will be divided between internal communications within the team and external communications between the team and the client, stakeholders, suppliers and subcontractors.

A multi-level client engagement plan will be developed and implemented by the project team. The purpose is to ensure that a set of communication channels have been established, built on trust and mutual understanding that will enable timely resolution of issues. The plan requires the

pairing of personnel at comparable levels in the client and AECOM organizations, and encouraging direct, open and “off the record” communications between the team and stakeholders.

One of four methods will be deployed by the team depending upon purpose and recipient. They include:

- Hard copy mail: May be used between the team and external companies for both transmittal and receipt of information or for providing direction using the contract forms or appropriate PEP form.
- Aconex mail: Will be used for document management and project collaboration; to transmit documents and to issue / receive formal direction and design input.
- Electronic mail: Will be used for general communications. Email will NOT be used to issue / receive formal direction and design input or to provide formal direction to subcontractors and suppliers. The appropriate contract documents will be used to give or receive direction.
- Collaborative shared drive: May be used between the team and external companies for both transmittal and receipt of information or for providing direction using the appropriate contract.
- Verbal: Used as a general communication between the team and external companies, but not to give or receive directions. Verbal communications can be used to give directions internally within the project team from the manager to a subordinate. Significant verbal communications will be documented by the participating team member, distributed to all participants as well as to project management as appropriate and filed in the project files.

12.0 – Engineering Plan (To Be Further Developed or eliminated)

The Task Coordination Matrix for the Project is shown below:

For Pre-FEED:

Task	AECOM	Alstom	B&W	EIO	EPRI	GE	SCS	SoCO	TE	YT		Notes
1.0 - Project Management and Planning												
1.1 Develop and Maintain Project Management Plan	L	S	S	L	L	S	S	S	S	S		AECOM/EPRI will develop the plan, with EIO guidance and interface with DOE. All parties support and provide input.
1.2 Develop Plan and Project Organization for Phase II	L	S	S	S	L	S	S	S	S	S		AECOM/EPRI/EIO will develop with all providing input, including YT on site host agreement.
2.0 Pre-Front End Engineering for AUSC Steam Turbine Component Test (ComTest)												
2.1 Perform Pre-FEED Process Engineering of ComTest	L	S	S		L	S	S		S			AECOM will be lead under EPRI's guidance. Each supplier will provide process support.
2.2 Perform Pre-FEED Design Engineering of ComTest Steam Turbine	S				S	L						GE will lead and provide the thermodynamic data for the steam turbine design. EPRI and AECOM will support on interface issues.
2.3 Perform pre- FEED Design Engineering of ComTest AUSC Steam Generating and Piping Components	S	L	L		S							B&W will lead on design for fired superheater. Alstom will lead on design of piping, desuperheater and cycling header. AECOM and EPRI will support on interface issues.
2.4 Perform pre- FEED Site Engineering	L				S		S	S	S	S		AECOM will lead with input and review by TE and YT and review by EPRI
3.0 Supply Chain Assessment for AUSC Components		S	S	L	L	S						EPRI and EIO will lead the supply chain effort with support from all component suppliers
4.0 Identification of a Host Site for High Pressure Testing of AUSC Steam Generation and Piping Components	L	S	s		L	S						AECOM and EPRI will lead with input from each supplier.
Reporting												
Periodic Progress Reports	S				L							EPRI will lead all reports, supporting roles assumed depending on task.
Project Management Plan	S	S	S	S	L	S	S		S			
Final Technical Report	S	S	S		L	S	S	S	S	S		

For the Project:

Task	AECOM	Alstom	B&W	EIO	EPRI	GE	SCS	SoCO	TE	YT		Notes
1.0 - Project Management and Planning												
1.1 Develop and Maintain Project Management Plan	L	S	S	L	L	S	S	S	S	S		AECOM/EPRI will develop the plan, with EIO guidance and negotiations with DOE. All parties support and provide input.
1.2 Monitor and Report Progress on the Project Management Plan	L	S	S	L	L	S	S		S			EIO will monitor budget. AECOM/EPRI will monitor technical progress with input from all and provide to EIO for reporting to DOE.
1.3 Develop Plan and Project Organization for Phase II	L	S	S	S	L	S	S	S	S	S		AECOM/EPRI/EIO will develop with all providing input, including YT on timing of construciton
2.0 Front End Engineering Design (FEED) of the ComTest Facility												
2.1 Perform FEED Process Engineering on the ComTest Flowsheet	L	S	S		S	S	S		S			AECOM will lead. Each supplier will provide process support.
2.2 Perform FEED Engineering on the ComTest AUSC Tube Membrane Wall	S	S	L									B&W will lead and provide the design. Alstom will advise on fabricability as they will eventually fabricate the wall. AECOM will support on interfaces with existing YT facilities and utilities.
2.3 Perform FEED Engineering on the ComTest AUSC Steam Superheater and the AUSC Pressure Relief Valve	S	S	L									B&W will lead, AECOM support. Alstom support on interface issues related to their components.
2.4 Perform FEED Engineering on the ComTest AUSC Desuperheater	S	L										ALSTOM will lead, AECOM support. The actual design work will be carried by Alstom under a separate contract with DOE (thick-walled cycling header)
2.5 Perform FEED Engineering on the ComTest AUSC Steam Headers and Steam Piping	L	S										AECOM will lead the design of the steam piping. Alstom will advise on fabrication.
2.6 Perform FEED Engineering on the ComTest Steam Turbine and Stop, Bypass and Turbine Inlet Control Valves	S					L						GE will lead the steam turbine and valve design. AECOM will support by interfacing to the rest of the design.
2.7 Perform FEED Engineering on the Miscellaneous ComTest Equipment	L				S							AECOM will lead on all necessary "non-AUSC" equipment to support ComTest. EPRI will review for consortium.
2.8 Perform ComTest Site Interface Engineering	L						S		S			AECOM will lead on all site interface engineering. TE will act as YT's "owner's engineer"

Task	AECOM	Alstom	B&W	EIO	EPRI	GE	SCS	SoCO	TE	YT		Notes
2.9 Complete Assesment of Supply Chain for AUSC Components	L	S	S	L	L	S						AECOM, EPRI, and EIO will lead on this. All equipment suppliers will provide support as appropriate.
2.10 Develop preliminary process control system and safety interlock diagrams	L	S	S		S	S	S		S			AECOM will lead with input/review by the others.
2.11 Develop FEED level Cost Estimate, Plan and Schedule for Phase II	L	S	S	L	L	S	S	S	S	S		See details below.
Cost Estimate	L	S	S			S	S		S			AECOM will lead the cost estimating effort. All suppliers will provide input. TE will provide guidance on site interace requirements.
Plan and Schedule for Phase II	L	S	S	L	L	S	S	S	S	S		AECOM/EPRI/EIO will create plan and schedule with input from all.
Identify items which need to be purchased for testing/validation during the Detailed Phase	S	S	S		L	S	S		S			Additional step recommended for inclusion by Alstom
3.0 Environmental Assessment for Phase II	L			S	S		L	S	L	S		AECOM will write the EIS with input from TE and YT. TE manages technical aspects of YT's permits. EIO and EPRI will support.
4.0 Detailed Engineering and Environmental Permitting												
4.1 Finalize Process Engineering Design of the ComTest Facility	L	S	S		S	S	S		S			AECOM will lead. Each supplier will provide process support.
4.2 Perform Detailed Engineering Design of the ComTest AUSC Tube Membrane Wall	S	S	L									B&W will lead the design, AECOM and Alstom will support.
4.3 Perform Detailed Engineering Design of the ComTest AUSC Steam Superheater and the AUSC Pressure Relief Valve	S		L									B&W will lead, AECOM support.
4.4 Perform Detailed Engineering on the ComTest AUSC Desuperheater	S	L										ALSTOM will lead, AECOM support
4.5 Perform Detailed Engineering of the ComTest AUSC Steam Headers and Steam Piping	L	S										AECOM will lead the design of the steam piping. Alstom will fabricate.
4.6 Perform Detailed Engineering Design of the ComTest Steam Turbine and Stop, Bypass, and Turbine Inlet Control Valves	S					L						GE will lead the steam turbine and valve design. AECOM will support by interfacing to the rest of the design.
4.7 Perform Detailed Engineering Design of Miscellaneous ComTest Equipment	L											AECOM will lead on all necessary "non-AUSC" equipment to support ComTest.
4.8 Finalize ComTest Site Interface Engineering	L						S		S			AECOM will lead on all site interface engineering. TE will act as YT's "owner's engineer"

Task	AECOM	Alstom	B&W	EIO	EPRI	GE	SCS	SoCO	TE	YT		Notes
5.0 Supply Chain Development for AUSC Components	L	S	S	L	L	S						AECOM, EPRI, and EIO will lead on this. All equipment suppliers will have a vested interest.
6.0 Preparation of Firm budget, Plan and Schedule for Phase II	L	S	S	L	L	S	S	S	S	S		AECOM will lead the cost estimating effort. All suppliers will provide input. TE will provide guidance on site interace requirements. EPRI will lead on operating & testing plan. TE and YT will support AECOM on EHS plan.
7.0 Procurement and Fabrication of ComTest Equipment and Components	L	S	S			S						AECOM will lead the overall procurement effort. All suppliers will procure the components for their subsystems.
8.0 Installation and Construction of ComTest Facility	L	S	S			S	S	S	S	S		Assuming AECOM will lead the construction effort. All suppliers as well as TE and YT will support.
9.0 Commissioning and Operation of the ComTest Facility	S	S	S		S	S	S	L	S	L		Assumes operating labor will be by YT, so they will have the lead on this effort. All parties will support.
10.0 De-Commissioning of the ComTest Facility, Evaluation of AUSC Components after ComTest Operating Period, and Techno-Economics Study of the AUSC Power Plant Technology												
10.1 De-Commissioning of the ComTest Facility	L	S	S			S	S	L	S	L		Assuming AECOM will either perform the de-commissioning or subcontract it out. YT will lead due to being their site. TE to support YT. Assuming that Alstom, B&W and GE will want their components back, so will be involved.
10.2 Evaluation of AUSC Components after ComTest Operating Period		L	L		L	L						Alstom, B&W and GE will do the evaluations. EPRI will serve as technical lead.
10.3 Techno-Economics Study of AUSC Power Plant Technology	S	S	S		L	S						EPRI will lead, will get cost, construction inputs from participants.
Reporting												
Periodic Progress Reports	S				L							EPRI will lead all reports, supporting roles assumed depending on task.
Pre-FEED Report	S	S	S		L	S						
FEED Report	S	S	S		L	S						
Detailed Engineering, Environmental Permitting, Supply Chain and Phase II Planning Report	S	S	S	S	L	S	S		S			
Procurement, Fabrication, Installation and Construction report	S	S	S		L	S	S	S	S	S		
Final Technical Report	S	S	S		L	S	S	S	S	S		

13.0 - Procurement Management

13.1 Purchasing

13.1.1 Equipment, Component and Material List

A project equipment, component and materials list will be developed to identify equipment, component or materials to be purchased. At a minimum, the list will identify a tag no. if applicable; name of the equipment, component or material and which stakeholder [client or AECOM] is responsible for procurement of the item(s). The lists will be maintained mutually by Engineering and Procurement and kept in the project files.

13.1.2 Procurement Responsibility Matrix

The project will develop a Procurement Responsibility Matrix using Form 202-05 (MM) which will be attached to this Project Execution Plan.

13.1.3 Client Recommended suppliers

[Provide a list of suppliers and what they can supply]

13.1.4 Special or site contractual requirements

[Document herein any special contract or site requirements that will affect suppliers and the terms and conditions of the purchase order.]

13.1.5 Expediting

Certain equipment and materials will require expediting services by AECOM. The items requiring expediting are listed on the Purchase Order Log list previously mentioned in paragraph 15.1.1. The list will be updated monthly as addition expediting services may be required. The person performing expediting duties will maintain records in the purchase order files and will report the status of the effort.

13.1.6 Logistics and Transportation

Certain equipment and materials will require logistical and transportation support by AECOM. The items requiring support are list on the equipment, component and materials list previously mentioned in paragraph 15.1.1. The list will be updated monthly as addition support services may be required. The person performing support will maintain records in the purchase order files and will report the status of the effort..

13.1.7 PO Administration

The Procurement and Materials Management Manager is responsible for the administration of the purchase orders. This includes the execution of change orders, back-charge documentation and closeout at completion of the agreement.

13.1.8 Documentation

All purchase order information will be retained in individual purchase order files.

13.2 Subcontracts

13.2.1 Subcontracts List

A project subcontract list will be developed to identify all of the subcontracts to be executed by AECOM to perform certain project tasks. At a minimum, the list will identify the subcontract with a brief scope. The list will be maintained by Procurement and kept in the project files. The list will be updated on a monthly basis as required and the P&MM Manager will report the status..

13.2.2 Client Recommended subcontractors: [Provide a list of contractors]

13.2.3 Special or Site Contractual Requirements

[Document herein any special contract or site requirements that will affect-subcontractors and-the terms and conditions of the subcontract agreement.]

13.2.4 Subcontract Administration

The Procurement and Materials Management Manager is responsible for the administration of the purchase orders. This includes the execution of change orders, back-charge documentation and closeout at completion of the agreement.

13.2.5 Documentation

All Subcontract information will be retained in individual purchase order files under file code 14.010 F.

13.3 Procurement of Nickel Components

At the end of FEED, all suppliers shall provide estimates of quantity of nickel alloys required to fabricate their components to AECOM. AECOM shall tabulate these quantities and provide them to EIO who will order the materials in bulk form (ingots, tubing, etc.) which will be stored at the alloy supplier. These quantities will be updated as the project proceeds through Detailed Engineering.

As the purchase orders of the nickel components are generated, it will be specified in the P.O. terms and conditions that the nickel materials for these components will be supplied from this

inventory. EIO will work with the alloy supplier to deliver the appropriate quantity of nickel material to each manufacturer.

14.0 - Construction Plan

Construction Management will be executed by the AECOM or its subcontractors. The detailed plan for construction management will be finalized during Detailed Engineering. It is important that the construction management team interfaces early with the project team and the host sites engineering to assist in developing a constructible design. Site construction will be governed by the project construction plan. The construction plan will cover construction mobilization, construction permits, craft labor management, construction equipment, tools and consumables management, sub-contractor management, contract management, site HSE and security management, quality control and assurance, and construction site closeout. Once the detail plan is developed, it will be included in this PEP.

14.1 Design Interface

14.1.1 Constructability

Beginning early in the design phase of the project, construction personnel will be assigned to participate in design reviews and to review the design for potential constructability issues. These issues will be documented in the Company Knowledge Management database on the Source and tracked until included in the design documents.

14.1.2 Work/Bid Packages

The project team will identify the sequence of construction and ensure the design information is packaged into work or bid packages to support the construction schedule. The packaging strategy will be defined in the project master schedule.

14.1.3 Request for Information (RFI)

An RFI process will be established for the project as a means to resolve design related questions. All subcontractors will establish an RFI process for questions or issues that they need resolved. All RFIs will be logged and tracked to closure. The log will be maintained by the Field Engineer.

14.1.4 Engineering Change Instructions-{ECI)

An ECI process will be established for the project as a means to document required design document changes after they have been issued for purpose. All ECIs will be logged and tracked to closure. The log will be maintained by the Design Engineer.

14.2 Construction Site

14.2.1 Site Layout

A site layout plan/drawing will be prepared to define existing and future facility/structures, parking areas, laydown areas, warehousing, security fencing, temporary power and gates,

drainage, subcontractor office and laydown space, crane set up areas and any other site requirement.

14.2.2 Site Conditions/Facilities/Services

[Describe the site conditions; and available facilities and services. Also describe what facilities or services have to be developed during mobilization]

14.2.3 Security

The Construction Manager will develop a site security plan that identifies required gate and access control, gate security and time clocking of trade personnel, and security guards.

14.3 Site Material Management

14.3.1 AECOM Supplied Materials

Materials purchased by AECOM for installation by direct hire labor will be received, and inspected by QA and/or Field supervision. Materials needed for immediate installation/erection will be formally received by Field Supervision. Materials not ready for installation/erection will be stored on site in a [laydown area or warehouse].

When needed for installation/erection the materials will be formally received by Field Supervision for installation/erection. The status and location of all materials received and formally issued to the Field Supervision will be tracked using [SmartPlant Materials]

14.3.2 Client Supplied Materials

Materials purchased by the Client for AECOM use will be received, and inspected by QA and/or Field supervision. Materials needed for immediate installation/erection will be formally received by Field Supervision. Materials not ready for installation/erection will be stored on site in a [laydown area or warehouse]. When needed for installation/erection the materials will be formally received by Field Supervision for installation/erection. The status and location of all Client supplied materials received and formally issued to the Field Supervision will be tracked using [SmartPlant Materials]

14.3.3 Subcontractor Materials

14.3.3.1 Subcontractor Supplied

All materials supplied by subcontractors are the responsibility of the subcontractors from receipt until AECOM final acceptance

14.3.3.2 Supplied to the Subcontractor

Materials supplied to the Subcontractor for their installation/erection will be managed in the same way AECOM supplied materials are managed, except that they will be formally received by the Subcontractor.

14.4 Engineered/Fabricated Equipment

All engineered/fabricated equipment will be received, and inspected by QA and/or Field supervision. Equipment/fabrications needed for immediate installation/erection will be formally received by Field Supervision for direct hire work or the Subcontractor. Equipment/Fabrications not ready for installation/erection will be stored on site in a [laydown area or warehouse]. When needed for installation/erection the materials will be formally received by Field Supervision for direct hire or Subcontractors. The status and location of all Equipment received and formally issued to the Field Supervision will be tracked using [SmartPlant Materials]

14.5 Material/Equipment Storage

14.5.1 Laydown Area

A [x ft. X x ft.] laydown area has been established on the site as shown on the Site Layout Plan. The plan will be expanded to detail how the laydown area will be subdivided for storing and locating for retrieval of material, component and equipment. It is anticipated that the following types of equipment will be placed in the laydown area.

14.5.2 Indoor Storage

A [x ft. X x ft.] indoor storage facility will be erected to store and secure certain materials and equipment. A plan will be developed for the indoor storage area to indicate what types of materials will be stored in each divided area for easy retrieval. The following materials and equipment types will be stored in the Indoor Storage Area:

14.5.3 Indoor Heated/Environmentally Controlled Storage

A [x ft. X x ft.] indoor heated storage facility will be erected to store and secure certain materials and equipment. A plan will be developed for the indoor heated/environmentally controlled storage area to indicate what types of materials will be stored in each divided area for easy retrieval. The following materials and equipment types will be stored in the Indoor Heated Storage Area:

14.5.4 Equipment Maintenance

All stored equipment and devices will be maintained in accordance with the manufacturer recommendations from the time of receipt until turnover of the facility.

14.5.5 Tagging

All material/equipment/fabrications/components will be appropriately tagged for tracking and retrieval through [SmartPlant Materials]

14.6 Construction Equipment

An Installation and Erection plan will be developed by the Construction Manager which identifies the type of equipment, its uses on the site and the time periods when the equipment is needed. The plan will be maintained in the project files.

The equipment will be obtained [through a lease with manned operators or AECOM Equipment Group]. The Construction Manager is responsible for efficient utilization of the equipment as well as ensuring it receives the required maintenance.

14.7 Small Tools

The Construction Manager will develop a list of the small tools required for the project and secure them through Procurement. A [central tool crib or Foreman gang boxes] will be established to manage the tools used by the trades. A period [monthly] inventory will be established to minimize theft.

14.8 Labor

The Construction Manager will develop a construction trade manpower plan which identifies the types of skills, number of each required by monthly through the duration of the construction work. Labor will be obtained through the union hall under [agreement]. The staffing level will be reviewed weekly and adjusted as necessary.

14.9 Field Subcontract Administration

The Construction Manager with assistance from Procurement and Field Supervision will manager field subcontract administration activities which will include:

- Conducting a kickoff meeting for each subcontractor after award and prior to their mobilization on site.
- Ensure that all subcontractor employees are provided the site safety orientation training.
- Managing and approving submittals. [Where the engineer of record is not AECOM]
- Conducting weekly subcontractor status meetings
- Managing the subcontractors Requests for Information.
- Managing subcontractor change order process.

- Providing field management oversight during construction.
- Conduct inspections and observe subcontractor conducted tests.
- Approval of progress and performance payments to the subcontractors.
- Conducting walk-downs and final acceptance.
- Closing out subcontract, including final payments, warrantees and demobilization.
- Maintaining documentation of all of the above activities.

15.0 - Commissioning Plan

15.1 Start-up Plan

A Start-up Plan will be developed for the project which defines how the [systems, areas, or components] will be sequenced for startup and turnover to the client. The Start-up Plan will define:

- The start-up organization
- Start-ability Review Checklist
- List of start-up procedures
- Required testing
- Operator training
- Define the required start-up documentation
- Turn-over packages
- Documentation required to formally transfer care, custody and control to the client.

15.2 Start-up Schedule

A start-up schedule will be developed and incorporate into the project master schedule.

15.3 Startup-Ability Review

A startup-ability review will be conducted to determine if the project is mature enough to begin the startup process. Areas requiring further maturity will be identified for the construction team to correct.

15.4 Start-up Documentation

The following start-up documentation will be developed:

- Start-up procedures
- Test procedures
- System descriptions and operating instructions
- Training materials

15.5 Start-up Activities

The following start-up activities will be implemented:

- Conduct testing and maintain documentation
- Develop turnover packages for the Client
- Conduct operator training
- Formally transfer care, custody and control to the Client

16.0 - Operations Plan

The operations team will be responsible for establishing the operation of the ComTest facility. It is intended that the ComTest facility will be operated by the staff of the host site with support from the project team. Their operations manager will be responsible for assembling a team that ensure the safe successful operation of the ComTest facility. The operations team will be brought in early on to review the design of the plant to ensure the operability of the plant. The project team will coordinate with the operations team to insure that all safety aspects of the ComTest facility are incorporated into their standard operating procedures.

As the operations plan gets further developed the PEP will be updated.

17.0 - Closure Management (Develop During FEED)

18.0 - Risk Management

18.1 Periodic Risk and Opportunity Review

On a monthly basis, the key project team members will review project risks and opportunities. This review will be chaired by the Project Manager.

18.2 Evaluating the Status of Previously Identified Risks

Each high and medium risk will be evaluated to determine if the risk still exists; if it is still a potential risk with the same impact; or a reduced or residual risk.

18.3 New Risks

Any new risks that have not been previously identified will be identified; quantitatively assessed for probability and consequence; establish a mitigation strategy for medium and high risks; and identify the impact to cost and/or schedule. (See Table Below)

18.4 Evaluating Opportunities

Each previously identified and new opportunity will evaluated to determine if it is still a viable opportunity and what is its currently predicted impact.

18.5 Update the Risk and Opportunity Plan

Based on the monthly review the Project Manager will update the risk and opportunity plan spreadsheet and maintain in the project records.

RISK MANAGEMENT FORM(S) INSTRUCTIONS

There are three sections to the Risk Register, the Register, the Legend and the Worksheets (numbered sequentially). When a risk is identified and needs to be placed on the Risk Register, use the first available (unsued) worksheet and begin there.

In the Risk Description/Type Section (yellow) fill in the following:
Risk No: Automatically populated - pick the next available number
Owner: The name of ther person responsible for the identified risk
Date: The date that the risk was identified
R/O[6] (Risk/Opportunity): Drop down menu - select the one appropriate answer
Risk Description: A description of the identified risk. (Must be measurable and specific, not a general statement)
Type[1]: Drop down menu - select the type that is most appropriate for the risk
In the Risk Evaluation Section (beige) fill in the following:
Probability[2] and Evaluation: Drop down menu - select the appropriate evaluation of the risk
Mitigation Plan: The details of the Mitigation Plan. (Must be specific to the risk identified explaining how the impacts will be dealt with.)
Risk Cost: The cost of the risk identified
Mitigation Cost: The cost of the mitigation
Final Action Date: Date risk is mitigated
In the Impact Section (blue) fill in the following:
Area Criticality[3]: Drop down menu - select the area of criticality affected by the risk
Schedule Impact[4]: Drop down menu - select the appropriate impact to the schedule
Cost Impact[5]: Drop down menu - select the appropriate cost impact to the project
The Note Sections are meant for clarifying the choices made, if needed.
[1,2,3,4,5,6] ***NOTE:*** *The Legend tab will provide details for each of these Sections.*

When you have completed the worksheet, the Total Impact and Total Risk will automatically be calculated based on the selections made. The Register is linked to the individual worksheets, and once the worksheet is complete, the information will populate the Register.

Figure 18-1 – Risk Register Instructions

Figure 18-2 Risk Register Example

RISK WORKSHEET LEGEND

[1] Risk Type

Technical
- Requirements
- Technology
- Complexity & Interfaces
- Performances & Reliability
- Quality

External
- Subcontractors & Suppliers
- Regulatory
- Market
- Customer
- Weather

Organizational
- Project Dependencies
- Resources
- Funding
- Prioritization

Project Management
- Estimating
- Planning
- Controlling
- Communication
- Procurement
- Construction
- Engineering

[2] Evaluation & Probability

Evaluation	Probability
Almost surely will occur	1.0
Will most probably occur	0.7
Will probably occur	0.5
Will probably not occur	0.3
Will most probably not occur	0.1

[3] Area Criticality *(weighted 10%)*

Area	Criticality
Overall Site	1.0
DPHOST	0.9
Infrastructure	0.8
Utilities	0.7
CISi Recovery	0.6
Decomp	0.5
Power Dist.	0.4
Front Campus	0.3
Finishing	0.2

Color Rating

	0.01 - 0.33
	0.34 - 0.66
	0.67 - 1.00

[4] Schedule Impact *(weighted 30%)*

Weeks	Impact
> 8 wks	1.0
4 - 8 wks	0.7
2 - 4 wks	0.5
0 - 2 wks	0.3

[5] Cost Impact *(weighted 60%)*

Dollars	Impact
> $500k	1.0
$100 - $500k	0.6
< $100k	0.3

[6] R/O

R/O	Pick
R	Risk
O	Opportunity

Figure 18-3 – Risk Worksheet Legend

	RISK WORKSHEET	AREA:

RISK NO:	OWNER:	DATE:
Manually Enter Owner Name and Date.		

R/O[6]	RISK DESCRIPTION:	TYPE[1]
Manually Enter Risk Description. Select appropriate response for T/O[6] and Type[1] from drop-down boxes.		

PROBABILITY	EVALUATION[2]:
0%	
Select appropriate response for Evaluation[2] from drop-down box, probability will automatically populate.	

MITIGATION PLAN
Enter Mitigation Plan details.

RISK COST	MITIGATION COST	FINAL ACTION DATE
$0	$0	
Enter Risk Cost.	Enter Mitigation Cost.	Enter Final Action Date

IMPACT		
#N/A	AREA CRITICALITY[3]	Notes
0.0	SCHEDULE IMPACT[4]	Notes
0.0	COST IMPACT[5]	Notes
Select the appropriate response for the three areas of impact, one from each drop-down box. Once complete, the Total Impact and Total Risk will be calculated.		
#N/A	Total Impact	
#N/A	Total Risk	

Figure 18-4 Risk Template

Youngstown Thermal Piping and Instrumentation Diagrams

PID-YTT-00

VALVE SYMBOLS

- GATE (OR GENERIC)
- CHECK
- STOP CHECK
- GLOBE
- BUTTERFLY
- NEEDLE
- NON RETURN
- BALL
- GENERIC ROTARY (1/4 TURN)
- PLUG
- DIAPHRAGM
- 3-WAY
- 4-WAY
- PINCH
- ANGLE
- KNIFE
- PRESSURE RELIEF OR SAFETY VALVE
- VACUUM BREAK
- FIRE WATER VALVE
- PRESSURE REGULATOR
- BACKFLOW PREVENTER

PIPING FITTINGS

- FLANGE
- WELDED CONNECTION
- CAP
- CONCENTRIC (OR GENERIC) REDUCER
- ECCENTRIC REDUCER
- HOSE CONNECTION
- SPACER
- BLANK
- OPEN FIGURE 8 BLIND
- CLOSED FIGURE 8 BLIND
- PLUG
- BLIND FLANGE
- WELDOLET

PIPING SPECIALTY ITEMS

- Y-TYPE STRAINER
- CONE STRAINER
- T-TYPE STRAINER
- DUPLEX STRAINER
- BASKET STRAINER
- TEMPORARY STRAINER
- FILTER
- DETONATION ARRESTOR
- FLAME ARRESTOR
- STEAM TRAP
- EJECTOR / EDUCTOR
- PULSATION DAMPER
- INLINE SILENCER
- VENT SILENCER
- REMOVABLE SPOOL
- FLEXIBLE HOSE
- EXPANSION JOINT
- DAMPER
- BREATHER
- VENT COVER
- INLINE MIXER
- DIVERTER VALVE
- ROTARY VALVE
- EXCESS FLOW VALVE
- RUPTURE DISC
- CHEMICAL SEAL
- RAIN CAP
- DRAIN
- RESTRICTION ORIFICE

ACTUATOR SYMBOLS

- MANUAL OPERATOR
- DIAPHRAGM
- PRESSURE BALANCED DIAPHRAGM
- CYLINDER / PISTON
- MOTOR OPERATOR
- ELECTRO-HYDRAULIC OPERATOR
- SINGLE SOLENOID

NOMENCLATURE & NUMBERING

FUNCTIONAL AREAS
- 1 - WT & DEAREATOR
- 2 - BOILER
- 3 - SUPERHEATER
- 4 - TURBINE
- 5 - HEADER & HT PIPING
- 6 - SITE / INTEGRATION
- 7 - COOLING TOWER

DRAWING NUMBERS PID-YTT-AN
- YTT - YOUNGSTOWN THERMAL
- A - FUNCTIONAL AREA (1-7)
- N - SEQUENCE NUMBER (0-9)

EQUIPMENT NUMBERS TTT-ANNN
- TTT- EQUIPMENT TYPE (TWO OR THREE CHARACTERS)
- AN - ORIGINATING DRAWING NUMBER
- NN - ITEM NUMBER (01-99)

INSTRUMENT NUMBERING TTT-ANNN
- TTT - INSTRUMENT TYPE (TWO OR THREE CHARACTERS)
- AN - ORIGINATING DRAWING NUMBER
- NN - ITEM NUMBER (01-99)

LINE NUMBERING XX"YYY-ZZZ-ANNN-II-T
- XX - NOMINAL DIAMETER (INCHES)
- YYY - SPEC
- ZZZ - SERVICE
- AN - ORIGINATING DRAWING NUMBER
- NN - SEQUENCE NUMBER (01-99)
- II - INSULATION CODE
- T - TRACING CODE

SERVICES

	PSIA	F	SPEC
WATERS			
WC - CITY WATER	60	60	011
WT - TREATED WATER	60	60	011
WBF - BOILER FEED WATER	1015	250	061
WCS - COOLING WATER SUPPLY	75	90	011
WCR - COOLING WATER RETURN	75	125	011
WLPF - LOW PRESSURE FEED WATER	395	250	061
FUEL			
FG - FUEL GAS	60	60	011
AIR			
AC - COMBUSTION AIR	<1	77	011
AI - INSTRUMENT AIR	115	90	011
O2 - OXYGEN	115	90	011
STEAMS			
SB - BOILER STEAM	965	850	152
SA - ATTENUATED STEAM	75	450	152
SS - SUPERHEATED STEAM	640	1400	999
SC - COOLING STEAM	640	1100	153
SU - AUXILIARY STEAM	300		152
SE - TURBINE EXHAUST STEAM	70	1140	LATER
COND - CONDENSATE			
MISCELLANEOUS			
VENT - VENT	115	90	011
O'FLOW - OVERFLOW	115	90	011

DRAWING LIST

PID-YTT-00	LEGEND
PID-YTT-10	DEAERATOR
PID-YTT-11	WBF DISTRIBUTION
PID-YTT-12	OWT
PID-YTT-20	BOILER 1
PID-YTT-22	SB DISTRIBUTION
PID-YTT-30	SUPERHEATER 1
PID-YTT-31	SUPERHEATER 2
PID-YTT-32	SUPERHEATER 3
PID-YTT-40	TURBINE
PID-YTT-41	DYNOMOMETER
PID-YTT-42	EXHAUST STEAM
PID-YTT-43	CONTACT CONDENSER
PID-YTT-44	TURBINE SUPPORT SYSTEMS
PID-YTT-50	SS DISTRIBUTION
PID-YTT-51	HEADER TEST
PID-YTT-60	DUMP EXCHANGER
PID-YTT-61	FUEL GAS DISTRIBUTION
PID-YTT-70	COOLING TOWER
PID-YTT-80	AIR DISTRIBUTION

PIPE SPECIFICATIONS

PIPE SPEC	CLASS / MATERIAL
011	150 / CS
031	300 / CS
061	600 / CS
152	1500 / CS
153	LATER
999	INCONEL 740H

PIPING LINE SYMBOLS

- PRIMARY
- SECONDARY / UTILITY
- FUTURE OR EXISTING
- FINNED
- JACKETED OR DOUBLE CONTAINMENT
- OUT OF SERVICE OR ABANDONED
- PIPE INSULATION
- PIPE INSULATION & STEAM TRACING
- PERSONNEL PROTECTION (P)
- PIPE INSULATION & ELECTRICAL TRACING E
- COVERED PIPE C

MISCELLANEOUS

- REF. DRAWING / DESCRIPTION — OFF PAGE CONNECTOR
- TG1 TG2 / TG1 TG2 — POINT OF CHANGE FOR: RESPONSIBILITY, PIPE CLASS / SPEC, INSULATION, ABOVE / BELOW GROUND
- SP-XXXX — PIPING SPECIALTY ITEM
- LINE BREAK
- FLOW ARROW
- PACKAGED EQUIPMENT LIMITS
- BATTERY LIMITS OR MATCH LINE
- T XXX — TIE POINT
- DEMOLITION

	FIELD MOUNTED	PRIMARY LOCATION NORMALLY ACCESSIBLE TO OPERATOR	PRIMARY LOCATION NORMALLY INACCESSIBLE OR BEHIND PANEL DEVICES	AUXILIARY LOCATION OR PANEL NORMALLY ACCESSIBLE TO OPERATOR	AUXILIARY LOCATION OR PANEL NORMALLY INACCESSIBLE OR BEHIND PANEL DEVICES
DISCRETE INSTRUMENTS (END DEVICES OR STAND-ALONE CONTROLLER)	○	⊖ IP1*	⊖	⊖	⊖
SHARED DISPLAY, SHARED CONTROL, DISTRIBUTED CONTROL (OR VIDEO DISPLAY)	▢	▢	▢	▢	▢
COMPUTER FUNCTION FLOW	⬡	⬡	⬡	⬡	⬡
PROGRAMMABLE LOGIC CONTROL	◇	◇	◇	◇	◇

REVISION APPROVAL RECORD					
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
D	07/18/16	ISSUED FOR REVIEW AND COMMENT	GG	
C	03/31/16	ISSUED FOR FEED	GG	
B	02/19/16	ISSUED FOR PHA	GG	
A	02/10/16	ISSUED FOR REVIEW	GG	

DRAWING STATUS

ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	D	07/18/16	CB	DM
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV.NO.

PROJECT NO.: 31609
DRAWN: GG DATE: 01/25/16
CHECKED: RW DATE:
SCALE: NTS

URS ENERGY & CONSTRUCTION Inc, - an AECOM Company
1500 West 3rd St., Suite 200
Cleveland, OH 44113
(216) 523-5600
AECOM

ENERGY INDUSTRIES of OHIO
6100 Oak Tree Boulevard, Suite 200
Independence, OH 44131
(216) 643-2952

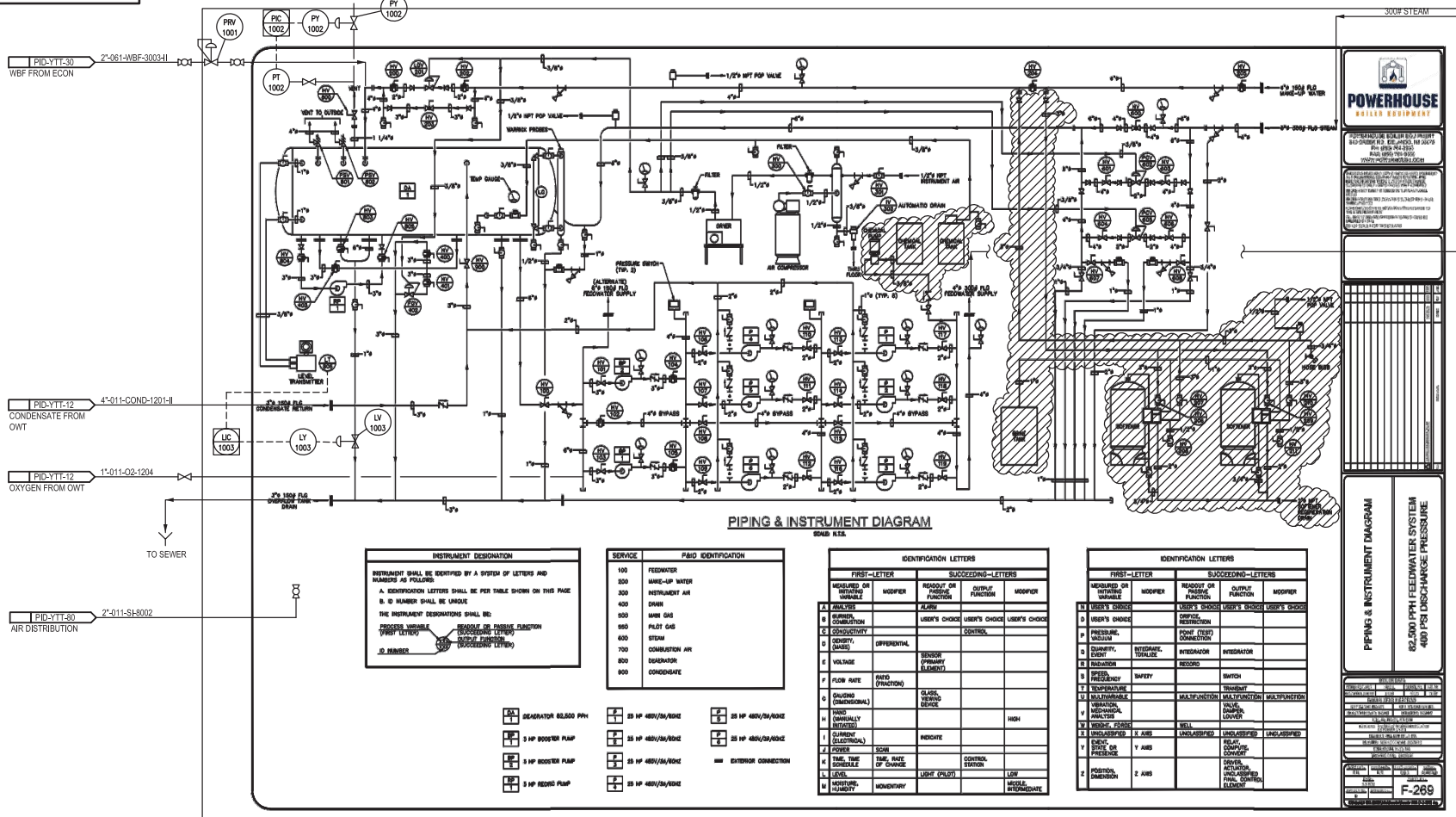
A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
LEGEND

DWG. NO. PID-YTT-00 REV D

EC_D_Size.dwg

INCHES / CENTIMETERS

PID-YTT-10



PIPING & INSTRUMENT DIAGRAM

SCALE: N.T.S.

INSTRUMENT DESIGNATION

INSTRUMENT SHALL BE IDENTIFIED BY A SYSTEM OF LETTERS AND NUMBERS AS FOLLOWS:

A. IDENTIFICATION LETTERS SHALL BE PER TABLE SHOWN ON THIS PAGE

B. ID NUMBER SHALL BE UNIQUE

THE INSTRUMENT DESIGNATIONS SHALL BE:

PROCESS VARIABLE (FIRST LETTER) — READOUT OR PASSIVE FUNCTION (SUCCEEDING LETTER); OUTPUT FUNCTION (SUCCEEDING LETTER)

ID NUMBER

SERVICE	P&ID IDENTIFICATION
100	FEEDWATER
200	MAKE-UP WATER
300	INSTRUMENT AIR
400	DRAIN
500	MAIN GAS
550	PILOT GAS
600	STEAM
700	COMBUSTION AIR
800	DEAERATOR
900	CONDENSATE

DA — DEAERATOR 82,500 PPH

BP — 3 HP BOOSTER PUMP

BP — 5 HP BOOSTER PUMP

BP — 5 HP FEEDS PUMP

P — 25 HP 480V/3Ø/60HZ

P — 25 HP 480V/3Ø/60HZ

P — 25 HP 480V/3Ø/60HZ

P — 25 HP 480V/3Ø/60HZ

P — 25 HP 480V/3Ø/60HZ

EXTERIOR CONNECTION

IDENTIFICATION LETTERS

	FIRST–LETTER: MEASURED OR INITIATING VARIABLE	FIRST–LETTER: MODIFIER	SUCCEEDING–LETTERS: READOUT OR PASSIVE FUNCTION	SUCCEEDING–LETTERS: OUTPUT FUNCTION	SUCCEEDING–LETTERS: MODIFIER
A	ANALYSIS		ALARM		
B	BURNER, COMBUSTION		USER'S CHOICE	USER'S CHOICE	USER'S CHOICE
C	CONDUCTIVITY			CONTROL	
D	DENSITY, (MASS)	DIFFERENTIAL			
E	VOLTAGE		SENSOR (PRIMARY ELEMENT)		
F	FLOW RATE	RATIO (FRACTION)			
G	GAUGING (DIMENSIONAL)		GLASS, VIEWING DEVICE		
H	HAND (MANUALLY INITIATED)				HIGH
I	CURRENT (ELECTRICAL)		INDICATE		
J	POWER	SCAN			
K	TIME, TIME SCHEDULE	TIME, RATE OF CHANGE		CONTROL STATION	
L	LEVEL		LIGHT (PILOT)		LOW
M	MOISTURE, HUMIDITY	MOMENTARY			MIDDLE, INTERMEDIATE

IDENTIFICATION LETTERS

	FIRST–LETTER: MEASURED OR INITIATING VARIABLE	FIRST–LETTER: MODIFIER	SUCCEEDING–LETTERS: READOUT OR PASSIVE FUNCTION	SUCCEEDING–LETTERS: OUTPUT FUNCTION	SUCCEEDING–LETTERS: MODIFIER
N	USER'S CHOICE		USER'S CHOICE	USER'S CHOICE	USER'S CHOICE
O	USER'S CHOICE		ORIFICE, RESTRICTION		
P	PRESSURE, VACUUM		POINT (TEST) CONNECTION		
Q	QUANTITY, EVENT	INTEGRATE, TOTALIZE	INTEGRATOR	INTEGRATOR	
R	RADIATION		RECORD		
S	SPEED, FREQUENCY	SAFETY		SWITCH	
T	TEMPERATURE			TRANSMIT	
U	MULTIVARIABLE		MULTIFUNCTION	MULTIFUNCTION	MULTIFUNCTION
V	VIBRATION, MECHANICAL ANALYSIS			VALVE, DAMPER, LOUVER	
W	WEIGHT, FORCE		WELL		
X	UNCLASSIFIED	X AXIS	UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED
Y	EVENT, STATE OR PRESENCE	Y AXIS		RELAY, COMPUTE, CONVERT	
Z	POSITION, DIMENSION	Z AXIS		DRIVER, ACTUATION, UNCLASSIFIED FINAL CONTROL ELEMENT	

REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
D	07/18/16	ISSUED FOR REVIEW AND COMMENT	GG	
C	03/31/16	ISSUED FOR FEED	GG	
B	02/19/16	ISSUED FOR PHA	GG	
A	02/10/16	ISSUED FOR REVIEW	GG	

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	D	07/18/16	CB	DM
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV NO.

PROJECT NO.: 31609

DRAWN: GG — DATE: 01/25/16

CHECKED: RW — DATE:

SCALE: NTS

URS ENERGY & CONSTRUCTION Inc, - an AECOM Company
1500 West 3rd St., Suite 200
Cleveland, OH 44113
(216) 523-5600
AECOM

ENERGY INDUSTRIES of OHIO
6100 Oak Tree Boulevard, Suite 200
Independence, OH 44131
(216) 643-2952

A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
DEAERATOR

DWG. NO.: PID-YTT-10 — REV: D

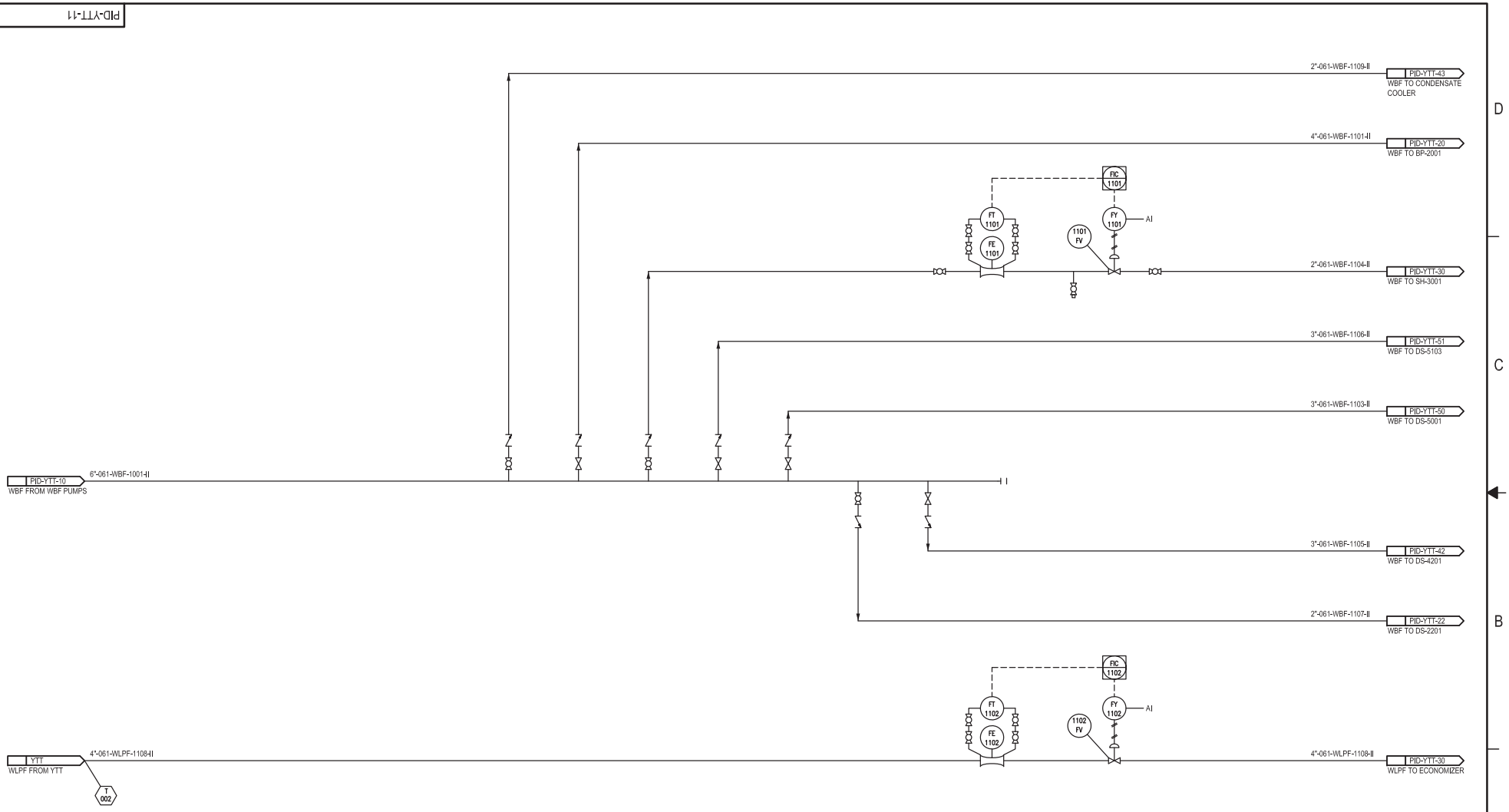
EC_D_Size.dwg

INCHES / CENTIMETERS

8 7 6 5 4 3 2 1

D C B A

PID-YTT-11



REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
D	07/18/16	ISSUED FOR REVIEW AND COMMENT	GG	
C	03/31/16	ISSUED FOR FEED	GG	
B	02/19/16	ISSUED FOR PHA	GG	
A	02/10/16	ISSUED FOR REVIEW	GG	

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	D	07/18/16	CB	DM
APPROVED FOR CONSTRUCTION				

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PROJECT NO.: 31609

DRAWN: GG DATE: 01/25/16

CHECKED: RW DATE:

SCALE: NTS

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A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
WBF DISTRIBUTION

DWG. NO. PID-YTT-11 REV D

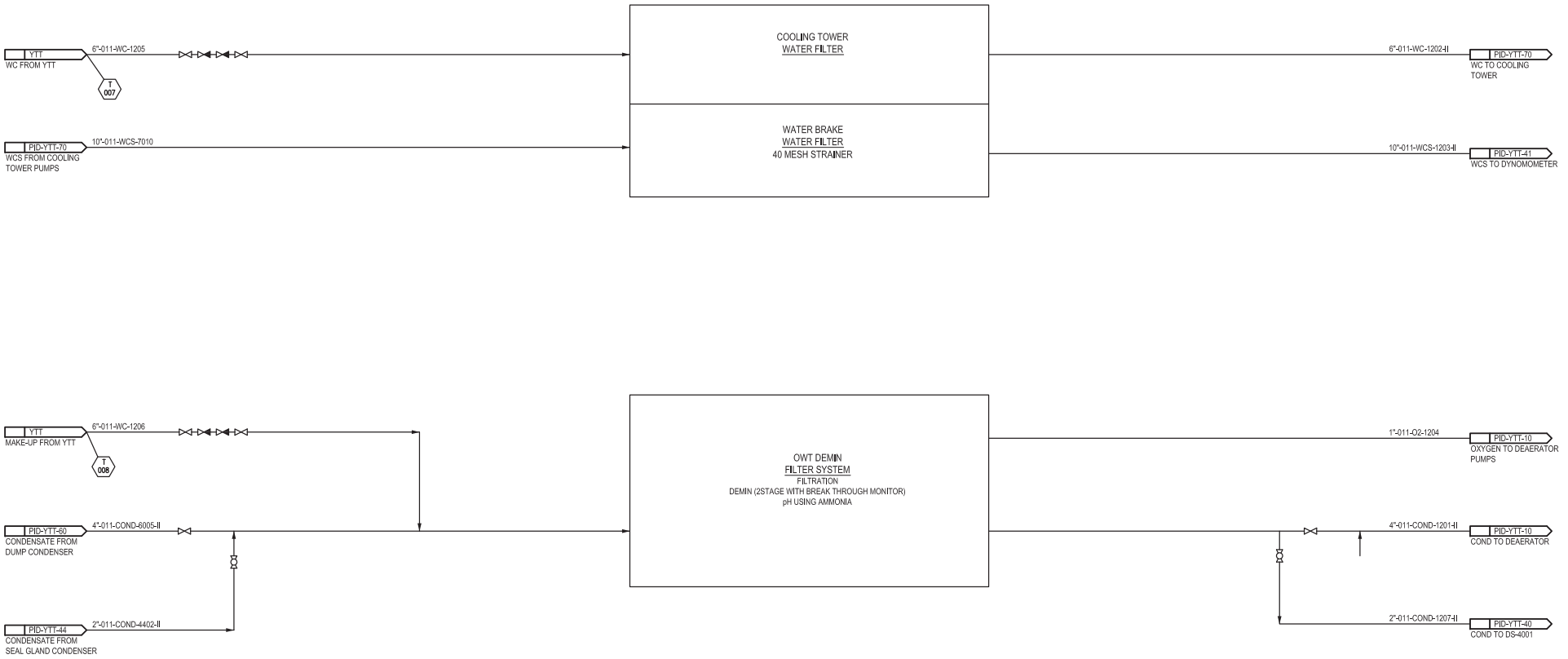
EC_D_Size.dwg

INCHES 1 2 CENTIMETERS 1 2 3 4 5 6

8 7 6 5 4 3 2 1

D C B A

PID-YTT-12



REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
C	07/18/16	ISSUED FOR REVIEW AND COMMENT	GG	
B	03/31/16	ISSUED FOR FEED	GG	
A	02/19/16	ISSUED FOR PHA	GG	

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	C	07/18/16	CB	DM
APPROVED FOR CONSTRUCTION				

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PROJECT NO.: 31609
DRAWN: GG DATE: 02/17/16
CHECKED: RW DATE:
SCALE: NTS

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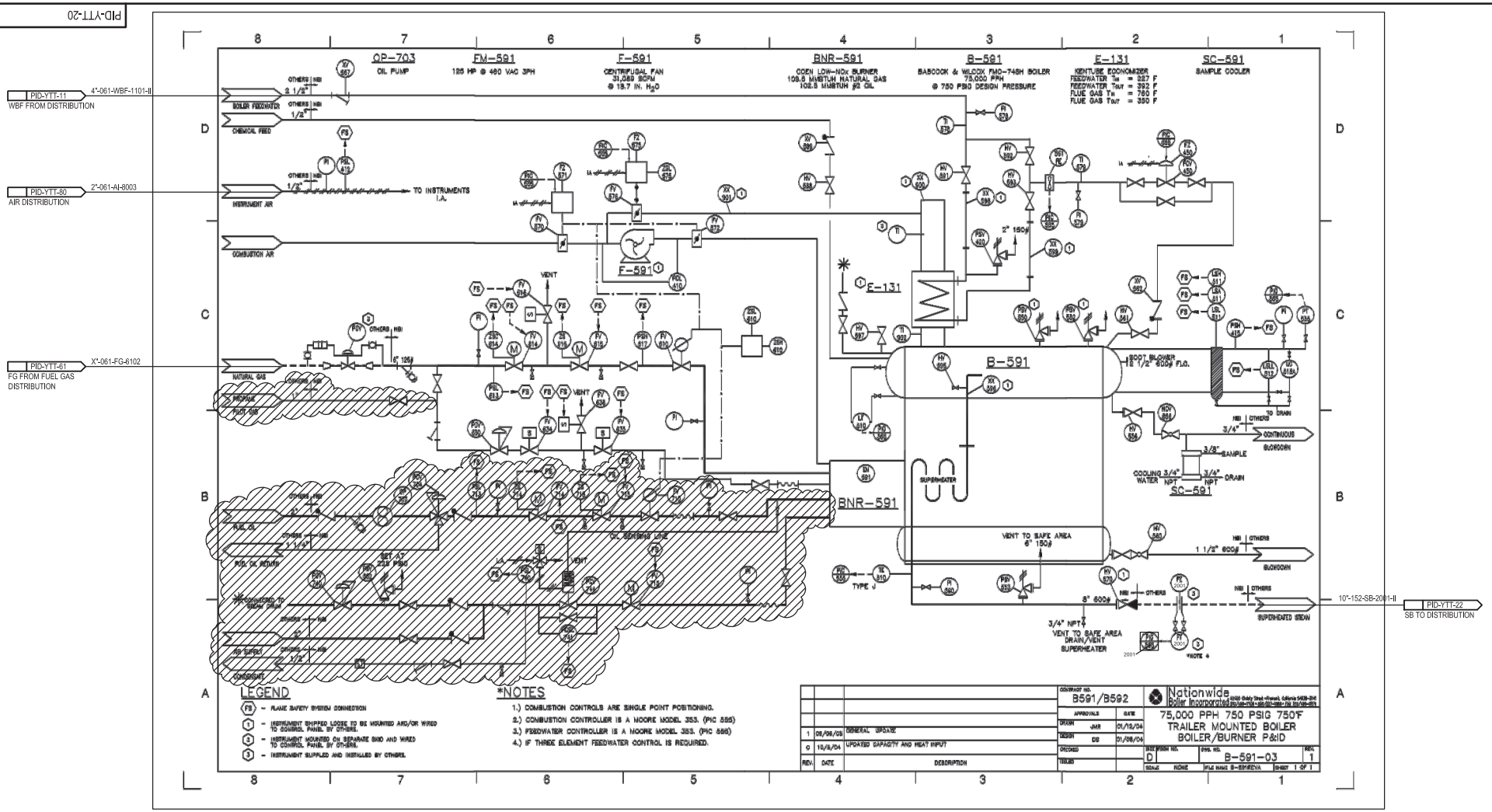
A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
WATER TREATMENT

DWG. NO. PID-YTT-12 REV C

INCHES CENTIMETERS

EC_D_Size.dwg



REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
SULFING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
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A	02/10/16	ISSUED FOR REVIEW	GG	

DRAWING STATUS				
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PRELIMINARY	D	07/18/16	CB	DM
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DRAWN: GG DATE: 01/25/16
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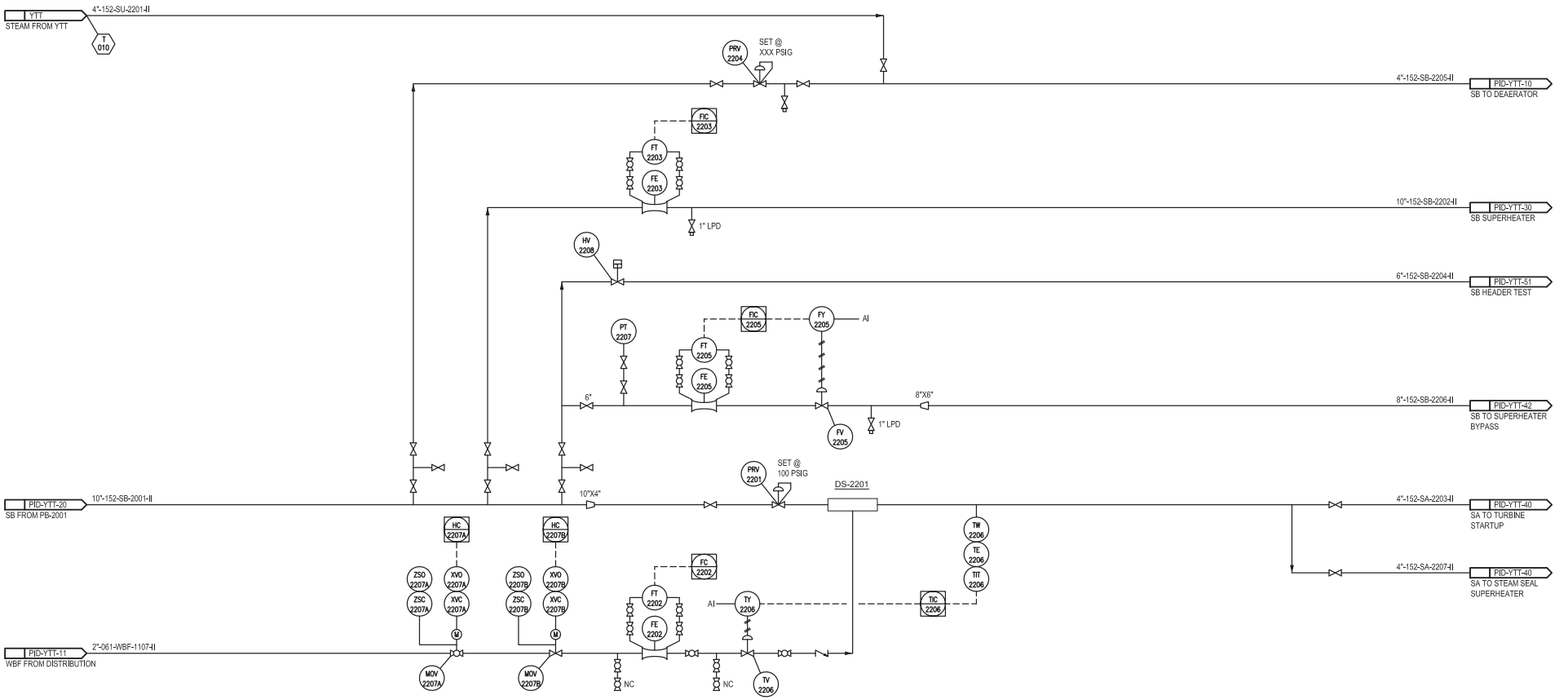
A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
BOILER

DWG. NO. PID-YTT-20 REV D

EC_D_Size.dwg

PID-YTT-22



REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
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B	02/19/16	ISSUED FOR PHA	GG	
A	02/10/16	ISSUED FOR REVIEW	GG	

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	D	07/18/16	CB	DM
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PROJECT NO.: 31609
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A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
BOILER STEAM DISTRIBUTION

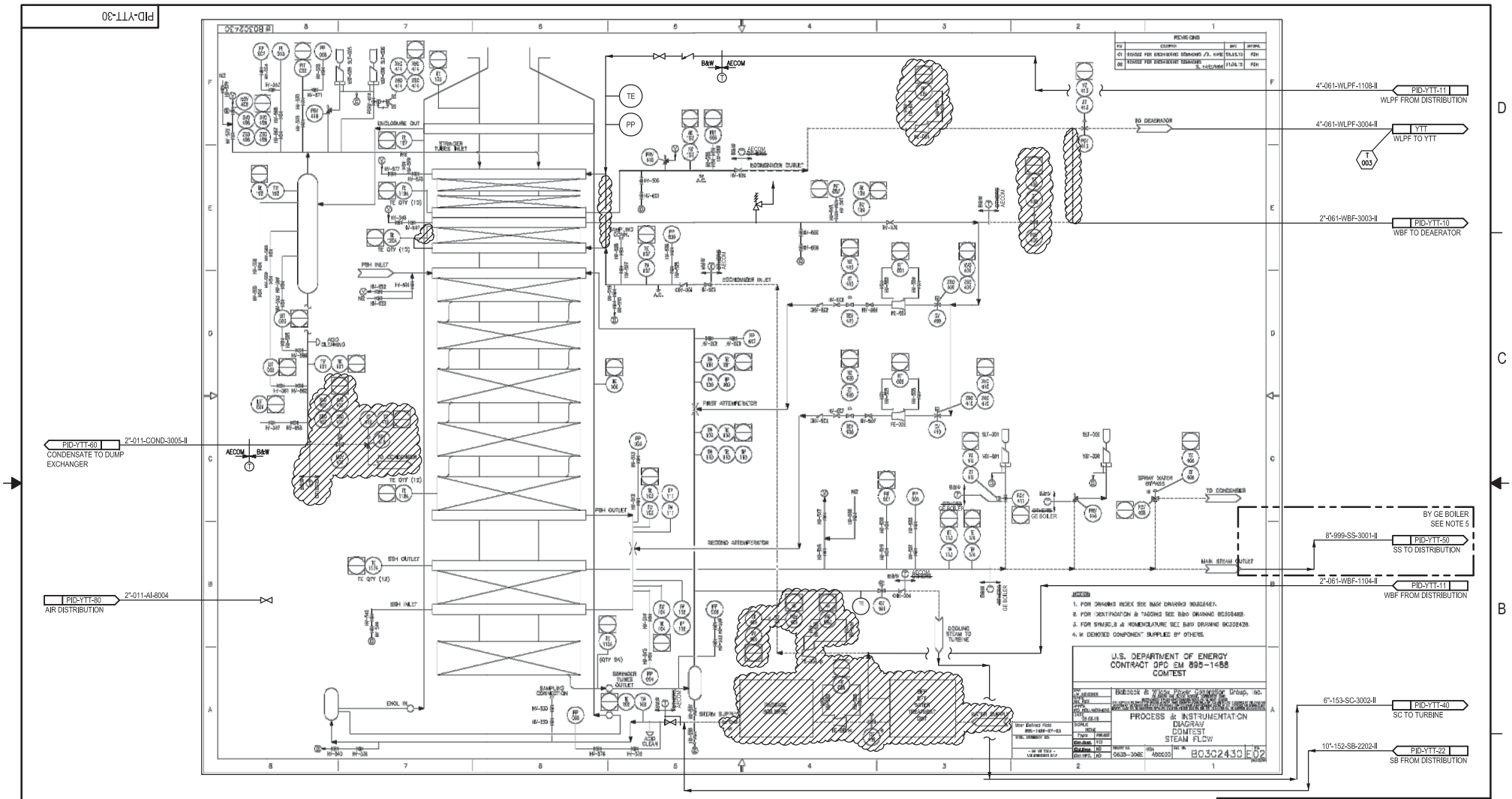
DWG. NO. PID-YTT-22 REV D

EC_D_Size.dwg

INCHES 1 2 CENTIMETERS 1 2 3 4 5 6

8 7 6 5 4 3 2 1

D C B A



NOTES:

5. ALL CONTROL VALVES, INSTRUMENTATION, MANUAL VALVES AND PIPING WITHIN THE SHOWN BOUNDARY SHALL BE SUPPLIED BY GE BOILER. PIPING AND PIPING COMPONENT SYSTEMS SHALL BE DESIGNED BY AECOM.

REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

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DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	D	07/18/16	CB	DM
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SCALE: NTS

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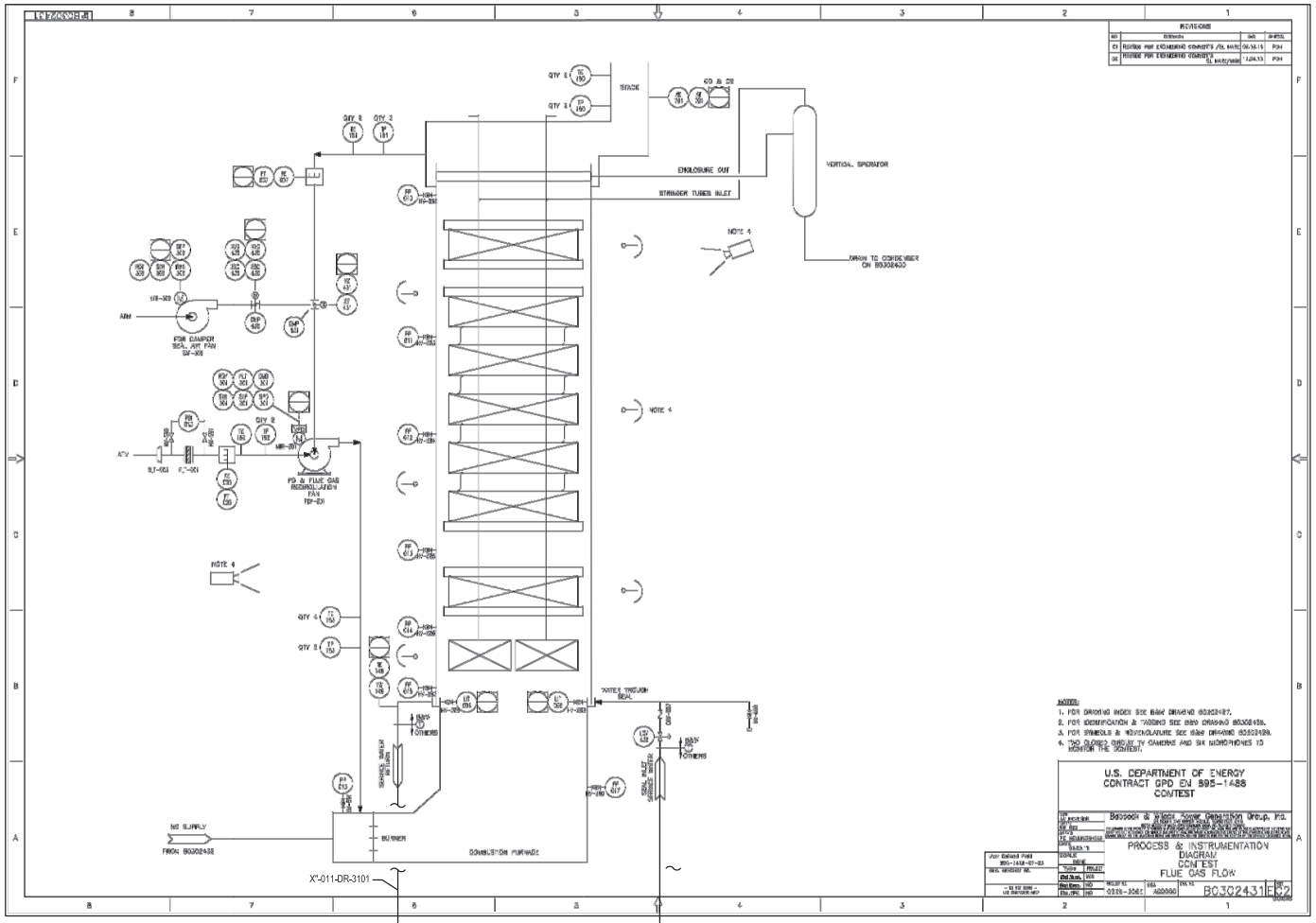
A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
SUPERHEATER - STEAM SIDE

DWG. NO. PID-YTT-30 REV D

EC_D_Size.dwg

PID-YTT-31



PID-YTT-70 2"-011-WCR-7011
WCR FROM HOT WELL PUMPS

REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
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A	02/10/16	ISSUED FOR REVIEW	GG	

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	D	07/18/16	CB	DM
APPROVED FOR CONSTRUCTION				

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PROJECT NO.: 31609
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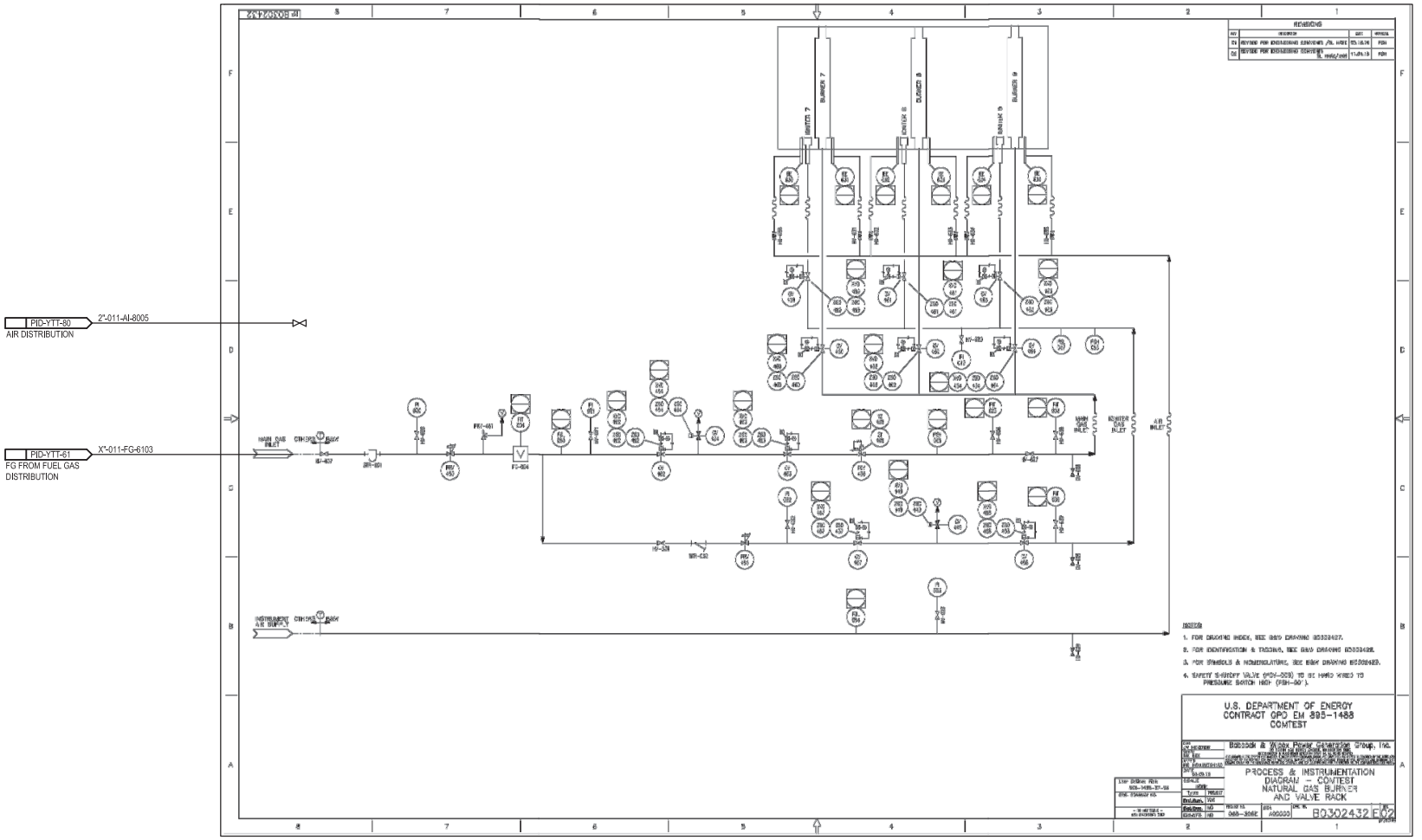
A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
SUPERHEATER - GAS SIDE

DWG. NO. PID-YTT-31 REV D

EC_D_Size.dwg

INCHES CENTIMETERS

PID-YTT-32



REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
C	07/18/16	ISSUED FOR REVIEW AND COMMENT	GG	
B	03/31/16	ISSUED FOR FEED	GG	
A	02/19/16	ISSUED FOR PHA	GG	

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	C	07/18/16	CB	DM
APPROVED FOR CONSTRUCTION				

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PROJECT NO.: 31609
DRAWN: GG DATE: 02/18/16
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SCALE: NTS

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A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
SUPERHEATER 3

DWG. NO. PID-YTT-32 REV C

EC_D_Size.dwg

INCHES CENTIMETERS

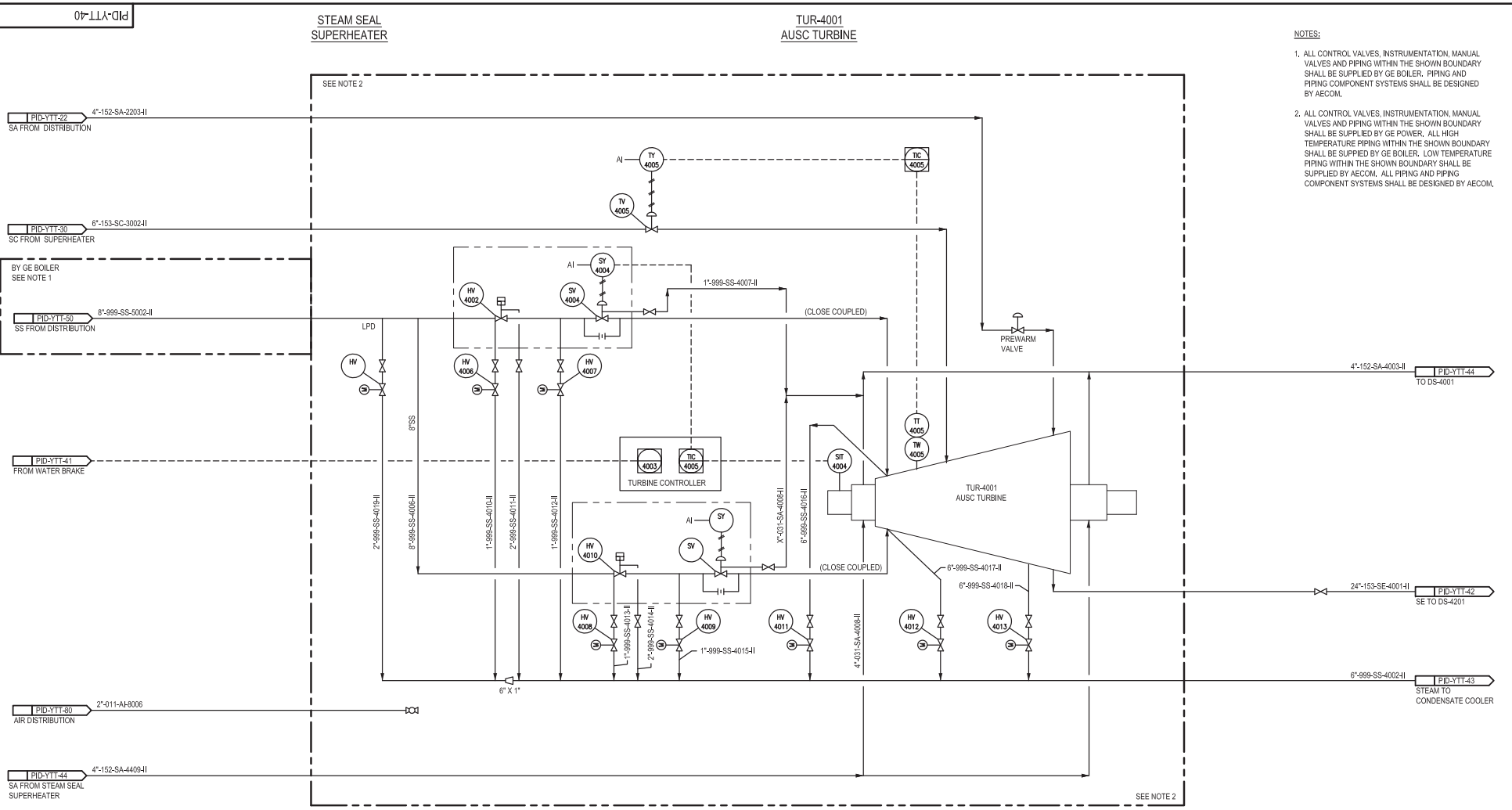
PID-YTT-40

STEAM SEAL SUPERHEATER

TUR-4001 AUSC TURBINE

NOTES:

1. ALL CONTROL VALVES, INSTRUMENTATION, MANUAL VALVES AND PIPING WITHIN THE SHOWN BOUNDARY SHALL BE SUPPLIED BY GE BOILER. PIPING AND PIPING COMPONENT SYSTEMS SHALL BE DESIGNED BY AECOM.
2. ALL CONTROL VALVES, INSTRUMENTATION, MANUAL VALVES AND PIPING WITHIN THE SHOWN BOUNDARY SHALL BE SUPPLIED BY GE POWER. ALL HIGH TEMPERATURE PIPING WITHIN THE SHOWN BOUNDARY SHALL BE SUPPIED BY GE BOILER. LOW TEMPERATURE PIPING WITHIN THE SHOWN BOUNDARY SHALL BE SUPPLIED BY AECOM. ALL PIPING AND PIPING COMPONENT SYSTEMS SHALL BE DESIGNED BY AECOM.



REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

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D	07/18/16	ISSUED FOR REVIEW AND COMMENT	GG	
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A	02/10/16	ISSUED FOR REVIEW	GG	

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ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	D	07/18/16	CB	DM
APPROVED FOR CONSTRUCTION				

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PROJECT NO.: 31609
DRAWN: GG DATE: 01/25/16
CHECKED: RW DATE:
SCALE: NTS

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A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
TURBINE

DWG. NO. PID-YTT-40 REV D

EC_D_Size.dwg

INCHES CENTIMETERS

8 7 6 5 4 3 2 1

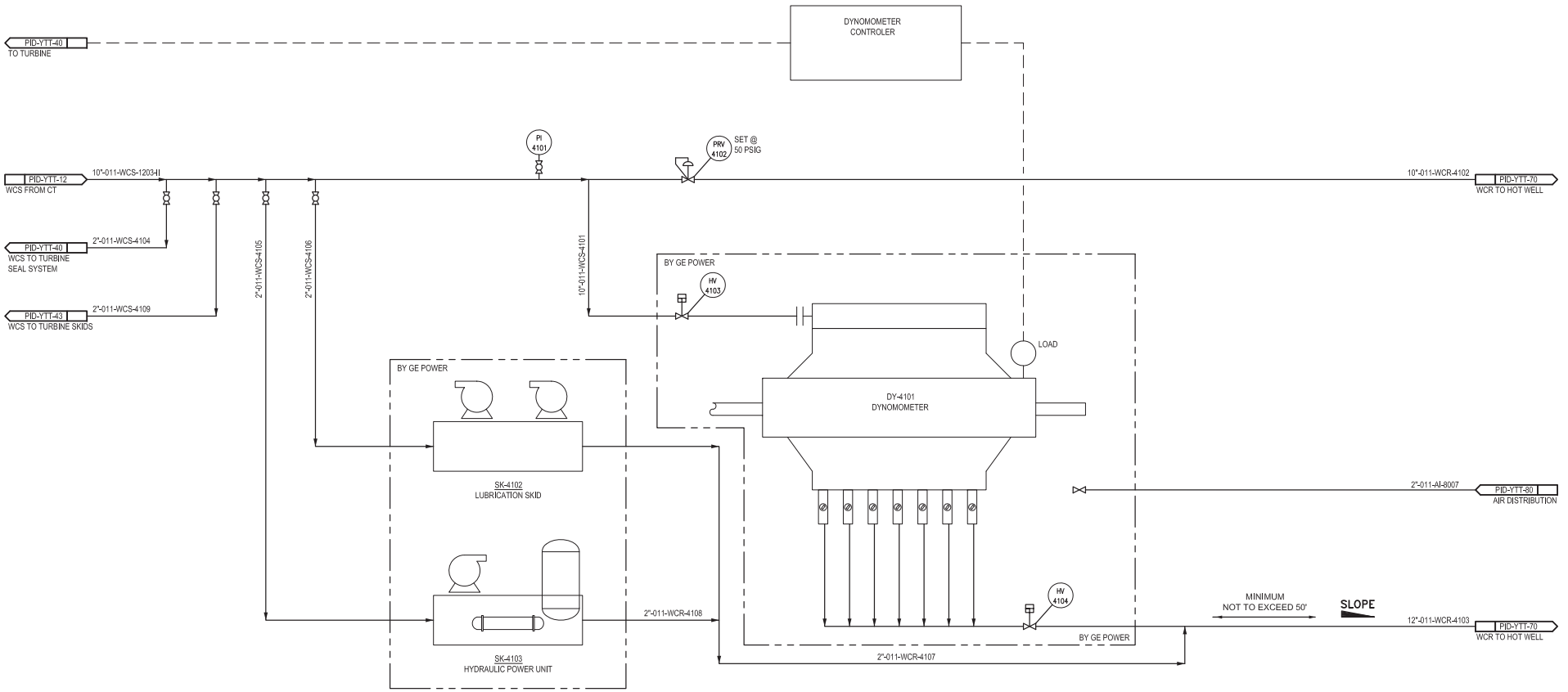
D C B A

PID-YTT41

SK-4102
LUBRICATION SKID

SK-4103
HYDRALIC POWER UNIT
20 HP

DY-4101
DYNOMOMETER



REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
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C	03/31/16	ISSUED FOR FEED	GG	
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DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	D	07/18/16	CB	DM
APPROVED FOR CONSTRUCTION				

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PROJECT NO.: 31609
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A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
DYNOMOMETER

DWG. NO. PID-YTT-41 REV D

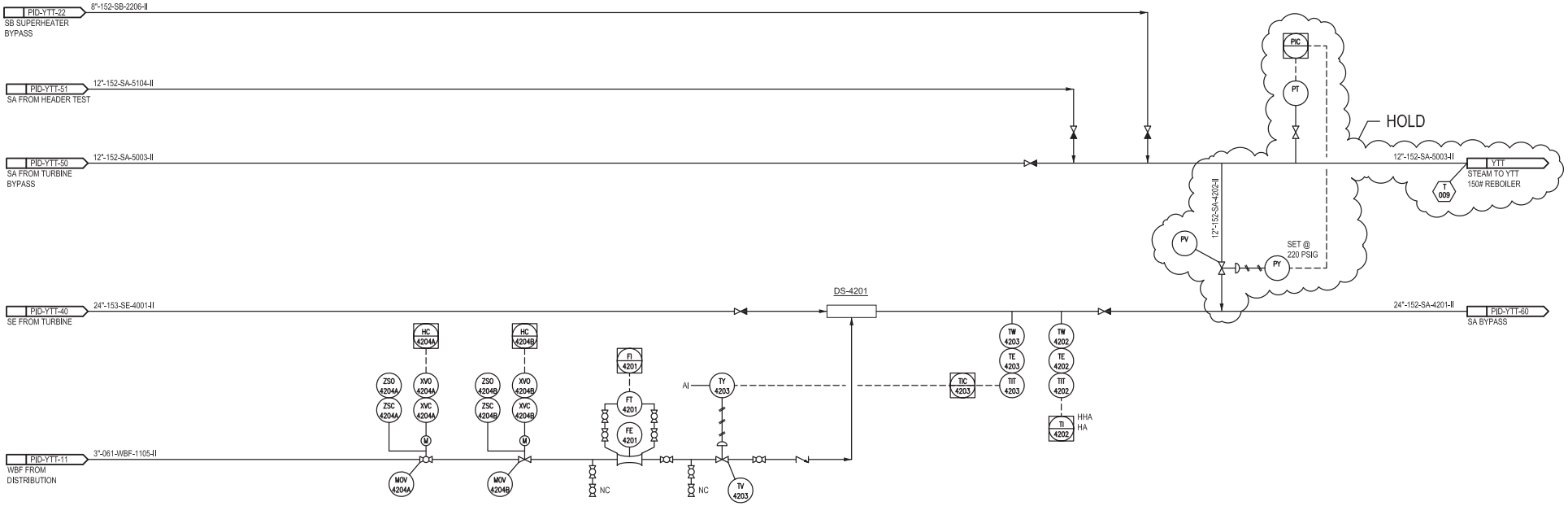
EC_D_Size.dwg

INCHES 1 2 CENTIMETERS 1 2 3 4 5 6

8 7 6 5 4 3 2 1

D C B A

PID-YTT42



REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
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B	02/19/16	ISSUED FOR PHA	GG	
A	02/10/16	ISSUED FOR REVIEW	GG	

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	D	07/18/16	CB	DM
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A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
EXHAUST STEAM

DWG. NO. PID-YTT-42 REV D

EC_D_Size.dwg

INCHES 1 2 CENTIMETERS 1 2 3 4 5 6

8 7 6 5 4 3 2 1

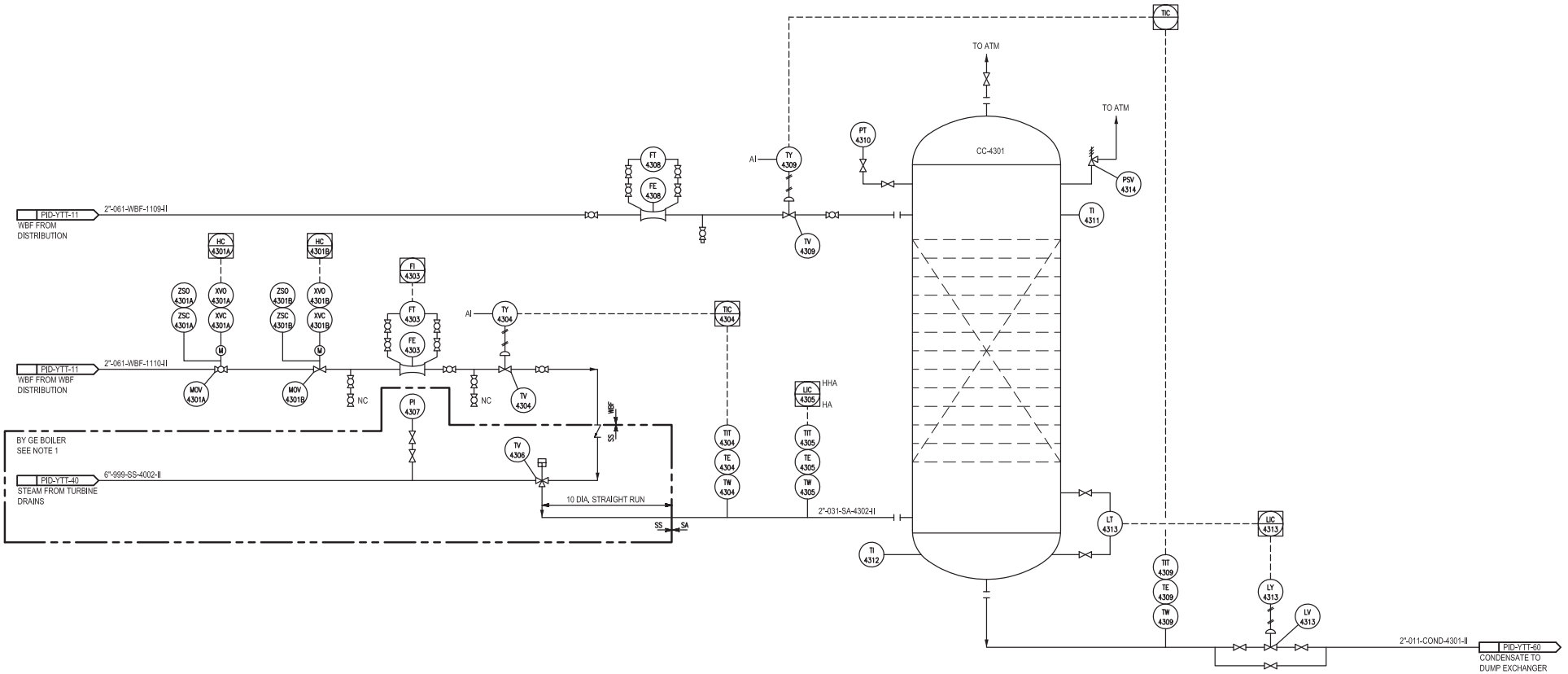
D C B A

PID-YTT-43

CC-4301
CONTACT CONDENSER

NOTES:

1. ALL CONTROL VALVES, INSTRUMENTATION, MANUAL VALVES AND PIPING WITHIN THE SHOWN BOUNDARY SHALL BE SUPPLIED BY GE BOILER. PIPING AND PIPING COMPONENT SYSTEMS SHALL BE DESIGNED BY AECOM.



REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
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A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
CONTACT CONDENSER

DWG. NO. PID-YTT-43 REV A

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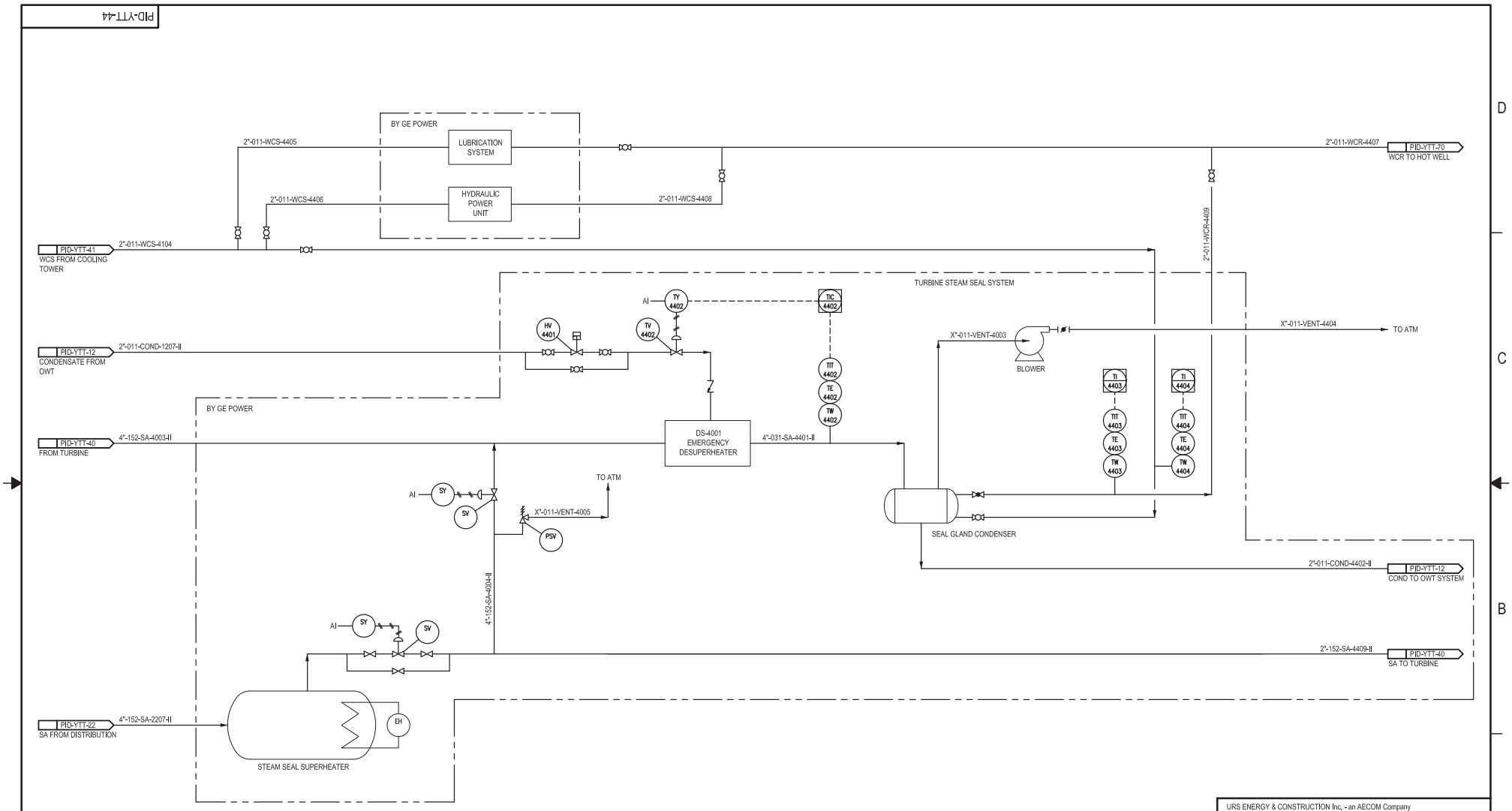

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A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
TURBINE SUPPORT SYSTEMS

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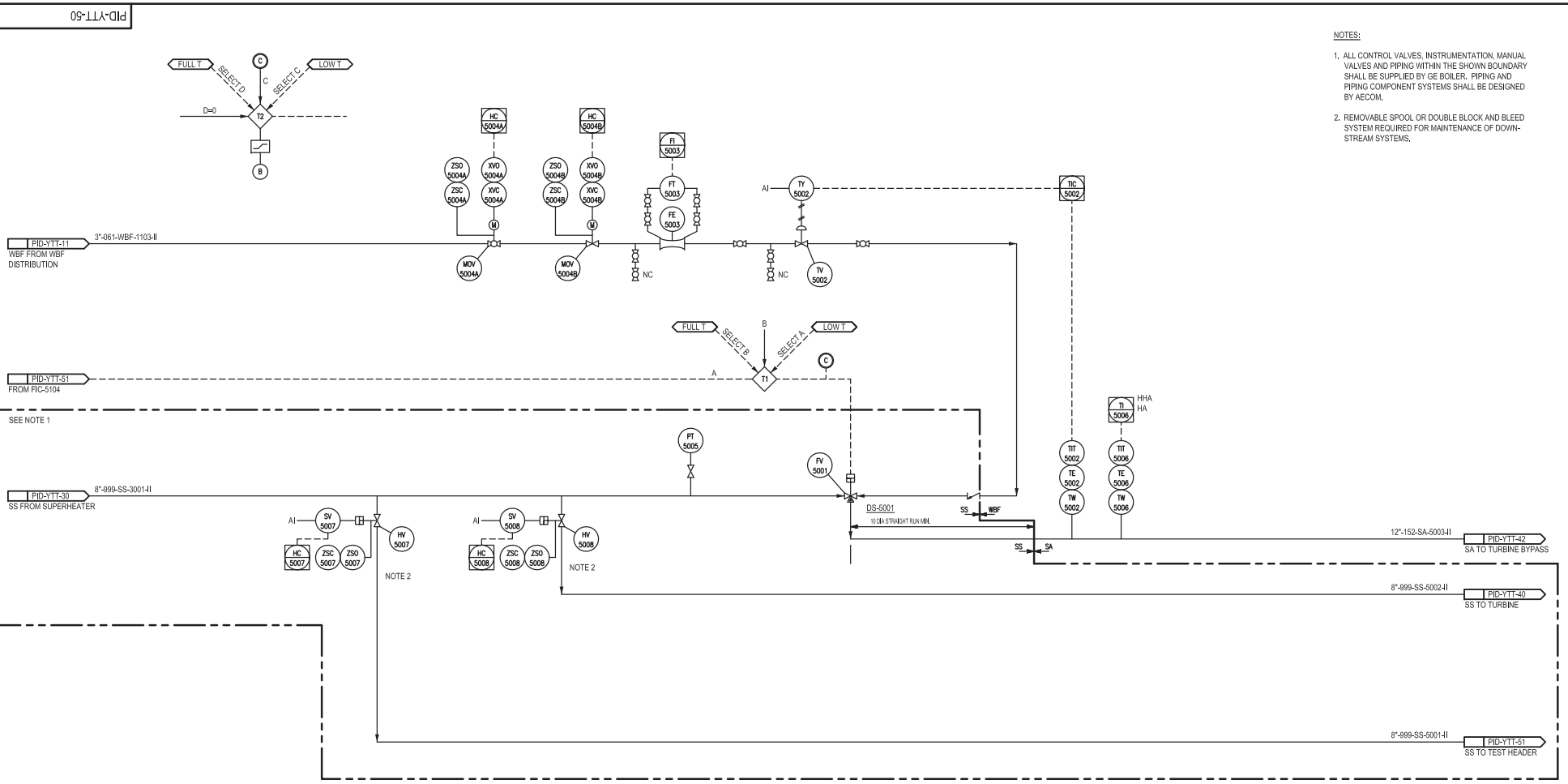

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A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
SUPER HEATED STEAM DISTRIBUTION

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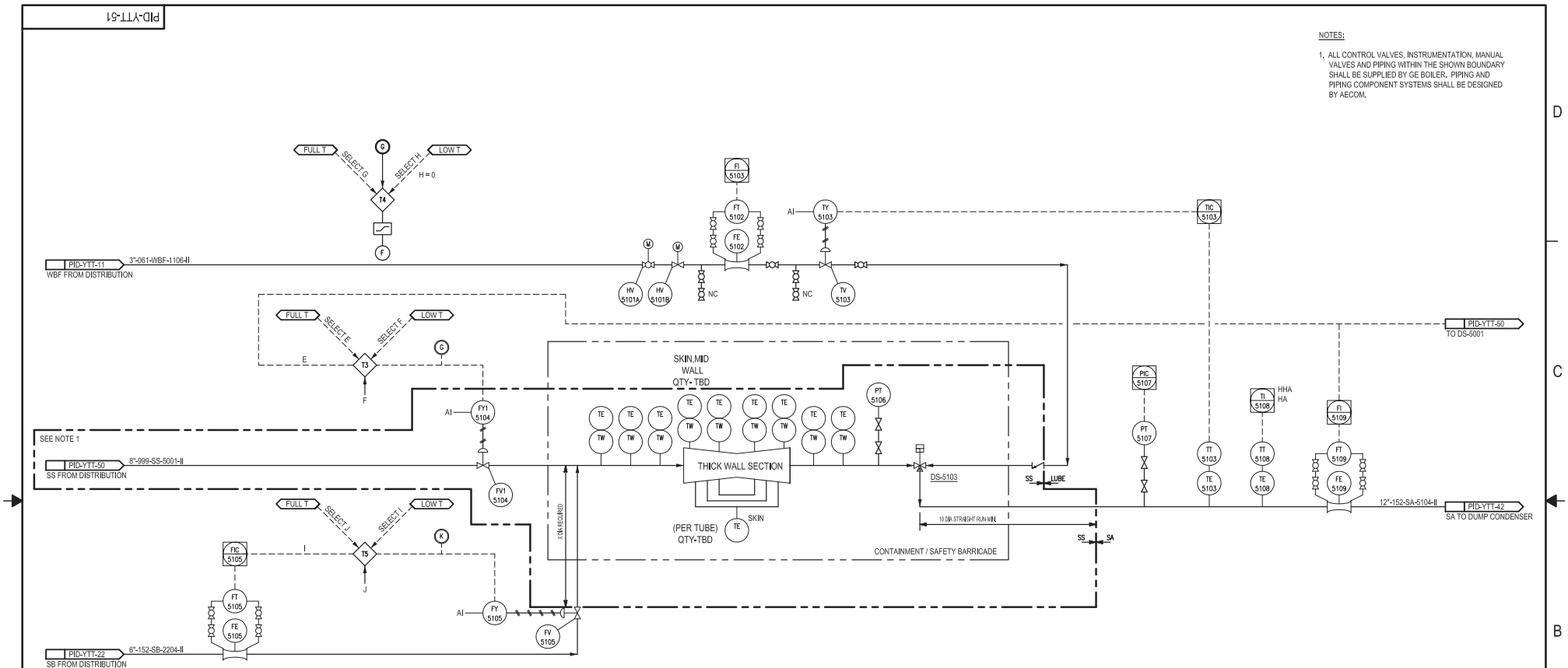

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A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
HEADER TEST

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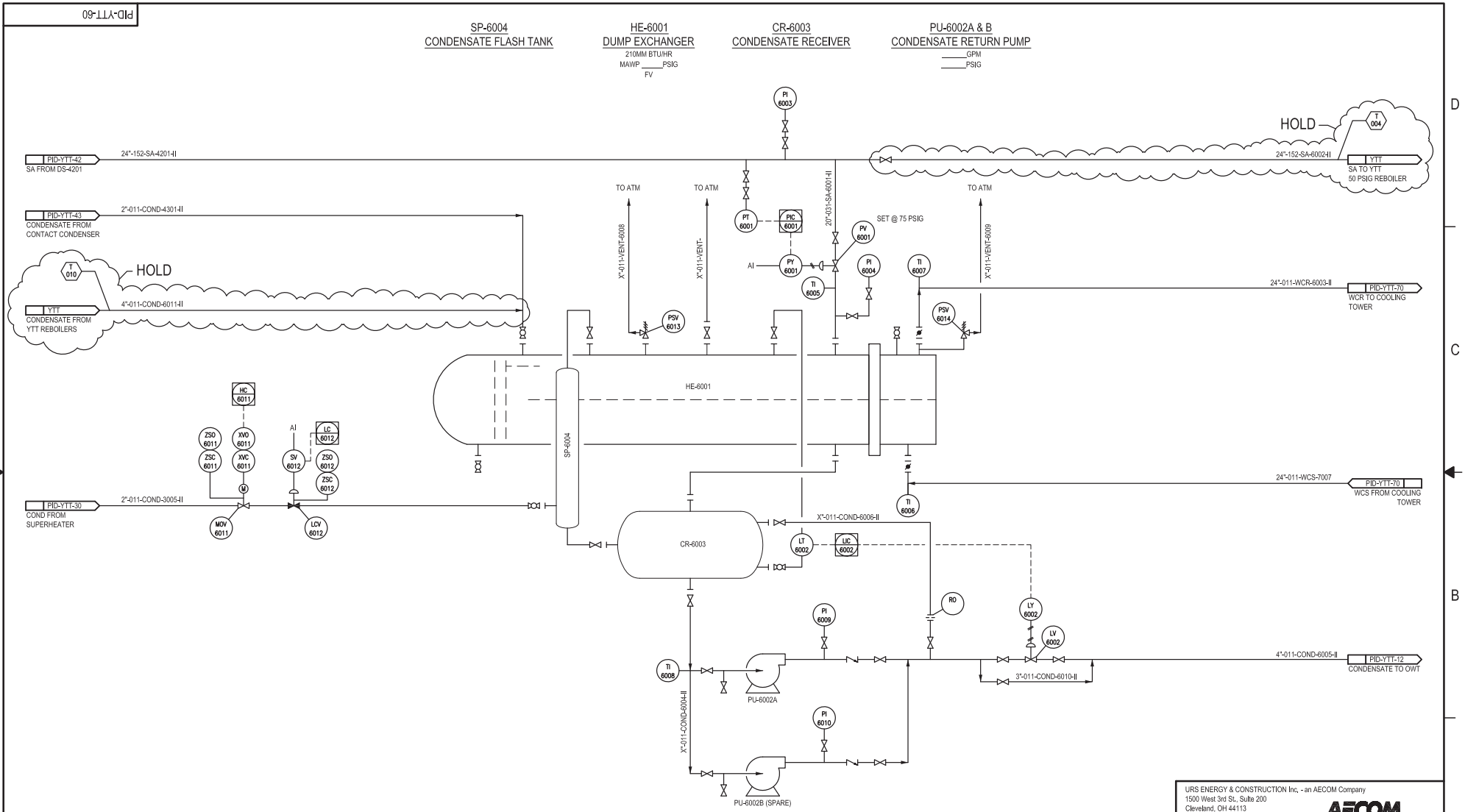

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A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
DUMP EXCHANGER

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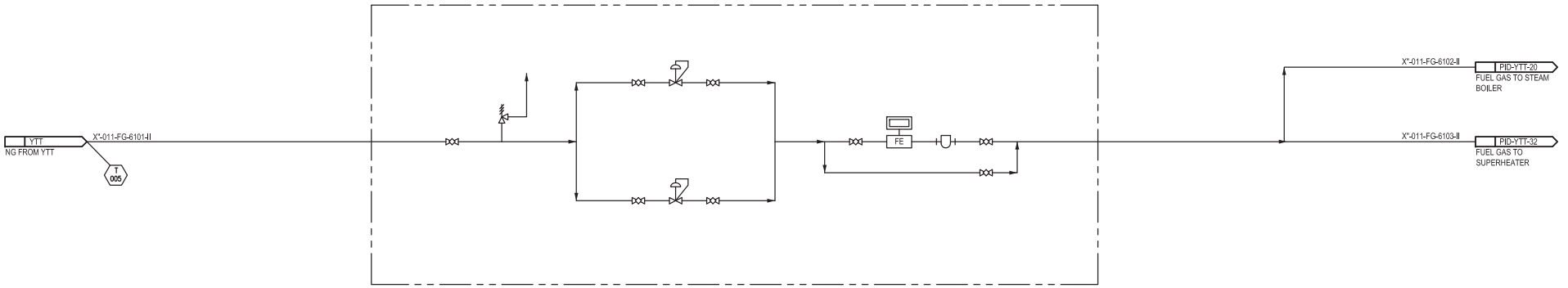

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A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
FUEL GAS DISTRIBUTION

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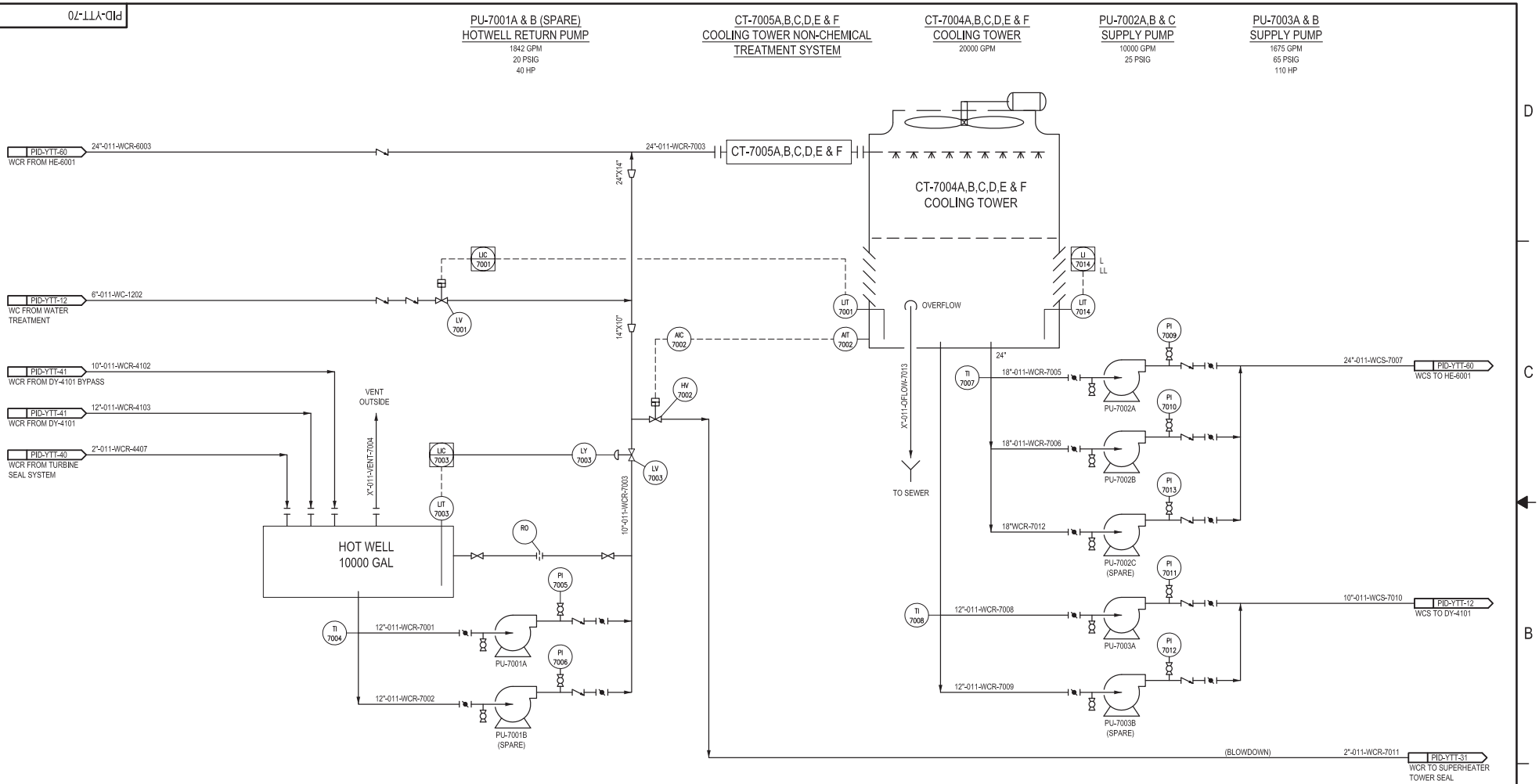

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A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
COOLING TOWER

DWG. NO. PID-YTT-70
REV D

EC_D_Size.dwg

INCHES 1 2 3 4 5 6
CENTIMETERS 1 2 3 4 5 6

8 7 6 5 4 3 2 1

D C B A

PID-YTT-80

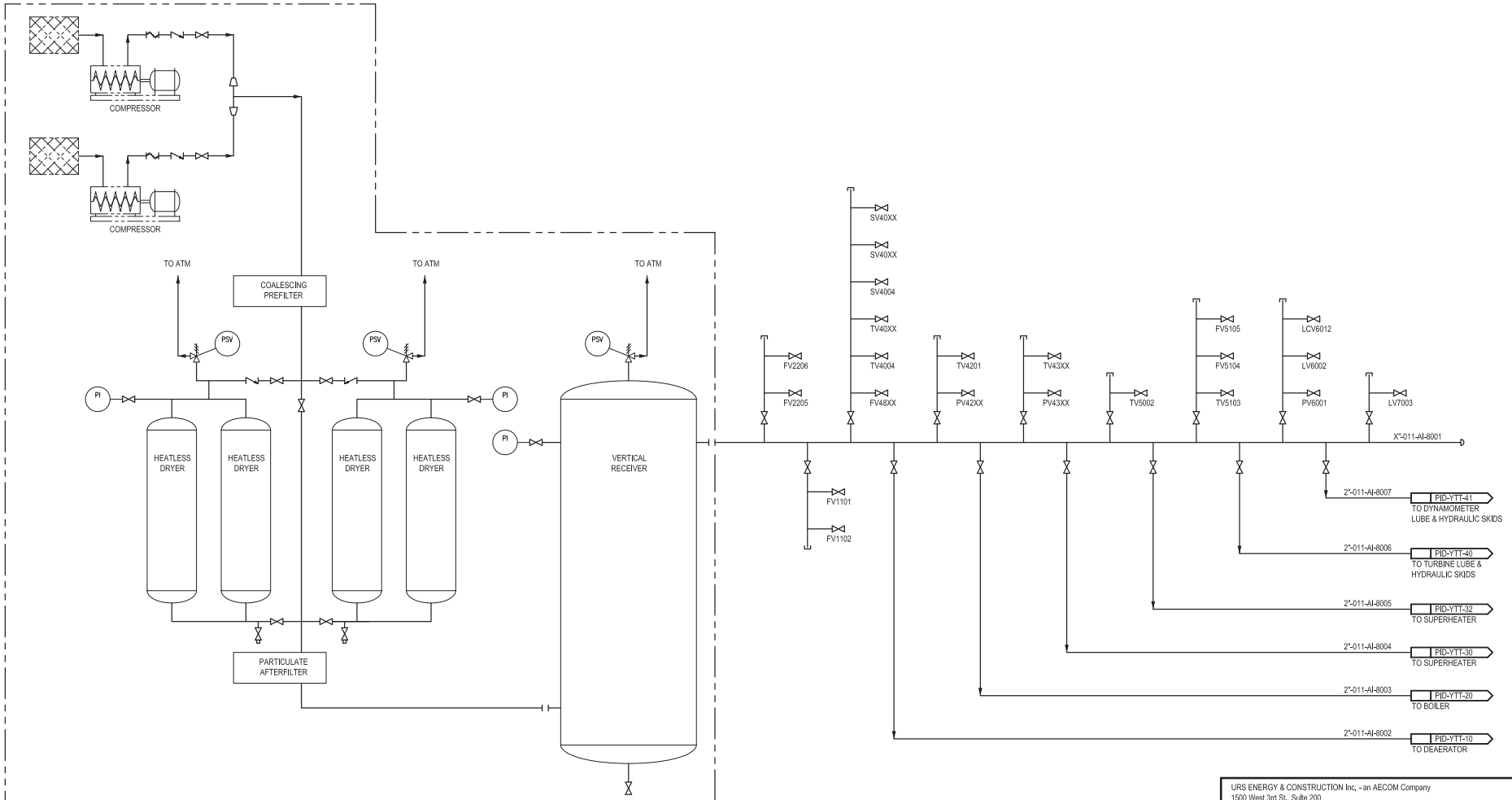
COMPRESSOR
33.4 ACFM
10 HP

COALESCING PREFILTER

HEATLESS DRYER
40 ACFM

PARTICULATE AFTERFILTER

VERTICAL RECEIVER
240 GALLON
200 PSI



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A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
AIR DISTRIBUTION

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INCHES CENTIMETERS

8 7 6 5 4 3 2 1

D C B A

Youngstown Thermal Process Hazards Analysis

PHA Report: **A-USC Comtest Project**

Youngstown Thermal
A-USC

URS Energy & Construction, Inc. - an AECOM Company
Cleveland, Ohio

Bluefield Process Safety, LLC Project No.: **16012**

Revision: **A**
26-Feb-2016

BLUEFIELD
PROCESS SAFETY

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SUMMARY

A team from the AUSC Consortium met at the offices of URS Energy & Construction, Inc. - an AECOM Company (AECOM) in Cleveland, Ohio to complete a Process Hazard Analysis (PHA) of the Advanced Ultra Supercritical Components (AUSC) research facility to be constructed and operated at the Youngstown Thermal (YTT) plant. The PHA was performed in the form of a Hazard and Operability Review (HazOp) during February 23 – 25, 2016, except where checklists for specific sections made more sense. The review addressed the 17 piping and instrument diagrams (P&IDs) that described the process. Altogether, 109 nodes were considered, resulting in recommendations for 134 different deviations. There were 82 unique recommendation; some recommendations were duplicated for related deviations and six recommendations were repeated several times throughout the PHA.

BACKGROUND

A consortium of companies is working on Advanced Ultra Supercritical Components (AUSC) and is developing a research facility to be constructed and operated at the Youngstown Thermal (YTT) plant in Youngstown, Ohio. The consortium is sponsored by the Department of Energy (DOE) through the Electric Power Research Institute (EPRI). AECOM is the engineering, procurement, and construction company for the project. Representatives from member companies—Alstom Power, Babcock & Wilcox, and GE Power—met with representatives of EPRI and AECOM to review the preliminary designs of the project for the purposes of assuring that hazards were identified and that necessary safeguards were put in place.

TERMINOLOGY

Acronyms

Acronym and abbreviations used in this HazOp are shown in the table below.

Acronym	Description
AUSC	Advance Ultra Supercritical Component
CFR	Code of Federal Regulations
DOE	Department of Energy
EPRI	Electric Power Research Institute
HazOp	Hazard and Operability Review
IEC	International Electrotechnical Commission
NCOI	No Cause of Interest, No Consequence of Interest
OSHA	Occupational Safety and Health Administration
P&ID	Piping and Instrument Diagram
PHA	Process Hazard Analysis
PSM	Process Safety Management
YTT	Youngstown Thermal

Definitions

Cause – The specific event, component failure, or human failure that initiates the chain of events leading to a hazardous consequence.

Guideword – A prompt to remind HazOp team members to consider conditions that exceed safe limits in an effort to identify process deviations that are hazardous. Examples include too high and too low.

Node – A narrowly-defined portion of the process where specific hazards may arise, typically a vessel or a line.

Process Deviation – Within a node, exceeding the safe limits of a relevant process parameter.

Process Parameter – A property or characteristic of a node that has normal operating limits and beyond that, safe limits, within which the process can operate with resulting in a hazard. Examples include temperature, pressure, level, and composition.

Process Equipment Names

Much of the documentation describing the A-USC refers to equipment numbers, nicknames, or descriptions. The following table relates unit numbers to their commonly used names.

Equip Number	Common Name	Equipment Name
	Deaerator Trailer	Deaerator
	OWT Skid	OWT Demin Filter System
	Package Boiler 1	Rental Boiler 1
	Package Boiler 2	Rental Boiler 2
	Superheater	Superheater
TUR-4001	Turbine	AUSC Turbine
DY-4101	Water break	Dynomometer
DS-4201	Desuperheater	Desuperheater
DS-5001	Desuperheater	Desuperheater
	Header Test	Thick Wall Section
HE-6001	Dump Exchanger	Dump Exchanger
PU-6002A/B	Condensate Pump A/B	Condensate Return Pump A/B
	Hot Well	Hot Well
CT-7004A/B/C/D/E/F	Cooling Tower	Cooling Tower
PU-7002A/B/C	Exchanger CT Pump A/B/C	Cooling Tower Supply Pump A/B/C
PU-7003A/B/C	Dyno CT Pump A/B	Cooling Tower Supply Pump A/B

HAZOP METHODOLOGY

The HazOp method of PHA is one of six methods recognized by the Occupational Safety and Health Administration (OSHA) as appropriate to determine and evaluate hazards of a process. Originally developed by engineers from ICI in 1963, it was introduced as a class in 1974. The first class happened to come shortly after the Flixborough disaster, and the method quickly gained wide acceptance. Trevor Kletz, of ICI, first introduced the term "HazOp" in 1983[1]. Several versions of the method have developed since it was first introduced. In 2001, one version was described in a standard developed by the International Electrotechnical Commission as IEC 61882(2001), *Hazard and operability Studies (HAZOP Studies) – Application Guide*.

Procedural Basis

The HazOp methodology is based on the use of P&IDs that accurately describe the process being reviewed and consists of three steps:

- Divide the process into nodes
- Systematically review each node for process deviations that represent hazards
- Develop a list of action items to address recommendations and concerns identified during the review of nodes for hazards

1. Nodes

Nodes typically consist of vessels or lines. When two separate parts comprise a vessel, such as the shell side and the tube side of a heat exchanger, each part is a separate node. An entire line is a node. When a line includes a pump, the pump is included as part of the node. Depending on the nature of the line, it also may be appropriate to include branches of the line as part of the node.

Nodes are identified in terms of the drawing upon which they originate and a sequence number. In the case of a line, a node may originate on one sheet and terminate on other sheet, yet only have one node number. A P&ID of typical density will consist of about 15 nodes.

Whether lines or vessels, nodes will typically include accessories, like vents, drains, or bypass loops, unless there are compelling reasons to treat the accessory as a separate node.

Because of the judgment required, the division of a process into nodes will typically be similar from one analyst to another, but differences should be expected.

2. Process Deviations

Process deviations consist of two components: parameters and guidewords.

[1] Kletz, T. A. *HAZOP & HAZAN Notes on the Identification and Assessment of Hazards*, IChemE, 1983.

Parameters are those properties or characteristics beyond a limit of which represents a hazard. OSHA has particularly called out temperature, pressure, flow, and composition in the process safety information section of the Process Safety Management (PSM) standard—29 CFR 1910.119(d)(2)(D)—but other properties and characteristics should be considered. One of the more common differences between versions of the HazOp methodology are the parameters that are considered important to review. This methodology considered the following parameters:

- Temperature
- Pressure
- Flow (typically only lines, or in vessels where space-time is very short, such as in gas service where entrainment is an issue)
- Level (typically only vessels, except in vessels that operate liquid full)
- Composition
- Mixing
- Reaction

To each parameter, guidewords are applied to identify a potential hazard. Five guidewords are used – too high, too low, reverse, other than, and surging -- and only to the extent they are meaningful. So, while a reaction may be too high, too low, reverse, or other than, temperature can only be too high or too low. In some instances, the meaning of a guideword/parameter combination is pre-defined. For instance, other than flow or other than level are always taken to mean loss of containment, other than composition is always taken to mean the presence of a contaminant, reverse mixing is always taken to mean stratification, and other than reaction is always taken to mean a side reaction.

When considering a deviation as a potential hazard, the first task was to identify whether there was a limit beyond which the process should not go. Is there a flow that is too high or too low? If so, what failure could cause the process to exceed that limit. If there was not a process limit for the node in question, the field labeled “Causes” was marked “N/A” for that deviation. If there was a limit, but no credible failure that could result in exceeding that limit, then the field labeled “Causes” for that deviation was marked “NCOI” – No Cause of Interest.

In the particular case of composition, three deviations were addressed. In the case of “composition - too high”, the deviation was whether there was some substance that was normally present, but that when present in too high a concentration caused a problem. In the case of “composition – to low”, the deviation was whether there was some substance that was normally present, but that when present in too low a concentration or not present at all caused a problem. In the case of “composition – other than”, the deviation regarded the presence of a substance that is not normally present at all, a contaminant.

Only when there was a limit and a potential failure that could cause that limit to be exceeded were consequences considered. Consequences have two components: the event that occurs, and the impact of the event on any of a number of receptors. Consequence impacts are defined however appropriate, whether in terms of personnel health and safety, community impact, environmental, or financial. All consequences listed represent possible events with potential impacts; there was no need to continually identify consequences as such. When the potential or possible consequences were minor or trivial, then the “Consequences” for that deviation is marked “NCOI” – No Consequence of Interest.

When there was a consequence of the deviation, then the deviation and its cause was a hazard. For every hazard, existing safeguards were identified and additional safeguards to consider are identified. When evaluating existing safeguards, the team carefully considered the stated failure that caused the hazard. If the cause was a control loop failure, it was inappropriate to list the alarm from that control loop as a safeguard, as the failure of one is likely to result in the failure of the other. Recommendations for additional safeguards were simply recommendations to evaluate other ideas. A HazOp is not the place to perform detailed design. The final resolution of a recommendation may be to conclude that existing safeguards are sufficient and that installation of an additional safeguard is not effective or not warranted.

During the HazOp review, the team assumed that instrumentation was sized and specified to meet the design intent, that instruments were correctly installed and calibrated, and that programming correctly reflected the logic for which the instruments were intended. This review was designed to uncover hazards resulting from failures, not hazards associated with improper specification or installation.

3. Action List

The final task of a HazOp is to assure that all actions recommended during the review are assigned to the appropriate party, and tracked to resolution. Recommendations were typically identified with the words “consider” or “confirm” are used. Because it was not necessarily the case that the team assembled to identify hazards is the best suited to assigned responsibility for resolution, this HazOp identifies action items, but leaves assignment and tracking as a subsequent task.

Previous Incidents

The process hazards analysis section of the PSM standard requires the identification of any previous incident which had a likely potential for catastrophic consequences in the workplace (see 29 CFR 1910.119(e)(3)(ii)). Because this is the review of a new process, there are no previous incidents in the process to consider. However, there are extensive codes and standards to which the new facility will be designed, constructed, operated, and maintained, all of which address the incidents that have occurred in the power industry.

Facility Siting

The process hazards analysis section of the PSM standard requires that facility siting be addressed (see 29 CFR 1910.119(e)(3)(v)). Because facility siting typically informs a HazOp review in terms of consequences and safeguards, the HazOp methodology used here explicitly addresses facility siting issues in the HazOp worksheets when considering specific deviations and hazards. For instance, the location of relieve valve discharges and vent locations was identified as a hazard for each relief valve or vent in the process. General issues of layout and arrangement will be addressed separately as the layout is developed.

Human Factors

The process hazards analysis section of the PSM standard requires that human factors be addressed (see 29 CFR 1910.119(e)(3)(v)). Process hazards are not typically about slip, trips, and falls or ergonomic hazards. The role that human factors play in process hazards

is in the interaction of personnel with the process, either as their contribution to the initiating cause of a hazardous event or in their contribution to a safeguard that prevents that hazardous event.

The causes of each hazard are explicitly identified in the HazOp worksheet, in terms of the specific failure that would initiate the chain of events leading to the consequence. In the cases where human factors apply, the cause was identified as an inadvertent event or failure to follow a procedure.

Where human factors apply to a safeguard, the need for operator response is specifically called out, as well as the stimulus to which to respond. In particular, alarms are called out. This will aid in a subsequent study of alarm rationalization, which is an important component in preventing alarm flooding.

In addition, the HazOp team explicitly considered human factors when addressing each node. When considering human factors on a node, the team considered the opportunity for error related to the control system interface, the opportunity for error in aligning manual valves, the difficulty operating valves and equipment, and the difficulty of maintaining equipment. Where no human factors were identified, the node deviation labeled “Human Factors” was marked “N/A”.

CHECKLIST METHODOLOGY

The Checklist method of PHA is one of six methods recognized by OSHA as appropriate to determine and evaluate hazards of a process. Checklists capture experience in the form of questions on the checklist, and so do not depend on the experience of the team to identify hazards. It is particularly useful for frequently replicated processes for which good checklists have been developed, such as packaged units. The Checklist methodology is only appropriate when a good checklist is available and is applicable to the process being evaluated.

In this study, burner management systems (BMS) and the compressed air system for instrument air were identified as candidates for review by checklist. The review of the compressed air system and the of the burner management systems on the package boilers were deferred until more specific data is available. However, the BMS for the superheater was reviewed with a checklist.

Procedural Basis

The Checklist methodology is based on answering the questions posed by the checklist. The answers are either Yes, No, or Not applicable. The answers are then justified with a comment to explain the basis for the answers.

Previous Incidents, Facility Siting, and Human Factors

It is the nature of checklists that previous incidents, facility siting, and human factors are implicitly addressed with questions that comprise the checklist. In the absence of explicit items in the checklist that are identified as facility siting or human factors, these items need to addressed separately.

RECOMMENDATIONS

Recommendations were typically shown as items to consider or items to confirm, unless there was unanimous agreement among the team members that a certain item needed to be done.

Items to confirm were those safeguards believed to be already in place, but for which certainty was less than absolute. The recommendation to confirm that the safeguard is in place should not be interpreted to mean that the safeguard is required to achieve risk reduction to a tolerable level. Should subsequent investigation reveal that the safeguard is not in place, a follow-on recommendation would be to investigate whether such a safeguard is required.

Items to consider are typically those items that would act as additional safeguards against the hazard being reviewed. The recommendation is to evaluate the unmitigated risk of the hazard and then to compare it to the mitigated risk achieved after taking credit for the existing safeguards. Should the mitigated risk be greater than the risk that the AUSC Consortium is able to tolerate, the evaluation should then go on to consider whether the suggested safeguard would be effective in reducing the specific risk of the hazard as well as the overall risk of the process, whether alternatives not recognized by the HazOp team would be more effective, and what the plan should be for implementation. A recommendation to consider a safeguard should not be treated as an absolute recommendation to implement it or preclude the development of alternate solutions to address the hazard.

Recommendations from all worksheets are summarized in the accompanying summary list of all recommendations. Altogether, recommendations were made for 134 different deviations. Many of the recommendations were repeated, so there were only 82 unique recommendations. Seven of the recommendations were repeated several times and should be considered as general recommendations to apply to the entire project:

1. Confirm lines are insulated for heat protection as necessary.

The team stipulated at the beginning of the review that it would be necessary to evaluate each line for its potential to exceed 140 F, the highest temperature considered safe for operator to touch, and insulate accordingly.

2. Confirm lines are insulated and traced as necessary.

The team made this recommendation eleven times, each instance being a case where the team identified a potential for water lines to freeze solid if the facility was down during cold weather. In general, the team recommended that all lines be evaluated for their potential to freeze, and then traced and insulated as necessary.

3. Consider need for independent desuperheating water supply on bypass.

The team recognized that the water for desuperheating steam at each of the desuperheaters in the process all came from the same place, and strongly recommended that there be a diversity of desuperheating water supply to avoid concerns of common-cause failure.

4. Confirm that control on boiler package limits temperature to operating envelope.

The team wants to avoid the cost of nickel construction for high temperature steam except where absolutely necessary, so recommended that the package boiler obtained to provide steam for the process be equipped with controls that assures the steam temperature will not exceed the limits of any equipment with which it may come in contact.

5. Tower entry procedures should be as rigorous as other work permit procedures.

The team was acutely aware of the harm a steam leak could cause to personnel, given the pressure and temperature of the process. As such, it determined that it would be advisable to restrict access to the superheater tower as much as possible. This recommendation was made sixteen separate times. Access to the superheater tower should restricted and follow work permit procedures as rigorous as vessel entry permit procedures or lockout-tagout procedures, even acknowledging that this a research facility.

6. Confirm that design addresses issues of steam leak from high pressure system.

In addition to restricting entry to the superheater tower, the team recommended on six different occasions that the design and layout of the steam piping explicitly take into account the potential for high pressure/high temperature steam leaks that could harm personnel elsewhere in the facility. This recommendation should be applied generally.

7. Confirm that design addresses issues of steam leak from high pressure system.

In addition to restricting entry to the superheater tower, the team recommended on six different occasions that the design and layout of the steam piping explicitly take into account the potential for high pressure/high temperature steam leaks that could harm personnel elsewhere in the facility. This recommendation should be applied generally.

8. Confirm that cooling water treatment is adequate for DY-4101 and HE-6001.

Both pieces of equipment depend on cooling water and both have requirements for water of a certain quality. The team was concerned that the source of cooling tower make-up water might compromise this quality and wanted to call attention to it.

REVISION HISTORY

Revision	Revision Date	Revised By	Revision Description
A	26-Feb-2016	Mike Schmidt	Initial issue

APPENDIX A:

PHA Participants

Tuesday, 23-Feb-2016

Participant	Organization	Role
Mark Burnett	GE Power	Turbine design and operation
Howard Hendrix	Hendrix Engineering Services	Project management
Dan Mardovin	AECOM-Cleveland	Project management
Mike Schmidt	Bluefield Process Safety	Facilitator
Rick Weiss	AECOM-Cleveland	Process engineering
Paul Weitzel	Babcock and Wilcox	Superheater design and operation
Wei Zhang	Alstom Power	Test design and operation

Wednesday, 24-Feb-2016

Participant	Organization	Role
Mark Burnett	GE Power	Turbine design and operation
Howard Hendrix	Hendrix Engineering Services	Project management
Dan Mardovin	AECOM-Cleveland	Project management
Mike Schmidt	Bluefield Process Safety	Facilitator
Rick Weiss	AECOM-Cleveland	Process engineering
Paul Weitzel	Babcock and Wilcox	Superheater design and operation
Wei Zhang	Alstom Power	Test design and operation

Thursday, 25-Feb-2016

Participant	Organization	Role
Mark Burnett	GE Power	Turbine design and operation
Horst Hack	EPRI	Project management
Howard Hendrix	Hendrix Engineering Services	Project management
Gail Lance	Babcock and Wilcox	Superheater design and operation
Dan Mardovin	AECOM-Cleveland	Project management
Mitch Rex	Babcock and Wilcox	Superheater design and operation
Mike Schmidt	Bluefield Process Safety	Facilitator
Rick Weiss	AECOM-Cleveland	Process engineering
Paul Weitzel	Babcock and Wilcox	Superheater design and operation
Wei Zhang	Alstom Power	Test design and operation

APPENDIX B:

HazOp Summary Lists

Electronic copies of this report should include one Microsoft Excel workbook:

- 16012-AUSC YTT PHA Summary.xls

It contains separate tabs entitled “Drawing List”, “Node List”, and “Recommendations”.

Paper copies of the report should simply include copies of the lists.

APPENDIX C:

PHA Worksheets

Electronic copies of this report should include two Microsoft Excel workbooks, one for the HazOp and one for the burner management system checklist on the superheater. They are:

- 16012-AUSC YTT HazOp Workbook RevA.xlsm
- 16012-AUSC YTT Checklist-Superheater RevA.xls

Paper copies of the report should simply include copies of the 115 worksheets that comprise the HazOp workbooks and the single worksheet that comprises the Checklist workbook.

Youngstown Thermal Environmental Assessment

Preliminary Draft

Environmental Assessment

Advanced Ultrasupercritical Component Test
Youngstown, Ohio

(DOE/EA-2034)

August 2016

U.S. Department of Energy
National Energy Technology Laboratory

COVER SHEET

Responsible Agency: U.S. Department of Energy (DOE)

Title: Draft Environmental Assessment for the Advanced Ultra Supercritical Component Test Project (DOE/EA-2034)

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Abstract: The United States (U.S.) Department of Energy (DOE) National Energy Technology Laboratory (NETL) prepared this Environmental Assessment (EA) to analyze the potential environmental, cultural, and socioeconomic impacts of partially funding a proposed project to design, procure, construct and test a prototype of an advanced ultrasupercritical (AUSC) steam turbine and AUSC components. The AUSC Component Test (ComTest) Project would be located at the existing Youngstown Thermal steam plant in Youngstown, Ohio. DOE proposes, through a cooperating agreement with the Energy Industries of Ohio (EIO), to provide financial assistance for the proposed AUSC ComTest Project, which would involve the construction and 2-year operation of a full-scale pilot test facility to evaluate new steam turbine system components designed to operate at higher pressures and temperatures. The purpose of the project is to test these advanced components and provide the research and data necessary to support commercial-scale development of technologies that can increase the efficiency of coal power plants. Increasing coal power plant efficiency would reduce water use and plant emissions (including greenhouse gases). Under the Proposed Action, DOE proposes to provide EIO with up to $55.5 million of cost-shared financial assistance under the Office of Fossil Energy's Crosscutting Technology Research Program. DOE's contribution would constitute about 75 percent of the estimated $74.1 million total project cost.

Availability: This draft EA is available to the public on DOE's National Energy Technology Laboratory website at http://www.netl.doe.gov/publications/others/nepa/ea.html and at the following location:

Public Library of Youngstown and Mahoning County
305 Wick Ave
Youngstown, OH 44503
330-744-8636

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Acronyms

Acronym	Definition
°F	degrees Fahrenheit
APE	Area of Potential Effect
AQRV	Air quality related value
ARPA	Archeological Resources Protection Act
AUSC	Advanced Ultrasupercritical
CAA	Clean Air Act
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CHP	combined heat and power
ComTest	Component Test
CO_2	carbon dioxide
CO_2-eq	carbon dioxide equivalents
CWA	Clean Water Act
DOE	Department of Energy
EA	Environmental assessment
EIO	Energy Industries of Ohio
EO	Executive Order
GHG	Greenhouse gases
HAPs	Hazardous air pollutants
HDPE	High-density polyethylene

Acronym	Definition
M-TAPCA	Mahoning-Trumbull Air Pollution Control Agency
MW	megawatt
NAAQS	National Ambient Air Quality Standards
NETL	National Energy Technology Laboratory
NO_x	nitrogen dioxide
NSR	New Source Review
Ohio EPA	Ohio Environmental Protection Agency
PM_x	particulate matter with a diameter of 2.5 microns or less;
PSD	Prevention of Significant Deterioration
psia	pounds per square inch absolute
psig	Pounds per square inch gage
RCRA	Resource Conservation and Recovery Act
ROI	Region of Influence
SHPO	State Historic Preservation Office
U.S.	United States
USC	United States Code
USEPA	U.S. Environmental Protection Agency
VOC	volatile organic compound

1

CHAPTER 1 INTRODUCTION

The United States (U.S.) Department of Energy (DOE) National Energy Technology Laboratory (NETL) prepared this Environmental Assessment (EA) to analyze the potential environmental, cultural, and socioeconomic impacts of partially funding a proposed project to design, procure, construct, and test a prototype of an advanced ultrasupercritical (AUSC) steam turbine and AUSC components. The project is referred to as the AUSC Component Test (ComTest) Project, and would be located at the existing Youngstown Thermal steam plant in Youngstown, Ohio.

1.1 BACKGROUND

DOE began funding research into materials technology for use in advanced ultrasupercritical steam turbines in 2002. Estimates show that a plant operating with AUSC steam turbines, which have temperatures up to 760 degrees Celsius (ºC) (1,400 degrees Fahrenheit [ºF]) and 35 megapascal (MPa) (5,000 pounds per square inch gage [psig] pressure), could have as much as 27 percent higher net efficiency and lower emissions than current subcritical plants, and a 5 percent improvement over state-of-the-art pulverized coal plants (EIO 2015). Current boiler materials do not have the necessary fabrication properties and resistance to creep, oxidation, corrosion, and fatigue at higher steam temperatures and pressures that would allow implementation of AUSC in existing pulverized coal-fired plants.

The proposed AUSC ComTest Project is an expansion and continuation of three previous DOE research and development (R&D) projects that were conducted in order to close the material technology gap and move towards commercialization (see Table 1-1). The AUSC ComTest Project would include the design, procurement, construction, and testing of a prototype AUSC steam turbine and the prototype scale AUSC components (boiler superheater, boiler tube membrane walls, steam de-superheater, steam headers, main steam piping, and main steam line valves) needed to produce the steam feed to the AUSC steam turbine. The technical goal of this project is to bring AUSC technology to the commercial-scale demonstration level of readiness by designing, procuring, constructing and operating a test facility with an AUSC steam turbine and components.

Table 1.1. Prior DOE Materials Technology R&D Projects

Year – DOE Project	Overview
2002 - DE-NT41175	DOE selected this project to develop materials for AUSC boilers. The project resulted in the selection of an alloy for boiler tubing and thick wall steam piping. The project was completed by a consortium consisting of EIO; their subcontractors Babcock & Wilcox, Alstom Power, Foster Wheeler, and Riley; the Electric Power Research Institute; and Oak Ridge National Laboratory. The project also received non-DOE funding from the Ohio Coal Development Office.
2006 - DE-NT42442	DOE selected this project to develop the materials for an AUSC steam turbine. Under this project evaluated a wide spectrum of alloys and coatings for oxidation/erosion resistance and weldability. The project was completed by a consortium consisting of EIO, General Electric, Alstom Power, and Siemens; the Electric Power Research Institute; Oak Ridge National Laboratory; and DOE's NETL.
2010 - DE-FE00000234	DOE selected this project at the end of project DE-NT42442. The project included an in-depth evaluation of the long-term mechanical properties of the alloys; scale-up and validation of casting, forging, and welding technologies needed for large thick wall components; performance of high temperature creep and fatigue tests on component specimens; and performance of a preliminary design and techno-economic analysis of an AUSC steam turbine.

Energy Industries of Ohio (EIO) is leading a consortium of industries to develop and implement the AUSC ComTest Project. The consortium includes the Ohio Coal Development Office, Babcock and Wilcox, the Electric Power Research Institute, Foster Wheeler, General Electric's Boiler (formerly ALSTOM Power) and Turbine groups, and Riley Power, Inc., in conjunction with NETL's Albany Research Center and Oak Ridge National Laboratory. Based on the prior R&D projects, EIO identified for DOE a weldable form of Inconel 740 Nickel superalloy with the necessary properties for an AUSC boiler and other pressurized components, and the Haynes 282 (H282) Nickel superalloy with the necessary properties for an AUSC steam turbine and valves. The EIO-led consortium also obtained the American Society of Mechanical Engineers Code approval to use the Inconel 740 in boilers, tubing, and pressure piping.

Because the AUSC ComTest Project arose out of R&D efforts on the three previous DOE projects, the project was not selected under a competitive solicitation. Instead, the participants submitted an unsolicited application for financial assistance, which DOE reviewed using a Noncompetitive Merit Review Plan. The independent reviewers considered the proposed project and found it to meet the merit criteria for funding. DOE prepared a Determination of Non-Competitive Financial Assistance, which was approved on September 24, 2015.

1.2 DOE'S PROPOSED ACTION

DOE's proposed action is to provide financial assistance to EIO for the AUSC ComTest Project. DOE proposes to provide EIO with up to $55.5 million of cost-shared financial assistance under the Office of Fossil Energy's Crosscutting Technology Research Program. DOE's contribution would constitute about 75 percent of the estimated $74.1 million total project cost.

1.3 PURPOSE AND NEED

The purpose and need for DOE action is to advance the AUSC steam technology by testing it at the pilot-scale. This technology is important to the existing fleet of pulverized coal-fired power plants because it represents a significant increase in steam generation efficiency, reducing the amount of coal fuel required and related decrease in CO_2 emissions. This increase in efficiency supports the Plant Optimization Technologies goals of the DOE's Crosscutting Technology Research Program. Upon successful completion of this pilot scale test, AUSC steam technology will be ready for commercial-scale demonstration.

1.4 NATIONAL ENVIRONMENTAL POLICY ACT AND RELATED PROCEDURES

DOE prepared this Environmental Assessment (EA) in accordance with the National Environmental Policy Act (NEPA), as amended (42 United States Code [USC] 4321), the President's Council on Environmental Quality (CEQ) regulations for implementing NEPA (40 Code of Federal Regulations [CFR] 1500-1508), and DOE's implementing procedures for compliance with NEPA (10 CFR 1021). This statute and the implementing regulations require that DOE, as a federal agency:

- assess the environmental impacts of its proposed action;
- identify any adverse environmental effects that cannot be avoided, should the proposed action be implemented;
- evaluate alternatives to the proposed action, including a no action alternative; and
- describe the cumulative impacts of the proposed action together with other past, present, and reasonably foreseeable future actions.

These provisions must be addressed before a final decision is made to proceed with any proposed federal action that has the potential to cause impacts to the natural or human environment, including providing federal funding to a project. This EA is intended to meet DOE's regulatory requirements under NEPA and provide DOE with the information needed to make an informed decision about providing financial assistance. In accordance with the above regulations, this EA allows for public input into the federal decision-making process; provides federal decision-makers with an understanding of potential environmental effects of their decisions before making these decisions; and documents the NEPA process.

CHAPTER 2 PROPOSED ACTION AND ALTERNATIVES

2.1 INTRODUCTION

This chapter describes the Proposed Action and No Action Alternative analyzed in this EA, as well as those alternatives dismissed from further consideration. As described in Chapter 1, CEQ's regulations direct all federal agencies to use the NEPA process to identify and assess the reasonable alternatives to proposed actions that would avoid or minimize adverse effects of these actions upon the quality of the human environment (40 CFR 1500.2[e]).

2.2 DEPARTMENT OF ENERGY'S PROPOSED ACTION

DOE proposes, through a cooperating agreement with the EIO, to provide financial assistance for the proposed AUSC ComTest Project at the Youngstown Thermal campus, an existing steam plant in Youngstown, Ohio. The AUSC ComTest Project would involve the construction and 2-year operation of a full-scale pilot test facility to evaluate new steam turbine system components designed to operate at higher pressures and temperatures. The purpose of the project is to test these advanced components and provide the research and data necessary to support commercial-scale development of technologies that can increase the efficiency of coal power plants. Increasing coal power plant efficiency would reduce water use and plant emissions (including greenhouse gases). Under the Proposed Action, DOE would provide financial assistance to EIO for the AUSC ComTest Project. DOE proposes to provide EIO with up to $55.5 million of cost-shared financial assistance under the Office of Fossil Energy's Crosscutting Technology Research Program. DOE's contribution would constitute about 75 percent of the estimated $74.1 million total project cost. See Section 2.5 for detailed discussion of the proposed project.

2.3 NO ACTION ALTERNATIVE

Because the AUSC ComTest Project arose out of R&D efforts on three previous DOE projects, the project was not selected under a competitive solicitation. Instead, the participants submitted an unsolicited application for financial assistance, which DOE reviewed using a Noncompetitive Merit Review Plan. The independent reviewers considered the proposed project and found it to meet the merit criteria for funding. DOE prepared a Determination of Non-Competitive Financial Assistance, which was approved on September 24, 2015. The only alternative to this action is the No-Action Alternative.

Under the No-Action Alternative, DOE would not provide cost-shared funding to the proposed project. The AUSC steam turbine technology would not be tested and validated, and steam cycle efficiency improvements through advancement of these technologies would not occur. As a consequence, the opportunity to reduce the amount of fuel used to generate steam in the existing coal-fueled power plant fleet through deployment of these technologies, and related reductions in CO_2 emissions (estimated to be 27 percent on average), could be lost.

2.4 ALTERNATIVES CONSIDERED BUT DISMISSED

The AUSC ComTest Project is part of a larger AUSC ComTest Program that includes testing of turbine, headers, and valve technologies under multiple test conditions including high-temperature and high-pressure The AUSC ComTest Project at Youngstown Thermal would address the high temperature testing of the turbine and header aspects of the program, but would not address high-pressure valve testing. The applicant does not consider conducting the high-pressure valve testing at the Youngstown Thermal site feasible. However, as presented by EIO, DOE considered siting the high-pressure test of the valves at two alternate Southern Company sites. Both of these

alternative sites have existing coal-fueled power plants with the space and capacity to meet the needs of a

high-pressure test. However, due to budgetary constraints, these alternatives were removed from further consideration.

2.5 AUSC COMTEST PROJECT DESCRIPTION

2.5.1 Project Location

The Youngstown Thermal campus located in Mahoning County, Ohio, which includes an existing steam-generating plant, would serve as the host site for the project (see Figure 2-1 and Figure 2-2). Youngstown Thermal operates a district energy/heating plant, in operation since 1895, which produces steam from city water and delivers the steam through underground piping to over 77 buildings in the densely populated central business district of Youngstown, including Youngstown State University. Youngstown Thermal delivers the steam at approximately 150 pounds per square inch absolute (psia) for heating, domestic hot water, cooking, industrial uses, laundry, and other uses. The steam plant has historically used a combination of coal- and natural gas-fired units, including three coal-fired boilers (two 100,000 pounds per hour and one 90,000 pounds per hour) and one natural gas-fired boiler (100,000 pounds per hour). However, as of May 2016, Youngstown Thermal began using liquefied wood pulp as their fuel source for their natural gas boiler as part of a renewable fuel oil test project, currently providing approximately 90 percent of their customers' needs (Youngstown Thermal 2016a). The Ohio EPA has issued a temporary permit to burn the biomass-derived liquid fuel until December 31, 2016 (Ohio EPA 2016a).

Youngstown Thermal is also in the process of designing a new, 34 megawatt (MW) combined heat and power (CHP) (also known as cogeneration) system for the campus (Youngstown Thermal 2016b). CHP systems capture and utilize the heat (thermal energy) that would otherwise be rejected from the power plant, thereby increasing the energy efficiency of the system. The new system would include a combustion turbine (10,000 horsepower) and a waste heat recovery boiler system (operating at 1,000 psig, with a capacity of 180,000 pounds per hour). The new CHP would produce steam for Youngstown Thermal customers and electricity for the campus, with excess power going to the grid. The new waste heat recovery boiler would become the primary boiler for Youngstown Thermal, such that the existing natural gas and coal boilers would be used only rarely, such as during maintenance of the new system or during excessive peaks in demand.

Youngstown Thermal is uniquely suited as a host site for the AUSC ComTest Project since it is an existing steam plant, has the necessary utilities (steam, water, gas, power, etc.) to perform the test, and has existing trained operational staff that could support the AUSC ComTest equipment.

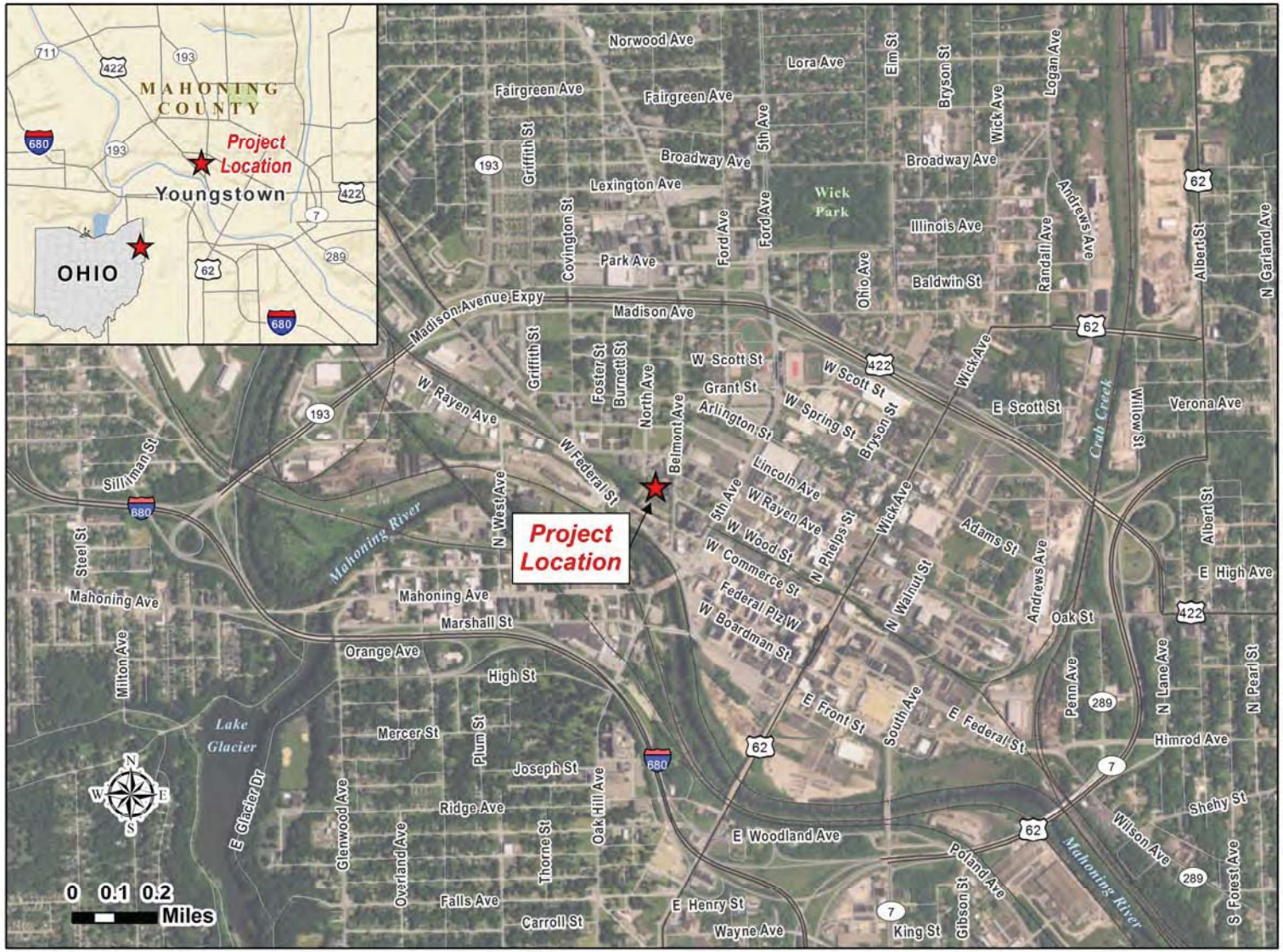

Figure 2-1. Project Location

Figure 2-2. Proposed Project Area

The Youngstown Thermal steam plant is located on the northern portion of the approximately 3-acre campus that includes the boiler plant, turbine building, management/engineering office, storage building, fly ash silo, coal storage area and pit, coal tower, four 120-foot stacks, and paved surfaces (gravel, asphalt, and concrete). Figure 2-3 (Project Site and Youngstown Thermal Campus) shows the existing steam plant buildings and features and the locations of the proposed AUSC ComTest Project components on the Youngstown Thermal campus. The AUSC ComTest would be integrated into the Youngstown Thermal campus by utilizing a combination of open plant property, relocation of some existing steam plant features, and use of an adjacent property for construction laydown (see Figure 2-2).

Figure 2-3. Project Site and Youngstown Thermal Campus

2.5.2 AUSC ComTest Project Base Case Configuration

The AUSC ComTest Project would evaluate the effect of AUSC high temperature (1,400°F) and low pressure (620 psia) conditions and thermal/pressure cycling on the mechanical integrity of the AUSC components, including the turbine, lines, and headers. The proposed project would feature two main tests including the superheater header test and the steam turbine test (see Section 2.5.5). Each component test would occur individually and never concurrently, with the superheater header test taking place before the steam turbine test. The proposed project would also evaluate advanced materials including fabricated nickel superalloy and other AUSC components; test and validate fabrication techniques and the ability to construct, install, and repair AUSC ComTest components under both steady-state and cycling operating modes; and provide sufficient research and development test data and metallurgical analysis data to support the development of future commercial-scale technology.

The AUSC ComTest Project base case configuration would consist of a natural gas-fired superheater and superheater tower, a steam turbine and turbine building, a natural gas-fired boiler, a cooling tower, and other ancillary equipment. The AUSC ComTest Project would also require a new natural gas line to supply the fuel for the project. Figure 2-4 (below) presents the general arrangement of the base case configuration, which includes all the major components of the AUSC ComTest. Table 2-1 provides details about the components of the project including the buildings, AUSC ComTest equipment, and balance of plant equipment.

2.5.3 AUSC ComTest Project Alternate Configuration

For purposes of this NEPA analysis, DOE assumes the Proposed Action reflects the base case configuration where all the AUSC ComTest equipment would be furnished and operated by the EIO and the project participants. Figure 2-3 (above) and the descriptions in the following sections (Section 2.5.4 Construction and 2.5.5 AUSC ComTest Operations) are consistent with this assumption. However, an alternate configuration may be used for the project if Youngstown Thermal's planned CHP project is constructed and in operation prior to the AUSC ComTest Project, and all financial and legal agreements with EIO are finalized.

For the alternate configuration, Youngstown Thermal's new waste heat boiler would supply the steam for the Proposed Action. In addition, Youngstown Thermal would purchase and install some of the components included in the Proposed Action, and would provide them to the AUSC ComTest through lease agreements with EIO. Therefore, some of the equipment discussed and analyzed in this EA under the base case would no longer be part of the Proposed Action. This equipment includes the proposed package natural gas-fired boiler, the deaerator and boiler feed water treatment equipment, the oxygenated water treatment system, the cooling tower, the cooling tower water treatment system, the cooling tower water supply pumps, and the packaged air compressor. Youngstown Thermal would incorporate these processes into their operations and supply steam to the AUSC ComTest. In addition, as Youngstown Thermal would need the natural gas line to supply their new CHP system, they would likely arrange the installation of the new natural gas line to the site with Dominion East Ohio. Table 2-1 identifies equipment that would no longer be part of the Proposed Action under the alternate configuration.

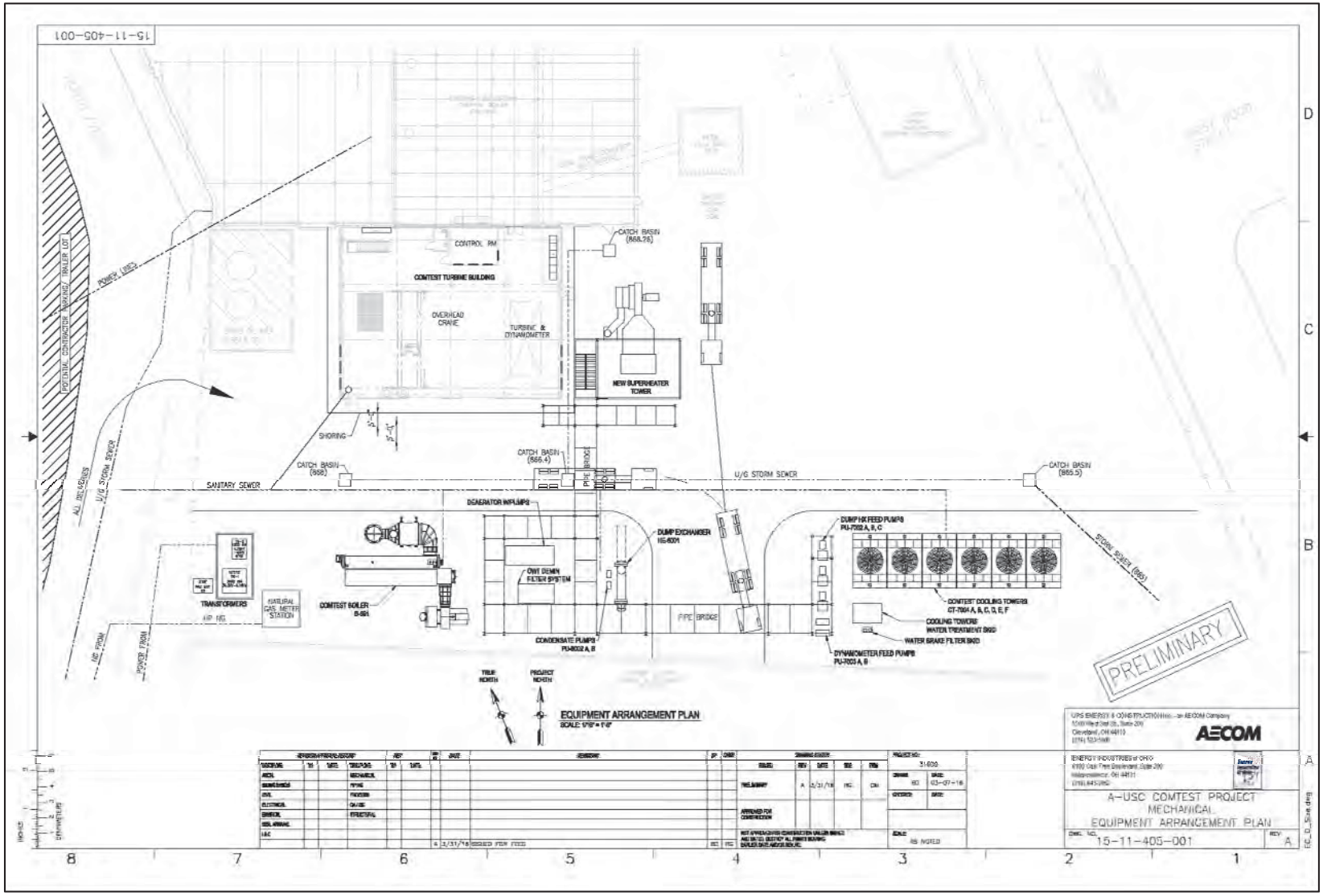

Figure 2-4. AUSC ComTest Mechanical Equipment Arrangement Plan (Base Case)

Table 2-1. AUSC ComTest Equipment Components

Component/Equipment	Details
	BUILDINGS
ComTest Turbine Building	A new pre-engineered steel framed building to house the ComTest steam turbine, the control room, and associated turbine components, including a 30-ton bridge crane. A 14.5-foot deep basement would connect to the existing boiler building basement for passageway and connection of piping. The building would include an HVAC system. The building would be 70 feet by 90 feet, 32 feet high, and contain 6,330 square feet of space.
Superheater Tower	A new super structure to house the superheater equipment and components required to increase the steam to AUSC levels. Includes exhaust fans and an exhaust stack for cooled flue gas. The tower would be 34 feet by 49 feet, 130 feet high, and 1,666 square feet of space.
	AUSC COMTEST EQUIPMENT
Superheater	An air-blown, natural gas-fired steam superheater. utilizes steam from Youngstown Thermal's planned waste heat boiler or the ComTest package boiler to increase the steam temperature to AUSC levels.
Superheater Header	A piping component used to evaluate the ability of the AUSC materials to operate reliably under varying boiler loads. Steam temperature through the header would cycle hourly between 750°F to 1,400°F.
Steam Turbine	An 8 MW steam turbine used to evaluate the ability of the turbine and components to operate reliably at AUSC levels, including throttle conditions of 1,400°F, 620 psia, and 119,500 pounds per hour. Electricity generated by the turbine would be captured by a dynamometer.
	BALANCE OF PLANT EQUIPMENT
Package Boiler[a] (Not required for alternate configuration)	Natural gas-fired 600 horsepower package boiler rated at 150,000 pounds per hour, 1,100 psig and 850°F for design conditions, and 950 psig and 750°F for operating conditions. Includes a low-NOx gas-fired burner, economizer, stack, burner management control system, a water treatment system, deaerator, and dump condenser/exchanger.
Cooling Tower[a] (Not required for alternate configuration)	Six cooling tower cells designed for a load of 87 mmBtu per hour to maintain proper scale, microbiological and corrosion control. Cooling water would be used for the dump condenser and the dynamometer. The AUSC ComTest proposes to use a pre-assembled energy-efficient cooling tower system with low drift rates, and options to integrate additional plume abatement and water conservation technologies (SPX 2016).
Water Treatment[a] (Not required for alternate configuration)	Two separate water treatment areas would accommodate the package boiler and the cooling tower. The package boiler would also receive feedwater from a deaerator, which removes oxygen and dissolved gases from the feedwater.
Dump Condenser/Exchanger[a] (Not required for alternate configuration)	Condenses the ComTest exhaust steam that exceeds the demands of Youngstown Thermal customers. Water would be supplied to the condenser from the cooling tower.

Table 2-1. AUSC ComTest Equipment Components

Component/Equipment	Details
Dynamometer	Mounted to the ComTest steam turbine to dissipate the electrical load generated by the turbine. Water would be supplied to the dynamometer from the cooling tower.
Electrical	Electrical upgrades to accommodate the operating load of the ComTest equipment of approximately 3 MW, with several 500 to 600 HP motors requiring 4,160 V service. Additionally, a 480 V service would be added for smaller electrical loads and 120 V service for all new equipment areas. The upgrades would also include sub-transmission service lines, pad mounted circuit breaker, two liquid filled transformers, and other associated components.
Natural Gas Pipeline[a] (Not required for alternate configuration)	A new 12-inch HDPE natural gas service pipeline would provide fuel for the ComTest boiler, superheater, and the unit heaters in the turbine building. The line would extend approximately 1.45 miles from the tie-in point on McGuffey Road to the AUSC ComTest Project area. The demand would be approximately 6,400 scfm. The line would operate at approximately 85 psig at the tie-in point in the winter and 75 psig at the tie-in point in the summer. A gas meter for this new line would be installed south of the turbine building within a pre-assembled enclosure for weather protection.
Utility Racks	Steel-framed open utility racks to support piping and cable trays between onsite equipment including the ComTest turbine building/control room, superheater tower, and boiler area.
Storm Sewer System	Storm sewer pipes form the new structures would tie into the existing storm sewer system.
Sanitary/Industrial Sewer System	Process floor drains in the ComTest turbine building would tie into a pre-fabricated sump and pump to discharge into the process sewer. Process drains would also be located in the yard area for the superheater, cooling tower and water treatment skid, package boiler and water stream skid. These process flows and sanitary waste from the ComTest turbine building rest room would tie into the existing sanitary/industrial sewer system. The wastewater would be discharged under Youngstown Thermal's current wastewater discharge permit (Permit #M1002) issued by the City of Youngstown Public Works Department.
Control Room	Central location for operation of the ComTest would be located in the ComTest turbine building and include control systems and work stations.

Source: AECOM 2016b

a. The alternate configuration assumes that Youngstown Thermal would supply the required steam for the AUSC-ComTest Project and thereby purchase, install, and operate some of the equipment required for the project, as discussed in Section 2.4.3.

HDPE = high density polyethelene; HVAC = heating, ventilation, and air conditioning; mmBtu = million British Thermal Units; MW = megawatt; psig = pounds per square inch gage; NO_x = nitrogen oxides; PVC = polyvinyl chloride; scfm = standard cubic feet per minute; V = volt

2.5.4 Construction

Youngstown Thermal Campus

The AUSC ComTest facility would be constructed east of North Avenue on available areas on the Youngstown Thermal campus, just south of the existing steam plant (See Figure 2-2). To support construction staging and laydown, the project would use an adjacent property located immediately west of North Avenue and the campus (see Figure 2-2). In addition, Dominion East Ohio would construct an approximately 1.45-mile natural gas line to supply natural gas needed to operate the AUSC ComTest.

The EIO anticipates that the construction phase for all facets of the AUSC ComTest Project would last approximately 2 years. Construction would begin in fall 2016 with the offsite construction of the natural gas line and electrical supply infrastructures. In January 2017, the onsite construction would begin at the Youngstown Thermal campus and adjacent laydown area, with demolition, clearing, grading, paving, etc. to prepare the site for construction of the foundations, buildings, and infrastructure. EIO anticipates that construction would be completed and the equipment connected and ready for operation by approximately August 2018 (AECOM 2016a).

During the construction phase, the project would clear, grade, and utilize the adjacent property directly across North Avenue for a trailer, parking, and laydown area (see Figure 2-2). Space would also be made available on the bottom floor of the five-story brick and concrete building located south of the Youngstown Thermal campus for small parts laydown, and possibly a construction office(s).

During construction, all deliveries would be routed from Martin Luther Blvd onto North Street and into the construction site. At times the entrance and driveway into the construction area would be completely closed to the Youngstown Thermal campus, and access to the Ensys Oil area would be extremely limited during the construction of the turbine building. There would be available parking for construction workers at various locations in the vicinity of the project site, including within the adjacent lot used for laydown and staging, possibly in the church parking lot on W. Rayen Avenue, or in nearby public garages.

Natural Gas Pipeline

Dominion East Ohio would construct a new gas line to supply natural gas for the new Youngstown Thermal CHP in the long term, and provide natural gas to the AUSC ComTest Project in the short term. Figure 2-5 presents the route of the new natural gas pipeline that Dominion East Ohio has proposed as the least disruptive route from their closest tie-in point (on McGuffey Road) to the connection location at Youngstown Thermal (on Belmont Avenue). The route would avoid the downtown area and the Youngstown State University campus. The proposed route is approximately 7,700 feet (1.45 miles) and within the existing road rights-of-way.

The natural gas line would be a 12-inch diameter high-density polyethylene (HDPE) pipe, conforming to ASTM D2513 with a pressure rating of 1,600 psi at 73°F. The anticipated operating pressures during the 2-year project will vary by season, with 85 psig at the tie-in point in winter and 75 psig at the tie-in point in summer. EIO anticipates that construction of the gas line would occur from October 2016 to approximately July 2017.

Dominion East Ohio anticipates installing the new line using trenching techniques along the entire distance. The minimum trench width for a 12-inch diameter pipe and stable soil conditions would likely be 24 inches, however, DOE assumes an approximate trench width of 36 inches to account for variations in soil conditions and backfill placement around the pipe. Anticipated trench depth would be roughly 36 inches, dependent on soil conditions, obstructions along the route, and burial depth required under roadways. The installation contractor would likely use a chain or wheel trencher for most of the route or

a conventional excavator if rock is found, and would construct using hand excavation in areas of close proximity to existing underground utilities.

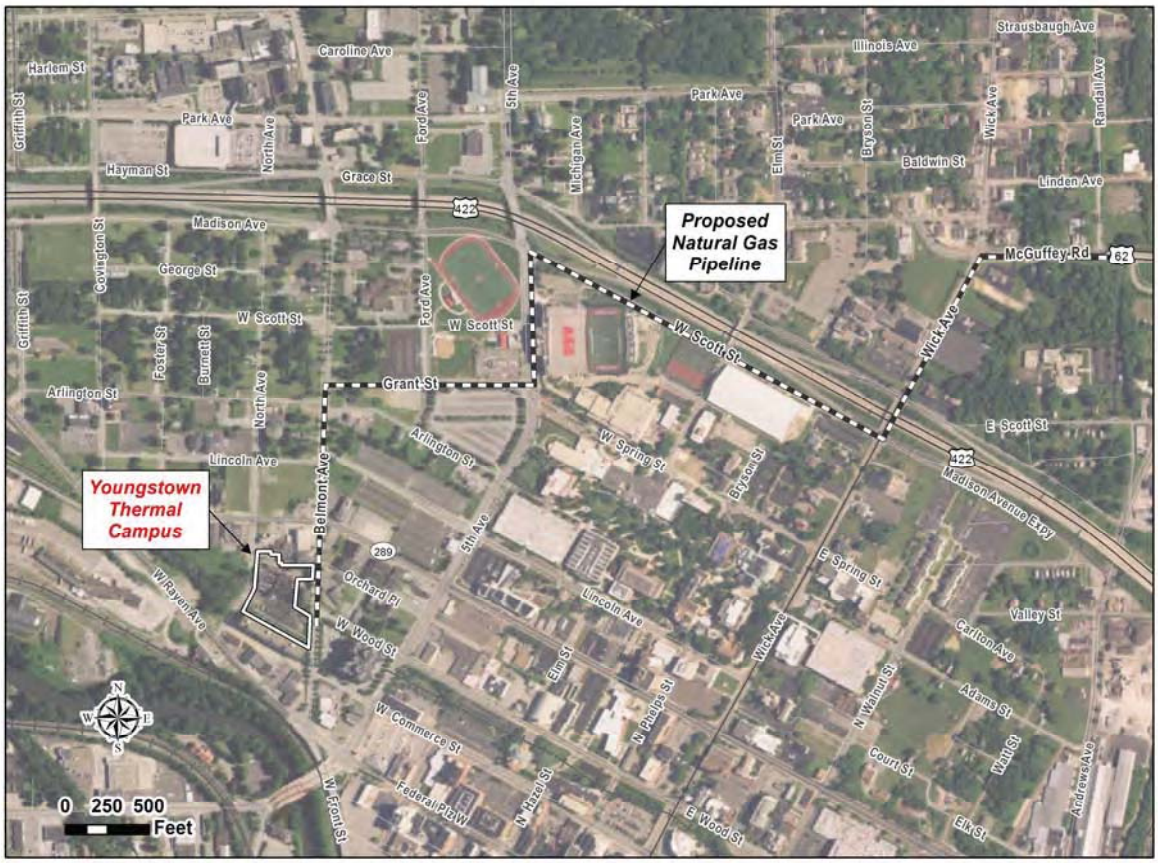

Figure 2-5. Proposed Location of Natural Gas Line

2.5.5 AUSC ComTest Operations

The AUSC ComTest would operate for a two-year period (2018 – 2020), totaling at least 14,000 test hours (6,000 hours for the superheater header test and 8,000 hours for the turbine test). Due to the steam load required for each test, the superheater header test and the steam turbine test would never occur concurrently. The AUSC ComTest would first conduct the superheater header test, and once complete, would then commence the steam turbine test. The tests would involve cycling of temperatures to evaluate the ability of the AUSC materials to operate reliably under varying boiler loads.

Superheater Header Test

The boiler would supply steam to the superheater where it would go through components and processes to increase the steam's temperature and pressure to the required AUSC ComTest levels. The superheater processes would involve steam and water flowing through the natural gas-fired superheater, headers (inlet, outlet, support), vertical separator, spray attemperators, superheater tube banks, economizers (upper and lower) for flue gas cooling, and desuperheating processes. The superheater would heat the steam to a temperature of 1,400°F at a pressure of 620 psia. The superheater header test would involve cycling the temperature of the header test section by flowing high-temperature steam (1,400°F) and low-temperature steam (750°F) through the superheater header. The cycling between high and low temperatures would occur approximately 10 times per day, holding each temperature extreme for approximately 1 hour before ramping up or down to the other temperature extreme. Steam leaving the superheater header test would flow through the outlet of the header where it would be processed through a heat exchanger to depressurize and reduce the temperature using spray water to meet the outlet conditions required for Youngstown Thermal (650°F and 205 psia). Figure 2-6 depicts a simplified block diagram for the superheater header test of the AUSC ComTest Project.

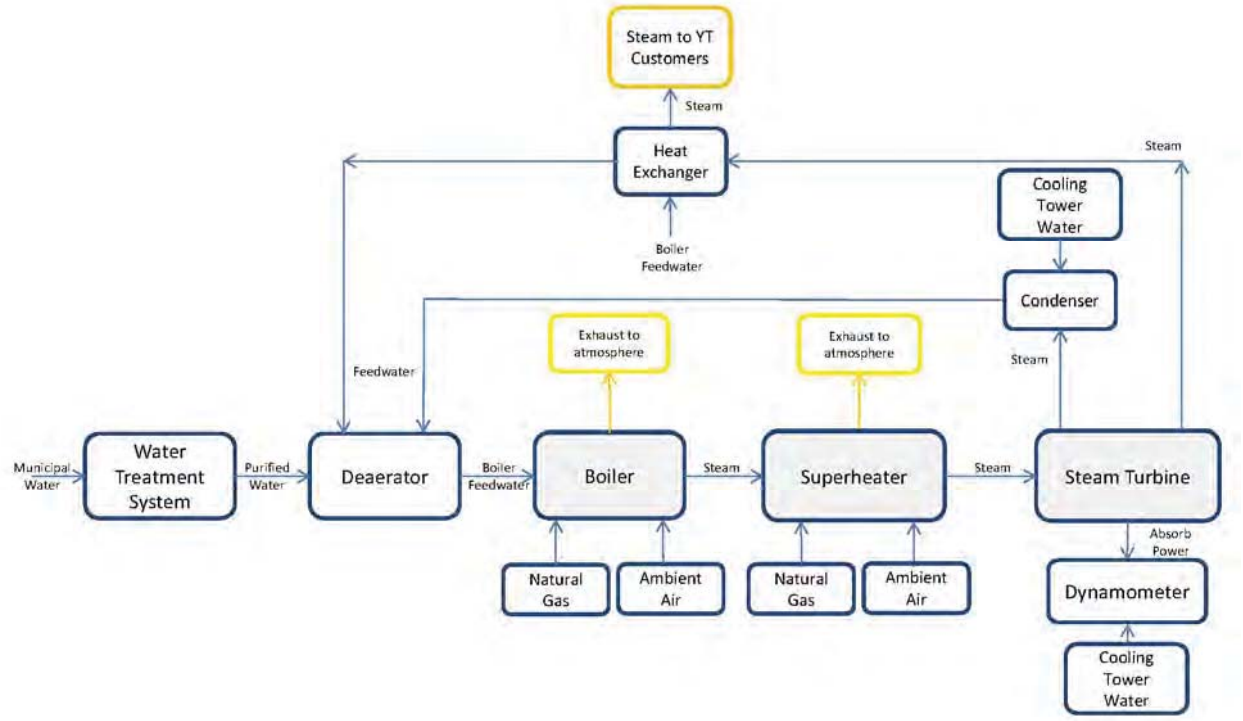

Figure 2-6. Simplified Block Flow Diagram of the AUSC ComTest Project – Superheater Header Test

Steam Turbine Test

Similar to the superheater header test, the steam turbine test would involve the package boiler supplying steam to the superheater where it would go through many components and processes to increase the steam's temperature and pressure to the required AUSC ComTest levels. The steam would leave the superheater at 1,400°F and 620 psia to the steam turbine stop and control valves, before entering the steam turbine. Steam exiting the turbine would then be sent to the heat exchanger where it would be cooled and returned to Youngstown Thermal for distribution to its customers. Additionally, the steam turbine would be connected to a dynamometer to absorb the energy generated by the steam turbine. The dynamometer functions similar to a water pump and requires cooling water from the cooling tower. Figure 2-7 depicts a simplified block diagram for the steam turbine test of the AUSC ComTest Project.

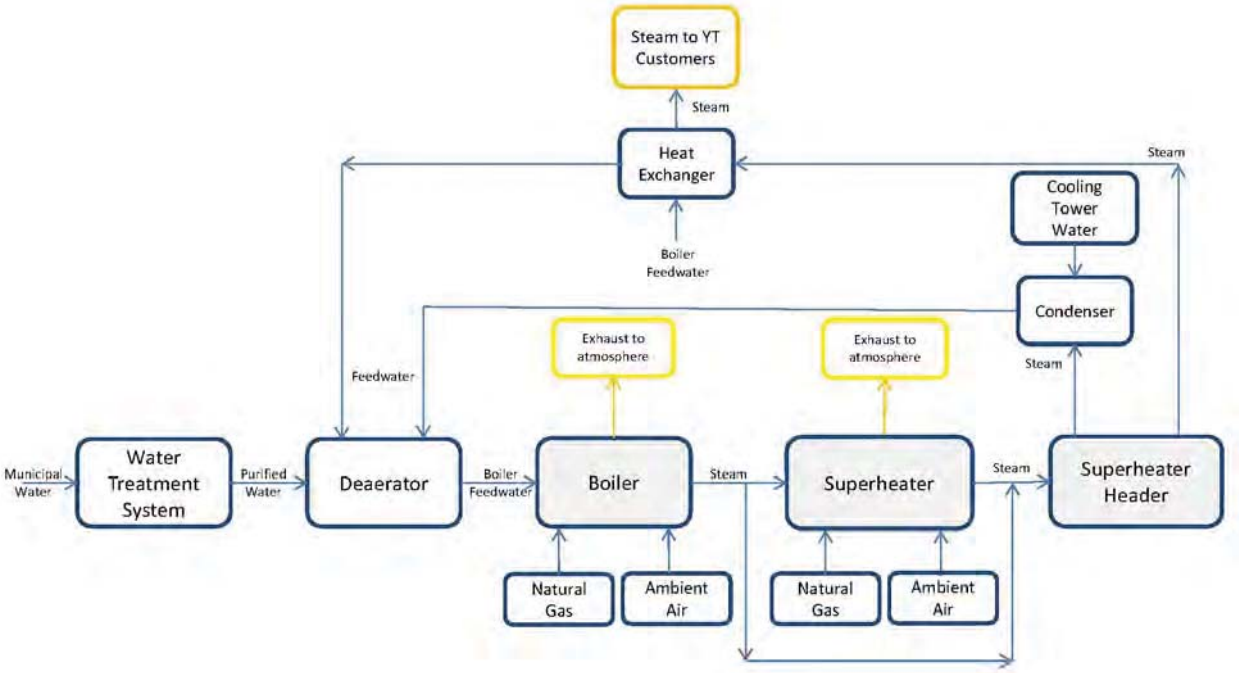

Figure 2-7. Simplified Block Flow Diagram of the AUSC ComTest Project – Steam Turbine Test

2.5.6 Decommissioning

After the 2-year operation of the AUSC ComTest Project, the equipment purchased with government funds would be decommissioned through removal, transfer of ownership, or disposal, depending on the item and negotiated conditions. Upon program completion, the EIO would prepare a comprehensive inventory of infrastructure, equipment, materials and residual hardware that was purchased with government funds, and submit it to the government plant clearance officer according to government plan clearance procedures.

To gain valuable research data on the impacts of the AUSC ComTest on the materials and equipment, EIO companies may remove some components for metallurgical testing and analysis, particularly certain sections and hardware of the turbine device, superheater, and superheater header. After removal of the test materials, the remaining components would be considered government property and go through a formal disposition process. The process would involve offering the equipment and components to project proponents and contractors and then to the site (i.e., Youngstown Thermal). If offers are not accepted or tendered, the facility and hardware would be disposed through a structured process that may include equipment sales, evaluation of scrap value, or abandonment in place at the host site.

Government purchased items to be decommissioned include fixed infrastructure improvements and process equipment supporting the project. Infrastructure improvements include the turbine building foundations, steel structure, HVAC system, control room and lighting, and also utilities such as power, underground plumbing, natural gas and city water services. It is anticipated that process equipment used for the project would have a majority of its service life available after the AUSC ComTest. This equipment includes, but is not limited to, the gas-fired package boiler, water treatment equipment, cooling tower cells, circulation pumps, and heat exchanger. All process equipment would be decommissioned and disposed of in accordance with government plant clearance procedures.

2.6 COMPARISON OF IMPACTS

Table 2.2 compares impacts of the No Action Alternative to impacts of the proposed AUSC ComTest Project, assuming all equipment is furnished and installed by the EIO and the project participants. The table also indicates how the impacts from the proposed project would change if Youngstown Thermal provided the steam and other ancillary equipment as described in Section 2.5.3 (Alternate Configuration).

Table 2-2. Comparison of Impacts

Resource	No Action Alternative	AUSC ComTest Proposed Project	Alternative Configuration[a]
Air Quality	No Impact	**Construction:** minor, short-term impacts. Emissions of criteria pollutants and GHGs from construction equipment, delivery trucks, and worker vehicles; fugitive dust emissions from ground-disturbing activities. **Operations:** minor impacts. Emissions of criteria pollutants and GHGs from boiler, superheater, and employee vehicles; temporary ground fog in the vicinity of the cooling tower during conditions of high humidity.	Construction impacts would be similar to the proposed project. Operational impacts associated with boiler emissions and cooling tower operations would not be part of the Proposed Action, but would contribute to cumulative impacts from increased emissions from Youngstown Thermal.
Biological Resources	No Impact	**Construction:** No impacts on the Youngstown Thermal campus or along proposed natural gas pipeline route. Minor adverse impacts could occur due to vegetation clearing on the adjacent site to be used as a laydown area. DOE is consulting with the USFWS and the Ohio Department of Natural Resources to receive concurrence that the Proposed Action would not significantly affect federal and state-listed species. At the time of this Draft EA, consultation was still ongoing. **Operations:** No impacts.	Impacts would be similar to the proposed project.
Cultural Resources	No Impact	**Construction:** No adverse impacts on National Register eligibility of historic properties; no impacts expected on archaeological resources. DOE is consulting with the Ohio Historic Preservation Office in accordance with Section 106 to receive concurrence that the Proposed Action would have no adverse effect within the Area of Potential Effect. At the time of this Draft EA, consultation was still ongoing. **Operations:** No impacts.	Overall, impacts would be similar to the proposed project; however, any potential impacts from construction of the natural gas line would not be part of the Proposed Action, but would contribute to cumulative impacts.

Table 2-2. Comparison of Impacts

Resource	No Action Alternative	AUSC ComTest Proposed Project	Alternative Configuration[a]
Health and Safety	No Impact	**Construction:** Potential for accidental injuries during construction of the AUSC ComTest and the natural gas pipeline. **Operations:** As the proposed project would implement robust safety procedures, and has been subject to a Process Hazard Analysis to minimize the potential for accidents, the potential for impacts to human health and safety are considered low. Given the very low likelihood of an incident occurring on the pipeline (on the order of 1 in 15,000 per year) and the safety protocols in place, DOE assesses the overall potential impact to human health and safety to be not significant.	Impacts would be minor and similar to the proposed project, however any potential impacts associated with the construction and operation of the natural gas line would not be part of the Proposed Action, but would contribute to cumulative impacts.
Infrastructure, Utilities, and Traffic	No Impact	**Construction:** No impact on utilities including water, electricity, and natural gas, and minor impacts on stormwater and sanitary discharge infrastructure. Minor impact on traffic due to truck and vehicle traffic entering and leaving the site. **Operations:** Negligible to minor impact on utilities including water, electricity, and natural gas; negligible impact on stormwater and sanitary discharge infrastructure. Negligible impacts on traffic due to permanent employee traffic.	Construction impacts on traffic associated with the natural gas pipeline would not be part of the Proposed Action, but would contribute to cumulative impacts. Potential operational impacts on increased natural gas demand at Youngstown Thermal would not be part of the Proposed Action, but would contribute to cumulative impacts. Other impacts would be similar to the proposed project.
Land Use and Aesthetics	No Impact	**Construction:** No impacts to land use on Youngstown Thermal campus. Adjacent property would be cleared of vegetation; however, land use would be consistent with current zoning. **Operations:** Minor impacts to aesthetics due to construction of stacks and other features, and from removal of vegetation on adjacent site.	Impacts to aesthetics associated with the boiler stack and cooling tower would not be part of the Proposed Action. Impacts to land use and other impacts on aesthetics would be similar to the proposed project
Noise	No Impact	**Construction:** Minor to moderate short-term impacts from operation of construction equipment on the Youngstown Thermal campus, at the adjacent site, and for installation of the natural gas pipeline. **Operation:** Minor to moderate increase in noise levels from operation of the AUSC ComTest equipment.	Construction impacts would be similar to the proposed projects. Operational impacts may be reduced in magnitude, as the alternate configuration would not require the installation and use of the AUSC ComTest boiler or cooling tower.
Cumulative	No Impact	Minor cumulative impacts to air quality, noise, and traffic could occur as a result of ongoing and proposed construction projects in the vicinity of the proposed project.	Cumulative impacts would be similar to the proposed project, however, minor additional cumulative impacts would result due to Youngstown Thermal's increased operations to provide steam for the AUSC ComTest.

a. The alternate configuration assumes that Youngstown Thermal would supply the required steam for the AUSC ComTest Project and thereby purchase, install, and operate some of the equipment required for the project, as discussed in Section 2.5.3.

CHAPTER 3 ENVIRONMENTAL SETTING AND CONSEQUENCES

3.1 INTRODUCTION

This section provides relevant environmental, cultural, and socioeconomic baseline information, and identifies and evaluates the individual or cumulative environmental and socioeconomic changes likely to result from constructing and operating the proposed AUSC ComTest at Youngstown Thermal. The Region of Influence (ROI) for this EA includes the Youngstown Thermal campus, the immediately adjoining properties, the utility right-of-way (ROW), and adjacent properties along the proposed route of the natural gas pipeline.

CEQ regulations encourage NEPA analyses to be as concise and focused as possible, consistent with 40 CFR Part 1500.1(b) and 1500.4(b): "…NEPA documents must concentrate on the issues that are truly significant to the action in question, rather than amassing needless detail … prepare analytic rather than encyclopedic analyses." Consistent with the NEPA and CEQ Regulations, this EA focuses on those resources and conditions potentially subject to effects.

The methodology used to identify the existing conditions and to evaluate potential impacts on the physical and human environment involved the following: review of documentation provided by Youngstown Thermal (the host site), project information provided by EIO and their consultants, searches of various environmental and agency databases, agency consultations, and a site visit conducted on January 7, 2016. For purposes of this EA, DOE also conducted a field study of the cultural resources within and surrounding the Youngstown Thermal campus. All references are cited, where appropriate, throughout this EA.

Wherever possible, the analyses presented in this chapter quantify the potential impacts associated with the Proposed Action and the No Action Alternative. Where it is not possible to quantify impacts, the analyses present a qualitative assessment of the potential impacts. The following descriptors qualitatively characterize impacts on each resource area analyzed:

- Beneficial – impacts would improve or enhance the resource.
- Negligible – no apparent or measurable impacts expected.
- Minor – the action would have a barely noticeable or measurable adverse impact on the resource.
- Moderate – the action would have a noticeable or measure adverse impact on the resource. This category could include potentially significant impacts that could be reduced to a lesser degree by the implementation of mitigation measures.
- Significant – the action would have obvious and extensive adverse impacts that could result in potentially significant impacts on a resource despite mitigation measures.

Each of the subsequent resource discussions within this chapter present the criteria or threshold used to determine the significance of a potential impact to that individual resource area.

3.1.1 Resource Areas Screened from Detailed Analysis

Table 3-1 identifies and describes the resources that DOE determined would either not be affected or would sustain negligible impacts from the proposed project and not require further evaluation. The resource areas retained for further analysis include air quality, biological resources, cultural resources, health and safety, infrastructure (including utilities and traffic), land use (including aesthetics), noise, and cumulative effects. The subsections presented throughout the remainder of this chapter provide a concise summary of the current affected environment within the region of influence, and an analysis of the potential effects to each resource area considered from implementation of the No Action Alternative and the Proposed Action.

Table 3-1. Resource Areas Screened from Further Analysis

Resource Area	Rationale
Community Services	The EA does not include a detailed analysis of community services. Construction of the proposed AUSC ComTest and the natural gas line would be short-term and most likely rely on the current local workforce, and operation of the project would require only approximately 17 new employees (4 operators per each 8-hour shift, and 5 supervisors). Therefore, neither construction nor operations would result in a noticeable increase in population to the region, and the Proposed Action would not increase demand for community services (e.g., emergency, fire and police services, schools, libraries, churches).
Geology and Soils	The EA does not include a detailed analysis of geology or soils. AECOM, the construction contractors, and Dominion East Ohio would follow industry standard best management practices to manage soils during construction (e.g., use of erosion control devices, and wetting workspaces to reduce wind erosion). Construction would involve grading approximately 1.5 acres at the approximate 3-acre Youngstown Thermal site, which have been previously disturbed and used for industrial purposes. Preparation of the proposed construction laydown/staging area across North Avenue (see Figure 2-2) would disturb approximately 2.9 acres of existing soils, but such activities would have a negligible effect. The adjacent property is underlain by loamy udorthents, or areas in which the original soil has been removed and replaced or covered by loamy fill material. These soils have no erosion rating, are not prime farmland soils, and are not hydric. Construction of the proposed natural gas line within an existing ROW would disturb soils classified as Chili-urban land complex, rolling. As these soils are previous disturbed, not hydric, and not prime farmland, only negligible adverse impacts would be anticipated. Construction and operation activities would have no effect on existing geology.
Materials and Waste	The EA does not include a detailed analysis of materials and wastes. Aside from construction materials and waste, the Proposed Action would require negligible amounts of materials to operate and generate negligible amounts of solid waste. The solid waste and recyclables generated onsite include general refuse, oil filters, scrap metal, and cardboard/paper. Waste oil and used rags are burned in the boilers. Fly ash and bottom ash are stored in the silo and sold to offsite companies. According to a 2010 Phase I Environmental Site Assessment, the site does not generate hazardous waste nor was any found onsite during the inspection (Conestoga-Rovers & Associates 2010). The site is not listed as a hazardous waste generator or facility (USEPA 2016a).
Socioeconomics and Environmental Justice	The EA does not include a detailed analysis of socioeconomic conditions. Socioeconomics is defined as the basic attributes and resources associated with the human environment, particularly population and economic activity. The Proposed Action would not result in any appreciable effects to the local or regional socioeconomic environment. The Proposed Action would have minor beneficial effects associated with temporary employment of construction personnel and transportation of goods and materials to the construction sites, as well as permanent employment of 17 individuals during the 2 years of operation of the AUSC ComTest. There would be no permanent change in sales volume, income, employment, or population because of the Proposed Action. There would be no effects on environmental justice or the protection of children, as the Proposed Action would not result in disproportionate adverse environmental or health effects on low-income or minority populations or children. As such, no socioeconomic impacts would result from implementation of the Proposed Action.
Water Resources (including Surface Water, Groundwater, Wetlands, and Floodplains)	The EA does not include a detailed analysis of water resources. Youngstown Thermal is not located within a floodplain, and no wetlands or groundwater wells exist on the site or the adjacent property proposed for construction laydown/staging. Construction and operation of the Proposed Action would not require any change in hydrology. While construction activities at the construction laydown/staging property would remove existing vegetation, the area would not be converted to an impervious surface. The Mahoning River exists approximately 0.1 mile to the south of the site, but is an impaired waterway. This river may receive negligible amounts of additional sedimentation or runoff from the proposed construction activities, but overall quality of the surface water would not be affected in any adverse or measurable manner. In addition, implementation of routine soil best management practices would further reduce the potential for runoff.

3.2 AIR QUALITY AND GREENHOUSE GASES

3.2.1 Affected Environment

Air Quality Management

The purpose of the air quality analysis is to determine whether emissions from a proposed new or modified source of air pollution, in conjunction with emissions from existing sources, would not cause or contribute to the deterioration of the air quality in the area. The Clean Air Act (CAA) requires the U.S. Environmental Protection Agency (USEPA) to set National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to public health and the environment. NAAQS include two types of air quality standards (40 CFR 50.1(e)). Primary standards protect public health, including the health of sensitive populations such as asthmatics, children, and the elderly. Secondary standards protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings. The USEPA is also responsible for ensuring that air quality standards are met or attained in cooperation with state, tribal, and local governments through national strategies to control air pollutant emissions.

The USEPA has established NAAQS for six principal pollutants, called "criteria pollutants": ozone, carbon monoxide, nitrogen dioxide, particulate matter (particulate matter 10 microns or less [PM_{10}], particulate matter 2.5 microns or less [$PM_{2.5}$]), sulfur dioxide, and lead. A state's air quality regulations may further regulate concentrations of the criteria pollutants. The Ohio Environmental Protection Agency (Ohio EPA) adopts the national standards, which are listed in Table 3-2.

Table 3-2. National Ambient Air Quality Standards

Pollutant	Standard	Averaging Time	Standard Type
Carbon Monoxide	35 ppm (40 mg/m^3)	1-hour	Primary
	9 ppm (10 mg/m^3)	8-hour	
Lead	0.15 µg/m^3	Rolling 3-Month Average	Primary and Secondary
	1.5 µg/m^3	Quarterly Average	
Nitrogen Dioxide	0.053 ppm (100 µg/m^3)	Annual (Arithmetic Mean)	Primary and Secondary
PM_{10}	150 µg/m^3	24-hour	Primary and Secondary
$PM_{2.5}$	12.0 µg/m^3	2012 Annual (Arithmetic Mean)	Primary and Secondary
	15.0 µg/m^3	1997 Annual (Arithmetic Mean)	
	35 µg/m^3	24-hour	
Ozone	0.070 ppm (2015 std)	8-hour[(a)]	Primary and Secondary
	0.075 ppm (2008 std)	8-hour	
Sulfur Dioxide	0.5 ppm (1300 µg/m^3)	3-hour	Secondary
	75 ppb	1-hour	Primary

Source: USEPA 2016b; Ohio EPA 2016b

PM_{10} = particulate matter with a diameter of 10 microns or less; $PM_{2.5}$ = particulate matter with a diameter of 2.5 microns or less; µg/m^3 = microgram/per cubic meter; ppm – parts per million; ppb = parts per billion; std – standard.

a. Final USEPA rule signed October 1, 2015, and effective December 28, 2015. The previous (2008) O_3 standards additionally remain in effect in some areas. Revocation of the previous (2008) O_3 standards and transitioning to the current (2015) standards would be addressed in the implementation rule for the current standards.

To determine compliance with the NAAQS, emissions of criteria pollutants from a new or modified source are modeled to determine their air dispersion concentrations. In addition to the six criteria pollutants outlined in the CAA, several other substances raise concerns with regard to air quality and are regulated through the CAA Amendments of 1990. These substances include hazardous air pollutants (HAPs), and toxic air pollutants such as metals, nitrogen oxides, and volatile organic compounds (VOCs). Nitrogen oxides and VOCs are precursors for ozone.

Geographic areas that are in violation of the NAAQS are classified as nonattainment areas, while those in compliance with the NAAQS are designated as being in attainment. Attainment and nonattainment areas are typically defined by county. The CAA requires states that contain nonattainment areas to submit to the USEPA a State Implementation Plan, which is a compilation of goals, strategies, schedules, and enforcement actions designed to lead the state into compliance with all NAAQS. Maintenance areas are those that previously had not met the NAAQS but are currently complying with the standards through the requirements in the State Implementation Plan.

The USEPA Region 5, the Ohio EPA, and the Mahoning-Trumbull Air Pollution Control Agency (M-TAPCA) regulate air quality in the city of Youngstown, Ohio, where the proposed project is located. The M-TAPCA, as a representative of the Ohio EPA, has the authority to enforce the state air pollution regulations and to establish, maintain and operate air quality monitoring stations throughout their jurisdiction (Youngstown City Health District 2016). The M-TAPCA operates 19 air monitors located throughout Mahoning and Trumbull County that monitor for $PM_{2.5}$, PM_{10}, lead, sulfur dioxide and ozone. Air quality reports are generated and sent to the Ohio EPA to establish a record to determine whether the areas under M-TAPCA's jurisdiction are meeting Ohio EPA's air quality attainment requirements. Mahoning County, Ohio is in attainment for all criteria pollutants as designated by the USEPA (USEPA 2016c).

For areas that are already in compliance (in attainment) with the NAAQS, the Prevention of Significant Deterioration (PSD) requirements provide maximum allowable increases in concentrations of pollutants, which are expressed as increments (40 CFR 52.21). One set of allowable increments exists for Class II areas, which covers most of the United States and another set of more stringent allowable increments exists for Class I areas. Because of their pristine environment, Class I areas require more rigorous safeguards to prevent deterioration of their air quality. As defined in the CAA, the following are considered Class I areas if they were in existence as of August 7, 1977: national parks over 6,000 acres, national wilderness areas and national memorial parks over 5,000 acres, and international parks (NPS 2016a). In general, proposed projects that are within 62 miles (100 kilometers) of Class I areas must evaluate impacts of the project on air quality related values (AQRVs) such as visibility, flora/fauna, water quality, soils, odor, and any other resources specified by the Federal Land Manager. There are no federal mandatory Class I areas within Ohio and none within 62 miles (100 kilometers) of the proposed project location, therefore a PSD increment and AQRV analysis for Class I area would not be required (NPS 2016b).

Climate and Greenhouse Gases

The climate in Youngstown, Ohio is characterized by warm summers and very cold winters. July is historically the warmest month with an average maximum temperature of 73.1 degrees Fahrenheit (°F), and January is historically the coldest with an average low temperature of 26.8°F. Precipitation is evenly distributed throughout the year with the wettest month being June having an average rainfall of 4.3 inches (Idcide 2016).

Greenhouse gases (GHGs) are components of the atmosphere that trap heat relatively near the surface of the earth, and therefore, contribute to the greenhouse gas effect and global warming, which significantly affects the Earth's climate (CEQ 2016). Most GHGs occur naturally in the atmosphere, but increases in their concentration result from human activities such as the burning of fossil fuels. Global temperatures are expected to continue to rise as human activities continue to add carbon dioxide (CO_2), methane, nitrogen dioxide NO_x, and other greenhouse (or heat-trapping) gases to the atmosphere. Human health, agriculture, natural ecosystems, coastal areas, and heating and cooling requirements are examples of climate-sensitive systems. Some observed changes include shrinking of glaciers, thawing of permafrost, later freezing and earlier break-up of ice on rivers and lakes, lengthening of growing seasons, shifts in plant and animal ranges and earlier flowering of trees (Melillo et al 2014)

GHGs include water vapor, CO_2, methane, nitrogen oxides, ozone, and several chlorofluorocarbons. Water vapor is a naturally occurring GHG and accounts for the largest percentage of the greenhouse effect. Next to water vapor, CO_2 is the second-most abundant GHG and is typically produced from human-related activities. The largest source of CO_2 emissions globally is the combustion of fossil fuels such as coal, oil, and gas in power plants, automobiles, industrial facilities and other sources.

Federal agencies, states, and local communities address global warming by preparing GHG inventories and adopting policies that would result in a decrease of GHG emissions. Executive Order 13514, *Federal Leadership in Environmental, Energy, and Economic Performance,* outlines policies intended to ensure that federal agencies evaluate climate change risks and vulnerabilities, and to manage the short- and long-term effects of climate change on their operations and mission. The Executive Order specifically requires federal agencies to measure, report, and reduce their GHG emissions from both their direct and indirect activities. Direct activities include sources the agencies own and control, and from the generation of electricity, heat, or steam they purchase. Indirect activities include their vendor supply chains, delivery services, and employee travel and commuting. In addition, the CEQ has released final guidance for federal agencies on considering GHG emissions and climate change in NEPA analysis (CEQ 2016). The guidance recommends a quantitative analysis of GHG emissions using available data and quantification tools that are suitable for the proposed action. The guidance further recommends that agencies use projected GHG emission as a proxy for assessing potential climate change effects.

Regulatory agencies are also taking action to address GHG effects. In response to the *FY2008 Consolidated Appropriations Act* (H.R. 2764; Public Law 110–161), the USEPA issued the *Final Mandatory Reporting of Greenhouse Gases Rule* (GHG Reporting Rule), which became effective on December 29, 2009. The GHG Reporting Rule requires annual reporting of GHG emissions to USEPA from large sources and suppliers in the United States, including suppliers of fossil fuels or industrial GHGs; manufacturers of vehicles and engines; and facilities that emit greater than 25,000 metric tons per year (27,558 tons per year) each of CO_2 and other GHGs. The intent of the rule is to collect accurate and timely emissions data to inform future policy decisions and programs to reduce emissions, as well as fight against the effects of climate change.

Additionally, the USEPA published the Greenhouse Gas Tailoring Rule in May 2010 under the CAA New Source Review and Title V operating permit programs. The rule defines new GHG thresholds that would trigger review and permitting, if permitting thresholds for at least one criteria pollutant are also exceeded. This proposed requirement would cover many of the nation's largest stationary source GHG emitters (including power plants, refineries, and cement production facilities), while shielding small businesses and farms from permitting requirements.

Youngstown Thermal Existing Conditions

Youngstown Thermal is an existing district energy/heating plant that supplies steam to customers throughout downtown Youngstown. The plant produces steam from city water and delivers it to customers through underground piping at approximately 150 psia for heating, domestic hot water, cooking, industrial uses, laundry, etc. Youngstown Thermal utilizes a combination of coal- and natural gas-fired units, including three coal-fired boilers (two 100,000 pounds per hour and one 90,000 pounds per hour) and one natural gas and Number 2 oil-fired boiler (100,000 pounds per hour). In addition, Youngstown Thermal recently added the infrastructure to use wood-derived biomass liquid as the fuel, and in May 2016 began operations of the biomass system (Business Journal 2016). Each boiler exhausts through a separate 120-foot stack. Other areas of the plant, such as coal unloading, handling, and storage areas, may be sources of fugitive particulates.

The Youngstown Thermal steam generating plant is a major stationary source of air emissions and currently operates under the Title V Permit Number P0120126, Facility ID: 0250110024, effective

January 29, 2016 (Ohio EPA 2016c). Over the past year, Youngstown Thermal met numerous times with Ohio EPA regarding improvements the facility is implementing or planning to implement, such as using more natural gas in place of coal. The plant's revised Title V permit incorporates these improvements and thereby meets the USEPA standards for reduction in hazardous pollutants using maximum achievable control technology (MACT). These standards are referred to as the "Boiler MACT" standards (40 CFR 63, Subpart DDDD) (Ohio EPA 2016d). The current Title V permit for the Youngstown Thermal facility, dated 29 January 2016, provides for the following air emissions limits (Ohio EPA 2016c):

- No more than 4,700 tons of coal may be burned facility-wide within any 12-month period, to be evaluated on a rolling basis;
- Annual emissions of total HAPs may not exceed 24.9 tons and emissions of any individual HAP may not exceed 9.9 tons, to be evaluated on a rolling 12-month average;
- Additional limits apply to continuous visible emissions, particulate emissions, and sulfur dioxide emissions from each boiler;
- Operational restrictions on coal-fired boilers require the use of pollution control equipment and limit the maximum allowable steam flow rate; and
- Monitoring, recordkeeping, and reporting requirements must be met.

Youngstown Thermal is currently conducting trials to test the suitability of burning wood-derived fuel oil in one of its boilers, and has obtained authorization from Ohio EPA for this purpose (Ohio EPA 2016a). The authorization letter, dated March 28, 2016, permits Youngstown Thermal to conduct test burns using wood-derived renewable fuel oil at a rate of up to 60 MMBtu/hour, for a total of up to 60 days. The authorization is valid until December 31, 2016. If the trial is successful and Youngstown Thermal begins to use the renewable fuel oil on a permanent basis, it would need to apply for a modification to the facility's Title V permit.

Additionally, the facility plans to install a new 34 MW combined heat and power (CHP) cogeneration system (Youngstown Thermal LLC 2016b). A 14 MW combustion turbine, a waste heat recovery boiler rated at 180,000 pounds of steam per hour, and a 9.5 MW steam turbine, that are part of the CHP project, will be installed prior to the start of the AUSC ComTest. An additional 10.5 MW steam turbine will be installed in 2020, to coincide with the end of the AUSC ComTest. Youngstown Thermal is currently coordinating with the Ohio EPA to apply for modifications to its Title V permit to accommodate the CHP system and the AUSC ComTest.

3.2.2 No Action – Environmental Consequences

Implementation of the No Action Alternative would result in no increased potential for adverse impact to air quality and no increases in greenhouse gas emissions. Construction of the Proposed Action would not occur, the AUSC ComTest would not take place at Youngstown Thermal, and the proposed natural gas line would not be constructed to support the proposed project. Existing conditions would remain unchanged.

3.2.3 Proposed Action – Environmental Consequences

Construction

Construction would cause minor short-term impacts to air quality. The proposed project would result in a temporary increase in emissions of criteria pollutants and greenhouse gases from construction equipment,

delivery trucks, and worker vehicles. During the construction process, the equipment used to construct the facilities would intermittently emit quantities of the criteria pollutants as well as greenhouse gases (reported in carbon dioxide equivalents, CO_2-eq). Criteria pollutants and greenhouse gases would also be emitted by trucks making deliveries and by construction worker vehicles. In addition, construction activities would include some excavation and grading that would generate localized intermittent fugitive dust emissions from the disturbed soils. Table 3-3 presents the estimated emissions associated with the construction of the proposed project based on estimated types of construction equipment and hours of usage, and worker and delivery truck estimated numbers and mileage.

Table 3-3. Construction Emissions for AUSC ComTest Project Site

Construction Activity	Annual Emissions (tons)[a]					
	CO	NO_x	VOC	SO_x	PM[b]	CO_2-eq[c]
Construction – AUSC ComTest Site	9.3	11.5	1.8	0	0.6	1566
Construction – Natural Gas Pipeline	0.8	1.1	0.2	0	0.1	153
Construction Worker Vehicles[d]	0.4	0.1	0	0	0	96
Delivery Trucks[e]	0	0.2	0	0	0	62
Total Construction Emissions	**10.5**	**12.9**	**2.0**	**0**	**0.7**	**1877**

Source: AECOM 2016a; CARB 2016; CEQA 2016; UNFCCC 2016
AUSC ComTest = Advanced Ultra-Supercritical Component Test; CO = carbon monoxide; CO_2-eq = carbon dioxide equivalent; NO_x = nitrogen oxide; PM = particulate matter; SO_x = sulfur oxides; VOC = volatile organic compounds
[a] Emissions associated with construction of the natural gas pipeline were estimated based on information obtained for other, similar projects.
[b] Includes PM with a diameter of 10 microns or less (PM_{10}) and with diameter of 2.5 microns or less ($PM_{2.5}$)
[c] Assumes global warming potential of methane (CH4) is 21.
[d] Assumes average one-way commute distance of 10 miles.
[e] Assumes average truck delivery roundtrip distance of 100 miles.

In addition to tailpipe emissions from heavy equipment, ground surface disturbances during excavation and grading activities could potentially generate fugitive dust. Fugitive dust, such as dirt stirred up from construction sites, can affect both environmental and public health. The type and severity of the effects depend in large part on the size and nature of the dust particles. The types of effects that can occur to humans include inhalation of fine particles that can accumulate in the respiratory system causing various respiratory problems including persistent coughs, wheezing, eye irritations, and physical discomfort. Given the small footprint of the newly proposed infrastructures, the proximity to paved roads, and the anticipated short duration of the construction, DOE expects potential impacts from fugitive dust emissions to be temporary in duration, localized to the immediate project area, and of minor intensity.

Exhaust emissions from equipment used during construction, coupled with likely fugitive dust emissions, could cause minor, short-term degradation of local air quality. DOE expects the overall impacts to air quality from the construction of the AUSC ComTest Project at the Youngstown Thermal campus and the proposed natural gas line would be short term and minor.

Operations

Operation of the AUSC ComTest Project would result in minor impacts to air quality due to emissions from the package boiler, the superheater, and particulate matter from the cooling tower. Both the boiler and the superheater would have their own new emissions stack. The package boiler stack would have a flow about 341,000 pounds per hour, and the superheater stack would flow about 150,000 pounds per hour. Construction worker vehicles for permanent employees would also emit criteria pollutants and greenhouse gases. Table 3-4 presents the current emissions from Youngstown Thermal and the estimated

emissions from Youngstown Thermal's future operations using its proposed CHP system. Table 3-5 presents the estimated performance emissions that could occur from the AUSC ComTest for the base case configuration and the alternate configuration of the AUSC ComTest as discussed in Sections 2.5.2 and 2.5.3. The base case configuration assumes the AUSC ComTest operates independent of Youngstown Thermal, and thus uses a package boiler to generate the required steam. The sources of emissions for the Proposed Action under the base case configuration are the natural gas-fired package boiler, the natural gas-fired superheater, and the associated cooling tower. The alternate configuration assumes Youngstown Thermal would use its proposed CHP system to provide the steam required for the AUSC ComTest. The only source of emissions for the Proposed Action under the alternate configuration would be the superheater. Table 3-5 also presents the estimated emissions that could occur from the AUSC ComTest employees' vehicles.

As stated in Section 3.2.1, Youngstown Thermal is currently coordinating with the Ohio EPA to apply for modifications to its Title V permit to accommodate the CHP system and to account for the Proposed Action of the AUSC ComTest. These modifications would be in place prior to operations of the AUSC ComTest. The AUSC ComTest Project emissions would occur over the two-year test period, with emissions directly related to the project being greatest for the base case configuration. However, these emissions would be overall lower than those that would otherwise occur from the Youngtown Thermal facility once their new CHP system is operational. Air emissions specific to the AUSC ComTest Project would be lowest for the alternate configuration as Youngtown Thermal would provide steam to the AUSC ComTest, and the package boiler would no longer be required. However, air emission that would occur under either AUSC ComTest configuration would not exceed any permit limits or federal or state regulations, and would not significantly affect air quality.

Table 3-4. Emissions for Youngstown Thermal Plant

Equipment	Annual Emissions (Tons)					
	CO	NO_x	VOC	SO_x	PM[a]	CO_2-eq[b]
YT Current Operations[c]	25.1	41.7	1.0	236.7	29.4	77,754
YT Future Operations with CHP System[d]	158.4	161.4	11.8	241.5	51.8	244,867

CO = carbon monoxide; CO_2-eq = carbon dioxide equivalent; NO_x = nitrogen oxide; PM = particulate matter; SO_x = sulfur oxides; VOC = volatile organic compounds

a. Includes PM with a diameter of 10 microns or less (PM_{10}) and with a diameter of 2.5 microns or less ($PM_{2.5}$)

b. Assumes global warming potential of methane (CH_4) is 21.

c. Based on natural gas for Youngstown Thermal boiler B001 and 4,700 tons per year limit for coal in boilers B002, B003, and B004 per current Title V permit (Ohio EPA 2016c).

d. Includes Youngstown Thermal proposed combustion turbine, heat recovery steam generator, and cooling tower (assuming particulate emissions at 1200 micromhos and drift at 0.005 percent of circulation).

Table 3-5. Emissions for AUSC ComTest Project

Equipment	Annual Emissions (Tons)					
	CO	NO_x	VOC	SO_x	PM[a]	CO_2-eq[b]
Base Case – AUSC ComTest						
Package Boiler	75.2	75.2	7.2	3.2	14.1	111,863
Superheater	49.7	74.5	2.7	0.3	3.7	58,125
Other[c]					1.4	
TOTAL AUSC ComTest	**124.9**	**149.7**	**9.9**	**3.5**	**19.2**	**169,988**
Alternate Configuration – AUSC ComTest						
Superheater	49.7	74.5	2.7	0.3	3.7	
TOTAL AUSC ComTest	**49.7**	**74.5**	**2.7**	**0.3**	**3.7**	
Employee Vehicles[d]	0.2	0	0	0	0	50

AUSC ComTest = Advanced Ultra-Supercritical Component Test; CO = carbon monoxide; CO_2-eq = carbon dioxide equivalent; NO_x = nitrogen oxide; PM = particulate matter; SO_x = sulfur oxides; VOC = volatile organic compounds

[a.] Includes PM with a diameter of 10 microns or less (PM_{10}) and with a diameter of 2.5 microns or less ($PM_{2.5}$)

[b.] Assumes global warming potential of methane (CH_4) is 21.

[c.] Cooling tower particulate emissions at 1200 micromhos and drift at 0.005 percent of circulation

[d.] Assumes average one-way commute distance of 10 miles (CARB 2016).

Greenhouse Gas Emissions

The Proposed Action would result in a minor increase in GHG emissions to the atmosphere, amounting to approximately 387,596 tons CO_2-eq over the 2-year operation of the proposed project. This is equivalent to the annual GHG emissions from approximately 41,000 passenger vehicles or the 20,500 homes for one year (USEPA 2016d). The Proposed Action, however, as discussed in Chapters 1 and 2, would beneficially serve to further the development of technologies to increase the efficiency of coal power plants, thereby reducing plant emissions including greenhouse gases.

Cooling Tower Emissions

The proposed project would construct and utilize a cooling tower that would consist of six cells located lengthwise in the east-west direction, perpendicular to Belmont Avenue to the east and parallel to the existing warehouse structure to the south. The cooling tower would have an overall dimension of approximately 85 feet in length, 22 feet in width. The elevation of the cooling tower stack is approximately 23 feet above the Belmont Avenue pavement grade in that area.

Cooling towers are heat exchangers used to cool liquids in industrial processes by evaporating water and thereby transferring the heat to the air passing through the cooling tower and releasing the heat to the atmosphere. Some of the liquid water evaporates, and some becomes entrained in the air stream and is carried out of the tower as "drift" droplets. Since water droplets generally contain the same dissolved solids as the water circulating in the tower, these solids can be carried out of the tower in the drift. When the drift droplets evaporate before being deposited, they produce particulate matter emissions. Mechanical draft cooling towers can produce some adverse environmental effects due to the liquid water plume coming directly from the tower (drift), as well as from the secondary liquid water formation caused by the condensation of water vapor ("fogging"). These adverse effects include fogging at ground level and ice build-up, deposition of dissolved salt particles, and local shading of the sun due to a visible plume (USEPA 1995).

The AUSC ComTest Project proposes to use a pre-assembled SPX Marley NC cooling tower system that incorporates plume abatement and water conservation technologies (SPX 2016). During normal operating periods, the cooling tower plume would not be expected to flow downward and cross Belmont Avenue at an elevation lower than the tower discharge. The warehouse building to the south is approximately 35 feet from the cooling tower and would not likely be affected by drift due to the low drift features of this model. During high humidity conditions with the fans off, it is expected that a small amount of ground fog in the vicinity of the tower may appear. However, the orientation of the tower should minimize the occurrence of fog and overall impacts are expected to be minor.

3.3 BIOLOGICAL RESOURCES

3.3.1 Affected Environment

The Youngstown Thermal campus is a developed, disturbed approximately 3.0-acre site located in an urban, industrial setting. No habitat currently exists within this property. Therefore, no reptiles, mammals, amphibians, or fish are anticipated to be found onsite.

The adjacent property across North Avenue to the west of the Youngstown Thermal campus, proposed for use as the construction laydown area, currently supports low-quality habitat typical of successional sites that have been disturbed in the past. The approximately 3.9-acre site supports approximately 2.9 acres of successional habitat consisting of deciduous trees, shrubs, and herbaceous plants, but remains isolated from other habitat areas due to the industrial surroundings. Wildlife, including bird and mammal species, may utilize this property as habitat. Representative small mammal species known to inhabit disturbed habitats in Ohio in close proximity to human development include raccoon (*Procyon lotor*), eastern chipmunk (*Tamias striatus*), eastern gray squirrel (*Scirus carolinensis*), deer mouse (*Peromyscus maniculatus*), house mouse (*Mus musculus*), and skunk (*Mephitis mephitis*), among others (ODNR 2016). Bird species common to the region and habitat would include song birds, passerine species, and some migratory species that have adapted to urban environs.

The United States Fish and Wildlife Service lists two threatened or endangered species as potentially found in Mahoning County: the endangered Indiana bat (*Myotis sodalis*) and the threatened northern long-eared bat (*Myotis septentrionalis*) (USFWS 2016a). Indiana bats are small and only weigh approximately 0.25 ounce (i.e., about the weight of three pennies). Their fur is dark-brown to black, and they have a wingspan of 9 to 11 inches. Indiana bats hibernate during winter in caves and would not be found hibernating within the proposed construction laydown property. During summer, they roost and form maternity colonies under the peeling bark or cavities of dead and dying trees. Indiana bats eat a variety of flying insects found along rivers or lakes and in uplands. Important habitat includes small stream corridors with well-developed riparian woods and woodlots within 1 to 3 miles of small to medium rivers, and large areas of upland woods (USFWS 2016b). Located approximately 0.1 mile north of the Mahoning River and supporting upland tree species, the proposed construction laydown property could support suitable habitat for the endangered Indiana bat.

The threatened northern long-eared bat is a heavier species but has a wingspan similar to that of the Indiana bat (i.e., 9 to 10 inches). Along with their long ears, these bats are identified by a medium to dark brown back and a tan or pale belly. Northern long-eared bats also hibernate in caves and mines, which means that they would not be found within the proposed construction laydown property during winter months. Summer roosting and foraging habitat consists of trees in upland forests with crevices and exfoliating bark and diameters of at least 3 inches (USFWS 2016c; USFWS 2015). While it remains possible that the adjacent property could support suitable habitat for the northern long-eared bat, it is not anticipated that these bats would be found at the site.

Construction of the proposed natural gas line would require trenching activities, which would disturb any vegetation within the proposed ROW. However, the proposed natural gas pipeline route lies within an existing ROW along an existing road in an urban setting. As such, the land to be trenched has already been disturbed, and any vegetation currently supported along the route consists of mowed grass.

3.3.2 No Action – Environmental Consequences

Implementation of the No Action Alternative would result in no increased potential for adverse impact to biological resources. Construction of the Proposed Action would not occur, the AUSC ComTest would not take place at Youngstown Thermal, the proposed construction laydown area on the adjacent property would not be cleared of vegetation, and the proposed natural gas line would not be constructed to support the proposed project. Existing conditions would remain unchanged.

3.3.3 Proposed Action – Environmental Consequences

Due to the disturbed nature and lack of existing suitable habitat of the Youngstown Thermal campus and the proposed natural gas pipeline route, implementation of the Proposed Action is likely to have no effect on biological resources within these sites.

The proposed clearing of approximately 2.9 acres of the adjacent site for use as a construction laydown area would remove the existing trees, shrubs, and plants. Wildlife currently inhabiting or foraging within this property would be displaced when disturbed by construction vehicles and activity. As only species accustomed to human activity and more urban environments are likely to occur in this location, they would likely be able to find other suitable habitat within the region. Current vegetation has been disturbed in the past due to the presence of an existing utility ROW through the property. Minor adverse effects could occur to existing vegetation and wildlife within the adjacent property due to implementation of the Proposed Action.

The DOE sent a consultation letter to the USFWS on July 7, 2016 to receive concurrence that the Proposed Action would not significantly affect the federally listed Indiana bat or northern long-eared bat. The USFWS responded in a letter sent July 21, 2016 and advised that trees measuring at least 3 inches diameter at breast height (dbh) may provide suitable summer habitat for the Indiana bat and the northern long-eared bat. In order to minimize potential effects to these federally listed species, trees measuring at least 3 inches dbh should be left undisturbed whenever possible. However, if the clearing of trees measuring at least 3 inches dbh cannot be avoided, then the USFWS recommends that tree removal occur between October 1 and March 31. Furthermore, if the seasonal tree clearing is not possible, the USFWS recommends conducting summer surveys of the site between June 1 and August 15 to determine the presence of these bats. Appendix A contains the correspondence with the USFWS. For the Proposed Action, EIO has agreed to abide by these mitigation practices as described in the USFWS letter, and will coordinate with DOE in preparation for and during the clearing activities to assure compliance. In consideration of EIO's commitment to these measures, DOE has provided USFWS with a "Determination of Effect" letter for their review and concurrence, indicating no adverse effects are anticipated to the federally listed species. In addition, DOE sent a consultation letter to the Ohio Department of Natural Resources on August 8, 2016 to receive concurrence that the Proposed Action would not significantly affect any state listed species. At the time of publication of this Draft EA, consultation with these agencies is still ongoing.

3.4 CULTURAL RESOURCES

The National Historic Preservation Act (NHPA) of 1966 (36 CFR Part 800) provides for the identification, evaluation, and preservation of cultural resources. Section 106 of the NHPA requires federal agencies to consider effects of undertakings on resources listed in, or eligible for inclusion in, the National Register of Historic Places (National Register) through a process of consultation. The process for compliance with Section 106 consists of the following steps:

1. Establishment of an Area of Potential Effect (APE). This is defined as the area in which eligible properties may be affected by the proposed undertaking, including direct effects and indirect effects (such as visual, audible, and changes which affect the character and setting of the property).
2. Identification of cultural resources located within the APE of a proposed undertaking. This is accomplished through review of existing documentation and field surveys.
3. Cultural resources evaluation is conducted using National Register criteria. Properties that meet the criteria are considered eligible for listing in the NRHP and are subject to further review under Section 106. Properties that do not meet the criteria are considered not eligible for inclusion in the NRHP and are generally not subject to further Section 106 review.
4. Determination of effect of the proposed undertaking is assessed on properties that meet the NRHP criteria. One of the following effect findings would be made: No Historic Properties Affected, No Adverse Effect, or Adverse Effect.
5. Resolution of adverse effects/mitigation occurs when adverse effects are found. Consultation continues between the federal agency and consulting parties to attempt resolution. Successful consultation results in an agreement of the efforts to be taken to avoid or mitigate adverse effects.

The significance of historic properties is judged against a property's ability to meet the four criteria for inclusion on the National Register (36 CFR 60.4):

- Criterion A: Association with events that have made a significant contribution to the broad patterns of our history; or
- Criterion B: Association with the lives of persons significant in our past; or
- Criterion C: That embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or
- Criterion D: That has yielded, or may be likely to yield, information important in prehistory or history.

Properties may be eligible for the National Register for contributions at the national, state, or local level. Ordinarily, properties achieving significance within the last 50 years are not considered eligible unless they are integral parts of historic districts or unless they are of exceptional importance. The most common types of properties less than 50 years old listed on the National Register are works of modern architecture or scientific facilities. In practice, Criteria A through C generally apply to historic structures and districts, while Criterion D generally pertains to archaeological resources. Additionally, in order for a structure or building to be listed in the National Register, it must possess historic integrity of those features necessary to convey its significance (i.e., location, design, setting, workmanship, materials,

feeling, and association see National Register Bulletin #15, *How to Apply the National Register Criteria for Evaluation* (NPS 1990).

Due to the differing nature of the proposed undertaking at the proposed ComTest site and the proposed natural gas line construction, evaluation of cultural resources for the two components would be considered separately.

3.4.1 Affected Environment

3.4.1.1 Area of Potential Effect (APE)

ComTest Site

The APE for historic structures has been determined to be a radius of 500 feet from the center point of the proposed location of the new superheater tower. The APE is based upon the fact that the new tower would be the element with the greatest visibility at a height of 130 feet. Visual impacts would be the most likely impacts to have adverse effects to National Register-eligible resources within the project area. No long-term impacts to historic structures would occur at the proposed staging area west of North Avenue. The APE for archaeological resources would be limited to the areas of ground disturbance.

Natural Gas Line

It is anticipated that most of the trenching for the proposed natural gas line would be performed with power equipment at a width of between 24 and 36 inches. Anticipated trench depth would be roughly 36 inches. Trenching would likely be with a chain or wheel trencher for most of the route. Trenching would take place completely within the existing right-of-way. Due to the nature of this part of the undertaking, indirect effects, including those related to noise and visual effects, would be short term and temporary. In terms of Section 106, these effects would not be considered adverse. As adverse effects to aboveground resources are not expected, impacts due to the natural gas line would only be addressed as potential impacts to archaeological resources.

3.4.1.2 Historic Structures and Districts

Youngstown Thermal, 201 North Avenue (Tax ID: 53-71-20-00-P; 53-71-158-00-P) OHI No. MAH0043804

Description

The Youngstown Thermal campus consists of six buildings and structures including: the main steam plant, a one story engineering office, part of a former two story dry cleaning building, a former two story brick transformer building facing Belmont Avenue, a fly ash silo, a bottom fly ash tipple, and a coal tower.

The Youngstown Thermal Steam Plant building originally consisted of a steel frame structure with brick curtain walls, concrete floor, and concrete slab ceiling. The original brick section facing North Avenue consists of two, three-bay-wide gabled sections each originally having large arched window and door openings. At least one of these openings on the second floor still has insulated tubes for exiting power cables. Nearly all of the original doors and windows have been removed and the openings have been bricked in completely, while some accommodate small modern windows and one opening on the south side has a late twentieth century steel overhead door.

Existing photographic evidence shows that alterations in 1947 to accommodate new boilers resulted in the demolition of the central section of the original brick building. The new central section was a steel frame building clad with transite (fiber-cement) siding. This central section houses the boilers and has four iron or steel smokestacks rising above its roof. Historical photographs indicate that these stacks were constructed during and after 1947. The easternmost section of the main plant is a one story steel frame

building structure with brick curtain walls and shed roof. Nearly all the arched openings on this section have been fully bricked in, while the few remaining windows on the south side appear to be steel sash replacements identical to those of the central section that date from the late 1940s or 1950s.

A one story engineering office, constructed between 1928 and 1950 is located north of the central section of the steam plant. It is a side-gabled, five by two bay structure with metal siding and steel sash windows. The roof is clad with asphalt roll roofing.

A two-story brick building that fronts Belmont Avenue was originally a transformer building for the trolley system and was constructed around 1928. It is a one by three bay, two story building set on a concrete foundation. It has a steel frame clad with brick. The rear of the building has a walk-out basement entrance. The front of the building has a double wooden door with an eight light arched transom. The second floor openings on both front and rear have been replaced with steel panels. The rear first story opening has been filled in with vinyl siding and two modern double-hung sash windows. The building no longer houses any transformers or electrical equipment and is utilized for storage. Other structures include a fly ash silo, a bottom fly ash tipple, a coal storage area and pit, and a coal tower.

The Youngstown Thermal campus was originally developed in 1895 as a co-generation plant to produce power for trolleys in the downtown area of Youngstown. Sanborn maps from 1896 list the property as the Mahoning Electric Co. Power & Light Station (Sanborn 1907). The North Avenue power plant provided electricity for the Youngstown, Sharon, Wheatland, Mill Creek Park, and Falls Street Car Lines during its early history (Butler 1921). In the 1890s, there were many independent trolley lines in the city operated by different corporations. Many of these companies combined trolley and electrical power service since they needed to generate power for the trolley lines.

Historical sources state that the plant was taken over by the Mahoning & Shenango Valley Railway & Light Company in 1902 as part of a consolidation of the multitude of independent trolley lines (Sanderson 1907). This consolidation resulted in the construction of an entirely new plant on the site. Sanborn maps from 1907 show that the buildings present in 1896 were demolished and replaced with larger buildings to accommodate new dynamos, coal storage, and steam boilers. The property had two large main buildings. One faced North Avenue and shared its east wall with the second building located in the approximate center of the property. Sanborn maps describe the buildings as having exposed steel frames, brick curtain walls and concrete slab ceilings and floors. By 1907, the property was labeled the Youngstown Consolidated Gas and Electric Company. Directly east along Belmont Avenue was an automobile repair shop and residences. Residences also occupied most of the land north of the site, while south of seven railroad lines and several sidings of the Pittsburgh and Lake Erie Railroad lie offices, a foundry and the Mahoning Valley Car Barn and Power House. The west side of North Avenue contained a feed warehouse and residences (Sanborn 1907).

In the 1920s, the property became part of the Ohio Edison Company. By 1928, an addition was added to the north wall of the central building. By this date, the dwellings and automobile repair shop were gone. A coal hopper was now located east of the plant and a transformer building for the trolley lines had been constructed at 216 Belmont Avenue (Sanborn 1928). This transformer building is still extant on the property. The property was operated by the Pennsylvania-Ohio Power and Light Company. The present Ohio Edison substation building was constructed in 1928 at 210 Belmont Avenue and it was likely soon after that the plant ceased electric power generation. Sanborn maps after 1928 describe the building as a steam heat plant operated by the Ohio Edison Company (Sanborn 1950).

In 1946-7, boilers 1 and 3 were installed. There were also major alterations done to the plant in 1953 when boiler number 4 was installed. Boiler number 1 was retrofitted in the 1970s to burn natural gas and fuel oil. The plant has been operated by Youngstown Thermal since 1979. Sometime after 1979, the railroad tracks were abandoned and removed. The adjacent dry cleaning/steam laundry property at 205

North Avenue was purchased by Youngstown Thermal in 2004. This building, which was constructed sometime between 1907 and 1928, has been partially demolished since its acquisition by Youngstown Thermal. Originally composed of three two-story sections and a one-story section, it is constructed of ceramic tile and concrete block having a flat roof and brick front facade. While some of the second story steel sash windows remain, many of the building's openings have been filled in, including a large window opening on the front facade. The entire southernmost two-story section of the building has been demolished.

National Register Evaluation

The Youngstown Thermal plant is historically significant under National Register Criterion A for its role in the development of early electrical power generation for electric lighting, power and trolley systems in Youngstown. Under National Register Criterion C, it is representative of the type of power plants constructed for trolley service and residential power in the late nineteenth century.

Alterations, demolition and infill during the late 1940s has significantly diminished the property's integrity of design, materials and workmanship. These alterations include the loss of nearly every original window and door opening of the steam plant resulting in the majority of these openings being filled in. The demolition of the original central portion of the plant and replacement with steel frame clad with transite has significantly affected the plant's original design. No original power generation equipment remains in the plant nor in the transformer building at 216 Belmont Avenue. Therefore, the Youngstown Thermal plant is not eligible for the National Register.

Ohio Edison Sub-Station, 210 Belmont Avenue (Tax ID: 53-71-20-01-P) OHI No. MAH0037604

Description

This substation, constructed in 1928, is a two-story, five by three bay brick building with concrete floor and flat roof. It is located immediately adjacent to the Youngstown Thermal plant and is accessed from that property. Sometimes referred to as Starved Classicism, the architecture exhibits elements of Neoclassical styling commonplace in industrial and commercial buildings of this era, including substations and powerhouses. Brick is laid in running bond. The roof has a molded concrete parapet and the main entrance door is surrounded by a molded concrete architrave trim. The entrance door is comprised of a set of steel doors capped with large steel sash transom windows. Windows are large industrial style multi-pane steel sashes. To the upper left of the front entrance is a molded concrete medallion with the words: "Ohio Edison".

National Register Evaluation

The Ohio Edison Sub-station served Youngstown when it was a prosperous industrial town. It is associated with events that have made a significant contribution to the broad patterns of our history and is eligible for the National Register under Criterion A at the local level for its association with the growth of Youngstown and its community planning and development in the first decades of the twentieth century. Construction of the sub-station reflects city growth patterns during the early twentieth century.

The building is also eligible under Criterion C as it is an intact example of its type, being an early twentieth century substation built with minimal classical styling, having transformers and wiring support structures mounted on the roof in contrast with modern facilities that generally screen the electrical equipment or house it completely within the building. Although electrical equipment has been updated throughout the years, this structure is remarkably unchanged from its original appearance. The period of significance for the building extends from the date of construction, 1928, to the 50-year cut-off date of 1966. The building retains integrity of materials, design, location, and workmanship.

So So's Lounge, 232 North Avenue (Tax ID: 53-071-0-053.00-0)

Description

This building, originally depicted as a duplex housing unit on Sanborn maps in 1907, was later used as a storage building and more recently as a restaurant and bar. Little remains of its original appearance. The building has a stone foundation that was later added to with concrete block and concrete. The original foundation is only visible on the south facade. The front of the building is covered with stone facing on its first story and painted plywood panels on its second story. There are two steel doors on its main facade. Some vinyl siding from earlier alterations is visible to the rear of the building. The roof is difficult to read, but appears to have been originally a double front gable. Little remains of the original appearance of the structure.

National Register Evaluation

So So's Lounge does not possess the historical significance to be eligible under Criterion A of the National Register. It is not associated with significant historical persons (Criterion B) and is not representative or a type, nor does it represent high artistic values and is therefore is not eligible under Criterion C. The building has lost nearly all of its integrity of design, workmanship, and materials and is therefore not eligible for the National Register.

Diagnostics Direct, Inc. Warehouse (Allstate Public Warehouse) 117 North Avenue (Tax ID: 53-71-19) OHI No. MAH0043704

Description

Originally utilized as a general warehouse for the Pittsburgh and Lake Erie Railroad, this building was constructed in 1927 by the Charles Shutrump and Sons Company, General Contractors, according to its cornerstone. Prior to its construction, the site was occupied by a number of industries, including a foundry and the Orient Electric Company in 1896, and later by the Mahoning Valley Car Barn and Power House (Sanborn 1896, 1907). The building is five stories high, 21 bays long, and four bays deep. It is constructed of a reinforced concrete frame with concrete floor and roof, having brick panel walls. The south side of the building is comprised of continuous loading bays. While the majority of these loading bays have been filled in with concrete block, three remain in use with modern steel overhead doors. The entire north side of the building originally had an open first floor that served as a loading platform for the adjacent railroad tracks. These open bays were framed, closed, and sided with vinyl siding in the first decade of the twenty-first century. Windows are predominantly original multi-pane steel sashes that form continuous bands around the building. These bands are interrupted only at each of the three elevator shafts. Some of the openings have been filled in with brick. The reinforced concrete frame of the building is deteriorated and large portions of concrete are missing both on the concrete frame and window surrounds.

National Register Evaluation

This warehouse is typical of reinforced concrete warehouse buildings constructed by the railroads in the early twentieth century. Larger, more intact examples include the Lackawanna Freight Terminal Warehouse of Jersey City, New Jersey, constructed in 1930. That warehouse was larger, being eight stories above ground with basement (Engineering News-Record 1930).

The building is not associated with persons significant in the past (Criterion B), but is associated with events that have made a significant contribution to the broad patterns of our history due to its association with the railroad industry (Criterion A). Although it does exhibit some of the distinctive characteristics of early twentieth century railroad warehouse construction utilizing reinforced concrete to create large spans with great strength (Criterion C), it is not among the best examples of its type.

Although the building possesses integrity of location and a reasonable integrity of setting and design, integrity of association and feeling are somewhat diminished by the loss of surrounding buildings and of the railroad tracks that once serviced the building. The building also suffers from a moderate degree of integrity of materials and workmanship due to alterations, infill, and lack of maintenance. Due to integrity issues, the building is not eligible for the National Register.

Domestic Linen Rental, 234 Belmont Avenue (Tax ID: 53-71-0-021.00-0) OHI No. MAH0037704

Description

This building was constructed sometime around 1928 according to Sanborn maps (Sanborn 1928). Originally known as the Thornton Laundry and Dry Cleaning Company, it originally consisted of a brick two-story building with five bays and flat roof facing Belmont Avenue. Over the years, all of the first story openings have been bricked in, and most of the second story window openings have been altered with infill or modern windows replacing the original multi-pane steel sashes. The original main double entrance door has also been replaced with a smaller single door. Recently, a large two story, steel frame addition with concrete curtain walls was added to the north facade of the original building, more than doubling its size. Additional infill has been constructed between these buildings and North Avenue in the recent past.

National Register Evaluation

The Domestic Linen Rental building is not associated significant historical events (Criterion A) or with significant historical persons (Criterion B). It does not embody the distinctive characteristics of a type, period, and method of construction (Criterion C). Although the building possesses integrity of location and a reasonable integrity of setting and association, it suffers from integrity of design, materials, and workmanship due to alterations, additions, and infill. Therefore, the building is not eligible for the National Register.

Private Garage, Corner of MLK Drive and North Avenue (Tax ID 53-71-0-110.00-0)

Description

Sanborn maps and physical inspection indicate that this building, constructed in 1963, was originally a rectangular, one story concrete block automobile service station with five overhead bays facing Martin Luther King Jr. Boulevard. By 1985, the southwest corner had been altered to create a five-sided structure. All but one of the service bays have been enclosed with either concrete block or plywood.

National Register Evaluation

The garage is not associated significant historical events (Criterion A) or with significant historical persons (Criterion B). It does not embody the distinctive characteristics of a type, period, and method of construction (Criterion C). Although the building possesses integrity of location and a reasonable integrity of setting and association, it suffers from some loss of integrity of design, materials, and workmanship due to alterations, additions, and infill. The building is not eligible for the National Register.

City of Youngstown Sign Shop, 480 MLK Drive (Tax ID 53-71-0-112.00-0; 53-71-0-113.00-0; 53-71-0-114.00-0)

Description

According to Sanborn maps, this building was constructed in 1950 and originally housed a truck sales and service business. It is a one-story, L-shaped building of concrete block with brick face and a flat roof. All

original window openings and nine large service bays have been altered in some fashion. Six of the bays have been filled in and the remaining doors have been replaced. The western ell section has a four by two bay addition that appears to date from the twenty first century. The building is currently operated as a sign shop by the City of Youngstown.

National Register Evaluation

The City of Youngstown sign shop is not associated significant historical events (Criterion A) or with significant historical persons (Criterion B). Neither does it embody the distinctive characteristics of a type, period, and method of construction (Criterion C). Although the building possesses integrity of location and a reasonable integrity of setting and association, it suffers from the loss of integrity of design, materials, and workmanship due to alterations, additions, and infill. The building is not eligible for the National Register.

Biomat USA Plasma Center, 444 MLK Drive (450?) (Tax ID 53-71-0-115.00-0, 53-71-0-117.00-0) OHI No. MAH0040204

Description

This property consists of two connected masonry buildings that have been altered to the point that it is difficult to ascertain if they are the same buildings represented in historic Sanborn and aerial photographs (Sanborn 1950). Although the buildings have the same basic plan as those depicted around 1950, the present buildings have been updated with new windows, doors and stucco finish. According to the Ohio Inventory, the building to the rear was the Youngstown Mattress Company, 450 West Federal Avenue, constructed in 1920 (Sanborn 1928).

National Register Evaluation

The Biomat USA Plasma Center building is not associated significant historical events (Criterion A) or with significant historical persons (Criterion B). Neither does it embody the distinctive characteristics of a type, period, and method of construction (Criterion C). The building possesses integrity of location and setting, however, extensive alterations and additions to the building have greatly diminished integrity of design, materials and workmanship. The building is not eligible for the National Register.

Penn Central Railroad Bus and Passenger Station, 529 MLK Drive (Tax ID 53-71-0-159.00-0) (Tax ID 53-71-0-159.01-0)

Description

This property was constructed in 1948 as the Penn Central railroad's bus and rail passenger station. It is a one-story brick building with flat roof set back from the road and having a semi-elliptical drive leading to a canopied walkway and waiting area. The canopy is a flat roofed structure supported by steel columns. Windows are large aluminum frame fixed panes. The main entrance consists of a set of four entrance doors with glass side lights topped by large transom windows. A secondary entrance at the east end of the front facade is a more modest single entry door surrounded by side lights and transom window. A massive brick chimney pierces the roof at the east end of the building. The rear of the building opens up to a waiting area by the railroad tracks. The interior appears to have original stone floors and ceramic tile walls. Presently vacant, the building was most recently occupied by the Phantom Fireworks business.

National Register Evaluation

The Penn Central Railroad Bus and Passenger Station is eligible for the National Register under Criterion A for its association with the history of transportation in Youngstown. The station served passengers for both the railroad and buses for the second half of the twentieth century. It is eligible under Criterion C as an intact example of the more utilitarian type of station being constructed by railroads and bus companies

during the late 1940s through the 1960s. The building, while still showing some of the features of the former Streamline Moderne Style, followed the architectural trends towards a more boxy, International styling with large expanses of wall, glass and fewer curves, however the building retains the large roof canopy as well as the passenger waiting area canopies. The building possesses integrity of location, setting, feeling, and association as well as design, workmanship, and materials.

F. D. Mason Memorial Funeral Home, 511-515 West Rayen Avenue (Tax ID 53-003-0-083.00-0)

Description

Although composed of two connected dwellings constructed in the early twentieth century, no evidence of their original appearance is visible. The connected buildings appear to be frame dwellings, having a brick facing on the first floor and vinyl siding on the second floor. Windows are a combination of fixed pane, casement and various other vinyl and aluminum clad sashes. The front entrance has a gabled main porch roof with a slightly sloping shed roof to the east side that shelters patron's automobiles. The roof of the building is a combination of flat and low-sloped gables clad with asphalt shingles. Sanborn maps depict a gradual change from two frame dwellings in 1950, to a combined dwelling in 1978. By 1985, the two lots adjacent to the house were demolished and a parking lot installed, and by 1989, the original dwellings had been completely enclosed by additions in the present form (Sanborn 1950, 1978, 1985, 1989).

National Register Evaluation

The F. D. Mason Memorial Funeral Home is not associated with events that have made a significant contribution to the broad patterns of our history and is therefore not eligible for the National Register under Criterion A. It is not a noteworthy example of its type, does not represent the work of a master or possess high artistic values, and is not eligible for the National Register under Criterion C.

Although the Mason family can be considered to have significance at the local level as important members of the community, due to integrity issues, it is not eligible for the National Register under Criterion B. The F.D. Mason Memorial Funeral Home has undergone wholesale changes and alterations. Originally, two separate dwellings, the two homes have been connected and altered to the point where no original materials are visible and integrity of design, materials, and workmanship have been completely lost. While the building possesses integrity of location, its setting has been diminished by the demolition of most of the original buildings to the north and northeast. The building is not eligible for the National Register.

Frieda's Bar, 381 West Rayen Avenue (Tax ID 53-003-0-083.00-0) OHI No. MAH0046204

Description

This trapezoid-shaped building first shows up on the 1928 Sanborn maps (Sanborn 1928); however, the Ohio State Historic Preservation Office's online mapping system indicates a construction date of 1911. It is a two-story, five by three bay brick building that currently serves as a bar. Although most of the first story openings have been enclosed with plywood, their size suggests that the lower floor served as a storefront. Second story windows are vinyl clad double-hung sashes capped by cast concrete lintels. There is a brick belt course at the first story level and a cast concrete belt course at the roof line with brick parapet. The building has a built-up asphalt roof. There are three entrances. One entrance is located along Belmont Avenue and is set into a recess in the building, accessed under a brick archway. A second entrance is located on the east facade of the building. The third entrance sits at the intersection of West Rayen and Belmont Avenues. Openings once present along West Rayen Avenue have been enclosed with plywood.

National Register Evaluation

Frieda's Bar is not associated with events that have made a significant contribution to the broad patterns of our history (Criterion A), nor is it known to be associated with an individual who is historically significant in a local, state, or national context (Criterion B). It is not a noteworthy example of its type and does not represent the work of a master or possess high artistic values (Criterion C). The building has lost some integrity of design, materials, and workmanship due to the removal of original windows and doors. Therefore, it is not eligible for the National Register under Criterion A, B or C.

Metropolitan Baptist Church 361, 363, 365 West Rayen Avenue (Tax ID 53-003-0-075.00-0; 53-003-0-076.00-0; 53-003-0-078.00-0; 53-003-0-079.00-0; 53-003-0-081.00-0) OHI No. MAH0021404

Description

This church is a two-story, minimally Gothic Revival styled building constructed of blond brick face over clay tile. According to the Ohio online mapping system, it was constructed in 1902, but it does not appear on the 1907 Sanborn map. It is first described as the Grace Evangelical English Lutheran Church on 1928 Sanborn maps (Sanborn 1928). The foundation is of ashlar stone. The front facade of the building is composed of a central gable flanked by two square bell towers. The central entrance is stone and concrete, having a central entrance door covered by a hooded gable. Above the gable is a circular stained glass window flanked by ornate rectangular Gothic Revival style stained glass windows. Windows on the two bell towers are triple rectangular stained glass windows. These windows are arranged two high, separated by brick recesses. Remaining windows to the sides of the church are arched stained glass windows. Lintels and sills are of cast concrete. Each side of the building has a cross gable with a large arched window with three stained glass panels below the arch. The roof of the original structure is clad with asphalt shingles. The gabled roof is clipped, or jerkin head to the rear.

A rear addition, also constructed of blond brick face over clay tile, is five bays deep and is three stories high. This addition first appears on the 1950 Sanborn map (Sanborn 1950). Much more utilitarian in design, its windows consist of triple double-hung, multi-pane wood sashes capped by multi-pane transoms on the first floor and three over one wood sashes on the second and third floors. It also has a gabled roof clad with asphalt shingles. The building is in a serious state of disrepair. Windows are mostly destroyed, having rotten sashes and missing and broken panes. The roof suffers from severe degradation and is leaking.

National Register Evaluation

The Metropolitan Baptist Church is not associated with events that have made a significant contribution to the broad patterns of our history (Criterion A), nor is it known to be associated with an individual who is historically significant in a local, state, or national context (Criterion B). It is not a noteworthy example of its type and does not represent the work of a master or possess high artistic values (Criterion C). The rear addition, although constructed of similar brick, diminishes the Gothic Revival Style of the original structure. The addition is in an advanced state of neglect, having severe roof failure and the near total degradation of all original windows diminishing its integrity of materials. Therefore, it is not eligible for the National Register under Criterion A, B, or C.

3.4.1.3 Archaeological Resources

ComTest Site

According to the Ohio online mapping system, there are no recorded archaeological resources present within the Youngstown Thermal campus or the proposed construction laydown property on the west side of North Avenue. It is anticipated that significant ground disturbance would be limited to the proposed

locations of the new building addition, ComTest cooling tower, superheater tower and ancillary structures. The land encompassing these areas was occupied by multiple railroad tracks and sidings from the mid-to-late 1800s until the 1980s. The extent of ground disturbance both prior to the railroad and, as a consequence of its removal, is unknown. Soils in these areas are both Udorthents Loamy, 2 - 25 percent slopes (Ua) and Chili-Urban Land Complex, Undulating (CoB). Given the highly industrialized nature of the APE for archaeology, it is unlikely that intact archaeological remains exist. Section 106 consultation for this project is currently in process. An Ohio Historic Preservation Office, *Section 106 Review Project Summary Form* has been completed and forwarded to the Ohio State Historic Preservation Office for review.

Natural Gas Line

According to the Ohio online mapping system, there are no recorded archaeological resources present within the planned route of the natural gas line. Recorded historic structures adjacent to the proposed pipeline include the following:

- 216 Belmont Avenue - Ohio Edison Transformer Station, MAH0037604
- 234 Belmont Avenue - Thornton Laundry & Dry Cleaning, MAH0037704
- 381 Rayen Avenue - Frieda's, MAH0046204
- 368-374 W Rayen Avenue - Deibel Motor Company, MAH0046104
- 431 Covington Streets - Sts. Peter & Paul Church, MAH0021504
- Wick Avenue Wick Avenue Historic District
- 750 Wick Avenue - Ursuline High School, MAH0109504
- 787 Wick Avenue - Youngstown Printing Company, MAH0109604
- 801 Wick Avenue - Memorial Presbyterian Church, MAH0109704
- 84 McGuffey Road - Madison Elementary School, MAH0098804

3.4.2 Environmental Consequences

Consistent with the Council on Environmental Quality regulations for implementing NEPA, impacts to cultural resources are described in terms of type, context, duration, and intensity. These impact analyses are intended, however, to comply with the requirements of both NEPA and Section 106 of the National Historic Preservation Act. In accordance with the Advisory Council on Historic Preservation's regulations implementing Section 106 (36 CFR Part 800, *Protection of Historic Properties*), a determination of either *adverse effect* or *no adverse effect* must be made for affected National Register-eligible cultural resources. An *adverse effect* occurs whenever an impact alters, directly or indirectly, any characteristic of a cultural resource that qualifies it for inclusion in the National Register. A determination of *no adverse effect* means there is an effect, but the effect would not diminish in any way the characteristics of the cultural resource that qualify it for inclusion in the National Register.

A Section 106 summary is included in the impact analysis sections for cultural resources. The Section 106 summary is intended to meet the requirements of Section 106 and is an assessment of the effect of the undertaking (implementation of the alternative) on cultural resources, based upon the criterion of effect and criteria of adverse effect found in the Advisory Council's regulations.

3.4.2.1 Definition of Intensity Levels

For purposes of analyzing potential impacts to cultural resources, the thresholds of change for the intensity of an impact are defined as follows:

- *negligible:* Impact(s) is at the lowest levels of detection and barely measurable with no perceptible consequences, either adverse or beneficial. For purposes of Section 106, the determination of effect would be *no adverse effect*.

- *minor* adverse impact: Impact would alter a feature(s) of a structure or building, but would not diminish the overall integrity of the resource. For purposes of Section 106, the determination of effect would be *no adverse effect*.

- *minor* beneficial impact: Stabilization/ preservation of features in accordance with the *Secretary of the Interior's Standards for the Treatment of Historic Properties*. For purposes of Section 106, the determination of effect would be *no adverse effect*.

- *moderate* adverse impact: Impact would alter a feature(s) of the structure or building, diminishing the overall integrity of the resource. For purposes of Section 106, the determination of effect would be *adverse effect*. A Memorandum of Agreement is executed among the National Park Service and applicable state or tribal historic preservation officer and, if necessary, the Advisory Council on Historic Preservation in accordance with 36 CFR 800.6(b). The mitigation measures identified in the Memorandum of Agreement reduce the intensity of impact from major to moderate.

- *moderate* beneficial impact: Rehabilitation of a structure or building in accordance with the *Secretary of the Interior's Standards for the Treatment of Historic Properties*. For purposes of Section 106, the determination of effect would be *no adverse effect*.

- *major* adverse impact: Impact would alter a feature(s) of the structure or building, diminishing the overall integrity of the resource. For purposes of Section 106, the determination of effect would be *adverse effect*. The National Park Service and applicable state or tribal historic preservation officer are unable to negotiate and execute a Memorandum of Agreement in accordance with 36 CFR 800.6(b).

- *major* beneficial impact: Restoration of a structure or building in accordance with the *Secretary of the Interior's Standards for the Treatment of Historic Properties*. For purposes of Section 106, the determination of effect would be *no adverse effect*.

- *short-term duration*: Effects would last for the duration of the construction activities (less than 1 year).

- *long-term duration*: Effects would last longer than the duration of the construction (longer than 1 year).

3.4.3 No Action – Environmental Consequences

ComTest Site

Implementation of the No Action Alternative would result in no increased potential for adverse impact to historic resources. Construction of the Proposed Action would not occur, the AUSC ComTest would not take place at Youngstown Thermal, the proposed construction laydown area on the adjacent property

would not be cleared of vegetation, and the proposed natural gas line would not be constructed to support the proposed project. Existing conditions would remain unchanged

3.4.4 Proposed Action – Environmental Consequences

3.4.4.1 Historic Structures and Districts

Ohio-Edison Substation, 210 Belmont Avenue (Tax ID: 53-71-20-01-P) OHI No. MAH0037604

The Ohio Edison substation is located approximately 300 feet northeast of the proposed superheater tower. The entire site and surrounding area is industrial in nature, with four 120-foot high smokestacks presently at the site. The construction of the proposed superheater tower, building additions, ComTest cooling tower, and ancillary structures would have a long-term, minor impact on the visual setting of this National Register-eligible building. It would not, however, significantly diminish those qualities that make the property eligible for the National Register. Therefore, in terms of Section 106, the proposed project would have *no adverse effect* to the Ohio Edison substation.

Penn Central Railroad Bus and Passenger Station, 529 MLK Drive (Tax ID 53-71-0-159.00-0) (Tax ID 53-71-0-159.01-0)

The Penn Central Railroad Bus and Passenger Station is located approximately 500 feet southwest of the proposed superheater tower. The entire site and surrounding area is industrial in nature and due to the presence of the Diagnostics Direct Inc. Warehouse building, is completely screened from the project site. The proposed project would have negligible impacts to this historic property. In terms of Section 106, these impacts relate to a finding of *no adverse effect* to the Penn Central Railroad and Passenger Station.

3.4.4.2 Archaeological Resources

ComTest Site

According to the Ohio online mapping system, there are no recorded archaeological resources present within the Youngstown Thermal campus or the adjacent area on the west side of North Avenue. Section 106 consultation for this project is currently in process and an Ohio SHPO, *Section 106 Review Project Summary Form* has been completed and forwarded to the Ohio SHPO for review. It is expected that no intact archaeological remains exist at the site and therefore there would be no impacts to archaeological resources. In the event of an unanticipated discovery of archaeological resources, contractors would immediately stop work at the site and notify DOE, and DOE will then notify the Ohio SHPO. In terms of Section 106, this would equate to a finding of *no adverse effec*t on historic properties.

Natural Gas Line

According to the Ohio online mapping system, there are no recorded archaeological resources present within the ROW of the proposed natural gas pipeline. Trenching is expected to occur entirely within the existing ROW adjacent to existing infrastructure. Soils in the majority of the route are Chili-Urban Land Complex, Rolling (CoC) with small amounts of Chili-Urban Land Complex, Undulating (CoB). As trenching would take place adjacent to existing infrastructure within the ROW, significant archaeological remains are not expected within the APE for the proposed natural gas pipeline and therefore there would be no impacts to archaeological resources. In the event of an unanticipated discovery of archaeological resources, contractors would immediately stop work at the site and notify DOE, and DOE will then notify the Ohio SHPO. In terms of Section 106, this would equate to a finding of *no adverse effec*t on historic properties. Section 106 consultation for this project is currently in process. An Ohio SHPO, *Section 106 Review Project Summary Form* has been completed and forwarded to the Ohio SHPO for review.

3.5 HEALTH AND SAFETY

3.5.1 Affected Environment

Activities at the project site would be conducted under the auspices of Youngstown Thermal and follow the facility's existing safety practices and guidelines. Youngstown Thermal maintains a safety policy that contains its plans, procedures, and standards. The Youngstown Thermal Safety Policy is an overview of the safety standards at Youngstown Thermal. The safety policy details general safety rules, and discusses safety related to human health, the operation and maintenance of facilities and their components, and the environment. Specific procedures regarding hazards and their prevention discussed within the Youngstown Thermal Safety Policy include (Youngstown Thermal 2016):

- Hazard communication
- Personal protective equipment
- Respiratory safety
- Bloodborne pathogens
- Hazardous material handling
- Emergency response
- Confined space entry
- Isolation/lockout
- Electrical safety
- Working from heights
- Company vehicle operation
- Abrasive wheel operation

3.5.2 No Action – Environmental Consequences

Implementation of the No Action Alternative would result in no increased potential for adverse impact to public or employee health and safety. Construction of the Proposed Action would not occur and Youngstown Thermal would continue to operate under existing conditions and would continue to adhere to existing safety practices, procedures, and standards.

3.5.3 Proposed Action – Environmental Consequences

Construction and operation of the Proposed Action would introduce minor potential for health and safety impacts. Primary concerns to human health and safety regarding the proposed AUSC ComTest Project would include accidental injuries during construction and operation; exposure to air pollutants and noise levels that could be harmful to humans; and scalding, explosive, or fire hazards associated with the combustion of natural gas and operations involving very high water temperatures and pressures. Adherence to OSHA requirements and the safety practices listed below would minimize these potential risks to health and safety.

Potential occupational health and safety risks during construction are expected to be typical of risks for any industrial or commercial construction site. These include, but are not limited to: the movement of heavy objects, including construction equipment; slips, trips, and falls; risk of fire or explosion from general construction activities; and spills and exposures related to the storage and handling of any chemicals and disposal of hazardous waste. According to the Bureau of Labor Statistics, approximately 3.5 nonfatal occupational injuries occurred for every 100 workers throughout the construction industry in 2014. The rate among nonresidential building construction workers was 2.6 injuries per 100 workers (Bureau of Labor Statistics 2014). The health and safety of construction workers would be protected by adherence to accepted work standards and regulations set forth by the Occupational Safety and Health Association (OSHA) (29 CFR 1910). During construction, safety measures, such as providing fencing

around the construction site, establishing contained storage areas, and controlling the movement of construction equipment and personnel, would reduce the potential for accidents to occur.

During operations, prevention is the first step in dealing with incidents where equipment, the environment, or personnel may be harmed by errors or accidents. For this reason, the minimum requirements of OSHA standards would be met or exceeded in the design of equipment, buildings, and access. Safety training shall also be given to employees and visitors.

To minimize the potential for accidents, a Process Hazard Analysis of the proposed AUSC ComTest Project at Youngstown Thermal was conducted. The analysis identified seven recommendations regarding items to confirm or items to consider that would improve health and safety of workers operating the AUSC ComTest components. Items to confirm were those believed, but not certain, to be already in place, while items to consider would serve as additional safeguards against identified hazards. The recommendations included the following (Bluefield Process Safety 2016):

1. Confirm lines are insulated for heat protection as necessary. Evaluate each steam and water line for its potential to exceed 140°F, the highest temperature considered safe to touch, and confirm that any lines having the potential to exceed that temperature are insulated properly.
2. Confirm lines are insulated and traced as necessary. Evaluate each water line's potential to freeze if the facility stops operation during cold weather, then trace each line and confirm that it is insulated properly.
3. Consider need for independent desuperheating water supply on bypass. Consider diversifying the desuperheating water supply in order to avoid concerns of common-cause failure.
4. Confirm that controls on boiler package limits temperature to operating envelope. Equip the package boiler with controls that assure the steam temperature would not exceed the limits of any equipment with which it may come in contact.
5. Tower entry procedures should be as rigorous as other work permit procedures. Given the pressure and temperatures resulting from operation of the proposed AUSC ComTest equipment, a steam leak could harm facility personnel. To reduce this potential, restrict access to the superheater tower as much as possible.
6. Confirm that design addresses issues of steam leak from the high temperature and pressure system, as steam could harm personnel throughout the facility.

As the proposed project would implement robust safety procedures, and has been subject to a Process Hazard Analysis to minimize the potential for accidents, the potential for impacts to human health and safety are considered low.

As described in Sections 3.1 (Air Quality) and 3.7 (Noise), impacts from the Proposed Action would be minor to the air quality and to the noise environment. Future air emissions from the proposed project would be within ambient air quality standards that represent the maximum allowable atmospheric concentrations that may occur and still protect public health and welfare within a reasonable margin of safety. Noise levels during operation of the AUSC ComTest would generally be consistent with existing noise levels produced by Youngstown Thermal and in accordance with OSHA occupational noise standards.

Natural Gas Line

Construction of the proposed natural gas pipeline would introduce minor potential for health and safety impacts. As with most construction activities, primary concerns for health and safety would include accidental injuries from use of heavy equipment, or from slips, trips and falls around the construction site, and from exposure to air pollutants and elevated noise levels generated by the equipment and activities. In addition, trenching and emplacement of the pipe within the utility ROW would involve construction

work within and alongside roadways that may or may not be closed to traffic, depending on the construction work plans to be developed by Dominion East Ohio. Similar potential for impacts to health and safety would occur during maintenance and repair activities during operation of the natural gas pipeline. Dominion East Ohio would follow their safety protocols to protect the health and safety of their workers and the public during construction, maintenance, and repair activities.

During operations, the underground pipeline would transport natural gas to the Youngstown Thermal campus. Transport of natural gas could cause minor to significant adverse impacts to humans and the environment if there were to be an accidental release of natural gas from a rupture or leak of the pipeline. While exposure to small amounts of natural gas is not likely to result in measurable adverse health effects, especially when in the open outdoor environment, exposure to high concentrations (i.e., from a severe pipeline leak) could cause dizziness, fatigue, nausea, headache, and irregular breathing (U.S. National Library of Medicine 2016). Further, natural gas is highly flammable and explosive, presenting additional risk of potential adverse health and safety impacts to the surrounding areas. Over recent years, consequences from ruptures to natural gas pipelines have resulted in injuries and fatalities as well as destruction of property and the environment (National Transportation Safety Board 2008, 2010, 2011). However, based on annualized incident rate data from the U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration, the likelihood of an incident occurring on the proposed 1.45-mile underground natural gas pipeline would be very unlikely, on the order of approximately 1 in 15,000 per any given year (PHMSA 2016a, 2016b).

Dominion East Ohio, the utility company responsible for providing natural gas service to Youngstown Thermal, would be responsible for conducting inspections, integrity management, and ensuring safe operation of natural gas pipeline in compliance with federal and state regulations. Given the very low probability of an incident occurring on the pipeline and the safety protocols in place, DOE assesses the overall potential impact to human health and safety to be not significant.

3.6 INFRASTRUCTURE, UTILITIES, AND TRAFFIC

3.6.1 Affected Environment

The Youngstown Thermal campus consists of an approximate 3-acre property developed with a 28,000 square-foot boiler steam plant, a three-story meter building, a one-story plant/engineering office, storage building, fly ash silo, a bottom ash tipple, a coal storage area, a coal tower and adjacent pit, and paved and unpaved surfaces (Conestoga-Rovers and Associates 2010).

Youngstown Thermal is a district energy/heating plant that produces and provides steam to their customers in the downtown business district of Youngstown, Ohio through approximately 6 miles of underground piping. In recent years, Youngstown Thermal provided approximately 40,000 to 60,000 pounds per hour of steam to its customers, which equates to 350 to 525 million pounds per year. This steam is used for space heating, hot water heating, and absorption chilling. The steam is generated by the use of up to four boilers. Three of these boilers use coal as the fuel source and the fourth boiler uses natural gas. The steam is supplied to their customers at approximately 150 psia and saturated conditions. The total steam load supplied is seasonal and also varies through the day. Water supplied to the boilers is from the municipal water system. The condensate is not returned from the customers, it is directed to drains at each customer's facility.

Potable Water

The Mahoning Valley Sanitary District provides treated potable water to the City of Youngstown, which in turn distributes to the Youngstown Thermal plant. The City of Youngstown is a licensed public water distribution system (ID OH5002303). The primary source of the water supply is the Meander Creek Reservoir, a surface waterbody that requires treatment prior to distribution as drinking water (City of

Youngstown 2016a, 2016b). The Mahoning Valley Sanitary District water treatment plant has a design capacity of 60 million gallons per day (Meander Water 2016). Youngstown Thermal currently uses approximately 91,300 gallons per day.

Sanitary and Stormwater Discharge

The City of Youngstown has a combined sanitary and storm sewer system that flows to the Youngstown Waste Water Treatment Plant located on the Mahoning River approximately two miles southeast of the Youngstown central business district bounded by Gibson Street, Alpine Street and Poland Avenue, with a service area of approximately 35,000 acres. The plant has a daily average flow of 35 million gallons per day and treats a peak capacity of approximately 80 million gallons per day. The treatment plant is in the process of expanding and upgrading it capacity to treat 180 million gallons per day in order to prevent untreated wet weather overflow and upgrade several existing treatment processes and associated equipment (City of Youngstown 2016c).

The Youngstown Thermal facility has a wastewater discharge permit (Permit #MI002) issued by the City of Youngstown Public Works Department. Wastewater generated at the plant consists of sanitary wastewater and blowdown and backwash waters from the boilers. Stormwater runoff from the campus flows into storm catch basins that are part of the sanitary/storm sewer system. In accordance with the permit, discharge is monitored for compliance with the permit (Conestoga-Rovers and Associates 2010; Weston 1990). Currently, Youngstown Thermal discharges negligible amounts of wastewater, as the majority of water is evaporated in the cooling tower.

Electricity

Ohio Edison currently provides electricity to the Youngstown Thermal plant. Ohio Edison is one of 10 regional electric utility operating companies forming the parent energy company called FirstEnergy. FirstEnergy operates over 24,000 miles of transmission lines throughout the Midwest and Mid-Atlantic regions, generating a total capacity of 17,000 megawatts (MW). Ohio Edison provides electricity to the northeast and central regions of Ohio (FirstEnergy 2016). Currently, Youngstown Thermal uses approximately 1,875 MWh of electricity per year, with a peak demand of approximately 200 kW.

Natural Gas

Dominion East Ohio currently provides natural gas to the Youngstown Thermal plant to operate one of its boilers. Dominion East Ohio is the natural gas distribution company in Ohio for the parent company Dominion. Dominion is one of the nation's largest producers and transporters of energy, including 12,200 miles of natural gas transmission and 933 billion cubic feet of natural gas storage capacity. Dominion operates in 14 states for both natural gas and electric services (Dominion 2016). Currently, Youngstown Thermal uses approximately 26 billion cubic feet of natural gas per year.

Traffic

The Youngstown Thermal campus is located approximately 0.5 miles northwest of downtown Youngstown and approximately 0.5 miles west of Youngstown State University. The property is located in a mixed-use industrial and commercial area, with primarily commercial and institutional areas located to the north, east, and south, and industrial properties to the west (City of Youngstown 2016d). The property is bordered by North Avenue to the west, Belmont Avenue to the east, and other industrial and commercial properties immediately to the north and south. Railroad tracks and the Mahoning River lie further south. The nearest residential area is approximately 0.2 miles to the north.

Interstate 76, Interstate 80 (and Interstate 680), and Highways 62 and 422 are the major east-west arterials near the facility. Highways 11, 193, and 7 are the major north-south arterials near the facility. The only access road to the property is the north-south oriented North Avenue that borders the western edge of the

property, and terminates at Martin King Luther Jr. Boulevard/W. Federal Street approximately 0.1 miles to the south. The facility currently experiences a low volume of truck traffic related to deliveries and shipments (estimated at one to two trucks per day) and the local roadway network can easily accommodate this volume.

3.6.2 No Action – Environmental Consequences

Under the No Action Alternative, construction of the Proposed Action would not occur, the AUSC ComTest would not take place at Youngstown Thermal, and the natural gas line would not be constructed to support the proposed project. Existing conditions would remain unchanged and no impacts would occur to infrastructure, utilities, and traffic.

3.6.3 Proposed Action – Environmental Consequences

The Proposed Action would have negligible to minor impacts to sanitary and stormwater discharge during construction and negligible impacts during operations. Impacts to potable water supply, electricity, and natural gas would be negligible to minor during construction and operations. Minor impacts to traffic and transportation could occur during construction, while impacts of operations would be negligible.

Ground disturbing activities would consist of proposed construction activities at the Youngstown Thermal plant and the proposed natural gas line route. Table 2-1 and Figure 2-3 in Chapter 2, Proposed Action and Alternatives, present the proposed new buildings, structures, and other infrastuctures that would be a part of the AUSC ComTest Project. Major ground disturbing activities at the Youngstown Thermal plant include: (1) construction of a 70 x 90-foot (6,330 square-foot), 32-foot high ComTest turbine building with a 14.5-foot deep basement that would connect to the existing boiler building basement for passageway and connection of piping; (2) a 34 x 49-foot (1,666 square-foot), 130-foot high superheater tower located to the east of the ComTest turbine building supported by six columns resting on a foundation of drilled piers extending into the bedrock approximately 30 feet below grade; (3) a cooling tower area supported approximately eight feet above grade by a structural steel platform with each column of the platform resting on a concrete spread footing foundation; (4) a boiler area including foundations for the boiler, water treatment system, transformers, and a condenser/exchanger; (5) a steel-framed open utility rack supporting piping and cable trays between equipment on the site extending between the ComTest turbine building/control room, superheater tower, cooling tower area and boiler area. These steel columns would rest on shallow concrete spread footings. Other site work would include some demolition of existing underground piping and other equipment, finish grading, installation of gravel surfacing on all work-vehicle traffic areas, and tie-in to the existing sanitary sewer and storm sewer systems.

Potable Water

The proposed project would result in negligible to minor impacts on potable water demand. Negligible adverse impacts are expected during construction. Longer-term impacts to the water supply utility during operations would be minor. During construction, it is expected that potable water would be either provided by the construction contractor or construction workers would bring their own bottled water. It is also expected that temporary portable toilets would be provided by commercial services for use by the construction workers.

Once in operation, the turbine building restroom would utilize potable water for the five employees working each shift. Cold water would be provided from the municipal water supply, and hot water would be furnished by a local electric water heater. During any given shift, the five or six employees onsite could use approximately 180 gallons per day of potable water for drinking, sink usage, and toilet use, assuming approximately 30 gallons per day per person at the workplace (USGS 2016). For the AUSC ComTest, the municipal water demand would be 297,258 gallons per day from the header test and 314,247 gallons per day for the turbine test. These two tests would not overlap. The steam produced by

the proposed project would be used to replace steam currently produced by Youngstown Thermal for its existing customers and therefore be similar to existing demand. The demand for the AUSC ComTest Project would amount to approximately 0.5 percent of the capacity of the Mahoning Valley Sanitary District and would likely have a negligible to minor impact on the City of Youngstown's ability to provide potable water to the City of Youngstown.

Sanitary and Stormwater Discharge

The proposed project would result in negligible to minor impacts on sanitary and stormwater discharge. Negligible to minor adverse impacts are expected during construction. Longer-term impacts on sanitary and stormwater discharge during operations would be negligible.

Construction would include installation of catch basins and all underground storm sewers allowing draining towards the southwest corner of the construction site. The new storm sewer piping would tie into the existing sewer system with 12-inch diameter PVC sewer piping. Risers would be installed during the final grading and paving stage. Rainwater from the turbine building would be collected in a gutter system and discharged to grade via downspouts. The grade elevation would be modified to route stormwater to a local catch basin. Process floor drains would be installed as required for the first floor and basement levels. These drains would tie into a pre-fabricated sump and pump that would discharge into the process sewer. Process hub drains would be located in the yard area for the Superheater, Cooling Tower, Cooling Tower Water Treatment Skid, Boiler, Dump Condenser/Exchanger, Deaerator and Boiler Water Treatment skids. Construction would also include installation of underground sanitary sewer piping, and final fixtures would be installed when buildings or structures are completed. Sanitary waste piping from the turbine building (rest room) would tie into the sewer system with 8-inch diameter sewer piping. During construction, it is expected that temporary portable toilets would be provided for workers and sanitary wastewater transported by commercial services for disposal.

During operations, the new stormwater collection and drainage system would convey stormwater to the existing City of Youngstown main sewer system. There would be a minor increase in sanitary wastewater generated by the 17 new employees of the AUSC ComTest Project. During any given shift, the five or six employees onsite could generate approximately 180 gallons per day of sanitary wastewater, assuming approximately 30 gallons per day per person at the workplace (USGS 2016).

Electricity

The proposed project would result negligible to minor impacts on electricity supply. Negligible adverse impacts are expected during construction. Longer-term impacts on electricity supply during operations would be negligible to minor. During construction, Electrical power would be provided by portable generators until construction of the electrical infrastructure is completed and operational.

The operation of the AUSC ComTest Equipment would require significant electrical upgrades to the existing Youngstown Thermal facility. The proposed new electrical improvements would include a new electrical 23 kV sub-transmission service would be brought to the site from several blocks away (approximately 1,500 feet away from the site on a pole line). This cable would be mostly located on poles with the last 50-100 feet being installed underground to avoid interference with construction activities. In addition, other equipment would be installed including a new 23 kV pad mounted outdoor circuit breaker with metering, two liquid filled transformers installed in the boiler area, a 4160V Motor Control Center (MCC) and a 480V MCC, two uninterruptible power supplies (UPS) and a backup diesel generator. Lighting would be provided to all work areas. A security system and security cameras would also be provided, and security cameras with microphones would be provided to monitor the superheater during operation.

The peak electrical demand for the ComTest facility would be 2637 kW, with an average annual electricity usage of 18,540 MWh. This would represent more than a ten-fold increase over Youngstown Thermal's current peak demand of 200 kW, and would be less than 0.02 percent of First Energy's total generating capacity. Because this represents a very small demand on First Energy's current generating and distribution capacity of electricity, and because the project would only operate for a 2-year period, it is expected that the proposed project would have a minor impact on Ohio Edison's ability to provide electrical service to its customers.

Natural Gas

The Proposed Action would result in negligible to minor impacts on natural gas supply. Negligible adverse impacts are expected during construction. Longer-term impacts on natural gas supply during operations would be negligible to minor.

As part of the AUSC ComTest Project, Dominion East Ohio would construct a new pipeline to supply the Youngstown Thermal property with natural gas. Figure 2-5 in Chapter 2, Proposed Action and Alternatives, presents the route of the new natural gas pipeline that Dominion East Ohio has proposed as the least disruptive route from their closest tie-in point (on McGuffey Road, approximately 1.45 miles away) to the connection location at Youngstown Thermal (on Belmont Avenue). The natural gas line would be a 12-inch diameter high-density polyethylene (HDPE) pipe, conforming to ASTM D2513 with a pressure rating of 1,600 psi at 73°F. The anticipated operating pressures during the 2-year project, vary by season, with 85 psig at the tie-in point in winter and 75 psig at the tie-in point in summer.

The proposed project would supply the natural gas to the package boiler and the superheater, as well as to the gas-fired unit heaters in the ComTest turbine building. The natural gas flow to the boiler is about 11,000 pounds per hour and to the superheater is 5,200 pounds per hour for a total flow of 16,200 pounds per hour. Using 60°F and 14.7 psia as "standard" conditions, this is a volumetric flow of about 6,400 standard cubic feet per minute, which equates to approximately 3.36 billion standard cubic feet per year.

During the 2-year period of the proposed project, the AUSC ComTest Project will provide steam to Youngstown Thermal's current customers, thereby reducing the current demand for natural gas by Youngstown Thermal. Because this annual rate represents less than 0.4 percent of Dominion's current capacity of 933 billion cubic feet of natural gas storage capacity, and because the project would only operate for a 2-year period, it is expected that the proposed project would have a minor impact on the utility's ability to provide and distribute natural gas.

Traffic

The proposed project would result in only minor impacts on traffic. Short-term but measurable adverse impacts are expected during construction. Longer-term impacts on traffic conditions during operations would be negligible.

During construction, all deliveries would be off Martin Luther King Jr. Boulevard onto North Avenue and into the construction site. Typically, no more than one to two deliveries would occur per day (AECOM 2016). However, there may be periods when six to eight trucks per day could access the facility, for one to two weeks. Oversize truck deliveries would typically be less than one delivery per day, but could peak at up to four deliveries per day for up to one week. The proposed route for truck deliveries related to the Proposed Action (Martin Luther Boulevard on to North Avenue) currently does not experience significant traffic congestion, except for minor delays during periods of peak traffic. The additional truck trips to the facility would be easily accommodated within existing roadway and intersection capacity. Impacts from truck trips during construction would be short term and minor.

For the majority of the construction phase, the number of construction workers onsite at any one time would be less than 30 (AECOM 2016). For approximately 6 months during construction, this number would be between 40 and 50 workers, and could reach 60 to 70 workers for approximately 1 month. There would be available parking for construction workers at various locations in the vicinity of the project site, including within the adjacent lot used for laydown and staging, the church parking lot on West Rayen Avenue, and in nearby public garages. Construction worker vehicles would have a minor impact on traffic conditions.

In addition to the onsite construction activities, an offsite natural gas pipeline would be constructed from an existing tie-in point at the intersection of McGuffey Road and Randall Ave (north-east of the Youngstown Thermal facility), to the facility connection location on Belmont Avenue. The proposed route is approximately 7,700 feet (1.45 miles) and within the existing road rights-of-way, and construction of the pipeline is expected to take approximately 9 months. However, construction would occur only within sections of the full pipeline route at any one time, and traffic disruptions would be localized to that portion of the route. Further, the proposed route would avoid the downtown area and the Youngstown State University campus to minimize disruptions to traffic. Therefore, traffic impacts from pipeline construction would be minor and short term.

Additionally, North Avenue would need to be temporarily closed to connect new sanitary discharge piping from the project site to the city's sanitary sewer system. Either partial or complete road closure would be required, depending on the actual location of the tie-in point to existing main sewer line. The worst case would be a complete road closure for no more than 2 days, and required permits would be obtained from the city before performing the work. Typically, in such situations, the city of Youngstown allows a temporary bypass to be established along the berm of the road for the duration of the closure. Therefore, impacts to traffic from closure of North Avenue would be negligible to minor.

The Proposed Action would generate a minor, long-term increase in personal vehicle traffic due to the hiring of approximately 17 permanent employees when the pilot facility is fully operational. However, the employees would be spread across three 8-hour shifts, which would further reduce the number of employees arriving at or leaving from the facility at any one time. Because the Proposed Action is an addition to an existing industrial facility that currently operates production equipment and has existing truck and personal-vehicle traffic, this small increase in vehicle traffic would have a negligible impact to the surrounding community.

3.7 LAND USE AND AESTHETICS

3.7.1 Affected Environment

As explained in Chapter 2 (Proposed Action and Alternatives), the AUSC ComTest Project would be constructed and integrated into operations at the Youngstown Thermal plant located in Youngstown, Ohio. Youngstown Thermal, which has been in operation since 1895, supplies steam heat through 6 miles of underground pipeline to approximately 50 customers in 75 buildings in downtown Youngstown (Hall 2016).

The Youngstown Thermal campus is located northwest of downtown Youngstown, west of Youngstown State University, and north of the Mahoning River in Mahoning County, Ohio. The property is bounded by Belmont Avenue to the east, North Avenue to the west, a commercial facility to the north between the plant and West Raven Avenue, and an existing 5-story concrete building and other facilities to the south between the plant and West Federal Street/Martin Luther King Jr. Boulevard. See Figures 2-1 and 2-2 in Chapter 2.

The approximately 3.0-acre Youngstown Thermal campus and the approximate 3.9-acre adjacent property proposed for use as a construction laydown area are currently zoned as a Mixed Use-Community District (MU-C) (City of Youngstown 2016d). According to the City of Youngstown's zoning ordinance, this designation includes areas providing retail and services to secondary markets in the city, "as well as wholesaling, servicing, distributing, storing, processing, and medium-density residential uses" (City of Youngtown 2013). Building requirements of this zoning district include a 10-foot minimum front yard setback from a ROW, a 25-foot minimum rear yard, and a 75-foot maximum building height (City of Youngstown 2013). This 75-foot maximum height does not apply to a structure not intended for human occupancy, as long as the structure does not affect airport approach zones (City of Youngstown 2001). As such, the existing 120-foot towers present at the Youngstown Thermal campus do not violate the property's current zoning designation.

The surrounding properties immediately adjacent to the Youngstown Thermal campus and the proposed construction laydown area also hold MU-C zoning designations. Other zoning designations found in the vicinity of the site include multi-family residential, mixed use, and industrial green (industrial technologies that have positive or minimal negative impacts on surrounding residential areas) (City of Youngstown 2016d).

The proposed construction laydown property, across North Avenue from Youngstown Thermal, is owned by Holy Trinity Ukrainian Catholic Church and is currently undeveloped. Youngstown Thermal proposes to either lease the area or buy it from the church. A utility ROW bisects the property, extending from the northwestern point at W Rayen Avenue and W Federal Street/Martin Luther King Jr. Boulevard to the southeastern point where the line crosses North Avenue. The majority of the property supports deciduous vegetation, herbaceous shrubs, and maintained grass lawn. Section 3.3 provides further details regarding biological resources, including vegetation, found on the site.

The local visual landscape consists of a downtown mixed-use area. Adjacent structures range from conex storage units to 5-story buildings and from a church to a county jail. The adjacent property considered for use as a construction laydown area supports low-quality habitat, including deciduous trees, herbaceous shrubs, and maintained lawn.

3.7.2 No Action – Environmental Consequences

Implementation of the No Action Alternative would not affect the local land use or the visual landscape of the site. Construction of the Proposed Action would not occur, the AUSC ComTest would not take place at Youngstown Thermal, the proposed construction laydown area on the adjacent property would not be cleared of vegetation, and the proposed natural gas line would not be constructed to support the proposed project. Existing conditions would remain unchanged.

3.7.3 Proposed Action – Environmental Consequences

3.7.3.1 Land Use

Under the Proposed Action, Youngstown Thermal would continue to operate and provide steam heat to customers in downtown Youngstown. The construction and operation of facilities required to conduct the proposed AUSC ComTest would align with the property's current mission and would not conflict with the property's existing zoning designation. Construction of the components required to conduct the proposed AUSC ComTest would involve the construction of new buildings and the development of currently undeveloped portions of the Youngstown Thermal campus. However, all areas of the campus are already disturbed. As such, land use at the Youngstown Thermal campus would not change under the Proposed Action, and no anticipated land use impacts would occur.

Construction of facilities required to support the proposed AUSC ComTest would involve clearing approximately 2.9 acres of vegetation currently existing at the 3.9-acre adjacent property. Clearing and grading the site for use as a construction laydown area would change the current land use of the now undeveloped parcel. However, the site is designated as a mixed-use area, and the proposed construction would not conflict with the city's zoning ordinance. As such, the Proposed Action may have a minor direct impact on the land use of the adjacent property.

Whether the minor impacts to the construction laydown property would be temporary or permanent depends upon whether Youngstown Thermal would permanently acquire the use of the site. At the time of this EA, it is unknown whether the property would be purchased by Youngstown Thermal or leased from the Holy Trinity Ukrainian Catholic Church. If Youngstown Thermal permanently acquires the 3.9-acre property, the steam plant would utilize it for industrial purposes such that the land use impacts would likely be permanent. However, if after the construction phase of the Proposed Action, the property reverts back to the church, the vegetation could potentially be left to regrow and the land use impact would have been temporary.

3.7.3.2 Aesthetics

Construction of the facilities required to conduct the proposed AUSC ComTest at the Youngstown Thermal campus would include a new structure to support the superheater reaching a height of approximately 119 feet above grade. While this construction would introduce new features to the visual landscape, they would be visually comparable to the existing four Youngstown Thermal stacks, each of which measures 120 feet tall. Other proposed features would remain consistent with the site's current use as a steam heat plant and would not significantly change local aesthetics. As such, only minor impacts would be likely to occur.

Clearing the vegetation currently existing on the adjacent church property would change the local aesthetics of the parcel from an undeveloped area to a construction laydown site. However, due to the degraded habitat quality of the location, the surrounding land use, the evidence of past disturbance, and the lack of adjacent sensitive receptors, such a change would result in only minor adverse impacts to aesthetics. Like the potential land use impacts discussed above, the minor adverse impacts to the adjacent property's aesthetics could be temporary or permanent depending upon whether Youngstown Thermal would permanently acquire the use of the site.

3.8 NOISE

3.8.1 Affected Environment

Noise and sound share the same physical aspects, but differ in their perception by nearby sensitive receptors. Sound is defined as a particular auditory effect produced by a given source. Noise is defined as any sound that is undesirable because it interferes with communication, is intense enough to damage hearing, or is otherwise annoying. Noise can be readily identifiable or generally nondescript, intermittent or continuous, steady or impulsive, and can involve any number of sources and frequencies. Human response to increased sound levels varies according to the source type, characteristics of the sound source, distance between source and receptor, receptor sensitivity, and time of day. Affected receptors are specific (e.g., schools, churches, or hospitals) or broad (e.g., nature preserves or designated districts) areas in which occasional or persistent sensitivity or noise above ambient levels exist.

Ambient or background noise is a combination of various sources heard simultaneously. Calculating noise levels of combinations of sounds does not involve simple addition, but instead uses the logarithmic scale (HUD 1985). Sound is measured in decibels (dB), which is a logarithmic unit that expresses the ratio of a sound pressure level to a standard reference level. A-weighted decibels (dBA) account for how humans perceive sound. The USEPA provided information suggesting that continuous and long-term

noise levels in excess of 65 dBA are normally unacceptable for noise-sensitive land uses such as residences, schools, churches, and hospitals (USEPA 1974). Similarly, the U.S. Department of Housing and Urban Development has established 65 dBA as a threshold for unacceptable noise levels for residential areas (HUD 1985). Table 3-6 presents examples of common sound levels.

Table 3-6. Perceived Noise Levels in Decibels

Noise Level (dBA)	Description	Typical Source
140	Threshold of pain	--
125	Uncomfortably loud	Automobile assembly line
120	Uncomfortably loud	Jet aircraft
100	Very loud	Diesel truck
80	Moderately loud	Motor bus
60	Moderate	Low conversation
40	Quiet	Quiet room
20	Very quiet	Leaves rustling

Source: Liu and Liptak 1997
dBA = A-weighted sound level in decibels

The existing ambient noise environment in the vicinity of the site's location is dominated by the current operation of Youngstown Thermal and local road traffic on the two-lane roads that border the property. Current operations comply with the City of Youngstown ordinances related to noise. Depending on the vehicles found on the bordering thoroughfares at any given time, mobile noise sources could approach 100 dBA (see Table 3-6). Most of the noise generated in the vicinity of the site would arise from mobile sources.

3.8.2 No Action – Environmental Consequences

Implementation of the No Action Alternative would not affect the existing ambient noise environment of the site. Construction of the Proposed Action would not occur, and the AUSC ComTest would not take place at Youngstown Thermal, the proposed construction laydown area on the adjacent property would not be cleared of vegetation, and the proposed natural gas line would not be constructed to support the proposed project. Existing conditions would remain unchanged.

3.8.3 Proposed Action – Environmental Consequences

Minor to moderate, short-term adverse noise impacts would be expected during construction of the proposed AUSC ComTest, while clearing the proposed construction laydown area on the adjacent property, and during construction of the proposed underground natural gas line. Construction equipment typically generate noise levels of 80 to 90 dBA at a distance of 50 feet; however, noise levels fluctuate depending on the type, number, and duration of use of heavy equipment, and are influenced by the existing site conditions and ambient noise levels. Receptors located at 500 feet from the construction activities would hear construction noises ranging from approximately 59 to 64 dBA, and receptors located at 1,000 feet from the construction activities would hear construction noises ranging from 52 to 57 dBA (Bolt et al. 1971, FHWA 2006). Non-industrial properties located within 500 feet of the proposed construction areas include the Mahoning County Jail, Holy Trinity Ukrainian Catholic Church, and a funeral home.

Operations of the Proposed Action would generate minor to moderate noise impacts to the workers and the sensitive receptors near the Youngstown Thermal campus over the course of the 2-year project. The primary noise producing equipment would include the superheater, the package boiler and the cooling

tower. (Note that if Youngstown Thermal uses their boiler to produce the steam for the proposed project under the alternate configuration, the proposed package boiler and the proposed cooling tower would not be used). During operations of the Proposed Action, the AUSC ComTest would operate during approximately 14,000 hours over the course of a 2-year timeframe. The loudest collective noise from the AUSC ComTest equipment would be from the proposed cooling tower, which could generate a noise level of approximately 84 dBA at 50 feet. The nearest sensitive receptor to the location of the cooling tower would be the Mahoning County Jail located at a distance of approximately 350 feet. At this distance, the cooling tower noise could reach a level of 68 dBA outdoors, which would slightly exceed the 65 dBA suggested as a threshold for residential areas (USEPA 1971, HUD 1985). However, because Youngstown Thermal is an existing industrial facility that currently operates equipment related to power generation, any potentially perceptible increases in noise levels resulting from the Proposed Action would be expected to be minor from the perspective of any sensitive receptors in the surrounding community. However, EIO has stated they could install sound-reducing options for the cooling tower (e.g. quiet fans) if associated noise levels are deemed to cause unacceptable increases in local noise (SPX Cooling Technologies, Inc. 2012). Noise levels produced during operation of the proposed AUSC ComTest would generally be consistent with existing noise levels produced by Youngstown Thermal, and Youngstown Thermal would continue to operate in accordance with OSHA occupational noise standards.

3.9 CUMULATIVE EFFECTS

As defined by CEQ 40 CFR 1508.7, cumulative effects are those that "result from the incremental impact of the Proposed Action when added to other past, present, and reasonably foreseeable future actions, without regard to the agency (federal or non-federal) or individual who undertakes such other actions." Cumulative effects analysis captures the effects that result from the Proposed Action in combination with the effects of other actions taken during the duration of the Proposed Action at the same time and place. Cumulative effects may be accrued over time and/or in conjunction with other pre-existing effects from other activities in the area (40 CFR 1508.25); therefore, pre-existing impacts and multiple smaller impacts should also be considered. Overall, assessing cumulative effects involves defining the scope of the other actions and their interrelationship with the Proposed Action to determine if they overlap in space and time.

The NEPA and CEQ regulations require the analysis of cumulative environmental effects of a Proposed Action on resources that may often manifest only at the cumulative level. Cumulative effects can result from individually minor, but collectively significant actions taking place at the same time, over time. As noted above, cumulative effects are most likely to arise when a Proposed Action is related to other actions that could occur in the same location and at a similar time.

3.9.1 No Action – Environmental Consequences

Implementation of the No Action Alternative would result in no increased potential for adverse cumulative impacts. Construction of the Proposed Action would not occur, the AUSC ComTest would not take place at Youngstown Thermal, the proposed construction laydown area on the adjacent property would not be cleared of vegetation, and the proposed natural gas line would not be constructed to support the proposed project. As such, the No Action Alternative would not contribute to cumulative effects within the Youngstown Thermal campus or the City of Youngstown.

3.9.2 Proposed Action – Environmental Consequences

The following projects are identified as those that may have cumulative, incremental impacts in conjunction with the Proposed Action.

In recent years, Youngstown Thermal has begun to plan and implement improvements to their facility that will increase efficiency and reduce air pollution. Since October 2015, the plant has significantly reduced

their use of coal, relying more on natural gas (and other liquid fuels as discussed below), in order to meet the USEPA MACT standards reflected in the plant's new Title V air permit, dated January 29, 2016 (Ohio EPA 2016c). In addition, Youngstown Thermal has implemented a temporary test project, with approval from the Ohio EPA valid until December 2016, to utilize biomass fuel (produced from liquefied wood pulp) to power the steam heat plant instead of natural gas (Youngstown Thermal 2016a). Youngstown Thermal's reduction in coal use, and focus on natural gas or biomass fuel has resulted in moderate beneficial impacts to transportation, noise, air quality and greenhouse gas emissions. Currently traffic and noise impacts are reduced as compared to past years, as the plant is now receiving only one to two trucks per day delivering the biomass to the facility compared to when the plant would receive up five truckloads of coal per day in the winter and one to two trucks per day in the summer. Further, as reflected in their new Title V permit, emissions of hazardous air pollutants from the utility are reduced and limited in accordance with the Boiler MACT standards (40 CFR 63, Subpart DDDDD) and the Ohio EPA requirements (Ohio EPA 2016d).

Youngstown Thermal also plans to install a new 34 MW CHP cogeneration system (Youngstown Thermal LLC 2016b). A 14 MW combustion turbine, a waste heat recovery boiler rated at 180,000 pounds of steam per hour, and a 9.5 MW steam turbine is planned to be installed prior to the start of the AUSC ComTest (as discussed in Section 2.5.3). An additional 10.5 MW steam turbine may be installed in 2020, to coincide with the end of the AUSC ComTest Project. While project design is currently underway, it is expected that construction of the CHP system would involve activities similar to the Proposed Action within the existing site footprint, and would likely have minor impacts to air quality and traffic and transportation during construction. There would be no additional cumulative air quality impacts during operation of the AUSC ComTest because Youngstown Thermal's proposed waste heat recovery boiler would be permitted under the current Title V discussed in Section 3.2, Air Quality and Greenhouse Gases. At this time, it is not possible to estimate any increase or decrease in air emissions that could result from operations of future phases (after 2020) of the CHP system since those components are in early planning stages. However, the CHP system would comply with all conditions specified in the facility's Title V permit. Overall, implementation of the CHP project would have minor cumulative impacts in conjunction with the Proposed Action.

Two of the main roadways around Youngstown State University would undergo major construction during the second half of 2016 and into 2017. These include Lincoln Avenue and Wick Avenue, both wide enough for four lanes of traffic and/or parked vehicles. Proposed improvements include new street surfaces, sidewalks, curbing, lighting, and landscaping. In addition, the utility lines currently existing aboveground along Wick Avenue between Rayen Avenue and Madison Avenue Expressway would be moved underground under this proposed construction project. Work along Lincoln Avenue is planned to begin in mid-2016 and is anticipated to be completed by the end of the calendar year (December 2016). During this time, the roadway would be closed to vehicular traffic between Wick Avenue and Fifth Avenue. The improvements along Wick Avenue are also planned to begin in mid-2016 and are anticipated to remain ongoing for a full calendar year with completion planned in August 2017. During this time, lane restrictions and closures would occur between Wood Street and McGuffey Road (Youngstown State University 2016a). Figure 3-1 depicts the locations of these planned improvements.

The proposed improvements to Lincoln Avenue and Wick Avenue would result in temporary adverse impacts to local traffic, but these impacts would be minor due to the availability of alternative transportation routes. In addition, the proposed replacement of existing overhead utility lines with underground utilities would result in long-term minor positive impacts to local utility infrastructure. Underground utilities are not as susceptible to outages due to storms or other weather events as overhead lines. Overall, the proposed road improvements would result in temporary minor adverse cumulative impacts when combined with the potential effects arising from implementation of the Proposed Action.

Youngstown State University is also in the process of expanding student housing. One new development, University Edge, would accept its first 162 residents for the fall 2016 semester. An additional 220-bed and retail phase would follow. This development is located less than 400 feet northeast of the Youngstown Thermal campus. These additional residents would result in minor adverse cumulative impacts to transportation, community services, noise, and utilities, as well as minor positive cumulative impacts to socioeconomics due to increased local spending (Youngstown State University 2016b).

Additionally, Youngstown has undergone significant revitalization in recent years, and considerable new construction and renovation of existing buildings has been carried out especially in the downtown area (Calvert 2016). It is likely that additional renovation and revitalization projects would be implemented over the next few years in downtown Youngstown and surrounding areas. While no specific projects have been identified at this time other than those discussed above, it is possible that any such projects would have minor but short-term cumulative impacts on air quality, traffic, noise, and other resources in conjunction with the Proposed Action.

Figure 3-1. Projects Analyzed for Cumulative Impacts

In addition to the cumulative impacts of the past, present, and reasonably foreseeable future actions discussed above, climate change is also considered a potential cumulative effect. Scientific research has linked increases in greenhouse gas concentrations in the atmosphere to a range of ongoing and potential changes in global climate, including rising surface temperatures, changes in snow and ice cover, rising sea levels, changes in precipitation regimes, and a possible increase in extreme weather events

(Melillo et al 2014). Greenhouse gas emissions from the Proposed Action would contribute incrementally to the global concentrations of greenhouse gases.

As discussed in Section 3.2, Air Quality and Greenhouse Gases, because climate change is a cumulative global phenomenon, it is generally accepted that any successful strategy to address climate change must rest on a global approach to controlling GHG emissions. Part of the purpose and need of the research proposed in this AUSC ComTest Project is geared toward development of technologies to increase the efficiency of coal power plants, which would lower the lifecycle carbon footprint compared to currently operating coal power plants. Advancement of this technology would be beneficial in reducing the rate and magnitude of climate change.

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APPENDIX A. AGENCY CORRESPONDENCE

This Appendix contains copies of the following correspondence:

SHPO Section 106 Review Letter

USFWS Environmental Assessment Letter

USFWS Response

USFWS Determination of Effects Letter

ODNR Environmental Assessment Letter

U.S. DEPARTMENT OF ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY
Albany, OR • Morgantown, WV • Pittsburgh, PA
NETL

July 13, 2016

Ohio Historic Preservation Office
Attn: Mark J. Epstein, Department Head
Resource Protection and Review
1982 Velma Avenue
Columbus, Ohio 43211-2497

RE: Section 106 Review - Project Summary Form and Attachments for Energy Industries of Ohio's Advanced Ultra Supercritical (AUSC) Component Test (ComTest) Project at Youngstown Thermal in Youngstown, Ohio

Dear Mr. Everson:

The U.S. Department of Energy (DOE) is preparing an Environmental Assessment (EA) for the Proposed Action of providing financial assistance to Energy Industries of Ohio (EIO) for the Advanced Ultra Supercritical (AUSC) Component Test (ComTest) Project at the Youngstown Thermal campus in Youngstown, Ohio. The EA is being prepared to fulfill DOE's obligations under the National Environmental Policy Act (NEPA), the Council on Environmental Quality's NEPA regulations, and DOE's NEPA implementing procedures. The EA will evaluate the potential effects of construction and 2-year operation of this full-scale pilot test facility. As part of DOE's obligations under Section 106 of the National Historic Preservation Act, DOE is sending this letter, along with a Section 106 Review - Project Summary Form and requisite attachments to initiate consultation with the Ohio State Historic Preservation Office.

The Youngstown Thermal campus is an approximately 3-acre site located at 205 North Avenue, Youngstown, Mahoning County, Ohio. Under the Proposed Action, DOE would provide approximately $55.5 million in cost-shared funding to EIO to construct and operate the AUSC ComTest Project at the Youngstown Thermal campus. This pilot test facility would be used to test new steam turbine system components designed to operate at higher pressures and temperatures with the purpose of increasing the efficiency of coal power plants, thereby reducing water use and plant emissions (including greenhouse gases). The pilot test facility would be constructed east of North Avenue on available areas on the campus, just south of the existing Youngstown Thermal steam plant. To support construction staging and laydown, an adjacent property located immediately west of North Avenue and the campus would be used. In addition, an approximately 1.45-mile natural gas line would be installed by Dominion East Ohio to supply natural gas needed to operate the pilot test facility.

DOE anticipates a finding of No Adverse Effect within the Area of Potential Effect (APE) for indirect effects to historic properties and anticipates a finding of No Historic Properties within the APE for direct effects to historic properties. We respectfully ask that you provide any information or comments within 30 days to enable us to complete this phase of the project within the scheduled timeframe, using the following contact information:

National Energy Technology Laboratory M/S 922-342C
P.O. Box 10940
Pittsburgh, PA 15236
Attention: Pierina Fayish

Pierina.Fayish@NETL.DOE.GOV
(412) 386-5428

If you have any questions or require additional information, please do not hesitate to call or email. Thank you for your assistance in this matter.

Sincerely,

Pierina N. Fayish

Attachments:
Ohio Historic Preservation Office Section 106 Review Form
Descriptions and Evaluation of Properties Within APEs for Direct and Indirect Effects
Maps, Photographs and Project Plans

OHIO HISTORICAL SOCIETY
Ohio Historic Preservation Office

OHIO HISTORIC PRESERVATION OFFICE: RESOURCE PROTECTION AND REVIEW

Section 106 Review - Project Summary Form

For projects requiring a license from the Federal Communications Commission, please use FCC Forms 620 or 621. DO NOT USE THIS FORM.

SECTION 1: GENERAL PROJECT INFORMATION

All contact information provided must include the name, address and phone number of the person listed. Email addresses should also be included, if available. Please refer to the Instructions or contact an OHPO reviewer (mailto:Section106@ohiohistory.org) if you need help completing this Form. Unless otherwise requested, we will contact the person submitting this Form with questions or comments about this project.

Date: 07/08/2016

Name/Affiliation of person submitting form: David Berg, Potomac Hudson Engineering

Mailing Address: 9801 Washingtonian Boulevard, Suite 350 Gaithersburg, Maryland 20878

Phone/Fax/Email: 570-465-2614 / dberg@nep.net

A. Project Info:

1. This Form provides information about:
   New Project Submittal:
   YES ☒ NO ☐

   Additional information relating to previously submitted project:
   YES ☐ NO ☒

   OHPO/RPR Serial Number from previous submission:

2. Project Name (if applicable):
   Energy Industries of Ohio's (EIO) Advanced Ultra Supercritical (AUSC) Component Test (ComTest) Project at Youngstown Thermal in Youngstown, Ohio.

3. Internal tracking or reference number used by Federal Agency, consultant,

and/or applicant to identify this project (if applicable):

B. Project Address or vicinity:
205 North Avenue

C. City/Township:
Youngstown

D. County:
Mahoning

E. Federal Agency and Agency Contact. *If you do not know the federal agency involved in your project, please contact the party asking you to apply for Section 106 Review, not OHPO, for this information. HUD Entitlement Communities acting under delegated environmental review authority should list their own contact information.*

U.S. Department of Energy
National Energy Technology Laboratory M/S 922-342C
P.O. Box 10940
Pittsburgh, PA 15236
Attention: Pierina Fayish
Pierina.Fayish@NETL.DOE.GOV
(412) 386-5428

F. Type of Federal Assistance. *List all known federal sources of federal funding, approvals, and permits to avoid repeated reviews.*
Cost sharing agreement between Department of Energy (DOE) and The Energy Industries of Ohio (EIO).

G. State Agency and Contact Person (if applicable):
N/A

H. Type of State Assistance:
N/A

I. Is this project being submitted at the direction of a state agency **solely** under Ohio Revised Code 149.53 or at the direction of a State Agency? *Answering yes to this question means that you are sure that no federal funding, permits or approvals will be used for any part of your project, and that you are seeking comments only under ORC 149.53.*

YES ☐ NO ☒

J. Public Involvement- Describe how the public has been/will be informed about this project and its potential to affect historic properties. Please summarize how they will have an opportunity to provide comments about any effects to historic properties. (This step is required for all projects under 36 CFR § 800.2):
A Notice of Availability for the Draft EA will be published in local newspapers announcing the 30-day public review comment period to solicit agency and public input on the proposed project. Copies of the Draft EA will also be available at the Public Library of Youngstown and Mahoning County at 305 Wick Avenue. Comments received on the Draft EA will be addressed in the Final EA.

K. Please list other consulting parties that you have contacted/will contact about this project, such as Indian Tribes, Certified Local Governments, local officials, property owners, or preservation groups. (See 36 CFR § 800.2 for more information about involving other consulting parties). Please summarize how they will have an opportunity to provide comments:

Agency coordination has been initiated with the State Historic Preservation Office (SHPO) per requirements of Section 106 of the National Historic Preservation Act. Copies of the Draft EA will also be sent to the Youngstown Mayor's office, the Ohio Governor's office and Mahoning Valley Historical Society.

SECTION 2: PROJECT DESCRIPTION AND AREA OF POTENTIAL EFFECTS (APE)

Provide a description of your project, its site, and geographical information. You will also describe your project's Area of Potential Effects (APE). Please refer to the Instructions or contact an OHPO reviewer if you need help with developing the APE or completing this form.

For challenging projects, provide as much information as possible in all sections, and then check the box in Section 5.A. to ask OHPO to offer preliminary comments or make recommendations about how to proceed with your project consultation. This is recommended if your project involves effects to significant historic properties or if there may be challenging procedural issues related to your project. Please note that providing information to complete all Sections will still be required and that asking OHPO for preliminary comments may tend to delay completion of the review process for some projects.

A. Does this project involve any Ground-Disturbing activity: YES ☒ NO ☐
(If **Yes**, you must complete all of Section 2.A. If **No**, proceed directly to Section 2. B.)

1. General description of width, length and depth of proposed ground disturbing activity:

Ground disturbing activities will consist of proposed construction activities at the Youngstown Thermal plant and the proposed natural gas line route. Major ground disturbing activites at the Youngstown Thermal plant include: (1) construction of a 70 x 90-foot (6,330 square-foot), 32-foot high ComTest Turbine Building with a 14.5-foot deep basement that would connect to the existing boiler building basement for passageway and connection of piping; (2) a 34 x 49-foot (1,666 square-foot), 130-foot high SuperHeater Tower located to the East of the ComTest Turbine Building supported by six columns resting on a foundation of drilled piers extending into the bedrock approximately 30 feet below grade; (3) a cooling tower area supported approximately eight feet above grade by a structural steel platform with each column of the platform resting on a concrete spread footing foundation; (4) a boiler area including foundations for the boiler, water treatment system, transformers, and a condenser/exchanger; (5) a steel framed open utility rack supporting piping and cable trays between equipment on the site extending between the ComTest Turbine Building/Control Room, Superheater Tower, Cooling Tower Area and Boiler Area. These steel columns will rest on shallow concrete spread footings. Other site work will include some demolition of existing underground piping and other equipment, finish grading, installation of gravel surfacing on all work/vehicle traffic areas, tie-in to the existing sanitary sewer and storm sewer systems.

The route of the new natural gas pipeline is approximately 7,700 feet (1.45 miles) and within the existing road rights-of-way. Dominion East Ohio anticipates installing the new line using trenching techniques along the entire distance. The minimum trench width for the 12-inch diameter pipe and stable soil conditions would likely be 24 inches, however, DOE assumes an approximate trench width of 36 inches to account for variations in soil conditions and backfill placement around the pipe. Anticipated trench depth would be roughly 36 inches, dependent on soil conditions, obstructions along the route, and burial depth required under roadways. The installation contractor would likely use a chain or wheel trencher for

most of the route or a conventional excavator if rock is found, and would excavate by hand in areas of close proximity to existing underground utilities.

2. Narrative description of previous land use and past ground disturbances, if known:

The Youngstown Thermal plant site was originally developed in 1895 as a co-generation plant to produce power for trolleys in the downtown area of Youngstown. The facility present in 1895 was completely demolished and rebuilt in a different configuration around 1907 as is evidenced by Sanborn maps. Historical photographs available at the plant show that extensive excavation and re-grading took place in 1946-7 when boilers number 1 and 3 were installed. There were also major alterations done to the plant in 1953. Work during both periods involved excavations of about 15 feet in depth on the south side of the property adjacent to the railroad tracks.

The areas of proposed construction activities on site are to be located in the area south of the steam plant buildings. The land encompassing these areas was occupied by multiple railroad tracks and sidings from the mid-to-late 1800s until about 1979, when the railroad tracks were removed and the area graded. The exent of ground disturbance in this area is not fully known. The eastern portion of the site was heavily re-graded when the railroad tracks were removed and the roadway overpass (Belmont Avenue) on the eastern side of the property traversing the railroad tracks was removed.

The proposed natural gas line is expected to be constructed entirely within the existing right-of-way adjacent to existing infrastructure. Land use along this right-of-way has historically been a mixture of industrial, commercial and residential. Ground disturbance is likely to vary, but it is expected that the right-of-way adjacent to existing infrastructure is heavily disturbed.

3. Narrative description of current land use and conditions:

Youngstown Thermal is an existing steam-generating plant originally constructed in the early twentieth century. Youngstown Thermal is a district energy/heating plant that produces steam from city water and delivers the steam through underground piping to customers for heating, domestic hot water, cooking, industrial uses, laundry, etc. The steam plant utilizes a combination of coal and natural gas-fired units, including three coal-fired boilers and one natural gas-fired boiler. The steam plant is located on an approximately 3-acre parcel of developed land that includes the boiler plant, turbine building, management/engineering office,

storage building, fly ash silo, coal storage area and pit, coal tower, four 120-foot stacks, and paved surfaces (gravel, asphalt, and concrete).

4. Does the landowner know of any archaeological resources found on the property? YES ☐ NO ☒ If yes, please describe:

B. Submit the exact project site location on a USGS 7.5-minute topographic quadrangle map for all projects. Map sections, photocopies of map sections, and online versions of USGS maps are acceptable as long as the location is clearly marked. Show the project's Area of Potential Effects (APE). It should be clearly distinguished from other features shown on the map:
   1. USGS Quad Map Name:
      Youngstown
   2. Township/City/Village Name:
      Youngstown

C. Provide a street-level map indicating the location of the project site; road names must be identified and legible. Your map must show the exact location of the boundaries for the project site. Show the project's Area of Potential Effects (APE). It should be clearly distinguished from other features shown on the map:

D. Provide a verbal description of the APE, including a discussion of how the APE will include areas with the potential for direct and indirect effects from the project. Explain the steps taken to identify the project's APE, and your justification for the specific boundaries chosen:

The APE for indirect effects has been determined to be a radius of 500 feet from the center point of the proposed location of the new superheater tower. The APE is based upon the fact that the new tower will be the element with the greatest visibility at a height of 130 feet. Visual impacts would be the most likely impacts to have adverse effects to National Register eligible resources within the project area. No significant indirect effects will occur at the proposed staging area west of North Avenue. The APE for direct effects for both the ComTest site and the Natural Gas Line would be limited to the areas of ground disturbance.

E. Provide a detailed description of the project. This is a critical part of your submission. Your description should be prepared for a cold reader who may not be an expert in this type of project. The information provided must help support your analysis of effects to historic properties, not other types of project impacts. Do not simply include copies of environmental documents or other types of specialized project reports. If there are multiple project alternatives, you should include information about all alternatives that are still under active consideration:

The U.S. Department of Energy (DOE) proposes, through a cooperating agreement with The Energy Industries of Ohio (EIO), to provide financial assistance for the proposed Advanced Ultrasupercritical (AUSC) Component Testing (ComTest) Project at the Youngstown Thermal

campus, an existing steam plant in Youngstown, Ohio. The AUSC ComTest Project would involve the construction and 2-year operation of a full-scale pilot test facility to evaluate new steam turbine system components designed to operate at higher pressures and temperatures. The purpose of the project is to increase the efficiency of coal power plants, thereby reducing water use and plant emissions (including greenhouse gases). Under the Proposed Action, DOE would provide approximately $55.5 million in cost-shared funding to EIO to construct and operate the AUSC ComTest Project at the Youngstown Thermal campus.

The pilot test facility would be constructed east of North Avenue on available areas on the campus, just south of the existing Youngstown Thermal steam plant. To support construction staging and laydown, an adjacent property located immediately west of North Avenue and the campus would be used. The adjacent property currently supports deciduous trees, herbaceous shrubs, and maintained lawn. In addition, an approximately 1.45-mile natural gas line would be installed by Dominion East Ohio to supply natural gas needed to operate the pilot test facility.

SECTION 3: IDENTIFICATION OF HISTORIC PROPERTIES

Describe whether there are historic properties located within your project APE. To make that determination, use information generated from your own Background Research and Field Survey. Then choose one of the following options to report your findings. Please refer to the Instructions and/or contact an OHPO reviewer if you are unsure about how to identify historic properties for your project.

If you read the Instructions and you're still confused as to which reporting option best fits your project, or you are not sure if your project needs a survey, you may choose to skip this section, but provide as much supporting documentation as possible in all other Sections, then check the box in Section 5.A. to request preliminary comments from OHPO. After reviewing the information provided, OHPO will then offer comments as to which reporting option is best suited to document historic properties for your project. Please note that providing information to complete this Section will still be required and that asking OHPO for preliminary comments may tend to delay completion of the review process for some projects.

Recording the Results of Background Research and Field Survey:

A. **Summary of discussions and/or consultation with OHPO** about this project that demonstrates how the Agency Official and OHPO have agreed that no Field Survey was necessary for this project (typically due to extreme ground disturbance or other special circumstances). Please **attach copies** of emails/correspondence that document this agreement. You must explain how the project's potential to affect both archaeological and historic resources were considered.

B. **A table that includes the minimum information** listed in the OHPO Section 106 Documentation Table (which is generally equivalent to the information found on an inventory form). This information must be printed and mailed with the Project Summary Form. To provide sufficient information to complete this Section, you must also include summary observations from your field survey, background research and eligibility determinations for each property that was evaluated in the project APE.

C. **OHI (Ohio Historic Inventory) or OAI (Ohio Archaeological Inventory) forms**- New or updated inventory forms may be prepared using the OHI pdf form with data population capabilities, the Internet IForm, or typed on archival quality inventory forms. To provide sufficient information to complete this Section, you must include summary observations from your field survey and background research. You must also include eligibility determinations for each property that was evaluated in the project APE

D. **A historic or archaeological survey report** prepared by a qualified consultant that meets professional standards. The survey report should meet the Secretary of the Interior's Standards and Guidelines for Identification and OHPO Archaeological Guidelines. You may also include new inventory forms with your survey, or update previous inventory forms. To complete this section, your survey report must include summary observations from your field survey, background research and eligibility determinations for each property that was evaluated within the APE.

E. **Project Findings**. Based on the conclusions you reached in completing Section 3, please choose one finding for your project. There are (mark one):
   - ☒ Historic Properties Present in the APE:
   - ☐ No Historic Properties Present in the APE:

SECTION 4: SUPPORTING DOCUMENTATION

This information must be provided for all projects.

A. Photographs must be keyed to a street-level map, and should be included as attachments to this application. Please label all forms, tables and CDs with the date of your submission and project name, as identified in Section 1. You must present enough documentation to clearly show existing conditions at your project site and convey details about the buildings, structures or sites that are described in your submission. Faxed or photocopied photographs are not acceptable. See Instructions for more info about photo submissions or 36 CFR § 800.11 for federal documentation standards.
   1. Provide photos of the entire project site and take photos to/from historic properties from/towards your project site to support your determination of effect in Section 5.
   2. Provide current photos of all buildings/structures/sites described.

B. Project plan, specifications, site drawings and any other media presentation that conveys detailed information about your project and its potential to affect historic properties.

C. Copies or summaries of any comments provided by consulting parties or the public.

SECTION 5: DETERMINATION OF EFFECT

A. **Request Preliminary Comments.** For challenging projects, provide as much information as possible in previous sections and ask OHPO to offer preliminary comments or make recommendations about how to proceed with your project consultation. This is recommended if your project involves effects to significant historic properties, if the public has concerns about your project's potential to affect historic properties, or if there may be challenging procedural issues related to your project. Please be aware that providing information in all Sections will still be required and that asking OHPO for preliminary comments may tend to delay completion of the review process for some projects.

1. We request preliminary comments from OHPO about this project:
   YES ☒ NO ☐

2. Please specify as clearly as possible the particular issues that you would like OHPO to examine for your project (for example- help with developing an APE, addressing the concerns of consulting parties, survey methodology, etc.):
   DOE has determined that there will be No Adverse Effect with respect to indirect effects to historic properties and seeks concurrence. DOE requests SHPO guidance on its opinion that no archaeological resources are likely within the APE for direct effects.

B. **Determination of Effect.** If you believe that you have gathered enough information to conclude the Section 106 process, you may be ready to make a determination of effect and ask OHPO for concurrence, while considering public comments. Please select and mark one of the following determinations, then explain the basis for your decision on an attached sheet of paper:

☐ **No historic properties will be affected** based on 36 CFR § 800.4(d) (1). Please explain how you made this determination:

☒ **No Adverse Effect** [36 CFR § 800.5(b)] on historic properties. This finding cannot be used if there are no historic properties present in your project APE. Please explain why the Criteria of Adverse Effect, [36 CFR Part 800.5(a) (1)], were found not to be applicable for your project:
Historic Structures and Districts

There are two National Register eligible properties within the APE for indirect effects: the Ohio-Edison Substation at 210 Belmont Avenue (OHI No. MAH0037604) and the Penn Central Railroad Bus and Passenger Station at 529 MLK Drive.

The Ohio-Edison substation is located approximately 300 feet northeast of the proposed superheater tower. The entire site and surrounding area is industrial in nature, with four 120-foot high smokestacks presently at the site. The construction of the proposed superheater tower, building addition, ComTest cooling towers and ancillary structures will have a long-term, moderate impact on the visual setting of this National Register eligible building. It will not, however, diminish those qualities that make the property eligible for the National Register. Therefore, in terms of Section 106, the proposed project will have No Adverse Effect to the Ohio-Edison substation.

The Penn Central Railroad Bus and Passenger Station is located approximately 500 feet southwest of the proposed

superheater tower. The entire site and surrounding area is industrial in nature and due to the presence of the Diagnostics Direct Inc. Warehouse building, is completely screened from the project site. The proposed project will have negligible impacts to this historic property. In terms of Section 106, these impacts relate to a finding of No Adverse Effect to the Penn Central Railroad and Passenger Station.

Archaeological Resources

ComTest Site
According to the Ohio online mapping system, there are no recorded archaeological resources present within the Youngstown Thermal property or the staging and laydown area on the west side of North Avenue. Due to extensive ground disturbance on the Yongstown Thermal site within the past 120 years, it is expected that no intact archaeological remains exist at the site.

Natural Gas Line
According to the Ohio online mapping system, there are no recorded archaeological resources present within the right-of-way of the proposed natural gas line. Trenching is expected to occur entirely within the existing right-of-way adjacent to existing infrastructure. Soils in the majority of the route are Chili-Urban Land Complex, Rolling (CoC) with small amounts of Chili-Urban Land Complex, Undulating (CoB). As trenching will take place adjacent to existing infrastrcture within the right-of-way, significant archaeological remains are not expected within the APE for the natural gas line and therefore there would be no impacts to archaeological resources.

☐ **Adverse Effect** [36 CFR § 800.5(d) (2)] on historic properties. Please explain why the criteria of adverse effect, [36 CFR Part 800.5(a) (1)], were found to be applicable to your project. You may also include an explanation of how these adverse effects might be avoided, reduced or mitigated:

Please print and mail completed form and supporting documentation to:

Ohio Historic Preservation Office
Attn: Mark J. Epstein, Department Head
Resource Protection and Review
1982 Velma Avenue
Columbus, OH 43211-2497

Descriptions and Evaluation of Properties within APEs for Direct and Indirect Effects

Architectural Resources

Youngstown Thermal, 201 North Avenue (Tax ID: 53-71-20-00-P; 53-71-158-00-P)
OHI No. MAH0043804

Description

The Youngstown Thermal property consists of six buildings and structures including: the main steam plant, a one story engineering office, part of a former two-story dry cleaning building, a former two-story brick transformer building facing Belmont Avenue, a fly ash silo, a bottom fly ash tipple, and a coal tower.

The Youngstown Thermal steam plant building originally consisted of a steel frame structure with brick curtain walls, concrete floor and concrete slab ceiling. The original brick section facing North Avenue consists of two, three-bay-wide gabled sections each originally having large arched window and door openings. At least one of these openings on the second floor still has insulated tubes for exiting power cables. Nearly all of the original doors and windows have been removed and the openings have been bricked in completely, while some accommodate small modern windows and one opening on the south side has a late twentieth century steel overhead door.

Existing photographic evidence shows that alterations in 1947 to accommodate new boilers resulted in the demolition of the central section of the original brick building. The new central section was a steel frame building clad with transite (fiber-cement) siding. This central section houses the boilers and has four iron or steel smokestacks rising above its roof. Historical photographs indicate that these stacks were constructed during and after 1947. The easternmost section of the main plant is a one story steel frame building structure with brick curtain walls and shed roof. Nearly all the arched openings on this section have been fully bricked in, while the few remaining windows on the south side appear to be steel sash replacements identical to those of the central section that date from the late 1940s or 1950s.

A one-story engineering office, constructed between 1928 and 1950 is located north of the central section of the steam plant. It is a side-gabled, five-by-two bay structure with metal siding and steel sash windows. The roof is clad with asphalt roll roofing.

A two-story brick building that fronts Belmont Avenue was originally a transformer building for the trolley system and was constructed around 1928. It is a one-by-three bay, two-story building set on a concrete foundation. It has a steel frame clad with brick. The rear of the building has a walk-out basement entrance. The front of the building has a double wooden door with an eight light arched transom. The second floor openings on both front and rear have been replaced with steel panels. The rear first story opening has been filled in with vinyl siding and two modern double-hung sash windows. The building no longer houses any transformers or electrical equipment and is utilized for storage. Other structures include a fly ash silo, a bottom fly ash tipple, a coal storage area and pit and a coal tower.

The Youngstown Thermal plant site was originally developed in 1895 as a co-generation plant to produce power for trolleys in the downtown area of Youngstown. Sanborn maps from 1896 list the property as the Mahoning Electric Co. Power & Light Station (Sanborn 1907). The North Avenue power plant provided electricity for the Youngstown, Sharon, Wheatland, Mill Creek Park and Falls Street Car Lines during its early history (Butler 1921). In the 1890s, there were many independent trolley lines in the city operated by different corporations. Many of these companies combined trolley and electrical power service since they needed to generate power for the trolley lines.

Historical sources state that the plant was taken over by the Mahoning & Shenango Valley Railway & Light Company in 1902 as part of a consolidation of the multitude of independent trolley lines (Sanderson

1907). This consolidation resulted in the construction of an entirely new plant on the site. Sanborn maps from 1907 show that the buildings present in 1896 were demolished and replaced with larger buildings to accommodate new dynamos, coal storage and steam boilers. The property had two large main buildings. One faced North Avenue and shared its east wall with the second building located in the approximate center of the property. Sanborn maps describe the buildings as having exposed steel frames, brick curtain walls and concrete slab ceilings and floors. By 1907, the property was labeled the Youngstown Consolidated Gas and Electric Company. Directly east along Belmont Avenue was an automobile repair shop and residences. Residences also occupied most of the land north of the site, while south of seven railroad lines and several sidings of the Pittsburgh and Lake Erie Railroad lie offices, a foundry and the Mahoning Valley Car Barn and Power House. The west side of North Avenue contained a feed warehouse and residences (Sanborn 1907).

In the 1920s the property became part of the Ohio-Edison Company. By 1928, an addition was added to the north wall of the central building. By this date, the dwellings and automobile repair shop were gone. A coal hopper was now located east of the plant and a transformer building for the trolley lines had been constructed at 216 Belmont Avenue (Sanborn 1928). This transformer building is still extant on the property. The property was operated by the Pennsylvania-Ohio Power and Light Company. The present Ohio Edison substation building was constructed in 1928 at 210 Belmont Avenue and it was likely soon after that the plant ceased electric power generation. Sanborn maps after 1928 describe the building as a steam heat plant operated by the Ohio-Edison Company (Sanborn 1950).

In 1946-7, boilers number 1 and 3 were installed. There were also major alterations done to the plant in 1953 when boiler number 4 was installed. Boiler number 1 was retrofitted in the 1970s to burn natural gas and fuel oil. The plant has been operated by Youngstown Thermal since 1979. Sometime after 1979, the railroad tracks were abandoned and removed. The adjacent dry cleaning/steam laundry property at 205 North Avenue was purchased by Youngstown Thermal in 2004. This building, which was constructed sometime between 1907 and 1928, has been partially demolished since its acquisition by Youngstown Thermal. Originally composed of three two-story sections and a one-story section, it is constructed of ceramic tile and concrete block having a flat roof and brick front facade. While some of the second story steel sash windows remain, many of the building's openings have been filled in, including a large window opening on the front facade. The entire southernmost two-story section of the building has been demolished.

National Register Evaluation

The Youngstown Thermal plant is historically significant under National Register Criterion A for its role in the development of early electrical power generation for electric lighting, power and trolley systems in Youngstown. Under National Register Criterion C, it is representative of the type of power plants constructed for trolley service and residential power in the late nineteenth century.

Alterations, demolition and infill since the late 1940s has significantly diminished the property's integrity of design, materials and workmanship. These alterations include the loss of nearly every original window and door opening of the steam plant resulting in the majority of these openings being filled in. The demolition of the original central portion of the plant and replacement with steel frame clad with transite has significantly impacted the plant's original design. No original power generation equipment remains in the plant nor in the transformer building at 216 Belmont Avenue. Therefore, the Youngstown Thermal plant is not eligible for the National Register.

Ohio Edison Sub-Station, 210 Belmont Avenue (Tax ID: 53-71-20-01-P) OHI No. MAH0037604

Description

This substation, constructed in 1928, is a two-story, five-by-three bay brick building with concrete floor and flat roof. It is located immediately adjacent to the Youngstown Thermal plant and is accessed from that property. Sometimes referred to as Starved Classicism, the architecture exhibits elements of

Neoclassical styling commonplace in industrial and commercial buildings of this era, including substations and powerhouses. Brick is laid in running bond. The roof has a molded concrete parapet and the main entrance door is surrounded by a molded concrete architrave trim. The entrance door is comprised of a set of steel doors capped with large steel sash transom windows. Windows are large industrial style multi-pane steel sashes. To the upper left of the front entrance is a molded concrete medallion with the words: "Ohio Edison".

National Register Evaluation

The Ohio Edison Sub-station served Youngstown when it was a prosperous industrial town. It is associated with events that have made a significant contribution to the broad patterns of our history and is eligible for the National Register of Historic Places under Criterion A at the local level for its association with the growth of Youngstown and its community planning and development in the first decades of the twentieth century. Construction of the sub-station reflects city growth patterns during the early twentieth century.

The building is also eligible under Criterion C as it is a very intact example of its type, being an early twentieth century substations built with minimal classical styling, having transformers and wiring support structures mounted on the roof in contrast with modern facilities that generally screen the electrical equipment or house it completely within the building. Although electrical equipment has been updated throughout the years, this structure is remarkably unchanged from its original appearance. The period of significance for the building extends from the date of construction, 1928, to the 50-year cut-off date of 1966. The building retains integrity of materials, design, location and workmanship.

So So's Lounge, 232 North Avenue (Tax ID: 53-071-0-053.00-0)

Description

This building, originally depicted as a duplex housing unit on Sanborn maps in 1907, was later used as a storage building and more recently as a restaurant and bar. Little remains of its original appearance. The building has a stone foundation that was later added to with concrete block and concrete. The origiinal foundation is only visible on the south facade. The front of the building is covered with stone facing on its first story and painted plywood panels on its second story. There are two steel doors on its main facade. Some vinyl siding from earlier alterations is visible to the rear of the building. The roof is difficult to read, but appears to have been originally a double front gable. Little remains of the original appearance of the structure.

National Register Evaluation

So So's Lounge does not possess the historical significance to be eligible under Criterion A of the National Register. It is not associated with significant historical persons (Criterion B) and is not representative or a type, nor does it represent high artistic values and is therefore is not eligible under Criterion C. The building has lost nearly all of its integrity of design, workmanship and materials and is therefore Not Eligible for the National Register of Historic Places.

Diagnostics Direct Inc. Warehouse (Allstate Public Warehouse) 117 North Avenue (Tax ID: 53-71-19) OHI No. MAH0043704

Description

Originally utilized as a general warehouse for the Pittsburgh and Lake Erie railroad, this building was constructed in 1927 by the Charles Shutrump and Sons Company, General Contractors, according to its cornerstone. Prior to its construction, the site was occupied by a number of industries, including a foundry and the Orient Electric Company in 1896, and later by the Mahoning Valley Car Barn and Power House (Sanborn 1896, 1907). The building is five stories high, 21 bays long and four bays deep. It is constructed of a reinforced concrete frame with concrete floor and roof, having brick panel walls. The south side of the building is comprised of continuous loading bays. While the majority of these loading bays have been

filled in with concrete block, three remain in use with modern steel overhead doors. The entire north side of the building originally had an open first floor that served as a loading platform for the adjacent railroad tracks. These open bays were framed closed and sided with vinyl siding in the first decade of the twenty-first century. Windows are predominantly original multi-pane steel sashes that form continuous bands around the building. These bands are interrupted only at each of the three elevator shafts. Some of the openings have been filled in with brick. The reinforced concrete frame of the building is deteriorated and large portions of concrete are missing both on the concrete frame and window surrounds.

National Register Evaluation

This warehouse is typical of reinforced concrete warehouse buildings constructed by the railroads in the early twentieth century. Larger, more intact examples include the Lackawanna Freight Terminal Warehouse of Jersey City, New Jersey, constructed in 1930. That warehouse was larger, being eight stories above ground with basement (Engineering News-Record 1930).

The building is not associated with persons significant in the past (Criterion B), but is associated with events that have made a significant contribution to the broad patterns of our history due to its association with the railroad industry (Criterion A). Although it does exhibit some of the distinctive characteristics of early twentieth century railroad warehouse construction utilizing reinforced concrete to create large spans with great strength (Criterion C), it is not among the best examples of its type.

Although the building possesses integrity of location and a reasonable integrity of setting and design, integrity of association and feeling are somewhat diminished by the loss of surrounding buildings and of the railroad tracks that once serviced the building. The building also suffers from a moderate degree of integrity of materials and workmanship due to alterations, infill and lack of maintenance. Due to integrity issues, the building is not eligible for the National Register of Historic Places.

Private Garage, Corner of MLK Drive and North Avenue (Tax ID 53-71-0-110.00-0)

Description

Sanborn maps and physical inspection indicate that this building, constructed in 1963, was originally a rectangular, one story concrete block automobile service station with five overhead bays facing Martin Luther King Jr. Boulevard. By 1985, the southwest corner had been altered to create a five-sided structure. All but one of the service bays has been enclosed with either concrete block or plywood.

National Register Evaluation

The garage is not associated significant historical events (Criterion A) or with significant historical persons (Criterion B). It does not embody the distinctive characteristics of a type, period, and method of construction (Criterion C). Although the building possesses integrity of location and a reasonable integrity of setting and association, it suffers from some loss of integrity of design, materials and workmanship due to alterations, additions and infill. The building is not eligible for the National Register of Historic Places.

City of Youngstown Sign Shop, 480 MLK Drive (Tax ID 53-71-0-112.00-0; 53-71-0-113.00-0; 53-71-0-114.00-0)

Description

According to Sanborn maps, this building was constructed in 1950 and originally housed a truck sales and service business. It is a one-story, L-shaped building of concrete block with brick face with flat roof. All original window openings and nine large service bays have been altered in some fashion. Six of the bays have been filled in and the remaining doors have been replaced. The western section has a four-by-two bay addition that appears to date from the twenty first century. The building is currently operated as a sign shop by the City of Youngstown.

National Register Evaluation

The City of Youngstown sign shop is not associated significant historical events (Criterion A) or with significant historical persons (Criterion B). Neither does it embody the distinctive characteristics of a type, period, and method of construction (Criterion C). Although the building possesses integrity of location and a reasonable integrity of setting and association, it suffers from the loss of integrity of design, materials and workmanship due to alterations, additions and infill. The building is not eligible for the National Register of Historic Places.

Biomat USA Plasma Center, 444 MLK Drive (450?) (Tax ID 53-71-0-115.00-0, 53-71-0-117.00-0) OHI No. MAH0040204

Description

This property consists of two connected masonry buildings that have been altered to the point that it is difficult to ascertain if they are the same buildings represented in historic Sanborn and aerial photographs (Sanborn 1950). Although the buildings have the same basic plan as those depicted around 1950, the present buildings have been updated with new windows, doors and stucco finish. According to the Ohio Inventory, the building to the rear was the Youngstown Mattress Company, 450 West Federal Avenue, constructed in 1920 (Sanborn 1928).

National Register Evaluation

The Biomat USA Plasma Center building is not associated significant historical events (Criterion A) or with significant historical persons (Criterion B). Neither does it embody the distinctive characteristics of a type, period, and method of construction (Criterion C). The building possesses integrity of location and setting, however, extensive alterations and additions to the building have greatly diminished integrity of design, materials and workmanship. The building is not eligible for the National Register of Historic Places.

Penn Central Railroad Bus and Passenger Station, 529 MLK Drive (Tax ID 53-71-0-159.00-0) (Tax ID 53-71-0-159.01-0)

Description

This property was constructed in 1948 as the Penn Central railroad's bus and rail passenger station. It is a one story brick building with flat roof set back from the road and having a semi-elliptical drive leading to a canopied walkway and waiting area. The canopy is a flat roofed structure supported by steel columns. Windows are large aluminum frame fixed panes. The main entrance consists of a set of four entrance doors with glass side lights topped by large transom windows. A secondary entrance at the east end of the front facade is a more modest single entry door surrounded by side lights and transom window. A massive brick chimney pierces the roof at the east end of the building. The rear of the building opens up to a waiting area by the railroad tracks. The interior appears to have original stone floors and ceramic tile walls. Presently vacant, the building was most recently occupied by the Phantom Fireworks business.

National Register Evaluation

The Penn Central Railroad Bus and Passenger Station is eligible for the National Register of Historic Places under Criterion A for its association with the history of transportation in Youngstown. The station served passengers for both the railroad and buses for the second half of the twentieth century. It is eligible under Criterion C as an intact example of the more utilitarian type of station being constructed by railroads and bus companies during the late 1940s through the 1960s. The building, while still showing some of the features of the former Streamline Moderne Style, followed the architectural trends towards a more boxy, International styling with large expanses of wall, glass and fewer curves, however the building retains the large roof canopy as well as the passenger waiting area canopies. The building possesses integrity of location, setting, feeling, and association as well as design, workmanship and materials.

F. D. Mason Memorial Funeral Home, 511-515 West Rayen Avenue (Tax ID 53-003-0-083.00-0)

Description

Although composed of two connected dwellings constructed in the early twentieth century, no evidence of their original appearance is visible. The connected buildings appear to be frame dwellings, having a brick facing on the first floor and vinyl siding on the second floor. Windows are a combination of fixed pane, casement and various other vinyl and aluminum clad sashes. The front entrance has a gabled main porch roof with a slightly sloping shed roof to the east side that shelters patron's automobiles. The roof of the building is a combination of flat and low sloped gables clad with asphalt shingles. Sanborn maps depict a gradual change from two frame dwellings in 1950, to a combined dwelling in 1978. By 1985, the two lots adjacent to the house were demolished and a parking lot installed, and by 1989, the original dwellings had been completely enclosed by additions in the present form (Sanborn 1950, 1978, 1985, 1989).

National Register Evaluation

The F. D. Mason Memorial Funeral Home is not associated with events that have made a significant contribution to the broad patterns of our history and is therefore not eligible for the National Register under Criterion A. It is not a noteworthy example of its type. and does not represent the work of a master or possess high artistic values and is not eligible for the National Register under Criterion C.

Although the Mason family can be considered to have significance at the local level as important members of the community, due to integrity issues, it is not eligible for the National Register under Criterion B. The F.D. Mason Memorial Funeral Home has undergone wholesale changes and alterations. Originally, two separate dwellings, the two homes have been connected and altered to the point where no original materials are visible and integrity of design, materials and workmanship have been completely lost. While the building possesses integrity of location, its setting has been diminished by the demolition of most of the original buildings to the north and northeast The building is not eligible for the National Register of Historic Places.

Frieda's Bar, 381 West Rayen Avenue (Tax ID 53-003-0-083.00-0) OHI No. MAH0046204

Description

This trapezoid-shaped building first shows up on the 1928 Sanborn maps (Sanborn 1928), however, the Ohio State Historic Preservation Office's online mapping system indicates a construction date of 1911. It is a two story, five by three bay brick building that currently serves as a bar. Although most of the first story openings have been enclosed with plywood, their size suggests that the lower floor served as a storefront. Second story windows are vinyl clad double-hung sashes capped by cast concrete lintels. There is a brick belt course at the first story level and a cast concrete belt course at the roof line with brick parapet. The building has a built-up asphalt roof. There are three entrances. One entrance is located along Belmont Avenue and is set into a recess in the building, accessed under a brick archway. A second entrance is located on the east facade of the building. The third entrance sits at the intersection of West Rayen and Belmont Avenues. Openings once present along West Rayen Avenue have been enclosed with plywood.

National Register Evaluation

Frieda's Bar is not associated with events that have made a significant contribution to the broad patterns of our history (Criterion A). nor is it known to be associated with an individual who is historically significant in a local, state, or national context (Criterion B). It is not a noteworthy example of its type. and does not represent the work of a master or possess high artistic values (Criterion C). The building has lost some integrity of design, materials and workmanship due to the removal of original windows and doors. Therefore, it is not eligible for the National Register under Criterion A, B or C.

Metropolitan Baptist Church 361, 363, 365 West Rayen Avenue (Tax ID 53-003-0-075.00-0; 53-003-0-076.00-0; 53-003-0-078.00-0; 53-003-0-079.00-0; 53-003-0-081.00-0) OHI No. MAH0021404

Description

This church is a two story, minimally Gothic Revival styled building constructed of blond brick face over clay tile. According to the Ohio online mapping system, it was constructed in 1902. But it does not appear on the 1907 Sanborn map. It is first described as the Grace Evangelical English Lutheran Church on 1928 Sanborn maps (Sanborn 1928). The foundation is of ashlar stone. The front facade of the building is composed of a central gable flanked by two square bell towers. The central entrance is stone and concrete, having a central entrance door covered by a hooded gable. Above the gable is a circular stained glass window flanked by ornate rectangular Gothic Revival style stained glass windows. Windows on the two bell towers are triple rectangular stained glass windows. These windows are arranged two high, separated by brick recesses. Remaining windows to the sides of the church are arched stained glass windows. Lintels and sills are of cast concrete. Each side of the building has a cross gable with a large arched window with three stained glass panels below the arch. The roof of the original structure is clad with asphalt shingles. The gabled roof is clipped, or jerkin head to the rear.

A rear addition, also constructed of blond brick face over clay tile, is five bays deep and is three stories high. This addition first appears on the 1950 Sanborn map (Sanborn 1950). Much more utilitarian in design, its windows consist of triple double-hung, multi-pane wood sashes capped by multi-pane transoms on the first floor and three over one wood sashes on the second and third floors. It also has a gabled roof clad with asphalt shingles. The building is in a serious state of disrepair. Windows are mostly destroyed, having rotten sashes and missing and broken panes. The roof suffers from severe degradation and is leaking.

National Register Evaluation

The Metropolitan Baptist Church is not associated with events that have made a significant contribution to the broad patterns of our history (Criterion A), nor is it known to be associated with an individual who is historically significant in a local, state, or national context (Criterion B). It is not a noteworthy example of its type. and does not represent the work of a master or possess high artistic values (Criterion C). The rear addition, although constructed of similar brick, diminishes the Gothic Revival Style of the original structure. The addition is in an advanced state of neglect, having severe roof failure and the near total degradation of all original windows diminishing its integrity of materials. Therefore, it is not eligible for the National Register under Criterion A, B or C.

Domestic Linen Rental, 234 Belmont Avenue (Tax ID: 53-71-0-021.00-0) OHI No. MAH0037704

Description

This building was constructed sometime around 1928 according to Sanborn maps (Sanborn 1928). Originally known as the Thornton Laundry and Dry Cleaning Company, it originally consisted of a brick two story building with five bays and flat roof facing Belmont Avenue. Over the years, all of the first story openings have been bricked in and most of the second story window openings have been altered with infill or modern windows replacing the original multi-pane steel sashes. The original main double entrance door has also been replaced with a smaller single door. Recently, a large two story, steel frame addition with concrete curtain walls was added to the north facade of the original building, more than doubling its size. Additional infill has been constructed between these buildings and North Avenue in the recent past.

National Register Evaluation

The Domestic Linen Rental building is not associated significant historical events (Criterion A) or with significant historical persons (Criterion B). It does not embody the distinctive characteristics of a type, period, and method of construction (Criterion C). Although the building possesses integrity of location

and a reasonable integrity of setting and association, it suffers from integrity of design, materials and workmanship due to alterations, additions and infill. Therefore, the building is not eligible for the

Archaeological Resources

ComTest Site

According to the Ohio online mapping system, there are no recorded archaeological resources present within the Youngstown Thermal property or the staging and laydown area on the west side of North Avenue. It is anticipated that significant ground disturbance will be limited to the proposed locations of the new building addition, ComTest cooling towers, superheater tower and ancillary structures. The land encompassing these areas was occupied by multiple railroad tracks and sidings from the mid-to-late1800s until the 1980s. The extent of ground disturbance both prior to the railroad and as a consequence of its removal is unknown. Soils in these areas are both Udothents Loamy, 2 - 25 percent slopes (Ua) and Chili-Urban Land Complex, Undulating (CoB). Given the highly industrialized nature of the APE for archaeology, it is unlikely that intact archaeological remains exist. Section 106 consultation for this project is currently in process. An Ohio Historic Preservation Office, *Section 106 Review Project Summary Form* has been completed and forwarded to the Ohio State Historic Preservation Office for review.

Natural Gas Line

According to the Ohio online mapping system, there are no recorded archaeological resources present within the planned route of the natural gas line. Recorded historic structures adjacent to the proposed pipeline include the following:

216 Belmont Avenue - Ohio Edison Transformer Station, MAH0037604

234 Belmont Avenue - Thornton Laundry & Dry Cleaning, MAH0037704

381 Rayen Avenue - Frieda's, MAH0046204

368-374 W Rayen Avenue - Deibel Motor Company, MAH0046104

431 Covington Streets - Sts. Peter & Paul Church, MAH0021504

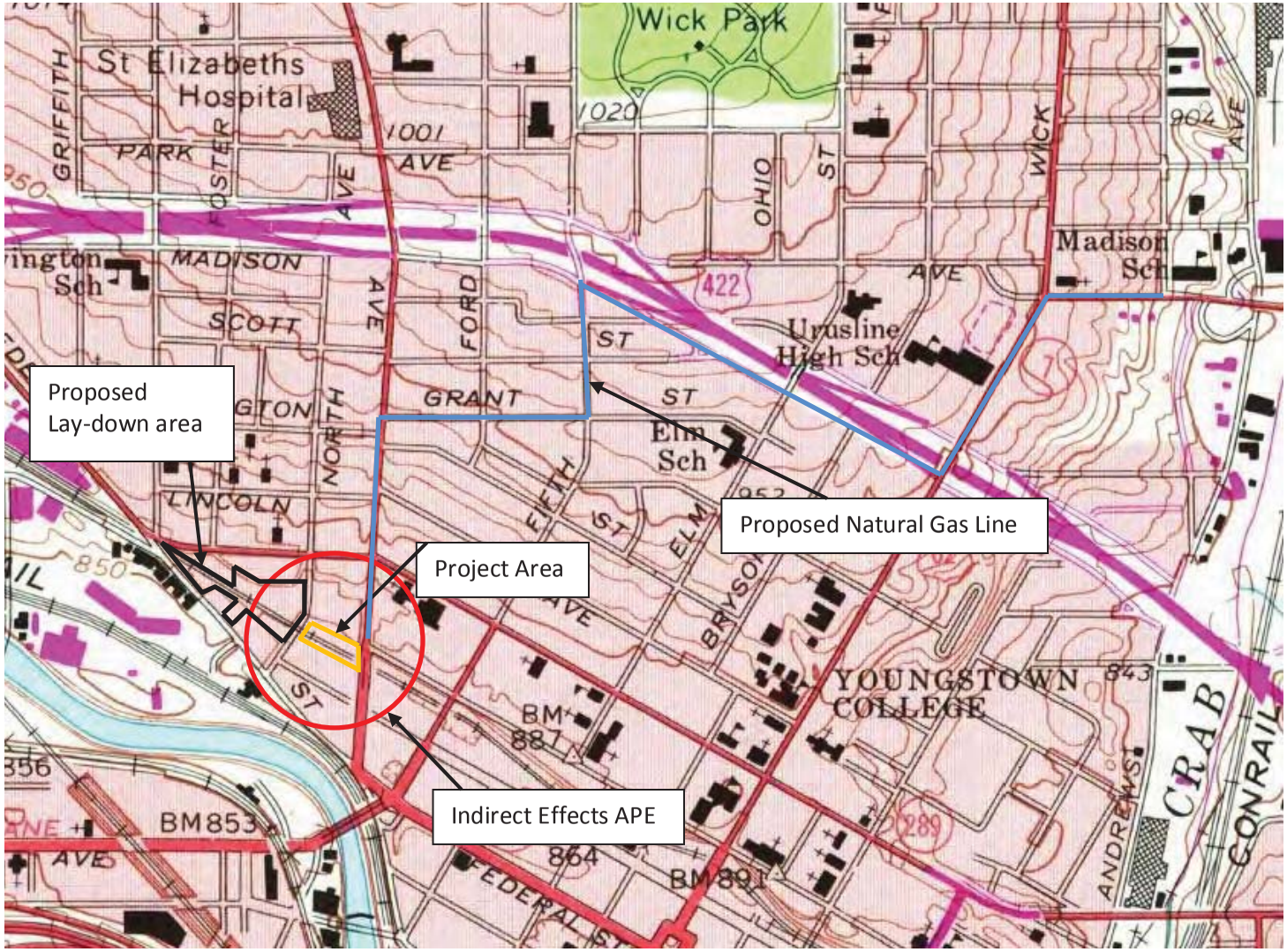
Wick Avenue Wick Avenue Historic District

750 Wick Avenue - Ursuline High School, MAH0109504

787 Wick Avenue - Youngstown Printing Company, MAH0109604

801 Wick Avenue - Memorial Presbyterian Church, MAH0109704

84 McGuffey Road - Madison Elementary School, MAH0098804

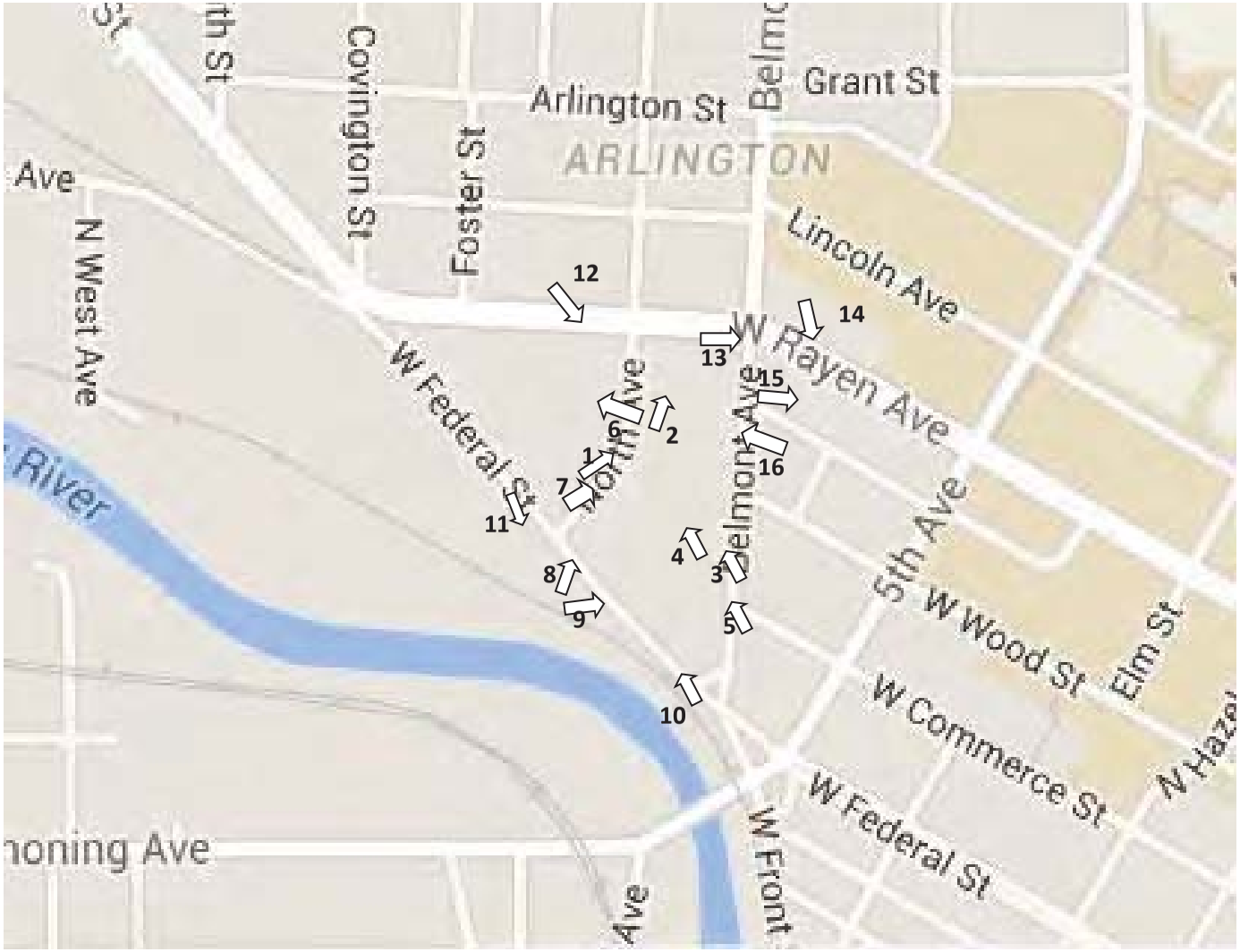


Source: 1963 USGS 7.5-Minute Quadrangle, Youngstown, Ohio

USGS Map of EIO ComTest Project, Showing APE, Lay-Down Area, Project Area and Proposed Natural Gas Line.

Source: http://www.geoplaner.com/

Street Map of EIO ComTest Project, Showing APE and Project Area.



Source: http://www.geoplaner.com/

Street Map of EIO ComTest Project, Showing Photographic Views.

Photo 1: Youngstown Thermal, 201 North Avenue , View to Northeast.

Photo 2: Youngstown Thermal, Remaining Portion of former Laundry at 205 North Avenue, View to North.

Photo 3: Youngstown Thermal, from Belmont Avenue Showing Project Area at Left, View to Northwest.

Photo 4: Youngstown Thermal Project Area, View to Northwest.

Photo 5: Ohio Edison Sub-Station, 210 Belmont Avenue, View to Northwest.

Photo 6: So So's Lounge, 232 North Avenue, View to West.

Photo 7: Diagnostics Direct Inc. Warehouse, View to Northeast.

Photo 8: Private Garage, Corner of MLK Drive and North Avenue with Youngstown Thermal Property Behind Warehouse, View to North.

Photo 9: City of Youngstown Sign Shop, 480 MLK Drive, View to East.

Photo 10: Biomat USA Plasma Center, 444 MLK Drive, View to Northwest.

Photo 11: Penn Central Railroad Bus and Passenger Station, 529 MLK Drive, View to Southeast.

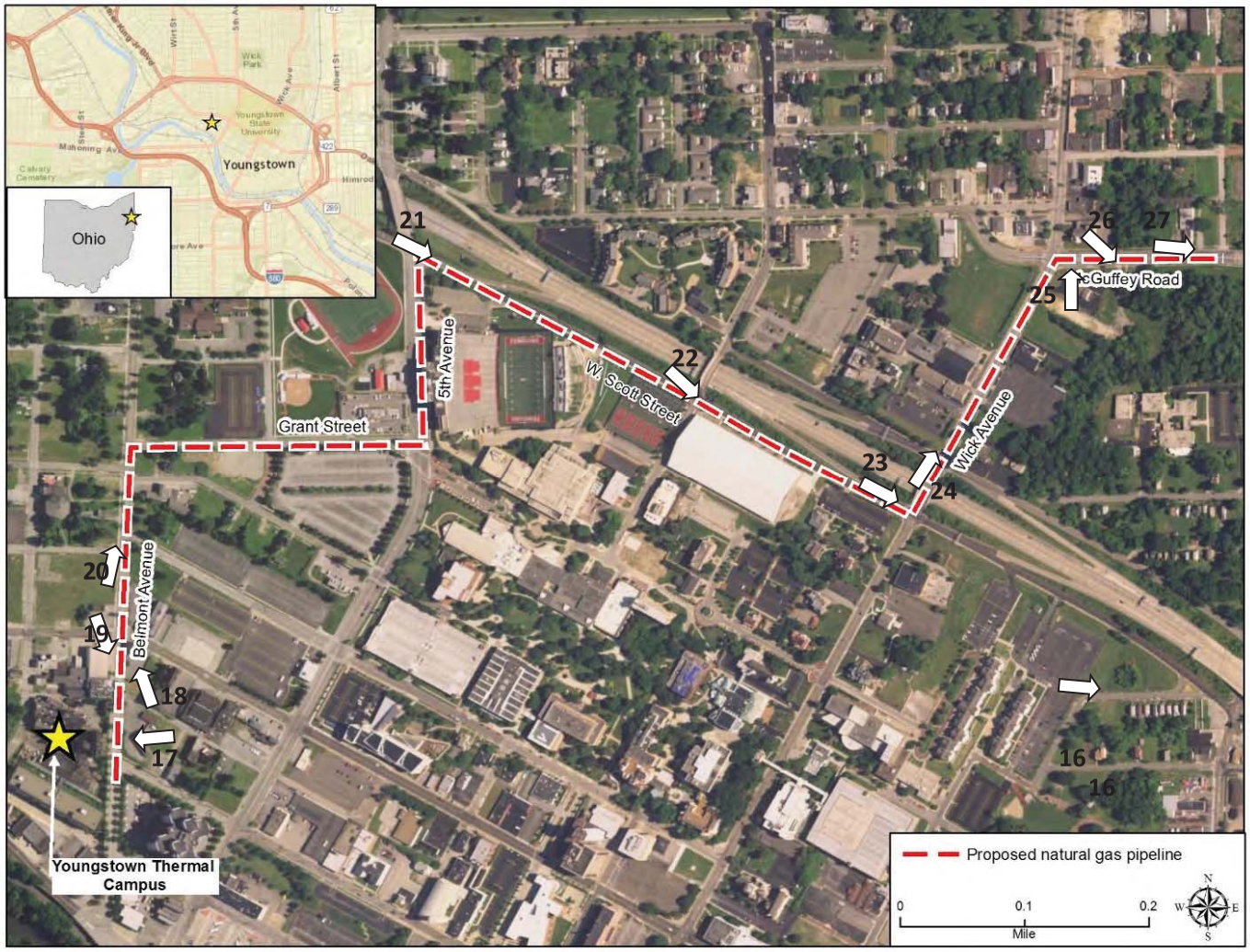
Photo 12: F. D. Mason Memorial Funeral Home, 511-515 West Rayen Avenue with Youngstown Thermal to Rear, View to Southeast.

Photo 13: Frieda's Bar, 381 West Rayen Avenue, View to East.

Photo 14: Metropolitan Baptist Church 361, 363, 365 West Rayen Avenue, View to South.

Photo 15: Metropolitan Baptist Church Addition, View to East.

Photo 16: Domestic Linen Rental, 234 Belmont Avenue, View to Northwest.



Source: http://www.geoplaner.com/

Street Map of Proposed Natural Gas Line for the EIO ComTest Project.

Photo 17: View of Youngstown Thermal, from Belmont Avenue.

Photo 18: View looking North on Belmont Avenue.

Photo 19: Lincoln Avenue at Intersection with Belmont Avenue Looking South.

Photo 20: Arlington Street. at Intersection with Belmont Avenue, Looking North.

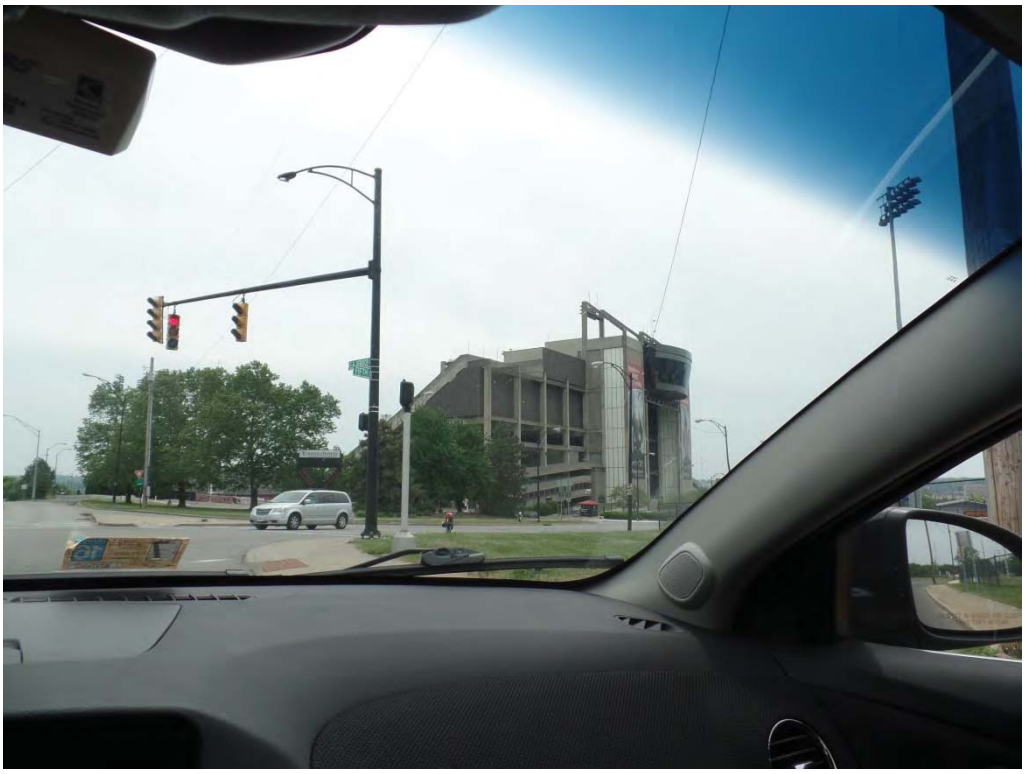


Photo 21: View of Youngstown State University Football Stadium from Intersection of Madison Avenue and 5th Avenue.

Photo 22: Corner of West Scott Street at Elm Street, Looking Southeast.

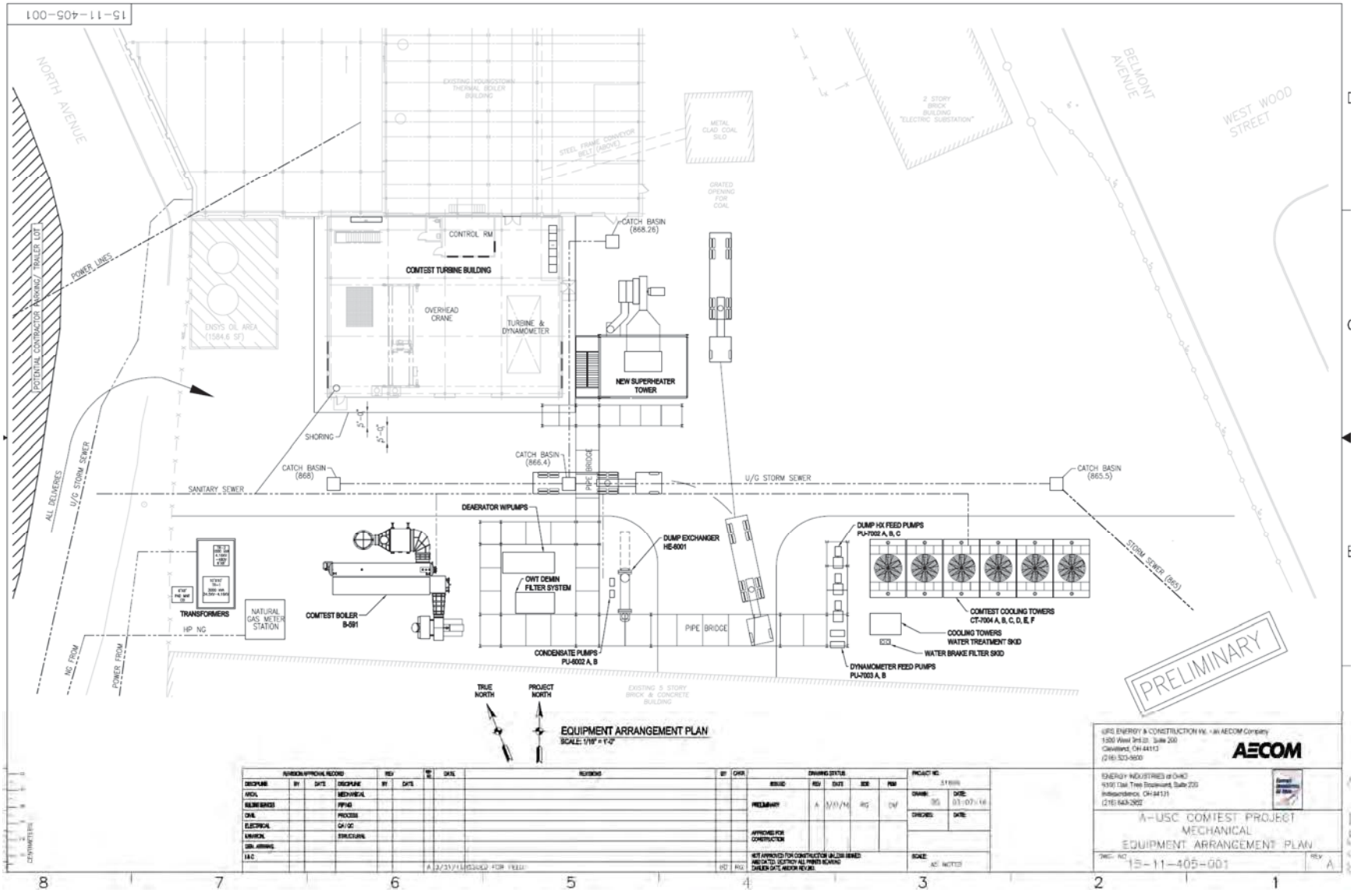
Photo 23: Intersection of West Scott Street and Wick Avenue, Looking East.

Photo 24: Intersection of Wick Avenue and Westbound Service Road, Looking Northeast.

Photo 25: Youngstown Metro Church at the Corner of Wick Avenue and McGuffey Road, Looking North.

Photo 26: Corner of Wick Avenue and McGuffey Road, Looking Southeast.

Photo 27: McGuffey Road Toward Natural Gas Tie-In, Looking Northeast.


15-11-405-001
NORTH AVENUE
BELMONT AVENUE
WEST WOOD STREET
POTENTIAL CONTRACTOR PARKING TRAILER LOT
POWER LINES
EXISTING YOUNGSTOWN THERMAL BOILER BUILDING
METAL CLAD COAL SILO
2 STORY BRICK BUILDING "ELECTRIC SUBSTATION"
CONTROL RM
COMTEST TURBINE BUILDING
OVERHEAD CRANE
TURBINE & DYNAMOMETER
ENSYS OIL AREA (1584.6 SF)
NEW SUPERHEATER TOWER
CATCH BASIN (868.26)
CATCH BASIN (868)
CATCH BASIN (866.4)
CATCH BASIN (865.5)
SHORING
SANITARY SEWER
U/G STORM SEWER
PIPE BRIDGE
ALL DELIVERIES
DEAERATOR W/PUMPS
DUMP EXCHANGER HE-6001
OWT DEMIN FILTER SYSTEM
DUMP HX FEED PUMPS PU-7002 A, B, C
COMTEST COOLING TOWERS CT-7004 A, B, C, D, E, F
COOLING TOWERS WATER TREATMENT SKID
WATER BRAKE FILTER SKID
DYNAMOMETER FEED PUMPS PU-7003 A, B
CONDENSATE PUMPS PU-5002 A, B
TRANSFORMERS
NATURAL GAS METER STATION
COMTEST BOILER B-591
HP NG
NG FROM
POWER FROM
STORM SEWER (865)
EXISTING 5 STORY BRICK & CONCRETE BUILDING
TRUE NORTH
PROJECT NORTH
PRELIMINARY
EQUIPMENT ARRANGEMENT PLAN
SCALE: 1/16" = 1'-0"
AECOM
A-USC COMTEST PROJECT
MECHANICAL
EQUIPMENT ARRANGEMENT PLAN
15-11-405-001
A

U.S. DEPARTMENT OF ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY
Albany, OR • Morgantown, WV • Pittsburgh, PA
NETL

July 6, 2016

Dan Everson
U.S. Fish and Wildlife Service
4625 Morse Road, Suite 104
Columbus, OH 43230

RE: Environmental Assessment for Energy Industries of Ohio's Advanced Ultra Supercritical (AUSC) Component Test (ComTest) Project at Youngstown Thermal in Youngstown, Ohio

Dear Mr. Everson:

The U.S. Department of Energy (DOE) is preparing an Environmental Assessment (EA) for the Proposed Action of providing financial assistance to Energy Industries of Ohio (EIO) for the Advanced Ultra Supercritical (AUSC) Component Test (ComTest) Project at the Youngstown Thermal campus in Youngstown, Ohio. The EA is being prepared to fulfill DOE's obligations under the National Environmental Policy Act (NEPA), the Council on Environmental Quality's NEPA regulations, and DOE's NEPA implementing procedures. The EA will evaluate the potential effects of construction and 2-year operation of this full-scale pilot test facility. The purpose of this letter is to initiate consultation with the U.S. Fish and Wildlife Service, Ohio Ecological Services Field Office and to request information on any federal- or state-listed threatened, endangered, or candidate species, or critical habitat within the vicinity of the project.

The Youngstown Thermal campus is an approximately 3-acre site located at 205 North Avenue, Youngstown, Mahoning County, Ohio. The campus and the immediately surrounding properties have been designated as Mixed Use-Community zoning districts by the City of Youngstown. The Youngstown Thermal campus is situated at an approximate latitude of 41°6'20.43"N and longitude of 80°39'24.73"W (see attached Figure 1).

Under the Proposed Action, DOE would provide approximately $55.5 million in cost-shared funding to EIO to construct and operate the AUSC ComTest Project at the Youngstown Thermal campus. This pilot test facility would be used to test new steam turbine system components designed to operate at higher pressures and temperatures with the purpose of increasing the efficiency of coal power plants, thereby reducing water use and plant emissions (including greenhouse gases). The pilot test facility would be constructed east of North Avenue on available areas on the campus, just south of the existing Youngstown Thermal steam plant (see attached Figure 2). To support construction staging and laydown, an adjacent property located immediately west of North Avenue and the campus would be used. The adjacent property currently supports deciduous trees, herbaceous shrubs, and maintained lawn. Youngstown Thermal has plans to acquire this 3.9-acre property for future use and clear approximately 2.9 acres of the existing vegetation. In addition, an approximately 1.45-mile natural gas line would be installed by Dominion East Ohio to supply natural gas needed to operate the pilot test facility (see attached Figure 3).

DOE does not anticipate any adverse effects on federal- or state-listed wildlife species based on the proposed construction and operation of the AUSC ComTest Project. As part of the NEPA process, we are seeking your input on any environmental issues or concerns your agency may have on the Proposed Action

626 Cochrans Mill Road, P.O. Box 10940, Pittsburgh, PA 15236
pierina.fayish@netl.doe.gov@netl.doe.gov • Voice (412) 386-5428 • Fax (412) 386-4775 • www.netl.doe.gov

and the potentially affected areas as described above. We respectfully ask that you provide any information or comments within 30 days to enable us to complete this phase of the project within the scheduled timeframe, using the following contact information:

National Energy Technology Laboratory M/S 922-342C
P.O. Box 10940
Pittsburgh, PA 15236
Attention: Pierina Fayish
Pierina.Fayish@NETL.DOE.GOV
(412) 386-5428

If you have any questions or require additional information, please do not hesitate to call or email. Thank you for your assistance in this matter.

Sincerely,

Pierina N. Fayish

Attachments:
Figure 1 – General Project Location
Figure 2 – Youngstown Thermal Campus and Project Site
Figure 3 – Proposed Location of Natural Gas Line

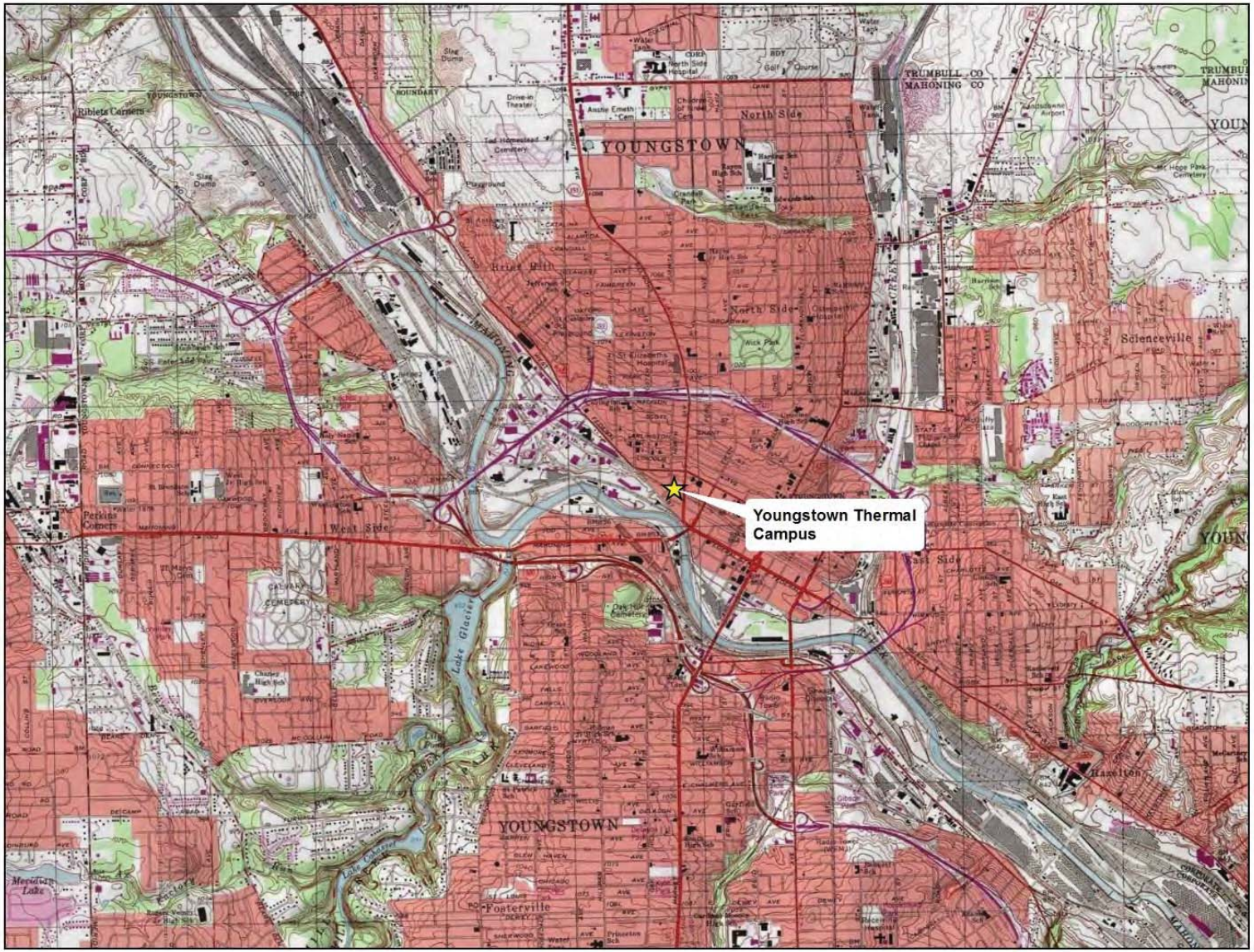


Figure 1. General Project Location

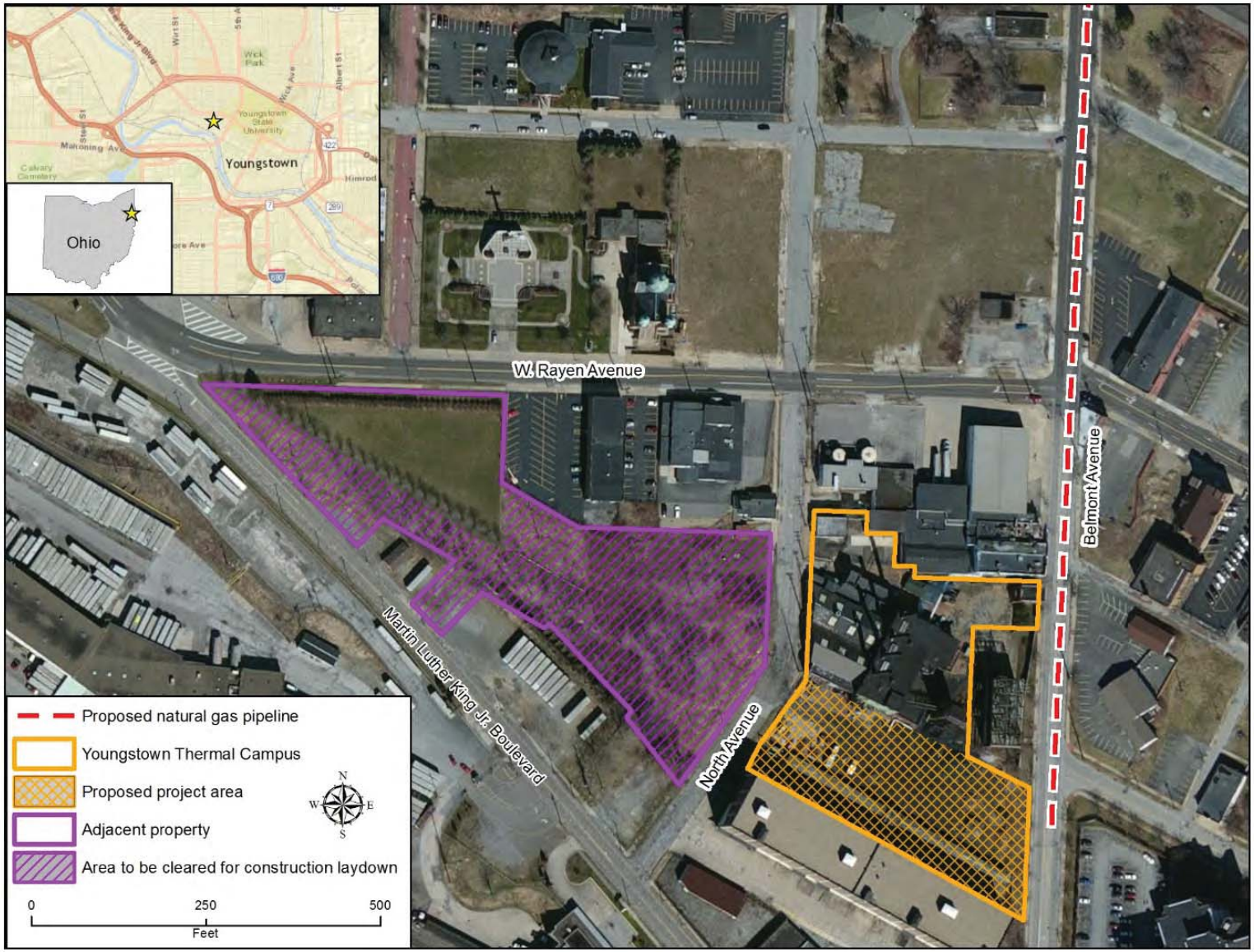


Figure 2. Youngstown Thermal Campus and Project Site

Figure 3. Proposed Location of Natural Gas Line

Andrea Wilkes

From: Fayish, Pierina M. <Pierina.Fayish@NETL.DOE.GOV>
Sent: Thursday, July 21, 2016 1:41 PM
To: Andrea Wilkes; Melissa Secor
Cc: Fred Carey
Subject: FW: DOE - Advanced Ultra Supercritical Component Test Project, Youngstown Thermal Campus

Follow Up Flag: FollowUp
Due By: Thursday, July 21, 2016 1:44 PM
Flag Status: Flagged

Good afternoon—
See response below for inclusion in the EA. FWS directed us to coordinate with Ohio and submit a determination of effects to their office (relative to the bats) to complete our consultation.
Pieri

From: susan_zimmermann@fws.gov [mailto:susan_zimmermann@fws.gov] **On Behalf Of** Ohio, FW3
Sent: Thursday, July 21, 2016 12:33 PM
To: Fayish, Pierina M. <Pierina.Fayish@NETL.DOE.GOV>
Cc: nathan.reardon@dnr.state.oh.us; Jenny Norris <jennifer.norris@dnr.state.oh.us>
Subject: DOE - Advanced Ultra Supercritical Component Test Project, Youngstown Thermal Campus

UNITED STATES DEPARTMENT OF THE INTERIOR
U.S. Fish and Wildlife Service
Ecological Services Office
4625 Morse Road, Suite 104
Columbus, Ohio 43230
(614) 416-8993 / Fax (614) 416-8994

TAILS# 03E15000-2016-TA-1394

Dear Ms. Fayish,

We have received your recent correspondence requesting information about the subject proposal. There are no federal wilderness areas, wildlife refuges or designated critical habitat within the vicinity of the project area. The following comments and recommendations will assist you in fulfilling the requirements for consultation under section 7 of the Endangered Species Act of 1973, as amended (ESA).

The U.S. Fish and Wildlife Service (Service) recommends that proposed developments avoid and minimize water quality impacts and impacts to high quality fish and wildlife habitat (e.g., forests, streams, wetlands). Additionally, natural buffers around streams and wetlands should be preserved to enhance beneficial functions. If streams or wetlands will be impacted, the Corps of Engineers should be contacted to determine whether a Clean Water Act section 404 permit is required. Best management practices should be used to minimize erosion, especially on slopes. All disturbed areas

should be mulched and revegetated with native plant species. Prevention of non-native, invasive plant establishment is critical in maintaining high quality habitats.

FEDERALLY LISTED SPECIES COMMENTS: All projects in the State of Ohio lie within the range of the federally endangered **Indiana bat** (*Myotis sodalis*) and the federally threatened **northern long-eared bat** (*Myotis septentrionalis*). In Ohio, presence of the Indiana bat and northern long-eared bat is assumed wherever suitable habitat occurs unless a presence/absence survey has been performed to document absence. Suitable summer habitat for Indiana bats and northern long-eared bats consists of a wide variety of forested/wooded habitats where they roost, forage, and travel and may also include some adjacent and interspersed non-forested habitats such as emergent wetlands and adjacent edges of agricultural fields, old fields and pastures. This includes forests and woodlots containing potential roosts (i.e., live trees and/or snags ≥3 inches diameter at breast height (dbh) that have any exfoliating bark, cracks, crevices, hollows and/or cavities), as well as linear features such as fencerows, riparian forests, and other wooded corridors. These wooded areas may be dense or loose aggregates of trees with variable amounts of canopy closure. Individual trees may be considered suitable habitat when they exhibit the characteristics of a potential roost tree and are located within 1,000 feet (305 meters) of other forested/wooded habitat. Northern long-eared bats have also been observed roosting in human-made structures, such as buildings, barns, bridges, and bat houses; therefore, these structures should also be considered potential summer habitat. In the winter, Indiana bats and northern long-eared bats hibernate in caves and abandoned mines.

Should the proposed site contain trees ≥3 inches dbh, we recommend that trees be saved wherever possible. If any caves or abandoned mines may be disturbed, further coordination with this office is requested to determine if fall or spring portal surveys are warranted. If no caves or abandoned mines are present and trees ≥3 inches dbh cannot be avoided, we recommend that removal of any trees ≥3 inches dbh only occur between October 1 and March 31. Seasonal clearing is being recommended to avoid adverse effects to Indiana bats and northern long-eared bats. While incidental take of northern long-eared bats from most tree clearing is exempted by a 4(d) rule (see http://www.fws.gov/midwest/endangered/mammals/nleb/index.html), incidental take of Indiana bats is still prohibited without a project-specific exemption. Thus, seasonal clearing is recommended where Indiana bats are assumed present.

If implementation of this seasonal tree cutting recommendation is not possible, summer surveys may be conducted to document the presence or probable absence of Indiana bats within the project area during the summer. If a summer survey documents probable absence of Indiana bats, the 4(d) rule for the northern long-eared bat could be applied. Surveys must be conducted by an approved surveyor and be designed and conducted in coordination with the Endangered Species Coordinator for this office. Surveyors must have a valid federal permit. Please note that summer surveys may only be conducted between June 1 and August 15.

If there is a federal nexus for the project (e.g., federal funding provided, federal permits required to construct), no tree clearing should occur on any portion of the project area until consultation under section 7 of the ESA, between the Service and the federal action agency, is completed. We recommend that the federal action agency submit a determination of effects to this office, relative to the Indiana bat and northern long-eared bat, for our review and concurrence.

Due to the project type, size, and location, we do not anticipate adverse effects to any other federally endangered, threatened, proposed, or candidate species. Should the project design change, or during the term of this action, additional information on listed or proposed species or their critical habitat become available, or if new information reveals effects of the action that were not previously considered, consultation with the Service should be initiated to assess any potential impacts.

These comments have been prepared under the authority of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.), the ESA, and are consistent with the intent of the National Environmental Policy Act of 1969 and the Service's Mitigation Policy. This letter provides technical assistance only and does not serve as a completed section 7 consultation document. We recommend that the project be coordinated with the Ohio Department of Natural Resources due to the potential for the project to affect state listed species and/or state lands. Contact John Kessler, Environmental Services Administrator, at (614) 265-6621 or at john.kessler@dnr.state.oh.us.

If you have questions, or if we can be of further assistance in this matter, please contact our office at (614) 416-8993 or ohio@fws.gov.

Sincerely,

Dan Everson

Field Office Supervisor

cc: Nathan Reardon, ODNR-DOW

Jennifer Norris, ODNR-DOW

U.S. DEPARTMENT OF ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY
Albany, OR • Morgantown, WV • Pittsburgh, PA
NETL

August 8, 2016

John Kessler
Ohio Department of Natural Resources
2045 Morse Road, Building E-2
Columbus, OH 43229

RE: Environmental Assessment for Energy Industries of Ohio's Advanced Ultra Supercritical (AUSC) Component Test (ComTest) Project at Youngstown Thermal in Youngstown, Ohio

Dear Mr. Kessler:

The U.S. Department of Energy (DOE) is preparing an Environmental Assessment (EA) for the Proposed Action of providing financial assistance to Energy Industries of Ohio (EIO) for the Advanced Ultra Supercritical (AUSC) Component Test (ComTest) Project at the Youngstown Thermal campus in Youngstown, Ohio. The EA is being prepared to fulfill DOE's obligations under the National Environmental Policy Act (NEPA), the Council on Environmental Quality's NEPA regulations, and DOE's NEPA implementing procedures. The EA will evaluate the potential effects of construction and 2-year operation of this full-scale pilot test facility. The purpose of this letter is to initiate consultation with the Ohio Department of Natural Resources and to request information on any state-listed threatened, endangered, or candidate species, or critical habitat within the vicinity of the project. DOE is also consulting with the U.S. Fish and Wildlife Service's Ohio Field Office regarding information on any federally listed species or critical habitat within the vicinity of the project.

The Youngstown Thermal campus is an approximately 3-acre site located at 205 North Avenue, Youngstown, Mahoning County, Ohio. The campus and the immediately surrounding properties have been designated as Mixed Use-Community zoning districts by the City of Youngstown. The Youngstown Thermal campus is situated at an approximate latitude of 41°6'20.43"N and longitude of 80°39'24.73"W (see attached Figure 1).

Under the Proposed Action, DOE would provide approximately $55.5 million in cost-shared funding to EIO to construct and operate the AUSC ComTest Project at the Youngstown Thermal campus. This pilot test facility would be used to test new steam turbine system components designed to operate at higher pressures and temperatures with the purpose of increasing the efficiency of coal power plants, thereby reducing water use and plant emissions (including greenhouse gases). The pilot test facility would be constructed east of North Avenue on available areas on the campus, just south of the existing Youngstown Thermal steam plant (see attached Figure 2). To support construction staging and laydown, an adjacent property located immediately west of North Avenue and the campus would be used. The adjacent property currently supports deciduous trees, herbaceous shrubs, and maintained lawn. Youngstown Thermal has plans to acquire this 3.9-acre property for future use and clear approximately 2.9 acres of the existing vegetation. In addition, an approximately 1.45-mile natural gas line would be installed by Dominion East Ohio to supply natural gas needed to operate the pilot test facility (see attached Figure 3).

DOE does not anticipate any adverse effects on federally or state-listed wildlife species based on the proposed construction and operation of the AUSC ComTest Project. As part of the NEPA process, we are

626 Cochrans Mill Road, P.O. Box 10940, Pittsburgh, PA 15236
pierina.fayish@netl.doe.gov@netl.doe.gov • Voice (412) 386-5428 • Fax (412) 386-4775 • www.netl.doe.gov

seeking your input on any environmental issues or concerns your agency may have on the Proposed Action and the potentially affected areas as described above. We respectfully ask that you provide any information or comments within 30 days to enable us to complete this phase of the project within the scheduled timeframe, using the following contact information:

National Energy Technology Laboratory M/S 922-342C
P.O. Box 10940
Pittsburgh, PA 15236
Attention: Pierina Fayish
Pierina.Fayish@NETL.DOE.GOV
(412) 386-5428

If you have any questions or require additional information, please do not hesitate to call or email. Thank you for your assistance in this matter.

Sincerely,

Pierina N Fayish

Pierina N. Fayish

Attachments:
Figure 1 – General Project Location
Figure 2 – Youngstown Thermal Campus and Project Site
Figure 3 – Proposed Location of Natural Gas Line

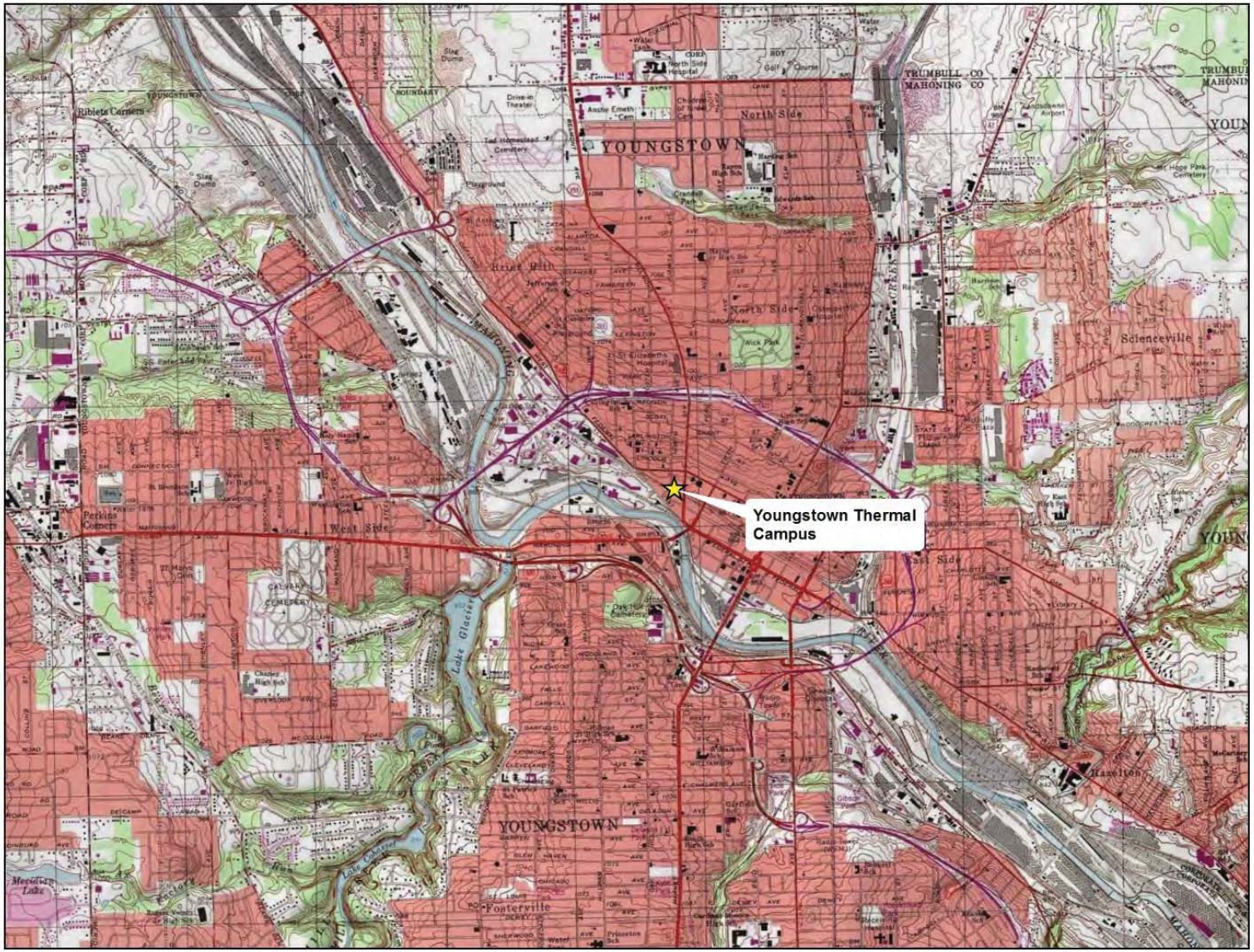


Figure 1. General Project Location

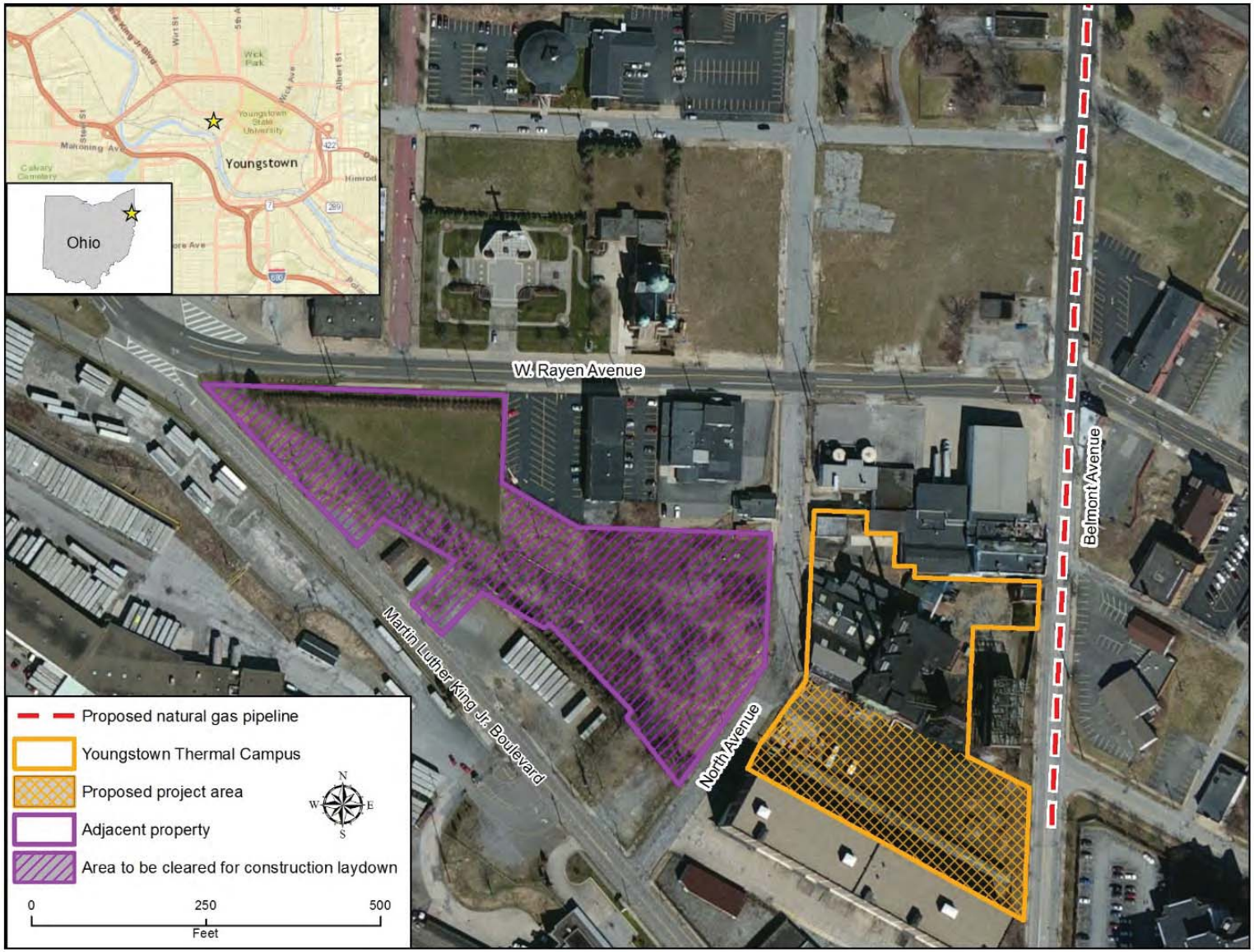


Figure 2. Youngstown Thermal Campus and Project Site

Figure 3. Proposed Location of Natural Gas Line

AECOM Engineering Package

AECOM Engineering Scope

ADVANCED ULTRA-SUPERCRITICAL COMPONENT TEST PROJECT

Youngstown, OH

PROJECT NUMBER 31609

SPECIFICATION NUMBER: FEED-00

FOR

AECOM ENGINEERING SCOPE (EPC)

PREPARED FOR

Energy Industries of Ohio (EIO)

By

AECOM

1500 W 3rd Street, Suite 200

Cleveland, OH 44113

Revision	Date	Status
A	March 31, 2016	Preliminary

SPECIFICATION REVISION PAGE

Project Name:	A-USC ComTest	Discipline:	Engineering
Client:	Energy Industries of Ohio		

Revision Signatures

Dan Mardovin (PEM)	3/31/2016		
Prepared by	Date	Approved by (PEM)	Date
		NA	
Checked by	Date	Approved by (if required) (title)	Date

Status	Rev. No.	Date	Prepared By	Pages	Description of Changes
Prelim.	A	3/31/2016	DM	All	For FEED use

PART 1- GENERAL

1.01 PROJECT DESCRIPTION:

The Advanced Ultra-Supercritical (A-USC) Component Test (ComTest) project is the next step in the A-USC program. The project is funded by the U.S. Department of Energy (DOE) and the Ohio Coal Development Office (OCDO) thru Energy Industries of Ohio (EIO) with technical oversight provided by Electric Power Research Institute (EPRI). The project team consists of EIO (prime contractor), EPRI (technical management), AECOM (EPC contractor), Babcock & Wilcox (A-USC steam superheater), General Electric Power (A-USC steam turbine) and General electric Boiler (formerly Alstom - 1400°F nickel alloy piping). The primary objective of the A-USC ComTest Project is to demonstrate a 1400°F (760°C) A-USC steam turbine to:

A. Minimize the risk for a utility desiring to build an A-USC power plant.

B. Demonstrate reliable operation for the high temperature superheater and steam turbine.

C. Evaluate the constraints in the supply chain for advanced materials including all necessary components, instruments, valves and fittings.

D. Validate the fabrication techniques and the ability to construct, install and repair ComTest materials and equipment.

The host site for the test is Youngstown Thermal. The plant provides steam to their customers in the downtown business district of Youngstown, Ohio.

The following is the engineering scope of work for AECOM as the EPC contractor of the project:

1.02 ARCHITECTURAL, STRUCTURAL, CIVIL:

The A-USC Com Test project at Youngstown Thermal includes the following new structures and equipment foundation:

A. Com Test Turbine Building

A new turbine building will be located adjacent to the existing Youngstown Thermal Boiler Building. The proposed turbine building addition will house the new GE steam turbine and associated equipment. The building will be approximately 70’x90’ in plan, 32’ in height (1 story with no mezzanine) with a total, main level, area of 6330 sf. The exterior envelop is a pre-engineered steel framed building with metal wall panels and roof panels. Insulated hollow metal personnel doors shall provide access to the building. Insulated coiling steel service doors with motor operators shall provide equipment access into the building. The first floor consists of steel framing with a concrete slab. There is a 30 ton bridge crane (for removal of turbine components and maintenance purposes) which is supported from the steel framed structure at approximately 23 feet above the main finish floor elevation. A control room and unisex toilet room shall be installed on the first floor. Wall construction for these rooms shall be gypsum board on metal stud framing. Lay-in ceilings shall cap these rooms. There is a basement under the entire main

level and has a 6" thick concrete slab on grade. Access to the basement will be from a steel framed stair. Housekeeping pads occur at equipment and tanks that occur at the basement level. The basement consists of unoccupied utility space. A 6'-0" man-door connects the new Turbine Building's basement and the existing boiler building basement to allow for a second means of egress out of the basement through the existing boiler building. The basement construction will require a significant excavation of earth.

B. Super heater tower Area

The B&W super heater tower is located to the west of the Com Test Turbine Building. The super heater tower is supported from (6) steel columns. The foundations consist of drilled piers at each of these columns and extend into bedrock which is approximately 30' below grade. The drilled piers are connected just below grade with concrete grade beams. These beams also support a structural concrete slab. The seal air fan and other super heater components bear on this slab.

C. Cooling Tower Area

The cooling tower is supported at approximately 8' above grade by a structural steel framed platform. Each column of the platform bears on a shallow concrete spread footing foundation. Steel caged ladders provide access to platforms that are integral with the cooling tower at each end. A 24" thick mat foundation supports the cooling tower pumps. An 18" thick mat also occurs for other miscellaneous equipment support.

D. Utility Rack

A steel framed open utility rack supports piping and cable tray between equipment on the site. The rack extends between the Com Test Turbine Building, Super heater tower, cooling tower, and boiler area. The steel columns bear on shallow concrete spread footing foundations except when the rack foundations share a mat foundation with equipment.

E. Boiler Area

The boiler area includes mat foundations for boiler, water treatment system, transformers, and the dump exchanger. The boiler mat is a large mat that is 18" in thickness. The water treatment system has individual mats that are 18" thick at each component. The transformers bear on a 18" thick mat which also has a 6" concrete containment wall. The dump exchanger beams on concrete saddles which then are support by an 18" thick concrete mat.

F. The A-USC Component Test project at Youngstown Thermal will require a minimal site work to support the installation and operation of the new facilities. The following work items are indicated on the scoping drawing:

1. Demolition will be by others.

2. Finish grading will be required for surface areas disturbed by demolition activities and new equipment and vehicle traffic areas.

3. Installation of gravel surfacing in all new work areas.

   a. 4" gravel surfacing in equipment areas.
   b. 8" gravel surfacing in vehicle traffic areas.

4. Extension of the storm sewer system

   1. Piping will be 12" PVC sewer piping.
   2. Inlets will be installed as indicated.

5. Installation of Sanitary/Industrial Sewer System

   a. Piping will be 8" PVC sewer piping.
   b. Manholes will be installed as indicated.
   c. Hub drains will be installed as indicated.

6. Connection of sewers to existing underground structures

   a. Connect new storm sewer pipe to existing storm system catch basin.
   b. Connect new sanitary sewer pipe to existing sanitary system manhole.

1.03 ELECTRICAL:

The A-USC Component Test project at Youngstown Thermal will require a highly reliable electrical power source. In addition to reliability, it needs the ability to start several comparatively large medium voltage motors. The total operating load is about three megawatts with five motors being in the medium voltage category at 500 and 600 horsepower which constitutes about 2 megawatts of the 3 megawatt total. The remainder of the facility will operate at 480 volts with miscellaneous smaller loads, (control power, lighting etc.) at 120V. The new service will be installed as follows:

A. A new electrical 23kV sub-transmission service will be brought to the site. Currently this service is several city blocks away. The service will be mostly on poles with the last 50 to 100 feet being below grade not to interfere with construction activities.

B. A new 23kV pad mounted outdoor circuit breaker with metering will be installed as the demarcation point with Ohio Edison. This breaker will be equipped with protective relays to protect the Ohio Edison system from any unusual events that may occur within the project equipment and also provide protection of the projects new downstream equipment.

C. This project will install two liquid filled transformers, about 3000KVA and about 1000KVA. The 3000KVA will transform power down to 4160V for the large motors and the second transformer will supply the remainder of the equipment at 480V. A preliminary motor starting study indicated that these transformers were adequate to start the motors but was based on using several assumptions about the characteristics of Ohio Edison's system and the

equipment being started. Under worse condition assumptions one or both transformers may need to be increased in size for motor starting purposes or add expensive soft starters to the project.

D. Both transformers will be filled with a seed based oil Envirotemp FR3 or equal. Envirotemp FR3 is an edible vegetable oil with food grade additives. In the event of a tank rupture, the clean-up is minimal as opposed to standard mineral oils found in most transformers.

E. If required, one or both transformers can be installed with oil containment. Both are of the size not normally requiring containment, however, this needs to be verified after transformers are selected.

F. The 4160V transformer will supply a 4160V Motor Control Center (MVC for short) which will control, start and protect the medium voltage motors. This MVC will have a main disconnect and a power meter for monitoring power consumption, power disturbances and any conditions that may have an adverse effect on the system. Each starter will have a motor protection relay, MPR, protecting an individual motor. The settings for the relay will be developed by AECOM for installation during commissioning. The settings for the MPR relays as well as all other relays will be done in the later stages of the project when all data is available and final.

G. The 480V MCC will provide motor control to all other motors and will also be used to distribute power to equipment that only requires a feed such as the bridge crane or skid mounted package equipment. This MCC will also have a power meter similar to the MVC. The motor starters will utilize electronic overloads.

H. Two Uninterruptible power supplies are included. One will supply power to the two lube oil systems until a diesel generator can start in the event of a power failure. The second will supply clean regulated power to the control systems. Both UPS will also be backed up by the diesel generator.

I. The generator will supply power to both UPS systems maintain the lube oil and control power. It also maintains powers to the turning gear equipment. The turbine must be rotating when the system is shut down not to cause damage to the shaft.

J. Electric heat tracing and instrument heaters will be provided to critical instrument lines to prevent freezing in winter months. Some process pipes will also be heat traced where freezing during a lengthy winter outage could causer damage.

K. Metal clad (armored) cable will be used for most power distribution. Cable trays will be installed for the major cable pathways.

L. Lighting will be provided using pulse-start metal halide lamps. LED are not being used because of the payback period being longer than the project duration. The turbine floor will have two levels of lighting, the lower level during normal operations at about 30 foot candles and a higher level during maintenance and inspections at about 70 foot candles. Outdoor lighting is being provided around the cooling tower and the outdoor boiler areas as well as the turbine building perimeter.

M. A security system will be provided as well as area security cameras.

N. Cameras with microphones are being provided within the super-heater to monitor special instruments while operating.

O. A grounding system is being installed that will bond all electrical equipment and building structures. The metal clad (armored) cable includes a ground wire. The transformers, motor control centers etc. will be connected to this grounding system. The 3MVA 23kV-4160V transformer will have its neutral connection low resistance grounded to limit phase to ground fault current.

1.04 MECHANICAL:

Mechanical Scope for HVAC, Plumbing, Fire Protection, Balance of Plant Equipment and Plant Operation Utility Costs:

A. HVAC Scope:

The new Turbine Building turbine hall area will be heated and ventilated. Heating will be provided by gas fired unit heaters located in the basement and operating level of the building. Ventilation will be provided by a MoffittVent™ natural ventilation system consisting of a motor operated ridge vent and manually operated wall louvers on the east and west walls of the building.

The Turbine Building rest room will be ventilated by a local exhaust fan. A transfer grill will allow air movement between the turbine hall and rest room.

The Turbine Building Control Room will be a temperature controlled space. A ductless heat pump system will provide the required cooling for controls equipment located in this room.

B. Plumbing Scope:

Rainwater from the Turbine Building will be collected in a gutter system and discharged to grade via downspouts. Grade elevations will be modified to route storm water to a local catch basin.

A sanitary waste and vent system will be provided for the Turbine Building rest room. Cold water will be provided from the domestic water system and hot water will be furnished by a local electric hot water heater above the room.

Process floor drains will be installed as required for the first floor and basement levels. Drains will tie-in to a pre-fabricated sump and pump, discharging into the process sewer located above the basement level.

Process hub drains will be located in the yard area for the Superheater, Cooling Tower, Cooling Tower Water Treatment Skid, Boiler, Dump Exchanger, Deaerator and Boiler Water Treatment skids.

C. Fire Protection:

An automatic sprinkler system will not be required for the Turbine Building, provided the header and valve test remains outside the battery limit as currently planned. Specific fire protection for equipment located in the yard will not be required.

D. Balance of Plant Equipment Scope:

The following balance of plant equipment will be specified purchased and installed by AECOM:

1. B-591 Boiler – Shop assembled package water tube boiler rated at 150,000 lbs. /hr., 1,100 psig design pressure, 850 deg. F design temperature, 950 psig operating pressure and 750 deg. F operating temperature. Equipped with boiler trim valves, forced draft fan with motor, low NOx gas fired burner, economizer, interconnecting ducts and stack, access platforms and ladders and PLC based BMS and CCS.

2. Deaerator Skid and Pumps – Rental unit providing deaerated feedwater to designated users.

3. Cooling Tower Water Treatment – Maintains proper scale, microbiological and corrosion control for cooling tower water.

4. OWT System – Provides oxygenated and filtered water to designated users.

5. DS-2201 Desuperheater – An attemperator type desuperheater providing attenuated steam to the turbine for start-up. All other high temperature desuperheaters are furnished by GE Boiler (Alstom).

6. HE-6001 Dump Exchanger – Condenses turbine exhaust steam using cooling tower water. A 54-132 TEMA type BEM shell & Tube heat exchanger. Tubes, tubesheets and shell side material are 304L stainless steel. Tubes are SA-213 304L seamless, 1" OD, and 14 BWG average wall. Mounted horizontally on saddles and concrete piers.

7. PU-6002-A, B Condensate Return Pumps – Vertical inline centrifugal pumps return condensate from the dump exchanger to the deaerator via the water treatment system. One pump is active, one is stand-by.

8. CT-7004-A, thru F Cooling Towers – Six crossflow cooling tower cells mounted to a structural frame provides cooling water for the dump exchanger and hydraulic dynamometer. Includes all electrical and control hardware, access ladders and platforms and water basins.

9. TK-7001-A, B Hot Well Tanks – Located in the turbine building lower level, receives circulation water with dissipated heat from the hydraulic dynamometer on the upper level.

10. PU-7001-A, B Hot Well Pumps - Horizontal end suction centrifugal pumps receive dynamometer circulation water from the hot well tanks and pump to the cooling towers. One pump is active, one is stand-by.

11. PU-7002-A, B, C Dump Exchanger Feed Pumps – Horizontal split case centrifugal pumps circulate cooling tower water through the dump exchanger and back to the cooling tower. Two pumps are active, one is stand-by.

12. PU-7003-A, B Dynamometer Supply Pumps – Horizontal end suction centrifugal pumps transfer cooling tower water to the hydraulic dynamometer.

13. Air Compressor Package – Skid mounted, factory pre-tested air compressor package featuring two Quincy 10 HP compressors, 240 gal. vertical receiver, desiccant dryers and factory mounted pre-wired control panel.

14. Bridge Crane – 30 Ton capacity, double girder top running crane equipped with runway rail, j-bolts, rail splices and mounting hardware. Options include test weights, rotating red beacon light and hand held radio control unit.

E. Plant Operation Utility Costs:

1. The following are the estimated utility costs during plant operation for a duration of 8,000 hours:

Natural Gas =	$6.1 million
Water =	$1.9 million
Electric =	$1.3 million
Total =	$9.3 million

1.05 INSTRUMENTATION & CONTROLS:

A. The A-USC Comtest project at Youngstown Thermal will have the following control systems:.

1. The control system will consist of a Mark VIe Distributed Control System (DCS) for the Steam Turbine System, a The PACSystems RX3i Programmable Automation Controller for the Balance of Plant systems and the package systems will contain standalone controllers. The HMI system will have a common database for the Steam Turbine system and the Balance of Plant systems and will consists of two workstations.

2. The Balance of Plant systems are: Steam Distribution, Superheater and Cooling Tower.

3. Standalone Package Systems are: Deaerator, Water Treatment, Boiler and the Condenser Unit.

4. Mark VIe Distributed Control System

5. GE Turbine will supply, install and wire the Mark VIe Distributed Control System and all of its components for the steam turbine. GE Turbine will also supply a Description of Operation, the DCS system programing and start-up services.

6. PACSystems RX3i Programmable Automation Controller System

7. The PACSystems RX3i Programmable Automation Controller System will control the

8. Balance of Plant. PLC system will consist of the PLC cabinet and 4 remote I/O racks.

9. The PLC cabinet will contain the I/O for all the devices located in the Turbine building.

10. The Boiler-Steam system remote I/O cabinet will consist of any miscellaneous devices located near the boiler.

11. The Deaerator remote I/O cabinet will consist of any miscellaneous devices located near the Deaerator.

12. The Cooling Tower remote I/O cabinet will consist of any miscellaneous devices located near the Cooling Towers.

13. The Superheater remote I/O cabinet will consist of Superheater I/O plus any miscellaneous devices located near the Superheater. The Superheater is a vender supplied system furnished by B & W. B & W will provide all of the Superheater instrumentation and control valves wired to a junction box. This project will wire between the junction box to a remote I/O cabinet. B & W will also supply a Description of Operation and a Control and Logic description that the project will use for programming.

B. Control Room Layout:

The Control room will house the PLC cabinet, the Control System cabinet, two work stations and a printer.

C. Work Stations Operator Interface – HMI:

Each Work Station – HMI will consist of dual monitors, with a mouse and displays for the Steam Turbine, the Balance of Plant with some high level of information from the Standalone Package Systems. Note: The HMI's will not to be able to do any control of the Standalone Package Systems.

D. Instrumentation:

A combined Instrumentation and I/O list is provided based on the project P & I Ds.

1.06 PIPING:

The A-USC Comtest project at Youngstown Thermal will require infrastructure upgrades for the following piping systems.

A. Natural gas service:

A new natural gas service is required to supply the ComTest boiler and superheater, as well as unit heaters inside the new turbine building. A pipeline must be routed approximately three miles to the nearest high pressure service available from the utility.

B. Existing plant tie-ins:

New piping will be routed into the existing boiler room to make tie-ins for city water, demineralized boiler feed water (which will be additionally OWT treated as part of the Comtest project), superheater economizer water inlet and discharge, and 150psig steam discharge. The project will produce 150psig steam, which will normally be used by Youngstown Thermal. This steam will also be piped to a dump condenser (provided as part of the project) so that ComTest can continue to operate in the event that Youngstown Thermal cannot accept the generated steam.

C. New plant piping:

New piping and site pipe racks will be required for the Comtest equipment. Site pipe racks will run from the new turbine building to the superheater tower and to the area adjacent to the existing warehouse building, where the boiler, cooling towers, water treatment and pumps will be located. Piping will also run through the new turbine building with major lines supported from the turbine building floor. Refer to the piping line list for line counts and sizing.

D. A-USC piping

The A-USC steam piping will be fabricated from Inconel 740H, and will consist of 10" NPD runs from the superheater outlet to the turbine and cycling header inlet, and will run from the 16" NPD turbine and header outlet to the desuperheaters. There will also be a superheated steam bypass that will be routed to a separate desuperheater. GE Boiler will purchase material and shop fabricate this piping and welded support attachments using AECOM layout drawings and isometrics. AECOM will install the shop fabricated piping spools, provide insulation and pipe supports. The steam from the desuperheaters will be routed to either the existing Youngstown Thermal facility or the ComTest dump condenser.

END OF SECTION

Architectural

18-11-100-001

ADVANCED ULTRA-SUPERCRITICAL COMPONENT TEST PROJECT

FOR

ENERGY INDUSTRIES OF OHIO

&

U.S. DEPARTMENT OF ENERGY

&

OHIO COAL DEVELOPMENT OFFICE

HOST SITE:

YOUNGSTOWN THERMAL

205 NORTH AVE., YOUNGSTOWN, OH 44502

PREPARED BY:

URS ENERGY & CONSTRUCTION - AN AECOM COMPANY

CODE INFORMATION

THIS FACILITY RENOVATION HAS BEEN DESIGNED PER THE FOLLOWING CODES:

1. 2015 OHIO BUILDING CODE (OBC)
2. 2009 ICC/ANSI A117.1 ACCESSIBILITY CODE
3. OCCUPATIONAL SAFETY & HEALTH ADMINISTRATION (OSHA)
4. 2011 NATIONAL ELECTRICAL CODE (NEC, NFPA 70)
5. 2011 OHIO MECHANICAL CODE (OMC)
6. 2011 OHIO PLUMBING CODE (OPC)
7. 2009 NATIONAL FIRE PROTECTION ASSOCIATION 101 (NFPA)

OCCUPANCY GROUP:
FACILITY USE GROUP F1 – FACTORY GROUP (SECTION 306 OBC)
CONSTRUCTION TYPE – IIB (TABLE 601 IBC)
THE BUILDING IS NOT SPRINKLERED

MAXIMUM TRAVEL DISTANCE ALLOWABLE: 200 L.F. (TABLE 1016.1 OBC)
MAXIMUM TRAVEL DISTANCE ACTUAL: 170 L.F.

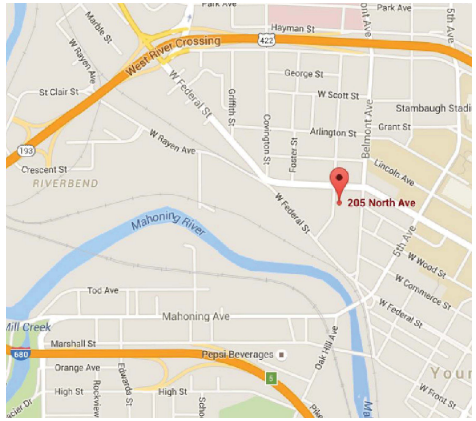
EXITS REQUIRED: 1 (SECTIONS 1005.1 OBC (6.6" INCHES REQ'D PER OCCUPANT LOAD)
EXITS PROVIDED: 2 (69 INCHES PROVIDED)

SMOKE VENTS NOT REQUIRED (SECTION 910.2 OBC).

BUILDING AREA ACTUAL – 6,367 S.F.
BUILDING AREA ALLOWABLE – 15,500 S.F. (SECTION 506.1 OBC)

BUILDING HEIGHT ACTUAL: APPROX. 34'–0" – 1 STORY
BUILDING HEIGHT ALLOWABLE: 55'–0" – 3 STORIES (TABLE 503 OBC)

OCCUPANT LOAD CALCULATED: 22 OCCUPANTS
(MECH. EQUIP ROOM – 300 GROSS PER TABLE 1004.1.1 OBC)
OCCUPANT LOAD ACTUAL: 4 OCCUPANTS – MAXIMUM SHIFT



VICINITY MAP

SCALE: N.T.S.

DRAWING LIST

ARCHITECTURAL

DRAWING #	DESCRIPTION	REV
18-11-100-001	TITLE SHEET	B
18-11-203-001	BASEMENT FLOOR PLAN	B
18-11-203-002	LEVEL 1 FLOOR PLAN	B
18-11-204-001	ROOF PLAN	A
18-11-205-001	EXTERIOR ELEVATIONS	A
18-11-206-001	BUILDING SECTIONS	B
18-11-207-001	WALL SECTIONS	A

CIVIL

DRAWING #	DESCRIPTION	REV
12-11-100-001	SITE PLAN	A

INSTRUMENTATION & CONTROLS

DRAWING #	DESCRIPTION	REV
19-11-250-001	CONTROL SYSTEM ARCHITECTURE	A

ELECTRICAL

DRAWING #	DESCRIPTION	REV
17-11-100-001	5KV SINGLE LINE DIAGRAM	B
17-11-100-002	480V MOTOR CONTROL CENTER SINGLE LINE DIAGRAM	B
17-11-100-003	480V & 5KV MCC ELEVATIONS	A
17-11-250-001	ELECTRICAL POWER PLAN SITE LAYOUT	B
17-11-353-001	ELECTRICAL LIGHTING LAYOUT - LOWER LEVEL	A
17-11-353-002	ELECTRICAL LIGHTING LAYOUT - LEVEL 1	A
17-11-353-003	ELECTRICAL LIGHTING LAYOUT - COOLING TOWER	A
17-11-353-004	ELECTRICAL LIGHTING LAYOUT - BOILER AREA	A
17-11-503-001	ELECTRICAL GROUNDING PLAN - TURBINE BUILDING	A
17-11-503-002	ELECTRICAL GROUNDING PLAN - COOLING TOWER	A
17-11-503-003	ELECTRICAL GROUNDING PLAN - BOILER AREA	A
17-11-652-001	ELECTRICAL CABLE TRAY ARRANGEMENT	A
17-11-702-001	ELECTRICAL POWER PLAN - LOWER LEVEL	A
17-11-702-002	ELECTRICAL POWER PLAN - LEVEL 1	A

PIPING

DRAWING #	DESCRIPTION	REV
16-11-215-001	PIPE RACK PLAN	A
16-11-215-002	PIPE RACK SECTIONS	A

MECHANICAL

DRAWING #	DESCRIPTION	REV
15-11-405-001	MECHANICAL EQUIPMENT ARRANGEMENT PLAN	A
15-11-405-002	MECHANICAL EQUIPMENT LAYOUT LEVEL 1 FLOOR PLAN	A
15-11-405-003	MECHANICAL EQUIPMENT LAYOUT LOWER LEVEL FLOOR PLAN	A
15-11-411-001	HVAC EQUIPMENT LAYOUT LEVEL 1 FLOOR PLAN	A
15-11-411-002	HVAC EQUIPMENT LAYOUT LOWER LEVEL FLOOR PLAN	A
15-11-432-001	PLUMBING LAYOUT LEVEL 1 FLOOR PLAN	A
15-11-432-002	PLUMBING LAYOUT LOWER LEVEL FLOOR PLAN	A

PROCESS

DRAWING #	DESCRIPTION	REV
PID-YTT-00	PIPING & INSTRUMENTATION DIAGRAM LEGEND	C
PID-YTT-10	PIPING & INSTRUMENTATION DIAGRAM DEAERATOR	C
PID-YTT-11	PIPING & INSTRUMENTATION DIAGRAM WBF DISTRIBUTION	C
PID-YTT-12	PIPING & INSTRUMENTATION DIAGRAM WATER TREATMENT	B
PID-YTT-20	PIPING & INSTRUMENTATION DIAGRAM BOILER	C
PID-YTT-22	PIPING & INSTRUMENTATION DIAGRAM BOILER STEAM DISTRIBUTION	C
PID-YTT-30	PIPING & INSTRUMENTATION DIAGRAM SUPERHEATER - STEAM SIDE	C
PID-YTT-31	PIPING & INSTRUMENTATION DIAGRAM SUPERHEATER - GAS SIDE	C
PID-YTT-32	PIPING & INSTRUMENTATION DIAGRAM SUPERHEATER 3	B
PID-YTT-40	PIPING & INSTRUMENTATION DIAGRAM TURBINE	C
PID-YTT-41	PIPING & INSTRUMENTATION DIAGRAM DYNOMOMETER	C
PID-YTT-42	PIPING & INSTRUMENTATION DIAGRAM EXHAUST STEAM	C
PID-YTT-50	PIPING & INSTRUMENTATION DIAGRAM SUPER HEATED STEAM DISTRIBUTION	C
PID-YTT-51	PIPING & INSTRUMENTATION DIAGRAM HEADER TEST	C
PID-YTT-60	PIPING & INSTRUMENTATION DIAGRAM DUMP EXCHANGER	C
PID-YTT-61	PIPING & INSTRUMENTATION DIAGRAM FUEL GAS DISTRIBUTION	B
PID-YTT-70	PIPING & INSTRUMENTATION DIAGRAM COOLING TOWER	C

STRUCTURAL

DRAWING #	DESCRIPTION	REV
13-11-200-001	GENERAL NOTES - CONCRETE	A
13-11-201-001	TURBINE BUILDING FOUNDATION PLAN	B
13-11-260-001	SUPERHEATER FOUNDATION PLAN	A
13-11-260-002	COOLING TOWER AREA FOUNDATION PLAN	A
13-11-260-003	BOILER AREA FOUNDATION PLAN	A
13-11-285-001	UTILITY RACK FOUNDATION PLAN	A
13-11-295-001	FOUNDATION SECTIONS & DETAILS	A
13-11-295-002	FOUNDATION SECTIONS & DETAILS	A
13-11-295-003	FOUNDATION SECTIONS & DETAILS	A
13-11-300-001	GENERAL NOTES - STEEL	A
13-11-305-001	TURBINE BUILDING 1st FLOOR FRAMING PLAN	B
13-11-360-001	COOLING TOWER PLATFORM FRAMING PLAN	A
13-11-385-001	UTILITY RACK STEEL FRAMING PLAN	A
13-11-385-002	UTILITY RACK STEEL FRAMING PLAN	A
13-11-385-003	UTILITY RACK STEEL FRAMING PLAN	A
13-11-385-004	UTILITY RACK ELEVATIONS	A

STRUCTURAL

DRAWING #	DESCRIPTION	REV
13-11-395-001	STEEL SECTIONS & DETAILS	A
13-11-395-002	STEEL SECTIONS & DETAILS	A
13-11-395-003	STEEL SECTIONS & DETAILS	B

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ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C						B	3/31/16	ISSUED FOR FEED		
						A	3/7/16	ISSUED FOR STAKEHOLDERS REVIEW		

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	B	3/31/16	FB	DM
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SCALE: NONE

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A-USC COMTEST PROJECT
ARCHITECTURAL
TITLE SHEET

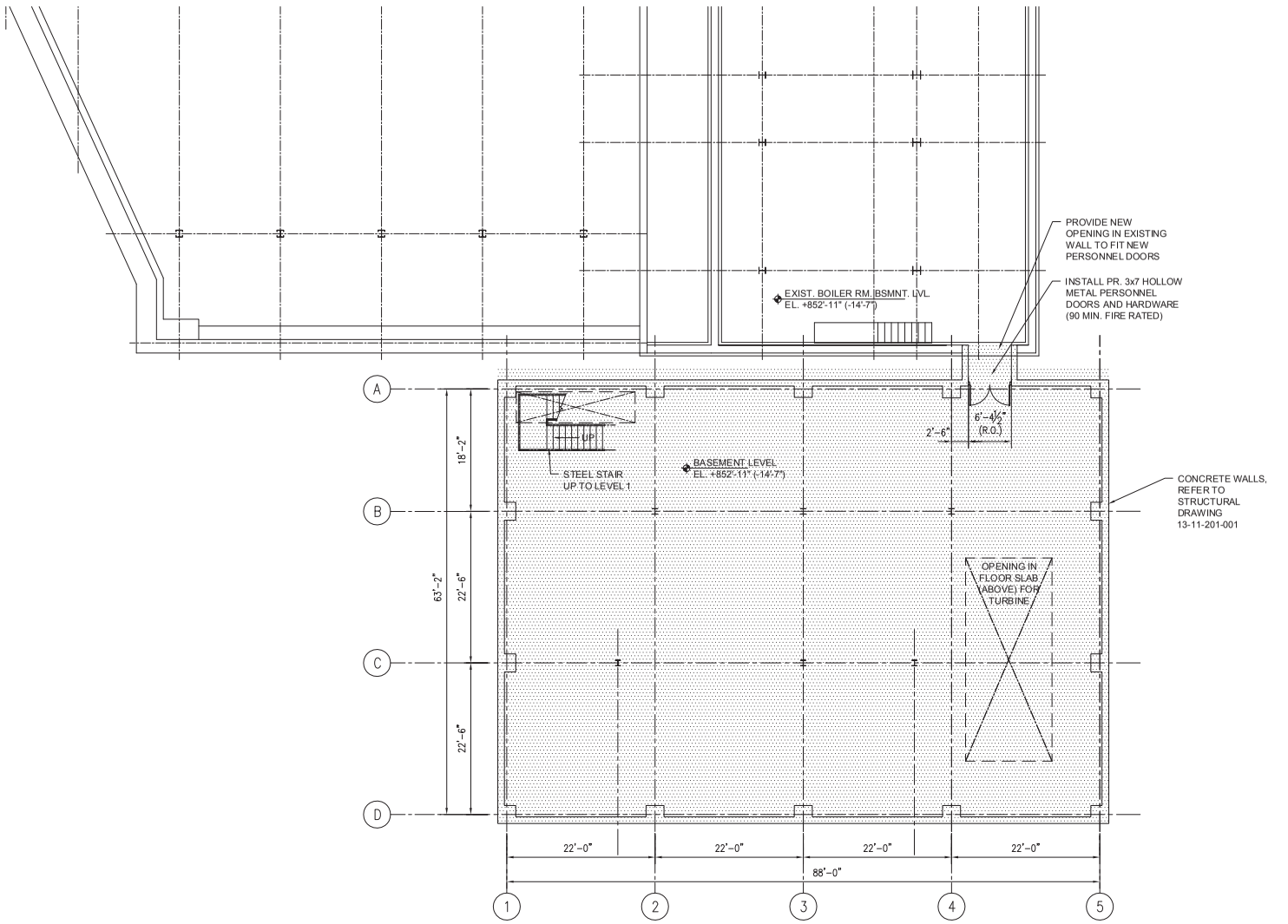
DWG. NO. 18-11-100-001

REV B

INCHES CENTIMETERS

8 7 6 5 4 3 2 1

18-11-203-001



LOWER LEVEL FLOOR PLAN
SCALE: ⅛" = 1'-0"

DENOTES AREA OF BUILDING EXPANSION

PRELIMINARY

REVISION APPROVAL RECORD				REV		REV NO	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C						B	3/31/16	ISSUED FOR FEED		
						A	3/7/16	ISSUED FOR STAKEHOLDERS REVIEW		

DRAWING STATUS				
ISSUED	REV	DATE	SCE	PEM
PRELIMINARY	B	3/31/16	FB	DM
APPROVED FOR CONSTRUCTION				

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CHECKED: DATE:
SCALE: AS NOTED

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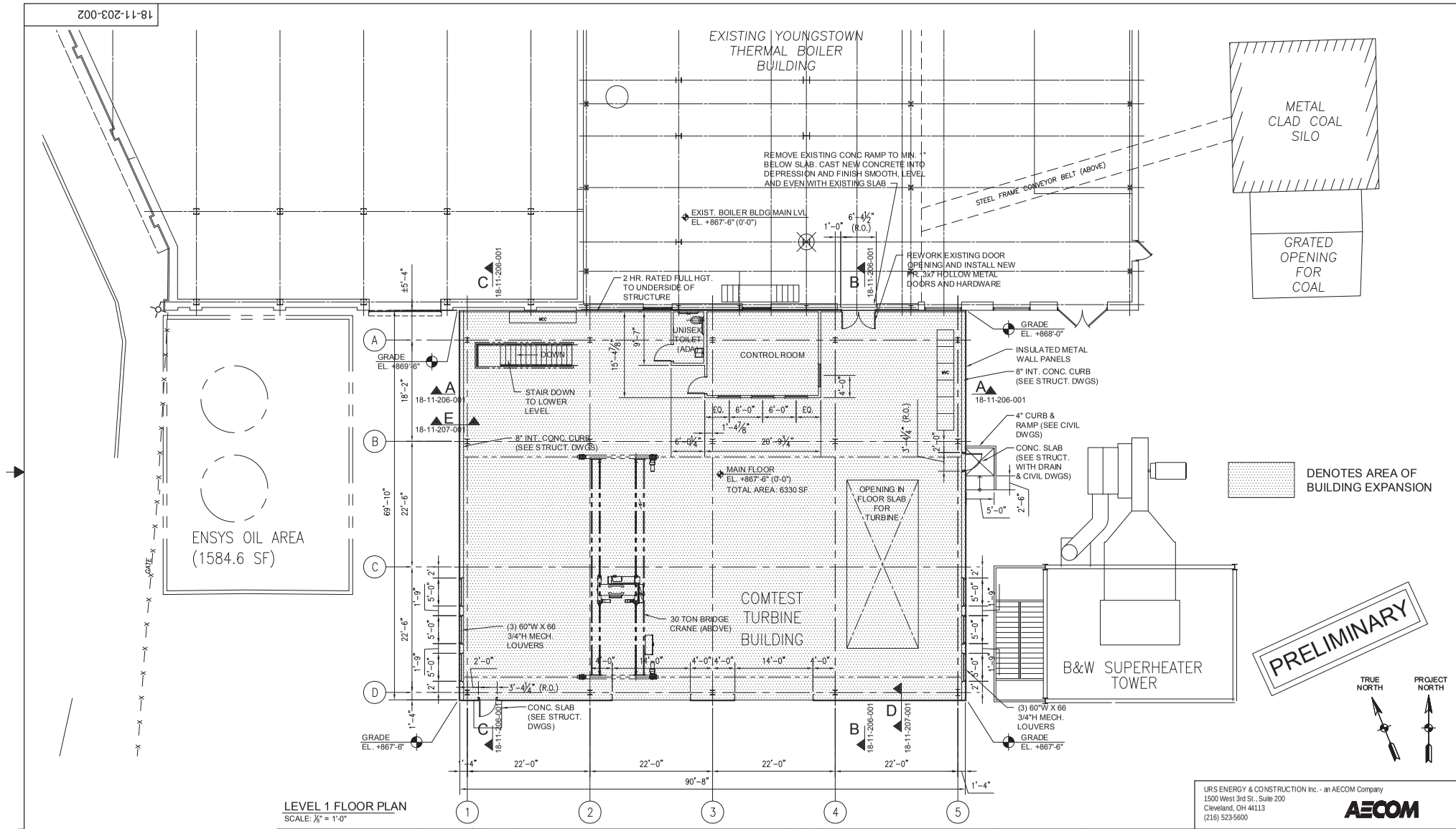
A-USC COMTEST PROJECT
ARCHITECTURAL
LOWER LEVEL FLOOR PLAN

DWG. NO. 18-11-203-001
REV B

INCHES
CENTIMETERS
FC_D Size dwn

18-11-203-002



LEVEL 1 FLOOR PLAN

SCALE: ⅛" = 1'-0"

REVISION APPROVAL RECORD				REV		REV NO	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C						B	3/31/16	ISSUED FOR FEED		
						A	3/7/16	ISSUED FOR STAKEHOLDERS REVIEW		

DRAWING STATUS				
ISSUED	REV	DATE	SCE	PEM
PRELIMINARY	B	3/31/16	FB	DM
APPROVED FOR CONSTRUCTION				

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A-USC COMTEST PROJECT
ARCHITECTURAL
LEVEL 1 FLOOR PLAN

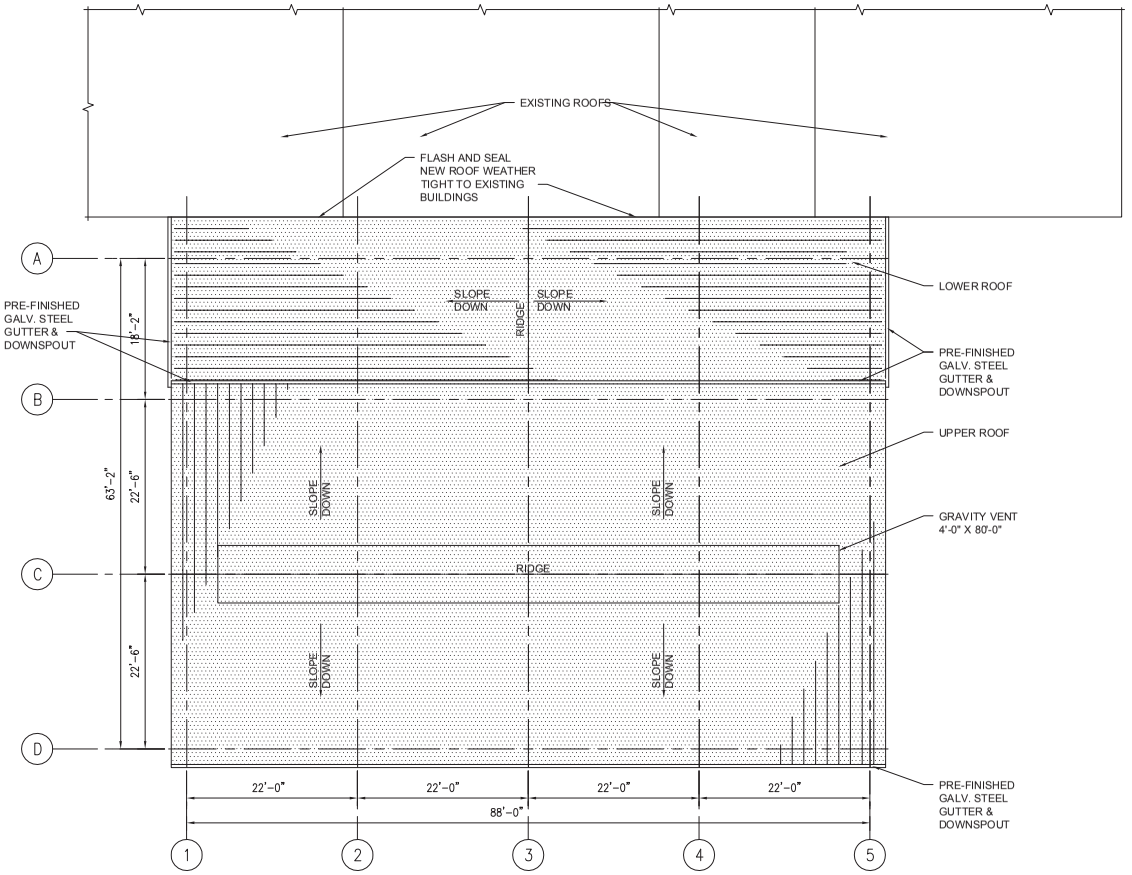
DWG. NO. 18-11-203-002

REV B

INCHES / CENTIMETERS

8 7 6 5 4 3 2 1

18-11-204-001



ROOF PLAN
SCALE: 1/8" = 1'-0"

DENOTES AREA OF BUILDING EXPANSION

PRELIMINARY

TRUE NORTH

PROJECT NORTH

REVISION APPROVAL RECORD				REV		REV NO	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C						A	3/31/16	ISSUED FOR FEED		

DRAWING STATUS				
ISSUED	REV	DATE	SCE	PEM
PRELIMINARY	A	3/31/16	FB	DM
APPROVED FOR CONSTRUCTION				

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SCALE: AS NOTED

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A-USC COMTEST PROJECT
ARCHITECTURAL
ROOF PLAN

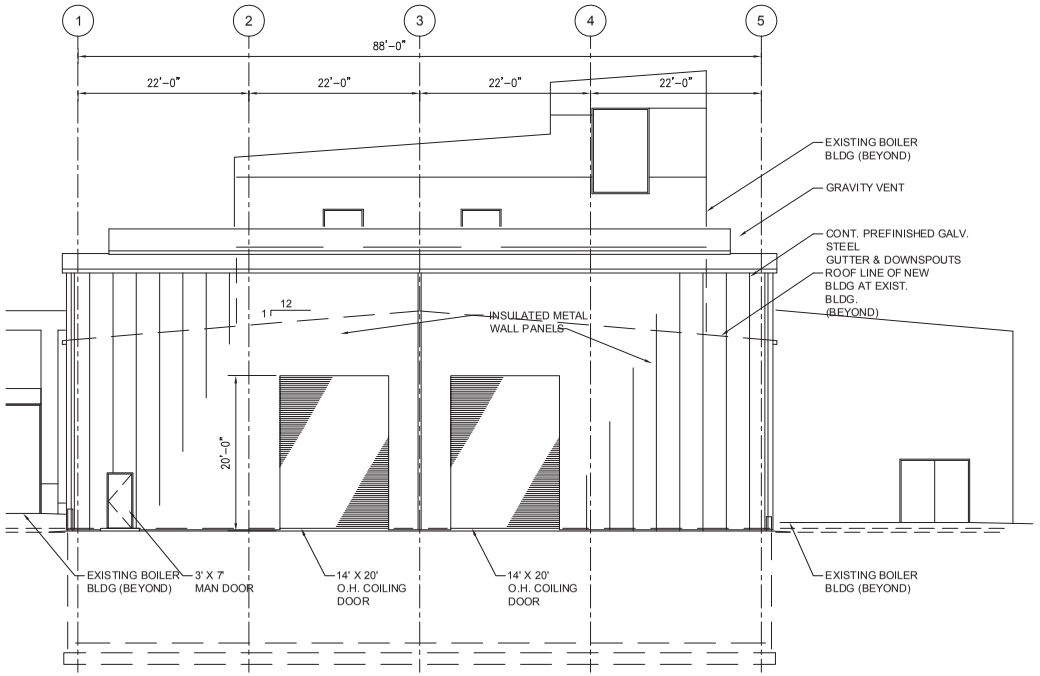
DWG. NO. 18-11-204-001

REV A

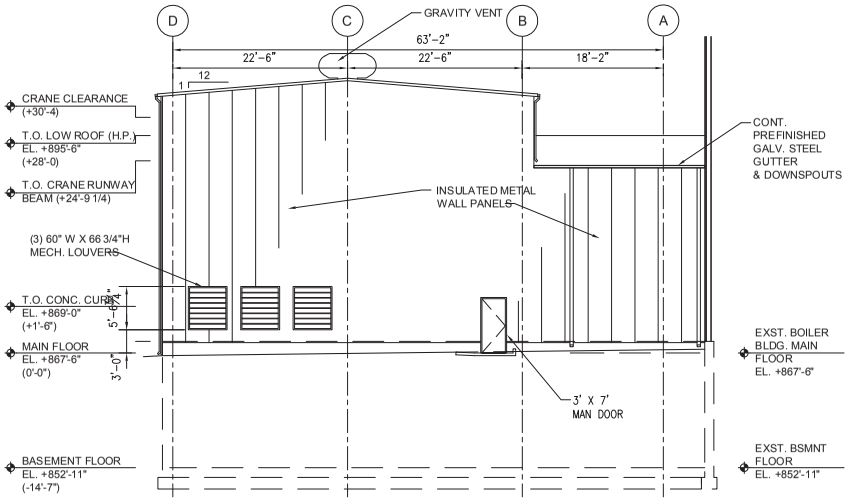
INCHES CENTIMETERS

8 7 6 5 4 3 2 1

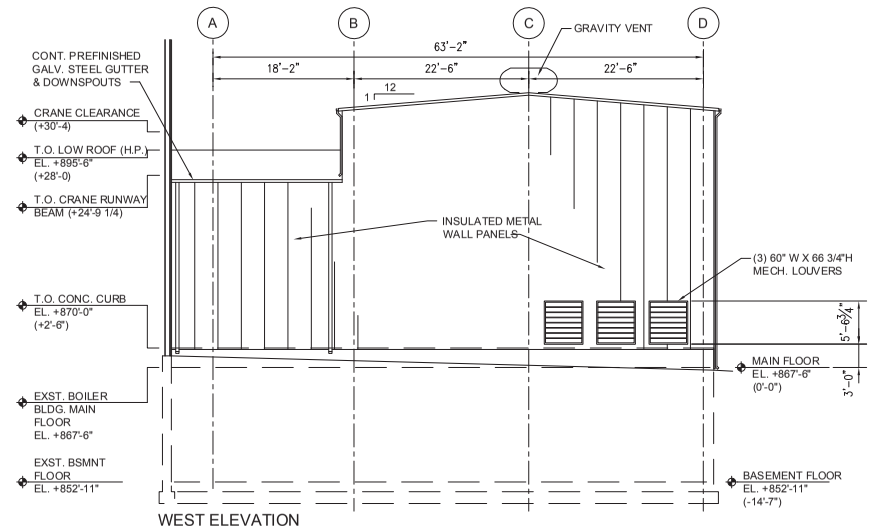
18-11-205-001



SOUTH ELEVATION
SCALE: ⅛" = 1'-0"



EAST ELEVATION
SCALE: ⅛" = 1'-0"



WEST ELEVATION
SCALE: ⅛" = 1'-0"

PRELIMINARY

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DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
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ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C										
						A	3/31/16	ISSUED FOR FEED		

DRAWING STATUS				
ISSUED	REV	DATE	SCE	PEM
PRELIMINARY	A	3/31/16	FB	DM
APPROVED FOR CONSTRUCTION				

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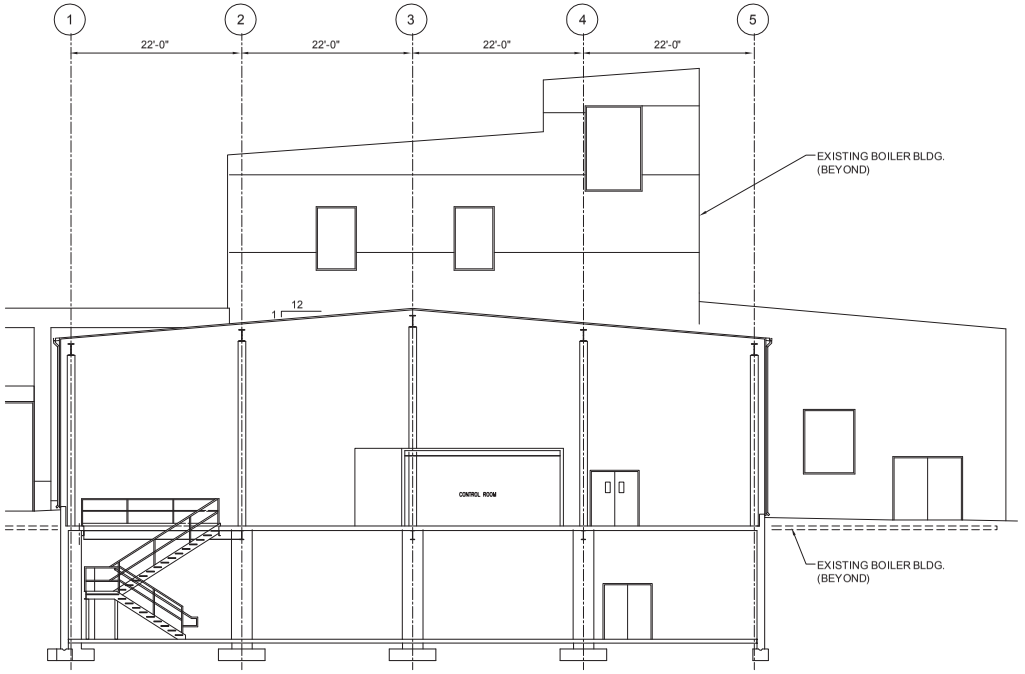
ARCHITECTURAL
EXTERIOR ELEVATIONS

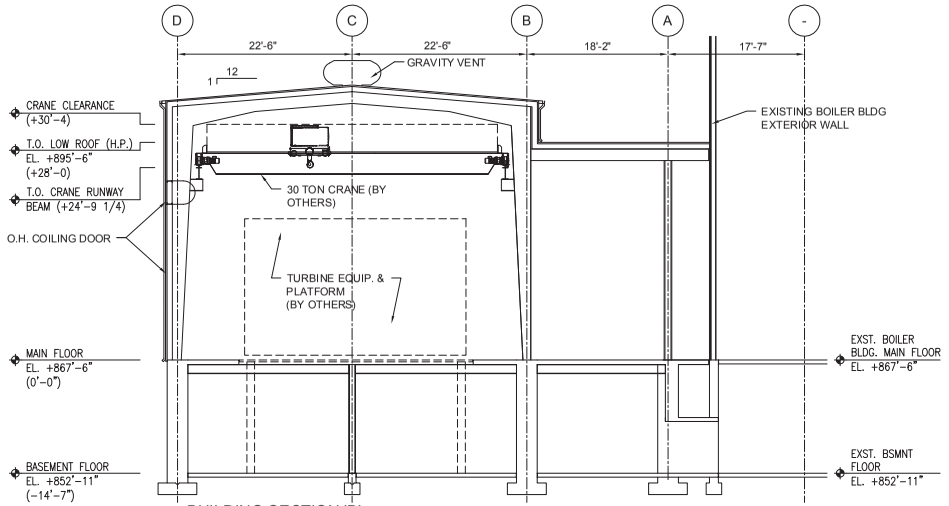
DWG. NO. 18-11-205-001
REV A

INCHES
CENTIMETERS
FC_D Size dwg

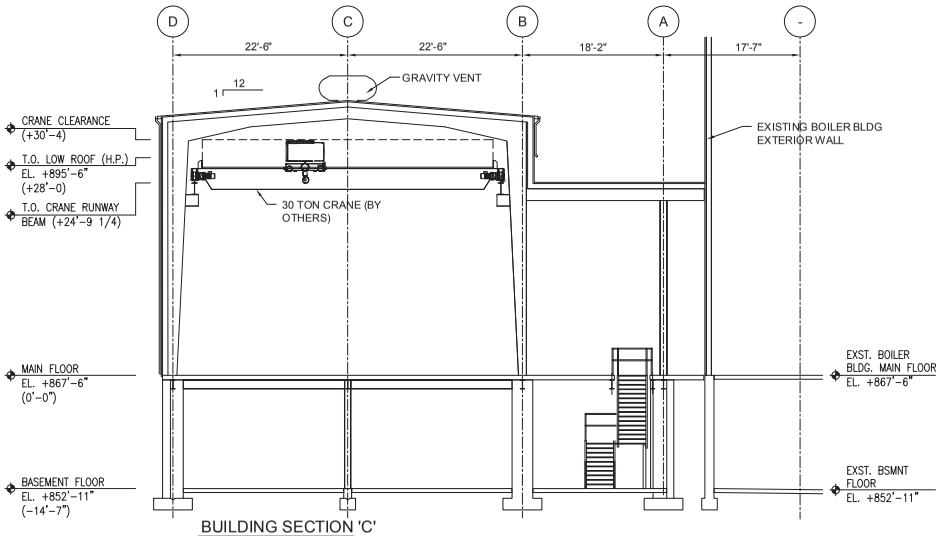
18-11-206-001



BUILDING SECTION 'A'
SCALE: ⅛" = 1'-0"



BUILDING SECTION 'B'
SCALE: ⅛" = 1'-0"



BUILDING SECTION 'C'
SCALE: ⅛" = 1'-0"

PRELIMINARY

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DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C						B	3/31/16	ISSUED FOR FEED		
						A	3/7/16	ISSUED FOR STACKHOLDERS REVIEW		

DRAWING STATUS				
ISSUED	REV	DATE	SCE	PEM
PRELIMINARY	B	3/31/16	FB	DM
APPROVED FOR CONSTRUCTION				

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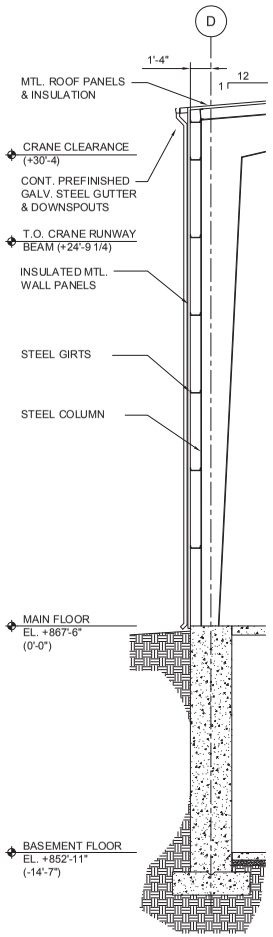
A-USC COMTEST PROJECT
ARCHITECTURAL
BUILDING SECTIONS

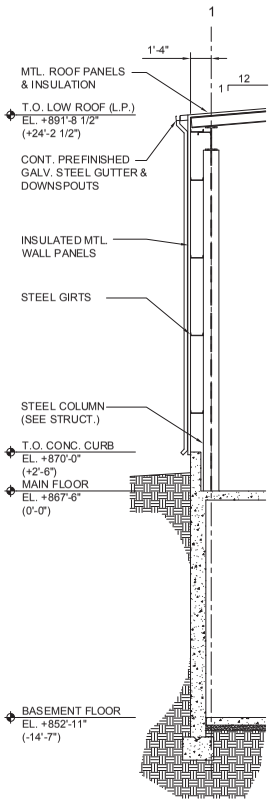
DWG. NO. 18-11-206-001
REV B

INCHES
CENTIMETERS
8 7 6 5 4 3 2 1

18-11-207-001



WALL SECTION 'D'
SCALE: 1/4" = 1'-0"



WALL SECTION 'E'
SCALE: 1/4" = 1'-0"

PRELIMINARY

REVISION APPROVAL RECORD				REV		REV NO	DATE	REVISIONS	BY	CHKR
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ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C										
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DRAWING STATUS				
ISSUED	REV	DATE	SCE	PEM
PRELIMINARY	A	3/31/16	FB	DM
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A-USC COMTEST PROJECT
ARCHITECTURAL
WALL SECTIONS

DWG. NO. 18-11-207-001
REV A

INCHES
CENTIMETERS
8 7 6 5 4 3 2 1

A-USC ComTest Project

Youngstown, OH

PROJECT NUMBER 31609

SPECIFICATION NUMBER 13-34-19

FOR

PRE-ENGINEERED METAL BUILDING

PREPARED FOR

Energy Industries of Ohio (EIO),

The Department of Energy,

&

Ohio Coal Development Office

By

AECOM

1500 W 3rd Street, Suite 200

Cleveland, OH 44113

Revision	Date	Status
A	March 31, 2016	Issued for FEED

SPECIFICATION REVISION PAGE

Project Name:	A-USC ComTest	Discipline:	Structural
Client:	Energy Industries of Ohio		

Revision Signatures

Jeff Morris	3/2/16	Dan Mardovin	3/31/16
Prepared by	Date	Approved by (PEM)	Date
David Lanning	3/2/16	NA	
Checked by	Date	Approved by (if required) (title)	Date

Status	Rev. No.	Date	Prepared By	Pages	Description of Changes
Prelim	A	3/31/16	JJM	All	Issue for FEED

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1.0 GENERAL

1.1. Scope of Work

This specification shall govern the design, material quality, fabrication and erection requirements for the pre-engineered, prefabricated metal building structure and components for the A-USC ComTest project at Youngstown Thermal in Youngstown, Ohio. The buildings purpose is to house a steam turbine and related components.

1.1.1. Definitions

A. Owner: Youngstown Thermal (Owner of the site)

B. Buyer: AECOM

C. Seller: Firm undertaking the scope of work as defined in this specification.

D. Engineer of Record: Professional Engineer registered in the State of Ohio responsible for sealing original engineered design documents.

1.1.2. Materials and Work by Seller

The work to perform hereunder includes, but shall not be limited to, the tasks below:

A. Design, fabrication, delivery, and erection of the steel building structure to include grouting of the base plates at the project site. Steel building structure includes:
   1. Steel frames
   2. Purlins
   3. Girts
   4. Crane runway beams (excluding crane rails)

B. Design, procurement, delivery, and installation of the following building components:
   1. Metal roof panel and insulation
   2. Insulated Metal wall panels
   3. Exterior overhead doors
   4. Exterior personnel doors
   5. Interior personnel doors
   6. Interior walls
   7. Interior Windows
   8. Toilet room with plumbing fixtures and accessories
   9. Roof top ridge ventilator
   10. Gutters and downspouts

C. Timely submittal of design data, calculations, drawings, certifications and other documentation to the Buyer for review and approval.

D. Submittal of anchor rod plans and detail drawings including anchor rod sizes, locations, projection, and grout thickness.

E. Furnishing of all labor, tools, materials, equipment, supervision, incidentals, and services necessary to perform the forgoing work in full compliance with this specification and referenced documentation.

1.2. Safety

1.2.1. Safety shall be of primary importance on this project. Seller shall comply with all site safety, OSHA, and local safety requirements and regulations.

1.2.2. All personnel shall utilize the necessary safety equipment, including but not limited to hard hats, safety glasses, safety boots and hearing protection. All personnel will be required to attend an Owner site safety orientation. All vehicles shall comply with local government jurisdiction and site/plant safety requirements.

1.3. References, Codes and Standards

The latest issues of the following Specifications, Codes and Standards, including revisions and supplements in effect as of February 1st, 2016, form a part of this specification in their entirety, except as modified by this Specification.

1.3.1. American Institute of Steel Construction (AISC):

A. AISC 360 - Specification for Structural Steel Buildings.

B. AISC 341 – Seismic Provisions for Structural Steel Buildings (when appropriate).

C. AISC Design Guide 3 – Serviceability for Steel Buildings

1.3.2. American Iron and Steel Institute (AISI):

A. AISI S100 - North American Specification for the Design of Cold-Formed Steel Structural Members.

1.3.3. American Welding Society (AWS):

A. AWS D1.1 / D1.1M – Structural Welding Code – Steel.

B. AWS D1.3 / D1.3M – Structural Welding Code – Sheet Steel.

1.3.4. American Society for Testing and Materials (ASTM)

1.3.5. Metal Building Manufacturers Association (MBMA):

A. MBMA Metal Building Systems Manual.

B. Seismic Design Guide for Metal Building Systems.

1.3.6. North American Insulation Manufacturers Association (NAIMA):

A. NAIMA 202 – Standard For Flexible Fiber Glass Insulation to be Laminated for Use in Metal Buildings.

1.3.7. Occupational Safety and Health Administration (OSHA), Department of Labor

1.3.8. The Society for Protective Coatings (SSPC)

1.3.9. 2011 Ohio Building Code

A. With Amendments thru January 1, 2016

B. With all local City and County Level Ordinances.

1.3.10. Drawing(s) included with this specification are preliminary and may require revision before commencement of work. Should changes to these Drawings become necessary, new copies of the Drawing(s) will be furnished to the Seller who shall adjust work accordingly and submit final information based upon the latest issue of the Drawing(s).

1.3.11. Should a conflict be found to exist between any applicable portion of the referenced Codes, Standards, Regulations, and this Specification, the conflict shall be submitted to the Buyer for resolution before proceeding with the affected work.

1.4. Pre-installation Meetings

1.4.1. Convene pre-installation meeting 2 weeks before start of installation of metal building system.

1.4.2. Require attendance of parties directly affecting work of this section, including Contractor, Architect, Engineer, Installer and metal building system Manufacturer's Representative.

1.4.3. Review materials, installation, protection, and coordination with other work.

1.5. Submittals

1.5.1. Product Data: Submit metal building system manufacturer's product information, specifications, and installation instructions for building components and accessories.

1.5.2. Erection Drawings: Submit metal building system manufacturer's and required building components erection drawings, including plans, elevations, sections, and details, indicating roof framing, transverse cross-sections, covering and trim details, and accessory installation details to clearly indicate proper assembly of building components.

1.5.3. Calculations: Submit design calculations for each building and building component prepared by a Professional Engineer, registered to practice in Ohio.

1.5.4. Foundation Loads and Reactions: Submit foundation loads, column reactions, and anchor rod requirements for the building.

1.5.5. Anchor Rod Setting Drawings: Submit drawings showing dimensioned locations, types or types, and details necessary for proper setting of anchor rods and forming of shear keys, if applicable.

1.5.6. Certification: Submit written "Certificate of design and manufacturing conformance" prepared and signed by a Professional Engineer, registered to practice in Ohio verifying that the metal building system design and metal roof system design (including panels, clips, and support system components) meet indicated loading requirements and codes of authorities having jurisdiction.

A. Certification shall reference specific dead loads, live loads, snow loads, wind loads/speeds, tributary area load reductions (if applicable), concentrated loads, collateral loads, seismic loads, end-use categories, governing code bodies, including year, and load applications.

B. Submit certification 1 week before bid date on the metal building system manufacturer's letterhead.

C. The building shall be designed by, or in the responsible charge of, a professional engineer registered in the state of Ohio. All drawings and calculations shall be sealed by the engineer and submitted to the building official for permit.

1.5.7. Dealer Certification: Submit certification 1 week before bid date that the metal building system supplier is a manufacturer's authorized and franchised dealer of the system to be furnished.

1.5.8. Installer Certification: Submit certification 1 week before bid date that the metal building system installer has been regularly engaged in the installation of building systems of the same or equal construction to the system specified.

1.5.9. Warranty Documentation: Submit manufacturer's standard warranty.

1.6. Quality Assurance

1.6.1. Manufacturer's Qualifications:

A. Manufacturer regularly engaged, for past 10 years, in manufacture of metal building systems of similar type to that specified.

B. Accredited based on IAS Accreditation Criteria AC472 and requirements in International Building Code (IBC), Chapter 17.

C. Manufacturer must submit a dedicated main contact person the project to the Buyer. Provide a name, phone number, email, and resume. If the manufacturer decides to change the main contact person at any time during the process, the Buyer should be notified immediately with a new main contact person.

1.6.2. Installer's Qualifications:

A. Installer regularly engaged, for past 5 years, in installation of metal building systems of similar type to that specified.

B. Employ persons trained for installation of metal building systems.

C. Installer must submit a dedicated main contact person for the project to the Buyer. Provide a name, phone number, email, and resume. If the manufacturer decides to change the main contact person at any time during the process, the Buyer should be notified immediately with a new main contact person.

1.6.3. Certificate of design and manufacturing conformance:

A. Metal building system manufacturer shall submit written certification prepared and signed by a Professional Engineer, registered to practice in Ohio verifying that building system design and metal roof panel design meet indicated loading requirements and codes of authorities having jurisdiction.

B. Certification shall reference specific dead loads, live loads, snow loads, wind loads/speeds, concentrated loads, collateral loads, seismic loads, end-use categories, governing code bodies, including year, and load applications.

C. Certificate shall be on metal building system manufacturer's letterhead.

D. Refer to Submittals article of this specification section.

1.6.4. Material Testing:

A. In addition to material certifications of structural steel, metal building system manufacturer shall provide, upon request at time of order, evidence of compliance with specifications through testing.

B. This quality assurance testing shall include testing of structural bolts, nuts, screw fasteners, mastics, and metal coatings (primers, metallic coated products, and painted coil products).

1.7. Delivery, Storage, and Handling

1.7.1. Delivery and Acceptance Requirements: Deliver materials to site in manufacturer's original, unopened containers and packaging, with labels clearly identifying product name and manufacturer.

1.7.2. Storage and Handling Requirements:

A. Store and handle materials in accordance with manufacturer's instructions.

B. Keep materials in manufacturer's original, unopened containers and packaging until installation.

C. Do not store materials directly on ground.

D. Store materials on flat, level surface, raised above ground, with adequate support to prevent sagging.

E. Protect materials and finish during storage, handling, and installation to prevent damage.

1.7.3. Throughout their shipping, handling and storage, building components and accessories shall be protected from deformation, physical damage, marring of finishes, loss of components, soiling, and similar detrimental effects.

1.7.4. Preparation for Shipping

A. All fabricated and furnished items to be delivered to the Project Site and shall be given an identifying number corresponding to its marking shown on the erection drawings. Such identifying markings shall be on a weather-resistant tag wire-attached, stamped, stenciled, or printed on those items.

B. Appropriate methods of protection including skids, carting, boxing, bundling, water proof covers, padding, dividers, and other suitable means shall be utilized by the building and component manufactures as necessary to insure complete and undamaged condition upon arrival at the project site.

C. Size and weight of building components as packaged and shipped shall be such that will permit transportation by common carrier.

1.8. Warranty

1.8.1. Metal building system manufacturer shall provide a written warranty for 25 years against perforation of metal roof panels due to corrosion under normal weather and atmospheric conditions.

A. Warranty shall be signed by metal roof system Manufacturer & the Installer.

1.8.2. Metal building system manufacturer shall provide a paint film written warranty for 25 years against cracking, peeling, chalking, and fading of exterior coating on wall panels.

A. Warranty shall be signed by metal building system or roof system manufacturer and state that the coating contains 70 percent "Kynar 500" or "Hylar 5000" resin.

B. Metal building system manufacturer shall warrant that the coating shall not peel, crack, or chip for 25 years.

C. For a period of 25 years, chalking shall not exceed ASTM D 4214, #8 rating and shall not fade more than 5 color difference units in accordance with ASTM D 2244.

1.8.3. Metal Building System Manufacturer's Certification: Metal building system manufacturer shall submit a signed written Certification one week before bid date, stating that the metal roof system manufacturer or approved representative will provide warranties and Inspection and Report Service specified in this specification section.

A. Warranty terms shall be submitted with bid.

2.0 PRODUCTS

2.1. Building Manufacturers

A. Metal Building System Manufacturer: Butler Manufacturing, PO Box 419917, Kansas City, Missouri 64141. Phone 816-968-3000. Website www.butlermfg.com.

B. Metal Building System Manufacturer: VP Buildings, 3200 Players Club Circle, Memphis, Tennessee 38125. Phone 901-748-8000. Website www.vp.com.

C. Metal Building System Manufacturer: Kirby Building Systems, 124 Kirby Drive, Portland, Tennessee 37148. Phone 615-325-4165. Website www.kirbybuidingsystems.com.

D. Metal Building System Manufacturer: Nucor Building Systems, 305 Industrial Parkway, Waterloo, Indiana 46793. Phone 888-314-0930. Website www.nucorbuidingsystems.com.

E. Metal Building System Manufacturer: American Buildings Company, 1150 State Docks Road, Eufaula, Alabama 36027. Phone 888-307-4338. Website www.americanbuildings.com.

F. Metal Building System Manufacturer: Star Building Systems, 8600 South Interstate 35 Service Road, Oklahoma City, OK 73149. Phone 800-879-7827. Website www.starbuildings.com

G. Approved alternate manufacturer.

2.2. Building Description

2.2.1. General: The turbine building is used to house a steam turbine, associated equipment, and support areas. The building has a basement level and main level with a concrete slab near grade elevation which is supported by steel framing (by others). The basement and main level are set at the same elevations as the existing Boiler building basement and main level. The pre-engineered building columns are support by concrete piers that extend up from the foundations at the basement level.

2.2.2. Building Dimensions:

A. Indicated on the drawings included in Attachment A.

B. Minimum height to top of crane runway beam: 24’-9 1/4” above finish floor

C. Minimum clearance to steel frame between runway beams: 30’-4” above finish floor

D. Eave height of crane bay: As required for crane clearances

E. Eave height of lean to: Per drawings included in Attachment A.

2.2.3. Design of Structural System: Single span rigid frame with a lean to.

2.2.4. Roof Slope: 1 inch in 12 inches.

2.3. Design Requirements

2.3.1. Governing Design Code:

A. Structural design for the building structural system shall be provided by the metal building system manufacturer for the following design criteria:

1. Governing Building Code: Ohio Building Code.
2. Year/Version: 2011 with January 2016 amendments.
3. Occupancy Category: III.

B. Insulation requirements for the building system shall be provided by for the following energy code or energy standard criteria:

1. Energy Standard (ASHRAE 90.1).
2. Year/Version: 2007.
3. Climatic Zone: 5.

COMcheck may be used to show code compliance using the envelope performance trade-off method.

2.3.2. Roof Live Load:

A. Roof live loads are loads produced during the life of the structure by moveable objects.

B. Wind, snow, seismic, or dead loads are not live loads.

C. Roof live loads shall not be reduced.

2.3.3. Roof Snow Load:

A. Roof snow load used for designing the structure shall not be reduced and shall be the product of the following criteria:

1. Snow Load Coefficient (Ce): 0.9
2. Thermal Factor (C_t): 1.0
3. Snow Importance Factor (I): 1.1
4. Ground Snow Load (Pg): 20 psf
5. Roof Snow Load (Pf): 20 psf
6. Roof Snow Load plus Rain on Snow Surcharge: 25 psf

B. Design snow load shall include the effects of minimum flat roof load limits, rain on snow, drifting snow, and unbalanced snow load as defined in the governing building code specified above.

C. Design for snow drift at adjacent existing higher building for the following parameters:

1. Length of existing higher building (Lu): 160ft
2. Consider step height greater than drift height

2.3.4. Wind Load:

A. Wind load used for designing the structure shall be the product of the following criteria:

1. Wind Exposure Category: B
2. Wind Topographic Factor (K_{zt}): 1.15
3. Wind Directionality Factor (K_d): 0.85

4. Wind Velocity (V), miles per hour: 90
5. Wind Importance Factor (I_w): 1.15

B. Wind Pressure Coefficients and the design pressures shall be applied in accordance with the governing code.

2.3.5. Seismic Load:

A. Seismic load used for designing the structure shall be based on the following criteria:
1. Spectral response acceleration for short periods (S_s): 0.152 % g
2. Spectral response acceleration for 1-sec. period (S_1): 0.049 % g
3. Site Class: C
4. Seismic Importance Factor (I): 1.25

B. Seismic loads shall be applied in accordance with the governing code.

2.3.6. Dead Load: Dead load shall consist of the weight of building system construction, such as, roof joist, bracing, frames, columns, girts, and walls.

A. Dead load of building system: By vendor

2.3.7. Live Loads:

Not applicable.

2.3.8. Collateral Dead Loads:

A. Collateral load in pounds per square foot shall be applied to the entire structure to account for the weight of additional permanent materials other than the building system, including insulation and roofing, sprinklers, mechanical systems, electrical systems, and ceilings.

B. Magnitude of Collateral Loads: 10 psf

2.3.9. Mechanical and Process Equipment Loads:

A. Furnish and install roof top ventilator, MoffittVent™ Eagle Series Model MV-48. See Attachment B for details.

2.3.10. Crane Design Parameters

A. Crane Lift Capacity: 30 tons

B. CMAA Crane Class: C

C. Crane loads:
1. Maximum wheel load: 32.1 kips (without impact)
2. Double girder crane weight: 14.8 kips (includes end trucks)
3. Hoist and Trolley weight: 5.2 kips

D. End truck wheel base: 8’- 10”

E. Crane runways shall be supported by either crane brackets or step columns. Section 2.6.1.C shall apply for both support conditions.

F. Crane rail: ASCE 60# (by others)

2.3.11. Contingency Load:

Not applicable.

2.3.12. Load Combinations: Load combinations used to design primary and secondary structural members shall be in accordance with the governing code.

2.4. Deflections

2.4.1. Structural Members:

A. Maximum deflection of main framing members shall not exceed 1/240 of their respective spans.

B. Maximum deflection due to snow load in roof panels and purlins shall not exceed 1/180 of their respective spans.

C. Maximum deflection due to wind load in wall panels and girts shall not exceed 1/180 of their respective spans.

2.4.2. Lateral deflections, or drift, at the roof level of the structure in relation to the floor or slab on grade, caused by deflection of horizontal force resisting elements

A. Shall not exceed H/200 under wind loading.

B. Shall be limited to building code requirements under seismic loading.

2.4.3. Calculations for deflections shall be done using only the bare frame method.

A. Reductions based on engineering judgment using the assumed composite stiffness of the building envelope shall not be allowed.

B. Drift shall be in accordance with AISC Serviceability Design Considerations for Low-Rise Buildings.

C. Use of composite stiffness for deflection calculations is permitted only when actual calculations for the stiffness are included with the design for the specific project.

D. When maximum deflections are specified, calculations shall be included in the design data.

2.5. Structural Steel Design

2.5.1. Structural Mill Sections or Welded-up Plate Sections: Design in accordance with AISC Specification for Structural Steel Buildings.

2.5.2. Cold-Formed Steel Structural Members: Design in accordance with AISI North American Specification for the Design of Cold-Formed Steel Structural Members.

2.5.3. Structural System: Design in accordance with specified building code (Refer to Design Loads and Building Codes).

2.6. Structural Steel Framing System

2.6.1. Primary Structural Framing:

A. Primary frames shall utilize a continuous frame consisting of rafters of tapered or uniform depth, rigidly connected to vertical columns of tapered or uniform depth. Frame clear spans across the width of the building shall be based on pre-determined bay spacing, and shall support the secondary framing, and the roof and wall coverings.

B. All columns shall be pin-based (such that no moment is transferred to the foundation).

C. All columns shall be a maximum of 12” deep at the base.

D. Endwall frames shall be rigid frames without vertical bracing.

E. All bolted connections in primary framing shall be made with high-strength bolts conforming to ASTM A325.

F. Base Plates: Bottom of base plates shall be at finish floor elevation of 867.5’ plus grout thickness.

G. Vertical bracing may be located in the following bays:
1. Line A: Not permitted. Provide portal braces as required.
2. Grid B: Lines 3 to 4
3. Grid D: Lines 4 to 5

H. Painting:
1. All framing members shall be prepared in accordance with SSPC-SP-2 and given one shop coat of primer.
2. Finish paint system not required.
3. Paint Primer Color: White

2.6.2. Secondary Structural Framing:

A. Purlins and girts shall be designed for the specified loading conditions, from standard gage steel.

B. Purlins and girts shall be “Z”, “C”, or “W” shaped sections.

C. Purlin and Girt Finish: Acrylic-coated G30 galvanized finish.

D. Lateral bracing shall be accomplished by diagonal bracing or moment frames, diaphragm action shall not be considered for design.

E. Flange braces shall be steel angles attached to purlins and/or girts and primary framing. The quantity and location of brace angles shall be dictated by sellers design.

F. All bolted connections in secondary framing shall be made with A307 common bolts or high-strength bolts conforming to ASTM A325.

G. All girts shall be designed as simple span members.

H. Provide sag rods as required by design.

I. Painting:

1. All secondary framing members shall be prepared in accordance with SSPC-SP-2 and given one shop coat of primer.
2. Finish paint system not required.
3. Paint Primer Color: White

2.6.3. Structural Steel Fabrication

A. All structural steel members shall have all shearing, forming, punching and welding performed and completed in the manufacturer's plant.

B. Shop welding shall be accordance with standard practices of AWS D1.1 and shall be performed only by certified welders in accordance with AWS D1.1.

C. Structural members fabricated of plate stock shall have flanges and webs joined by a continuous automatic submerged arc welding process.

2.6.4. General Design Requirements

A. The building shall be designed in accordance with the requirements specified herein, the requirements of the contract documents and in compliance with all applicable codes and standards.

B. The building shall be designed by, or in the responsible charge of, a professional engineer registered in the state of Ohio. All drawings and calculations shall be sealed by the architect and/or engineer and submitted to the building official for permit.

C. Changes from the requirements in the contract documents shall be approved by the Company.

2.6.5. Building Layout

A. Attached Drawings

1. Plan and elevation drawings are provided for design purposes
2. Building size is indicated on the included drawings; it is the Supplier's responsibility to ensure that the building meets all applicable building safety codes.

2.7. Building Components

2.7.1. Metal Wall and Roof Panels:

A. Steel sheets shall conform to any of the following material specifications:

1. *ASTM A1011/A1011M* - Grade 50 or 55
2. *ASTM A1008/A1008M* - Class 1 or 2, Grade 50, or higher
3. *ASTM A653* - SS, either Grade 50, Class 1 or 3, or Grade 80
4. *ASTM A792/A792M* - SS, either Grade 50 Type A or Grade 80
5. Steel coating shall have a factory applied finish with a manufacturer's 20 year warranty against blistering, peeling, cracking, chipping or rusting. Also the finish shall have a 20 year warranty against chalking not to exceed #8, ASTM D4214 and fading shall be 5^E color difference units or less

B. Trim

1. Unless otherwise required in the contract documents, flashing, corner trim, caps, and closure pieces shall be of the same material, finish, and color as adjacent material.
2. Trim profile shall be provided to suit.
3. Trim shall have a factory applied finish with a manufacturer's 20 year warranty against blistering, peeling, cracking, chipping or rusting. Also the finish shall have a 20 year warranty against chalking not to exceed #8, ASTM D4214 and fading shall be 5^E color difference units or less

C. Insulation

1. Insulation shall be rigid, semi-rigid, *ASTM C665*, batt or roll, faced or unfaced with a thickness or R-rating as required to comply with IECC 2009.
2. UL flame spread classification shall be 25 or less.

D. Fasteners

1. Wall and roofing through-fasteners shall be Supplier's standard self-drilling corrosion resistant screws with a building color washer and a sealing washer.
2. Clips for standing seam panels shall be Supplier's standard sliding design to allow for unrestrained expansion and contraction movement of panels, complete with plated self-drilling fasteners at each clip.
3. Exposed fasteners for eave, end lap, ridge cover, trim, and flashing shall be Supplier's standard self-drilling stainless steel screws with sealing washer.
4. All exposed fastener heads shall be factory colored to match color of panels.

E. Sealant

1. Factory-applied roof panel sealant shall be non-shrinking, non-drying, butyl-based sealant specifically formulated for factory application in standing seams and to allow roof panel assembly at temperatures from -23°C to +60°C (-10°F to +140°F) or Supplier's standard type if approved by the Company.
2. Field-applied roof panel sealant shall be a Company approved, non-shrinking, non-drying, butyl-based sealant specifically formulated for roof application at temperatures from 7°C to 49°C (20°F to 120°F) or Supplier's standard type if approved by the Company.
3. Manufacturer to conduct and submit all adhesion test as required to all adjoining materials where sealant is to be applied to the Buyer.

2.7.2. Gutters and Downspouts

A. Gutters shall be suspended box sections of a minimum of 22 gauge galvanized steel formed to match the configuration of the gable trim.

B. Gutters shall be independent of the roof seal and shall be attached to the eave strut adapter by means of a gutter hanger.

C. Downspouts shall be located in accordance with the contract documents and shall be 24 gauge minimum galvanized factory-colored steel to match the siding.

D. Supplier shall design the gutter and downspout sizes, lengths and quantities to meet 100 yr. rain requirements based on the building location.

E. Unless otherwise required in the contract documents, a 45-degree elbow shall be provided at the base of all downspouts. Concrete splash blocks shall be provided at the base of each downspout.

F. Downspout straps shall be galvanized steel, 1.5 mm by 25 mm (1/16 inch by 1 inch), and factory-colored to match the downspout.

G. Gutters and downspouts shall have a factory applied finish with a manufacturer's 20 year warranty against blistering, peeling, cracking, chipping or rusting. Also the finish shall have a 20 year warranty against chalking not to exceed #8, ASTM D4214 and fading shall be 5^E color difference units or less.

2.7.3. Personnel doors shall be 3' x 7' hollow metal with hollow metal frames and shall conform to Level 3 construction in accordance with Steel Door Institute (SDI) section 108-10. Doors shall be keyed with existing buildings on site. Exterior doors shall be insulated, and shall have closers, weather stripping, thresholds and panic hardware.

2.7.4. Overhead Roll-up Doors

A. Unless otherwise required in the contract documents, complete overhead roll-up door assemblies including door curtain, guides, counterbalance, hardware, operators, and installation accessories shall be provided as specified herein.

B. Doors and frames shall be insulated galvanized steel designed for a 20 psf wind load.

C. Doors shall be electronically operated and shall have a speed ranging from 0.67 to 1 foot per second. Operator control shall have open, close and stop functions, with safety operation in compliance with UL 325 2010 standard. Operator motor shall be sized per door manufacturer's standard requirements to accommodate the door size and weight.

D. Door Curtain

1. Interlocking steel slat door curtain with one-piece slats for the full length of door width shall be provided.
2. The door curtain shall be formed from minimum 0.70 mm (0.0269 inch), structural sheet steel.
3. Where required in the contract documents, insulation shall be manufacturer's standard rigid cellular polystyrene or polyurethane-foam-type thermal insulation complying with maximum flame-spread and smoke-developed indexes of 75 and

450, respectively, according to *ASTM E 84*. Enclose insulation completely within metal slat faces.

E. Bottom Bar

1. Bottom bar shall be provided on door curtain consisting of two 3 mm (1/8-inch) thick angles of the same metal as the door curtain slats.
2. A flexible rubber, vinyl, or neoprene weather seal and cushion bumper shall also be provided on the bottom bar.

F. Weather Seals

1. At exterior doors, 3 mm (1/8-inch) thick continuous rubber or neoprene sheet weather seals on metal pressure bars secured to inside of curtain coil hood shall be provided.
2. At doorjambs, 3 mm (1/8-inch) thick continuous strip secured to exterior side of jamb guide shall be provided.

G. Hood

1. The coiled curtain and operating mechanism shall be entirely enclosed at the opening head to act as a weather seal.
2. The end brackets, to which the hood is attached, shall be contoured to suit.
3. Top and bottom edges shall be rolled and reinforced for stiffness.
4. Closed ends shall be provided for surface-mounted hoods and any portion of between-jamb mounting projecting beyond wall face.
5. Intermediate support brackets shall be provided to prevent sag.
6. Hoods for steel doors shall be fabricated from 0.55 mm (0.0209 inch) minimum zinc-coated steel sheet and phosphate-treated before fabrication.

H. Finish shall be manufacturer's standard prime painted finish

2.7.5. Windows shall be fixed pane tempered safety glass with aluminum frames. Frame color to be painted white and finish to be flat.

2.7.6. Wall Louvers: Furnish and install six (6) 60" x 66.75" Moffitt Vent LV9090 wall louvers in the locations shown on the drawing attachments..

2.7.7. Weather Tightness

A. Closures, caulking, weather stripping, flashing, and any other approved method shall be used around windows, doors, panel seams and any other penetrations of the wall or roof to assure that the building and roof is weather tight. Colors and finish shall always match.

2.7.8. Provide control room with windows and drop ceiling

A. Wall Construction:

1. 3 5/8" Metal studs (light gauge) spaced at every 16" O.C.
2. 1 layer of 5/8" Gypsum wall board on both sides
3. Wall Height: 10'-0" A.F.F.
4. Windows: (see Item 2.7.5)
   a. Provide (4) four 4'-0"(w) x3'-0"(h) window units.
   b. Locate at 42" A.F.F.
5. Painting: All Gyp. Surfaces to be given one shop coat of primer. Color: White

B. Ceiling Construction:
   1. 3 5/8” Metal Studs (16 gauge) spaced at 24” O.C.

C. Acoustic drop ceiling panel (at 9’-0” A.F.F.):

   1. Water Felted, Mineral-Base with painted finish Acoustical Panels for acoustical ceiling panel.
      a. Available Product: USG Corporation "Radar™" - Item Number 2210
   2. Color Finish: White
   3. Edge Detail: Reveal sized to fit flange of exposed suspension system members: Square Edge
   4. Thickness: 5/8 in
   5. Panel Size: 2ft x 2ft
   6. Antimicrobial Treatment: Coating based.
   7. Panel Warranty: When used with a USG Donn Brand suspension system, this panel has a 30 year warranty that it shall be free from manufacturing defects. When used without a USG Donn Brand suspension system, the period of warranty is 10 years.

D. Metal Suspension System for Acoustical Ceiling Panel
   1. General: ASTM C635, commercial quality pretreated and painted hot-dipped galvanized cold-rolled steel, exposed surfaces prefinished in manufacturer's standard corrosion resistant enamel paint finish; color: Flat White #050 or as selected from manufacturer's standard colors. Flat White 050
   2. Available Products/ Systems:
      - USG Corporation: USG DONN® Brand DX®/DXL™ 15/16" Acoustical Suspension System
   3. Hanger Wire: Galvanized carbon steel; soft temper; pre-stretched; yield stress load at least three times the design load but not less than 12-gauge.
   4. Suspension System Warranty: When used with a USG acoustical ceiling panel, this suspension system has a Lifetime 30 year warranty that it shall be free from the occurrence of 50% red rust. When used without a USG acoustical ceiling panel, the period of warranty is 10 years.

2.7.9. Provide uni-sex barrier free toilet room with drop ceiling

A. Wall Construction:
   1. 3 5/8” Metal studs (light gauge) spaced at every 16” O.C.
   2. 1 layer of 5/8” Gypsum wall board on both sides
   3. Wall Height: 10’-0” A.F.F.
   4. Painting: All Gyp. Surfaces to be given one shop coat of primer. Color: White

B. Ceiling Construction:
   1. 3 5/8” Metal Studs (16 gauge) spaced at 24” O.C.

C. Acoustic drop ceiling panel (at 9’-0” A.F.F.):

   1. Water Felted, Mineral-Base with painted finish Acoustical Panels for acoustical ceiling panel.
      a. Available Product: USG Corporation "Radar™" - Item Number 2210
   2. Color Finish: White

3. Edge Detail: Reveal sized to fit flange of exposed suspension system members: Square Edge
4. Thickness: 5/8 in
5. Panel Size: 2 ft x 2 ft
6. Antimicrobial Treatment: Coating based.
7. Panel Warranty: When used with a USG Donn Brand suspension system, this panel has a 30 year warranty that it shall be free from manufacturing defects. When used without a USG Donn Brand suspension system, the period of warranty is 10 years.

D. Metal Suspension System for Acoustical Ceiling Panel

1. General: ASTM C635, commercial quality pretreated and painted hot-dipped galvanized cold-rolled steel, exposed surfaces prefinished in manufacturer's standard corrosion resistant enamel paint finish; color: Flat White #050 or as selected from manufacturer's standard colors. Flat White 050
2. Available Products/ Systems:
   a. USG Corporation: USG DONN® Brand DX®/DXL™ 15/16" Acoustical Suspension System
3. Hanger Wire: Galvanized carbon steel; soft temper; pre-stretched; yield stress load at least three times the design load but not less than 12-gauge.
4. Suspension System Warranty: When used with a USG acoustical ceiling panel, this suspension system has a Lifetime 30 year warranty that it shall be free from the occurrence of 50% red rust. When used without a USG acoustical ceiling panel, the period of warranty is 10 years.

2.7.10. Provide roof and wall assemblies including trim, flashing, fasteners, weather sealing materials and insulation.

2.7.11. Provide a 2 hour rated firewall assembly between the Comtest Turbine Building and the existing boiler building.

A. Firewall to be continuous and to full height to the underside of structure.

B. 2 hour Firewall assembly can be done with gypsum wall board (U.L. Design #U-419, 2 hour rated metal wall panel assembly, or 2 hour rated shaft wall.

C. Provide Firestop Sealant at wall perimeter, all penetrations, joints, cutouts and gaps.
1. Available Product: USG FIRECODE Smoke-Sound Sealant or approved equivalent.

D. Provide 90 min. fire rated doors for doors located in this 2 hour wall assembly.

2.8. Foundations

2.8.1. Foundations, Including Anchor Rod Embedment Length: By AECOM

2.8.2. Reactions for Proper Design of Foundations: Supplied by metal building system manufacturer.

2.8.3. Anchor Rods:

A. Anchor Rod Diameter: Indicated on anchor bolt layout drawings furnished by metal building system manufacturer.

B. Anchor Rods: Supplied by Buyer, not metal building system manufacturer.

3.0 EXECUTION

3.1. General

3.1.1. Erection shall conform to the Seller's approved shop and erection drawings.

3.1.2. Erection shall be performed by a qualified erector, having a minimum of 5 years of experience in the construction of pre-engineered metal building systems.

3.2. Foundations

3.2.1. Prior to commencing building erection thereon, the Seller shall inspect the foundations for correctness and accuracy of construction, and for readiness to receive the building system.

3.2.2. The Buyer shall be immediately notified, in writing, of any unsatisfactory condition needing correction prior to the start of the Sellers' work. Only after foundations have been checked, accepted and concrete has attained an age of 14 days or as permitted by the Buyer, shall erection commence.

3.3. Examination

3.3.1. Examine area to receive metal building system.

3.3.2. Notify Buyer of conditions that would adversely affect installation or subsequent use.

3.3.3. Do not begin installation until unacceptable conditions are corrected.

3.4. Structural Steel Framing System

3.4.1. Erect structural steel framing system in accordance with the Drawings and metal building system manufacturer's erection drawings.

3.4.2. Field Modifications:

A. Require approval of metal building system manufacturer.

B. Responsibility of building erector.

3.5. Building Components

3.5.1. Install building components per approved erection drawings and manufactures written installation instructions.

3.6. Touch Up

3.6.1. Following erection or installation, all damaged or marred areas of components shall be cleaned and touched up with the same material and color as the damaged finish.

3.7. Schedule

Not applicable.

END OF SECTION

Attachments:

Attachment A:

Reference Drawings:

18-11-100-001 A-USC COMTEST PROJECT ARCHITECTURAL TITLE SHEET

18-11-203-001 A-USC COMTEST PROJECT ARCHITECTURAL LOWER LEVEL FLOOR PLAN

18-11-203-001 A-USC COMTEST PROJECT ARCHITECTURAL LEVEL 1 FLOOR PLAN

18 11-204-001 A-USC COMTEST PROJECT ARCHITECTURAL ROOF PLAN

18-11-205-001 A-USC COMTEST PROJECT ARCHITECTURAL EXTERIOR ELEVATIONS

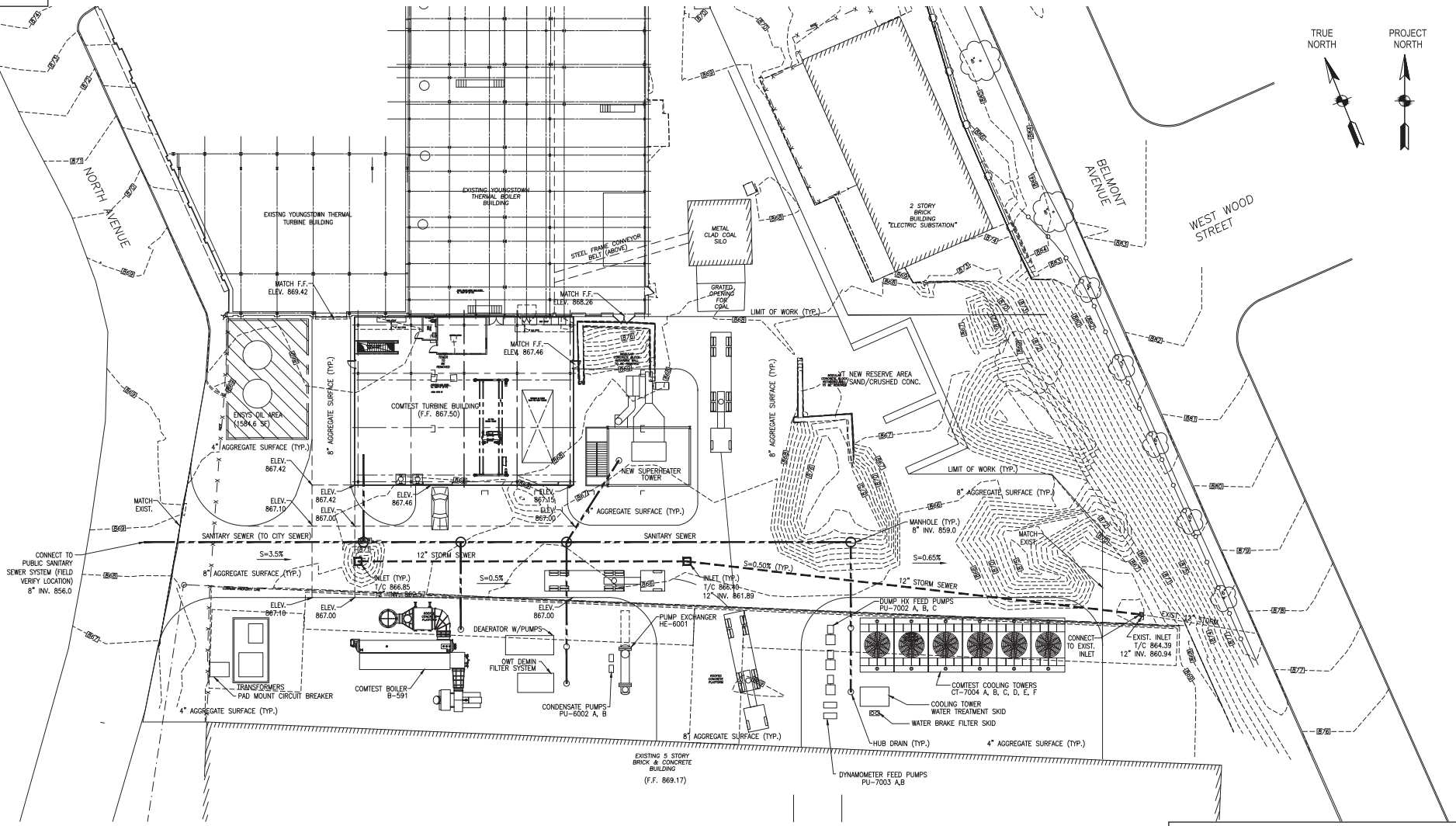
18-11-206-001 A-USC COMTEST PROJECT ARCHITECTURAL BUILDING SECTIONS

Attachment B:

Moffitt Corporation Vendor Information

Civil

12-11-100-001



SITE PLAN
SCALE: 1" = 20'-0"

NOTES:

1. NEW SURFACING IN VEHICLE TRAFFIC AREAS TO BE 8" COMPACTED AGGREGATE SURFACE, ODOT ITEM 304 OR EQUAL.
2. NEW SEWER PIPING SHALL BE PVC PIPE, ASTM D3034, TYPE PSM, SDR 35.
3. NEW MANHOLES AND INLETS SHALL BE PRECAST CONCRETE STRUCTURES PER ASTM C478 AND DESIGNED FOR H-20 STRUCTURAL LOADING.

REVISION APPROVAL RECORD				REV		REV NO.	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C						A	3/31/16	ISSUED FOR FEED		

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A	3/31/16	MTJ	DM
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV.NO.

PROJECT NO.: 31609
DRAWN: MTJ DATE:
CHECKED: DATE:
SCALE: 1" = 20'-0"

URS ENERGY & CONSTRUCTION Inc. - an AECOM Company
1500 West 3rd St., Suite 200
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Independence, OH 44131
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A-USC COMTEST PROJECT
CIVIL
SITE PLAN

DWG. NO. 12-11-100-001 REV A

INCHES 1 2 3 CENTIMETERS 1 2 3 4 5 6

8 7 6 5 4 3 2 1

D C B A

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13-11-200-001

GENERAL:

1. FOUNDATION AND SLAB ELEVATIONS ARE REFERENCED TO MEAN SEA LEVEL ELEVATION XXX-X" = REFERENCE (-0'-0").
2. IT SHALL BE THE CONTRACTOR'S RESPONSIBILITY TO VERIFY ALL DIMENSIONS AND CONDITIONS AT THE JOB SITE AND TO CROSS-CHECK DETAILS AND DIMENSIONS ON THE STRUCTURAL DRAWINGS WITH RELATED REQUIREMENTS ON THE ARCH'L, MECHANICAL, AND ELECTRICAL DRAWINGS. FLOOR AND WALL OPENINGS, SLEEVES, AND OTHER ARCH'L, MECHANICAL, AND ELECTRICAL REQUIREMENTS MUST BE COORDINATED BEFORE THE CONTRACTOR PROCEEDS WITH CONSTRUCTION.
3. ALL ENGINEERING DESIGN, CONSTRUCTION, AND TESTING SHALL CONFORM TO THE REQUIREMENTS OF THE OHIO BUILDING CODE (IBC 2009).
4. THESE DOCUMENTS DO NOT INCLUDE THE NECESSARY COMPONENTS FOR CONSTRUCTION SAFETY, SAFETY, CARE OF ADJACENT PROPERTIES DURING CONSTRUCTION, AND COMPLIANCE WITH LOCAL REGULATIONS REGARDING SAFETY IS, AND SHALL BE, THE CONTRACTOR'S RESPONSIBILITY.
5. REFER TO THE ARCHITECTURAL DRAWINGS FOR DIMENSIONS NOT SHOWN ON THE STRUCTURAL DRAWINGS.
6. ALL OMISSIONS OR CONFLICTS BETWEEN THE VARIOUS ELEMENTS OF THE WORKING DRAWINGS AND/OR SPECIFICATIONS SHALL BE BROUGHT TO THE ATTENTION OF THE ENGINEER BEFORE PROCEEDING WITH ANY WORK SO INVOLVED.
7. DESIGN LOADS; SEE DRAWING 13-11-300-001 FOR DESIGN NOTES

SPECIAL INSPECTIONS:

1. THE CONTRACTOR SHALL EMPLOY AN APPROVED AGENCY TO PERFORM TESTS, INSPECTIONS, AND REPORTS AS REQUIRED BY THE OHIO BUILDING CODE (IBC 2009). CONSTRUCTION REQUIRING SPECIAL INSPECTION ARE LISTED BELOW, ALL TEST RESULTS AND REPORTS ARE TO BE SUBMITTED TO THE BUILDING OFFICIAL AND TO THE REGISTERED DESIGN PROFESSIONAL IN RESPONSIBLE CHARGE.
2. CONCRETE CONSTRUCTION SHALL HAVE SPECIAL INSPECTIONS AS REQUIRED BY SECTION 1705.3 & TABLE 1705.3.
3. MASONRY CONSTRUCTION SHALL HAVE SPECIAL INSPECTION AS REQUIRED BY LEVEL B QUALITY ASSURANCE AS DEFINED IN TABLE 1.19.2 OF ACI 530.1H11. THE COMPRESSIVE STRENGTH OF THE CMU WALLS SHALL BE DETERMINED BY THE UNIT UNIT STRENGTH METHOD, PER SECTION 2105.2.2.1 OF THE CODE. THIS SECTION REQUIRES THE CMU UNITS BE TESTED IN ACCORDANCE WITH ASTM C 140.

SHOP DRAWING REVIEW:

1. AECOM, INC. WILL REVIEW CONTRACTORS SHOP DRAWINGS AND RELATED SUBMITTALS TO VERIFY THE PROPOSED MATERIALS AND FABRICATIONS FULFILL FULFILL THE DESIGN INTENT.
2. BEFORE SUBMITTING A SHOP DRAWING OR ANY RELATED MATERIAL TO AECOM, INC., CONTRACTOR SHALL: REVIEW EACH SUCH SUBMISSION FOR CONFORMANCE WITH THE MEANS , METHODS, TECHNIQUES, SEQUENCES, AND OPERATIONS OF CONSTRUCTION, AND SAFETY PRECAUTIONS AND PROGRAMS INCIDENTAL THERETO, ALL OF WHICH ARE THE SOLE RESPONSIBILITY OF CONTRACTOR; APPROVE EACH SUCH SUBMISSION BEFORE SUBMITTING IT; AND SO STAMP EACH SUCH SUBMISSION BEFORE SUBMITTING IT. THE CONTRACTOR IS FULLY RESPONSIBLE FOR ANY CHANGES CHANGES OR DELAYS CAUSED BY PREMATURELY SUBMITTING SHOP DRAWINGS WITHOUT THE CONTRACTORS' REVIEW AND STAMP. AECOM, INC. SHOP DRAWING REVIEW AND STAMP DOES NOT ALLEVIATE THE CONTRACTOR'S RESPONSIBILITY TO REVIEW AND STAMP THE SAME SHOP DRAWINGS. AECOM, INC. SHALL ASSUME THAT NO SHOP DRAWING OR RELATED SUBMITTAL COMPRISES A VARIATION UNLESS CONTRACTOR ADVISES AECOM, INC. OTHERWISE VIA A WRITTEN INSTRUMENT WHICH IS ACKNOWLEDGED BY AECOM, INC. IN WRITING.
3. THE SHOP DRAWINGS AND RELATED MATERIAL IF ANY, CALLED FOR SHALL BE INDICATED WITHIN THE GENERAL AND MATERIAL NOTES AND SPECIFICATIONS IF APPLICABLE. THE CONTRACTOR SHALL ALLOW TEN (10) DAYS FOR AECOM, INC. TO PERFORM THE REVIEW, AECOM, INC. SHALL RETURN SHOP DRAWING AND RELATED MATERIALS WITH COMMENTS PROVIDED THAT EACH SUBMISSION HAS BEEN CALLED FOR AND IS STAMPED BY CONTRACTOR AS INDICATED ABOVE. AECOM, INC. SHALL RETURN WITHOUT COMMENT MATERIAL NOT REQUIRED.

FOUNDATION:

1. ALL FOUNDATIONS ARE TO BE PLACED ON UNDISTURBED SOIL OR STRUCTURAL FILL COMPACTED IN ACCORDANCE WITH SITE GEOTECHNICAL ENGINEER. OPEN EXCAVATIONS SHALL BE PROTECTED WITH A 2 INCH THICK MAT OF LEAN CONCRETE.
2. CONTRACTOR TO PROVIDE ALL SHORING AND BRACING NECESSARY TO INSTALL FOUNDATIONS AND PROTECT EXISTING STRUCTURES AND FOUNDATIONS.
3. A GEOTECHNICAL REPRESENTATIVE SHALL BE EMPLOYED BY AECOM TO INSPECT AND APPROVE ALL EXCAVATIONS PRIOR TO PLACEMENT OF ANY COMPACTED FILL AND/OR CONCRETE FOUNDATIONS, SLABS, ETC, CONSTRUCTION CONTRACTOR TO GIVE A MINIMUM OF TWENTY-FOUR (24) HOURS NOTICE PRIOR TO REQUIRED INSPECTION.
4. ALL FOUNDATION BEARING AND FILL MATERIALS SHALL BE INSPECTED AND INSPECTED AND APPROVED BY THE INSPECTOR PRIOR TO PLACING CONCRETE.
5. ALL FILL AND BACKFILL MATERIALS SHALL BE GRANULAR SOILS COMPACTED TO 98% MAXIMUM DENSITY PER A.S.T.M. D-698 METHOD.

FOUNDATION: (CONT.)

6. THE CONTRACTOR SHALL BECOME FAMILIAR WITH THE SURVEY AND THE GEOTECHNICAL INVESTIGATION REPORT BEFORE STARTING CONSTRUCTION, ALL FOUNDATION WORK SHALL BE IN ACCORDANCE WITH THE RECOMMENDATIONS OF THE GEOTECHNICAL INVESTIGATION REPORT BY CTL ENGINEERING, INC. DATED FEB, 22, 2016, EXCEPT WHERE NOTED OTHERWISE ON DRAWINGS OR SPECIFICATIONS.
7. MAXIMUM ALLOWABLE NET BEARING PRESSURE: = 3.5 KSF.
8. ALL ORGANIC TOPSOILS SHALL BE STRIPPED FROM THE AREA UPON WHICH THE PROPOSED STRUCTURE IS TO BE LOCATED.
9. ALL EXCAVATION FOR STRUCTURES SHALL BE KEPT DEWATERED UNTIL BACKFILL IS IN PLACE. EXCAVATION FOR STRUCTURES SHALL INCLUDE ALL NECESSARY SHEETING AND SHORING.
10. WHERE THE FOUNDATION IS OVER EXCAVATED, REMOVE ALL DISTURBED FOUNDATION SOIL AND REPLACE WITH GRANULAR MATERIAL PROPERLY COMPACTED AS DIRECTED.
11. NOTIFY STRUCTURAL ENGINEER OF ANY UNUSUAL SOIL CONDITIONS THAT ARE IN VARIANCE WITH THE GEOTECHNICAL REPORT.

CONCRETE:

1. ALL WORK SHALL BE IN ACCORDANCE WITH THE OHIO BUILDING CODE (IBC 2009).
2. THE CONTRACTOR SHALL FIELD VERIFY LOCATIONS, DIMENSIONS AND ELEVATIONS OF EXISTING STRUCTURES AND UTILITIES WITHIN THE WORK AREA THAT MAY AFFECT THE PLACEMENT AND/OR ERECTION OF MATERIALS FOR THIS PROJECT. COORDINATE WITH OTHER DISCIPLINE'S WORK. THE OWNER'S REPRESENTATIVE SHALL BE NOTIFIED IMMEDIATELY OF ALL DISCEPANCIES FOUND.
3. EXCEPT AS SUPPLEMENTED AND/OR MODIFIED BY THE CONTRACT TECHNICAL SPECIFICATIONS, DETAILING, FABRICATION AND CONSTRUCTION OF ALL REINFORCED CONCRETE SHALL CONFORM TO:
   - ACI 318-11 BUILDING CODE REQUIREMENTS FOR STRUCTURAL CONCRETE
   - ACI 301-10 SPECIFICATIONS FOR STRUCTURAL CONCRETE
   - ACI 315-99 MANUAL OF STANDARD PRACTICE FOR DETAILING REINFORCED CONCRETE STRUCTURES.

4. CONCRETE:
   - 4.1 TYPE II CEMENT SHALL BE USED THROUGHOUT UNLESS OTHERWISE NOTED.
   - 4.2 COARSE AGGREGATE SHALL BE A MAXIMUM OF ¾" IN SIZE FOR ALL STRUCTURES.
   - 4.3 COMPRESSIVE STRENGTH OF CONCRETE (Fc') SHALL BE 4000 PSI AT 28 DAYS. EXCEPT SPREAD FOOTINGS WHICH SHALL BE 3000 PSI AT 28 DAYS.
   - 4.4 ALL DAMAGED CONCRETE STRUCTURES SHALL BE REPLACED PER THE ENGINEER'S DIRECTION.
   - 4.5 AIR ENTRAINED CONCRETE SHALL BE USED AT ALL EXTERIOR WALLS AND SLABS TO RECEIVE A BROOM FINISH. AIR ENTRAINED CONCRETE SHALL NOT BE USED FOR CONCRETE SLABS THAT ARE TO RECEIVE A TROWELED FINISH. ENTRAINED AIR SHALL BE 5.5% BY VOLUME +/- 1%. AIR ENTRAINING ADMIXURES SHALL CONFORM TO ASTM C-260.

5. ALL FILL AND BACK-FILL UNDER SLABS, SHALL BE COMPACTED #57 LIMESTONE.
6. ALL EXPOSED CONCRETE CORNERS TO BE CHAMFERED 3/4" @ 45° UNLESS NOTED OTHERWISE.
7. ALL ANCHOR RODS SHALL CONFORM TO ASTM F1554 GRADE 36 MATERIAL U.N.O.. GRADE IS SPECIFIED w/ANCHOR DETAIL. NUTS SHALL BE ASTM A563, GRADE A, HEAVY HEX.
8. PRIOR TO PLACEMENT OF BUILDING FOUNDATIONS AND SLAB, COORDINATE INSTALLATION OF ANY REQUIRED GROUNDING CABLES OR GROUNDING LOOPS WITH OWNER'S DESIGNATED ELECTRICAL ENGINEERING REPRESENTATIVE. EXERCISE CAUTION DURING EXCAVATION SO AS TO AVOID AND DAMAGE ANY EXISTING UNDERGROUND CABLES. ALSO COORDINATE ANY EXISTING OR NEW UNDERGROUND PIPING.
9. DEMOLITION REQUIRED TO INSTALL CONCRETE WORK MUST BE CARRIED OUT IN SUCH A MANNER AS TO NOT ADVERSELY AFFECT THE INTEGRITY OF, OR ACCESS TO, ADJACENT STRUCTURES AND TRAFFIC AREAS.
10. PROVIDE HORIZONTAL BENT BARS AT ALL CORNERS AND INTERSECTIONS OF CONCRETE FOUNDATION WALLS USING THE SAME SIZE AND SPACING AS FOR HORIZONTAL WALL REINFORCING, USE BENT DOWELS IF NECESSARY TO DEVELOP ANCHORAGE,
11. AT ALL RE-ENTRANT CORNERS AND AROUND ALL OPENINGS, ADD (2) #4 X 4'-0" LG. DIAGONAL AT TOP IN SLABS.
12. DOWELS DRILLED INTO EXISTING CONCRETE OR BLOCK MASONRY CONSTRUCTION SHALL BE FULLY ANCHORED USING HILTI HIT-HY 200 ANCHORING SYSTEM UNLESS OTHERWISE SPECIFIED ON DRAWINGS,
13. ALL EXTERIOR SLABS TO BE BROOM FINISHED, UNLESS NOTED ON PLAN.

CONCRETE: (CONT.)

14. JOINT FILLER AND SEALANT:
    - 14.1 JOINT FILLER SHALL BE OF THE PREFORMED NON-BITUMINOUS TYPE, CONFORMING TO ASTM D1752. SIZE AS NOTED ON THE DRAWINGS.
    - 14.2 JOINT SEALANT SHALL CONFORM TO ASTM C920, TYPE S, ONE PART POLYURETHANE ELASTOMERIC JOINT SEALANT, SEALANT SHALL BE GRADE P SELF-LEVELING, POUR GRADE FOR HORIZONTAL JOINTS AND GRADE NS NON-SAG, GUN GRADE FOR VERTICAL OR OVERHEAD JOINTS.
    - 14,3 CONTRACTION JOINT FILLER SHALL BE A TWO PART SEMI RIGID EPOXY.
    - 14.4 CONCRETE EDGES THAT ARE TO RECEIVE JOINT SEALANT SHALL BE PLACED AGAINST NON-OILED FORMS. THE NON-OILED PORTION SHALL EXTEND A MINIMUM OF 2½" FROM THE EDGE TO BE SEALED,
    - 14,5 JOINTS RECEIVING SEALANT SHALL FIRST BE COATED WITH PRIMER IF REQUIRED BY THE SEALANT MANUFACTURER, JOINT PREPARATION AND APPLICATION OF PRIMER AND SEALANT SHALL BE IN ACCORDANCE WITH MANUFACTURER'S INSTRUCTIONS.
    - 14,6 BACKER ROD SHALL MEET ASTM D5249, TYPE I.
15. EXPANSION, CONSTRUCTION AND CONTRACTION JOINTS:
    - 15.1 EXPANSION, CONSTRUCTION AND CONTRACTION JOINTS SHALL BE PROVIDED IN ACCORDANCE WITH TYPICAL DETAILS AND AS LOCATED OR DETAILED ON THE DRAWINGS. ANY OTHERS DEEMED NECESSARY SHALL BE APPROVED BY THE ENGINEER.
16. SLAB ON GROUND FLATNESS & LEVELNESS:
    - 16,1 FLOOR SLABS FOR THE AREAS DEFINED BELOW SHALL BE PLACED AND FINISHED TO THE MINIMUM FLATNESS AND LEVELNESS REQUIREMENTS AS DEFINED IN ACI 117-06,
    - 16,2 FLATNESS: OVERALL FF=25
      MINIMUM LOCAL FF=15
      LEVELNESS: OVERALL FF=20
      MINIMUM LOCAL FF=12

REINFORCING STEEL:

1. ALL REINFORCING STEEL SHALL BE NEW DEFORMED BARS CONFORMING TO A.S,T.M, A-615 GRADE 60 UNLESS NOTED OTHERWISE.
2. ALL MASONRY REINFORCING SHALL BE PLACED AND SUPPORTED IN CONFORMANCE WITH THE PROVISIONS OF THE LATEST EDITION OF A,C,I, 530,1/ ASCE 6/ TMS 602.
3. TIE WIRE SHALL CONFORM TO A,S,T,M, A-82.
4. WELDED WIRE FABRIC SHALL BE SPLICED WITH A MINIMUM LAP OF TWO MODULES.
5. WELDED WIRE FABRIC SHALL CONFORM WITH A,S,T,M, A-185.
6. ALL REINFORCING STEEL SHALL HAVE THE FOLLOWING MINIMUM CONCRETE COVERAGE, UNLESS NOTED OTHERWISE:
   - CONCRETE PLACED AGAINST EARTH = 3"
   - CONCRETE WITH FORMED SURFACES IN CONTACT WITH EARTH = 2"
   - CONCRETE EXPOSED TO WEATHER = 2"
   - SLABS, WALLS, AND JOISTS NOT EXPOSED TO WEATHER OR IN CONTACT WITH EARTH (#11 BARS AND SMALLER) = 1 1/2"
   - BEAMS, GIRDERS AND COLUMNS NOT EXPOSED TO WEATHER OR IN CONTACT WITH EARTH = 1 1/2"

7. DETAILING OF ALL BENT BARS SHALL COMPLY WITH THE ACI 318-08 CODE.
8. WELDING OF REINFORCING BARS IS NOT PERMITTED, UNLESS NOTED OTHERWISE.
9. THE MINIMUM LENGTH OF TENSION LAP SPLICES SHALL BE AS SHOWN BELOW, U,N,O,.

BAR SIZE	MIN. LAP LENGTH TOP BARS	OTHER BARS
#3	24"	19"
#4	33"	25"
#5	41"	31"
#6	50"	38"
#7	71"	54"
#8	81"	62"
#9	91"	70"

10. REINFORCING STEEL SHALL BE ACCURATELY PLACED AND ADEQUATELY SECURED IN POSITION. LOCATION OF REINFORCEMENT SHALL BE AS INDICATED ON DRAWINGS. THE FOLLOWING MINIMUM PROTECTION FOR REINFORCEMENT SHALL BE PROVIDED, EXCEPT AS NOTED ON DRAWINGS.
11. UNLESS OTHERWISE APPROVED BY THE ENGINEER, BAR SUPPORTS SHALL BE:
    - 11,1 PRECAST CONCRETE BLOCKS WHEN CONCRETE IS CAST ON GRADE
    - 11,2 CRSI CLASS 3-NO PROTECTION, BRIGHT BASIC WHERE CONCRETE WILL NOT BE EXPOSED TO VIEW UNLESS OTHERWISE NOTED ON THE DRAWINGS,
    - 11,3 CRSI CLASS 1-MAXIMUM PROTECTION. PLASTIC COATED WHERE CONCRETE WILL BE EXPOSED TO VIEW OR IN A CORROSIVE ENVIRONMENT, UNLESS OTHERWISE NOTED ON THE DRAWINGS.

ABBREVIATIONS

TYPE	DESCRIPTION	TYPE	DESCRIPTION
A.B.	ANCHOR BOLT	L	LENGTH
ALT.	ALTERNATE	LLBB	LONG LEGS BACK-TO-BACK
ARCH.	ARCHITECTURAL	SLBB	SHORT LEGS BACK-TO-BACK
AVG.	AVERAGE	L.P.	LOW POINT
BFF.	BELOW FINISH FLOOR	MAX.	MAXIMUM
BLDG.	BUILDING	MECH.	MECHANICAL
BM.	BEAM	MEZZ.	MEZZANINE
B.O.	BOTTOM OF	MFR.	MANUFACTURER
BRG.	BEARING	MIN.	MINIMUM
		MISC.	MISCELLANEOUS
C.J.	CONTROL JOINT		
CLR.	CLEAR	N.S.	NEAR SIDE
C.M.U.	CONCRETE MASONRY UNIT		
CONC.	CONCRETE	O.C.	ON CENTER
CONST. JT.	CONSTRUCTION JOINT	O.D.	OUTSIDE DIAMETER
CONT.	CONTINUOUS	O.H.	OVER HEAD
		O/O	OUT TO OUT
D	DEPTH	P.S.F.	POUNDS PER SQUARE FOOT
DET.	DETAIL	P.S.I.	POUNDS PER SQUARE INCH
DIA.	DIAMETER		
		R.	RADIUS
ELEV.	ELEVATION	REINF.	REINFORCEMENT
EQ.	EQUAL	REQ'D.	REQUIRED
E.W.	EACH WAY		
EXIST.	EXISTING	SIM.	SIMILAR
FIN.	FINISH	T&B	TOP AND BOTTOM
FLR.	FLOOR	T.O.	TOP OF
FNDN.	FOUNDATION	T.O.S.	TOP OF STEEL
F.S.	FAR SIDE	TYP.	TYPICAL
FTG.	FOOTING		
		U.N.O.	UNLESS NOTED OTHERWISE
GA.	GAUGE		
		VERT.	VERTICAL
HORIZ.	HORIZONTAL	V.S.C.	VERT, SLOTTED CONN.
H.P.	HIGH POINT		
		W.W.F.	WELDED WIRE FABRIC
INSUL.	INSULATION	W	WIDTH
		W/	WITH

PRELIMINARY

REVISION APPROVAL RECORD				REV		REV NO.	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C										
						A	3/31/16	ISSUED FOR FEED	JJM	

DRAWING STATUS	REV	DATE	SDE	PEM
ISSUED				
PRELIMINARY	A	3/31/16	JJM	DM
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED, DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV.NO.

PROJECT NO.: 31609
DRAWN: TCG DATE: 02-22-16
CHECKED: DATE:
SCALE: AS NOTED

URS ENERGY & CONSTRUCTION Inc, - an AECOM Company
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ENERGY INDUSTRIES of OHIO
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Independence, OH 44131
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A-USC COMTEST PROJECT
GENERAL NOTES - CONCRETE

DWG. NO. 13-11-200-001 REV A

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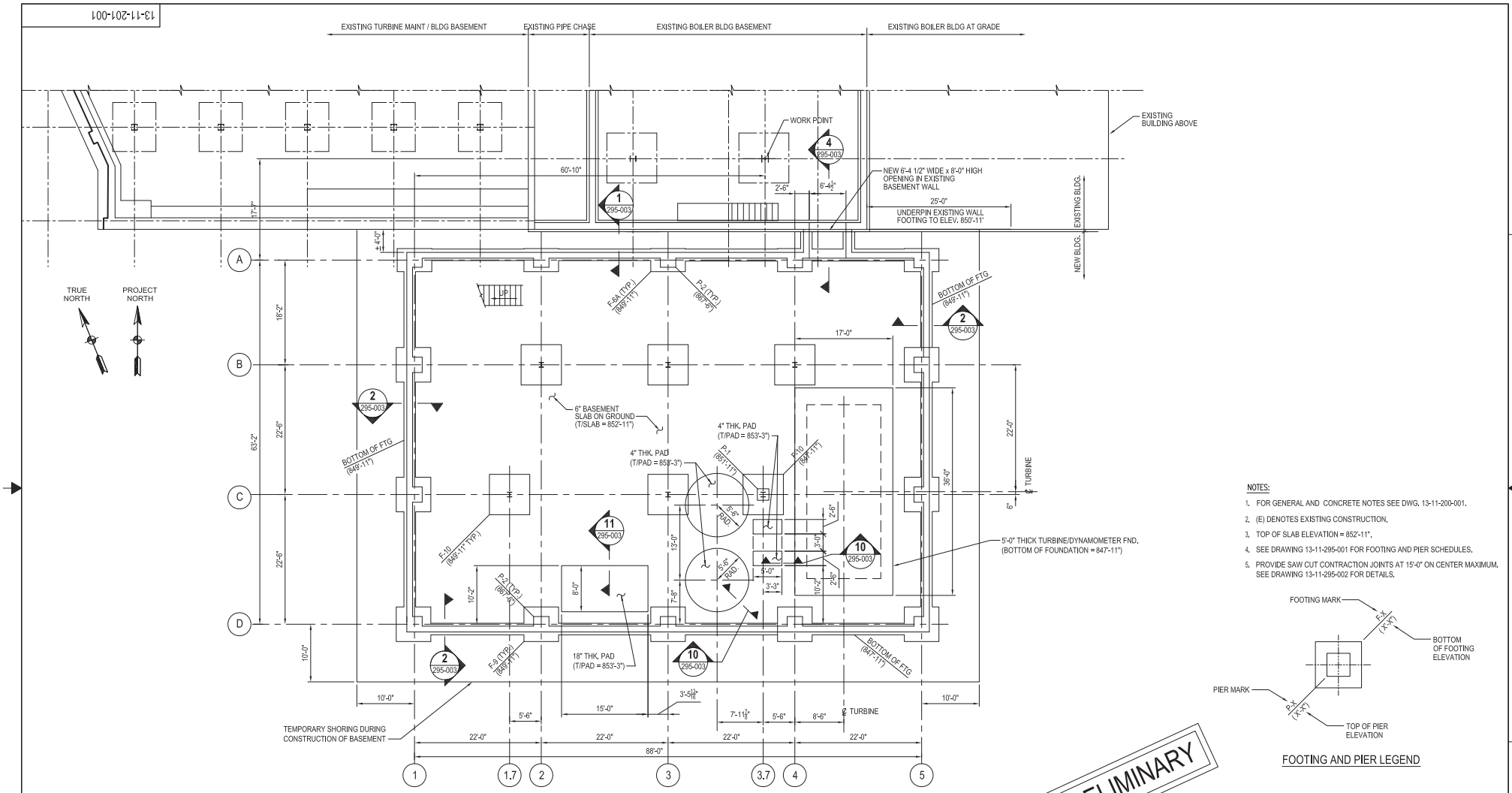
INCHES CENTIMETERS

13-11-201-001



FOUNDATION PLAN

SCALE: 1/8"=1'-0"

NOTES:

1. FOR GENERAL AND CONCRETE NOTES SEE DWG. 13-11-200-001.
2. (E) DENOTES EXISTING CONSTRUCTION.
3. TOP OF SLAB ELEVATION = 852'-11".
4. SEE DRAWING 13-11-295-001 FOR FOOTING AND PIER SCHEDULES.
5. PROVIDE SAW CUT CONTRACTION JOINTS AT 15'-0" ON CENTER MAXIMUM. SEE DRAWING 13-11-295-002 FOR DETAILS.

FOOTING AND PIER LEGEND

PRELIMINARY

REVISION APPROVAL RECORD				REV		REV ID	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
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ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C						B	3/31/16	ISSUED FOR FEED	JJM	
						A	2/16/16	ISSUED FOR REVIEW	JJM	

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	B	3/31/16	JJM	DM
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED, DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV.NO.

PROJECT NO.: 31609
DRAWN: TCG DATE: 01-21-16
CHECKED: DATE:
SCALE: AS NOTED

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A-USC COMTEST PROJECT
COMTEST TURBINE BUILDING
FOUNDATION PLAN

DWG. NO. 13-11-201-001 REV B

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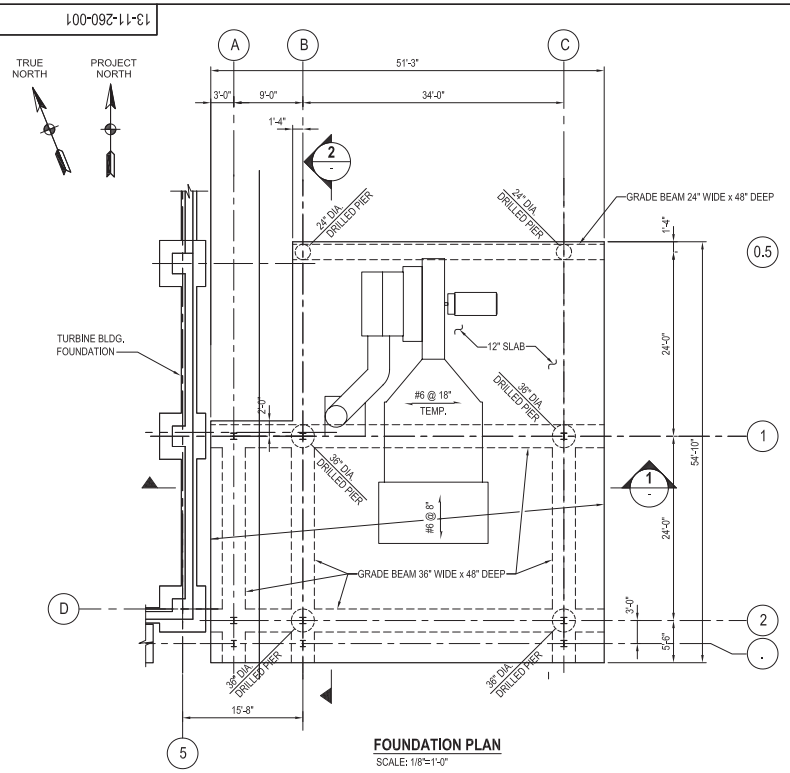
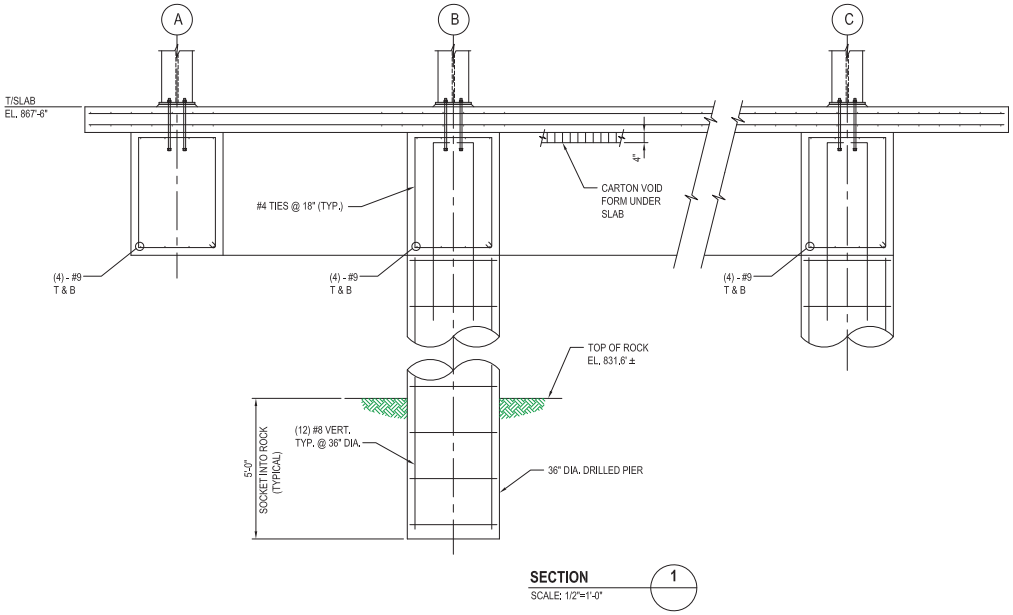
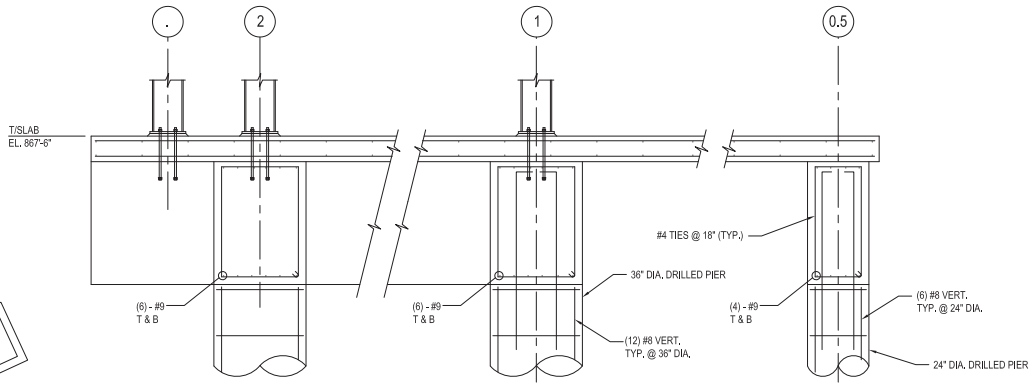
13-11-260-001



FOUNDATION PLAN
SCALE: 1/8"=1'-0"



SECTION 1
SCALE: 1/2"=1'-0"



SECTION 2
SCALE: 1/2"=1'-0"

PRELIMINARY

REVISION APPROVAL RECORD				REV		REV #	DATE	REVISIONS	BY	CHKR
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ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
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GEN. ARRANG.										
I & C										
						A	3/31/16	ISSUED FOR FEED	JJM	

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A	3/31/16	JJM	DM
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED, DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV.NO.

PROJECT NO.: 31609
DRAWN: TCG DATE: 01-21-16
CHECKED: DATE:
SCALE: AS NOTED

URS ENERGY & CONSTRUCTION Inc, - an AECOM Company
1500 West 3rd St., Suite 200
Cleveland, OH 44113
(216) 523-5600
AECOM

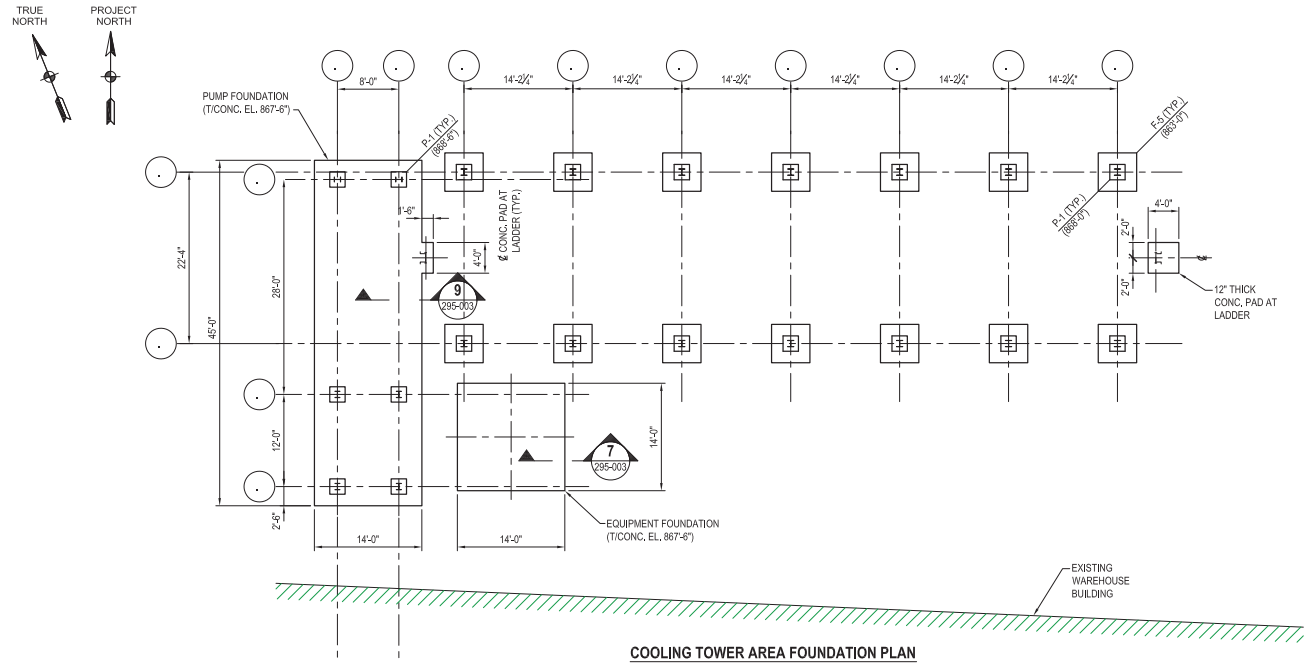
ENERGY INDUSTRIES of OHIO
6100 Oak Tree Boulevard, Suite 200
Independence, OH 44131
(216) 643-2952

A-USC COMTEST PROJECT
SUPER HEATER
FOUNDATION PLAN

DWG. NO. 13-11-260-001 REV A

INCHES CENTIMETERS
EC_D_Size.dwg

13-11-260-002

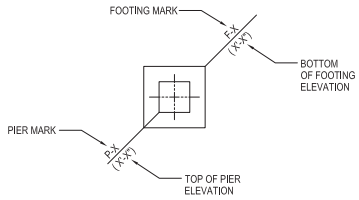


COOLING TOWER AREA FOUNDATION PLAN

SCALE: 1/8"=1'-0"

NOTES:

1. FOR GENERAL AND CONCRETE NOTES SEE DWG. 13-11-200-001.
2. SEE DRAWING 13-11-295-001 FOR FOOTING AND PIER SCHEDULES.
3. FINISHED GRADE CONSIDERED AT ELEVATION = 867'-0".



FOOTING AND PIER LEGEND

PRELIMINARY

REVISION APPROVAL RECORD				REV		REV #	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C										
						A	3/31/16	ISSUED FOR FEED	JJM	

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A	3/31/16	JJM	DM
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV.NO.

PROJECT NO.: 31609

DRAWN: TCG DATE: 02-25-16

CHECKED: DATE:

SCALE: AS NOTED

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AECOM

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6100 Oak Tree Boulevard, Suite 200
Independence, OH 44131
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A-USC COMTEST PROJECT
COOLING TOWER AREA
FOUNDATION PLAN

DWG. NO. 13-11-260-002 REV A

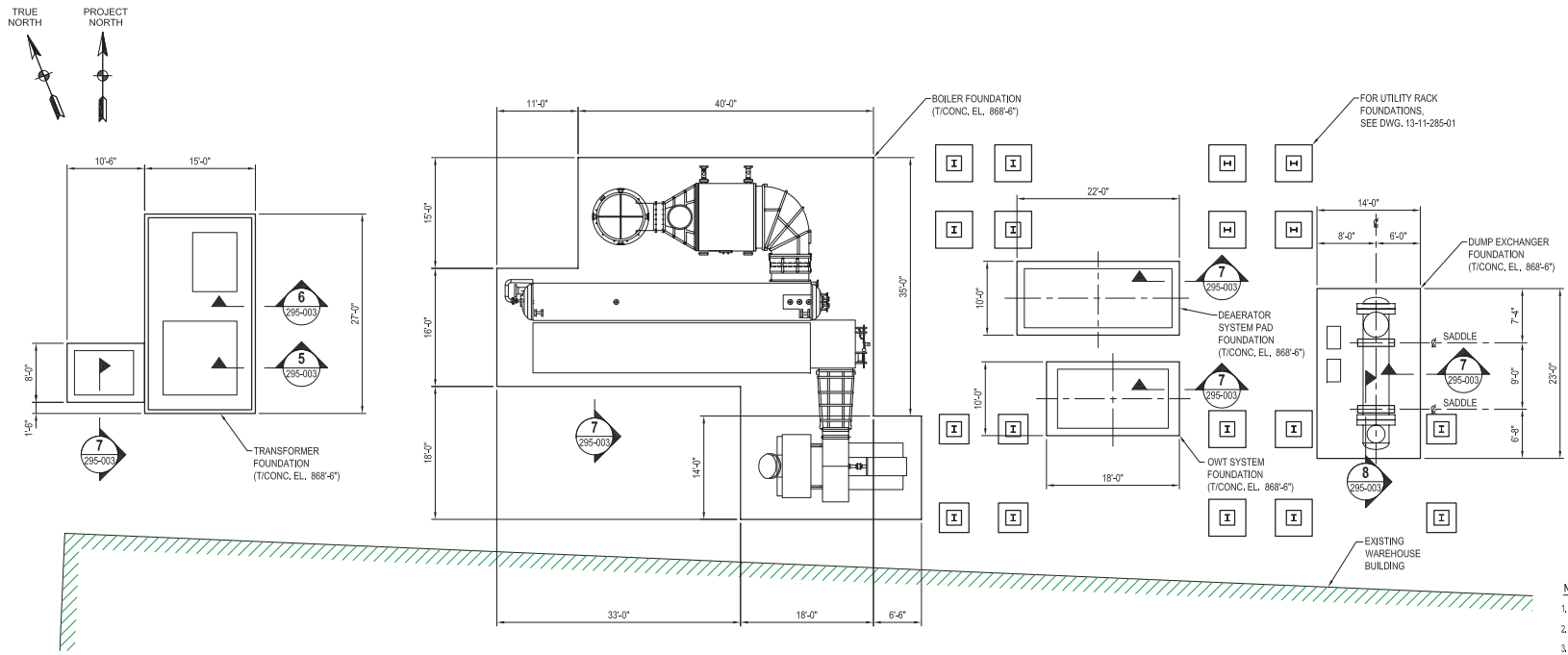
EC_D_Size.dwg

INCHES 1 2 CENTIMETERS 1 2 3 4 5 6

8 7 6 5 4 3 2 1

D C B A

13-11-260-003

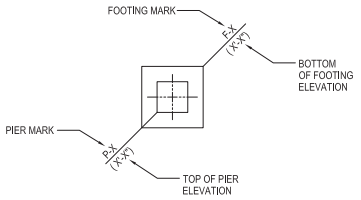


BOILER AREA FOUNDATION PLAN

SCALE: 1/8"=1'-0"

NOTES:

1. FOR GENERAL AND CONCRETE NOTES SEE DWG. 13-11-200-001.
2. SEE DRAWING 13-11-295-001 FOR FOOTING AND PIER SCHEDULES.
3. FINISHED GRADE CONSIDERED AT ELEVATION = 868'-0".



FOOTING AND PIER LEGEND

PRELIMINARY

REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
A	3/31/16	ISSUED FOR FEED	JJM	

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A	3/31/16	JJM	DM
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED, DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV.NO.

PROJECT NO.: 31609
DRAWN: TCG DATE: 02-25-16
CHECKED: DATE:
SCALE: AS NOTED

URS ENERGY & CONSTRUCTION Inc, - an AECOM Company
1500 West 3rd St., Suite 200
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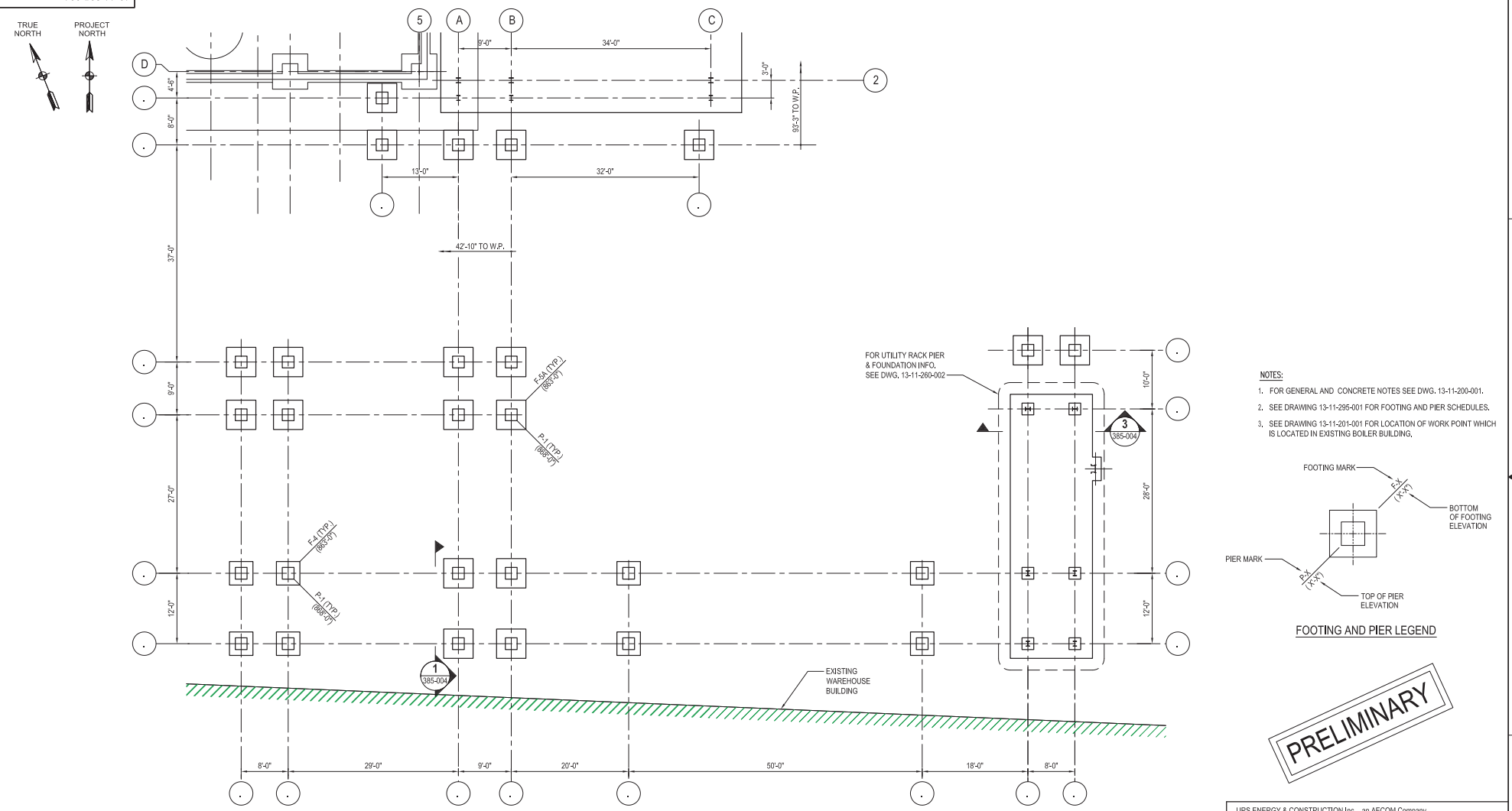
A-USC COMTEST PROJECT
BOILER AREA
FOUNDATION PLAN

DWG. NO. 13-11-260-003 REV A

INCHES CENTIMETERS

EC_D_Size.dwg

13-11-285-001



FOUNDATION PLAN
SCALE: 1/8"=1'-0"

NOTES:

1. FOR GENERAL AND CONCRETE NOTES SEE DWG. 13-11-200-001.
2. SEE DRAWING 13-11-295-001 FOR FOOTING AND PIER SCHEDULES.
3. SEE DRAWING 13-11-201-001 FOR LOCATION OF WORK POINT WHICH IS LOCATED IN EXISTING BOILER BUILDING.

FOOTING AND PIER LEGEND

PRELIMINARY

REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV	DATE	REVISIONS	BY	CHKR
A	3/31/16	ISSUED FOR FEED	JJM	

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A	3/31/16	JJM	DM
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED, DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV.NO.

PROJECT NO.: 31609
DRAWN: JMK DATE: 03-14-16
CHECKED: DATE:
SCALE: AS NOTED

URS ENERGY & CONSTRUCTION Inc, - an AECOM Company
1500 West 3rd St., Suite 200
Cleveland, OH 44113
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ENERGY INDUSTRIES of OHIO
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Independence, OH 44131
(216) 643-2952

A-USC COMTEST PROJECT
UTILITY RACK
FOUNDATION PLAN

DWG. NO. 13-11-285-001 REV A

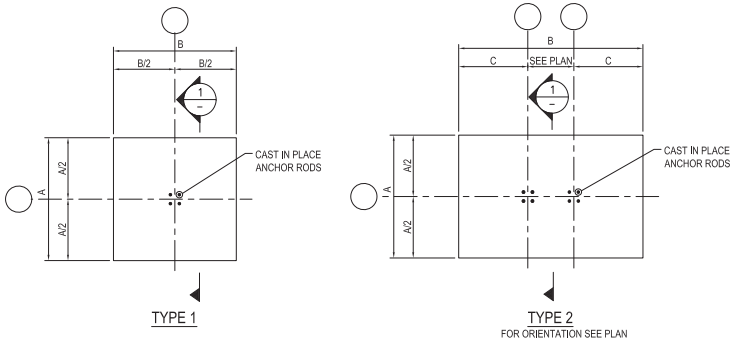
INCHES 1 2 CENTIMETERS 1 2 3 4 5 6

8 7 6 5 4 3 2 1

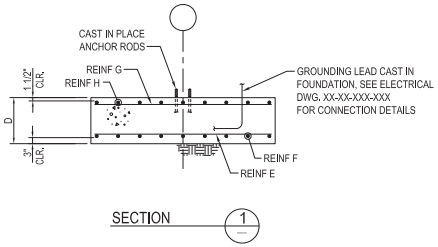
D C B A

EC_D_Size.dwg

13-11-295-001



COLUMN FOOTING PLANS



FOOTING SCHEDULE										
FTG. MARK	FTG. TYPE	FOOTING DIMS.				REINFORCING				REMARKS
		A	B	C	D	E	F	G	H	
F-4	1	4'-0"	4'-0"	-	1'-0"	(4) - #5	(4) - #5	(4) - #5	(4) - #5	
F-5	1	5'-0"	5'-0"	-	1'-0"	(5) - #5	(5) - #5	(5) - #5	(5) - #5	
F-5A	1	5'-0"	5'-0"	-	2'-0"	(5) - #5	(5) - #5	(5) - #5	(5) - #5	
F-6A	1	6'-0"	4'-0"	-	1'-2"	(7) - #5	(7) - #5	(7) - #5	(7) - #5	
F-9	1	9'-0"	9'-0"	-	1'-10"	(10) - #6	(10) - #6	(10) - #6	(10) - #6	
F-10	1	10'-0"	10'-0"	-	2'-0"	(9) - #7	(9) - #7	(9) - #7	(9) - #7	

PIER SCHEDULE			
PIER MARK	PIER SIZE	T/PIER ELEVATION	DETAIL
P-1	2'-0"x2'-0"	SEE PLAN	
P-2	2'-6"x2'-6"	SEE PLAN	

PRELIMINARY

REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
A	3/31/16	ISSUED FOR FEED	JJM	

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A	3/31/16	JJM	DM
APPROVED FOR CONSTRUCTION				

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PROJECT NO.: 31609
DRAWN: TCG DATE: 02-22-16
CHECKED: DATE:
SCALE: AS NOTED

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A-USC COMTEST PROJECT
FOUNDATION SECTIONS AND DETAILS

DWG. NO. 13-11-295-001 REV A

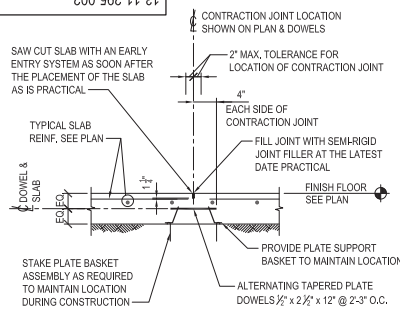
EC_D_Size.dwg

INCHES 1 2 CENTIMETERS 1 2 3 4 5 6

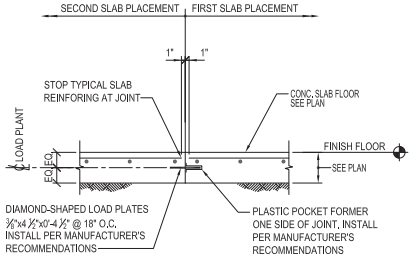
8 7 6 5 4 3 2 1

D C B A

13-11-295-002

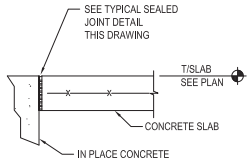


TYPICAL SLAB ON GROUND CONTRACTION JOINT DETAIL

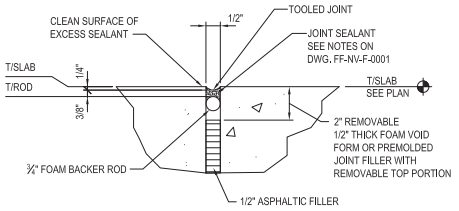


TYPICAL SLAB ON GROUND CONSTRUCTION JOINT DETAIL

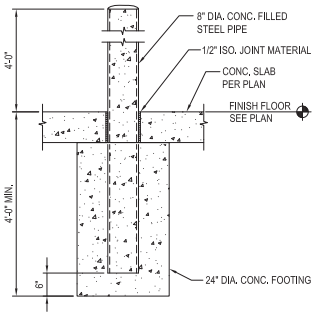
NOTES:
- CONSTRUCTION JOINT LOCATIONS SHOWN ON PLAN.
- CONTRACTOR MAY INSTALL A CONSTRUCTION JOINT AT ANY CONTRACTION JOINT LOCATION SHOWN ON PLAN AS REQUIRED TO FACILITATE CONSTRUCTION.



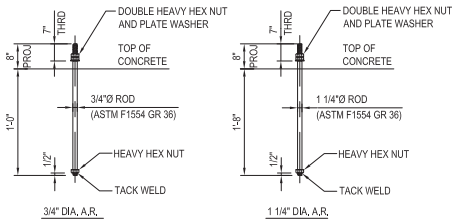
TYPICAL ISOLATION JOINT DETAIL



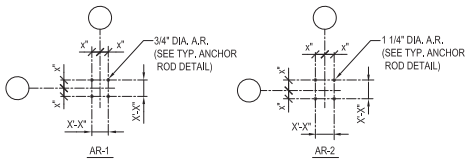
TYPICAL SEALED JOINT DETAIL



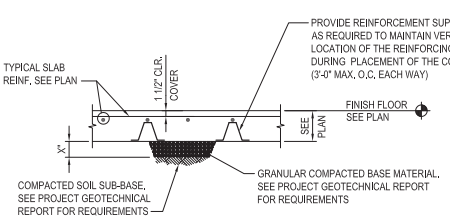
TYPICAL BOLLARD DETAIL



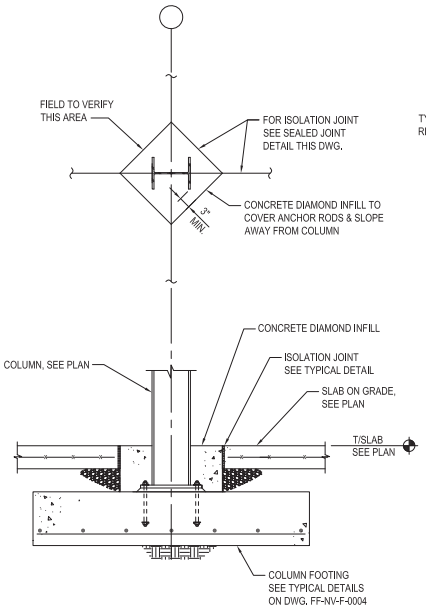
TYPICAL ANCHOR ROD DETAIL
NONE



ANCHOR ROD LAYOUT
NONE



TYPICAL SLAB ON GROUND DETAIL



TYPICAL SLAB @ COLUMN DETAIL

PRELIMINARY

REVISION APPROVAL RECORD				REV		REV #	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C						A	3/31/16	ISSUED FOR FEED	JJM	

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A	3/31/16	JJM	DM
APPROVED FOR CONSTRUCTION				

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PROJECT NO.: 31809
DRAWN: TCG DATE: 02-22-16
CHECKED: DATE:
SCALE: AS NOTED

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AECOM

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(216) 643-2952

A-USC COMTEST PROJECT
FOUNDATION SECTIONS AND DETAILS

DWG. NO. 13-11-295-002 REV A

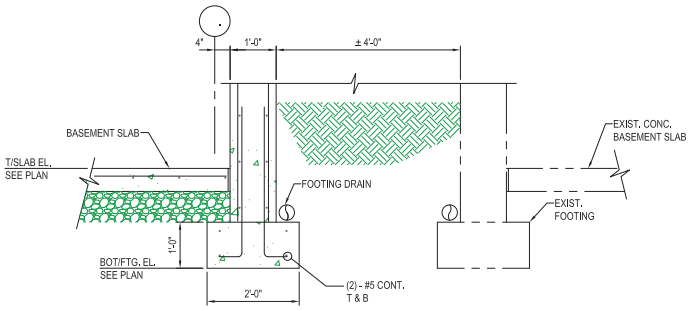
EC_D_Size.dwg

INCHES 1 2 CENTIMETERS 1 2 3 4 5 6

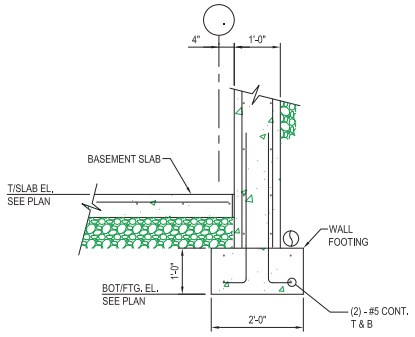
8 7 6 5 4 3 2 1

D C B A

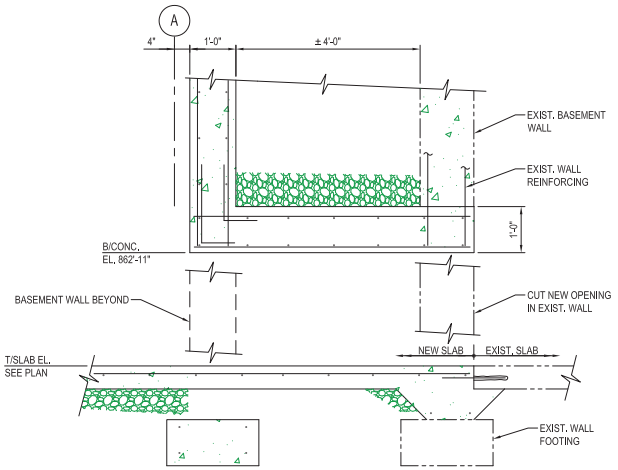
13-11-295-003



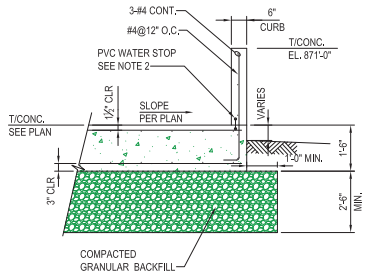
SECTION 1
SCALE: 3/4"=1'-0"



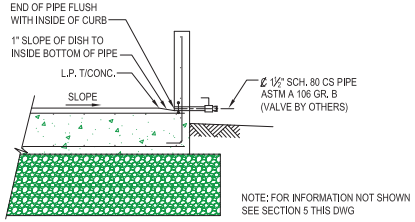
SECTION 2
SCALE: 3/4"=1'-0"



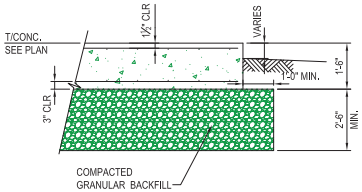
SECTION 4
SCALE: 3/4"=1'-0"



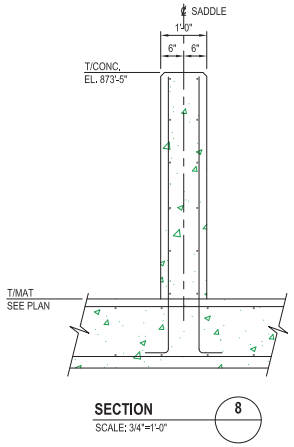
SECTION 5
SCALE: 1/2"=1'-0"



SECTION 6
SCALE: 1/2"=1'-0"

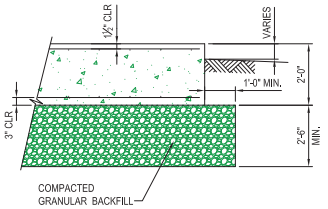


SECTION 7
SCALE: 1/2"=1'-0"

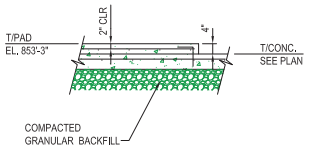


SECTION 8
SCALE: 3/4"=1'-0"

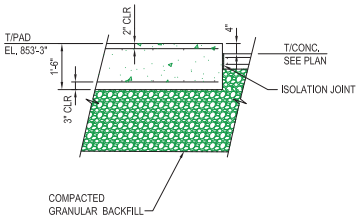
PRELIMINARY



SECTION 9
SCALE: 1/2"=1'-0"



SECTION 10
SCALE: 1/2"=1'-0"



SECTION 11
SCALE: 1/2"=1'-0"

NOTES:

1. FOR CONCRETE GENERAL NOTES SEE DWG. 13-11-200-001.
2. WATERSTOP SHALL BE ½" THICK, 6" WIDE, PVC DUMBELL PROFILE, AS MANUFACTURED BY GREENSTREAK PLASTIC PRODUCTS CO. OR APPROVED EQUAL.

REVISION APPROVAL RECORD				REV		REV #	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C						B	3/31/16	ISSUED FOR FEED	JJM	
						A	2/16/16	ISSUED FOR REVIEW	JJM	

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	B	3/31/16	JJM	DM
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED, DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV.NO.

PROJECT NO.: 31609
DRAWN: TCG DATE: 01-28-16
CHECKED: DATE:
SCALE: AS NOTED

URS ENERGY & CONSTRUCTION Inc, - an AECOM Company
1500 West 3rd St., Suite 200
Cleveland, OH 44113
(216) 523-5600
AECOM

ENERGY INDUSTRIES of OHIO
6100 Oak Tree Boulevard, Suite 200
Independence, OH 44131
(216) 643-2952

A-USC COMTEST PROJECT
SECTIONS & DETAILS

DWG. NO. 13-11-295-003
REV B

EC_D_Size.dwg

INCHES 1 2 CENTIMETERS 1 2 3 4 5 6

8 7 6 5 4 3 2 1

D C B A

13-11-300-001

GENERAL:

1. STEEL ELEVATIONS ARE REFERENCED TO MEAN SEA LEVEL ELEVATION XXX'-X" = REFERENCE (+0'-0").
2. IT SHALL BE THE CONTRACTOR'S RESPONSIBILITY TO VERIFY ALL DIMENSIONS AND CONDITIONS AT THE JOB SITE AND TO VERIFY DETAILS AND DIMENSIONS ON THE STRUCTURAL DRAWINGS WITH RELATED REQUIREMENTS ON THE ARCH'L. DRAWINGS WITH RELATED REQUIREMENTS ON THE ARCH'L, MECHANICAL, AND ELECTRICAL DRAWINGS, FLOOR AND WALL OPENINGS, SLEEVES, AND OTHER ARCH'L, MECHANICAL, AND ELECTRICAL REQUIREMENTS MUST BE COORDINATED BEFORE THE CONTRACTOR PROCEEDS WITH CONSTRUCTION.
3. ALL ENGINEERING DESIGN, CONSTRUCTION, AND TESTING SHALL CONFORM TO THE REQUIREMENTS OF THE OHIO BUILDING CODE (IBC 2009).
4. THESE DOCUMENTS DO NOT INCLUDE THE NECESSARY COMPONENTS FOR CONSTRUCTION SAFETY. SAFETY, CARE OF ADJACENT PROPERTIES DURING CONSTRUCTION, AND COMPLIANCE WITH LOCAL REGULATIONS REGARDING SAFETY IS, AND SHALL BE, THE CONTRACTOR'S RESPONSIBILITY.
5. REFER TO THE ARCHITECTURAL DRAWINGS FOR DIMENSIONS NOT SHOWN ON THE STRUCTURAL DRAWINGS.
6. ALL OMISSIONS OR CONFLICTS BETWEEN THE VARIOUS ELEMENTS OF THE WORKING DRAWINGS AND/OR SPECIFICATIONS SHALL BE BROUGHT TO THE ATTENTION OF THE ENGINEER BEFORE PROCEEDING WITH ANY WORK SO INVOLVED.
7. DESIGN LOADS: PER ASCE 7-05 FOR CATEGORY III STRUCTURE

TURBINE BUILDING LIVE LOAD	=	125	PSF
TURBINE BUILDING LAYOUT AREA LIVE LOAD	=	350	PSF
ROOF LIVE LOAD	=	20	PSF
STAIR LIVE LOAD	=	100	PSF

SNOW DESIGN DATA:

GROUND SNOW LOAD	=	20	PSF
RAIN ON SNOW:	=	5	PSF
SNOW EXPOSURE FACTOR, Ce	=	1,0	
SNOW IMPORTANCE FACTOR, Is	=	1,1	
THERMAL FACTOR, C_t	=	1,0	

WIND DESIGN DATA:

BASIC WIND SPEED	=	90	MPH
WIND IMPORTANCE FACTOR I_E	=	1,15	
WIND EXPOSURE	=	B	

EARTHQUAKE DESIGN DATA:
SEISMIC RISK CATEGORY II
SEISMIC IMPORTANCE FACTOR = 1.0
MAPPED SPECTRAL ACCELERATION PARAMETERS
Ss = 0,152 g
S_1 = 0,049 g

SPECTRAL RESPONSE ACCLERATIONS
Sds = 0,162 g
Sd1 = 0,079 g

SITE CLASS: D; SEISMIC DESIGN CATEGORY B
BASIC SEISMIC-FORCE-RESISTING SYSTEM:
SEISMIC SYSTEM NOT SPECIFICALLY DETAILED FOR SEISMIC RESISTANCE R=3
DESIGN BASE SHEAR = TBD KIPS
ANALYSIS PROCEDURE:
EQUIVALENT LATERAL FORCE PROCEDURE

SPECIAL INSPECTIONS:

1. THE CONTRACTOR SHALL EMPLOY AN APPROVED AGENCY TO PERFORM TESTS, INSPECTIONS, AND REPORTS AS REQUIRED BY THE OHIO BUILDING CODE (IBC 2009), ALL TEST RESULTS AND REPORTS ARE TO BE SUBMITTED TO THE BUILDING OFFICIAL AND TO THE REGISTERED DESIGN PROFESSIONAL IN RESPONSIBLE CHARGE.
2. STEEL CONSTRUCTION SHALL HAVE SPECIAL INSPECTION AS REQUIRED BY SECTION 1705.2 & TABLE 1705.2.2 OF THE CODE.

SHOP DRAWING REVIEW:

1. AECOM WILL REVIEW CONTRACTORS SHOP DRAWINGS AND RELATED SUBMITTALS TO VERIFY THE PROPOSED MATERIALS AND FABRICATIONS FULFILL THE DESIGN INTENT.
2. BEFORE SUBMITTING A SHOP DRAWING OR ANY RELATED MATERIAL TO AECOM, CONTRACTOR SHALL: REVIEW EACH SUCH SUBMISSION FOR CONFORMANCE WITH THE MEANS , METHODS, TECHNIQUES, SEQUENCES, AND OPERATIONS OF CONSTRUCTION, AND SAFETY PRECAUTIONS AND PROGRAMS INCIDENTAL THERETO, ALL OF WHICH ARE THE SOLE RESPONSIBILITY OF CONTRACTOR; APPROVE EACH SUCH SUBMISSION BEFORE SUBMITTING IT; AND SO STAMP EACH SUCH SUBMISSION BEFORE SUBMITTING IT, THE CONTRACTOR IS FULLY RESPONSIBLE FOR ANY CHANGES OR DELAYS CAUSED BY PREMATURELY SUBMITTING SHOP DRAWINGS WITHOUT THE CONTRACTORS' REVIEW WITHOUT THE CONTRACTORS' REVIEW AND STAMP. AECOM INC. SHOP DRAWING REVIEW AND STAMP DOES NOT ALLEVIATE THE CONTRACTOR'S RESPONSIBILITY TO REVIEW AND STAMP THE SAME SHOP DRAWINGS. AECOM SHALL ASSUME THAT NO SHOP DRAWING OR RELATED SUBMITTAL COMPRISES A VARIATION UNLESS CONTRACTOR ADVISES AECOM OTHERWISE VIA A WRITTEN INSTRUMENT WHICH IS ACKNOWLEDGED BY AECOM IN WRITING.
3. THE SHOP DRAWINGS AND RELATED MATERIAL, IF ANY, CALLED FOR SHALL BE INDICATED WITHIN THE GENERAL AND MATERIAL NOTES AND SPECIFICATIONS IF APPLICABLE, THE CONTRACTOR SHALL ALLOW TEN (10) DAYS FOR AECOM TO PERFORM THE REVIEW. AECOM SHALL RETURN SHOP DRAWING AND RELATED MATERIALS WITH COMMENTS PROVIDED THAT EACH SUBMISSION HAS BEEN CALLED FOR AND IS STAMPED BY STAMPED BY CONTRACTOR AS INDICATED ABOVE. AECOM SHALL RETURN WITHOUT COMMENT MATERIAL NOT REQUIRED.

STEEL FORM DECK:

1. ALL METAL FLOOR DECKING SHALL COMPLY WITH THE PROVISIONS OF THE LATEST EDITION OF THE STEEL DECK INSTITUTE "DESIGN MANUAL FOR COMPOSITE DECKS, FORM DECKS, ROOF DECKS AND CELLULAR METAL FLOOR DECK WITH ELECTRICAL DISTRIBUTION".
2. METAL FORM DECK SHALL BE BLACK HIGH STRENGTH STEEL, DECK SHALL BE PUDDLE WELDED AT ALL STEEL SUPPORTS AS FOLLOWS:
   A. PROVIDE PUDDLE WELDS AT ALL STEEL SUPPORTS USING 16 GAGE WELDING WASHERS WITH ⅜" DIA. HOLE FOR METAL FORM DECK 24 GAGE AND THINNER. PROVIDE ⅝" DIA. PUDDLE WELDS FOR METAL FORM DECK 22 GAGE AND THICKER.
      a. ALL PUDDLE WELDS SHALL BE SPACED @ 10" O.C. MAX. (30/4 PATTERN).
      b. WELD AT ALL LAPS OR EDGES OF PANELS.
      c. WELDS TO BE MADE FOLLOWING AWS D1.3 SPECIFICATIONS BY QUALIFIED WELDING OPERATORS.
      d. ALL DECK END LAPS SHALL BE A MINIMUM OF 2".
3. PROVIDE METAL POUR STOP AT ALL EDGES OF CONCRETE CONSTRUCTION (INCLUDING FLOOR OPENINGS) EXCEPT WHERE EDGE ANGLE IS DETAILED. POUR STOP SHALL BE OF GAGE AS RECOMMENDED BY MANUFACTURER FOR SPECIFIC CONDITIONS WITH A MINIMUM OF 20 GAGE.
4. METAL DECKING SHALL BE 3 SPAN MINIMUM LENGTH GALVANIZED BY "VULCRAFT" OR APPROVED EQUIVALENT.
5. DECK ERECTION CONTRACTOR SHALL CUT DECK TO SUIT DETAILS AT ALL FRAMED OPENINGS, COLUMNS, COLUMN CONNECTIONS, OR AS INDICATED ON THE DRAWINGS.
6. PIPE SLEEVES AND ALL OTHER REQUIRED OPENINGS SHALL BE FIELD CUT BY THE TRADE REQUIRING THE OPENING. ADEQUATE DECK SUPPORT, PIPE SLEEVES FILLERS, CLOSURES, FLASHINGS, ETC., SHALL BE PROVIDED AND PROPERLY WELDED IN PLACE BY THE TRADE CUTTING THE OPENING.
7. ALL WELDS AND ABRASIONS SHALL BE GIVEN A PROTECTIVE COAT OF GALVALLOY, DRI-GALV, GALVICOV OR APPROVED EQUAL.
8. ALL WELDING, EXCEPT WHEN PERFORMED AT THE SHOP OF AN APPROVED FABRICATOR, SHALL BE DONE BY WELDERS QUALIFIED IN ACCORDANCE WITH THE AMERICAN WELDING SOCIETY (AWS).
9. DESIGN, FABRICATION, STORAGE, HANDLING AND ERECTION OF METAL DECKING SHALL BE IN ACCORDANCE WITH STANDARD SPECIFICATIONS, MOST RECENT EDITION, OF THE STEEL DECK INSTITUTE.

STRUCTURAL AND MISCELLANEOUS STEEL:

1. DESIGN, DETAILING, FABRICATION AND ERECTION OF STRUCTURAL STEEL SHALL CONFORM TO THE FOLLOWING PUBLICATIONS, EXCEPT AS SPECIFICALLY INDICATED IN THE CONTRACT DOCUMENTS:
   a. AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC) "STEEL CONSTRUCTION MANUAL", 13TH EDITION.
   b. "SPECIFICATION FOR STRUCTURAL STEEL BUILDINGS", ANSI/AISC 360-05
   c. "SPECIFICATION FOR STRUCTURAL JOINTS USING HIGH STRENGTH BOLTS", RESEARCH COUNCIL ON STRUCTURAL CONNECTIONS (RCSC), 31 DEC 2009
   d. AMERICAN WELDING SOCIETY (AWS) STRUCTURAL WELDING CODE D1.1
   e. AISC 303-05: "CODE OF STANDARD PRACTICE FOR STEEL BUILDING AND BRIDGES"
2. STEEL MATERIAL
   a. W- AND WT-SHAPES: ASTM A992
   b. ROLLED ANGLES & CHANNELS, PLATE, AND ROUND ROD: ASTM A36
   c. HOLLOW STRUCTURAL SECTION (HSS): ASTM A500, GR B
   d. PIPE: ASTM A53, GR B, TYPE E SCHEDULE 40 (FY = 35 KSI)
3. STEEL CONNECTIONS
   a. PRIMARY BOLTED CONNECTIONS:
      I. BOLTS: ASTM A325 TYPE 1, BEARING TYPE, ¾" DIAMETER
      II. NUTS: ASTM A563, GRADE DH
      III. WASHERS: ASTM F436 PLAIN, HARDENED
      Iv. BOLTS SHALL BE USED IN AISC "STANDARD" HOLES UNLESS NOTED ON THE DRAWINGS. ALL BOLTS, NUTS AND WASHERS SHALL BE GALVANIZED.
   b. SECONDARY BOLTED CONNECTIONS: BUILDING GIRTS, STAIRS
      I. BOLTS: ASTM A307, GR A 3/4" DIAMETER FOR BUILDING GIRTS.
      II. NUTS: ASTM A563, GRADE DH
      iii. WASHERS: ASTM F436 PLAIN, HARDENED
   c. WELDING: E70XX ELECTRODES PER AWS D1.1, A5.1 OR A5.5. WELDING SHALL BE PERFORMED BY WELDERS QUALIFIED IN ACCORDANCE WITH AWS D1.1 AND THE AISC SPECIFICATIONS. WELD SYMBOLS SHALL BE AS PER AWS. ALL SHOP WELDING SHALL BE 100% VISUALLY INSPECTED BY THE SUPPLIER AND DOCUMENTED ON INSPECTION REPORTS, THE STANDARD FOR VISUAL INSPECTION SHALL BE IN ACCORDANCE WITH AWS D1.1
   d. SHOP CONNECTIONS SHALL BE WELDED, FIELD CONNECTIONS SHALL BE BOLTED UNLESS NOTED ON THE DRAWING,
   e. ANY HOLES INSTALLED IN THE FIELD SHALL BE DONE BY DRILLING. THERMAL CUTTING OF HOLES FOR CONNECTION BOLTS IS NOT PERMITTED.
   f. ERECTION BOLTS, COLUMN BASE PLATE LEVELING SHIMS AND TEMPORARY FASTENINGS REQUIRED FOR ERECTION SHALL BE FURNISHED BY THE STEEL ERECTOR.
   g. CONNECTION DESIGN FORCES SHOWN ON DRAWINGS ARE FACTORED FOR LRFD DESIGN.
   h. PRIMARY CONNECTIONS WITH ASTM A325 BOLTS SHALL ASSUME THREADS INCLUDED IN THE FAYING SURFACE ("N-TYPE")
   i. AS A MINIMUM, ALL CONNECTIONS FOR BEAM TO COLUMN SHALL BE DESIGNED FOR A 15K FACTORED TRANSFER FORCE.
4. PAINTING
   a. ALL STRUCTURAL STEEL SHALL BE PRIMED WHITE OR LIGHT GRAY IN THE SHOP, ASPHALTIC PAINTS ARE NOT ACCEPTABLE.
5. GENERAL
   a. SUBSTITUTIONS OF SPECIFIED MEMBER SIZE OR CHANGE IN DETAILS OR DIMENSIONS OF ANY KIND SHALL NOT BE PERMITTED WITHOUT PRIOR WRITTEN CONSENT OF THE ENGINEER
   b. BRACING CONNECTIONS SHALL BE SIZED TO DEVELOP THE FACTOR FORCES SHOWN ON THE DESIGN DRAWINGS. A MINIMUM CONNECTION SHALL CONSIST OF TWO BOLTS, MINIMUM GUSSET PLATE THICKNESS SHALL BE 5/16".
   c. COLUMNS SHALL HAVE FULL BEARING AT SPLICES AND AT BASE PLATES.
   d. AXIALLY STRESSED MEMBERS MEETING AT A POINT SHALL HAVE THEIR GRAVITY AXIS MEET AT A POINT; THAT IS CONCENTRICALLY.
   e. THE CONTRACTOR SHALL PROVIDE ALL NECESSARY LABOR, MATERIALS AND EQUIPMENT TO DETAIL, FABRICATE AND ERECT ALL STRUCTURAL AND MISCELLANEOUS STEEL SHOWN ON THESE DRAWINGS.

PRELIMINARY

REVISION APPROVAL RECORD				REV		REV NO	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C										
						A	3/31/16	ISSUED FOR FEED	JJM	

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A	3/31/16	JJM	DM
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV.NO.

PROJECT NO.: 31609
DRAWN: TCG DATE: 02-22-16
CHECKED: DATE:
SCALE: AS NOTED

URS ENERGY & CONSTRUCTION Inc, - an AECOM Company
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A-USC COMTEST PROJECT
GENERAL NOTES - STEEL

DWG. NO. 13-11-300-001 REV A

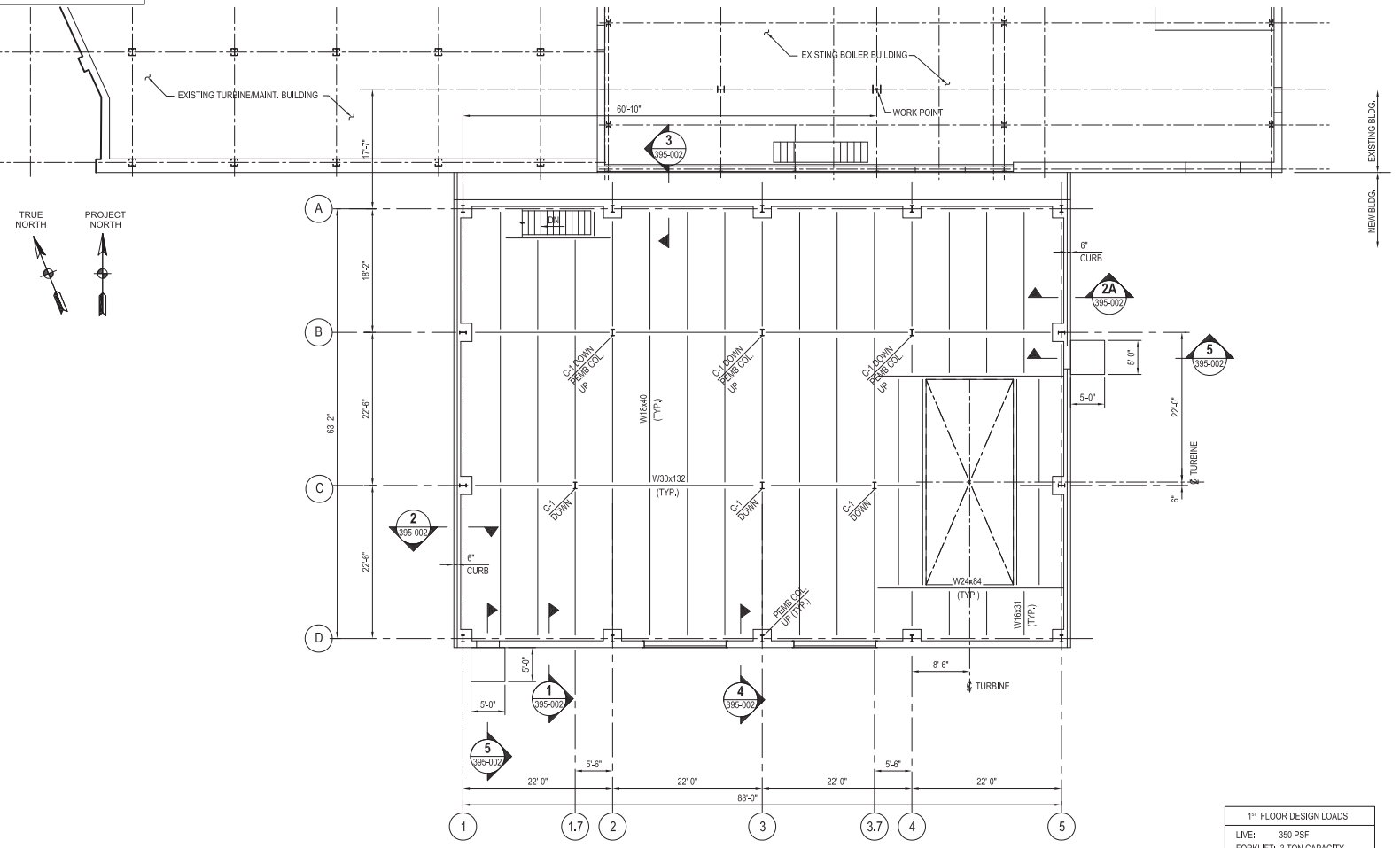
EC_D_Size.dwg

INCHES 1 2 CENTIMETERS 1 2 3 4 5 6

8 7 6 5 4 3 2 1

D C B A

13-11-305-001



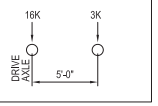
1ST FLOOR FRAMING PLAN

SCALE: 1/8"=1'-0"

NOTES:

1. FOR GENERAL AND STEEL NOTES SEE DWG. 13-11-300-001.
2. (E) DENOTES EXISTING CONSTRUCTION.
3. FLOOR CONSTRUCTION: 7" NORNAL WEIGHT CONCRETE SLAB WITH #5 BARS AT 12" O.C, EACH WAY TOP AND BOTTOM, PROVIDE 1/2" DIA, 4" LONG HEADED STUD AT 2'-0" O.C, ALONG ALL STEEL BEAMS.
4. TOP OF CONCRETE ELEVATION = 867'-6".
5. TOP OF STEEL ELEVATION = 866'-11"
6. SEE DRAWING 13-11-395-001 FOR COLUMN SCHEDULE.
7. FINISH GRADE AT PERIMETER OF BUILDING CONSIDERED AT ELEVATION = 867'-0".

1ST FLOOR DESIGN LOADS	
LIVE:	350 PSF
FORKLIFT:	3 TON CAPACITY



PRELIMINARY

REVISION APPROVAL RECORD				REV	
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ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
B	3/31/16	ISSUED FOR FEED	JJM	
A	2/16/16	ISSUED FOR REVIEW	JJM	

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	B	3/31/16	JJM	DM
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED, DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV.NO.

PROJECT NO.: 31609

DRAWN: TCG DATE: 01-28-16

CHECKED: DATE:

SCALE: AS NOTED

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A-USC COMTEST PROJECT
COMTEST TURBINE BUILDING
1ST FLOOR STEEL FRAMING PLAN

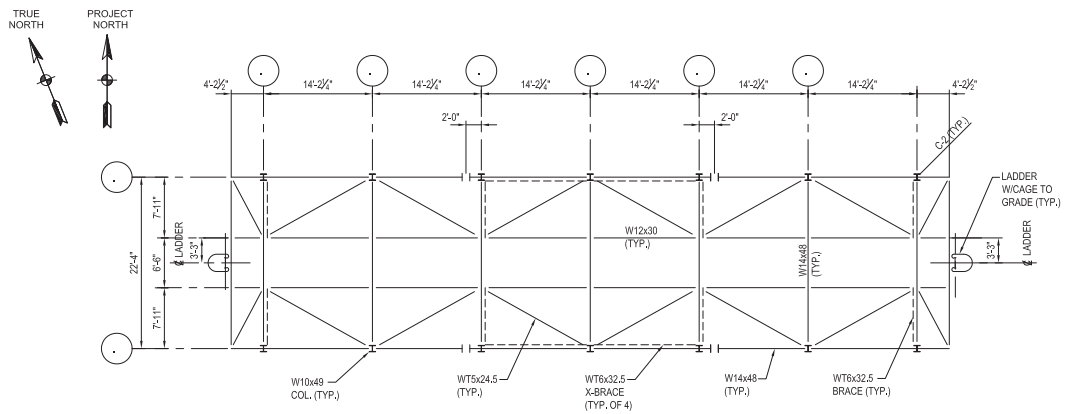
DWG. NO. 13-11-305-001 REV B

EC_D_Size.dwg

INCHES 1 2 CENTIMETERS 1 2 3 4 5 6

8 7 6 5 4 3 2 1

13-11-360-001



COOLING TOWER PLATFORM FRAMING PLAN

SCALE: 1/8"=1'-0"

NOTES:

1. FOR GENERAL AND STEEL NOTES SEE DWG. 13-11-300-001.
2. TOP OF STEEL ELEVATION = 875'-0"
3. SEE DRAWING 13-11-395-001 FOR COLUMN SCHEDULE.
4. — — — DENOTES X-BRACE.

PRELIMINARY

REVISION APPROVAL RECORD				REV		REV #	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C										
						A	3/31/16	ISSUED FOR FEED	JJM	

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A	3/31/16	JJM	DM
APPROVED FOR CONSTRUCTION				

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PROJECT NO.: 31609

DRAWN: TCG DATE: 02-22-16

CHECKED: DATE:

SCALE: AS NOTED

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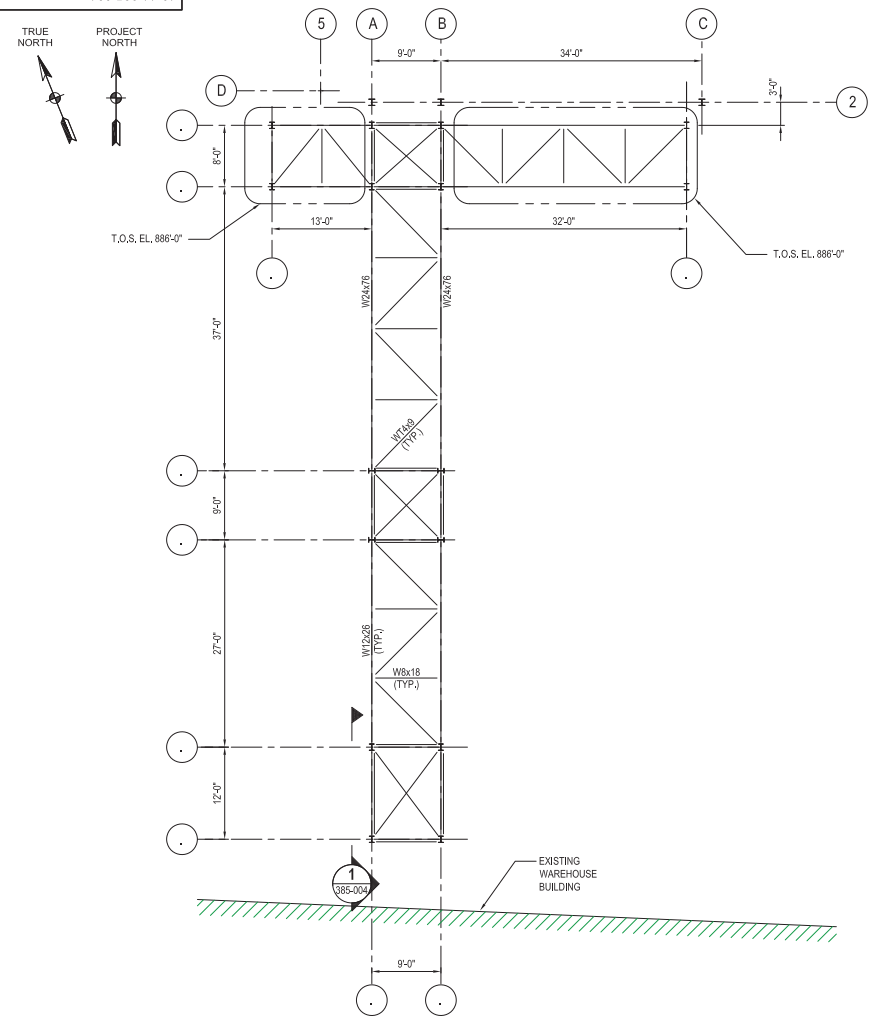
A-USC COMTEST PROJECT
COOLING TOWER
PLATFORM FRAMING PLAN

DWG. NO. 13-11-360-001 REV A

EC_D_Size.dwg

INCHES CENTIMETERS

13-11-385-001



STEEL FRAMING PLAN @ T.O.S. EL. 892'-0"

SCALE: 1/8"=1'-0" U.N.O.

NOTES:

1. FOR GENERAL AND STEEL NOTES SEE DWG. 13-11-300-001.
2. SEE DRAWING 13-11-395-001 FOR COLUMN SCHEDULE.
3. – – – DENOTES X-BRACE.

PRELIMINARY

REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
A	3/31/16	ISSUED FOR FEED	JJM	

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A	3/31/16	JJM	DM
APPROVED FOR CONSTRUCTION				

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PROJECT NO.: 31609
DRAWN: JMK DATE: 03-14-16
CHECKED: DATE:
SCALE: AS NOTED

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A-USC COMTEST PROJECT
UTILITY RACK
STEEL FRAMING PLAN

DWG. NO. 13-11-385-001 REV A

EC_D_Size.dwg

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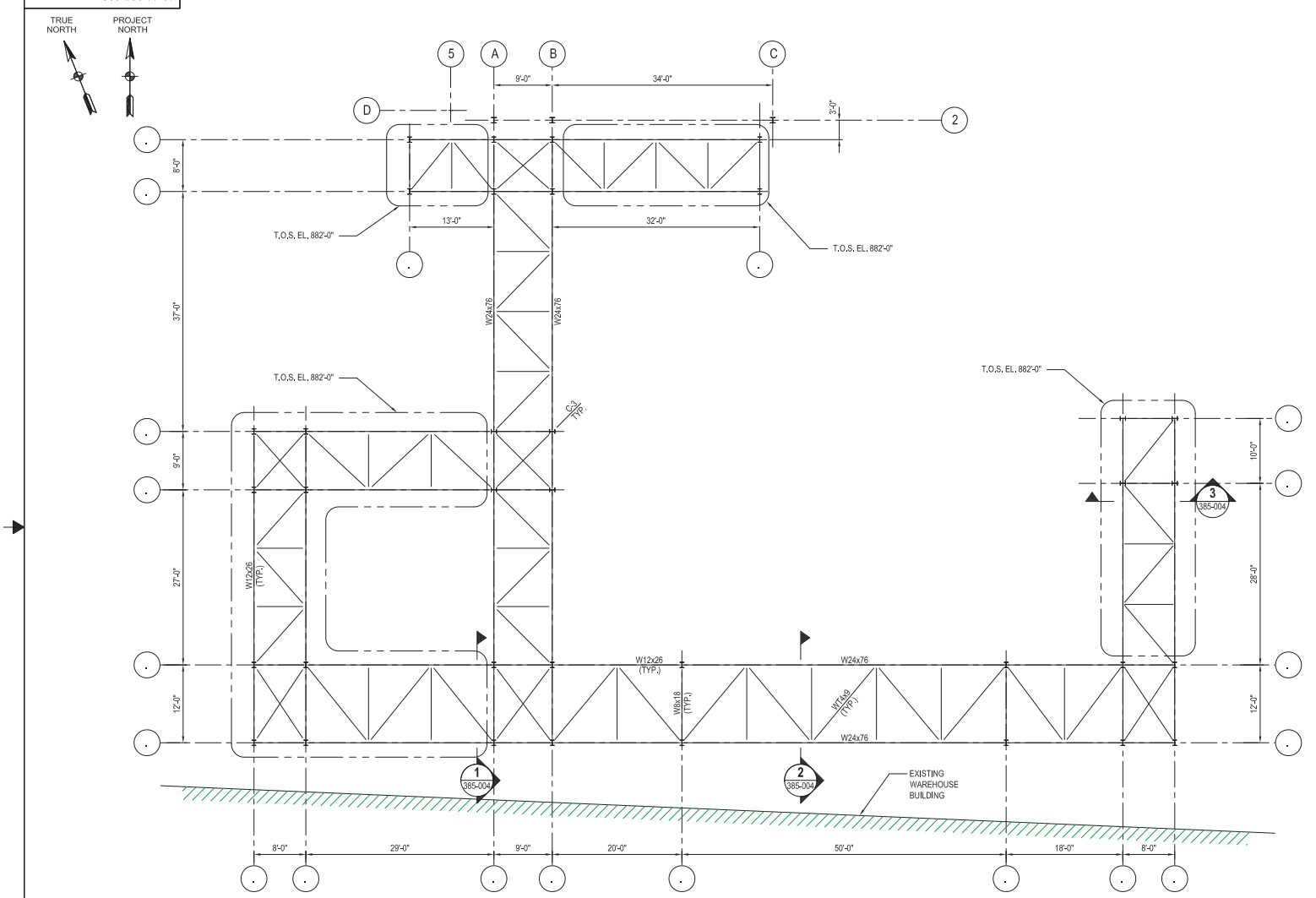
8 7 6 5 4 3 2 1

D C B A

13-11-385-002



STEEL FRAMING PLAN @ T.O.S. EL. 888'-0"

SCALE: 1/8"=1'-0" U.N.O.

NOTES:

1. FOR GENERAL AND STEEL NOTES SEE DWG. 13-11-300-001.
2. SEE DRAWING 13-11-395-001 FOR COLUMN SCHEDULE.
3. – – – DENOTES X-BRACE.

PRELIMINARY

REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
A	3/31/16	ISSUED FOR FEED	JJM	

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A	3/31/16	JJM	DM
APPROVED FOR CONSTRUCTION				

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PROJECT NO.: 31609

DRAWN: JMK DATE: 03-14-16

CHECKED: DATE:

SCALE: AS NOTED

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A-USC COMTEST PROJECT
UTILITY RACK
STEEL FRAMING PLAN

DWG. NO. 13-11-385-002 REV A

EC_D_Size.dwg

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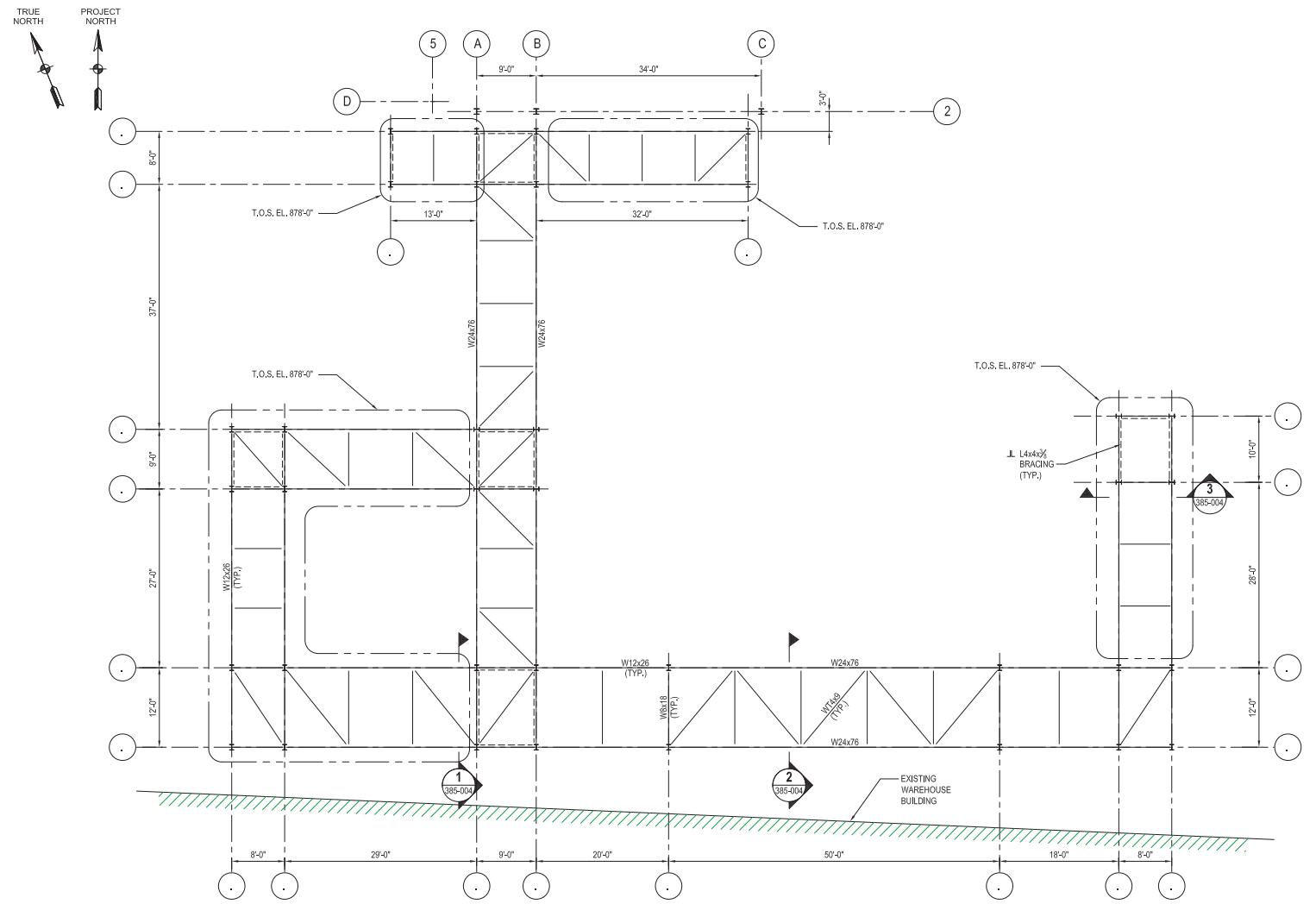
8 7 6 5 4 3 2 1

D C B A

13-11-385-003



STEEL FRAMING PLAN @ T.O.S. EL. 884'-0"

SCALE: 1/8"=1'-0" U.N.O.

NOTES:

1. FOR GENERAL AND STEEL NOTES SEE DWG. 13-11-300-001.
2. SEE DRAWING 13-11-395-001 FOR COLUMN SCHEDULE.
3. — — — DENOTES X-BRACE.

PRELIMINARY

REVISION APPROVAL RECORD				REV		REV #	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C										
						A	3/31/16	ISSUED FOR FEED	JJM	

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A	3/31/16	JJM	DM
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED, DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV.NO.

PROJECT NO.: 31609

DRAWN: JMK DATE: 03-14-16

CHECKED: DATE:

SCALE: AS NOTED

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A-USC COMTEST PROJECT
UTILITY RACK
STEEL FRAMING PLAN

DWG. NO. 13-11-385-003 REV A

EC_D_Size.dwg

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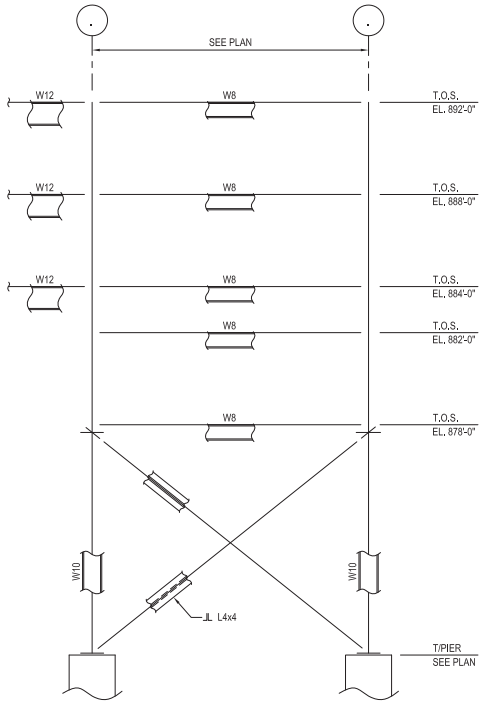
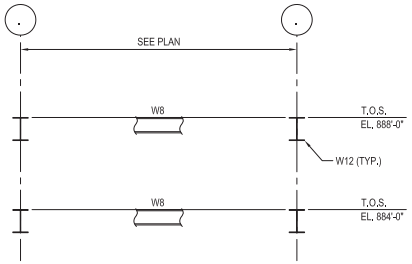
8 7 6 5 4 3 2 1

D C B A

13-11-385-004



SECTION 1
SCALE: 3/8"=1'-0"



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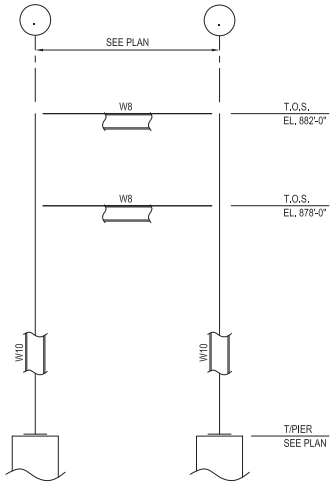

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PRELIMINARY

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ARCH.			MECHANICAL		
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CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
A	3/31/16	ISSUED FOR FEED	JJM	

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A	3/31/16	JJM	DM
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PROJECT NO.: 31609
DRAWN: JMK DATE: 03-14-16
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AECOM

ENERGY INDUSTRIES of OHIO
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A-USC COMTEST PROJECT
UTILITY RACK
ELEVATIONS

DWG. NO. 13-11-385-004
REV A

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INCHES 1 2
CENTIMETERS 1 2 3 4 5 6

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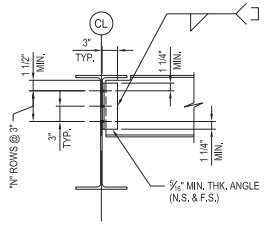
D C B A



STANDARD BEAM TO BEAM CONNECTION

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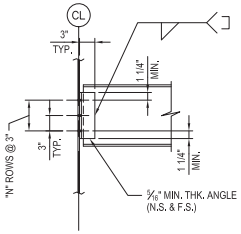


STANDARD BEAM TO COLUMN CONNECTION

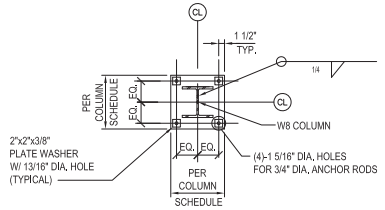
NONE

TYPICAL SHEAR CONNECTION SCHEDULE

BEAM SIZE	MINIMUM REQUIRED SHEAR FOR STANDARD CONNECTION		MINIMUM NUMBER OF ROWS OF 3/4" DIA. A325 BOLTS "N"
	LRFD (kip)	ASD (kip)	
ALL W8	20	15	2
W10x12 TO W10x30	20	15	2
W10x33 OR HEAVIER	30	20	2
W12x14 TO W12x35	30	20	3
W12x40 OR HEAVIER	45	30	3
W14x22 TO W14x43	50	35	3
W14x48 OR HEAVIER	60	40	3
W16x26 TO W16x45	65	45	4
W16x50 OR HEAVIER	75	50	4
W18x35 TO W18x50	75	50	4
W18x55 OR HEAVIER	85	60	4
ALL W21	130	90	5
ALL W24	130	90	5
ALL W27	165	110	6
ALL W30	230	150	7

COLUMN SCHEDULE

MARK	MEMBER	BASE PL.	DETAIL
C-1	W12x65	-	BP-1
C-2	W10x49	-	BP-1
C-3	W10x33	-	BP-1



BASE PLATE DETAIL BP-1

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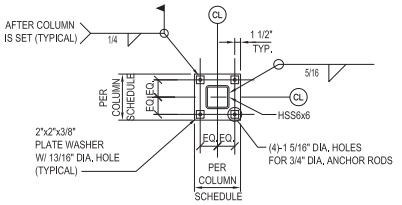

BASE PLATE DETAIL BP-2

1" = 1'-0"

NOTES:

1. FOR GENERAL AND STEEL NOTES SEE DWG. 13-11-300-001.

PRELIMINARY

REVISION APPROVAL RECORD				REV		REV NO	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
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ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C										
						A	3/31/16	ISSUED FOR FEED	JJM	

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
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A-USC COMTEST PROJECT
STEEL SECTIONS AND DETAILS

DWG. NO.	REV
13-11-395-001	A

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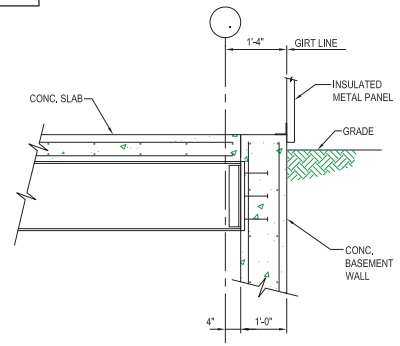
13-11-395-002



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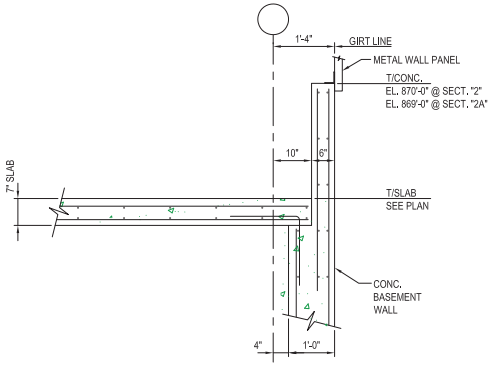

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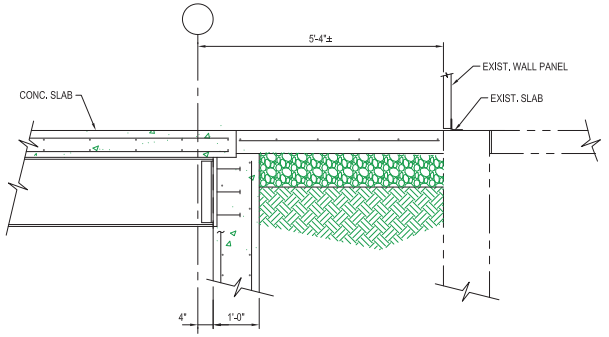

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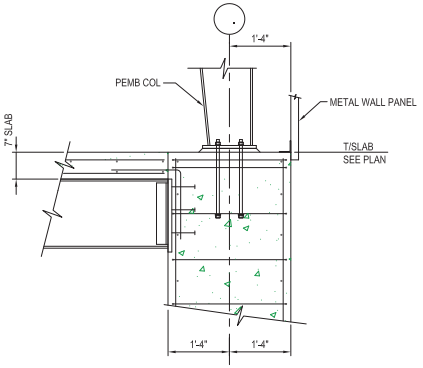

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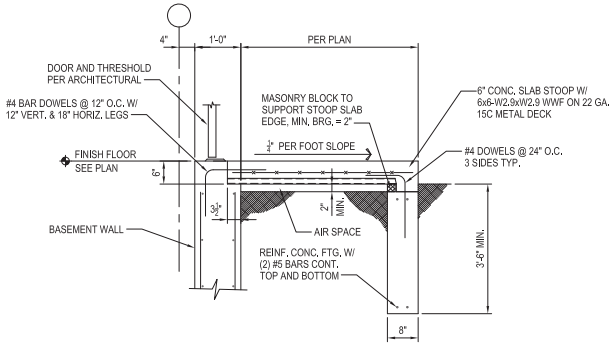

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PRELIMINARY

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CIVIL			PROCESS		
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ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
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DRAWING STATUS				
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PRELIMINARY	A	3/31/16	JJM	DM
APPROVED FOR CONSTRUCTION				

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A-USC COMTEST PROJECT
STEEL SECTIONS AND DETAILS

DWG. NO. 13-11-395-002
REV A

EC_D_Size.dwg

INCHES / CENTIMETERS

8 7 6 5 4 3 2 1
D C B A

CTL Engineering, Inc.
3085 Interstate Parkway, Brunswick, OH 44212
Phone: 330-220-8900 Fax: 330-220-8944

e-mail: ctlcle@ctleng.com

AN EMPLOYEE OWNED COMPANY

Consulting Engineer – Testing – Inspection Services – Analytical Laboratories Established 1927

March 7, 2016

AECOM
1500 West 3rd St.
Cleveland, Ohio 44141, USA

Attention: Mr. Jeffrey Morris, P.E., STS
Supervising Structural Engineer

Reference: Geotechnical Engineering Report
A-USC Com Test – Youngstown Thermal
205 North Avenue
Youngstown, Mahoning County, Ohio 44502

CTL Project No. 16050004CLE

Dear Mr. Morris:

CTL Engineering, Inc. has completed the geotechnical engineering report for the above referenced project. We performed the investigation in general accordance with our proposal dated January 12, 2016.

Enclosed is an electronic pdf copy of our report. Thank you for the opportunity to be of service on this project. If you have any questions, please contact our office.

Respectfully Submitted,
CTL ENGINEERING, INC.

H. Matthew Kairouz, P.E.
Project Engineer

GEOTECHNICAL ENGINEERING REPORT

A-USC COM TEST – YOUNGSTOWN THERMAL
205 NORTH AVENUE
YOUNGSTOWN, MAHONING COUNTY, OHIO 44502

CTL PROJECT NO. 16050004CLE

PREPARED FOR:

AECOM
1500 WEST 3RD ST.
CLEVELAND, OHIO 44141, USA

PREPARED BY:

CTL ENGINEERING, INC.
3085 INTERSTATE PARKWAY
BRUNSWICK, OHIO 44212
www.ctleng.com

March 7, 2016

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I. PROJECT LOCATION AND DESCRIPTION

The project site is located on the south side of the existing Youngstown Thermal Facility at 205 North Avenue in Youngstown, Mahoning County, Ohio. The project consists of developing a high temperature steam test facility referred to as A-USC Com Test. This facility will include the followings structures:

Turbine Building:
A steel frame/metal siding building with a basement that will house a turbine, crane, pipe rack, and a slab-on-grade section for research and development. This building is proposed adjacent to the south side of the existing Thermal facility. The finished floor elevations of the ground level and basement are proposed at 867.5 and 852.9 feet respectively matching the existing Thermal facility. The exterior and interior basement column loads are expected to be on the order of 200 and 300 kips respectively. The column load for the slab-on-grade section will be on the order of 50 kips. The Turbine is planned at the basement level and will be supported on a mat approximately 36' X 17' in plan dimension. The load to the turbine foundation is on the order of 200 kips.

Super-Heater Tower:
The Super-Heater Tower is proposed to be about 120 feet tall and approximately 44' X 44' in plan dimension. The Super-Heater is proposed about 10 feet east of the new Turbine facility at finished grade elevation of about 867.5 feet. Maximum column load for the super-heater is on the order of 550 kips and maximum gross load on the order of 1,800 kips.

Cooling Tower:
An elevated steel frame about 8 feet off the ground structure for the support of 6-unit cooling tower. The cooling towers location was modified after drilling completion, these units were moved and are now proposed along the eastern part of the site along Belmont Avenue. The column load for the cooling tower is on the order of 60 kips.

Boilers & Transformer:
Mechanical/Electrical skid mounted units/equipment such as Boilers, Transformers, Pumps, and Exchangers to be supported on open slab-on-grade pads. These equipment are proposed on the south/southwest side of the property at about finished grade elevation of 868 feet. The site of these units is occupied by an elevated canopy of concrete wall and slab to be demolished.

Total allowable settlement and differential settlement for this project are 1 and ¼ inch per 10 lf respectively.

II. SUBSURFACE INVESTIGATION

Soil Borings

During the period of January 26 to 29, 2016 CTL Engineering advanced 15 soil test borings to depths ranging from 25 to 46 feet below existing grades. CTL Engineering in coordination with AECOM selected and field marked the boring locations as shown approximately on the Boring Location Plan included in Appendix A. AECOM Surveying contractor provided the soil borings surface elevations for borings B-03, B-05 to B-08. CTL Engineering interpolated the surface elevations of the remaining borings B-01, B-02, B-04, B-09 to B-11 and B-15 using provided topographic map.

The borings locations, depths and elevations are summarized in *Table-1* below.

Table – 1: Boring Locations

Boring No.	Location	Latitude* (N)	Longitude* (W)	Elevation (feet)	Depth (feet)
B-01	Building/Turbine	41.10532º	80.65685º	869.0	25
B-02		41.10528º	80.65686º	868.5	25
B-03		41.10523º	80.65691º	868.1	25
B-04		41.10520º	80.65671º	868.2	39
B-05	Turbine Bldg. & Super-Heater	41.10534º	80.65662º	867.6	44
B-06	Super-Heater	41.10532º	80.65685º	867.2	25
B-07		41.10532º	80.65685º	868.0	25
B-08	Building/Turbine	41.10518º	80.65657º	868.5	25
B-09	Open Area	41.10516º	80.65634º	868.0	46
B-10		41.10475º	80.65603º	867.0	45
B-11	Mechanical/Electrical (Boilers, Transformer, Pumps)	41.10515º	80.65637º	866.0	25
B-12		41.10487º	80.65691º	869.0	25
B-13		41.10476º	80.65633º	869.2	25
B-14		41.10508º	80.65710º	869.2	25
B-15	Open Area	41.10504º	80.65607º	866.0	25

**Obtained using Hand Held GPS*

Borings were advanced using an ATV mounted drill rig. The drilling crew obtained soil samples through 2-inch O.D. split barrel samplers advanced in accordance with the Standard Penetration Test (SPT) procedure. Split spoon samples were obtained at 2.5-foot interval in the upper 15 feet and at 5-foot interval thereafter. The test borings were performed using hollow stem augers (HSA). Standard Penetration Tests (SPT) were conducted using an automatic, 140-pound hammer falling 30 inches to drive a 2-inch O.D. split barrel sampler for 18 inches. The energy transfer ratio associated with this automatic hammer was 81.9 percent, with a calibration date of July 1, 2015. Five (5) to ten (10) foot rock cores were extracted from borings B-04, B-05, B-9, and B-10. Ground water levels were recorded for each boring during drilling and at completion. All boreholes were back-filled with soil cuttings upon completion of drilling.

The drillers prepared field logs, secured the soil samples in glass jars, and delivered the samples to our laboratory for further testing.

Dynamic Testing

Multi-channel Analysis of Surface Wave (MASW) testing was performed in late January of 2016. One line test (line 3) was performed across the site in a west to east direction for the purpose of seismic classification, and two lines (line 1 and line 2) were performed respectively along the Turbine location and the initial super-heater location for the purpose of estimating the soil dynamic shear moduli for various subsurface layers. The dynamic soil modulus was determined for each distinct soil or rock layer, with a maximum individual layer thickness of 7.5 feet, for a minimum of four layers in the upper 30 feet. The seismic testing was performed in a standard test array to determine the shear wave velocities of the stratigraphy to a depth of 100 feet. This information was used to determine the site specific Seismic Site Class for the project.

The field MASW measurements was performed using an iSeis DAQlink III seismograph. The office interpretation of the data was performed using SeisOpt 2D software. The dynamic testing was performed using passive methods, with background vibrations as the seismic source.

The approximate locations of the Dynamic test lines are shown on an enclosed ReMi Test Location Map in Appendix E.

Laboratory testing

A CTL engineering geologist performed laboratory testing on selected samples as listed below:

- 127 Soil Classifications.
- 122 Moisture Contents.
- 11 Atterberg Limits tests.
- 11 Sieve Analysis with Hydrometer.
- 25 Sieve Analysis
- 4 Rock Unconfined Compressive Strength.
- 4 pH Tests
- 2 Resistivity Tests

Boring logs including the moisture content and the Atterberg Limits are enclosed in appendix B. The Sieve analysis, pH, Resistivity, and Rock Unconfined Compressive Strength test results are included in Appendix C.

III. FINDINGS

A. Visual Observations

The site of the proposed development is a laydown/storage area with driveway/parking zones adjacent to the Youngstown Thermal Facility located between Belmont and North Avenue at 205 North Avenue in Youngstown, Mahoning County, Ohio.

The topography of the site is fairly level with elevations ranging from about 870 to 865 feet. Exception to level grades are existing mounds of construction demolition material, and stockpiles of mulch or coal in open bin areas. The access surfaces are mostly covered with cinders at the plant and small vegetation and a long canopy at the adjacent south property. The canopy is supported on a concrete slab with a 3 feet high concrete retaining wall along its north side. The wall is dislodged at few locations with evidence of sinkhole or depression at isolated location at its toe. The cinder surfaces along driveway did not exhibit ruts or instability during coal delivery. The exiting Youngstown Thermal facility is a brick building with no sign of structural distress, noted distress are mostly associated with weathering due to old age.

B. Site Geology

The project area is located in the Killbuck-Glaciated Pittsburgh Plateau Physiographic Region of the Appalachian Plateau Province (*Physiographic Regions of Ohio*, Brockman, Scott C., ODNR Division of Geological Survey, 1998). This region is characterized by ridges and flat uplands which are covered with thin glacial drift and dissected by steep valleys. Soils in this region are thin to thick bedded Wisconsinan-age clay to loam till over Mississippian and Pennsylvanian-age shales, sandstones, conglomerates and coals.

In general, the project area is characterized by the hydrogeologic settings 7Ba, Outwash and 7G, Thin Till Over Bedded Sedimentary Rock (*Ground Water Pollution Potential of Mahoning County, Ohio,* Angle, Michael P., Ground Water Pollution Potential Report No. 51, ODNR Division of Water, Water Resources Section, 2003). Setting 7Ba, Outwash, is areas of outwash terraces that do not overlie buried valleys. This setting is generally associated with modern day streams and also encompasses some areas of kame terraces. This setting is characterized by flat-lying to gently rolling topography and low relief. Soils in this setting vary from silt loam to sandy loam and the principle aquifer consists of sand and gravel outwash deposits. Setting 7G, Thin Till over bedded sedimentary rock, generally consists of steep, bedrock-controlled ridges bordering river valleys. The glacial till in this setting is typically absent or very thinly overlies

the bedrock beneath it. Soils are generally sand loams which are derived from weathered bedrock as well as the uppermost thin till layer.

According to the United States Department of Agriculture, Natural Resources Conservation Service's Web Soil Survey (http://websoilsurvey.sc.egov.usda.gov/) the soil on site is as follows:

Table 2 – Soil Survey Soil Types found On-Site

Soil Series	Series Symbol	Drainage Characteristics	Soil Physiologic Features
Chili-Urban land complex, undulating	CoB	Well Drained	Landform: Terraces Parent Material: Outwash
Udorthents, loam, 2 to 25 percent slopes	Ua	N/A	N/A

The bedrock underlying the project area is comprised of the Mississippian System, dating from 322 to 359 million years before present, as defined in the Ohio Division of Geological Survey, 2006, Bedrock geologic map of Ohio: Ohio Department of Natural Resources, Division of Geologic Survey Map BG-1, generalized page size version with text. The Mississippian System consists of the Maxville Limestone; Rushville, Logan, and Cuyahoga Formations, Undivided (Mlc) (http://mrdata.usgs.gov/geology/state/sgmc-unit.php?unit=OHMlc;0 Geologic Units of Mahoning County, 2012, Ohio, U.S. Department of the Interior, U.S. Geological Survey). This formation consists of interbedded shale, siltstone and sandstone and ranges in color from various shades of gray, yellow, and brown and weathers to a similar color. The sandstone is silty to granular with local stringers of quartz pebbles. The shale is clayey to silty and may be locally fossiliferous.

According to the ODNR Division of Geologic Survey's Ohio Mine Locator (https://gis.ohiodnr.gov/MapViewer/?config=OhioMines), there are no active or abandoned mines in the immediate vicinity of the project area.

C. Subsurface Conditions

Surface Material:
Surface material was highly variable, it consisted of 12 inches of topsoil at boring B-13, paved section at borings B-01, B-02, B-08, and B-09. The paved section consisted of 2 to 6 inches of asphalt or 6 inches of concrete or brick over 6 inches of base. Below topsoil and paved section at the aforementioned borings and at all the remaining borings we encountered about 12 to 36 inches of intermixtures of silty sand with gravel, cinders, coal, slag, and mulch.

Obstruction:
Obstruction was encountered at boring B-08 at 1 foot below paved section, boring

B-08 was offset 14 feet to the east where another obstruction was noted at 11 feet below existing grades, the borings identified B-08B was offset again 4 feet to the south where no further obstruction were encountered. The obstruction sounds of metal but cannot be verified.

FILL:
The subsurface material consisted of about 3 to 13.5 feet of highly variable granular fill of various mixtures of sand, gravel, slag, coal, cinders, and clays. One exception, the fill appears to extend to boring termination depth of 25 feet at boring B-13. The Standard Penetration Test (SPT, N_{60}) and Moisture content of the fill ranged from 5 to over 50 blows per foot (bpf) and 6 to 29 % respectively. One exception, moisture content on the order of 59 % was noted at boring B-12 at 7 feet deep. The pH of the fill's upper portion is expected to range from 7.04 to 7.35 S.U. The minimum resistivity of the upper portion of the fill was measured to be on the order of 3,200 ohm-cm.

Natural Soils:
Natural deposits below the fills consisted of mixtures and interlayers of granular soil of silty or clayey sand with gravel or gravel with sand, or clayey gravel. A 3 to 6 feet thick cohesive layer of sandy lean clay or lean clay with sand was encountered within the natural granular deposits at borings B-04, B-06, B-07, B-08, B-9, and B-11 at depths ranging from 16 to 19 feet below existing grades. The natural granular deposits extended down to depths ranging from 27 to 34 feet below existing grades. Coble/boulders and rock formation was encountered at depths ranging from 27 to 34 feet below existing grades.

The Standard Penetration Test (SPT, N_{60}) and Moisture content of the natural granular deposits ranged from 7 to over 50 blows per foot (bpf) and 6 to 24 % respectively.

The Standard Penetration Test (SPT, N_{60}) and Moisture content of the cohesive zone ranged from 16 to 35 blows per foot (bpf) and 9 to 15 % respectively. The Liquid Limits (LL) and Plasticity Index (PI) of the natural cohesive material ranged from 26 to 28 % and 8 to 9 respectively.

The pH and minimum resistivity of natural soils were measured to be on the order of 7.81 S.U and 2,300 ohm-cm.

Rock Formation:
The rock formation encountered at 27 to 34 feet below existing grades consisted of layers of conglomerate rocks, sandstone, siltstone, and shale. The rock weathering varied from severely to slightly weathered and the strength varied from very weak to strong. The rock recovery and rock quality designation (RQD) varied from 38 to 100 % and from 28 to 82 % respectively. The compressive strength of intact rock pieces ranged from 6,300 to 8,990 psi.

Groundwater:
Depths and elevations of the observed groundwater levels for each test boring where groundwater was encountered is provided in *Table 3*. It should be noted that fluctuations in groundwater levels should be expected over time due to variations in precipitation, surrounding groundwater use, and the time of year the readings are obtained. Static groundwater levels can only be determined through observations made in cased holes over relatively long periods of time.

Table 3 – Groundwater Levels of Borings

Boring No.	Groundwater Levels (Feet)			
	Encountered at Drilling		At Completion of Drilling	
	Depth	Elevation	Depth	Elevation
B-01	24.0	845.0	None*	---
B-03	19.0	849.1	None*	---
B-04	24.5	843.7	11.0	857.2
B-05	24	843.6	13.7	853.9
B-09	12.5	855.5	11.5	856.5
B-10	12.5	854.5	17.3	849.7
B-14	6.0	863.2	None**	---
B-15	None	---	8.6	857.4

**Groundwater likely dropped or dissipated into drainage layer below.*
*** Groundwater on encounter was likely trapped within fill and dissipated at completion.*

IV. ANALYSIS AND RECOMMEDATIONS

The conclusions and recommendations presented herein are based on the data obtained from the field exploration, laboratory testing programs, and information regarding proposed construction.

Foundation analysis were based on general bearing capacity equation, settlement calculation using the Schmertman procedure mainly for granular material, and the settlement criteria for this project. The summary of settlement calculations is provided in *Table 4* below.

Table 4 – Settlement Analysis

Structure	Load	Net Pressure (ksf)	Settlement (inch)	Remark
Turbine Bldg. SOG	50 Kips Col.	3.5	1.00	OK
Turbine Bldg. Basement	200 Kips Col.	3.5	0.20	OK
	300 Kips Col.	3.5	0.25	OK
Turbine Mat	200 kips	1.0	0.68	OK
Supper Heater	550 kips Col.	3.5	1.5	No Good

Structure	Load	Net Pressure (ksf)	Settlement (inch)	Remark
Supper Heater	1,800 Kips Mat	1.25	0.78	OK*
Cooling Tower	60 Kips Col.	3.5	1.12	Not Good**

**Bearing on improved fill or engineered fill.*
*** Not suitable on existing Fill.*

Subgrade analysis was based on ODOT Geotechnical Bulletin GB1 and subgrade soil conditions/data.

Site seismic classification and shear moduli were based on ReMi testing. The dynamic shear Moduli are summarized in *Table 5* below.

Table -5: Turbine & Super-Heater (Borings B-04 & B-05)

Depth Range (ft)	Shear Wave Velocity V_s (ft/s)	Total Unit Weight γ (pcf)	Dynamic Shear Modulus G x 10^6 (psf)
0.0-7.5	746.4	118.3	2.05
7.5-15.0	954.4	120.0	3.40
15.0-22.5	923.2	125.0	3.31
22.5-30.0	1294.2	127.5	6.64

$$G = \frac{\gamma}{g} V_s^2$$

Reference: Kramer, Steven L. 1996. Geotechnical Earthquake Engineering. Prentice Hall, 653 pp

Site excavation and safe slope cut were analyzed based OSHA's Regulation using soil type C for excavation into mainly uncontrolled granular fill material.

Calculation and backup data are included in Appendices D and E of this report.

Our recommendations for the various section of this project are presented in the following items:

A. General Site Preparation and Earthwork

1. Remove all trees, tree stumps, vegetation, topsoil and debris from all proposed construction areas plus 10 feet beyond the perimeter of proposed structures including pad areas.

2. Remove any existing structures and substructures in their entirety from the proposed structures areas. Remove all existing fill from proposed structures if this option is selected for the specific structure.

3. Subsequent to vegetation and topsoil/debris removal and excavation of

unsuitable soils/existing fills, the exposed surface should be compacted with a sheep-foot/vibratory roller and/or proof-rolled until a relatively unyielding surface is achieved. Soft or loose soils, wherever encountered, should be stabilized with a stone, or undercut and replaced with compacted engineered fill, or otherwise as directed by the Soils Engineer.

4. Proper site drainage should be maintained during earthwork operations and permanently to minimize wet weather delays and reduce accumulation of moisture. If the surface soils become softened during wet weather or freezes, these soils should be removed before additional fill is placed. Ground surface in the vicinity of the construction site should be graded so that surface water flows away from the site. It is recommended that the surface of all fill areas be sealed with a smooth-wheel roller at the completion of each day's earthwork activities. Further protection of the site should include the construction of temporary ditches, berms or other surface water diversion devices in order to divert surface water from and not across the site.

5. Engineered fill should be placed in layers not to exceed 8 inches in loose thickness when heavy self-propelled compaction equipment is used, and in lifts not to exceed 6 inches when light portable compaction equipment is used. In structural areas, such as below footings, floor slabs, pavements and sidewalks, each layer of fill should be compacted to at least 98 percent of the maximum dry density as determined by ASTM D-698 standard method (AASHTO T-99), or as otherwise directed by the Soils Engineer. Soils weighing less than 120 pcf should be compacted to 100 percent of the standard Proctor maximum dry density. In non-structural areas such as landscape areas, the fill should be compacted to at least 95 percent. In all areas, the fill should be placed with moisture content within the range of ±3% of the optimum moisture content.

6. Fill material may consist of onsite suitable granular soils, or imported soils with Liquid Limit (LL) and Plasticity Index (PI) values that do not exceed 40% and 12%, respectively, crushed limestone such as #304 or cohesive soils could be used. Topsoil, coal, and organically contaminated materials are not suitable for use as fill. All fill materials should be observed and approved by the Soils Engineer.

7. Fill placement should extend beyond the limits of all structures a minimum horizontal distance equal to the height of fill or five (5) feet, whichever is greater. Fill placement adjacent to slopes or cuts steeper than 8:1 Horizontal to Vertical (H:V) should be benched to tie the new fill to existing soils.

8. Permanently exposed slopes should be laid back at a slope rate no steeper

than 3:1 H:V. These slopes should be seeded and vegetation growth permitted to limit sloughing or surface erosion.

9. Temporary excavations in excess of 4.0 feet in depth should be sloped or shored in accordance with OSHA regulations assuming soil type "C". The upper 27 to 34 feet of the onsite soils is classified as OSHA's soil type C. Temporary excavation up to 20 feet deep should be sloped at 1.5H:1V. Flatter slopes or temporary sheet piles may be required in seepage areas.

10. Excavation sidewalls for proposed temporary excavation of utility lines, basements, or any incidental retaining walls, should be laid back at a slope rate no steeper than 1.5:1 H:V in the granular fill material. If groundwater within sand seams are encountered during construction, then excavation sidewalls may need to be laid back at a flatter rate. Based on site restriction we believe basement excavation adjacent to existing building will require temporary sheet piles of PZ section or other temporary wall that able a supported top down excavation. Parameter for lateral loads and wall design are provided in subsequent *item D* of this Section.

B. Foundation Support

Turbine Building:

1. The Turbine building may be supported onto conventional shallow continuous wall and isolated column footings. The foundations in this area are expected to bear onto medium dense granular or very stiff cohesive natural deposits.

2. The Turbine may be supported on shallow mat at basement level. The mat may be designed using a modulus of subgrade reaction of 120 pci, and a dynamic shear Modulus of 23,000 psi.

3. Foundations bearing into the aforementioned material could be proportioned for a maximum allowable net bearing pressure of 3,500 psf.

The following guidelines should be implemented during shallow foundation construction:

1. All footing bearing surfaces should be free of water, loose cuttings, and frost and inspected and approved by the Soils Engineer. Temporary dewatering using a sump pit may be required in the area of boring B-03.

2. The minimum width for wall footing should be per Ohio Building Code but no less than 24 inches to prevent punching shear into granular deposits.

3. Exterior footings should be constructed at a minimum depth of 3.5 feet below the lowest adjacent grade to offset the effect of frost penetration. Interior footings in heated areas could be placed at a depth of 2 feet below proposed finished floor elevation or as deemed practical by the structural engineer. However interior foundation within granular deposits should be embedded a minimum of 3 feet below finished floor elevation.

4. Settlement of footings supported as recommended may vary across the site due to variations in the soil's composition, void ratio and loading. But are expected to be within tolerable limit of 1 inch total and ¼ inch per 10 lf differential.

Recommendations for the building floor slab support is provided in *Item C* of this Section.

Super-Heater:

About 3 to 10.5 feet of fill is expected at the proposed Super-heater site. The fill is considered unsuitable for the support of this structure. Conventional footings on natural medium dense deposits or engineered fill will undergo settlement in excess of 2 inches. Thus conventional footings are not acceptable. Three options in no specific orders can be considered:

1. Use of mat foundation.
2. Use of driven H Piles to practical refusal into rock.
3. Use of drilled Piers into rock.

1. <u>Mat Foundation:</u>

   Mat foundation will require the removal of existing fill and replacement with engineered fill per previous *Item A*, or improving the fill in place using Geopiers (Aggregate Piers). An array of 18-inch diameter Geopiers about 12 feet deep placed at 8-foot center to center spacing can be considered for budgeting purposes. Other Geopier size and spacing can be configured, Geopier is a proprietary system, a specialty contractor would provide design-build mat foundations based on the structural loads and the soil conditions.

   Upon fill site improvement or replacement, the mat foundation assuming granular medium dense subgrades may be designed based on a Modulus of Subgrade Reaction ($K_{1'x1'}$) of 130 pci, and an allowable net contact pressure not exceeding 1,350 psf. The subgrades for the mat should be prepared as recommended in *Item A* in previous Section. A perimeter frost wall may be required with this option pending on mat thickness and invert elevation.

2. Driven H Piles:

   HP10X42 piles driven to practical refusal onto rock may be considered for the support of the proposed Super-Heater. Practical refusal is anticipated within 1 to 1.5 feet of penetration into rock. The maximum factored structural resistance ($R_{R\ max}$) for HP10X42 is 310 kips. The $R_{R\ max}$ is valid for axially loaded 50 ksi steel piles. A minimum of 3 piles are required for each column cap.

   The pile pay length assuming pile caps are placed at invert elevation of 865.0 feet is estimated to be on the order of 35 feet long. This length is rounded up to the nearest 5-foot increment, assuming penetration of 1.5 feet into rock and 2 feet into column pad.

   The piles should be furnished and driven in accordance with ODOT CMS Item 507. Stress applied to the pile from the pile-driving hammer should be monitored during driving so as not to damage the pile. The piles should be kept at least 3 times its width from adjacent structures such as wall or other piles. Contractors may devise means and methods that would allow piles in a closer proximity to existing structures.

   Soil parameters for estimating lateral pile capacity are provided in Item D of this Section.

3. Drilled Piers:

   Drilled piers socketed 3 to 5 feet into rock maybe considered for the support of the super-Heater structure. Drilled pier socketed 3 to 5 feet into rock at elevation 831.6 maybe proportioned using a maximum allowable net bearing pressure of 129.5 ksf (0.3 $f'c$ of concrete).

   Drilled Piers should be kept at least 3 times its diameter from adjacent structures such as wall or other piers. Contractors may devise means and methods that would allow piers to be placed in a closer proximity to existing structures such as basement walls.

   Soil parameters for estimating lateral drilled pier capacity are provided in Item D of this Section.

Cooling Tower:

Our recommendations for the support of the cooling tower should be considered preliminary subject to verification by additional borings or possible test pits since no soil borings are available at the new proposed cooling tower location. Borings B-09, B-10, and B-15 located about 50 to 75 feet to the west of the proposed

cooling tower were used in formulating preliminary recommendations for foundation support. The existing 5.5 to 10.5 feet of fill is considered unsuitable for the support of the proposed cooling tower. The existing fill should be removed and replaced with engineered fill in accordance with Item A of prior section of this report. Upon fill completion conventional shallow footings bearing at frost depth can be used to support the cooling tower. Such foundations bearing into engineered fill can be proportioned for a maximum allowable net bearing pressure of 3,000 psf.

Other options to removal and replacement of exiting fill consist of the followings:

1. Use Geopiers (Aggregate Piers) 10 to 15 feet deep
2. Driven H Piles to practical refusal into rock.
3. Drilled Pier into rock.

1. Geopiers:

   Based on the subsurface conditions, the proposed cooling tower should be supported on modified/improved subsurface material. We recommend the use of Geopiers (aggregate piers) to support the column pads. The Geopiers should be extended below existing grades through the fill to depths ranging from 10 to 15 feet. The purpose of the Geopiers is to provide in-situ improvement of the existing fill. Geopier is a proprietary system. A specialty contractor would provide design-build foundations based on the structural loads and the soil conditions. We anticipate a minimum of 3 Geopiers per column pad and a single row of Geopiers along the bearing walls foundations if any. Foundations supported on such geopiers can be designed using maximum allowable net bearing pressures ranging from 4,500 to 6,500 psf pending on the geopiers size, spacing and configuration. For budgetary purposes assume a maximum allowable net bearing pressure of 4,500 psf, 18-inch diameter Geopiers average 12.5 feet long placed at 8 feet center to center spacing along the wall and at 4.5 feet center to center spacing at column pads.

2. Driven H Piles/Drilled Pier:

   See Driven H Pile and Drilled Pier Sections under the Super-Heater heading. Rock elevations may have to be verified with these options. For budgetary purpose assume rock elevations at 832 feet.

Boilers/Transformers

The Boilers, Transformers and other mechanical equipment are planned to be supported on mat or pad foundations. The subgrade soil relative densities or consistencies, moisture contents, and indices within the upper 5 feet are summarized in *Table 6* below.

Table 6. Summary of Subgrade Analysis

Standard Penetration (N_{60L})			Moisture Content (%)				Group Index (GI)	Subgrade Reaction
Low	High	Avg.	Low	High	Avg.	Opt.	Avg.	Design
10	14	12	9	29	20	10-15	2.0 - 8.0	130 pci

Our test boring data and analyses utilizing the ODOT Geotechnical Bulletin 1 (GB1) indicates that the existing subgrade soils are expected to be inadequate and expected to be unstable upon site grading. Subgrades improvement will be required. We recommend upon establishing proposed subgrades to proof-roll the area with a loaded 35 ton truck. We anticipate unstable subgrades in the areas of borings B-11 to B-14. The depths of undercut and replacement will depend upon proof-roll results. Based on GB1 we anticipated 12 to 15 inches of undercut to be required. If instability persist at undercut level, then we recommend the use of Geogrid such as TX-160 capped with aggregate such as ODOT #304 stone.

The average modulus of Subgrade Reaction (K) that may be used for the design of a new pad/mat section listed in Table 6. This value is valid if the existing soil material is compacted to about 98 percent of the standard Proctor dry density at ± 2 percent of the corresponding optimum moisture content in accordance with (AASHTO T-99) /ASTM D698).

The mat net contact pressure should not exceed 500 to 750 psf on exiting fills. A higher bearing capacity can be realized depending on load configuration, settlement evaluation, and to the extent the existing fill is improved.

C. Floor Slabs

Native soils at basement level of the proposed turbine building consisted of sandy lean clay or of silty sand or gravel with sand. Top layer material across the site consisted mainly of granular fill of various mixtures of sand, gravel, slag, coal, cinders, and clays. Depending upon the time of construction and amount of precipitation, near-surface exposed soils may exhibit soft and moist conditions. Air drying of fine-grained soils will be difficult to achieve, particularly during the winter and spring months. Any soils with a maximum dry weight of less than 100 pounds per cubic foot should be considered unsuitable for use in the upper 12 inches of subgrade.

Care should be made in verifying that surface soils are considered acceptable and exceed project specifications. Subgrades of paved and slab areas should be observed and approved by a Soils Engineer. Subsequent to site clearing, exposed surface should be proof-rolled where feasible or probed to verify that a relatively unyielding surface is achieved. Soft or loose soils should be undercut and

replaced with compacted-engineered fill, or otherwise as directed by the Soils Engineer. Based on the subgrade analysis we anticipate the exposed subgrades at the turbine building to be stable.

Subgrades of paved and slab areas should be observed and approved by a Soils Engineer.

1. The floor slab/mat should be supported directly on a base course of approved crushed aggregate material placed on top of the engineered fill.

2. The base should be of adequate thickness (at least 6 inches) to provide support and to act as a capillary moisture break (#57 stone is typically required as capillary moisture break.

3. If the site is prepared as previously described and the controlled fill is placed as described in this report using onsite soils, then the modulus of subgrade reactions are 130 pci for the onsite granular material and 120 pci for the cohesive material (typically noted at basement level). These Moduli could be used for the design of the grade slabs, mats, and concrete paved areas.

D. Lateral Support Structure Units

We recommend that a wedge of free-draining material, consisting of crushed stone, clean sand or other type of granular, porous or non-plastic soils are utilized to backfill a wedge behind all permanent retaining walls. The wedge of freely-draining material should have a minimum width of one (1) foot at the base of the wall footing and increase in width by a minimum of 0.8 feet per 1.0 foot of wall height. A footing drain should be used in conjunction with the free-draining backfill. We consider any clayey soils to be unsuitable for use as backfill since these soils have a tendency to "creep" with time. In addition, these soils provide minimal drainage of water behind the retaining wall. It is recommended those walls which are restrained from rotating be designed based on at-rest earth pressure conditions, and those walls which are allowed to rotate be designed based on the active earth pressure conditions.

The lateral earth pressure coefficients for wall or lateral load design are summarized in *Table 7* below. These parameters are based on the assumption of a level backfill surface and no excessive hydrostatic pressure.

Table 7- Soil Parameters for Lateral Load Design

Parameter	No. 57 Stone	Native Fill	Native Granular Material	Native Sandy Lean Clay
Cohesion (psf)	Ignore	Ignore	Ignore	500
Coefficient of Friction (∅°)	42	27	32	22

Parameter	No. 57 Stone	Native Fill	Native Granular Material	Native Sandy Lean Clay
Wall Friction Angle (Delta)	28	18	22	15
At rest Coefficient, (K_o)	0.33	0.55	0.47	0.63
Active Coefficient, (K_a)	0.20	0.38	0.31	0.45
Passive Coefficient, (K_p)	5.00	2.63	3.23	2.22
Moist Unit Weight (pcf)	140	120	130	130
Saturated Unit Weight (pcf)	N/A	130	138	135
Soil/Concrete Friction	0.53	0.32	0.39	0.27
Average Horizontal Subgrade Reaction (kcf)	2,500	850	1,500	875

Lateral pressure arising from surcharging loading should be added to the above soil earth pressures to determine the total lateral pressures which the walls must resist. In addition, transient loads imposed on the walls by construction equipment during backfilling should be taken into consideration during design and construction. Excessively heavy grading equipment (that could impose temporary excessive pressures or long-term excessive pressures against the constructed walls) should not be allowed within five (5) feet (horizontally) of the walls.

Excavation (permanent or temporary) should be either shored or sloped for stability purposes. Temporary flexible retaining walls (shoring) should be designed utilizing the relevant soil parameters shown in the Table above.

E. Seismic Considerations

Based upon Section 1615.1 of the 2003 Ohio Building Code (OBC), and ReMi tests Site Class C could be used for seismic design of the building and structures with occupancy.

F. Corrosion Considerations and Cement Type

Resistivity and pH tests have been performed from representative soil samples. The pH varied from 7.04 to 7.35 along surface material and was on the order of 7.81 for lower level material. The Resistivity varied from 3,200 ohm-cm along surface material to 2,300 ohm-cm along lower level material. Tabulations of these test results are included in Appendix C of this report. Based on the pH and Resistivity the on-site soil conditions exhibit general conditions that may be considered corrosive to ductile iron and steel pipe as determined by AWWA C105. PVC Pipes or other corrosion resistant pipe such as Polyethylene-encased ductile iron pipe may be considered. Based on the pH, type II Portland Cement Concrete can be used.

G. Pavement Design Parameters

The following parameters were used in the design of the minimum recommended pavement sections. CTL pavement design sections are based on AASHTO Guide (1993).

Traffic:

Standard Duty Pavement (Assumed)	= 100,000 EAL's
Heavy Duty Pavement: 20 H20 Truck/day	⇔500,000 EAL's

Design Period	= **7** years
Growth	= 0%
Reliability	= 85%
Terminal Serviceability	= 2.0
Initial Serviceability	= 4.2
Standard Deviation	= 0.45 (flexible)
	= 0.35 (rigid)

Soil Modulus:

California Bearing Ratio, (CBR)	Native Soils	= 7.0 %*
Subgrade Resilient Modulus (Mr)	Native Soils	= 8,400 psi
Modulus of Subgrade Reaction	Native Soils	= 130 pci

**Valid only if subgrades are stable and densified to 98% standard Proctor. Based on the SPT the CBR under current conditions is on the order of 4.0%. The pavement design is based on the assumption that the site subgrades will be prepared per recommendations outlined in this report and using a CBR of 6%.*

Our test boring data and analyses utilizing the ODOT Geotechnical Bulletin 1 (GB1) indicates that the existing subgrade soils are expected to be inadequate and expected to be unstable upon site grading. Subgrades improvement will be required. We recommend upon establishing proposed subgrades to proof-roll the area with a loaded 35 ton truck. We anticipate unstable subgrades in the areas of borings B-11 to B-14. The depths of undercut and replacement will depend upon proof-roll results. Based on GB1 we anticipated 12 to 15 inches of undercut to be required. If instability persist at undercut level, then we recommend the use of Geogrid such as TX-160 capped with aggregate such as ODOT #304 stone.

Pavement Design Sections

The following pavement compositions are based on the assumption that the on-site soil subgrades are properly prepared and compacted to at least 98% of the standard Proctor dry density at ± 2% of optimum moisture content.

Standard Duty - Flexible Pavement

Item	Course	Thickness, inches
ODOT 446/448	Type 1 Surface Medium	1-1/4"
ODOT 407	Tack Coat	0.04 gal/syd
ODOT 446	Type 1 Intermediate	------
ODOT 407	Tack Coat	------
ODOT 301	Bituminous Aggregate Base	2-3/4"
Existing Base	Aggregate Base (onsite)	6"
Subgrade	On-site Soils	Compacted

Heavy Duty - Flexible Pavement

Item	Course	Thickness
ODOT 446/448	Type 1 Surface Medium	1.5"
ODOT 407	Tack Coat	0.04 gal/syd
ODOT 446	Type 1 Intermediate	------
ODOT 407	Tack Coat	------
ODOT 301	Bituminous Aggregate Base	4.5"
ODOT 304	Aggregate Base (onsite)	8.0"
Subgrade	On-site Soils	Compacted

Heavy Duty - Rigid Pavement

Item	Course	Thickness
ODOT 452 Concrete	Portland Type I or II	6″
ODOT 304 Aggregate	Base	6″

V. CHANGED CONDITIONS

The evaluations, conclusions, and recommendations in this report are based on our interpretation of the field and laboratory data obtained during the exploration, our understanding of the project and our experience with similar sites and subsurface conditions using generally accepted geotechnical engineering practices. Although individual test borings are representative of the subsurface conditions at the boring locations on the dates drilled, they are not necessarily representative of the subsurface conditions between boring locations or subsurface conditions during other seasons of the year.

In the event that changes in the project are proposed, additional information becomes available, or if it is apparent that subsurface conditions are different from those provided in this report, CTL Engineering should be notified so that our recommendations can modified, if required.

VI. TESTING AND OBSERVATION

During the design process, it is recommended that CTL Engineering work with the project designers to confirm that the geotechnical recommendations are properly incorporated into the final plans and specifications, and to assist with establishing criteria for the construction observation and testing.

VII. CLOSURE

The report was prepared by CTL Engineering, Inc. (Consultant) solely for the use of the Client in accordance with an executed contract. The Client's use of or reliance on this report is limited by the terms and conditions of the contract and by the qualifications and limitations stated in the report. It is also acknowledged that the Client's use of and reliance of this report is limited for reasons which include: actual site conditions that may change with time; hidden conditions, not discoverable within the scope of the assessment, may exist at the site; and the scope of the investigation may have been limited by time, budget and other constraints imposed by the Client.

Neither the report, nor its contents, conclusions nor recommendations are intended for the use of any party other than the Client. Consultant and the Client assume no liability for any reliance placed on this report by such party. The rights of the Client under contract may not be assigned to any person or entity, without the consent of the Consultant which consent shall not be unreasonably withheld.

This geotechnical report does not address the environmental conditions of the site. The Consultant is not responsible for consequences or conditions arising from facts that were concealed, withheld, or not fully disclosed at the time the assessment was conducted.

To the fullest extent permitted by law, the Consultant and Client agree to indemnify and hold each other, and their officers and employees harmless from and against claims, damages, losses and expenses arising out of unknown or concealed conditions. Furthermore, neither the Consultant nor its employees shall be liable to the Owner in an amount in excess of the available professional liability insurance coverage of the Consultant. In addition, Client and Consultant agree neither shall be liable for any special, indirect or consequential damages of any kind or nature.

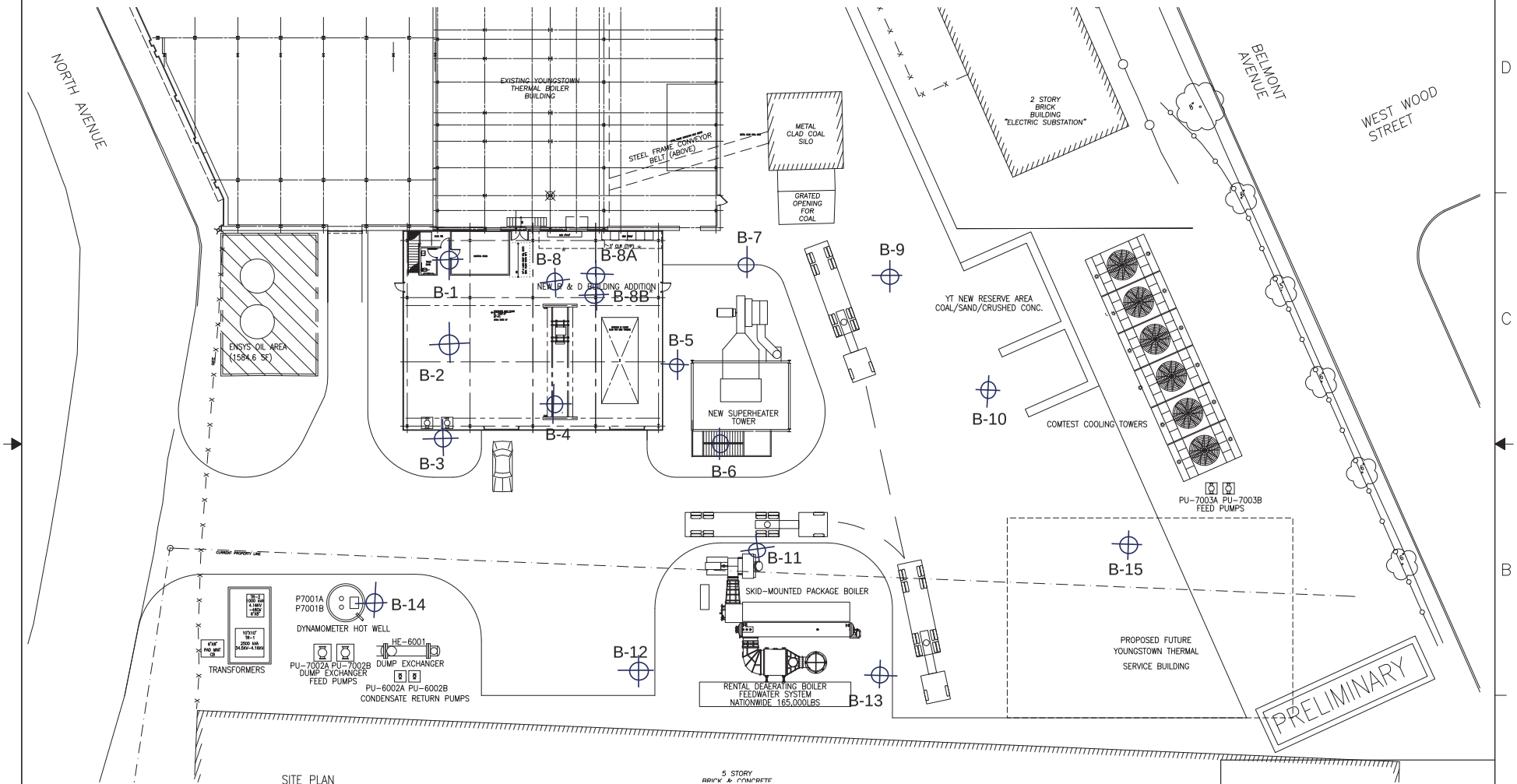
The Consultant's services have been provided consistent with its professional standard of care. No other warranties are made, either expressed or implied.

Respectfully Submitted,
CTL ENGINEERING, INC.

H. Matthew Karrouz, M.S., P.E.
Project Engineer

APPENDIX A

- **BORING LOCATION PLAN**
- **SOIL PROFILES**



SITE PLAN
SCALE: 1/16" = 1'-0"

REVISION APPROVAL RECORD						REV NO	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL					Approximate Boring Locations		
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC					* Hit Obstruction at B-8 at 1 ft, Moved to B-8A		
ENVIRON.			STRUCTURAL					Hit Obstruction at B-8A at 11 ft, Moved to B-8B		
GEN. ARRANG.										
I & C										

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY				
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV.NO.

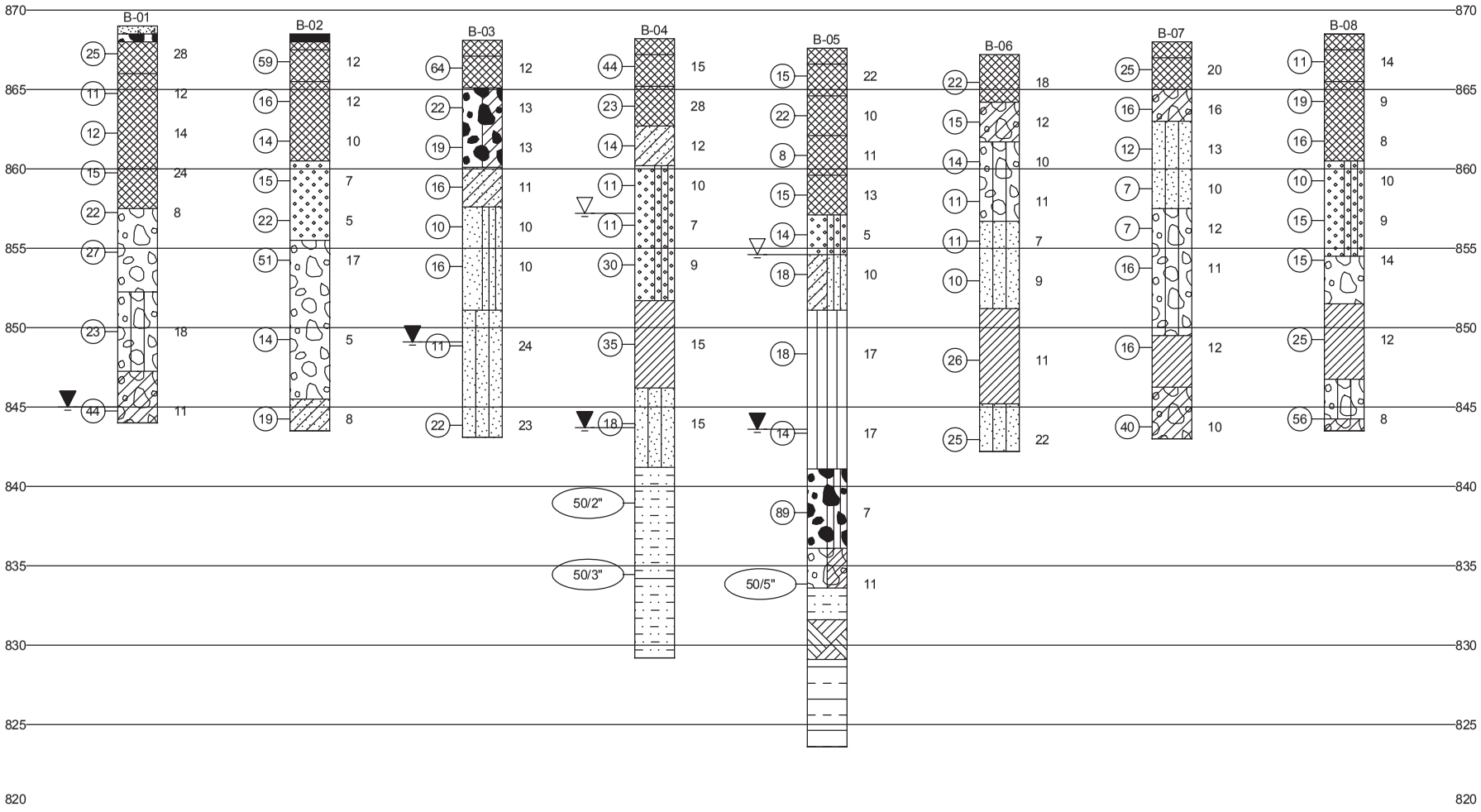
PROJECT NO.: 31609
DRAWN: TCG DATE: 02-04-16
CHECKED: DATE:
SCALE: AS NOTED

URS ENERGY & CONSTRUCTION Inc. – an AECOM Company
1500 West 3rd St, Suite 200
Cleveland, OH 44113
(216) 523-5600
AECOM

BORING LOCATION
SITE PLAN 02/11/16

DWG. NO. A2 REV –

EC_D_Size.dwg



LEGEND

TOPSOIL, ASPHALT, GW, GP, GW-GM, GW-GC, GP-GM, GP-GC, GM, GC, GC-GM, SW, SP, SW-SM, SW-SC, SP-SM, SP-SC, SM, SC, SC-SM, ML, CL, CL-ML, OL, CH, MH, OH, PT, SHALE, SILTSTONE, LIMESTONE, FILL

GROUND WATER DURING DRILLING

GROUND WATER AT COMPLETION OF DRILLING

GROUND WATER AT "N" HOURS AFTER COMPLETION

W — MOISTURE CONTENT IN PERCENT (w)

(N) — STANDARD PENETRATION IN BLOWS PER FOOT (N)

B-01

CTL ENGINEERING, INC.
CONSULTING ENGINEERS
3085 Interstate Parkway
Brunswick, Ohio 44212

SOIL PLAN/PROFILE

DATE	AECOM
2/17/2016	A-USC Com Test
SCALE	205 N. Ave., Youngstown, OH.
AS SHOWN	

DRAWN BY	PAGE	PROJECT NUMBER
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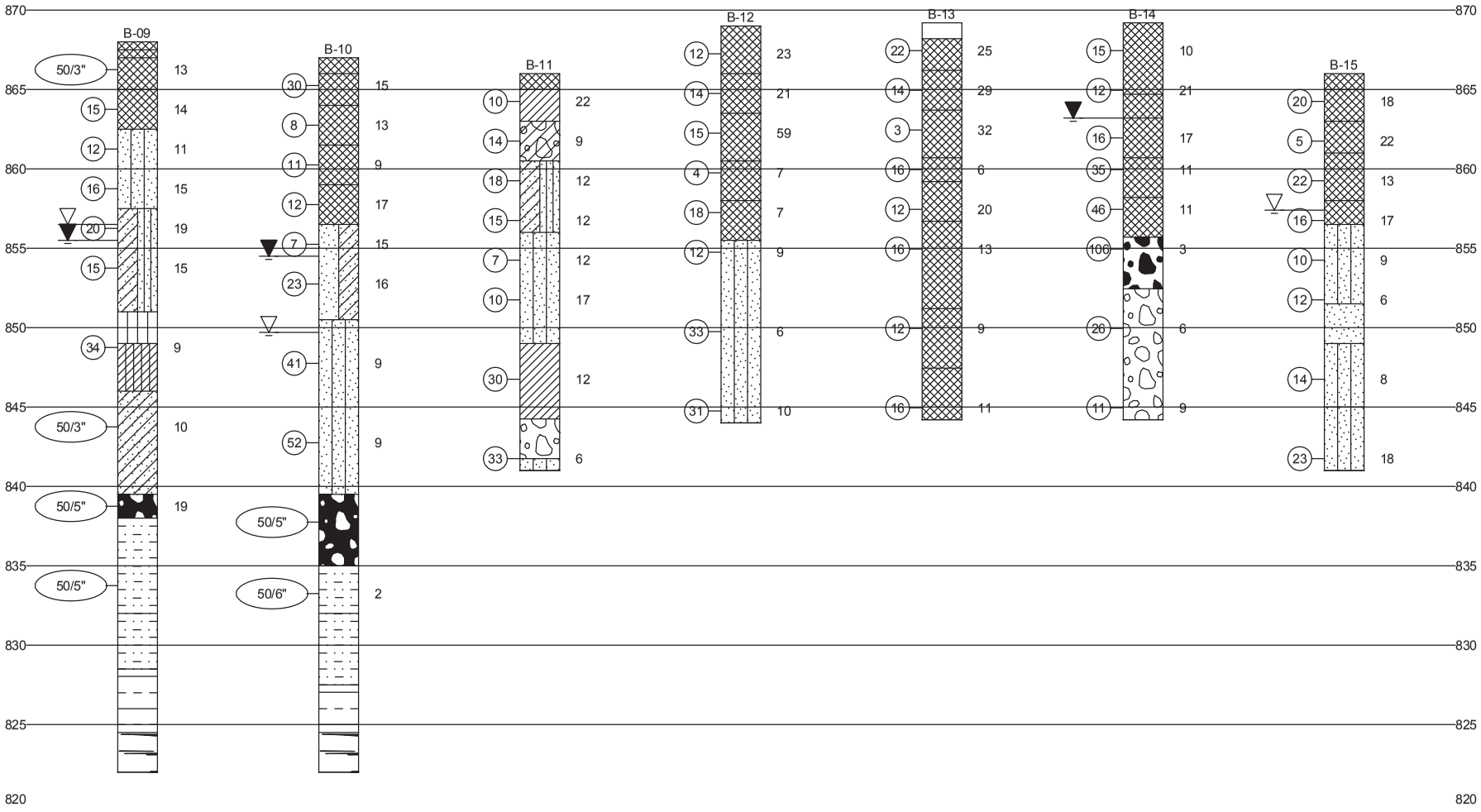


TOPSOIL
ASPHALT
GW
GP
GW-GM
GW-GC
GP-GM
GP-GC
GM
GC
GC-GM
SW
SP
SW-SM
SW-SC
SP-SM
SP-SC
SM
SC
SC-SM
ML
CL
CL-ML
OL
CH
MH
OH
PT
SHALE
SILTSTONE
LIMESTONE
FILL

LEGEND

GROUND WATER DURING DRILLING

GROUND WATER AT COMPLETION OF DRILLING

GROUND WATER AT "N" HOURS AFTER COMPLETION

W — MOISTURE CONTENT IN PERCENT (w)

(N) — STANDARD PENETRATION IN BLOWS PER FOOT (N)

B-01

CTL ENGINEERING, INC.
CONSULTING ENGINEERS
3085 Interstate Parkway
Brunswick, Ohio 44212

SOIL PLAN/PROFILE

DATE	AECOM
2/17/2016	A-USC Com Test
SCALE	205 N. Ave., Youngstown, OH.
AS SHOWN	

DRAWN BY	PAGE	PROJECT NUMBER
MK	1 OF 1	16050004CLE

APPENDIX B

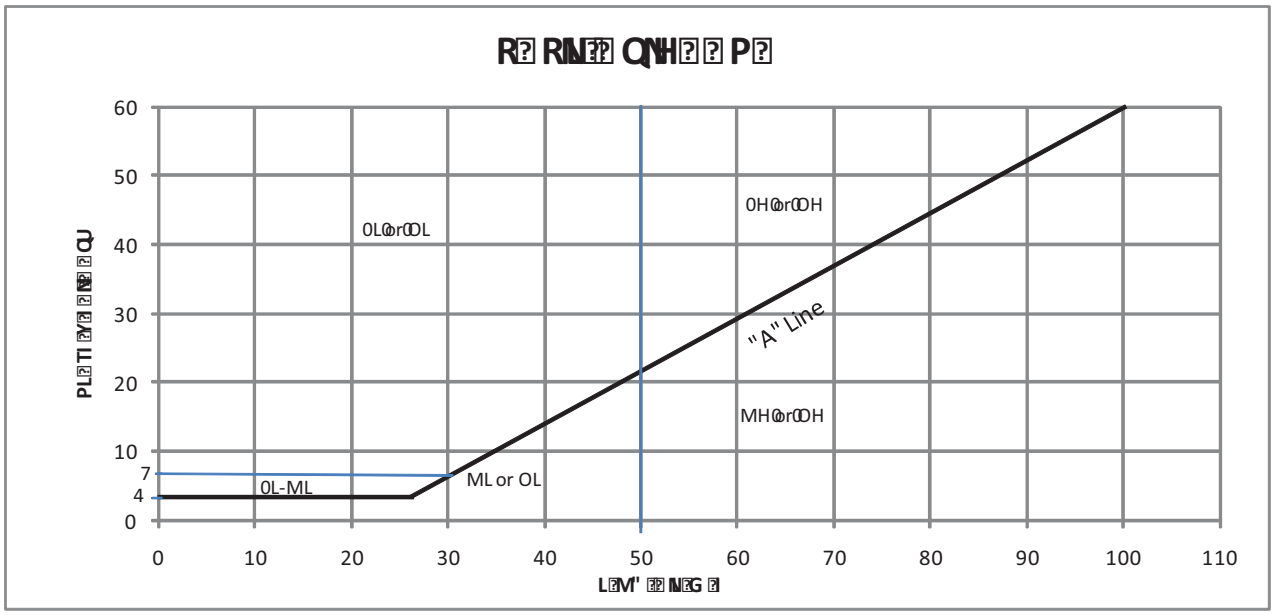
- **TEST BORING RECORDS**

SOIL DESCRIPTIONS BASED ON THE UNIFIED SOIL CLASSIFICATION SYSTEM

ASTM D 2487 and D 2488

Major Division			Group Symbol	Letter Symbol	Group Name*
Coarse Grained Soils Less Than 50 Percent Passing the # 200 Sieve	Gravel - Percent GRAVEL > percent SAND	Gravel with < 5% Fines		GW	Well Graded GRAVEL
				GP	Poorly Graded GRAVEL
		Gravel with Between 5 and 15% Fines		GW-GM	Well Graded GRAVEL with silt
				GW-GC	Well Graded Gravel with clay
				GP-GM	Poorly Graded GRAVEL with silt
				GP-GC	Poorly Graded GRAVEL with clay
		Gravel with ≥ 15% Fines		GM	Silty GRAVEL
				GC	Clayey GRAVEL
	Sand - Percent SAND ≥ percent GRAVEL	Sand with < 5% Fines		SW	Well Graded SAND
				SP	Poorly Graded SAND
		Sand with Between 5 and 15% Fines		SW-SM	Well Graded SAND with silt
				SW-SC	Well Graded SAND with clay
				SP-SM	Poorly Graded SAND with silt
				SP-SC	Poorly Graded SAND with clay
		Sand with ≥ 15% Fines		SM	Silty SAND
				SC	Clayey SAND
Fine Grained Soils 50 percent or more Passing the # 200 Sieve	SILT and CLAY	Liquid Limit Less Than 50		ML	SILT
				CL	Lean CLAY
				CL-ML	SILTY CLAY
				OL	Organic SILT, CLAY, or SILTY CLAY
		Liquid Limit 50 or Greater		MH	Elastic SILT
				CH	Fat CLAY
				OH	Organic SILT or CLAY
Highly Organic Soils				PT	Peat

* Additional Modifiers			
	Coarse Grained Soils	with silt or clay	5 to 12 % Silt or Clay by weight
		Silty or Clayey	more than 12 % Silt or Clay by weight
	Fine Grained Soils	with sand or gravel	15 to 29 % Sand or Gravel by weight
		Sandy or Gravelly	30 % or more Sand or Gravel by weight



SOIL DESCRIPTION

NON-COHESIVE SOIL DESCRIPTION	STANDARD PENETRATION BLOWCOUNTS PER FOOT (bpf)
Very Loose	0 – 4
Loose	5 – 10
Medium Dense	11 – 30
Dense	31 – 50
Very Dense	Over 50

COHESIVE SOIL DESCRIPTION	STANDARD PENETRATION BLOWCOUNTS PER FOOT (bpf)
Very Soft	0 – 1
Soft	2 – 4
Medium Stiff	5 – 8
Stiff	9 – 15
Very Stiff	16 – 30
Hard	Over 30

GRADATION COMPONENT	SIZE
Boulders	Larger Than 8”
Cobbles	8” – 3”
Coarse Gravel	Passing 3” Retained on ¾”
Fine Gravel	Passing ¾” Retained on #10
Coarse Sand	Passing #10 Retained #40
Fine Sand	Passing #40 Retained on #200
Silt	0.074 mm to 0.005 mm
Clay	Smaller Than 0.005 mm

COMPONENT MODIFIERS	SIZE
Trace	> 0 – 10%
Little	11 – 20%
Some	21 – 35%
And	36 – 50%

MOISTURE TERMS	DESCRIPTION
Dry	Powdery
Damp	Below Plastic Limit
Moist	Above Plastic Limit, Below Liquid Limit
Wet	Above Liquid Limit

TEST BORING RECORD

CLIENT : AECOM
PROJECT : A-USC Com Test
LOCATION : 205 N. Ave., Youngstown, OH.
PROJECT NO. : 16050004CLE

BORING NO.: **B-01**
SHEET 1 OF 1
DATE STARTED : 01-29-16
DATE COMPLETED : 01-29-16

BORING ELEVATION	: 869.0 Feet	RIG TYPE	: Mobile	DRILLER	: LH
STATION	:	CASING DIA.	: 3.25"	TEMPERATURE	: 28°
OFFSET	:	CORE SIZE	: N/A	WEATHER	: Snow
DEPTH	: 25.0 Feet	HAMMER	: AUTO		
BORING METHOD: HSA		ENERGY RATIO	: 81.9		

GROUNDWATER: Encountered at 24' At completion None Caved in at 10.7'

STRATUM ELEVATION	SAMPLE DEPTH	SOIL/MATERIAL DESCRIPTION	STRATUM DEPTH	SAMPLE NUMBER	SPT per 6"	N_{60}	RECOVERY (%)	MOISTURE CONTENT	TOTAL UNIT WEIGHT pcf	UNCONF. COMP., ksf	ATTERBERG LIMITS LL	PL	PI
868.5		6" CONCRETE	0.5										
868.0		6" BASE	1.0										
		Medium dense, gray to dark brown, WELL-GRADED SAND with SILT and GRAVEL, little slag, (FILL), moist		SS-1	3 4 14	25	100	28			NP	NP	NP
866.0			3.0										
	5			SS-2	6 4 4	11	100	12					
		Medium dense, brown, CLAYEY SAND with GRAVEL, trace silt, (FILL), moist		SS-3	6 5 4	12	100	14			NP	NP	NP
860.0			9.0										
	10	Stiff, brown to black, GRAVELLY LEAN CLAY, some silt, (FILL), moist		SS-4	5 5 6	15	11	24					
857.5			11.5	SS-5	6 7 9	22	100	8					
	15	Medium dense, brown, POORLY GRADED GRAVEL with SAND, trace silt, damp		SS-6	6 9 11	27	0						
852.3			16.8										
	20	Medium dense, reddish brown, SILTY GRAVEL with SAND, wet		SS-7	10 7 10	23	22	18					
847.3			21.8										
		Dense, brown to gray, SILTY, CLAYEY GRAVEL with SAND, damp		SS-8	10 10 22	44		11					
844.0	25	End of Boring at 25 Feet	25.0										

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BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling		SPT - Standard Penetration Test
HA - Hand Auger		N_{60} - Standard Penetration Normalized to 60% Drill Rod ER

TEST BORING/PIT RECORD 16050004CLE.GPJ CTL CORPORATE.GDT 3/7/16

TEST BORING RECORD

CLIENT : AECOM
PROJECT : A-USC Com Test
LOCATION : 205 N. Ave., Youngstown, OH.
PROJECT NO. : 16050004CLE

BORING NO.: **B-02**
SHEET 1 OF 1
DATE STARTED : 01-29-16
DATE COMPLETED : 01-29-16

BORING ELEVATION	: 868.5 Feet	RIG TYPE	: Mobile	DRILLER	: LH
STATION	:	CASING DIA.	: 3.25"	TEMPERATURE	: 30°
OFFSET	:	CORE SIZE	: N/A	WEATHER	: Cloudy
DEPTH	: 25.0 Feet	HAMMER	: AUTO		
BORING METHOD: HSA		ENERGY RATIO	: 81.9		

GROUNDWATER: Encountered at None At completion None Caved in at 8.5'

STRATUM ELEVATION	SAMPLE DEPTH	SOIL/MATERIAL DESCRIPTION	STRATUM DEPTH	SAMPLE NUMBER	SPT per 6"	N_{60}	RECOVERY (%)	MOISTURE CONTENT	TOTAL UNIT WEIGHT pcf	UNCONF. COMP., ksf	ATTERBERG LIMITS LL	PL	PI
868.0		6" Weathered ASPHALT	0.5										
867.5		6" BASE (FILL MATERIAL)	1.0										
		Very dense, gray to brown, POORLY GRADED GRAVEL with SAND, some slag, (FILL), damp		SS-1	40 23 20	59	100	12					
865.5			3.0										
	5	Medium dense, gray to brown, POORLY GRADED GRAVEL with SAND, little brick, sandstone fragments, (FILL), damp		SS-2	10 7 5	16	100	12					
				SS-3	8 6 4	14	66	10					
860.5			8.0										
	10	Medium dense, brown, WELL-GRADED SAND with GRAVEL, damp		SS-4	4 5 6	15	100	7					
				SS-5	7 8 8	22	100	5					
855.5			13.0										
	15	Very dense to medium dense, brown, POORLY GRADED GRAVEL with SAND, moist to damp		SS-6	36 27 10	51	16	17					
	20			SS-7	4 4 6	14	22	5					
845.5			23.0										
843.5	25	Medium dense, brown, CLAYEY SAND with GRAVEL, some silt, damp	25.0	SS-8	4 6 8	19	100	8			28	18	10
		End of Boring at 25 Feet											

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HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling		SPT - Standard Penetration Test
HA - Hand Auger		N_{60} - Standard Penetration Normalized to 60% Drill Rod ER

TEST BORING RECORD

CLIENT : AECOM
PROJECT : A-USC Com Test
LOCATION : 205 N. Ave., Youngstown, OH.
PROJECT NO. : 16050004CLE

BORING NO.: **B-03**
SHEET 1 OF 1
DATE STARTED : 01-29-16
DATE COMPLETED : 01-29-16

BORING ELEVATION	: 868.1 Feet	RIG TYPE	: Mobile	DRILLER	: LH
STATION	:	CASING DIA.	: 3.25"	TEMPERATURE	: 30°
OFFSET	:	CORE SIZE	: N/A	WEATHER	: Cloudy
DEPTH	: 25.0 Feet	HAMMER	: AUTO		
BORING METHOD: HSA		ENERGY RATIO	: 81.9		

GROUNDWATER: Encountered at 19' At completion None Caved in at 10.6'

STRATUM ELEVATION	SAMPLE DEPTH	SOIL/MATERIAL DESCRIPTION	STRATUM DEPTH	SAMPLE NUMBER	SPT per 6"	N_{60}	RECOVERY (%)	MOISTURE CONTENT	TOTAL UNIT WEIGHT pcf	UNCONF. COMP., ksf	ATTERBERG LIMITS LL	PL	PI
867.1		Black, COAL AND CINDERS, (FILL)	1.0										
		Very dense, gray, SLAG, little gravel, sand, (FILL), damp		SS-1	7 28 19	64	100	12					
865.1			3.0										
	5	Medium dense, brown, WELL-GRADED GRAVEL with CLAY and SAND, damp		SS-2	5 8 8	22	100	13			NP	NP	NP
				SS-3	20 8 6	19	100	13					
860.1			8.0										
		Medium dense, brown, CLAYEY SAND with GRAVEL, damp (auger cuttings)		SS-4	6 6 6	16	0	11					
	10												
857.6			10.5										
				SS-5	2 3 4	10	100	10					
		Loose to medium dense, brown, POORLY GRADED SAND with SILT and GRAVEL, damp		SS-6	4 2 10	16	100	10			NP	NP	NP
	15												
851.1			17.0										
				SS-7	2 3 5	11	100	24			NP	NP	NP
	20	Medium dense, brown, SILTY SAND with GRAVEL, wet											
				SS-8	11 7 9	22	66	23					
843.1	25		25.0										
		End of Boring at 25 Feet											

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BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling		SPT - Standard Penetration Test
HA - Hand Auger		N_{60} - Standard Penetration Normalized to 60% Drill Rod ER

TEST BORING RECORD

CLIENT : AECOM
PROJECT : A-USC Com Test
LOCATION : 205 N. Ave., Youngstown, OH.
PROJECT NO. : 16050004CLE

BORING NO.: **B-04**
SHEET 1 OF 2
DATE STARTED : 01-29-16
DATE COMPLETED : 01-29-16

BORING ELEVATION	: 868.2 Feet	RIG TYPE	: Mobile	DRILLER	: LH
STATION	:	CASING DIA.	: 3.25"	TEMPERATURE	: 45°
OFFSET	:	CORE SIZE	: N/A	WEATHER	: Cloudy
DEPTH	: 39.0 Feet	HAMMER	: AUTO		
BORING METHOD: HSA		ENERGY RATIO	: 81.9		

GROUNDWATER: Encountered at 24.5' At completion 11' Caved in at 24.8'

STRATUM ELEVATION	SAMPLE DEPTH	SOIL/MATERIAL DESCRIPTION	STRATUM DEPTH	SAMPLE NUMBER	SPT per 6"	N_{60}	RECOVERY (%)	MOISTURE CONTENT	TOTAL UNIT WEIGHT pcf	UNCONF. COMP., ksf	ATTERBERG LIMITS LL	PL	PI
867.2		23" Black, CINDERS. (FILL)	1.0										
865.2		Dense, gray to black, CLAYEY GRAVEL (SLAG) with SAND, little silt, cinders, (FILL), moist	3.0	SS-1	40 20 12	44	100	15					
862.7	5	Medium dense, black, SILTY SAND with GRAVEL, little cinders, (FILL), moist	5.5	SS-2	11 8 9	23	67	28	120		NP	NP	NP
860.2		Medium dense, brown, CLAYEY SAND with GRAVEL, little silt, (possible fill), moist	8.0	SS-3	9 5 5	14	100	12					
	10			SS-4	4 4 4	11	188	10	110		NP	NP	NP
		Medium dense, brown, WELL-GRADED SAND with SILT and GRAVEL, damp		SS-5	2 3 5	11	89	7					
		@ 13.5 trace COBBLE											
	15			SS-6	3 14 8	30	89	9	130		NP	NP	NP
851.7			16.5										
	20	Hard, reddish brown, SANDY LEAN CLAY, some silt, trace gravel, moist		SS-7	9 11 15	35	100	15	130		26	17	9
846.2			22.0										
	25	Medium dense, brown, SILTY SAND, little gravel, trace clay, coal, moist		SS-8	5 6 7	18	100	15	120		21	18	3

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BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling		SPT - Standard Penetration Test
HA - Hand Auger		N_{60} - Standard Penetration Normalized to 60% Drill Rod ER

TEST BORING RECORD

CLIENT : AECOM

BORING NO.: **B-04**

PROJECT : A-USC Com Test

SHEET 2 OF 2

STRATUM ELEVATION	SAMPLE DEPTH	SOIL/MATERIAL DESCRIPTION	STRATUM DEPTH	SAMPLE NUMBER	SPT per 6"	N_{60}	RECOVERY (%)	MOISTURE CONTENT	TOTAL UNIT WEIGHT pcf	UNCONF., COMP., ksf	ATTERBERG LIMITS LL	PL	PI
841.2			27.0										
	30	SANDSTONE, light brown to reddish brown, severely weathered, weak		SS-9	41 50/2"		63						
834.2			34.0	SS-10	50/3"		100		140				
	35	SANDSTONE, tan-gray, highly weathered, fine-medium grain, thin lamination, weak		CR-11 RQD= 28%			38		148	907.0*			
829.2		End of Boring at 39 Feet	39.0										
	40												
	45												
	50												
	55												

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HA - Hand Auger		N_{60} - Standard Penetration Normalized to 60% Drill Rod ER

TEST BORING/PIT RECORD 16050004CLE.GPJ CTL CORPORATE.GDT 3/7/16

TEST BORING RECORD

CLIENT : AECOM
PROJECT : A-USC Com Test
LOCATION : 205 N. Ave., Youngstown, OH.
PROJECT NO. : 16050004CLE

BORING NO.: **B-05**
SHEET 1 OF 2
DATE STARTED : 01-29-16
DATE COMPLETED : 01-29-16

BORING ELEVATION	: 867.6 Feet	RIG TYPE	: Mobile	DRILLER	: LH
STATION	:	CASING DIA.	: 3.25"	TEMPERATURE	: 30°
OFFSET	:	CORE SIZE	: N/A	WEATHER	: Overcast
DEPTH	: 44.0 Feet	HAMMER	: AUTO		
BORING METHOD: HSA		ENERGY RATIO	: 81.9		

GROUNDWATER: Encountered at 24' At completion 13'8" Caved in at 26.3'

STRATUM ELEVATION	SAMPLE DEPTH	SOIL/MATERIAL DESCRIPTION	STRATUM DEPTH	SAMPLE NUMBER	SPT per 6"	N_{60}	RECOVERY (%)	MOISTURE CONTENT	TOTAL UNIT WEIGHT pcf	UNCONF. COMP., ksf	ATTERBERG LIMITS LL	PL	PI
866.6		12" CINDERS and COAL, (FILL)	1.0										
864.6		Medium dense, black, SILTY GRAVEL with SAND, some slag, coal, cinders, (FILL), moist	3.0	SS-1	8 5 6	15	66	22					
862.1	5	Medium dense, SILTY GRAVEL with SAND trace clay, (FILL), damp	5.5	SS-2	8 7 9	22	66	10	120				
859.6		Loose, brown, SILTY SAND with GRAVEL, trace clay, (FILL), damp	8.0	SS-3	7 4 2	8	100	11	115		NP	NP	NP
857.1	10	Stiff, black to brown, GRAVELLY LEAN CLAY some silt, trace sand, cinders, (FILL), moist	10.5	SS-4	3 5 6	15	16	13					
854.6 ▽		Medium dense, brown, WELL-GRADED SAND with SILT and GRAVEL, damp	13.0	SS-5	5 5 5	14	100	5	120		NP	NP	NP
851.1	15	Medium dense, brown, SILTY, CLAYEY SAND, trace gravel, damp	16.5	SS-6	5 6 7	18	100	10			20	13	7
	20	Very stiff to stiff, gray to gray and brown, SANDY SILT, little to trace clay, trace gravel, moist		SS-7	7 5 8	18	100	17	120		19	16	3
▼	25			SS-8	3 4 6	14	83	17			NP	NP	NP

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BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling		SPT - Standard Penetration Test
HA - Hand Auger		N_{60} - Standard Penetration Normalized to 60% Drill Rod ER

TEST BORING RECORD

CLIENT : AECOM

PROJECT : A-USC Com Test

BORING NO.: **B-05**

SHEET 2 OF 2

STRATUM ELEVATION	SAMPLE DEPTH	SOIL/MATERIAL DESCRIPTION	STRATUM DEPTH	SAMPLE NUMBER	SPT per 6"	N_{60}	RECOVERY (%)	MOISTURE CONTENT	TOTAL UNIT WEIGHT pcf	UNCONF. COMP., ksf	ATTERBERG LIMITS LL	PL	PI
841.1			26.5										
	30	Very dense, brown, SILTY, CLAYEY SAND with GRAVEL, damp		SS-9	16 38 27	89	100	7	135		19	14	5
836.1			31.5										
		Very dense, gray to brown, CLAYEY GRAVEL with SAND, moist											
833.6		@34.0'; AUGER REFUSAL	34.0	SS-10	50/5"		33	11					
	35	SANDSTONE, gray, slightly weathered, fine to medium grain, thin black lamination, very strong		CR-11 RQD= 47%			92		148				
831.6			36.0										
		CONGLOMERATE ROCK, gray, rounded, slightly weathered, very strong		CR-12 RQD= 60%			94						
829.1			38.5										
	40	SILTSTONE, gray, slightly weathered, strong @ 42.8-44' weak with fine sandstone bedding/joints		CR-13 RQD= 82%			99		152	1085.0*			
823.6		End of Boring at 44 Feet	44.0										
	45												
	50												
	55												

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BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling		SPT - Standard Penetration Test
HA - Hand Auger		N_{60} - Standard Penetration Normalized to 60% Drill Rod ER

TEST BORING/PIT RECORD 16050004CLE.GPJ CTL CORPORATE.GDT 3/7/16

TEST BORING RECORD

CLIENT : AECOM
PROJECT : A-USC Com Test
LOCATION : 205 N. Ave., Youngstown, OH.
PROJECT NO. : 16050004CLE

BORING NO.: **B-06**
SHEET 1 OF 1
DATE STARTED : 01-29-16
DATE COMPLETED : 01-29-16

BORING ELEVATION	: 867.2 Feet	RIG TYPE	: Mobile	DRILLER	: LH
STATION	:	CASING DIA.	: 3.25"	TEMPERATURE	: 30°
OFFSET	:	CORE SIZE	: N/A	WEATHER	: Cloudy
DEPTH	: 25.0 Feet	HAMMER	: AUTO		
BORING METHOD: HSA		ENERGY RATIO	: 81.9		

GROUNDWATER: Encountered at None At completion None Caved in at 10.6'

STRATUM ELEVATION	SAMPLE DEPTH	SOIL/MATERIAL DESCRIPTION	STRATUM DEPTH	SAMPLE NUMBER	SPT per 6"	N_{60}	RECOVERY (%)	MOISTURE CONTENT	TOTAL UNIT WEIGHT pcf	UNCONF. COMP., ksf	ATTERBERG LIMITS LL	PL	PI
864.2		Medium dense, black, SILTY SAND, little cinders, coal, gravel, (FILL), moist	3.0	SS-1	8 8 8	22	100	18					
861.7	5	Medium dense, brown, CLAYEY GRAVEL with SAND, damp	5.5	SS-2	6 5 6	15	100	12					
		Medium dense, brown, SILTY GRAVEL with SAND, damp		SS-3	3 5 5	14	100	10					
856.7	10		10.5	SS-4	3 4 4	11	100	11					
		Medium dense to loose, brown, SILTY SAND, trace gravel, damp		SS-5	3 3 5	11	77	7					
851.2	15		16.0	SS-6	3 4 3	10	77	9			NP	NP	NP
	20	Very stiff, gray, LEAN CLAY with SAND, and silt, damp		SS-7	5 8 11	26	83	11					
845.2			22.0										
842.2	25	Medium dense, reddish brown, SILTY SAND, trace gravel, clay, moist	25.0	SS-8	3 7 11	25	66	22					
		End of Boring at 25 Feet											

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BORING METHOD
HSA - Hollow Stem Auger
SFA - Solid Flight Auger
RC - Rock Coring
MD - Mud Drilling
WD - Wash Drilling
HA - Hand Auger

SAMPLING METHOD
SS - Split Spoon Sample
ST - Shelby Tube Sample
CR - Rock Core Sample
BS - Bag Sample

ABBREVIATIONS
* - Hand Penetrometer
LL - Liquid Limit
PL - Plastic Limit
PI - Plasticity Index
SPT - Standard Penetration Test
N_{60} - Standard Penetration Normalized to 60% Drill Rod ER

TEST BORING RECORD

CLIENT : AECOM
PROJECT : A-USC Com Test
LOCATION : 205 N. Ave., Youngstown, OH.
PROJECT NO. : 16050004CLE

BORING NO.: **B-07**
SHEET 1 OF 1
DATE STARTED : 01-29-16
DATE COMPLETED : 01-29-16

BORING ELEVATION	: 868.0 Feet	RIG TYPE	: Mobile	DRILLER	: LH
STATION	:	CASING DIA.	: 3.25"	TEMPERATURE	: 30°
OFFSET	:	CORE SIZE	: N/A	WEATHER	: Cloudy
DEPTH	: 25.0 Feet	HAMMER	: AUTO		
BORING METHOD: HSA		ENERGY RATIO	: 81.9		

GROUNDWATER: Encountered at None At completion None Caved in at 8.3'

STRATUM ELEVATION	SAMPLE DEPTH	SOIL/MATERIAL DESCRIPTION	STRATUM DEPTH	SAMPLE NUMBER	SPT per 6"	N_{60}	RECOVERY (%)	MOISTURE CONTENT	TOTAL UNIT WEIGHT pcf	UNCONF., COMP., ksf	ATTERBERG LIMITS LL	PL	PI
867.0		Black, CINDERS and COAL, (FILL)	1.0										
		Medium dense, gray to black, SLAG with SAND, little coal, cinders, (FILL), moist		SS-1	16 10 8	25	77	20					
865.0			3.0										
		Medium dense, brown, CLAYEY SAND with GRAVEL, moist		SS-2	7 5 7	16	100	16			NP	NP	NP
863.0	5		5.0										
		Medium dense to loose, brown, SILTY SAND with GRAVEL, damp		SS-3	6 5 4	12	100	13					
				SS-4	5 2 3	7	100	10					
	10												
857.5			10.5										
				SS-5	5 3 2	7	72	12					
		Loose to medium dense, SILTY GRAVEL with SAND, moist		SS-6	3 5 7	16	44	11			NP	NP	NP
	15												
849.5			18.5										
				SS-7	6 6 6	16	100	12		9.0*			
	20	Very stiff, gray, LEAN CLAY with SAND, and silt, damp											
846.3			21.8										
		Dense, gray, CLAYEY GRAVEL with SAND, damp		SS-8	1 9 20	40	88	10					
843.0	25		25.0										
		End of Boring at 25.0 Feet											

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BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling		SPT - Standard Penetration Test
HA - Hand Auger		N_{60} - Standard Penetration Normalized to 60% Drill Rod ER

TEST BORING RECORD

CLIENT : AECOM
PROJECT : A-USC Com Test
LOCATION : 205 N. Ave., Youngstown, OH.
PROJECT NO. : 16050004CLE

BORING NO.: **B-08B**
SHEET 1 OF 1
DATE STARTED : 01-29-16
DATE COMPLETED : 01-29-16

BORING ELEVATION	: 868.5 Feet	RIG TYPE	: Mobile	DRILLER	: LH
STATION	:	CASING DIA.	: 3.25"	TEMPERATURE	: 36°
OFFSET	:	CORE SIZE	: N/A	WEATHER	: Clear
DEPTH	: 25.0 Feet	HAMMER	: AUTO		
BORING METHOD: HSA		ENERGY RATIO	: 81.9		

GROUNDWATER: Encountered at None At completion None Caved in at 8.6'

STRATUM ELEVATION	SAMPLE DEPTH	SOIL/MATERIAL DESCRIPTION	STRATUM DEPTH	SAMPLE NUMBER	SPT per 6"	N_{60}	RECOVERY (%)	MOISTURE CONTENT	TOTAL UNIT WEIGHT pcf	UNCONF. COMP., ksf	ATTERBERG LIMITS LL	PL	PI
868.5		2" Weathered ASPHALT	0.0										
867.5		10" BASE	1.0										
		Loose, black CINDERS, SAND and SLAG, (FILL), damp		SS-1	3 4 4	11	55	14					
865.5			3.0										
	5	Medium dense, brown, SILTY, CLAYEY GRAVEL with SAND, (FILL), moist		SS-2	10 7 7	19	100	9			NP	NP	NP
				SS-3	8 6 6	16	44	8					
860.5			8.0										
	10	Loose to medium dense, brown, WELL-GRADED SAND with SILT and GRAVEL, trace clay, damp @11.0'; Hit Obstruction - Moved Boring 5' South		SS-4	6 3 4	10	100	10			NP	NP	NP
				SS-5	3 4 7	15	44	9					
854.5			14.0										
	15	Medium dense, brown, POORLY-GRADED GRAVEL with SAND, trace silt, moist		SS-6	9 6 5	15	88	14					
851.5			17.0										
	20	Very stiff, gray, SANDY LEAN CLAY, and silt, trace gravel, damp		SS-7	8 8 10	25	100	12		9.0*			
846.8			21.8										
		Very dense, brown to gray, SILTY GRAVEL, trace sand, damp											
844.3			24.3										
843.5	25	Very dense, brown, CLAYEY SAND with GRAVEL, moist	25.0	SS-8	17 17 24	56	100	8 10					
		End of Boring at 25 Feet											

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BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling		SPT - Standard Penetration Test
HA - Hand Auger		N_{60} - Standard Penetration Normalized to 60% Drill Rod ER

TEST BORING RECORD

CLIENT : AECOM
PROJECT : A-USC Com Test
LOCATION : 205 N. Ave., Youngstown, OH.
PROJECT NO. : 16050004CLE

BORING NO.: **B-09**
SHEET 1 OF 2
DATE STARTED : 01-29-16
DATE COMPLETED : 01-29-16

BORING ELEVATION	: 868.0 Feet	RIG TYPE	: Mobile	DRILLER	: LH
STATION	:	CASING DIA.	: 3.25"	TEMPERATURE	: 47°
OFFSET	:	CORE SIZE	: N/A	WEATHER	: Sunny
DEPTH	: 46.0 Feet	HAMMER	: AUTO		
BORING METHOD: HSA		ENERGY RATIO	: 81.9		

GROUNDWATER: Encountered at 12.5' At completion 11.5' Caved in at 18'

STRATUM ELEVATION	SAMPLE DEPTH	SOIL/MATERIAL DESCRIPTION	STRATUM DEPTH	SAMPLE NUMBER	SPT per 6"	N_{60}	RECOVERY (%)	MOISTURE CONTENT	TOTAL UNIT WEIGHT pcf	UNCONF. COMP., ksf	ATTERBERG LIMITS LL	PL	PI
867.5		6" Red Brick	0.5										
867.0		6" Red weathered BRICK	1.0										
		Very dense, gray to black, SILTY GRAVEL (SLAG, LIMESTONE) with SAND, trace cinders, (FILL), damp		SS-1	40 50/3"		44	13					
865.0		@2.0'; Possible Railway Line - Moved Boring 3' North	3.0										
	5	Medium dense, brown, CLAYEY SAND with GRAVEL, little silt, (possible FILL) moist		SS-2	4 5 6	15	100	14			NP	NP	NP
862.5			5.5										
				SS-3	6 5 4	12	100	11	120				
		Medium dense, brown, SILTY SAND, trace gravel, (possible FILL), damp @ 8.5' trace clay		SS-4	11 7 5	16	100	15			NP	NP	NP
	10												
857.5			10.5										
				SS-5	7 8 7	20	100	19	120				
		Medium dense, reddish brown to brown, SILTY, CLAYEY SAND with GRAVEL, (possible FILL), moist		SS-6	10 5 6	15	100	15	130		NP	NP	NP
	15												
851.0			17.0										
		Dense, gray, SANDY SILT with GRAVEL, trace clay, damp											
849.0			19.0	SS-7	9 10 15	34	100	9					
	20	Hard, gray, SANDY SILTY CLAY, damp											
846.0			22.0										
		Very dense, gray, CLAYEY SAND with GRAVEL, moist		SS-8	50/3"		16	10	135				
	25												

Continued on next page

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BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling		SPT - Standard Penetration Test
HA - Hand Auger		N_{60} - Standard Penetration Normalized to 60% Drill Rod ER

TEST BORING RECORD

CLIENT : AECOM

PROJECT : A-USC Com Test

BORING NO.: **B-09**

SHEET 2 OF 2

STRATUM ELEVATION	SAMPLE DEPTH	SOIL/MATERIAL DESCRIPTION	STRATUM DEPTH	SAMPLE NUMBER	SPT per 6"	N_{60}	RECOVERY (%)	MOISTURE CONTENT	TOTAL UNIT WEIGHT pcf	UNCONF., COMP., ksf	ATTERBERG LIMITS LL	PL	PI
		Very dense, gray, CLAYEY SAND with GRAVEL, moist											
839.5			28.5										
		possible COBBLE		SS-9	42 50/5"		0	19					
838.0	30		30.0										
		SANDSTONE, gray, severely weathered, weak											
				SS-10	35 50/5"		61		140				
	35												
832.0			36.0										
		1" SANDSTONE, red 17" SANDSTONE, gray fine-medium, highly weathered, weak 5.5" CONGLOMERATE ROCK, weathered, strong		CR-11 RQD= 42%			70		154	1044.0*			
828.5	40		39.5										
		SILTSTONE, gray, slightly weathered, strong to weak											
824.5			43.5	CR-12 RQD= 70%			100		155				
	45	SHALE, gray, highly weathered, laminated bedding, weak											
822.0			46.0										
		End of Boring at 46 feet											
	50												
	55												

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WD - Wash Drilling		SPT - Standard Penetration Test
HA - Hand Auger		N_{60} - Standard Penetration Normalized to 60% Drill Rod ER

TEST BORING/PIT RECORD 16050004CLE.GPJ CTL CORPORATE.GDT 3/7/16

TEST BORING RECORD

CLIENT : AECOM
PROJECT : A-USC Com Test
LOCATION : 205 N. Ave., Youngstown, OH.
PROJECT NO. : 16050004CLE

BORING NO.: **B-10**
SHEET 1 OF 2
DATE STARTED : 01-29-16
DATE COMPLETED : 01-29-16

BORING ELEVATION	: 867.0 Feet	RIG TYPE	: Mobile	DRILLER	: LH
STATION	:	CASING DIA.	: 3.25"	TEMPERATURE	: 30°
OFFSET	:	CORE SIZE	: N/A	WEATHER	: Overcast
DEPTH	: 45.0 Feet	HAMMER	: AUTO		
BORING METHOD: HSA		ENERGY RATIO	: 81.9		

GROUNDWATER: Encountered at 12.5' At completion 17.3' Caved in at 27.6'

STRATUM ELEVATION	SAMPLE DEPTH	SOIL/MATERIAL DESCRIPTION	STRATUM DEPTH	SAMPLE NUMBER	SPT per 6"	N_{60}	RECOVERY (%)	MOISTURE CONTENT	TOTAL UNIT WEIGHT pcf	UNCONF. COMP., ksf	ATTERBERG LIMITS LL	PL	PI
866.0		12" MULCH, CINDERS and CRUSHED COAL, (FILL)	1.0										
		Medium dense, black, SILTY SAND with GRAVEL, little slag, cinders, coal, (FILL), moist		SS-1	8 10 12	30	77	15			NP	NP	NP
864.0			3.0										
	5	Medium stiff, black to brown, GRAVELLY LEAN CLAY, some silt, little sand, (FILL), moist		SS-2	2 3 3	8	100	13	110				
861.5			5.5										
		Medium dense, brown, CLAYEY SAND with GRAVEL, trace silt, (FILL), moist		SS-3	2 5 3	11	100	9			NP	NP	NP
859.0			8.0										
		Stiff, brown to black, SANDY LEAN CLAY, some silt, trace coal, (FILL), moist		SS-4	4 4 5	12	22	17	110				
	10												
856.5			10.5										
				SS-5	4 2 3	7	100	15			NP	NP	NP
		Loose to medium dense, brown, POORLY GRADED SAND with CLAY and GRAVEL, trace silt, moist		SS-6	7 7 10	23	100	16	125				
	15												
850.5			16.5										
				SS-7	8 14 16	41	100	9	135		17	14	3
	20	Dense to very dense, gray, SILTY SAND with GRAVEL, little clay, damp											
				SS-8	8 17 21	52	100	9	140				
	25												

Continued on next page

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BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling		SPT - Standard Penetration Test
HA - Hand Auger		N_{60} - Standard Penetration Normalized to 60% Drill Rod ER

TEST BORING RECORD

CLIENT : AECOM

PROJECT : A-USC Com Test

BORING NO.: **B-10**

SHEET 2 OF 2

STRATUM ELEVATION	SAMPLE DEPTH	SOIL/MATERIAL DESCRIPTION	STRATUM DEPTH	SAMPLE NUMBER	SPT per 6"	N_{60}	RECOVERY (%)	MOISTURE CONTENT	TOTAL UNIT WEIGHT pcf	UNCONF., COMP., ksf	ATTERBERG LIMITS LL	PL	PI
839.5		Dense to very dense, gray, SILTY SAND with GRAVEL, little clay, damp	27.5										
	30	COBBLE		SS-9	50/5"		10						
835.0			32.0										
		Very dense, gray to pink, SANDSTONE FRAGMENTS with SAND, (possible weathered sandstone), damp		SS-10	50/6"		100	2	145				
832.0	35	@35.0'; AUGER REFUSAL	35.0										
		SANDSTONE, gray with red seam, fine-medium grain, weathered-highly weathered, angular joints with clay, strong		CR-11 RQD= 55%			100						
827.5	40		39.5						158	1294.0*			
		SILTSTONE, gray slightly weathered, angular joints filled with clay, strong											
824.5			42.5	CR-12 RQD= 71%			95						
		SLATE/SHALE/MUDSTONE, Weathered, very weak											
822.0	45	End of Boring at 45 Feet	45.0										
	50												
	55												

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BORING METHOD

HSA - Hollow Stem Auger
SFA - Solid Flight Auger
RC - Rock Coring
MD - Mud Drilling
WD - Wash Drilling
HA - Hand Auger

SAMPLING METHOD

SS - Split Spoon Sample
ST - Shelby Tube Sample
CR - Rock Core Sample
BS - Bag Sample

ABBREVIATIONS

* - Hand Penetrometer
LL - Liquid Limit
PL - Plastic Limit
PI - Plasticity Index
SPT - Standard Penetration Test
N_{60} - Standard Penetration Normalized to 60% Drill Rod ER

TEST BORING/PIT RECORD 16050004CLE.GPJ CTL CORPORATE.GDT 3/7/16

TEST BORING RECORD

CLIENT : AECOM
PROJECT : A-USC Com Test
LOCATION : 205 N. Ave., Youngstown, OH.
PROJECT NO. : 16050004CLE

BORING NO.: **B-11**
SHEET 1 OF 1
DATE STARTED : 01-29-16
DATE COMPLETED : 01-29-16

BORING ELEVATION	: 866.0 Feet	RIG TYPE	: Mobile	DRILLER	: LH
STATION	:	CASING DIA.	: 3.25"	TEMPERATURE	: 30°
OFFSET	:	CORE SIZE	: N/A	WEATHER	: Cloudy
DEPTH	: 25.0 Feet	HAMMER	: AUTO		
BORING METHOD: HSA		ENERGY RATIO	: 81.9		

GROUNDWATER: Encountered at None At completion None Caved in at 7.8'

STRATUM ELEVATION	SAMPLE DEPTH	SOIL/MATERIAL DESCRIPTION	STRATUM DEPTH	SAMPLE NUMBER	SPT per 6"	N_{60}	RECOVERY (%)	MOISTURE CONTENT	TOTAL UNIT WEIGHT pcf	UNCONF. COMP., ksf	ATTERBERG LIMITS LL	PL	PI
865.0		Black, CINDERS, (FILL)	1.0										
		Stiff, brown, LEAN CLAY with SAND, and silt, moist		SS-1	5 4 3	10	100	22		1.0*	28	20	8
863.0			3.0										
	5	Medium dense, brown, CLAYEY GRAVEL with SAND, damp		SS-2	4 6 4	14	100	9					
860.5			5.5										
		Medium dense, brown, SILTY, CLAYEY GRAVEL with SAND, damp		SS-3	5 6 7	18	100	12					
				SS-4	4 6 5	15	100	12					
856.0	10		10.0										
		Loose, brown, SILTY SAND, trace gravel, damp to moist		SS-5	3 2 3	7	100	12					
	15			SS-6	2 3 4	10	100	17					
849.0			17.0										
	20	Very stiff, gray, LEAN CLAY, and silt, trace sand, damp		SS-7	7 10 12	30	100	12		9.0*			
844.3			21.8										
		Dense, gray, POORLY GRADED GRAVEL, dry											
841.8			24.3										
841.0	25	Dense, brown, SILTY SAND with GRAVEL, moist	25.0	SS-8	11 11 13	33	100	6 24					
		End of Boring at 25 Feet											

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BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling		SPT - Standard Penetration Test
HA - Hand Auger		N_{60} - Standard Penetration Normalized to 60% Drill Rod ER

TEST BORING RECORD

CLIENT : AECOM
PROJECT : A-USC Com Test
LOCATION : 205 N. Ave., Youngstown, OH.
PROJECT NO. : 16050004CLE

BORING NO.: **B-12**
SHEET 1 OF 1
DATE STARTED : 01-29-16
DATE COMPLETED : 01-29-16

BORING ELEVATION	: 869.0 Feet	RIG TYPE	: Mobile	DRILLER	: LH
STATION	:	CASING DIA.	: 3.25"	TEMPERATURE	: 30°
OFFSET	:	CORE SIZE	: N/A	WEATHER	: Snow
DEPTH	: 25.0 Feet	HAMMER	: AUTO		
BORING METHOD: HSA		ENERGY RATIO	: 81.9		

GROUNDWATER: Encountered at None At completion None Caved in at 11'

STRATUM ELEVATION	SAMPLE DEPTH	SOIL/MATERIAL DESCRIPTION	STRATUM DEPTH	SAMPLE NUMBER	SPT per 6"	N_{60}	RECOVERY (%)	MOISTURE CONTENT	TOTAL UNIT WEIGHT pcf	UNCONF. COMP., ksf	ATTERBERG LIMITS LL	PL	PI
866.0		Medium dense, brown to black, CINDERS, little gravel, coal, (FILL), moist	3.0	SS-1	4 4 5	12	100	23					
863.5	5	Medium dense, gray, brown and black, CLAYEY SAND with GRAVEL, little slag, coal, (FILL), moist	5.5	SS-2	2 3 7	14	100	21			NP	NP	NP
860.5		Medium dense, multicolored, SLAG SAND, some clay, gravel, cinders, (FILL), moist	8.5	SS-3	3 7 4	15	100	59					
858.0	10	Very loose, brown, CLAYEY GRAVEL with SAND, (FILL), damp	11.0	SS-4	4 1 2	4	38	7					
855.5		Medium dense, gray, SANDSTONE FRAGMENTS, little sand, (FILL), damp	13.5	SS-5	4 5 8	18	16	7					
	15			SS-6	3 5 4	12	100	9					
	20	Medium dense to dense, brown, SILTY SAND with GRAVEL, moist		SS-7	6 11 13	33	100	6					
844.0	25	End of Boring at 25 Feet	25.0	SS-8	7 11 12	31	100	10					

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BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling		SPT - Standard Penetration Test
HA - Hand Auger		N_{60} - Standard Penetration Normalized to 60% Drill Rod ER

TEST BORING RECORD

CLIENT : AECOM
PROJECT : A-USC Com Test
LOCATION : 205 N. Ave., Youngstown, OH.
PROJECT NO. : 16050004CLE

BORING NO.: **B-13**
SHEET 1 OF 1
DATE STARTED : 01-29-16
DATE COMPLETED : 01-29-16

BORING ELEVATION	: 869.2 Feet	RIG TYPE	: Mobile	DRILLER	: LH
STATION	:	CASING DIA.	: 3.25"	TEMPERATURE	: 30°
OFFSET	:	CORE SIZE	: N/A	WEATHER	: Snow
DEPTH	: 25.0 Feet	HAMMER	: AUTO		
BORING METHOD: HSA		ENERGY RATIO	: 81.9		

GROUNDWATER: Encountered at None At completion None Caved in at 14'

STRATUM ELEVATION	SAMPLE DEPTH	SOIL/MATERIAL DESCRIPTION	STRATUM DEPTH	SAMPLE NUMBER	SPT per 6"	N_{60}	RECOVERY (%)	MOISTURE CONTENT	TOTAL UNIT WEIGHT pcf	UNCONF. COMP., ksf	ATTERBERG LIMITS LL	PL	PI
868.2		12" TOPSOIL	1.0										
		Medium dense, brown, CLAYEY SAND with GRAVEL, trace silt, coal, (FILL), moist		SS-1	9 11 5	22	100	25			NP	NP	NP
866.2			3.0										
		Stiff, brown to black, GRAVELLY LEAN CLAY, little sand silt, trace slag, coal, (FILL), moist		SS-2	4 4 6	14	88	29					
	5												
863.7			5.5										
		Very loose, brown, CLAYEY SAND, little gravel, silt, slag, (FILL), moist		SS-3	2 1 1	3	88	32			NP	NP	NP
860.7			8.5										
		Medium dense, gray to red, SLAG and BRICK FRAGMENTS, (FILL), dry		SS-4	5 6 6	16	44	6					
859.2	10		10.0										
		Stiff, brown, LEAN CLAY with GRAVEL, and silt, some brick fragments, trace sand, (FILL), moist		SS-5	3 4 5	12	100	20		5.5*	33	17	16
856.7			12.5										
		Medium dense, brown, CLAYEY SAND with GRAVEL, little brick fragments, (FILL), moist		SS-6	5 6 6	16	100	13					
	15												
851.2			18.0										
		Medium dense, brown, SILTY SAND with GRAVEL, (FILL), damp		SS-7	4 3 6	12	66	9					
	20												
847.5			21.8										
		Medium dense, brown, CLAYEY GRAVEL with SAND, trace brick fragment, (FILL), damp		SS-8	5 6 6	16	16	11					
844.2	25		25.0										
		End of Boring at 25 Feet											

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BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling		SPT - Standard Penetration Test
HA - Hand Auger		N_{60} - Standard Penetration Normalized to 60% Drill Rod ER

TEST BORING RECORD

CLIENT : AECOM
PROJECT : A-USC Com Test
LOCATION : 205 N. Ave., Youngstown, OH.
PROJECT NO. : 16050004CLE

BORING NO.: **B-14**
SHEET 1 OF 1
DATE STARTED : 01-29-16
DATE COMPLETED : 01-29-16

BORING ELEVATION	: 869.2 Feet	RIG TYPE	: Mobile	DRILLER	: LH
STATION	:	CASING DIA.	: 3.25"	TEMPERATURE	: 30°
OFFSET	:	CORE SIZE	: N/A	WEATHER	: Snow
DEPTH	: 25.0 Feet	HAMMER	: AUTO		
BORING METHOD: HSA		ENERGY RATIO	: 81.9		

GROUNDWATER: Encountered at 6' At completion None Caved in at 11.7'

STRATUM ELEVATION	SAMPLE DEPTH	SOIL/MATERIAL DESCRIPTION	STRATUM DEPTH	SAMPLE NUMBER	SPT per 6"	N_{60}	RECOVERY (%)	MOISTURE CONTENT	TOTAL UNIT WEIGHT pcf	UNCONF. COMP., ksf	ATTERBERG LIMITS LL	PL	PI
		Medium dense, brown, SILTY SAND with GRAVEL, trace clay, (FILL), moist		SS-1	4 6 5	15	100	10			NP	NP	NP
864.7	5	Medium dense, black, CLAYEY SAND, some cinders, coal, (FILL), moist	4.5	SS-3	2 5 4	12	100	21			NP	NP	NP
863.2 ▼		Medium dense, brown, CLAYEY SAND with GRAVEL, (FILL), moist	6.0	SS-2	6 6 6	16	100	17					
860.7	10	Dense, brown, SILTY GRAVEL with SAND, (FILL), moist	8.5	SS-4	15 17 9	35	55	11					
858.2		Hard, brown to black, GRAVELLY LEAN CLAY with SAND, trace cinders, roots, (FILL), moist	11.0	SS-5	14 16 18	46	6	11					
855.7	15	Very dense, brown, WELL-GRADED GRAVEL with SAND, (possible FILL), dry	13.5	SS-6	26 46 32	106	4	3					
852.5	20	Medium dense, brown, POORLY GRADED GRAVEL with SAND, damp	16.8	SS-7	6 8 11	26	100	6					
844.2	25	End of Boring at 25 Feet	25.0	SS-8	5 6 2	11	55	9					

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BORING METHOD
HSA - Hollow Stem Auger
SFA - Solid Flight Auger
RC - Rock Coring
MD - Mud Drilling
WD - Wash Drilling
HA - Hand Auger

SAMPLING METHOD
SS - Split Spoon Sample
ST - Shelby Tube Sample
CR - Rock Core Sample
BS - Bag Sample

ABBREVIATIONS
* - Hand Penetrometer
LL - Liquid Limit
PL - Plastic Limit
PI - Plasticity Index
SPT - Standard Penetration Test
N_{60} - Standard Penetration Normalized to 60% Drill Rod ER

TEST BORING RECORD

CLIENT : AECOM
PROJECT : A-USC Com Test
LOCATION : 205 N. Ave., Youngstown, OH.
PROJECT NO. : 16050004CLE

BORING NO.: **B-15**
SHEET 1 OF 1
DATE STARTED : 01-29-16
DATE COMPLETED : 01-29-16

BORING ELEVATION	: 866.0 Feet	RIG TYPE	: Mobile	DRILLER	: LH
STATION	:	CASING DIA.	: 3.25"	TEMPERATURE	: 38°
OFFSET	:	CORE SIZE	: N/A	WEATHER	: Clear
DEPTH	: 25.0 Feet	HAMMER	: AUTO		
BORING METHOD: HSA		ENERGY RATIO	: 81.9		

GROUNDWATER: Encountered at None At completion 8.6'

STRATUM ELEVATION	SAMPLE DEPTH	SOIL/MATERIAL DESCRIPTION	STRATUM DEPTH	SAMPLE NUMBER	SPT per 6"	N_{60}	RECOVERY (%)	MOISTURE CONTENT	TOTAL UNIT WEIGHT pcf	UNCONF. COMP., ksf	ATTERBERG LIMITS LL	PL	PI
865.0		12" MULCH and CINDERS	1.0										
		Medium dense, black, COAL, CINDERS and SLAG, trace clay, (FILL), damp		SS-1	7 6 9	20	100	18					
863.0			3.0										
		Medium stiff, brown, SANDY LEAN CLAY with GRAVEL, and silt, (FILL), moist		SS-2	3 2 2	5	100	22		1.0*	29	18	11
861.0	5		5.0										
		Medium dense, brown SILTY SAND with GRAVEL, trace clay, (FILL), moist		SS-3	10 10 6	22	100	13					
858.0			8.0										
		Medium dense, black to brown, CLAYEY SAND with GRAVEL, trace silt, cinders, (FILL), moist		SS-4	5 5 7	16	100	17 6			30	17	13
856.5	10		9.5										
		Medium dense to loose, brown, SILTY SAND with GRAVEL, moist		SS-5	2 3 4	10	100	9					
851.5	15		14.5	SS-6	3 4 5	12	100	6					
		Medium dense, brown, POORLY GRADED SAND, moist											
849.0			17.0										
		Medium dense, brown, SILTY SAND with GRAVEL, moist		SS-7	5 5 5	14	100	8					
	20		21.0										
845.0													
		Medium dense, brown, SILTY SAND, trace gravel, moist		SS-8	6 5 12	23	100	18			NP	NP	NP
841.0	25		25.0										
		End of Boring at 25 Feet											

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BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling		SPT - Standard Penetration Test
HA - Hand Auger		N_{60} - Standard Penetration Normalized to 60% Drill Rod ER

APPENDIX C

- **LABORATORY TEST RESULTS**

CTL Engineering, Inc.
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AN EMPLOYEE OWNED COMPANY

Consulting Engineers – Testing – Inspection Services – Analytical Laboratories

Established 1927

REPORT ON SAMPLE OF CORES

CLIENT:

DATE REPORTED: 02/12/16
DATE TESTED: 02/12/16
DATE RECEIVED:

ATTN:

SAMPLED BY:

LAB CODE NO.:
PROJECT NO.: 16050004CLE
PROJECT:
IDENTIFICATION:

****

COMPRESSION & UNIT WEIGHT TEST RESULTS (ASTM D 2938)

CORE NO.	DIAMETER (in)	ACTUAL LENGTH (in)	WEIGHT (grams)	UNIT WEIGHT (lb/ft^3)	TOTAL LOAD (lbf)	COMPRESSIVE STRENGTH (psi)
B-9: 37.5-38	1.98	4.0	1.1	153.6	21,990	7,250
B-5: 41-41.9	1.99	4.1	1.1	151.7	23,160	7,540
B-4: 35-35.5	1.98	3.4	0.9	148.4	19,460	6,300
B-10: 39.8-40	1.99	4.1	1.2	157.8	27,720	8,990

NOTE: Cores were tested at "as-received" Moisture content.

****

Respectfully submitted,
CTL ENGINEERING, INC.

Dave S

Dave Stankiewicz
CML Manager

mlc

CTL Engineering, Inc.
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AN EMPLOYEE OWNED COMPANY

Consulting Engineers – Testing – Inspection Services – Analytical Laboratories

Established 1927

Report on Samples of Soil

Project No.: 16310004CLE February 16, 2016

Client: AECOM
1500 West 3rd
Cleveland, Ohio 44141 – Attn: Keith Karlyn

Identification: Four soil samples identified below collected by a CTL Engineering representative from Youngstown, Ohio and submitted February 11, 2016.

Test Methods: Determining pH of Soil for Use in Corrosion Testing, Method T 289 from Standard Specifications for Transportation Materials and Methods of Sampling and Testing, AASHTO, 34th edition, 2014.

Test Results:

Sample Identification	pH (S.U)
B-1, 2, 5, 6, 11; SS-2	7.04
B-6, 7, 8, 11; SS-7	7.81
B-9, S-2, 1'- 2.5'	7.06
B-10, S-2, 3.5'- 5'	7.35

Respectfully submitted,

Johnny Tjioe

Johnny Tjioe, Chemist

JT

CTL ENGINEERING, INC.

SOIL RESISTIVITY
ASTM G 57

Client: AECOM
Project Name: A-USC Com Test
Project Number: 16050004CLE
Lab Code: 16050715COL

Tech: MU
Date: 2/16/16
Reviewed by: JK

Sample ID: B-6,7,8,11 SS-7

Initial Moisture Content (%):	0.5	Final Moisture Content (%):	22.4
Initial Wet Unit Weight (pcf):	98.3	Final Wet Unit Weight (pcf):	121.3
Initial Dry Unit Weight (pcf):	97.8	Final Dry Unit Weight (pcf):	99.1

SOIL RESISTIVITY DETERMINATION:

Soil Condition	Time	Resistance (Ohm)	Resistivity (Ohm-cm)
As Received	10:35 AM	300000	300000
Moisture Added	10:40 AM	15000	15000
" "	10:45 AM	3200	3200
" "	10:50 AM	2700	2700
" "	10:55 AM	2500	2500
" "	11:00 AM	2300	2300
" "	11:05 AM	2300	2300

Minimum resistivity (Ohm-cm): 2300

CTL ENGINEERING, INC.

SOIL RESISTIVITY
ASTM G 57

Client: AECOM
Project Name: A-USC Com Test
Project Number: 16050004CLE
Lab Code: 16050715COL

Tech: MU
Date: 2/16/16
Reviewed by: JK

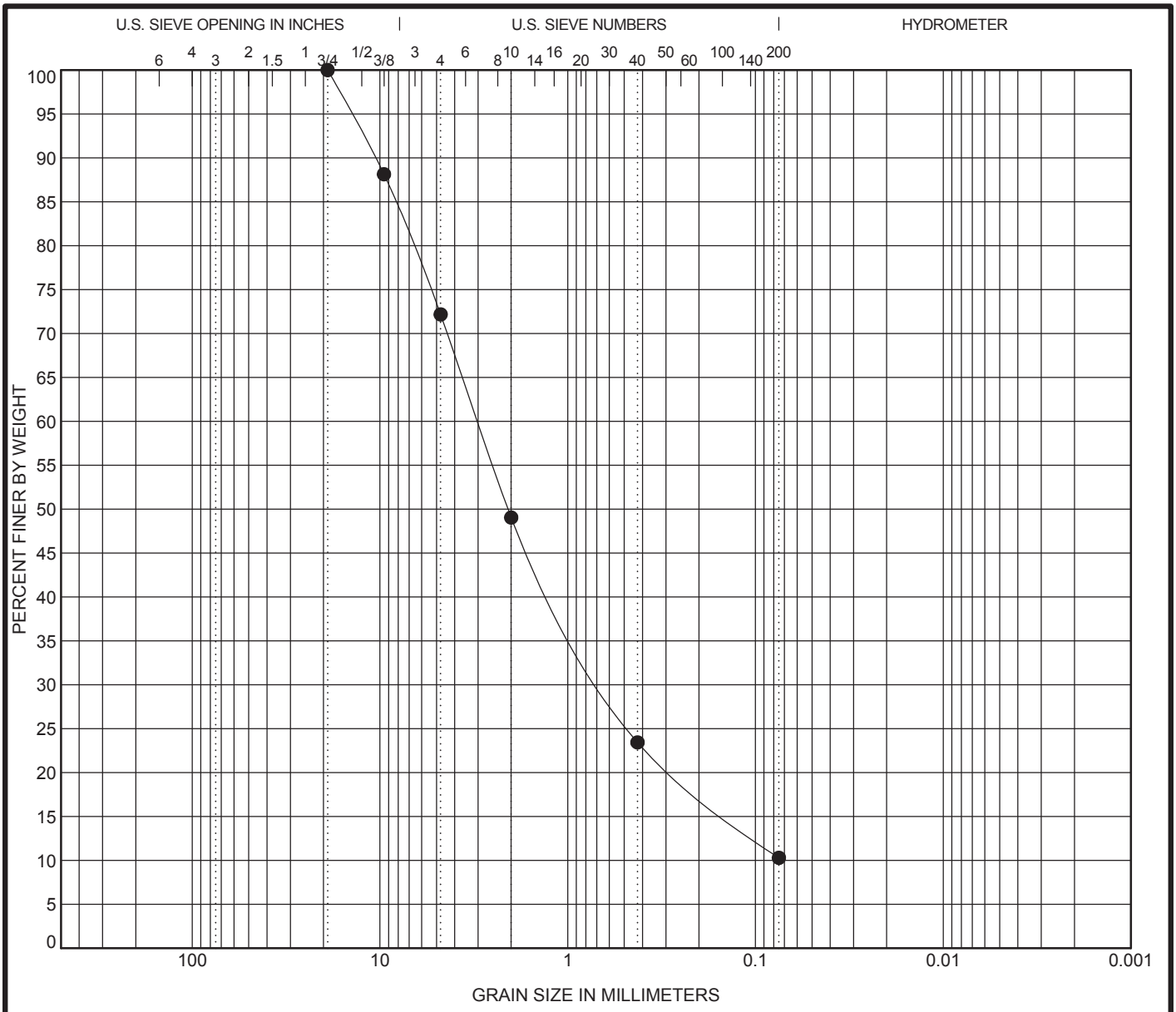
Sample ID: B-1,2,5,6,11 SS-2

Initial Moisture Content (%):	2.6	Final Moisture Content (%):	24.2
Initial Wet Unit Weight (pcf):	95.0	Final Wet Unit Weight (pcf):	117.7
Initial Dry Unit Weight (pcf):	92.6	Final Dry Unit Weight (pcf):	94.7

SOIL RESISTIVITY DETERMINATION:

Soil Condition	Time	Resistance (Ohm)	Resistivity (Ohm-cm)
As Received	10:35 AM	900000	900000
Moisture Added	10:40 AM	10000	10000
" "	10:45 AM	6100	6100
" "	10:50 AM	3900	3900
" "	10:55 AM	3200	3200
" "	11:00 AM	3200	3200

Minimum resistivity (Ohm-cm): 3200



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
● **B-01**	**SS-1**	**WELL-GRADED SAND with SILT and GRAVEL (SW-SM)**	**8**	**NP**	**NP**	**NP**	**1.84**	**41.79**

Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
● **B-01**	**SS-1**	**19**	**3.013**	**2.073**	**0.632**		**28**	**62**		

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GRAIN SIZE DISTRIBUTION

Project: A-USC Com Test

Location: 205 N. Ave., Youngstown, OH.

CTL Project Number: 16050004CLE

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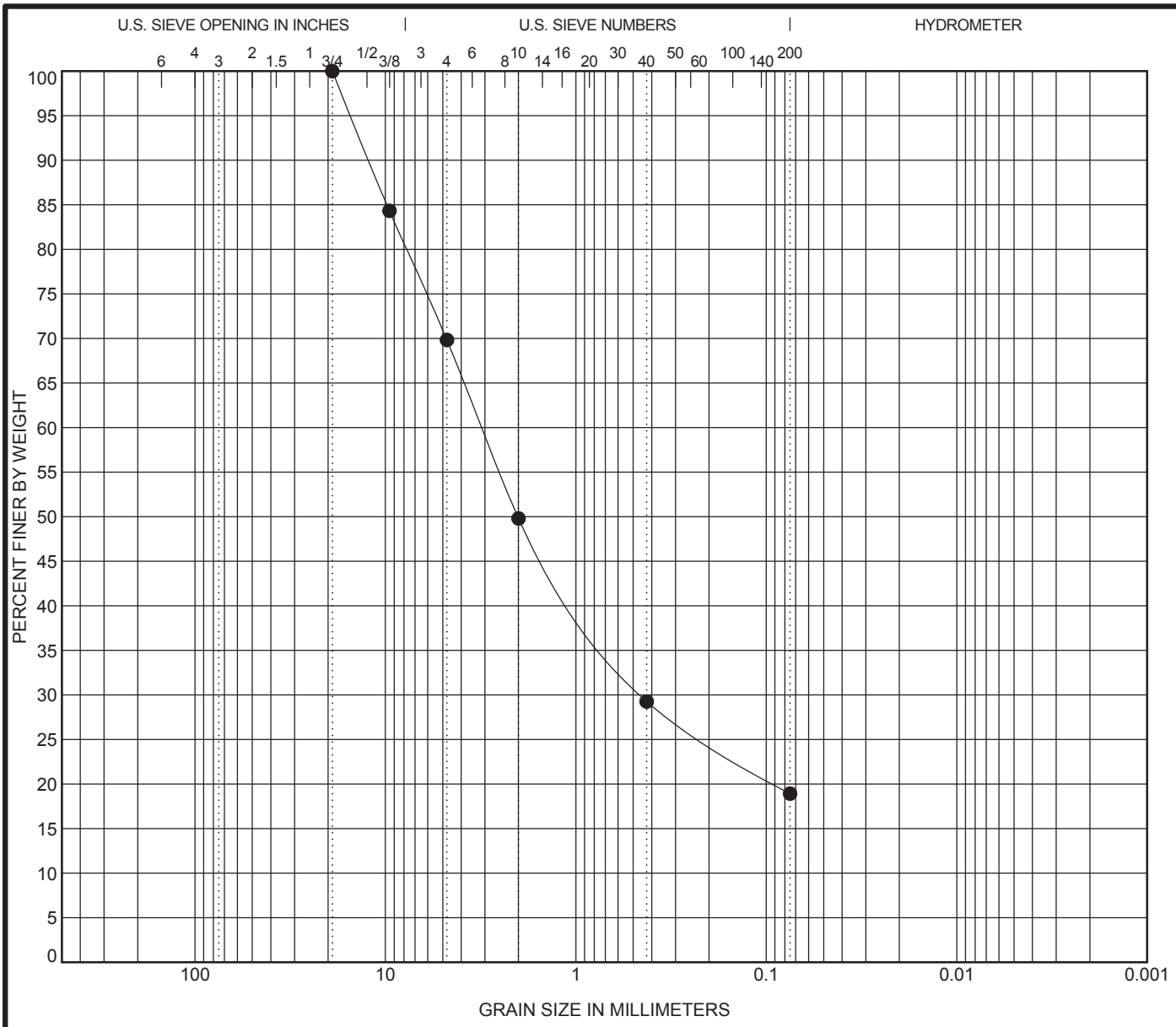

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
●	**B-01**	**SS-3 (TOP)**	**SILTY SAND with GRAVEL (SM)**	**14**	**NP**	**NP**	**NP**		

	Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-01**	**SS-3 (TOP)**	**19**	**3.107**	**2.017**	**0.45**		**30**	**51**		

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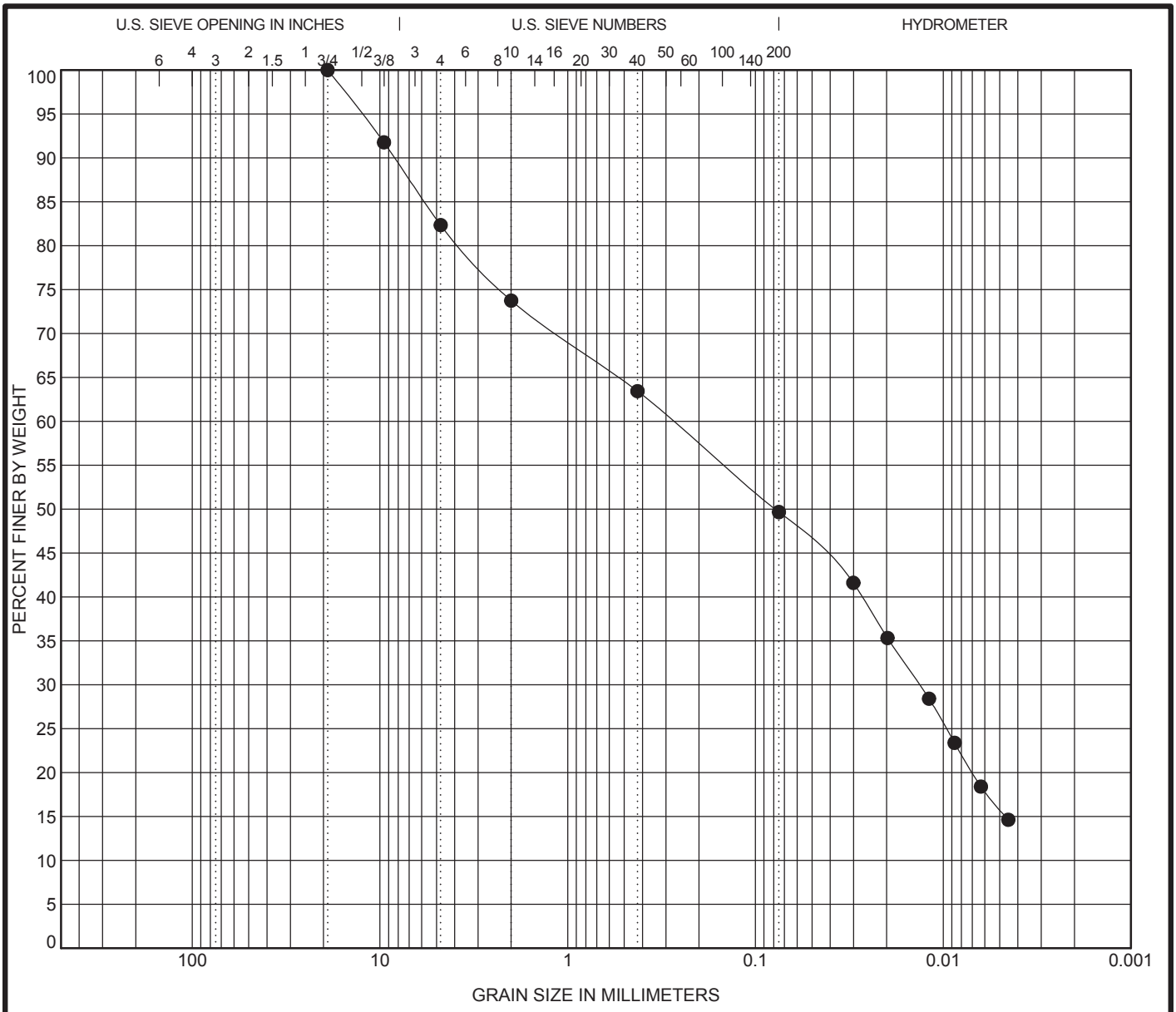

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
● **B-02**	**SS-8**	**CLAYEY SAND with GRAVEL (SC)**	**8**	**28**	**18**	**10**		

Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
● **B-02**	**SS-8**	**19**	**0.276**	**0.078**	**0.013**		**18**	**33**	**33**	**16**

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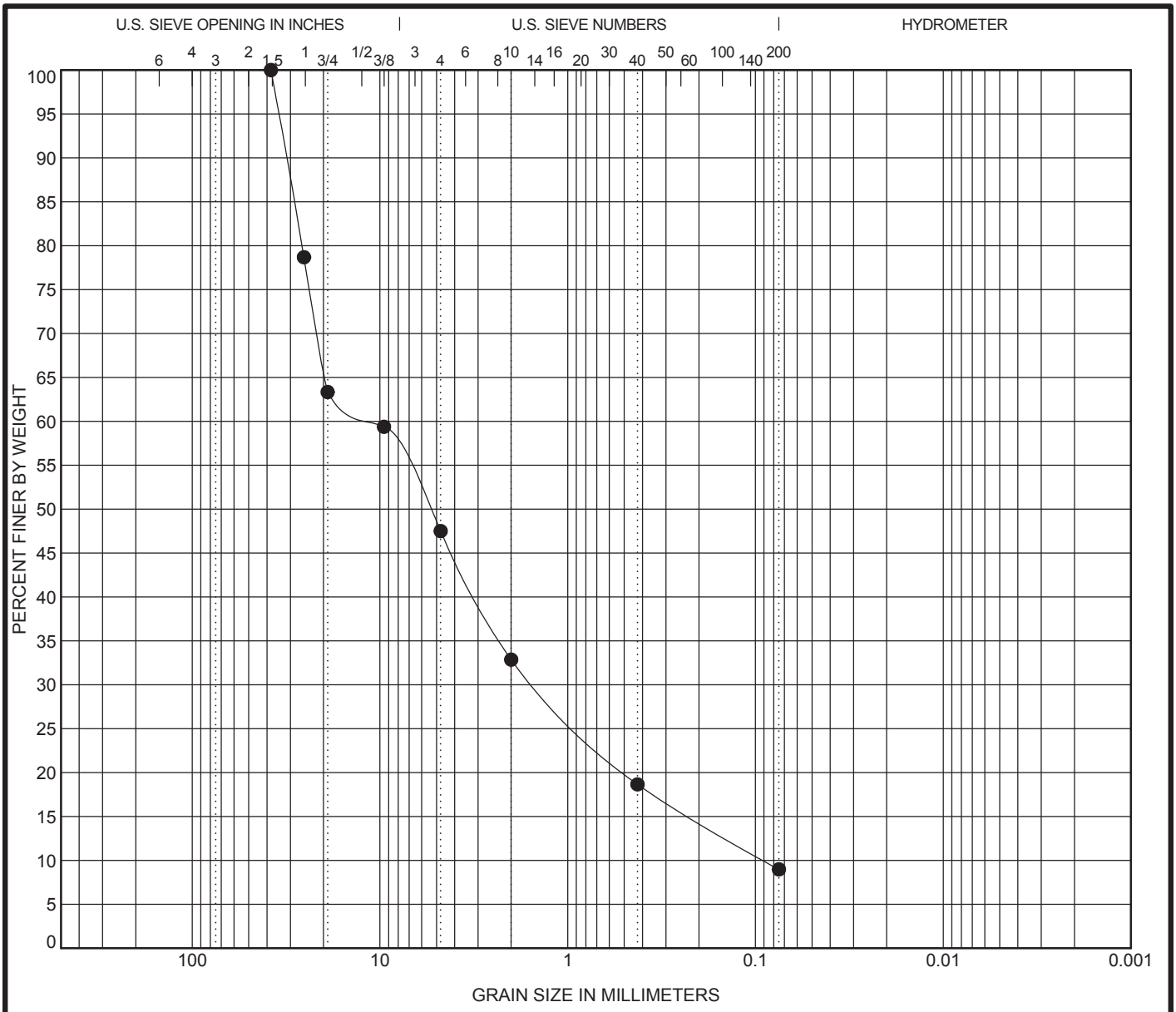

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
● **B-03**	**SS-2**	**WELL-GRADED GRAVEL with SILT and SAND (GW-GM)**	**13**	**NP**	**NP**	**NP**	**2.24**	**117.86**

Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
● **B-03**	**SS-2**	**38.1**	**10.621**	**5.499**	**1.464**	**0.09**	**52**	**39**		

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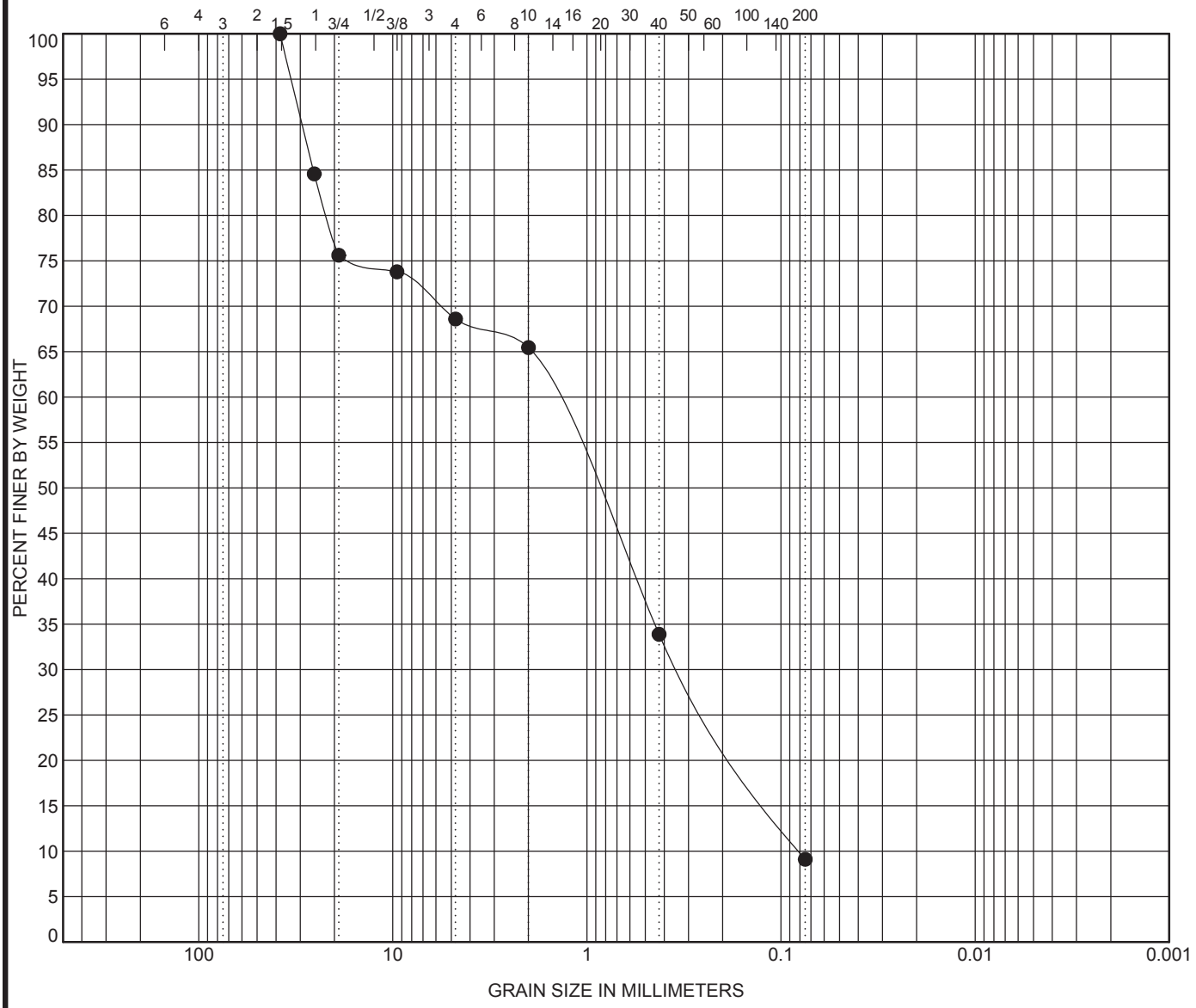

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
● **B-03**	**SS-6**	**POORLY GRADED SAND with SILT and GRAVEL (SP-SM)**		**NP**	**NP**	**NP**	**0.86**	**19.17**

Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
● **B-03**	**SS-6**	**38.1**	**1.531**	**0.937**	**0.324**	**0.08**	**31**	**59**		

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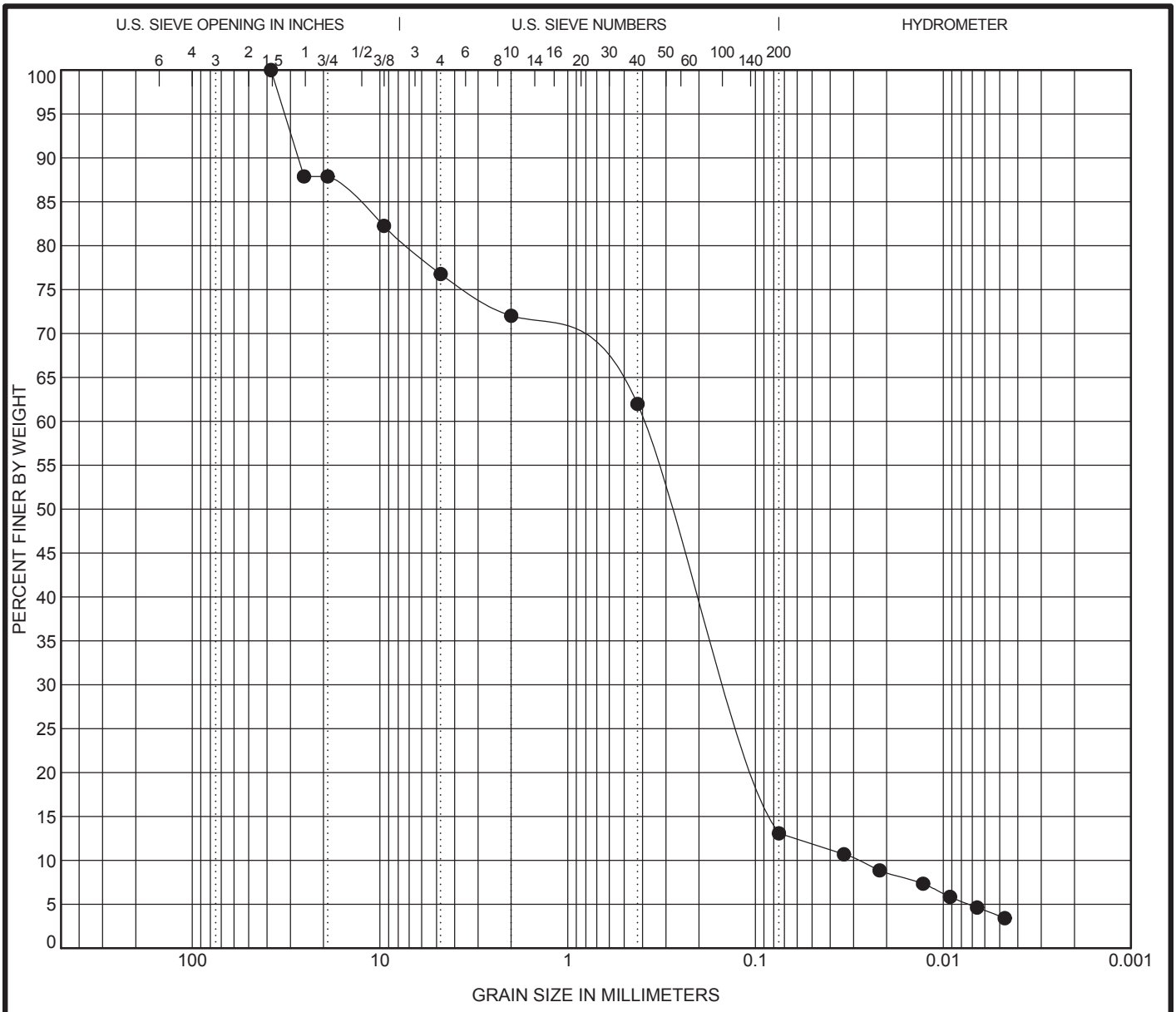

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
●	**B-03**	**SS-7**	**SILTY SAND with GRAVEL (SM)**	**24**	**NP**	**NP**	**NP**	**1.65**	**13.84**

	Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-03**	**SS-7**	**38.1**	**0.396**	**0.278**	**0.137**	**0.029**	**23**	**64**	**9**	**4**

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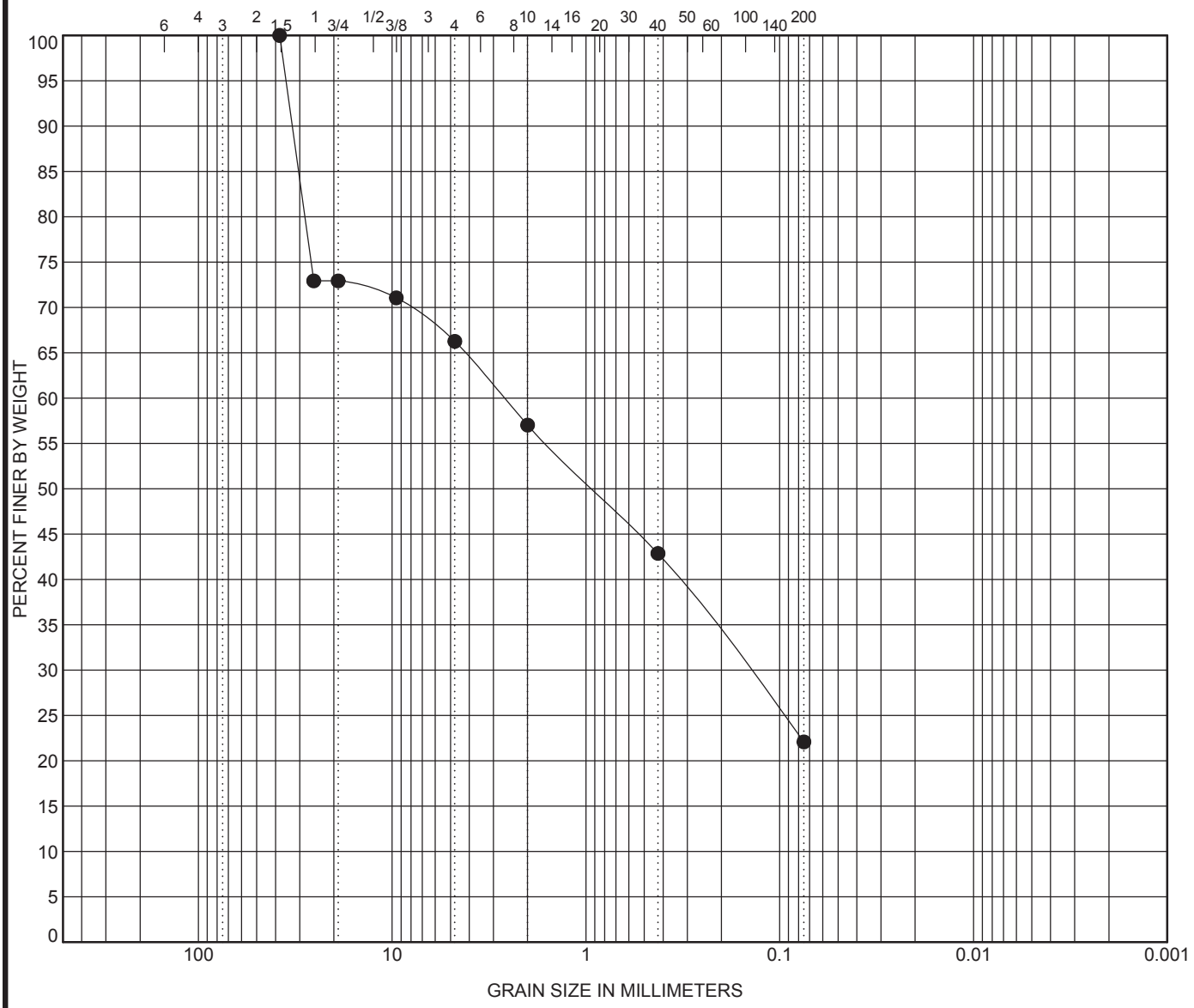

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
●	**B-04**	**SS-2**	**SILTY SAND with GRAVEL (SM)**	**28**	**NP**	**NP**	**NP**		

	Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-04**	**SS-2**	**38.1**	**2.643**	**0.928**	**0.145**		**34**	**44**		

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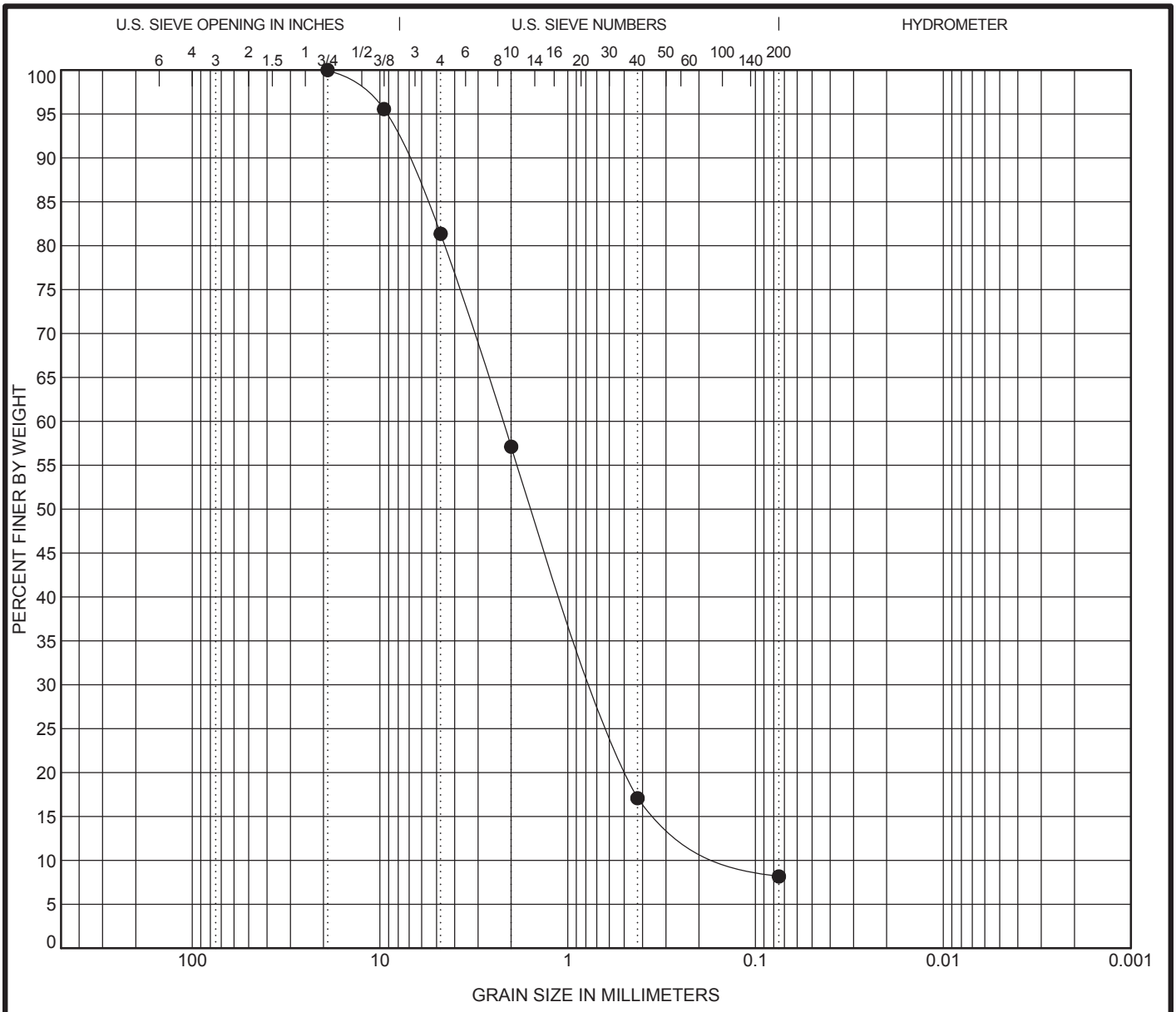

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
●	**B-04**	**SS-4**	**WELL-GRADED SAND with SILT and GRAVEL (SW-SM)**	**10**	**NP**	**NP**	**NP**	**2.07**	**20.71**

	Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-04**	**SS-4**	**19**	**2.217**	**1.519**	**0.701**	**0.107**	**19**	**73**		

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GRAIN SIZE DISTRIBUTION

Project: A-USC Com Test

Location: 205 N. Ave., Youngstown, OH.

CTL Project Number: 16050004CLE

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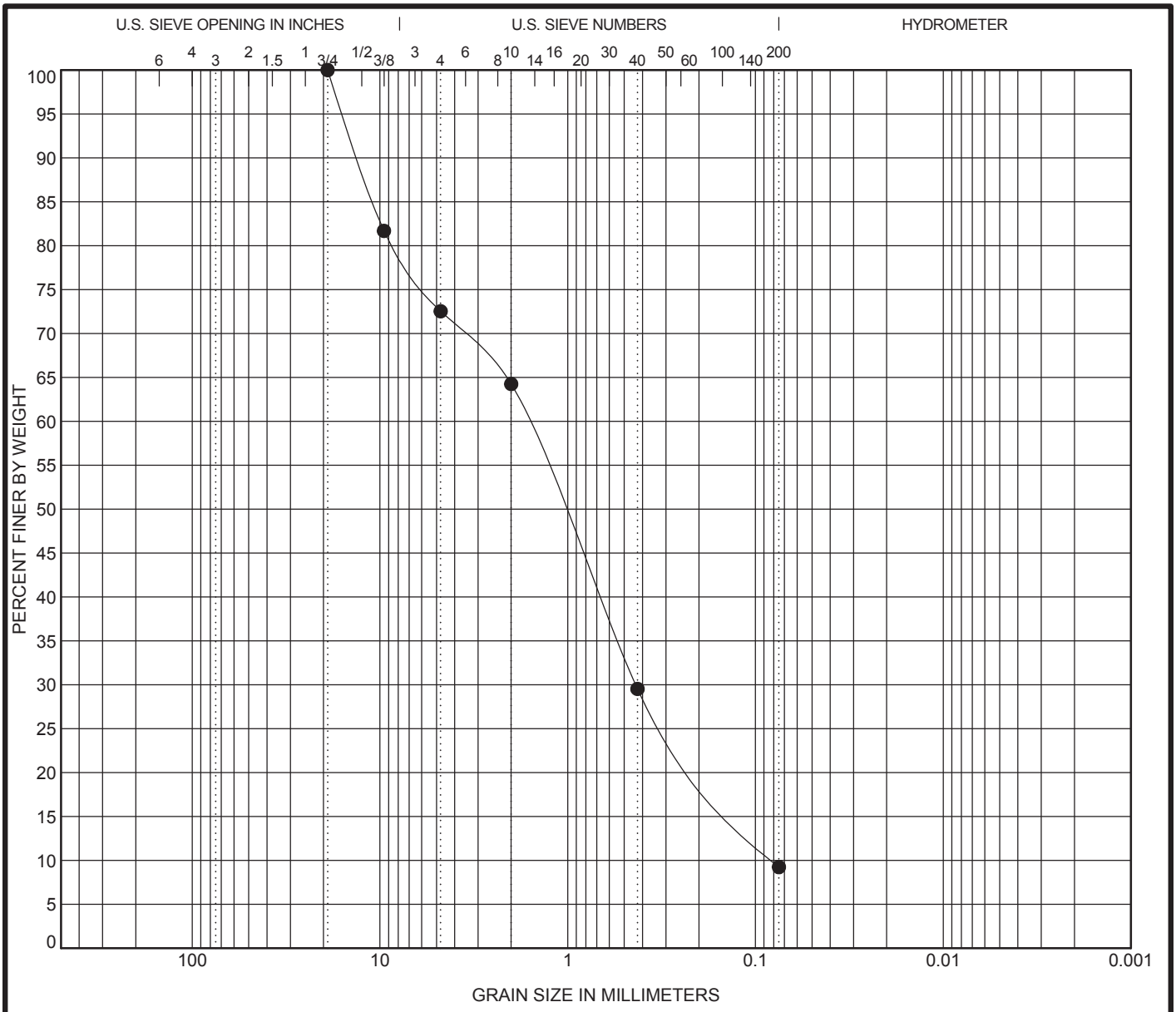

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
●	**B-04**	**SS-6**	**WELL-GRADED SAND with SILT and GRAVEL (SW-SM)**	**9**	**NP**	**NP**	**NP**	**1.42**	**20.67**

	Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-04**	**SS-6**	**19**	**1.655**	**1.059**	**0.434**	**0.08**	**27**	**63**		

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GRAIN SIZE DISTRIBUTION

Project: A-USC Com Test

Location: 205 N. Ave., Youngstown, OH.

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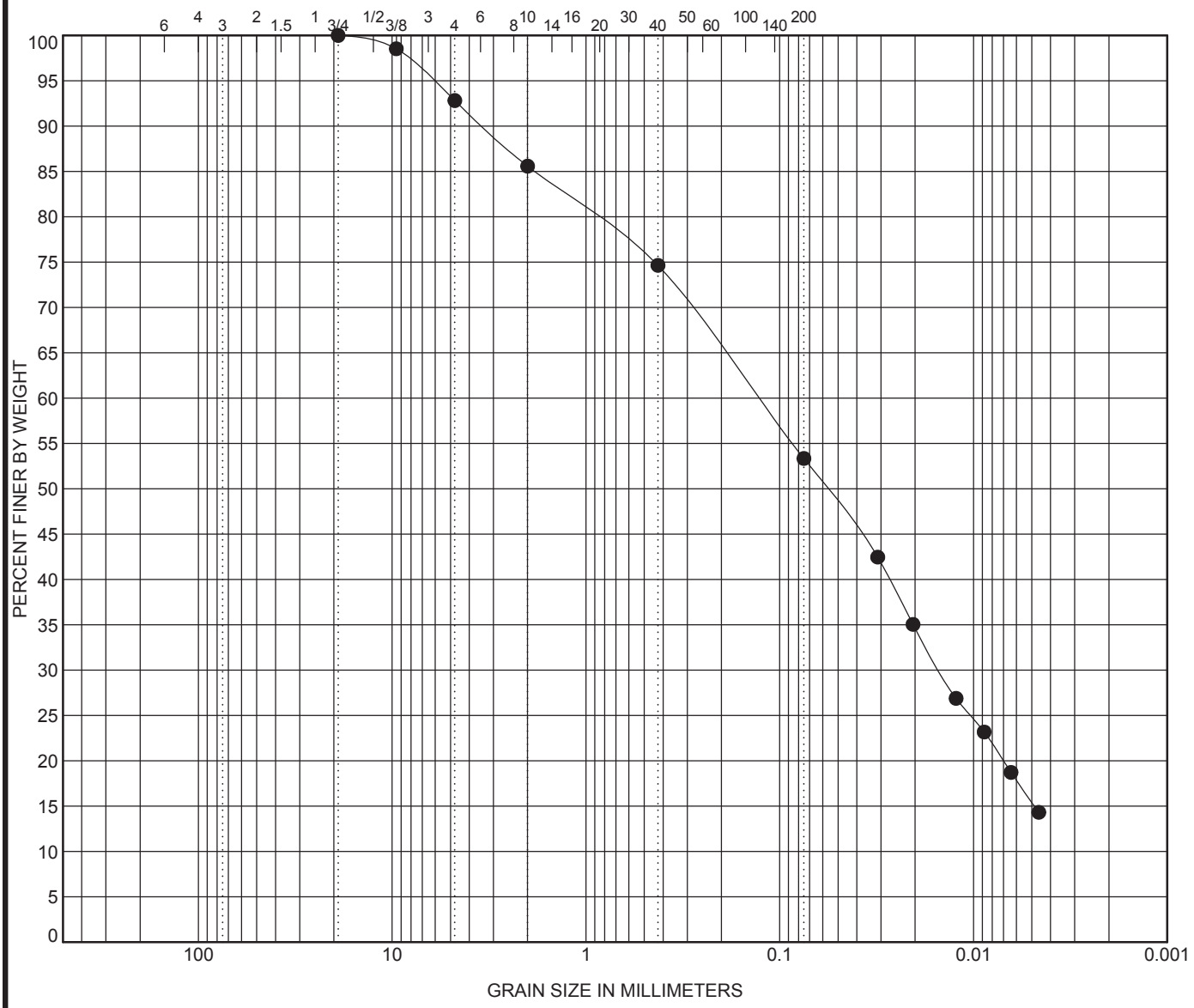

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
● **B-04**	**SS-7**	**SANDY LEAN CLAY (CL)**	**15**	**26**	**17**	**9**		

Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
● **B-04**	**SS-7**	**19**	**0.129**	**0.057**	**0.015**		**7**	**39**	**39**	**15**

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CTL Project Number: 16050004CLE

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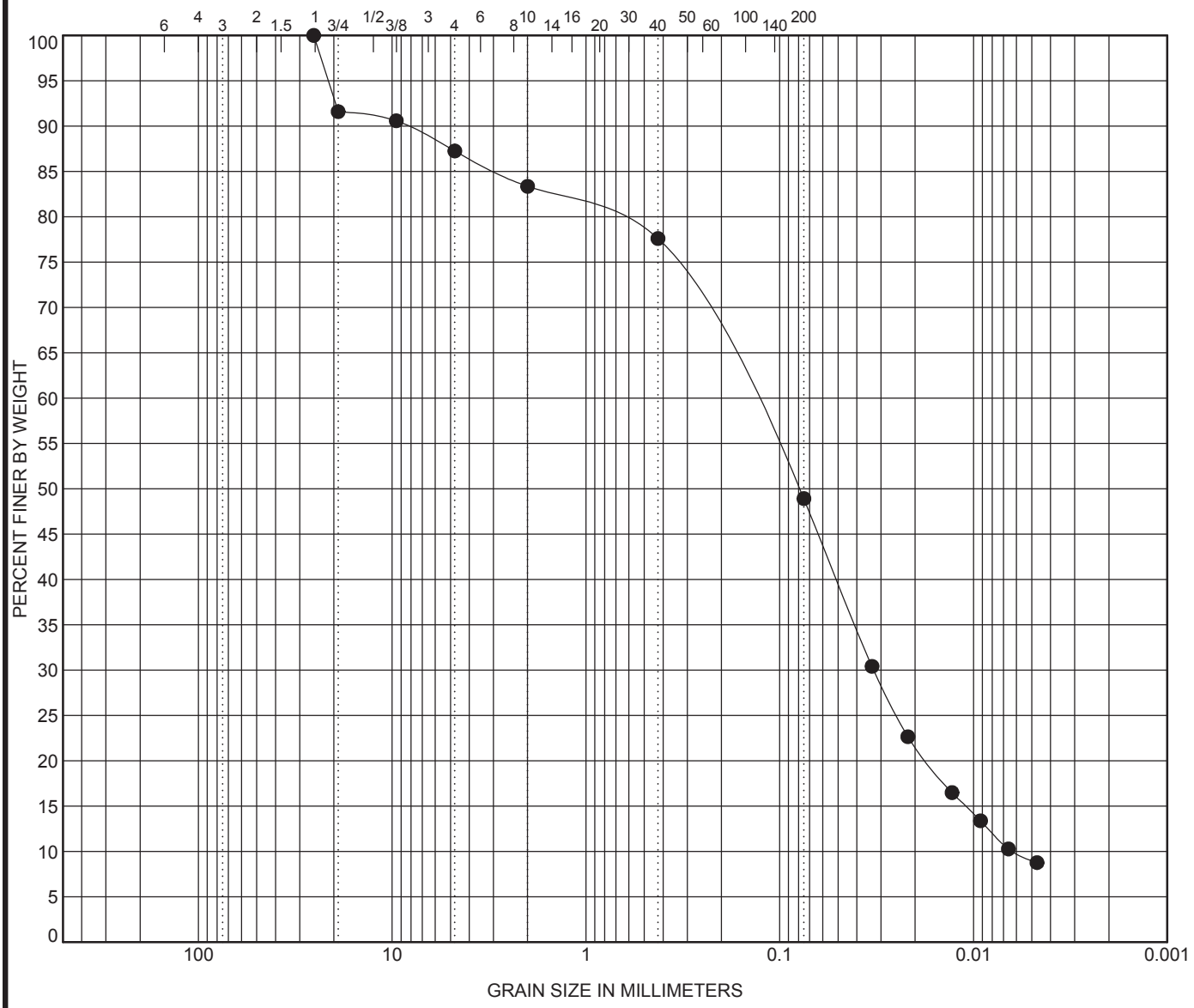

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
●	**B-04**	**SS-8**	**SILTY SAND (SM)**	**15**	**21**	**18**	**3**	**1.17**	**23.64**

	Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-04**	**SS-8**	**25.4**	**0.147**	**0.08**	**0.033**	**0.006**	**13**	**38**	**40**	**9**

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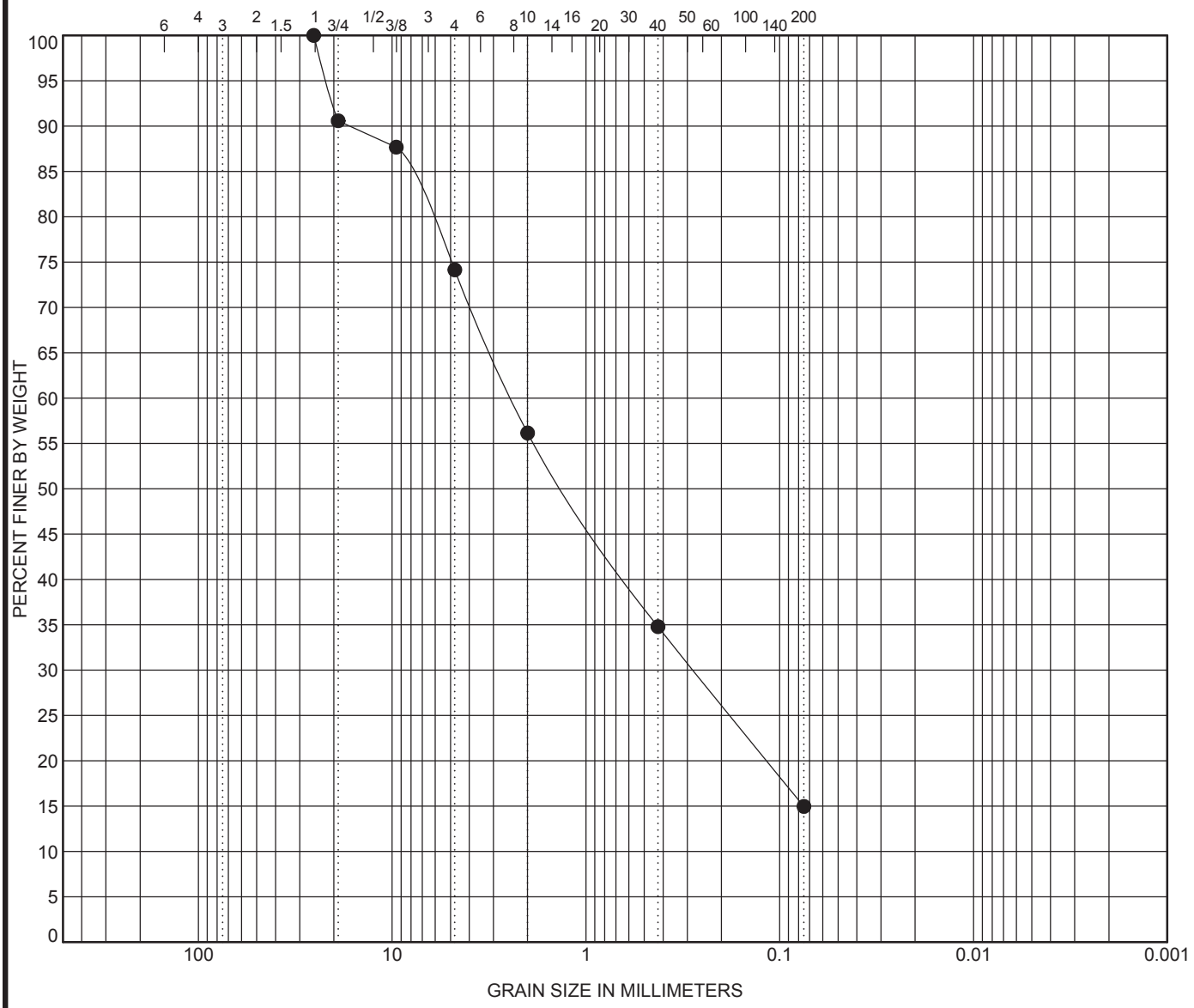

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
● **B-05**	**SS-3**	**SILTY SAND with GRAVEL (SM)**	**11**	**NP**	**NP**	**NP**		

Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
● **B-05**	**SS-3**	**25.4**	**2.406**	**1.28**	**0.279**		**26**	**59**		

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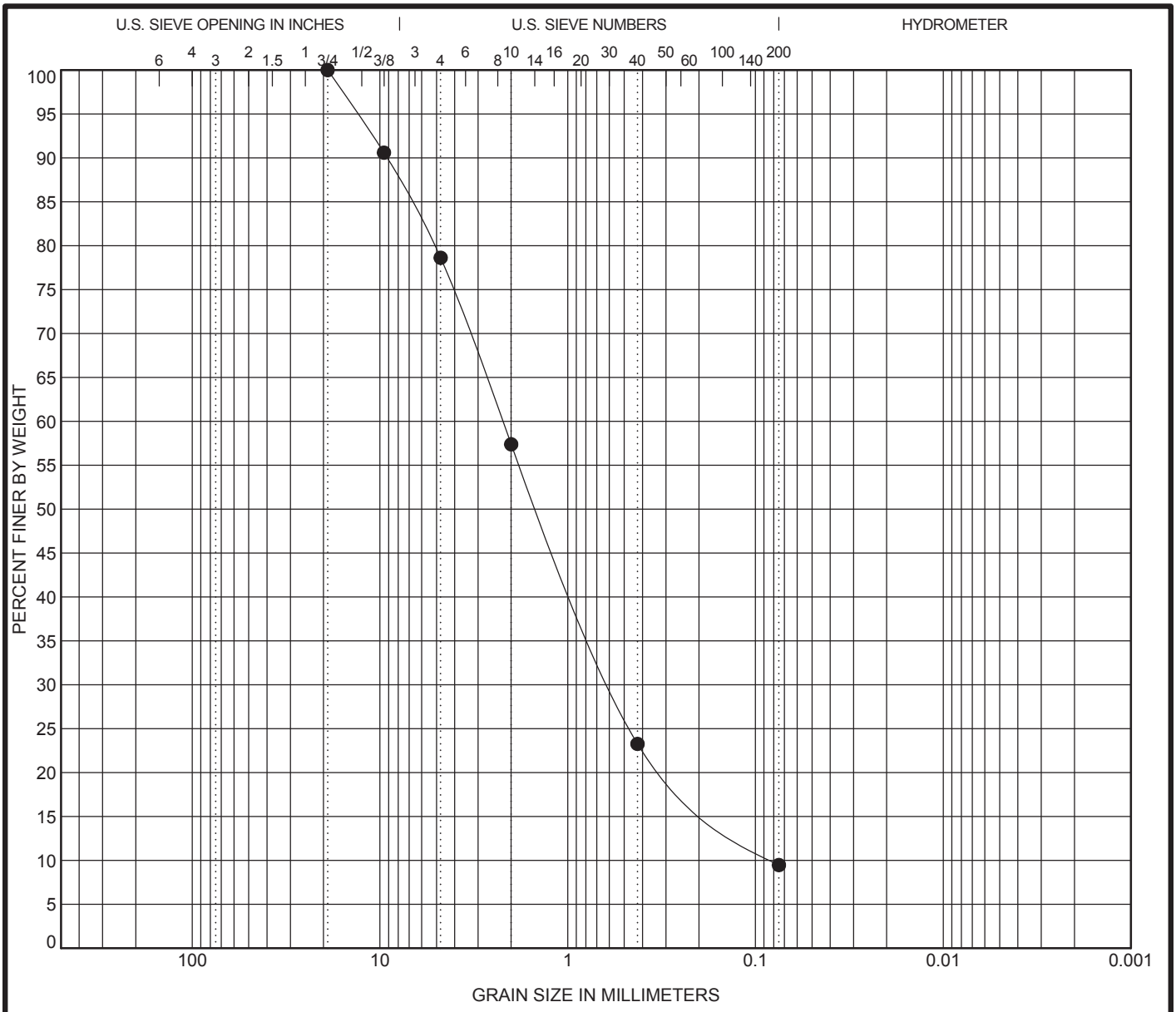

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
● **B-05**	**SS-5**	**WELL-GRADED SAND with SILT and GRAVEL (SW-SM)**	**5**	**NP**	**NP**	**NP**	**1.87**	**27.75**

Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
● **B-05**	**SS-5**	**19**	**2.225**	**1.431**	**0.577**	**0.08**	**21**	**69**		

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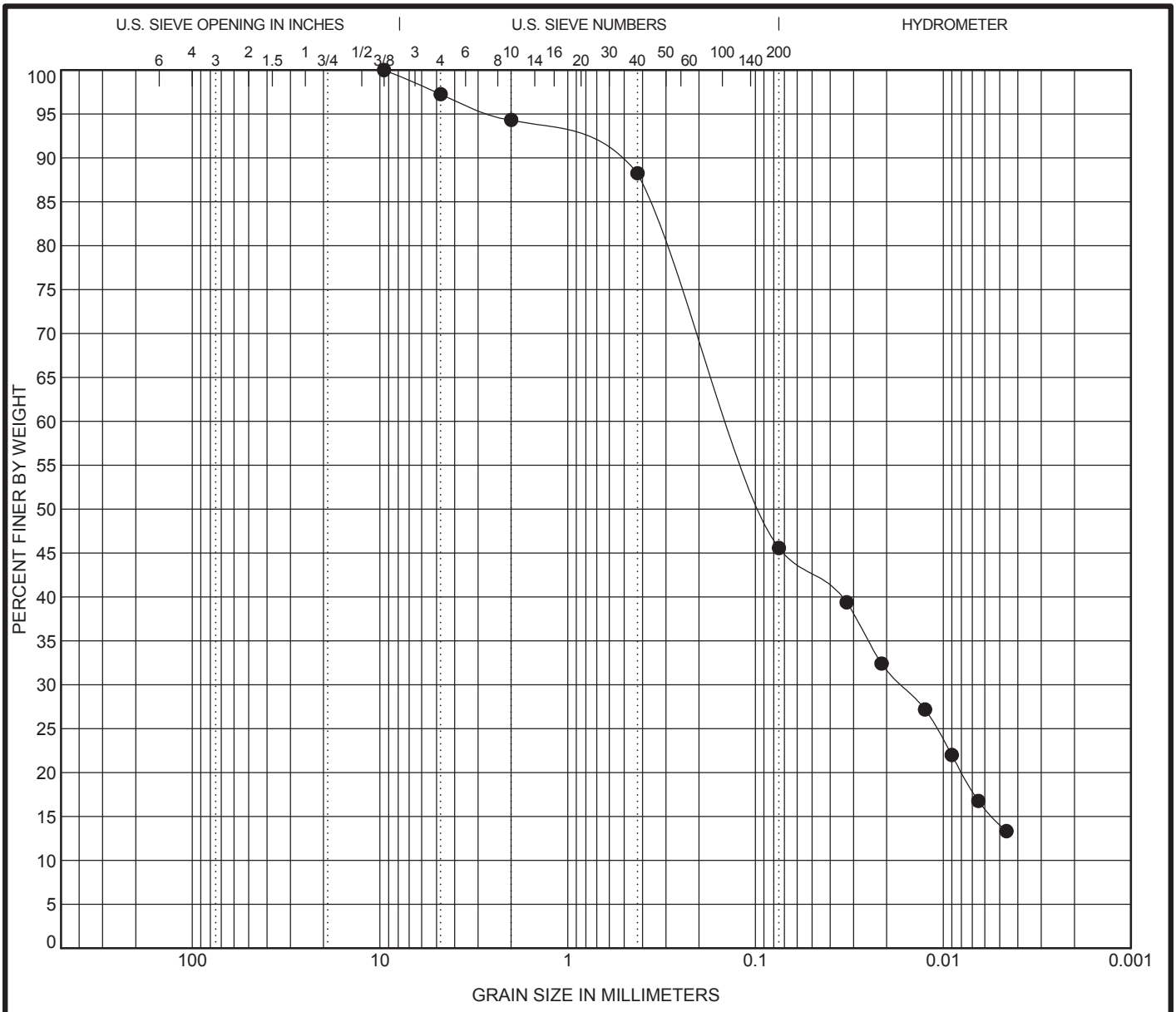

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
●	**B-05**	**SS-6**	**SILTY, CLAYEY SAND (SC-SM)**	**10**	**20**	**13**	**7**		

	Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-05**	**SS-6**	**9.525**	**0.135**	**0.09**	**0.017**		**3**	**52**	**31**	**14**

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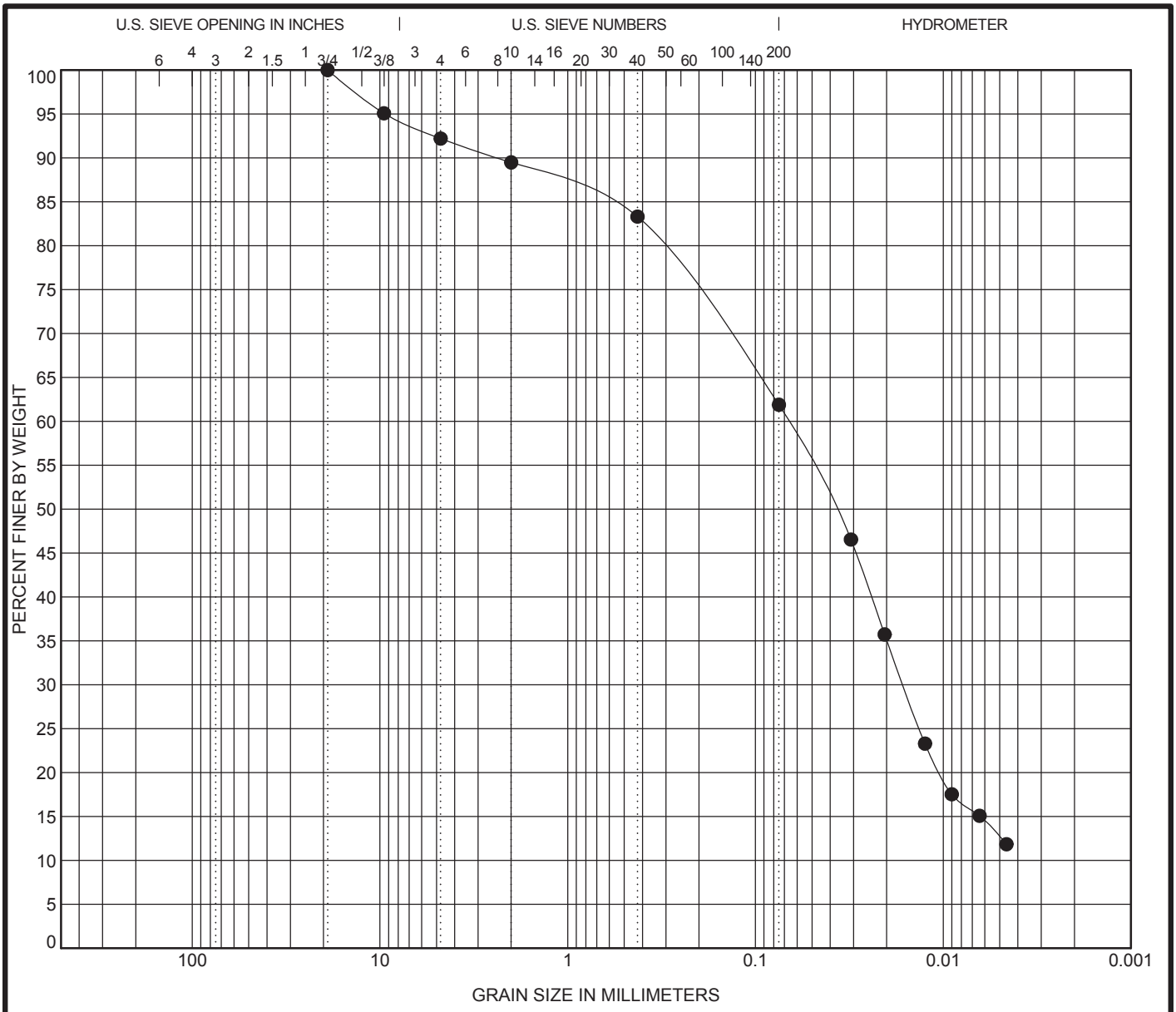

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
●	**B-05**	**SS-7**	**SANDY SILT (ML)**	**17**	**19**	**16**	**3**		

	Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-05**	**SS-7**	**19**	**0.067**	**0.038**	**0.016**		**8**	**30**	**49**	**13**

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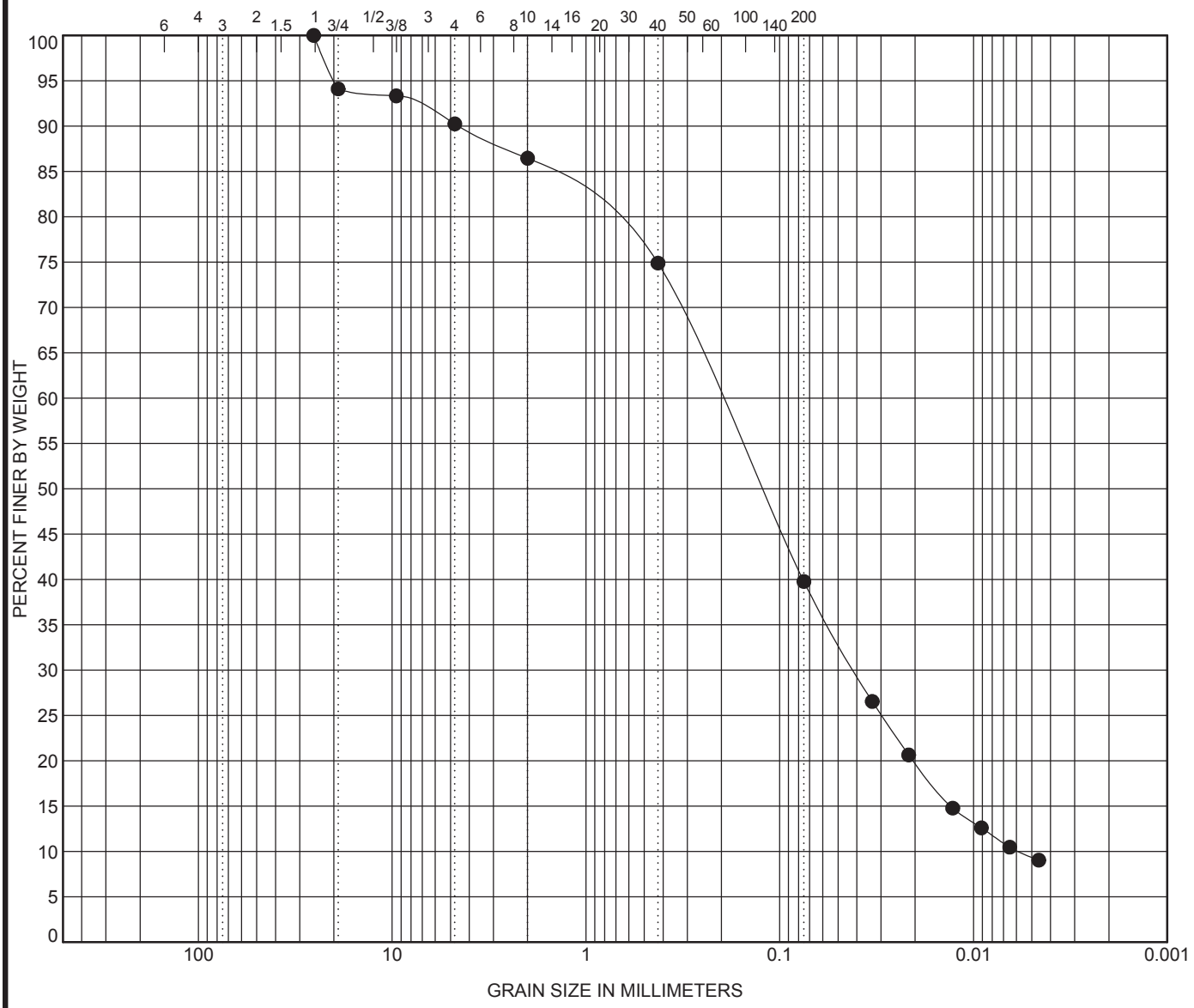

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
●	**B-05**	**SS-8**	**SILTY SAND (SM)**	**17**	**NP**	**NP**	**NP**	**1.43**	**35.09**

	Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-05**	**SS-8**	**25.4**	**0.204**	**0.124**	**0.041**	**0.006**	**10**	**50**	**31**	**9**

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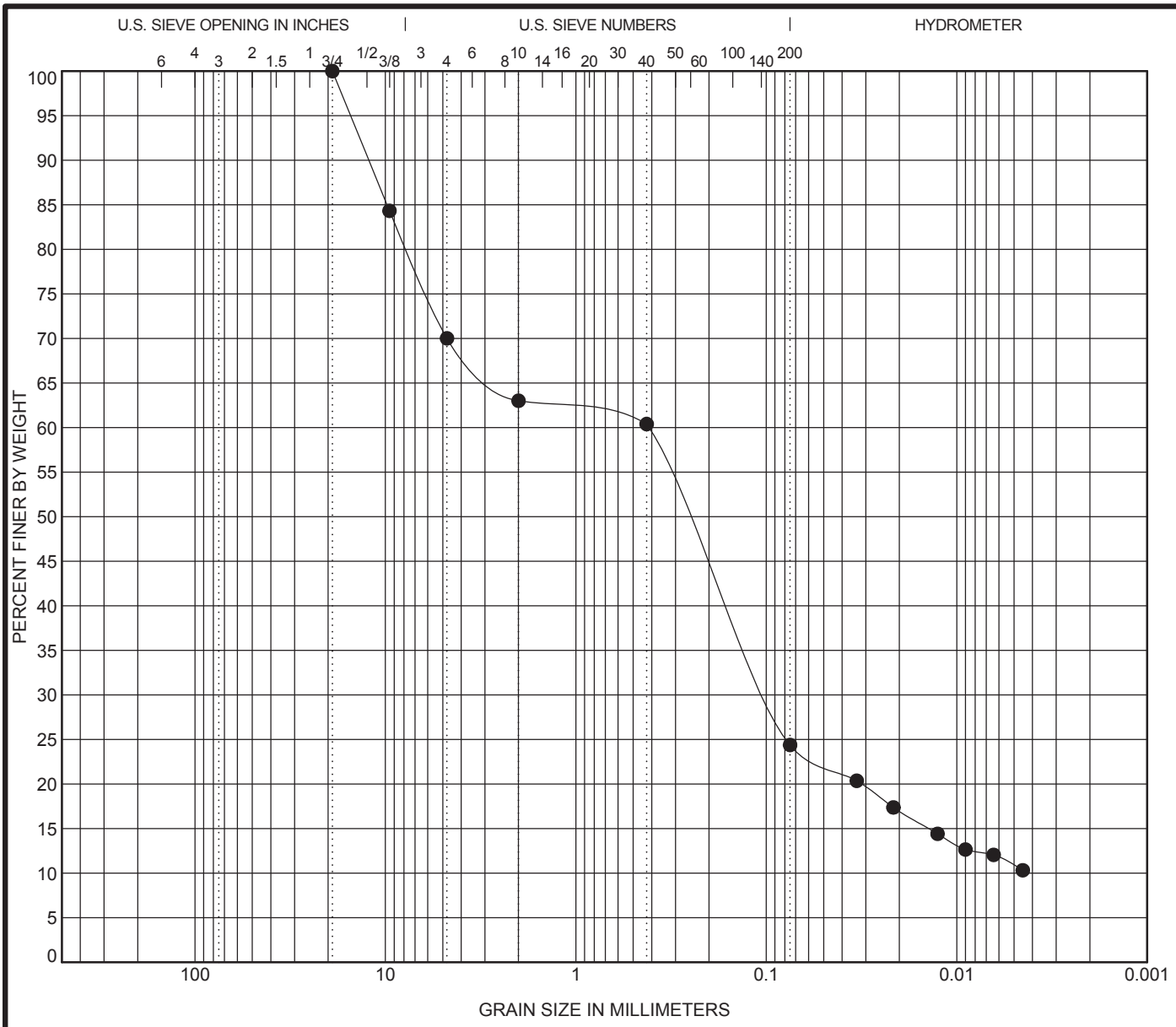

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
●	**B-05**	**SS-9**	**SILTY, CLAYEY SAND with GRAVEL (SC-SM)**	**7**	**19**	**14**	**5**		

	Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-05**	**SS-9**	**19**	**0.417**	**0.258**	**0.098**		**30**	**46**	**13**	**11**

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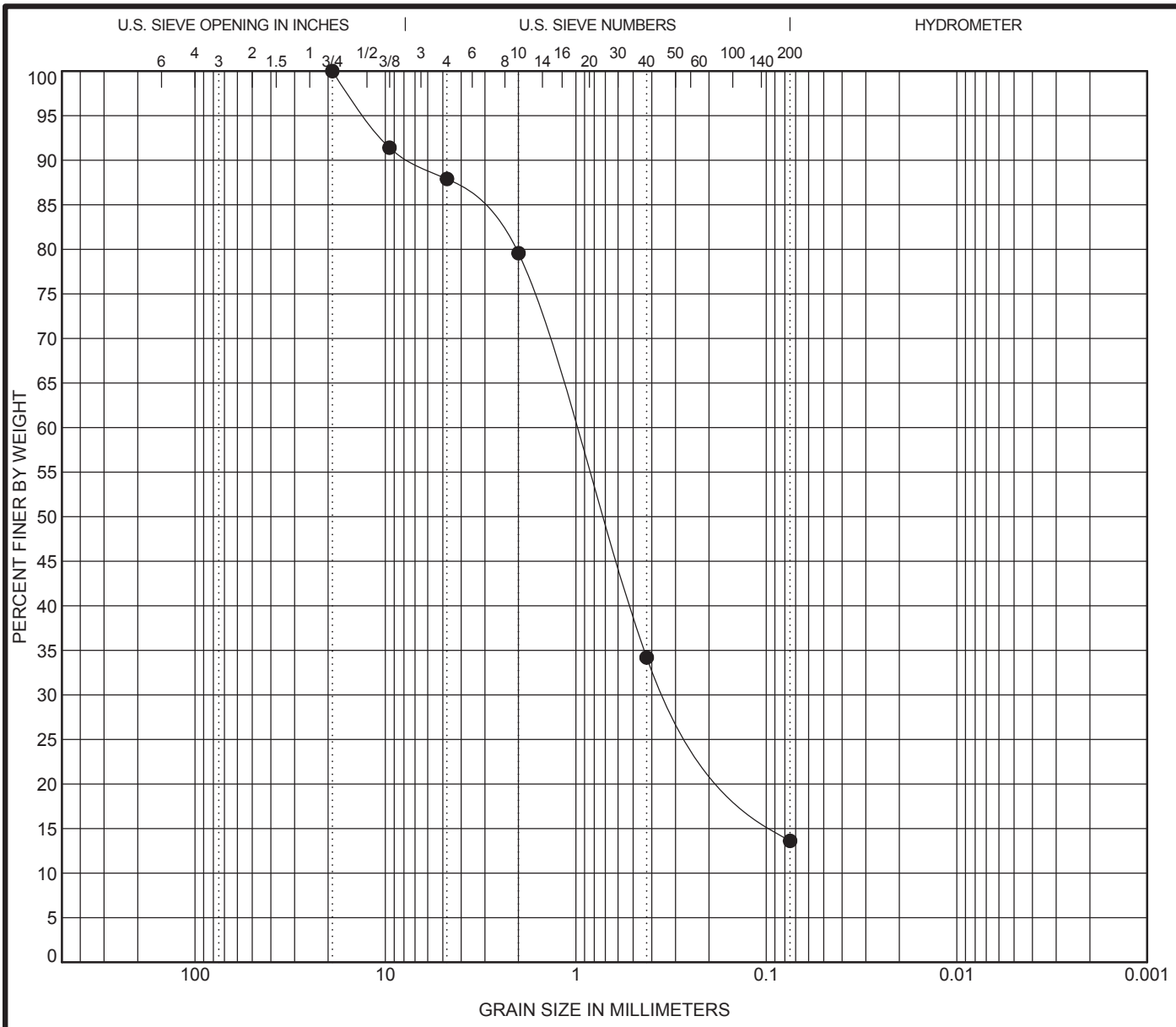

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
●	**B-06**	**SS-6**	**SILTY SAND (SM)**	**9**	**NP**	**NP**	**NP**		

	Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-06**	**SS-6**	**19**	**1.025**	**0.729**	**0.298**		**12**	**74**		

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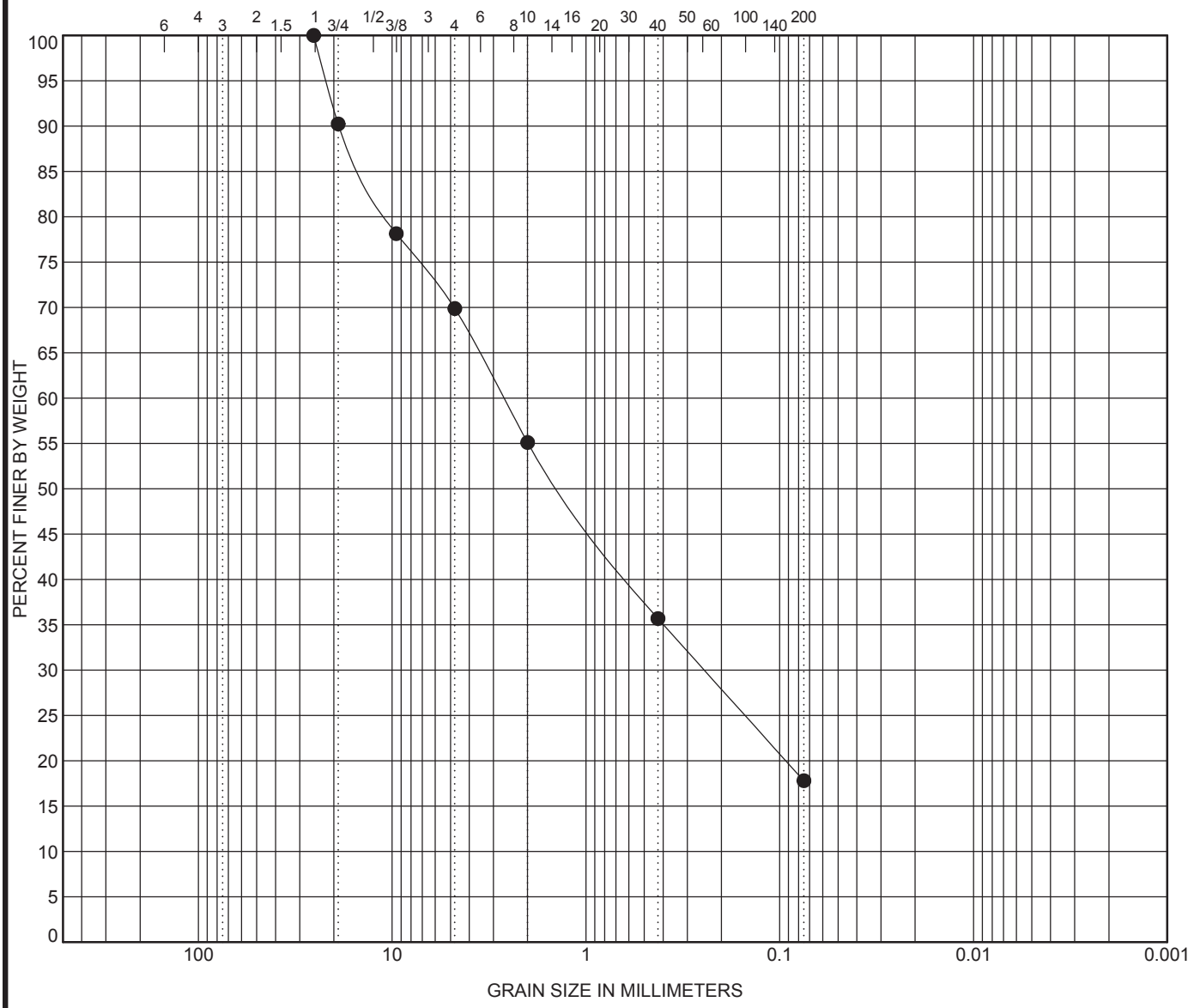

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
●	**B-07**	**SS-2**	**SILTY SAND with GRAVEL (SM)**	**16**	**NP**	**NP**	**NP**		

	Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-07**	**SS-2**	**25.4**	**2.664**	**1.331**	**0.245**		**30**	**52**		

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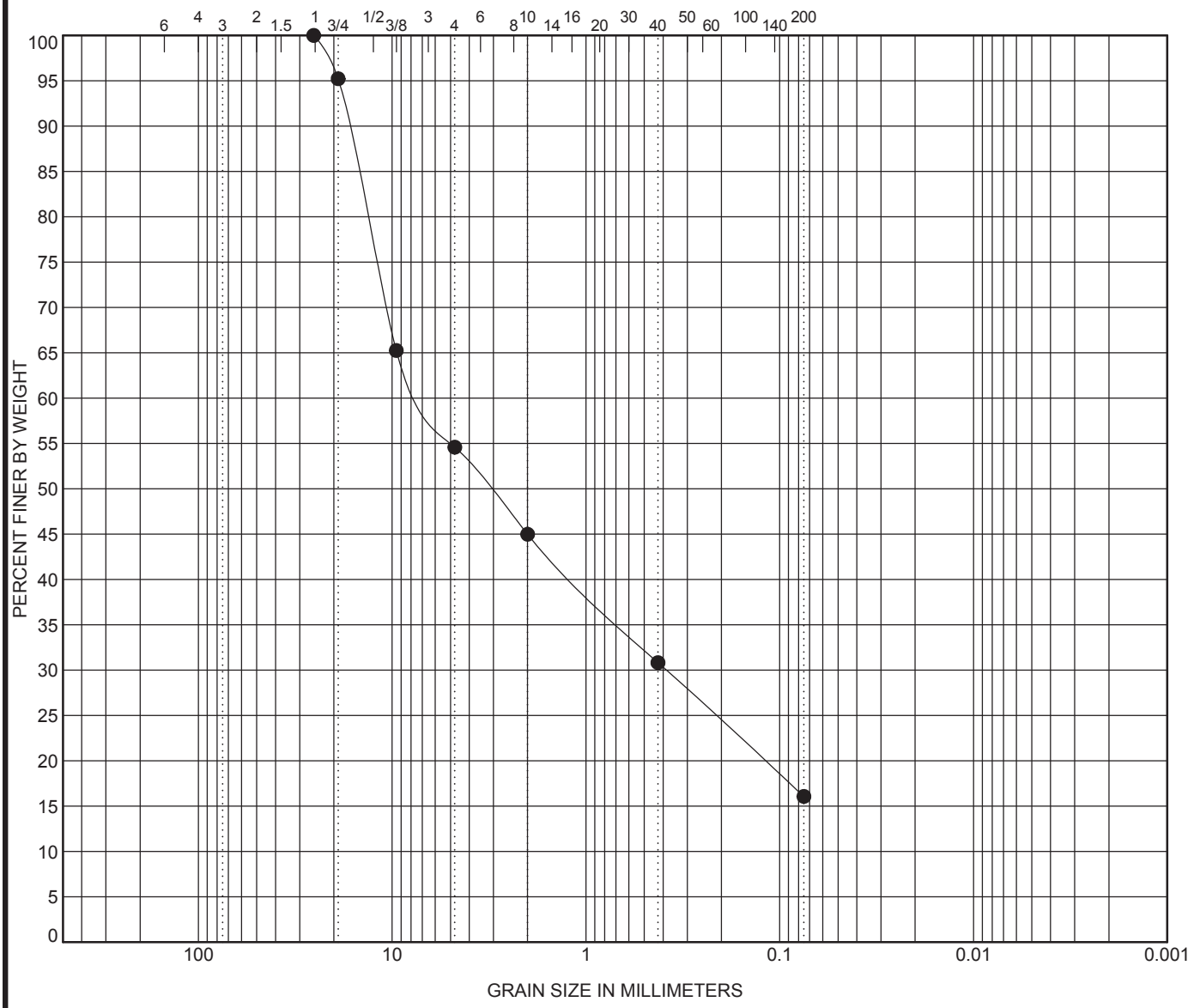

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
●	**B-07**	**SS-6**	**SILTY GRAVEL with SAND (GM)**	**11**	**NP**	**NP**	**NP**		

	Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-07**	**SS-6**	**25.4**	**6.763**	**3.143**	**0.386**		**45**	**39**		

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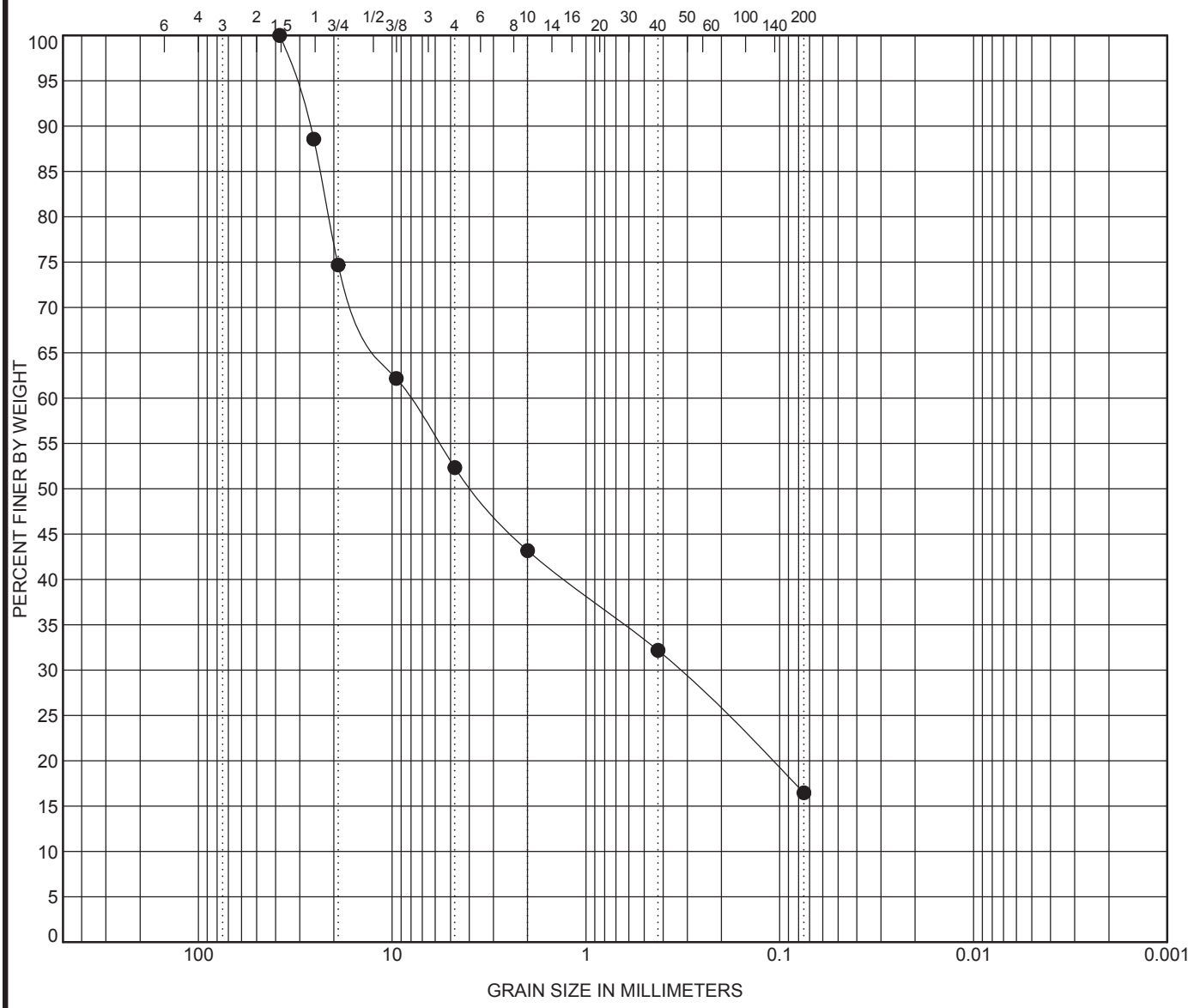

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
● **B-08B**	**SS-2**	**SILTY GRAVEL with SAND (GM)**	**9**	**NP**	**NP**	**NP**		

Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
● **B-08B**	**SS-2**	**38.1**	**8.169**	**3.81**	**0.334**		**48**	**36**		

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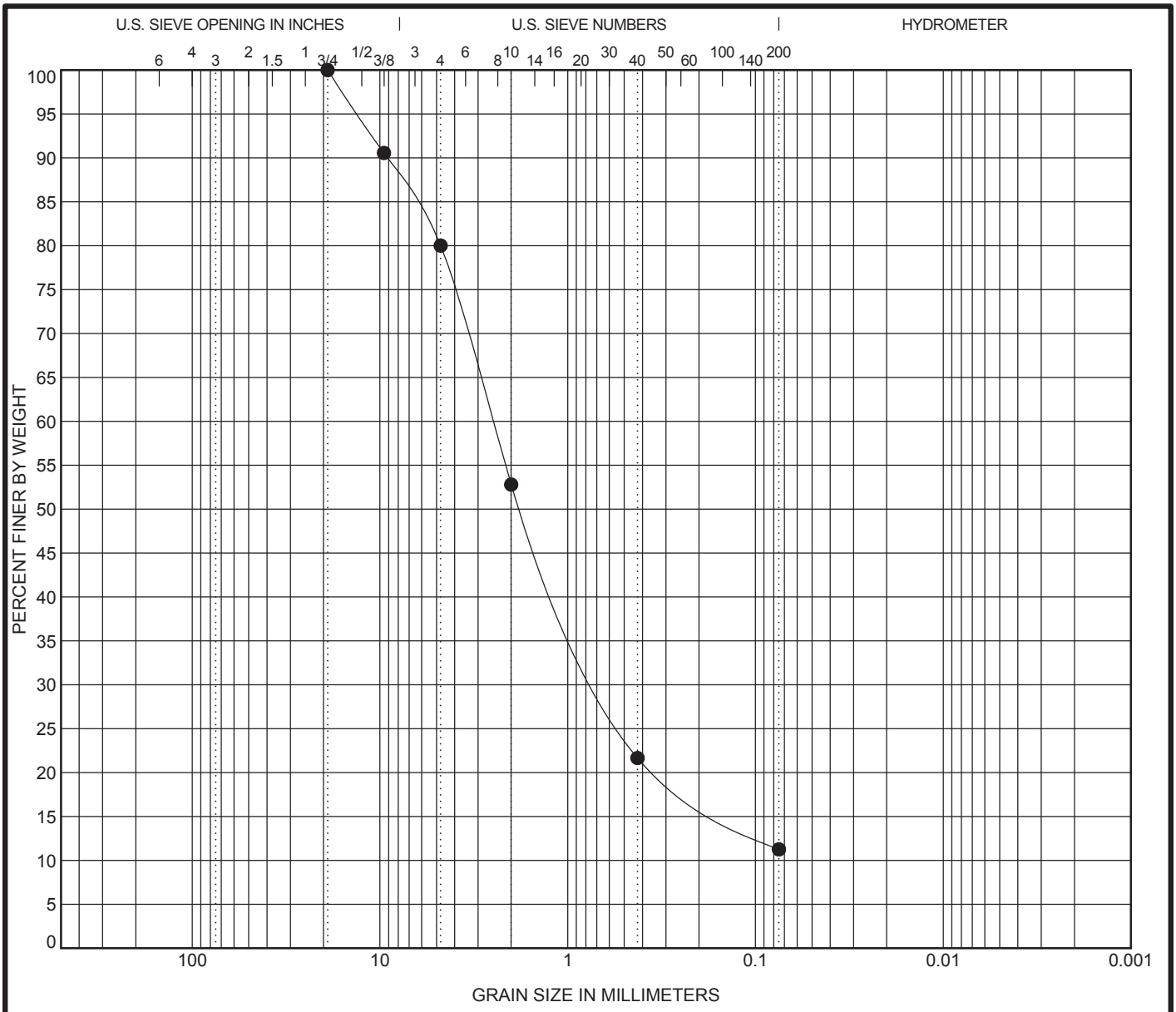

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
● **B-08B**	**SS-4**	**WELL-GRADED SAND with SILT and GRAVEL (SW-SM)**	**10**	**NP**	**NP**	**NP**	**2.71**	**41.34**

Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
● **B-08B**	**SS-4**	**19**	**2.515**	**1.74**	**0.644**		**20**	**69**		

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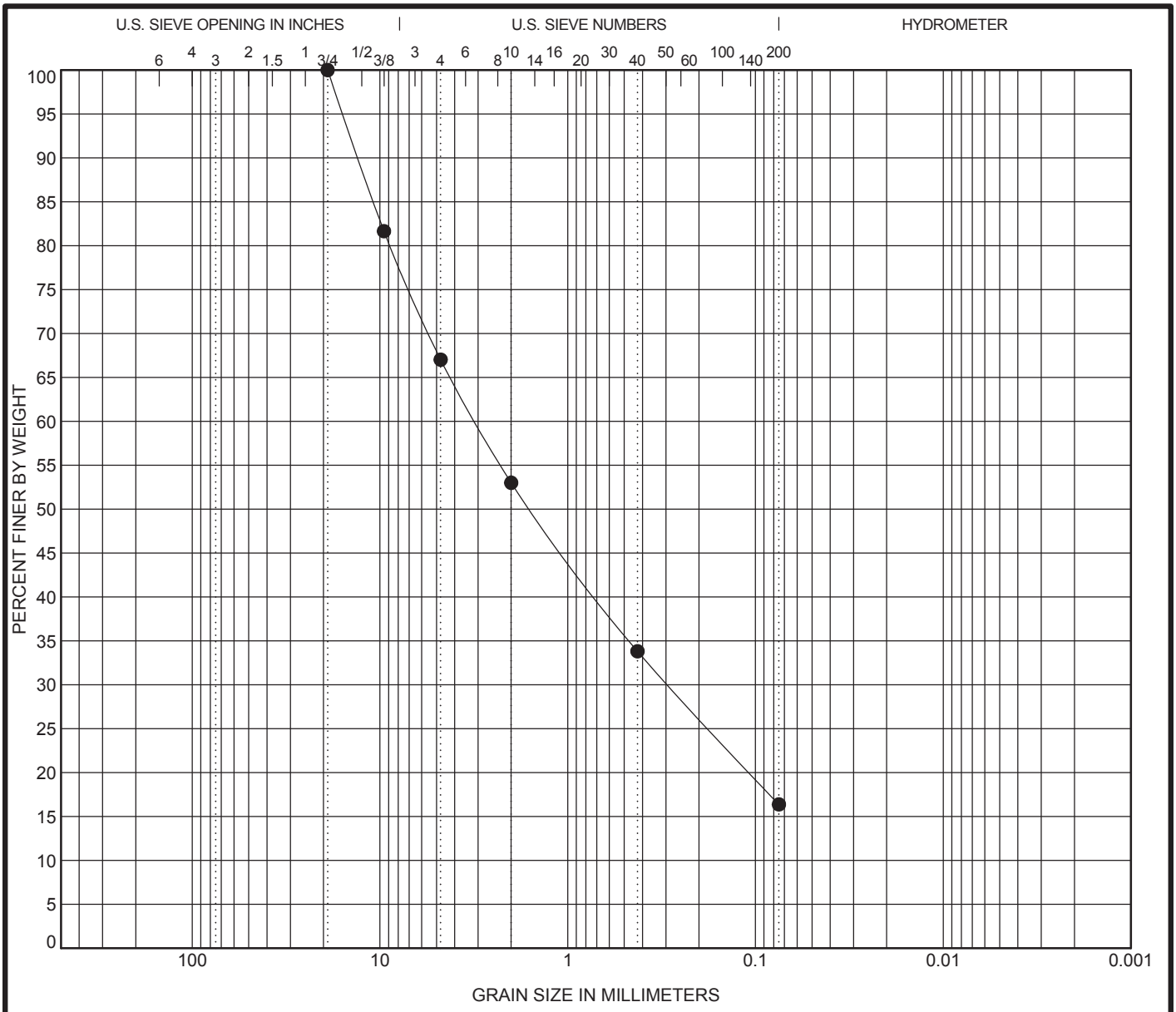

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
●	**B-09**	**SS-2**	**SILTY SAND with GRAVEL (SM)**	**14**	**NP**	**NP**	**NP**		

	Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-09**	**SS-2**	**19**	**3.08**	**1.57**	**0.291**		**33**	**51**		

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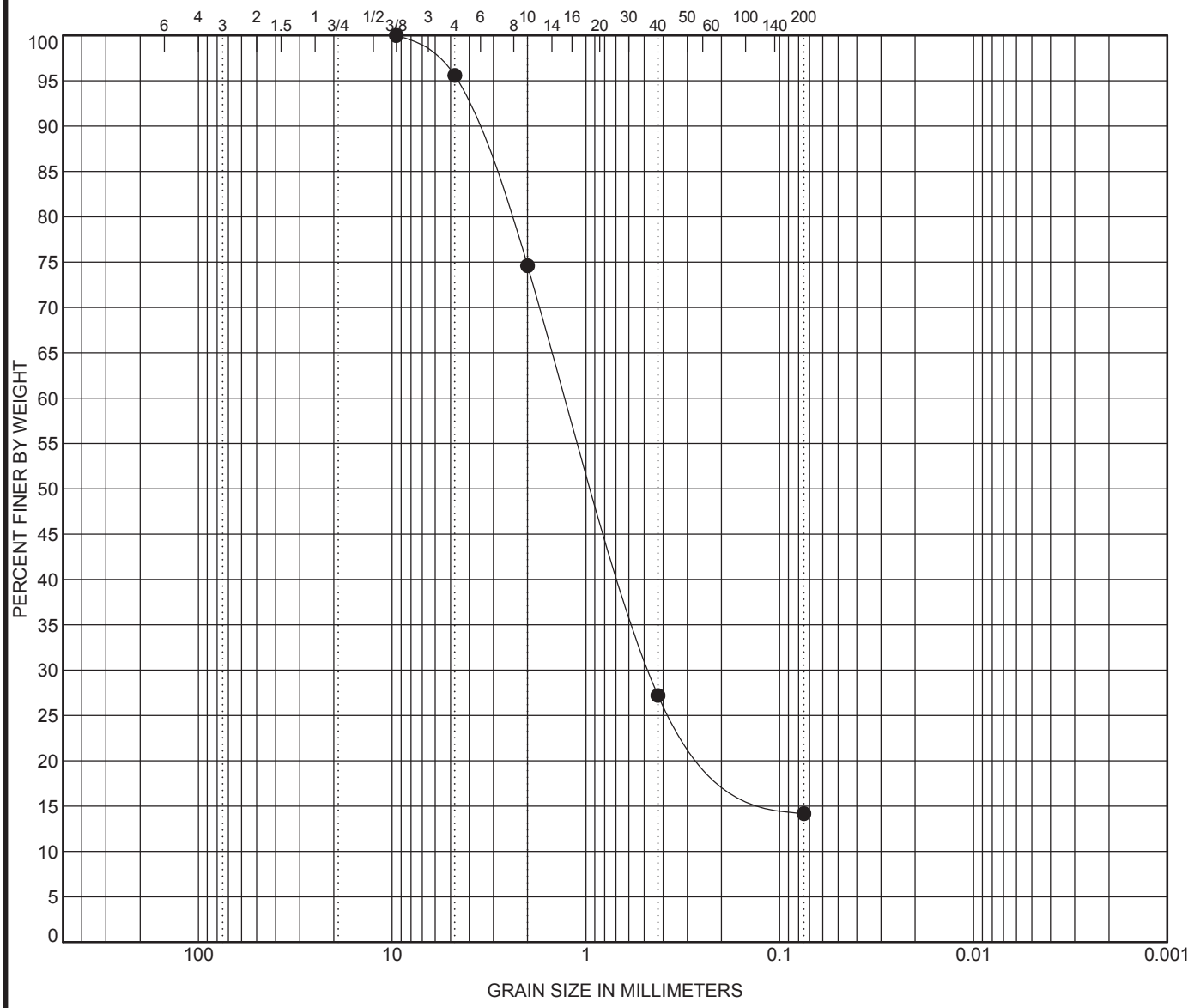

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
●	**B-09**	**SS-4**	**SILTY SAND (SM)**	**15**	**NP**	**NP**	**NP**		

	Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-09**	**SS-4**	**9.525**	**1.241**	**0.895**	**0.466**		**4**	**81**		

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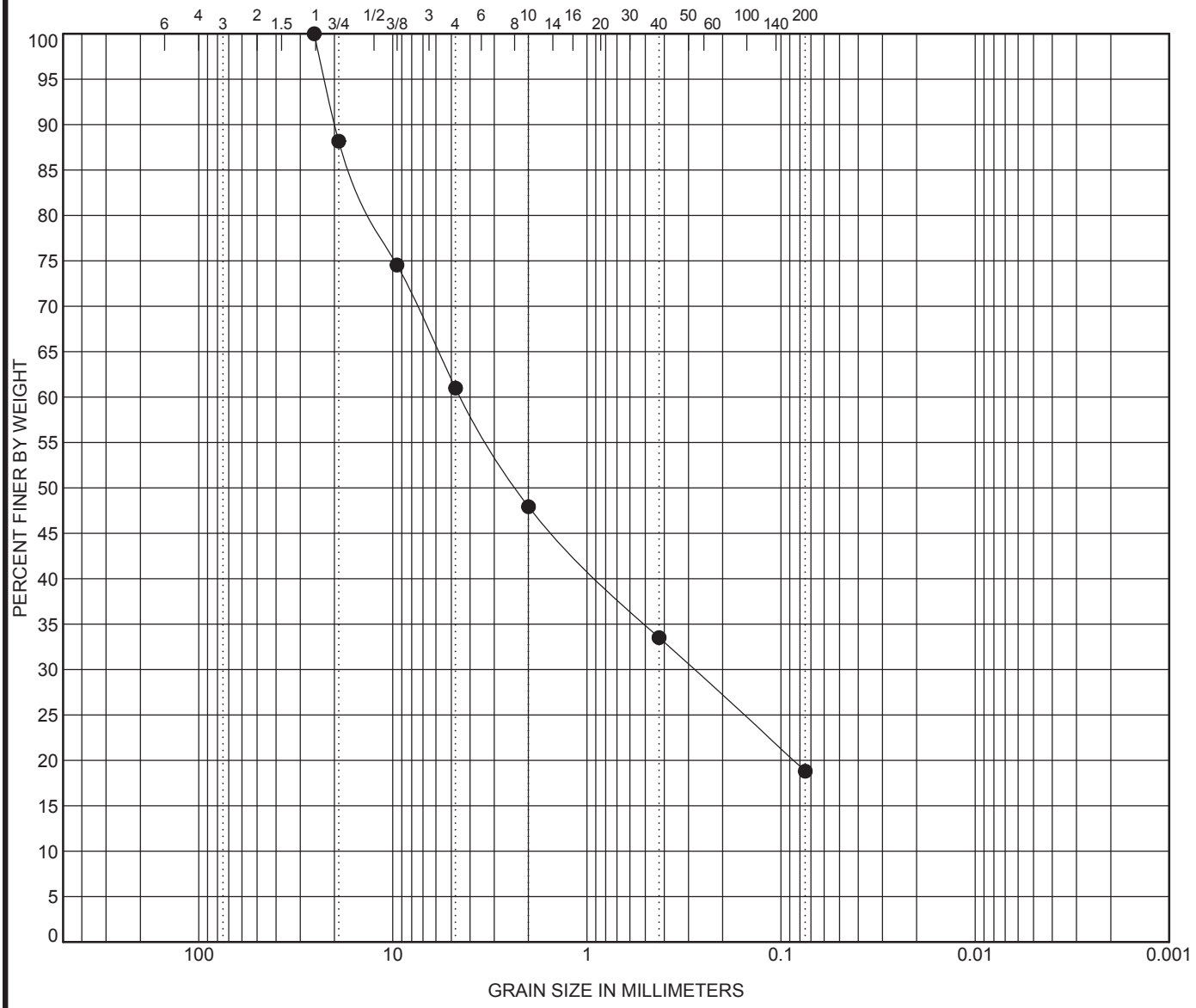

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
●	**B-09**	**SS-6**	**SILTY SAND with GRAVEL (SM)**	**15**	**NP**	**NP**	**NP**		

	Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-09**	**SS-6**	**25.4**	**4.45**	**2.294**	**0.281**		**39**	**42**		

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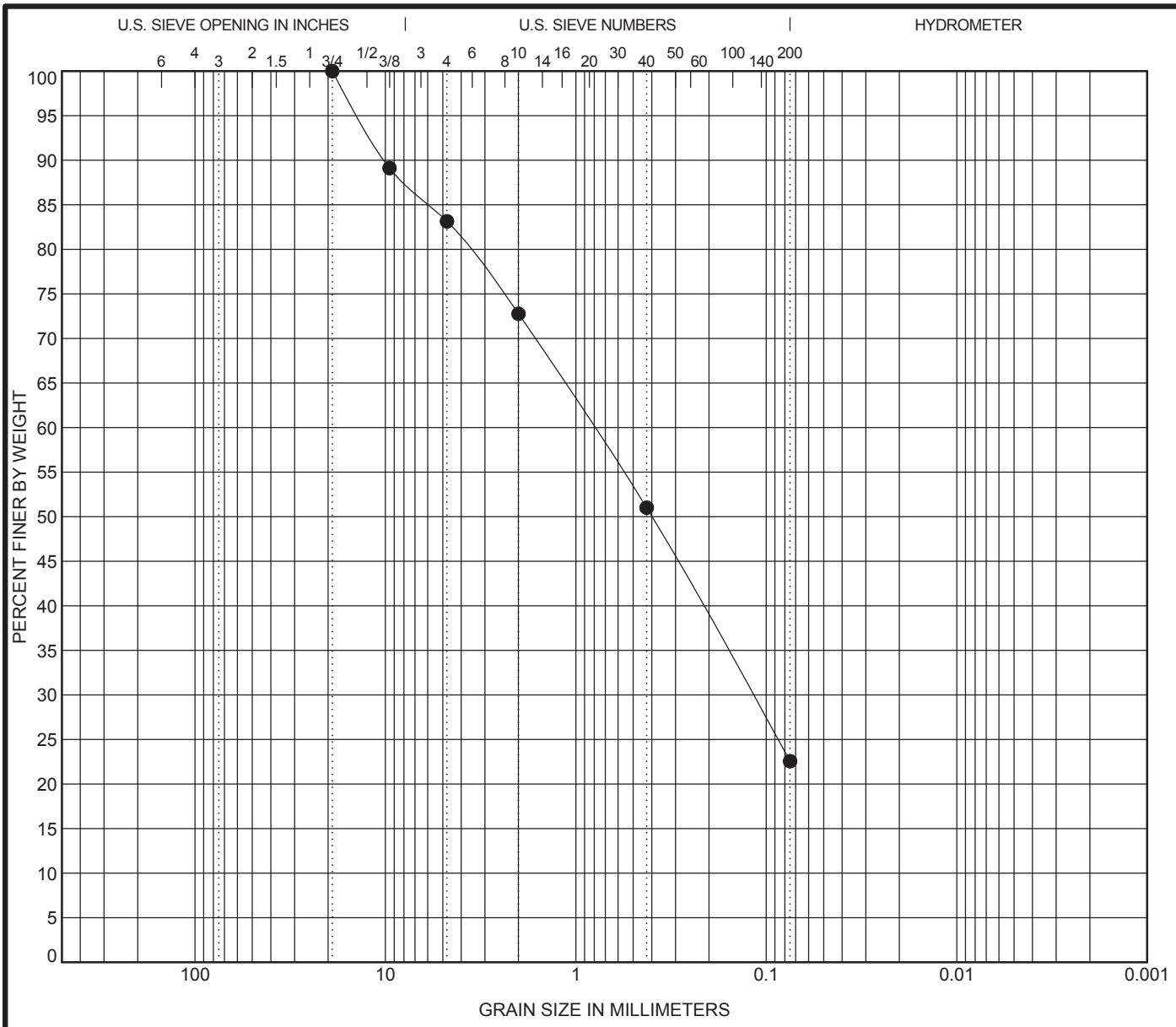

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
●	**B-10**	**SS-1**	**SILTY SAND with GRAVEL (SM)**	**15**	**NP**	**NP**	**NP**		

	Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-10**	**SS-1**	**19**	**0.806**	**0.4**	**0.118**		**17**	**61**		

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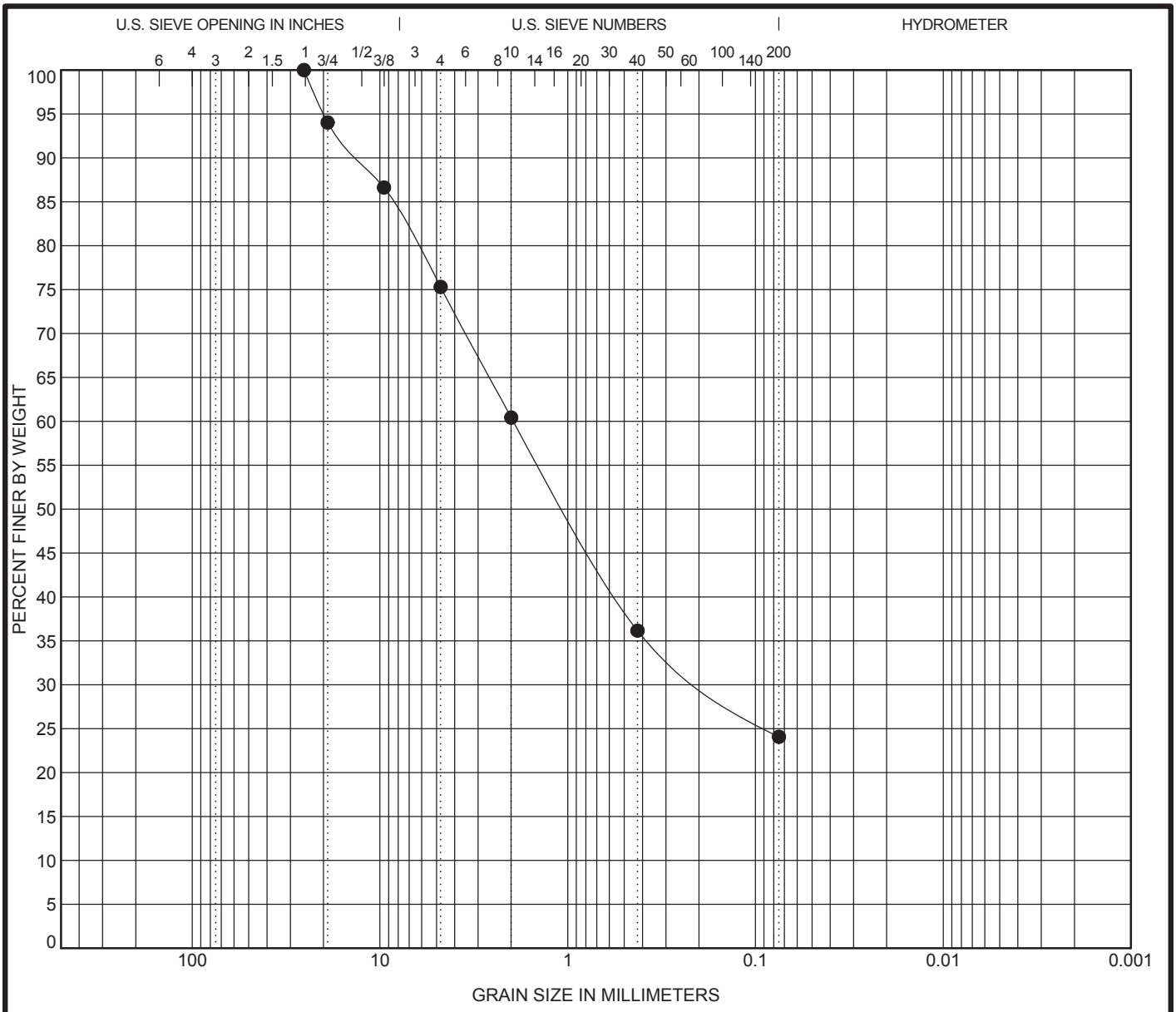

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
●	**B-10**	**SS-3**	**SILTY SAND with GRAVEL (SM)**	**9**	**NP**	**NP**	**NP**		

	Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-10**	**SS-3**	**25.4**	**1.947**	**1.028**	**0.175**		**25**	**51**		

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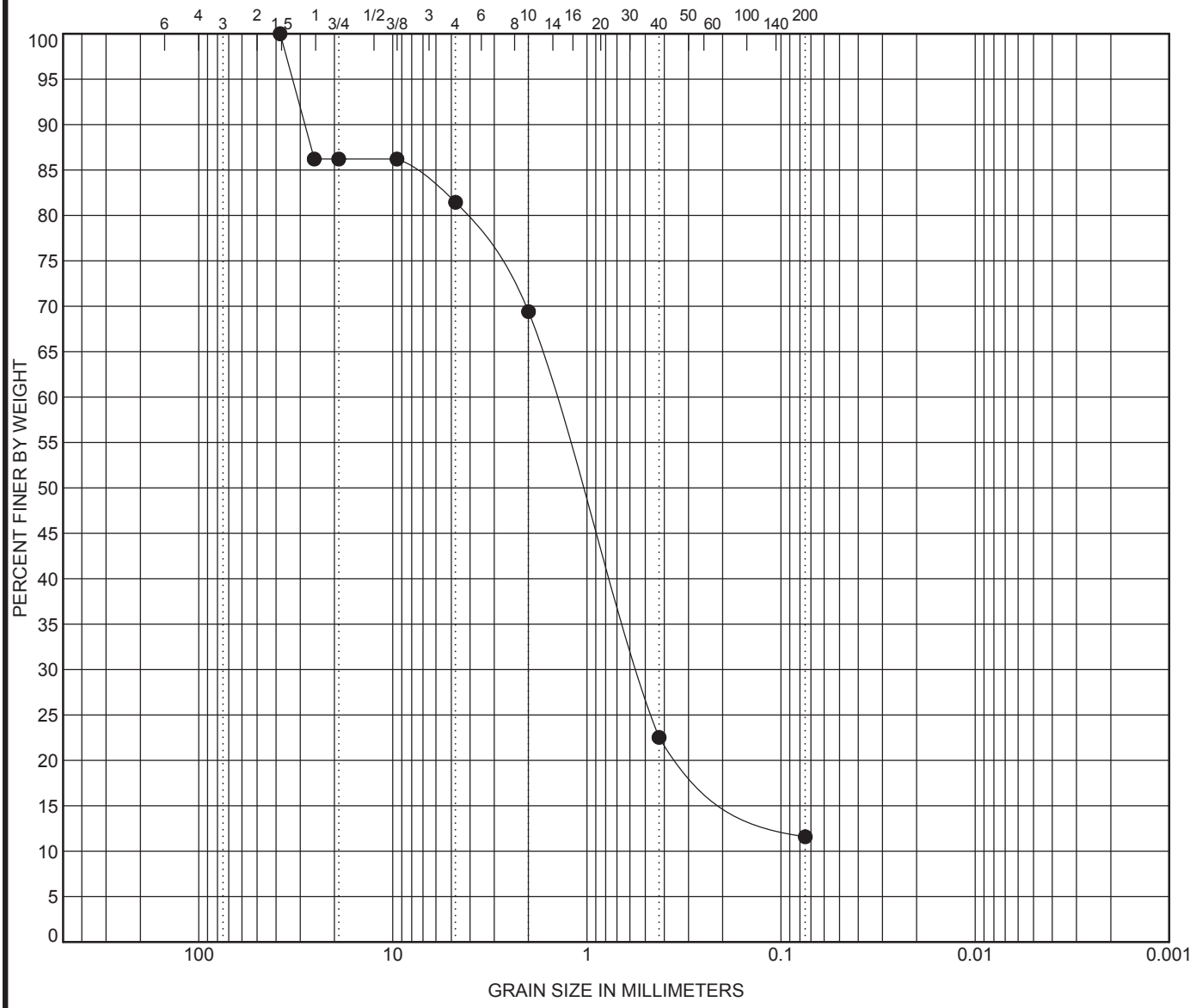
CTLLAB_GRAINSIZE 16050004CLE.GPJ CTL_CORPORATE.GDT 3/6/16



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
● **B-10**	**SS-5**	**POORLY GRADED SAND with SILT and GRAVEL (SP-SM)**	**15**	**NP**	**NP**	**NP**	**3.46**	**25.12**

Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
● **B-10**	**SS-5**	**38.1**	**1.466**	**1.053**	**0.544**		**19**	**70**		

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GRAIN SIZE DISTRIBUTION

Project: A-USC Com Test

Location: 205 N. Ave., Youngstown, OH.

CTL Project Number: 16050004CLE

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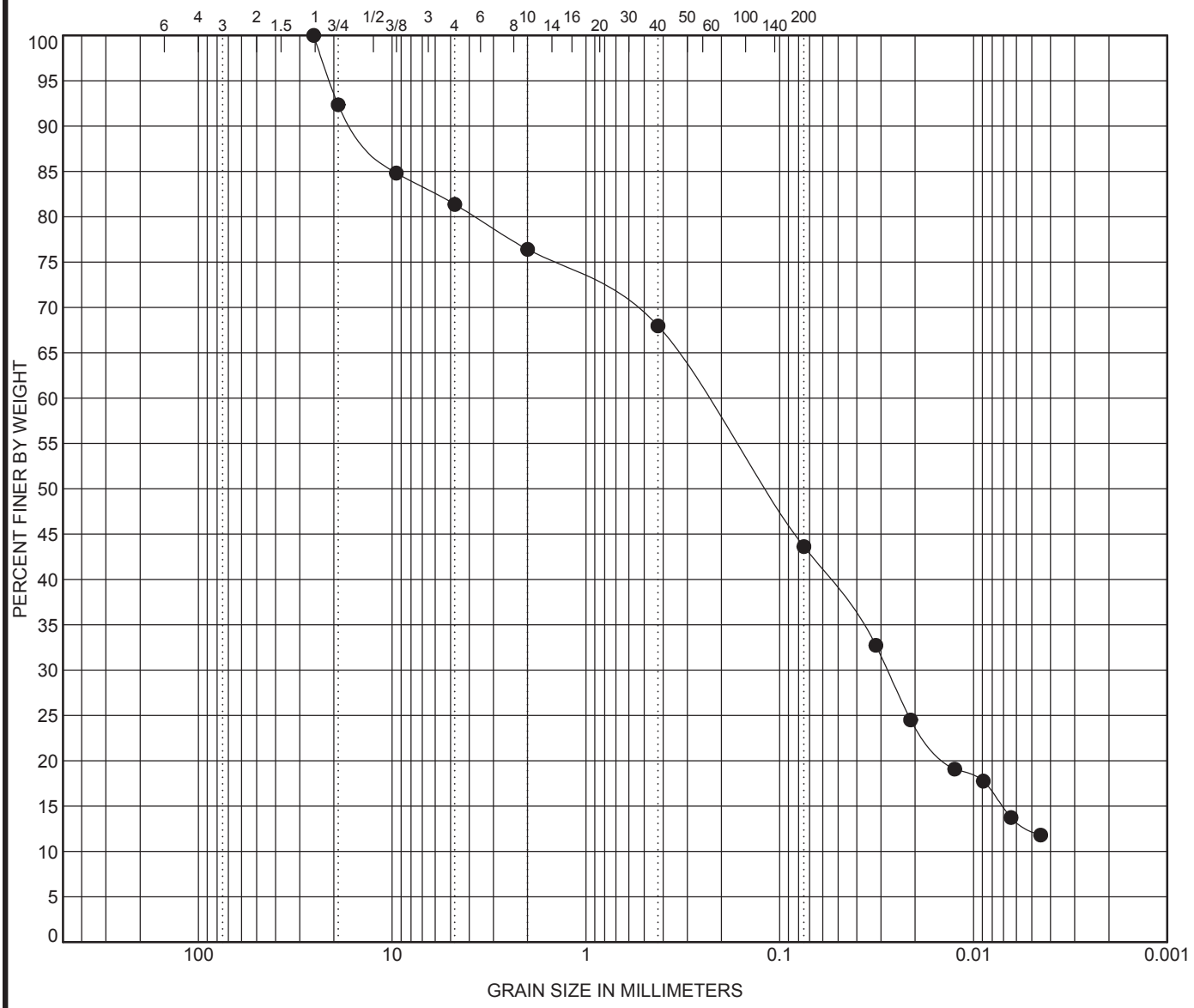

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
●	**B-10**	**SS-7**	**SILTY SAND with GRAVEL (SM)**	**9**	**17**	**14**	**3**		

	Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-10**	**SS-7**	**25.4**	**0.241**	**0.118**	**0.028**		**19**	**38**	**31**	**12**

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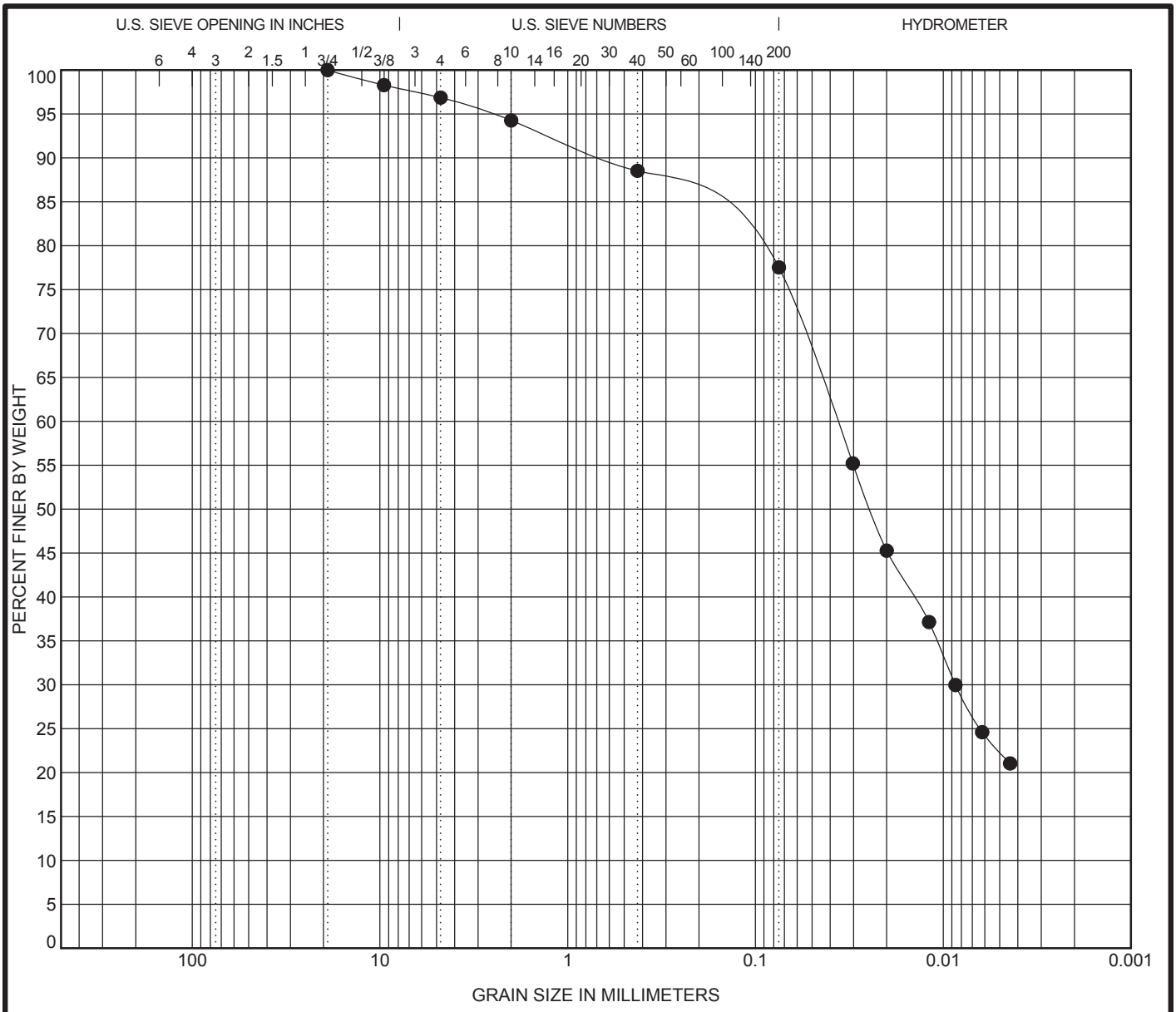

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
●	**B-11**	**SS-1**	**LEAN CLAY with SAND (CL)**	**22**	**28**	**20**	**8**		

	Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-11**	**SS-1**	**19**	**0.037**	**0.024**	**0.009**		**3**	**19**	**56**	**22**

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Location: 205 N. Ave., Youngstown, OH.

CTL Project Number: 16050004CLE

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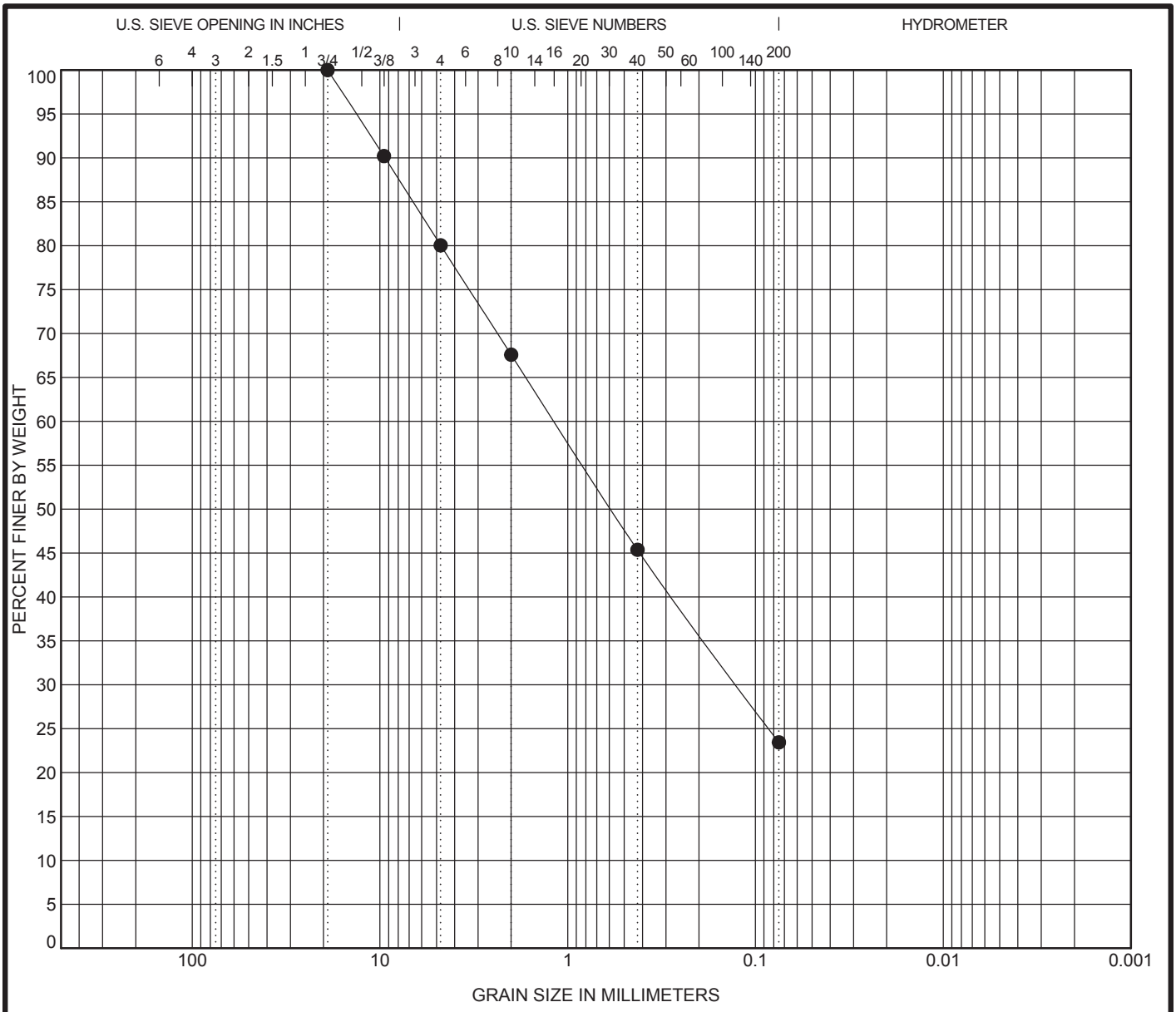

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
● **B-12**	**SS-2**	**SILTY SAND with GRAVEL (SM)**	**21**	**NP**	**NP**	**NP**		

Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
● **B-12**	**SS-2**	**19**	**1.179**	**0.587**	**0.126**		**20**	**57**		

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Location: 205 N. Ave., Youngstown, OH.

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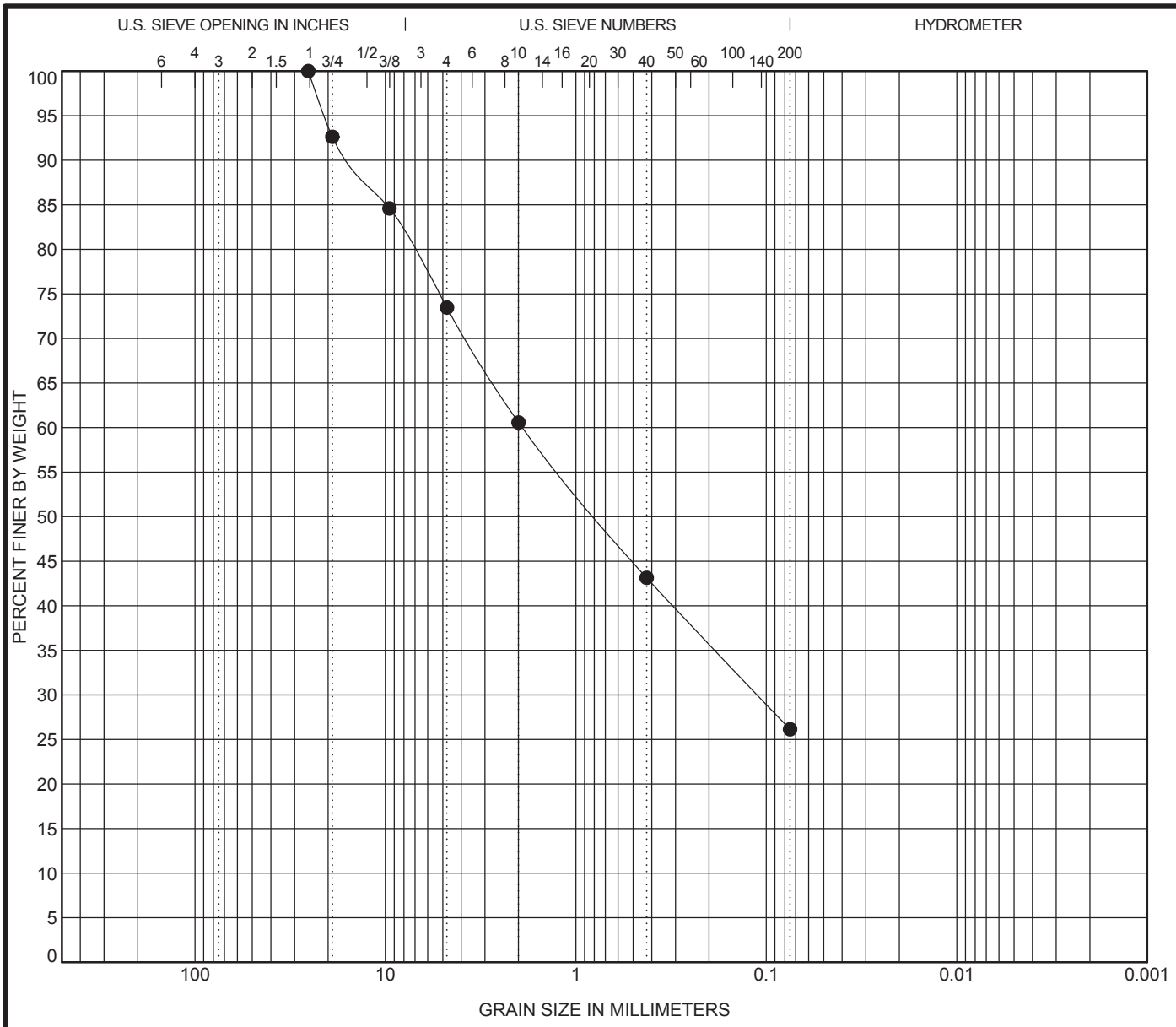

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
●	**B-13**	**SS-1**	**SILTY SAND with GRAVEL (SM)**	**25**	**NP**	**NP**	**NP**		

	Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-13**	**SS-1**	**25.4**	**1.901**	**0.782**	**0.111**		**27**	**47**		

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CTL Project Number: 16050004CLE

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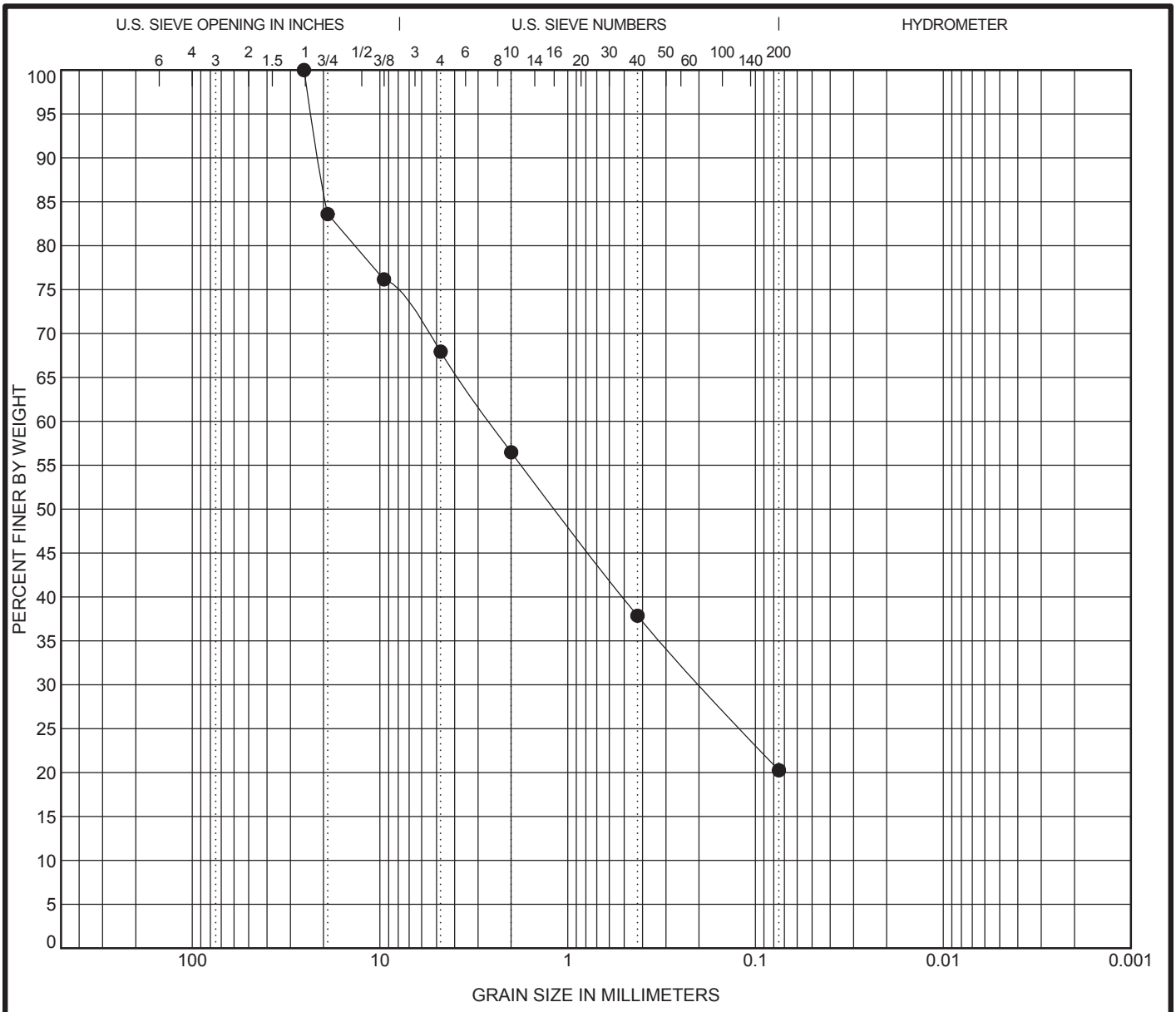

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
●	**B-13**	**SS-3**	**SILTY SAND with GRAVEL (SM)**	**32**	**NP**	**NP**	**NP**		

	Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-13**	**SS-3**	**25.4**	**2.61**	**1.167**	**0.196**		**32**	**48**		

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Project: A-USC Com Test

Location: 205 N. Ave., Youngstown, OH.

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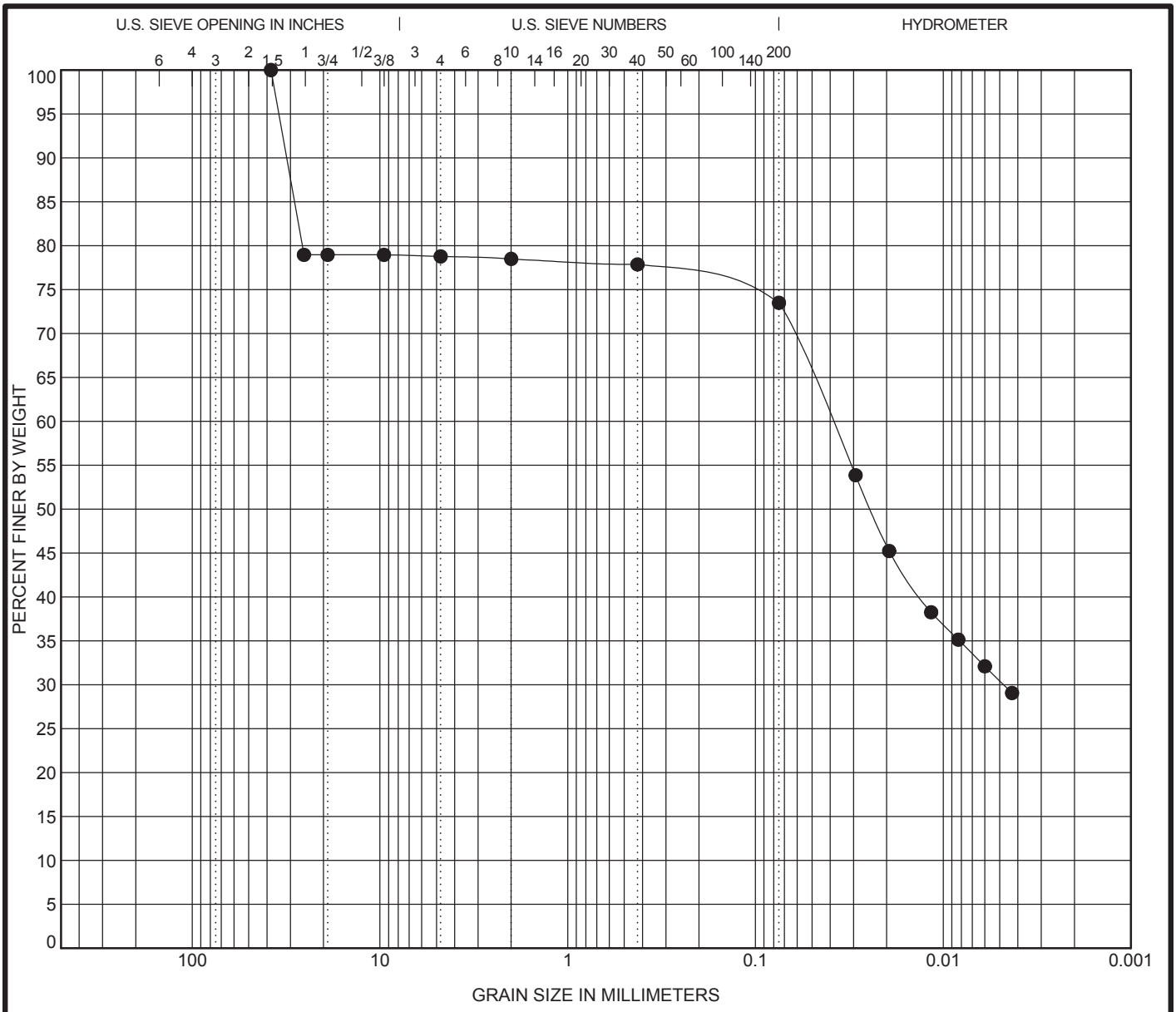

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
● **B-13**	**SS-5**	**LEAN CLAY with GRAVEL (CL)**	**20**	**33**	**17**	**16**		

Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
● **B-13**	**SS-5**	**38.1**	**0.039**	**0.024**	**0.005**		**21**	**5**	**44**	**30**

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GRAIN SIZE DISTRIBUTION

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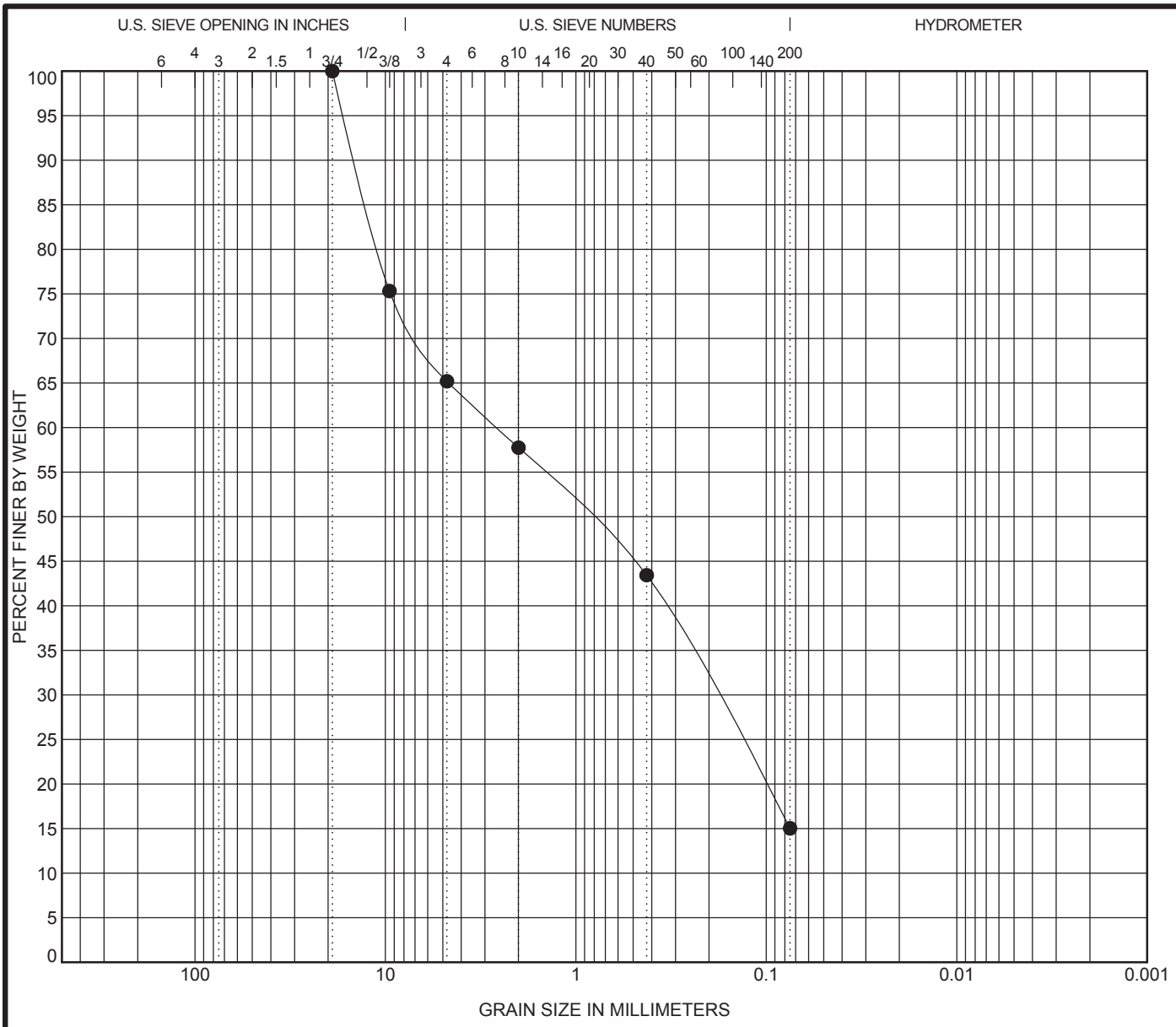

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
●	**B-14**	**SS-1**	**SILTY SAND with GRAVEL (SM)**	**10**	**NP**	**NP**	**NP**		

	Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-14**	**SS-1**	**19**	**2.598**	**0.865**	**0.187**		**35**	**50**		

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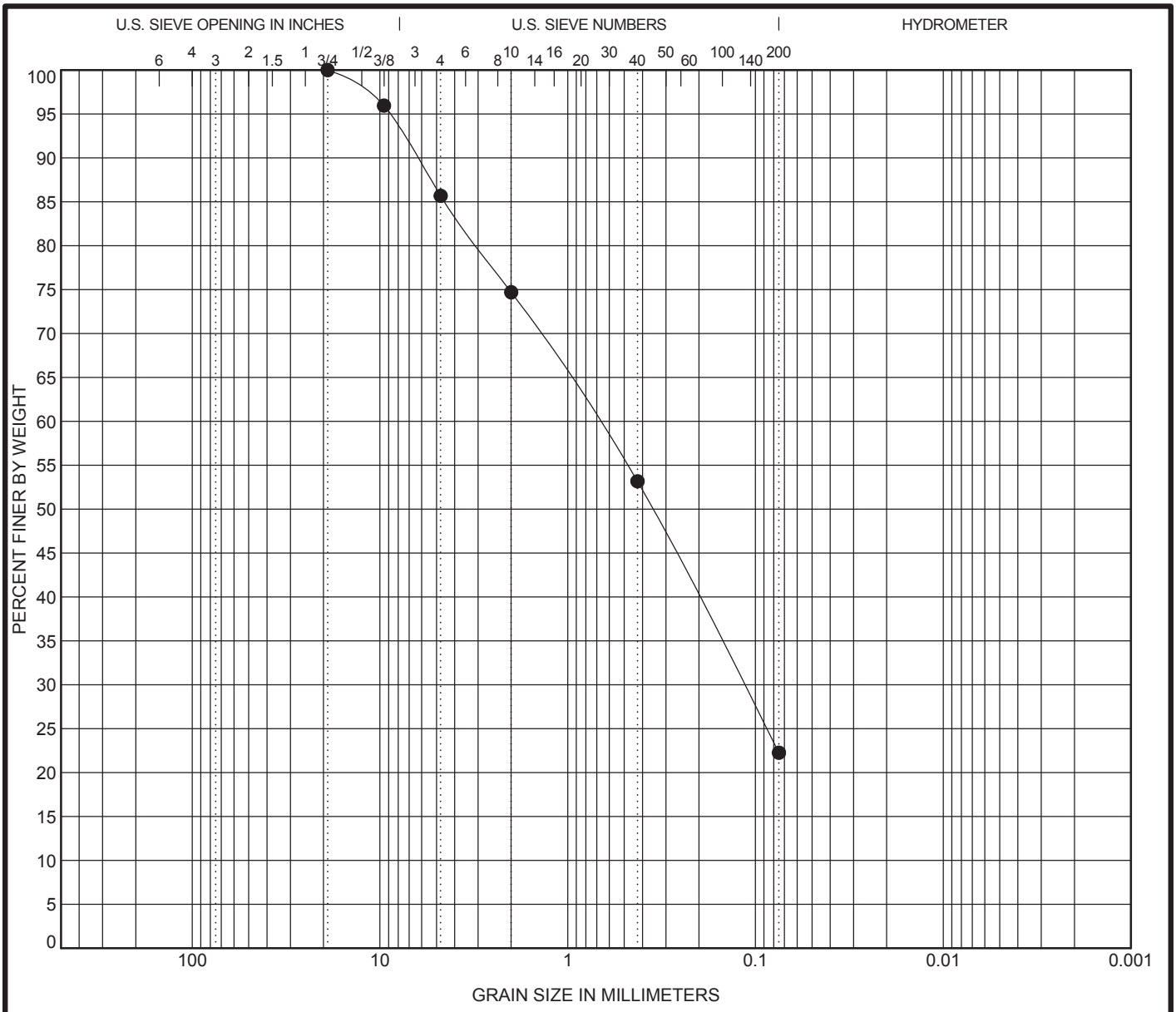

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
●	**B-14**	**SS-2**	**SILTY SAND (SM)**	**21**	**NP**	**NP**	**NP**		

	Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-14**	**SS-2**	**19**	**0.695**	**0.356**	**0.116**		**14**	**63**		

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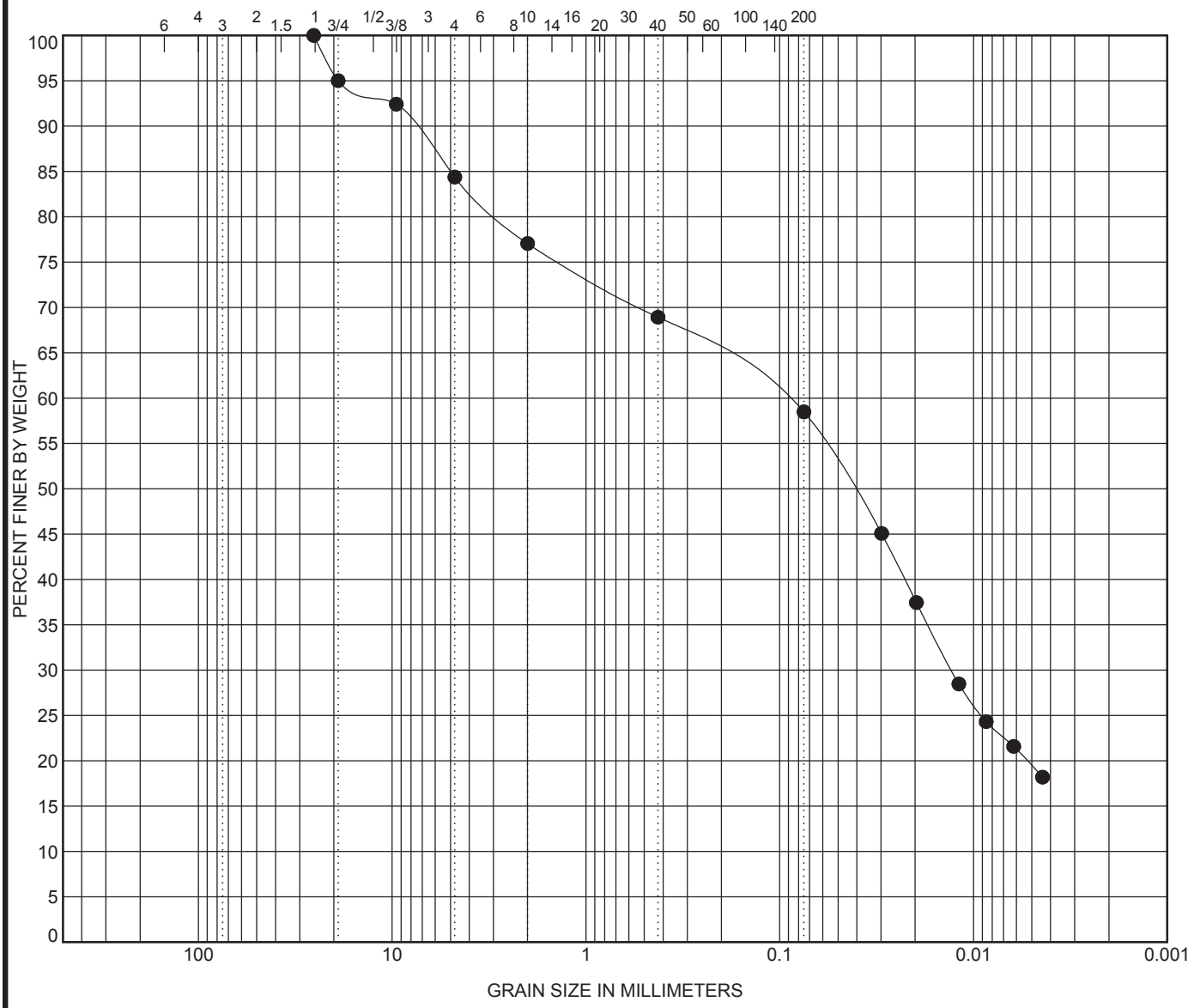

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
●	**B-15**	**SS-2**	**SANDY LEAN CLAY with GRAVEL (CL)**	**22**	**29**	**18**	**11**		

	Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-15**	**SS-2**	**25.4**	**0.096**	**0.042**	**0.013**		**16**	**26**	**39**	**19**

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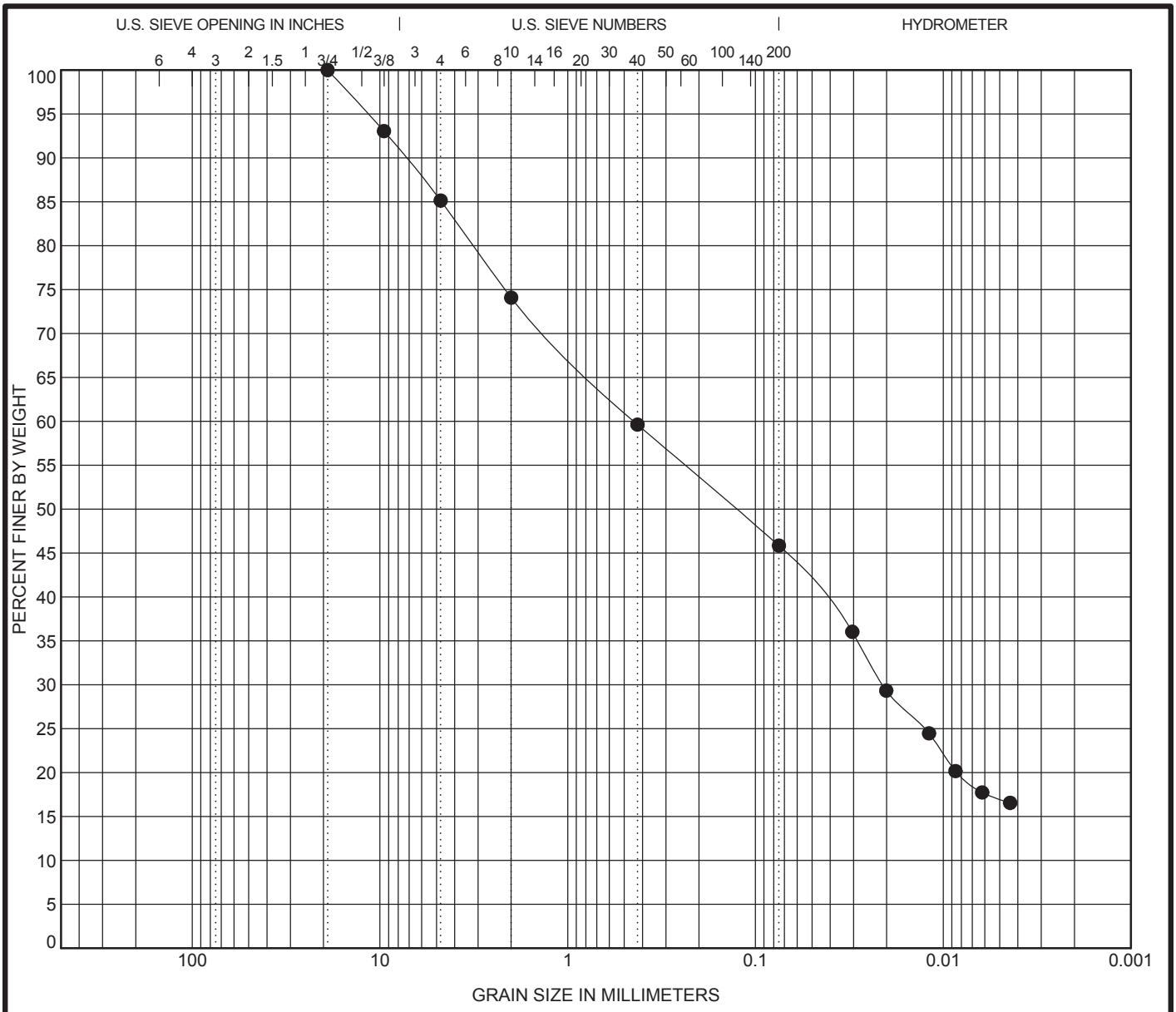

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
●	**B-15**	**SS-4**	**CLAYEY SAND (SC)**	**17**	**30**	**17**	**13**		

	Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-15**	**SS-4**	**19**	**0.442**	**0.127**	**0.021**		**15**	**39**	**29**	**17**

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GRAIN SIZE DISTRIBUTION

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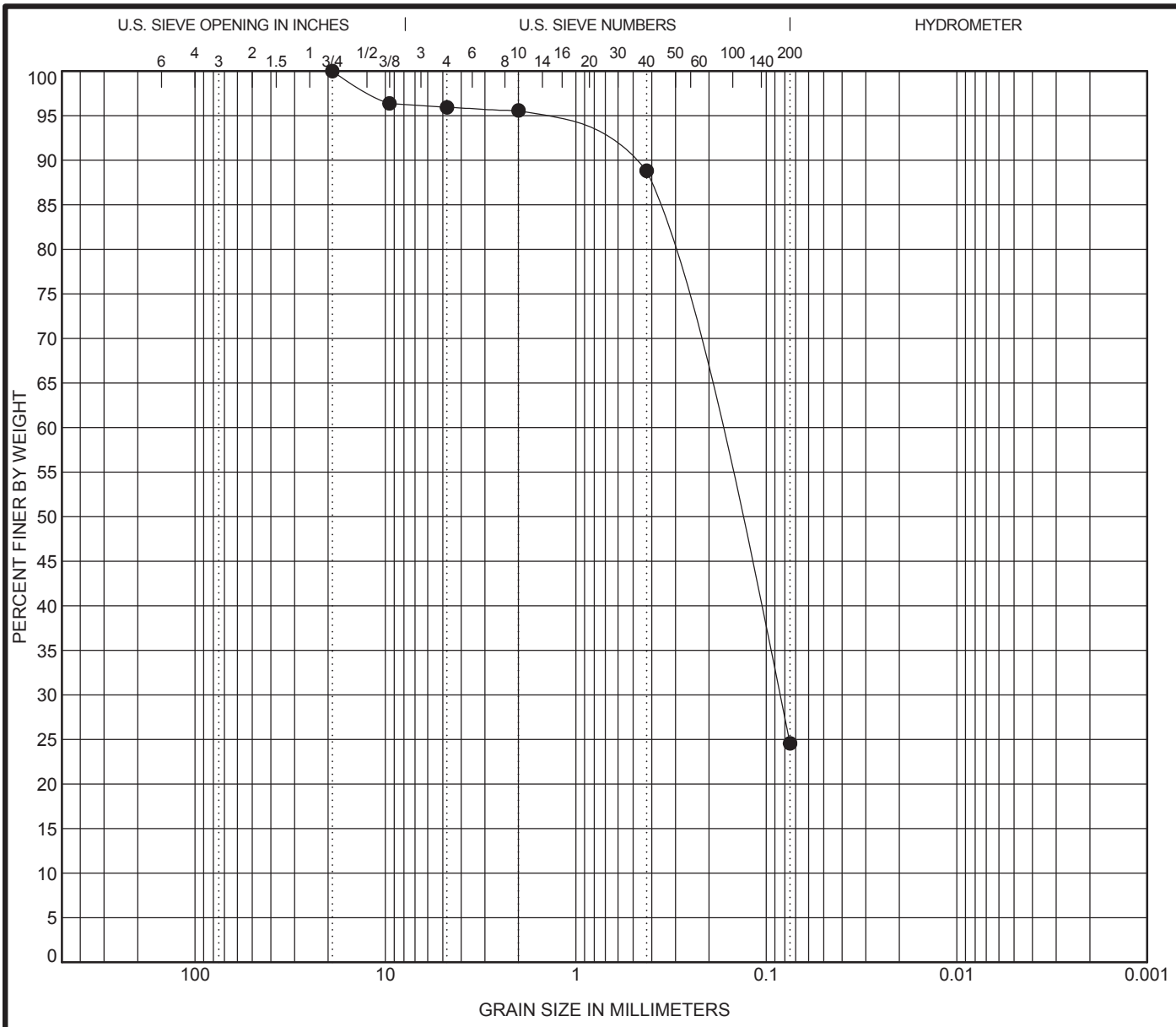

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
●	**B-15**	**SS-8**	**SILTY SAND (SM)**	**18**	**NP**	**NP**	**NP**		

	Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-15**	**SS-8**	**19**	**0.195**	**0.149**	**0.087**		**4**	**71**		

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APPENDIX D

- **CALCULATIONS**

A-USC									
GB1 Cut/Fill Calculations									
PointID	Reference	Station	Offset	Elevation (ft)	Assumed Slab Section (ft)	Proposed Grades (ft)	Subgrade Elev (ft)	Cut/Fill (ft)	Remark
B-11	Boilers, Transformer & Pavement	N/A	N/A	866.0	1.67	868.0	866.3	0.3	
B-12		N/A	N/A	869.0	1.67	868.0	866.3	-2.7	
B-13		N/A	N/A	869.2	1.67	868.0	866.3	-2.9	
B-14		N/A	N/A	869.2	1.67	868.0	866.3	-2.9	
B-01	Turbine Basement	N/A	N/A	869.0	1.67	852.9	851.2	-17.8	
B-02		N/A	N/A	868.5	1.67	852.9	851.2	-17.3	
B-03		N/A	N/A	868.1	1.67	852.9	851.2	-16.9	
B-04		N/A	N/A	868.2	1.67	852.9	851.2	-17.0	
B-05		N/A	N/A	867.6	1.67	852.9	851.2	-16.4	
B-06	Pavement	N/A	N/A	867.2	1.67	867.0	865.3	-1.9	
B-07	Turbine slab on grade	N/A	N/A	868.0	1.67	867.5	865.8	-2.2	
B-08B		N/A	N/A	868.5	1.67	867.5	865.8	-2.7	
B-09	Pavement	N/A	N/A	868.0	1.67	867.0	865.3	-2.7	
B-10		N/A	N/A	867.0	1.67	867.0	865.3	-1.7	
B-15		N/A	N/A	866.0	1.67	867.0	865.3	-0.7	

Subgrade Analysis

V. 12.00 12/30/11

Design CBR 12

Global Options		
320	R&R	Option
206	CS	?
	LS	?
	LKD	?
206	Depth	NA

Classification Counts by Sample																	
R	1a	1b	3	3a	2-4	2-5	2-6	2-7	4a	4b	5	6a	6b	7-5	7-6	8a	8b
0	0	8	0	2	0	0	3	0	3	0	0	0	0	0	0	0	0
		50%		13%			19%		19%								
0%	81%								19%								

Surface Class	
2-5	0
4b	0
5	0
7-5	0
7-6	0
8a	0
8b	0
R	0

% Borings	
N_{60L}<= 5	0%
<=10	13%
>=20	25%
M+	88%
R	0%

% Surface	
0%	
0%	0%

UC @ Surface
0.0
0
0

Rig	ER
A	82
B	
C	
D	
E	
F	
G	
H	

Total Borings	8
PID	
Location	Turbine Building

	N_{60}	N_{60L}	PI	Clay			M	M_{OPT}	GI
Average	21.9	17.1	6.3	11.5			14.3	7.9	1.06
Maximum	51	30		49	15	62	24	12	5
Minimum	10	10		9	4	13	5	6	0

	Boring				Cut	Subgrade		Standard Penetration						Physical Characteristics						Moisture		Class		Comments	Problem		Undercuts		Analysis
#	B #	Boring Location	Depth	To	Fill	Depth	To	n_2	n_3	N	Rig	N_{60}	N_{60L}	LL	PL	PI	% Silt	% Clay	P 200	M	M_{OPT}	Ohio DOT	GI		w/ Class	w/ MN	UC Class	UC MN	
1	B-01	Turbine Basement	13.5	15.0	-17.8	-4.3	-2.8	9	11	20	A	27									6	1b	0						
			18.5	20.0		0.7	2.2	7	10	17		23	23							18	6	1b	0			M			
2	B-02	Turbine Basement	13.5	15.0	-17.3	-3.8	-2.3	27	10	37	A	51								17	6	1b	0			M			
			18.5	20.0		1.2	2.7	4	6	10		14	14							5	6	1b	0						
3	B-03	Turbine Basement	13.5	15.0	-16.9	-3.4	-1.9	2	10	12	A	16								10	6	1b	0						
			18.5	20.0		1.6	3.1	3	5	8		11	11				9	4	13	24	8	3a	0			N		---	
4	B-04	Turbine Basement	13.5	15.0	-17.0	-3.5	-2.0	14	8	22	A	30		NP	NP	NP				9	6	1b	0						
			18.5	20.0		1.5	3.0	11	15	26		35	30	26	17	9	39	15	54	15	12	4a	4						
5	B-05	Turbine Basement	13.5	15.0	-16.4	-2.9	-1.4	6	7	13	A	18		20	13	7	31	14	45	10	10	4a	2						
			18.5	20.0		2.1	3.6	5	8	13		18	18	19	16	3	49	13	62	17	11	4a	5			M			
6	B-06	Turbine Basement	1.0	2.5	-1.9	-0.9	0.6	4	3	7	A	10		NP	NP	NP				18	8	3a	0			N		---	
			3.5	5.0		1.6	3.1	8	11	19		26	10							12	10	2-6	2						
7	B-07	Turbine At Grade	1.0	2.5	-2.2	-1.2	0.3	5	7	12	A	16								20	10	2-6	2			M			
			3.5	5.0		1.3	2.8	6	6	12		16	16							16	6	1b	0			M			
8	B-08B	Turbine At Grade	1.0	2.5	-2.7	-1.7	-0.2	6	5	11	A	15								14	10	2-6	2						
			3.5	5.0		0.8	2.3	8	10	18		25	15							9	6	1b	0						
9											A																		
10					0.0						A																		
11					0.0						A																		

Subgrade Analysis

V. 12.00 12/30/11

Design CBR 10

Global Options		
320	R&R	Option
206	CS	Option
	LS	No
	LKD	No
206	Depth	12

Classification Counts by Sample																	
R	1a	1b	3	3a	2-4	2-5	2-6	2-7	4a	4b	5	6a	6b	7-5	7-6	8a	8b
0	0	0	0	0	0	0	6	0	0	2	0	0	0	0	0	0	0
							75%			25%							
0%	75%								25%								

Surface Class		
2-5	0	
4b	2	50%
5	0	
7-5	0	
7-6	0	
8a	0	
8b	0	
R	0	

% Borings	
N_{60L}<= 5	0%
<=10	25%
>=20	0%
M+	100%
R	0%

% Surface	
50%	
50%	50%

Rig	ER
A	82
B	
C	
D	
E	
F	
G	
H	

Total Borings	4							
PID								
Location	Boilers/Transformers							

	N_{60}	N_{60L}			PI		Clay		M	M_{OPT}		GI
Average	14.1	12.0			8.0		11.4		20.0	10.6		2.00
Maximum	22	14	28	20	8	56	22	78	29	15		8
Minimum	10	10	28	20	8	10	5	15	9	10		0

UC @ Surface
24.8
36
12

	Boring					Subgrade		Standard Penetration						Physical Characteristics						Moisture		Class		Comments	Problem		Undercuts		Analysis
#	B #	Boring Location	Depth	To	Cut Fill	Depth	To	n_2	n_3	N	Rig	N_{60}	N_{60L}	LL	PL	PI	% Silt	% Clay	P 200	M	M_{OPT}	Ohio DOT	GI		w/ Class	w/ MN	UC Class	UC MN	
1	B-11	Boilers	1.0	2.5	0.3	1.3	2.8	4	3	7	A	10		28	20	8	56	22	78	22	15	4b	8		4b	N	36	15	
			3.5	5.0		3.8	5.3	6	4	10		14								9	10	2-6	2						
													10																
2	B-12	Boilers	1.0	2.5	-2.7	-1.7	-0.2	4	5	9	A	12								23	10	4b			4b	MN	36	12	
			3.5	5.0		0.8	2.3	3	7	10		14		NP	NP	NP	13	10	23	21	10	2-6	0			MN		12	
													12																
3	B-13	Boilers	1.0	2.5	-2.9	-1.9	-0.4	11	5	16	A	22					16	10	26	25	10	2-6	2			M			
			3.5	5.0		0.6	2.1	4	6	10		14								29	10	2-6	2			MN		12	
													14																
4	B-14	Transformers	1.0	2.5	-2.9	-1.9	-0.4	6	5	11	A	15		NP	NP	NP	10	5	15	10	10	2-6	0						
			3.5	5.0		0.6	2.1	5	4	9		12		NP	NP	NP	13	10	23	21	10	2-6	0			MN		12	
													12																
5					0.0						A																		
6					0.0						A																		
7					0.0						A																		
8					0.0						A																		
9					0.0						A																		
10					0.0						A																		
11					0.0						A																		

Subgrade Analysis

V. 12.00 12/30/11

Design CBR 11

Global Options		
320	R&R	No
206	CS	Option
	LS	No
	LKD	No
206	Depth	12

Classification Counts by Sample																	
R	1a	1b	3	3a	2-4	2-5	2-6	2-7	4a	4b	5	6a	6b	7-5	7-6	8a	8b
0	0	3	0	3	0	0	10	0	0	2	0	0	0	0	0	0	0
		17%		17%			56%			11%							
0%	89%								11%								

Surface Class		
2-5	0	
4b	2	22%
5	0	
7-5	0	
7-6	0	
8a	0	
8b	0	
R	0	

% Borings	
N_{60L}<= 5	11%
<=10	44%
>=20	0%
M+	100%
R	0%

% Surface	
22%	
22%	22%

Rig	ER
A	82
B	
C	
D	
E	
F	
G	
H	

Total Borings	9																					
PID																						
Location	Pavement																					
											N_{60}	N_{60L}			PI		Clay		M	M_{OPT}		GI
										Average	18.2	11.3			8.0		11.4		17.8	9.3		1.29
										Maximum	68	16	28	20	8	56	22	78	29	15		8
										Minimum	5	5	28	20	8	10	5	15	9	6		0

	Boring					Subgrade		Standard Penetration						Physical Characteristics						Moisture		Class		Comments	Problem		Undercuts	
#	B #	Boring Location	Depth	To	Cut Fill	Depth	To	n_2	n_3	N	Rig	N_{60}	N_{60L}	LL	PL	PI	% Silt	% Clay	P 200	M	M_{OPT}	Ohio DOT	GI		w/ Class	w/ MN	UC Class	UC MN
1	B-11	Boilers/Pavement	1.0	2.5	0.3	1.3	2.8	4	3	7	A	10		28	20	8	56	22	78	22	15	4b	8		4b	N	36	15
			3.5	5.0		3.8	5.3	6	4	10		14								9	10	2-6	2					
													10															
2	B-12	Boilers/Pavement	1.0	2.5	-2.7	-1.7	-0.2	4	5	9	A	12								23	10	4b			4b	MN	36	12
			3.5	5.0		0.8	2.3	3	7	10		14		NP	NP	NP	13	10	23	21	10	2-6	0			MN		12
													12															
3	B-13	Boilers/Pavement	1.0	2.5	-2.9	-1.9	-0.4	11	5	16	A	22					16	10	26	25	10	2-6	2			M		
			3.5	5.0		0.6	2.1	4	6	10		14								29	10	2-6	2			MN		12
													14															
4	B-14	Transformer/Pave	1.0	2.5	-2.9	-1.9	-0.4	6	5	11	A	15		NP	NP	NP	10	5	15	10	10	2-6	0					
			3.5	5.0		0.6	2.1	5	4	9		12		NP	NP	NP	13	10	23	21	10	2-6	0			MN		12
													12															
5	B-06	Pavement	1.0	2.5	-1.9	-0.9	0.6	4	3	7	A	10		NP	NP	NP				18	8	3a	0			N		---
			3.5	5.0		1.6	3.1	8	11	19		26								12	10	2-6	2					
													10															
6	B-07	Pvement	1.0	2.5	-2.2	-1.2	0.3	5	7	12	A	16								20	10	2-6	2			M		
			3.5	5.0		1.3	2.8	6	6	12		16								16	6	1b	0			M		
													16															
7	B-09	Pvement	1.0	2.5	-2.7	-1.7	-0.2	50		50	A	68								13	6	1b	0			M		
			3.5	5.0		0.8	2.3	5	6	11		15								14	6	1b	0			M		
													15															
8	B-10	Pvement	1.0	2.5	-2.7	-1.7	-0.2	10	12	22	A	30								15	8	3a	0			M		
			3.5	5.0		0.8	2.3	3	3	6		8								13	10	2-6	2			N		18
													8															
9	B-15	Pvement	1.0	2.5	-0.7	0.3	1.8	6	9	15	A	20								18	10	2-6	2			M		
			3.5	5.0		2.8	4.3	2	2	4		5								22	8	3a	0			N		---
													5															
10					0.0						A																	
11					0.0						A																	

Undercuts	
UC @ Surface	
24.8	
36	
12	

Analysis

Schmertmann's Method
Worksheet for Column Footings

From USACOE Suggested Worksheet

Project: A-USC
Client: AECOM
CTL Job # 16050004CLE

P= C1 C2 Delta P SUM (Iz/Es) Delta Z

Foundation Width, B (ft)	4		C1	0.935028
Embedment Depth (ft)	3.5		C2	1.339794
Soil Unit weight (pcf)	115	*	Po (tsf)	0.20125
Design Bearing Pressure (Ksf)	3.5		Delta P (tsf)	1.54875
Time Frame (years)	5	**		

Depth (ft) Below Grade	Depth (ft) Below footing	N	Es	Zcl	Iz	(Iz/Es) Delta Z
4.3	0.8	12	60	0.4	0.20	0.002667
5.1	1.6	12	60	1.2	0.40	0.005333
5.9	2.4	12	60	2	0.46	0.006067
6.7	3.2	7	35	2.8	0.39	0.008914
7.5	4	7	35	3.6	0.33	0.007429
8.3	4.8	7	35	4.4	0.26	0.005943
9.1	5.6	7	35	5.2	0.20	0.004457
9.9	6.4	16	80	6	0.13	0.0013
10.7	7.2	16	80	6.8	0.07	0.00065
11.5	8	16	80	7.6	0.00	0
						0.04276

Calculated Settlement (feet) 0.082962

Calculated Settlement (inches) 0.995539

Schmertmann's Method
Worksheet for Column Footings

From USACOE Suggested Worksheet

Project: A-USC
Client: AECOM
CTL Job # 16050004CLE

P= C1 C2 Delta P SUM (Iz/Es) Delta Z

Foundation Width, B (ft)	4.5		C1	0.935028
Embedment Depth (ft)	3.5		C2	1.339794
Soil Unit weight (pcf)	115	*	Po (tsf)	0.20125
Design Bearing Pressure (Ksf)	3.5		Delta P (tsf)	1.54875
Time Frame (years)	5	**		

Depth (ft) Below Grade	Depth (ft) Below footing	N	Es	Zcl	Iz	(Iz/Es) Delta Z
4.4	0.9	12	60	0.45	0.20	0.003
5.3	1.8	12	60	1.35	0.40	0.006
6.2	2.7	12	60	2.25	0.46	0.006825
7.1	3.6	7	35	3.15	0.39	0.010029
8	4.5	7	35	4.05	0.33	0.008357
8.9	5.4	7	35	4.95	0.26	0.006686
9.8	6.3	7	35	5.85	0.20	0.005014
10.7	7.2	16	80	6.75	0.13	0.001463
11.6	8.1	16	80	7.65	0.07	0.000731
12.5	9	16	80	8.55	0.00	0
						0.048104

Calculated Settlement (feet) 0.093332

Calculated Settlement (inches) 1.119981

Schmertmann's Method
Worksheet for Column Footings

From USACOE Suggested Worksheet

Project: A-USC
Client: AECOM
CTL Job # 16050004CLE

P= C1 C2 Delta P SUM (Iz/Es) Delta Z

Foundation Width, B (ft)	7.5		C1	0.514085
Embedment Depth (ft)	15		C2	1.339794
Soil Unit weight (pcf)	115	*	Po (tsf)	0.8625
Design Bearing Pressure (Ksf)	3.5		Delta P (tsf)	0.8875
Time Frame (years)	5	**		

Depth (ft) Below Grade	Depth (ft) Below footing	N	Es	Zcl	Iz	(Iz/Es) Delta Z
16.5	1.5	16	80	0.75	0.20	0.00375
18	3	14	70	2.25	0.40	0.008571
19.5	4.5	30	150	3.75	0.46	0.00455
21	6	50	250	5.25	0.39	0.00234
22.5	7.5	50	250	6.75	0.33	0.00195
24	9	50	250	8.25	0.26	0.00156
25.5	10.5	50	250	9.75	0.20	0.00117
27	12	50	250	11.25	0.13	0.00078
28.5	13.5	50	250	12.75	0.07	0.00039
30	15	50	250	14.25	0.00	0
						0.025061

Calculated Settlement (feet) 0.01532

Calculated Settlement (inches) 0.183835

Schmertmann's Method
Worksheet for Column Footings

From USACOE Suggested Worksheet

Project: A-USC
Client: AECOM
CTL Job # 16050004CLE

P= C1 C2 Delta P SUM (Iz/Es) Delta Z

Foundation Width, B (ft)	9.2		C1	0.514085
Embedment Depth (ft)	15		C2	1.339794
Soil Unit weight (pcf)	115	*	Po (tsf)	0.8625
Design Bearing Pressure (Ksf)	3.5		Delta P (tsf)	0.8875
Time Frame (years)	5	**		

Depth (ft) Below Grade	Depth (ft) Below footing	N	Es	Zcl	Iz	(Iz/Es) Delta Z
16.84	1.84	11	55	0.92	0.20	0.006691
18.68	3.68	14	70	2.76	0.40	0.010514
20.52	5.52	30	150	4.6	0.46	0.005581
22.36	7.36	50	250	6.44	0.39	0.00287
24.2	9.2	50	250	8.28	0.33	0.002392
26.04	11.04	50	250	10.12	0.26	0.001914
27.88	12.88	50	250	11.96	0.20	0.001435
29.72	14.72	50	250	13.8	0.13	0.000957
31.56	16.56	50	250	15.64	0.07	0.000478
33.4	18.4	50	250	17.48	0.00	0
						0.032833

Calculated Settlement (feet) 0.02007

Calculated Settlement (inches) 0.240842

Schmertmann's Method
Worksheet for Column Footings

From USACOE Suggested Worksheet

Project: A-USC
Client: AECOM
CTL Job # 16050004CLE

P= C1 C2 Delta P SUM (Iz/Es) Delta Z

Foundation Width, B (ft)	12.5		C1	0.935028
Embedment Depth (ft)	3.5		C2	1.339794
Soil Unit weight (pcf)	115	*	Po (tsf)	0.20125
Design Bearing Pressure (Ksf)	3.5		Delta P (tsf)	1.54875
Time Frame (years)	5	**		

Depth (ft) Below Grade	Depth (ft) Below footing	N	Es	Zcl	Iz	(Iz/Es) Delta Z
6	2.5	20	100	1.25	0.20	0.005
8.5	5	20	100	3.75	0.40	0.01
11	7.5	20	100	6.25	0.46	0.011375
13.5	10	20	100	8.75	0.39	0.00975
16	12.5	18	90	11.25	0.33	0.009028
18.5	15	18	90	13.75	0.26	0.007222
21	17.5	14	70	16.25	0.20	0.006964
23.5	20	50	250	18.75	0.13	0.0013
26	22.5	50	250	21.25	0.07	0.00065
28.5	25	50	250	23.75	0.00	0
						0.061289

Calculated Settlement (feet) 0.118913

Calculated Settlement (inches) 1.426954

Schmertmann's Method
Worksheet for Column Footings

From USACOE Suggested Worksheet

Project: A-USC
Client: AECOM
CTL Job # 16050004CLE

P= C1 C2 Delta P SUM (Iz/Es) Delta Z

Foundation Width, B (ft)	44		C1	0.762537
Embedment Depth (ft)	3.5		C2	1.339794
Soil Unit weight (pcf)	115	*	Po (tsf)	0.20125
Design Bearing Pressure (Ksf)	1.25		Delta P (tsf)	0.42375
Time Frame (years)	5	**		

Depth (ft) Below Grade	Depth (ft) Below footing	N	Es	Zcl	Iz	(Iz/Es) Delta Z
12.3	8.8	10	50	4.4	0.20	0.0352
21.1	17.6	18	90	13.2	0.40	0.039111
29.9	26.4	30	150	22	0.46	0.026693
38.7	35.2	50	250	30.8	0.39	0.013728
47.5	44	50	250	39.6	0.33	0.01144
56.3	52.8	50	250	48.4	0.26	0.009152
65.1	61.6	50	250	57.2	0.20	0.006864
73.9	70.4	50	250	66	0.13	0.004576
82.7	79.2	50	250	74.8	0.07	0.002288
91.5	88	50	250	83.6	0.00	0
						0.149052

Calculated Settlement (feet) 0.064528

Calculated Settlement (inches) 0.774335

Schmertmann's Method
Worksheet for Column Footings

From USACOE Suggested Worksheet

Project: A-USC
Client: AECOM
CTL Job # 16050004CLE

P= C1 C2 Delta P SUM (Iz/Es) Delta Z

Foundation Width, B (ft)	15		C1	2.045455
Embedment Depth (ft)	15		C2	1.339794
Soil Unit weight (pcf)	115	*	Po (tsf)	0.8625
Design Bearing Pressure (Ksf)	0.9		Delta P (tsf)	-0.4125
Time Frame (years)	5	**		

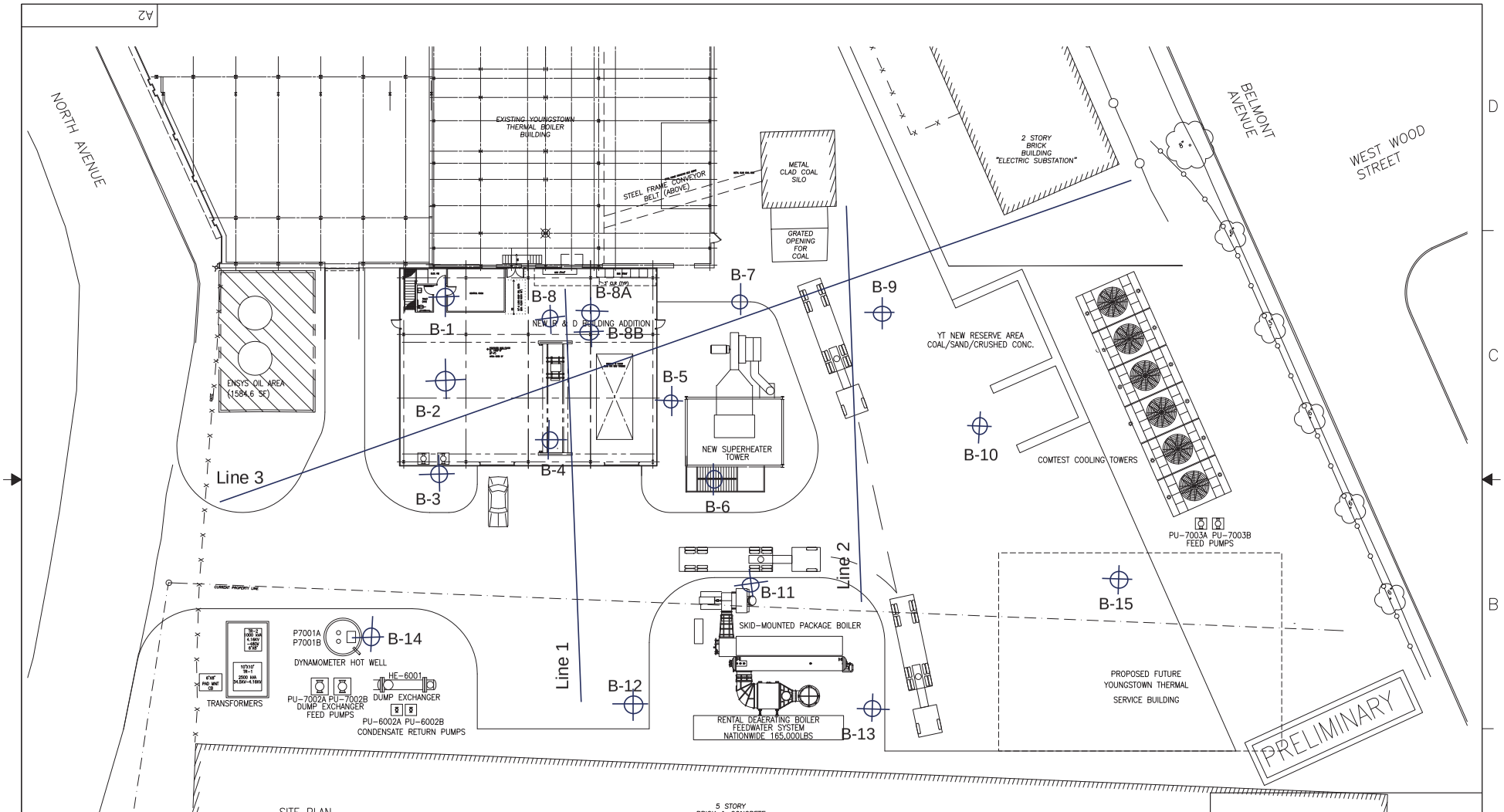
Depth (ft) Below Grade	Depth (ft) Below footing	N	Es	Zcl	Iz	(Iz/Es) Delta Z
18	3	16	80	1.5	0.20	0.0075
21	6	14	70	4.5	0.40	0.017143
24	9	30	150	7.5	0.46	0.0091
27	12	50	250	10.5	0.39	0.00468
30	15	50	250	13.5	0.33	0.0039
33	18	50	250	16.5	0.26	0.00312
36	21	50	250	19.5	0.20	0.00234
39	24	50	250	22.5	0.13	0.00156
42	27	50	250	25.5	0.07	0.00078
45	30	50	250	28.5	0.00	0
						0.050123

Calculated Settlement (feet) -0.05666

Calculated Settlement (inches) -0.67994

APPENDIX E

- **FIELD DYNAMIC TEST LINE LOCATIONS**
- **FIELD DYNAMIC TESTING RESULTS**



SITE PLAN
SCALE: 1/16" = 1'-0"

REVISION APPROVAL RECORD						REV NO	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL					Approximate Boring Locations		
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C										

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY				
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV.NO.

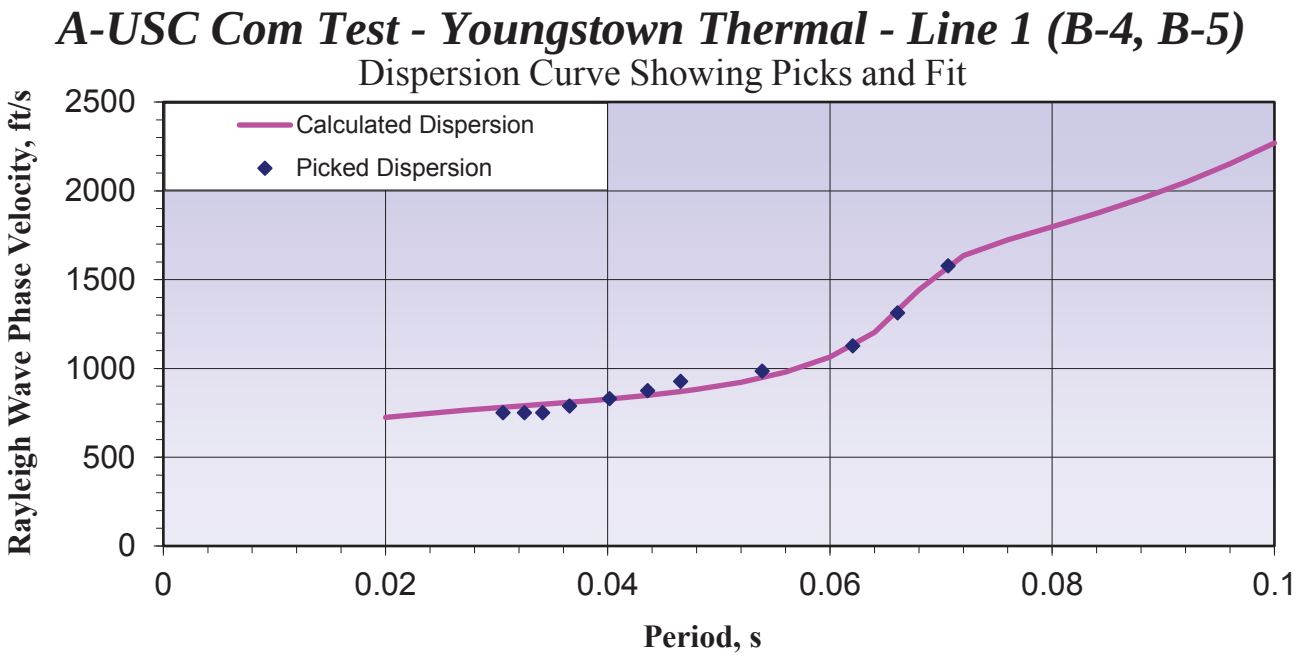
PROJECT NO.: 31609
DRAWN: TCG DATE: 02-04-16
CHECKED: DATE:
SCALE: AS NOTED

URS ENERGY & CONSTRUCTION Inc. – an AECOM Company
1500 West 3rd St, Suite 200
Cleveland, OH 44113
(216) 523-5600
AECOM

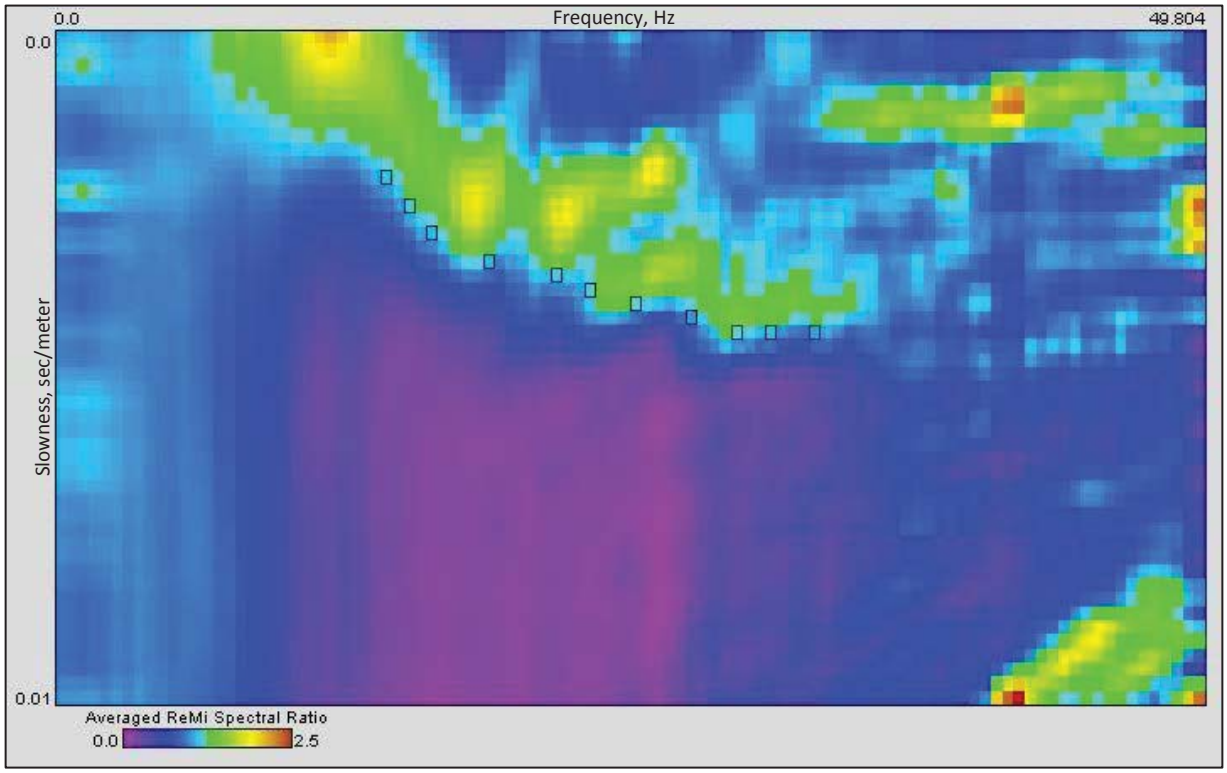
ReMi LINE LOCATIONS
SITE PLAN 02/11/16

DWG. NO. A2 REV –

EC_D_Size.dwg

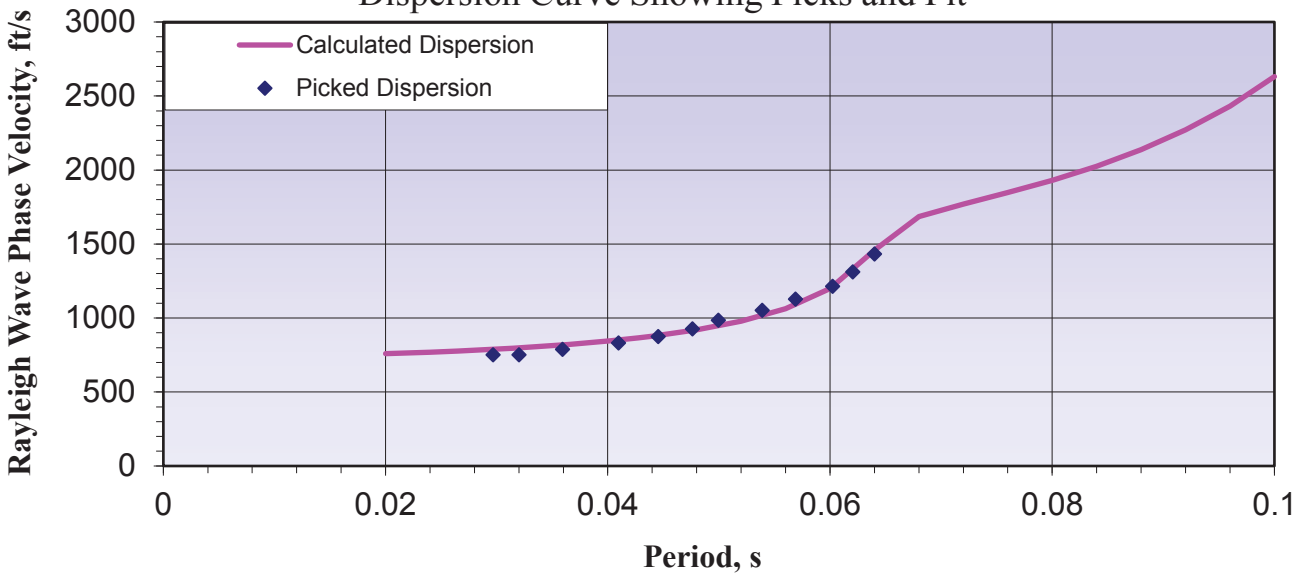


p-f Image with Dispersion Modeling Picks

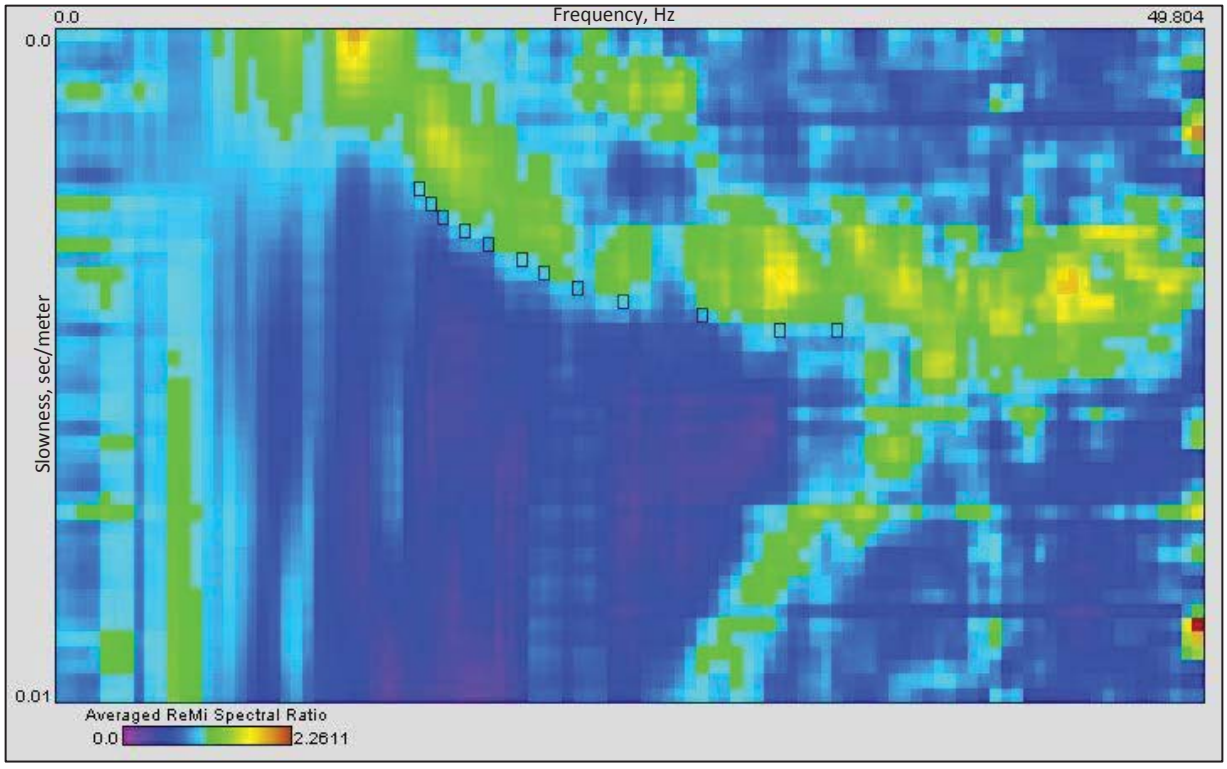


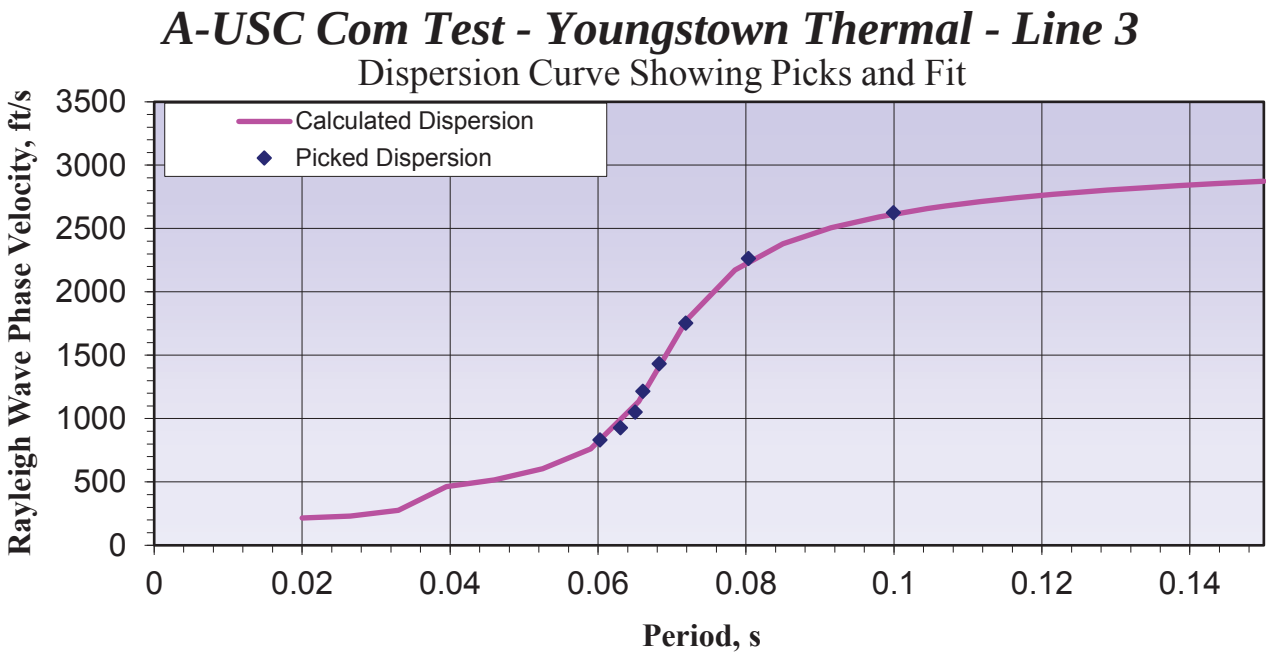
A-USC Com Test - Youngstown Thermal - Line 2 (B-9, B-10)

Dispersion Curve Showing Picks and Fit

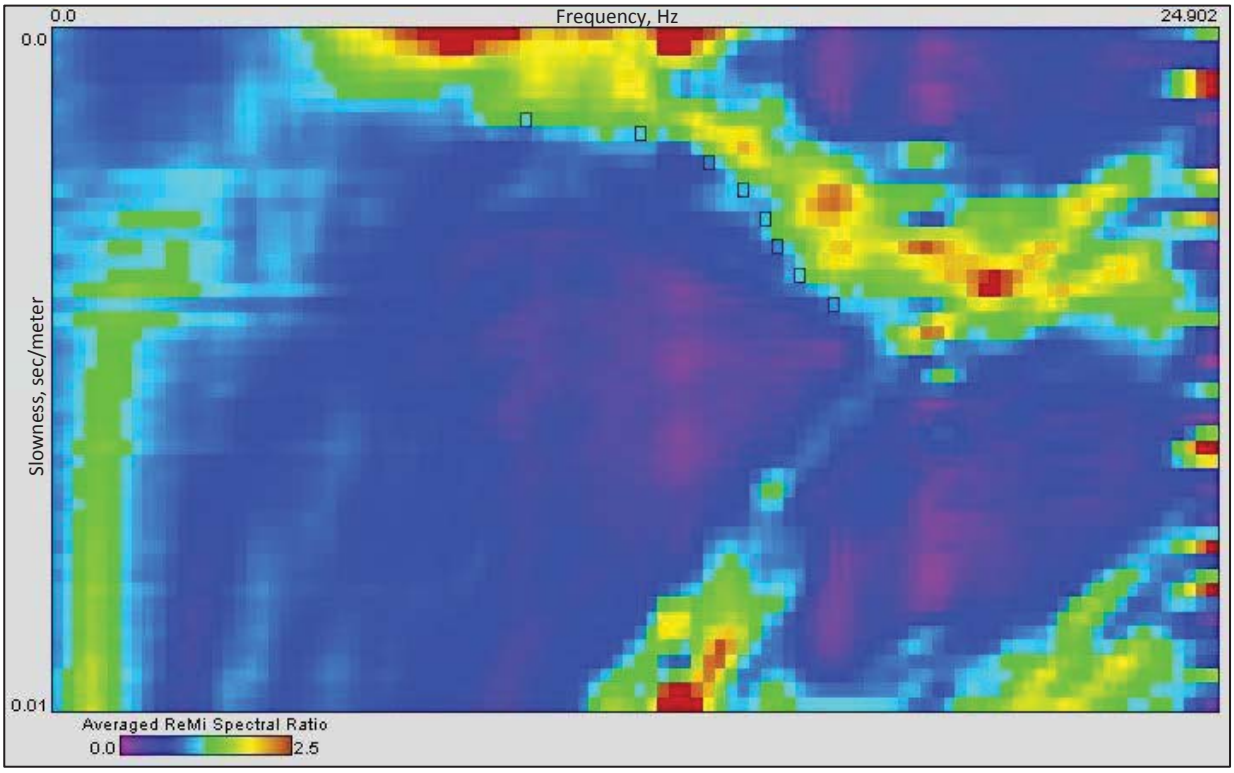


p-f Image with Dispersion Modeling Picks

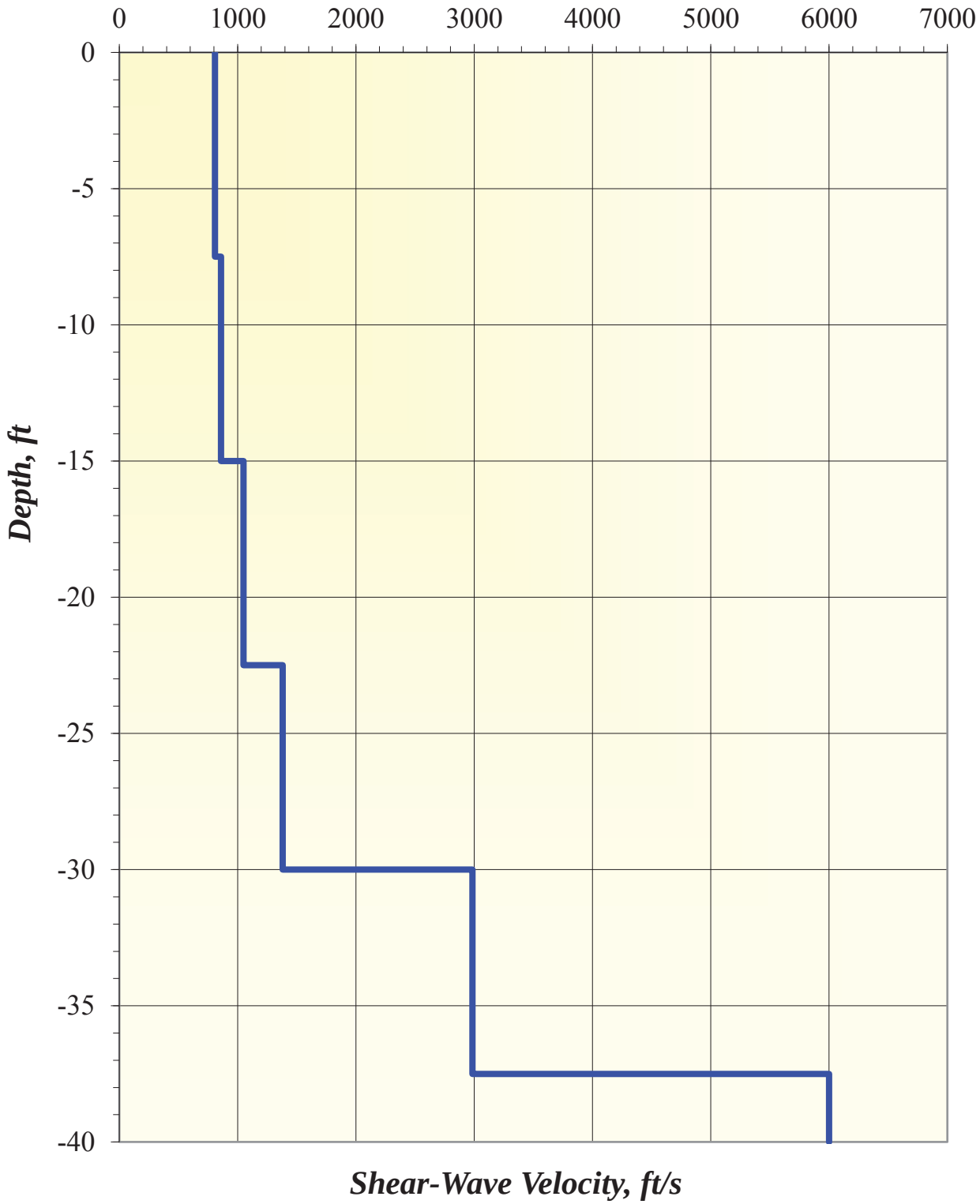




p-f Image with Dispersion Modeling Picks



A-USC Com Test - Youngstown Thermal - Line 2 (B-9, B-10): Vs Model



A-USC Com Test - Youngstown Thermal - Line 1 (B-4, B-5):
Dynamic Shear Modulus 'G' Calculations

Depth Range (ft)	Shear Wave Velocity V_s (ft/s)	Total Unit Weight γ (pcf)	Dynamic Shear Modulus G x 10^6 (psf)
0.0-7.5	746.4	118.3	2.05
7.5-15.0	954.4	120.0	3.40
15.0-22.5	923.2	125.0	3.31
22.5-30.0	1294.2	127.5	6.64

$$G = \frac{\gamma}{g} V_s^2$$

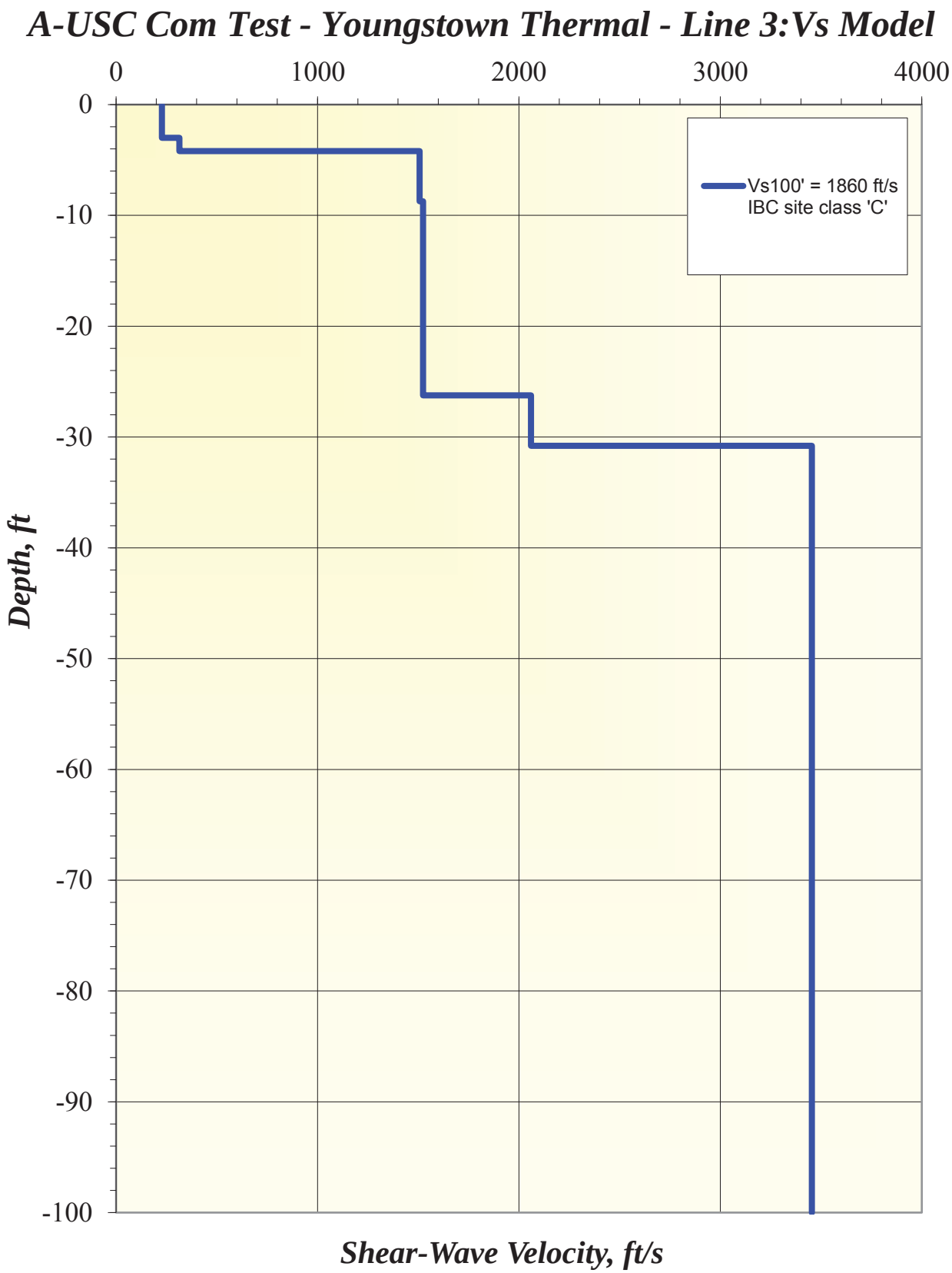
Reference: Kramer, Steven L. 1996. Geotechnical Earthquake Engineering. Prentice Hall, 653 pp

A-USC Com Test - Youngstown Thermal - Line 2 (B-9, B-10):
Dynamic Shear Modulus 'G' Calculations

Depth Range (ft)	Shear Wave Velocity V_s (ft/s)	Total Unit Weight γ (pcf)	Dynamic Shear Modulus G x 10^6 (psf)
0.0-7.5	808.6	115.0	2.34
7.5-15.0	860.2	121.3	2.79
15.0-22.5	1049.5	135.0	4.62
22.5-30.0	1380.6	137.5	8.15

$$G = \frac{\gamma}{g} V_s^2$$

Reference: Kramer, Steven L. 1996. Geotechnical Earthquake Engineering. Prentice Hall, 653 pp


A-USC Com Test - Youngstown Thermal - Line 3:Vs Model
0
1000
2000
3000
4000
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
Depth, ft
Vs100' = 1860 ft/s
IBC site class 'C'
Shear-Wave Velocity, ft/s

A-USC Com Test at Youngstown Thermal

Youngstown, OH

PROJECT NUMBER 31609

SPECIFICATION NUMBER 023200

FOR

GEOTECHNICAL INVESTIGATION

PREPARED FOR

Energy Industries of Ohio (EIO)

By

AECOM

1500 W 3rd Street, Suite 200

Cleveland, OH 44113

Revision	Date	Status
0	December 28, 2015	Final

SPECIFICATION REVISION PAGE

Project Name:	A-USC Com Test	Discipline:	Structural
Client:	Energy Industries of Ohio		

Revision Signatures

Jeff Morris	12/28/15	Dan Mardovin	
Prepared by	Date	Approved by (PEM)	Date
Mike Jones		NA	
Checked by	Date	Approved by (if required) (title)	Date

Status	Rev. No.	Date	Prepared By	Pages	Description of Changes
Prelim.	A	12/17/15	JJM	All	
Final	0	12/28/15	JJM	All	

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1.0 GENERAL

1.1. Scope of Work

1.1.1. Section Includes: Properly explore and analyze surface and subsurface conditions at the site, including ground water table, to depths which will be influenced by the proposed construction represented on the attached documents and as specified herein. Provide professional recommendations for foundations and other earthwork related construction. Include field exploration, sample recovery, testing, and the production of an early findings and recommendations report and a final report embodying findings and recommendations.

1.1.2. Materials and Work by Seller

The work includes furnishing all labor, tools, materials and equipment, and performing all work for subsurface investigation, performing analyses, field and laboratory testing, and providing recommended foundation design and other earthwork criteria for the A-USC Com Test project in accordance with the conditions existing at the project site, plot plan and this specification.

A. All work shall be accomplished under the direct supervision of an experienced and competent Geothechnical Engineer who shall be registered in the State of Ohio and who shall be named in the Proposal. The registered Geotechnical Engineer or their designee shall provide continuous onsite supervision during drilling and sampling operations. The Geotechnical Engineer shall be responsible for all field, laboratory and report activities.

B. The work shall comply with Federal, State, and Local agencies where the work will be performed.

C. The field survey to accurately locate and document each boring location and elevation.

D. Backfilling of bore holes upon completion of the investigation and the surface repaired or replaced to match adjacent existing surface.

1.1.3. Materials and Related Work by Others

A. The geotechnical investigation specified herein includes no environmental contamination related investigation or analysis.

1.2. Definitions

A. Owner (of site): Youngstown Thermal

B. Buyer: AECOM

C. Seller: Firm undertaking the scope of work as defined in this specification.

D. Geotechnical Engineer (Soils Engineer, Engineer Geologist, Geoscientist): A qualified person entitled and licensed to perform geotechnical engineering employed by the Seller. The Geotechnical Engineer must be registered in the state of Ohio.

E. Environmental Technician: A qualified person employed by the Seller who is given responsibilities as described herein.

F. Driller: The equipment operator performing drilling and sampling operations for the Seller.

1.3. Safety

1.3.1. Safety shall be of primary importance of this project. Comply with all site safety, OSHA, and local safety requirements and regulations.

1.3.2. All personnel shall utilize the necessary safety equipment, including but not limited to hard hats, safety glasses, safety boots and hearing protection. All personnel will be required to attend an Owner site safety orientation. All vehicles including drill rigs shall comply with local government jurisdiction and site/plant safety requirements.

1.4. Field and Laboratory Work

1.4.1. Sufficient borings, test pits, core holes, sampling, testing and other investigative operations shall be performed to adequately determine existing subsurface conditions within each of the specified areas of the project. The proposal shall include a plan showing locations and depths of proposed borings and other tests. Consideration shall be given to establishing the top of bedrock at all borehole locations.

1.4.2. Soil Borings

A. The soils borings at a minimum shall include:
- Eleven (11) borings to a depth of twenty five (25) feet
- Four (4) borings to a depth of fifty (50) feet

B. Refer to Attachment A showing the site layout and preliminary boring locations. Final locations will be determined during the on-site pre-drilling meeting.

1.4.3. The number of soil borings shown on the attached drawing are a minimum and their locations are approximate. Final locations shall be established in the field by the geotechnical engineer prior to the start of work. If additional soil borings, or other field work are required, the proposal shall state the number, location, estimated depth of borings, or other field work anticipated. The anticipated number and types of laboratory tests shall also be stated in the proposal. Additional soil borings, field work, and laboratory testing in excess of those stated in the proposal must be approved by the buyer prior to execution.

1.5. Codes and Standards

The latest issues of the following Specifications, Codes and Standards, including revisions and supplements in effect as of December 17th, 2015, form a part of this specification in their entirety, except as modified by this Specification.

1.5.1. American Association of State Highway and Transportation Officials (AASHTO)

1.5.2. American Society for Testing and Materials (ASTM)

1.5.3. United States Environmental Protection Agency (USEPA)

1.5.4. Occupational Safety and Health Administration (OSHA), Department of Labor

1.5.5. 2011 Ohio Building Code

A. With Amendments thru January 1, 2015

1.5.6. Drawing(s) included with this specification are preliminary and may require revision due to changes in structure locations, or for other reasons before commencement of work. Should changes to these Drawings become necessary, new copies of the Drawing(s) will be furnished to

the Seller who shall adjust work accordingly and submit final information based upon the latest issue of the Drawing(s).

1.5.7. Should a conflict be found to exist between any applicable portion of the referenced Codes, Standards, Regulations, and this Specification, the conflict shall be submitted to the Buyer for resolution before proceeding with the affected work.

1.6. Seller Documentation

1.6.1. A preliminary report shall be submitted to the Buyer.

1.6.2. The final report shall respond to Buyer's comments and questions related to the preliminary report.

1.6.3. The final report shall be signed by a Geotechnical Engineer registered in the State of Ohio. Two (2) bound copies of the Final Report shall be submitted to AECOM 1500 W3rd Street, Suite 200, Cleveland, OH 44113 Attention: Dan Mardovin

1.6.4. An electronic copy, in pdf format, of both the preliminary and final reports shall be emailed to the following:

A. Jeff Morris: jeffrey.morris@aecom.com

B. Mike Jones: michael.jones03@aecom.com

C. Dan Mardovin: daniel.mardovin@aecom.com

1.7. Quality Assurance

1.7.1. Conform to codes and standards stated in section 1.5. Perform services in accordance with accepted geotechnical engineering practices.

1.8. Site and Utility Data

1.8.1. The site of the work is located at 205 North Ave, Youngstown, OH 44502.

1.8.2. The nominal elevation of the plant site is +/- 868 feet above mean sea level.

1.9. Facility Description

The proposed facility expansion will consist of the following:

A. Superheater Tower
+-120’ tall steel framed tower supporting the superheater and associated components.

B. Building Structure
A single story steel framed building with an overhead crane that houses steam turbine and associated components.

C. Steam Turbine

D. Pipe Rack(s)

E. Miscellaneous Equipment

F. Underground Utilities

1.10. Structural Loads and Settlement Criteria

As a guide for determining the most appropriate foundation system(s) possible, the following anticipated structural loads (excluding foundation weights) and allowable settlements are given.

1.10.1. Maximum Anticipated Column Load (Service level) and Allowable Settlement

Superheater		**550**	**Kips**
Building Structure (Only includes gravity)		**150**	**Kips**
Turbine		**TBD**	**Kips**
Pipe Rack (Only includes gravity)		**50**	**Kips**
Allowable total settlement		**1**	**Inches**
Allowable differential settlement	**1/4 inch per**	**10**	**Feet**

2.0 PRODUCTS (NOT USED)

3.0 EXECUTION

3.1. Preparation

3.1.1. Be fully equipped and prepared with all requirements including containers, sample jars, core boxes, water, and power to accomplish the work. Include all transportation and other costs associated with mobilizing and demobilizing personnel and equipment to the site. Provide, erect, maintain, and later remove, temporary safeguards for the protection of personnel, the public, equipment and materials. Comply with all applicable rules and regulations of OSHA and the Owner.

3.1.2. Promptly notify the Buyer, both verbally and in writing if any human health or environmental hazard, e.g. substance, condition, event, etc., is encountered during the performance of these services and the impact the hazard will have on the performance of the geotechnical services as contracted.

3.1.3. Seller shall obtain all work permits, excavation permits, and other permits or authorizations required by the Buyer or by governmental or regulatory agencies and/or local jurisdictions for performance of the work, including permits or authorizations for borings, sounding, pits, wells, piezometers, transportation of samples, etcetera.

3.1.4. Prior to performing field work, the Seller shall verify that no overhead or underground utilities are located within a safe work distance from the test locations proposed.

3.1.5. Pre-Drilling Meeting: The Seller shall attend a pre-drilling meeting and site visit to finalize boring locations. This meeting can the same day the seller marks the bore hole locations in preparation for drilling.

3.2. Field Data Collection and Testing

3.2.1. Provide a qualified geotechnical engineering representative in the field, throughout the field exploration and investigation, to supervise, collect samples, maintain records, and observe the entire geotechnical exploration, investigation, and sample gathering program. Classify the samples as they are taken in accordance with ASTM D2487, ASTM D2488, or ASTM D653, as applicable.

3.2.2. Drill borings and perform sampling in accordance with ASTM D1586 and/or ASTM D1587. For other types of exploration, such as cone penetrometer, use ASTM or other widely accepted methods.

3.2.3. Logs of Borings: The Seller shall prepare and include in its report a detailed log, in accordance with ASTM D 5434, of each boring which, as a minimum, shall include names of the Driller and Geotechnical Engineer, date and time at beginning and completion of boring, elevation of the top of the hole, coordinate of the hole, a graphical representation showing the various strata encountered, the depth at which encountered, penetration resistance and a description of the consistency, moisture condition and character of the materials, as well as the classification of each by the Unified Classification System. Elevation of ground water at time of boring and 24 hours later shall be obtained when water is present in the borings.

3.2.4. Standard penetration tests shall be performed in the soils encountered at intervals of 2.5ft in the upper 15ft and then at intervals of 5ft below the upper 15ft. These drive samples shall be preserved at their natural moisture content insofar as possible. When cohesive soils are encountered, undisturbed samples shall be obtained from each significant stratum.

3.2.5. Dynamic Soil Moduli

Testing shall be performed to determine the pertinent engineering characteristics and design parameters of the materials. Dynamic soil property testing shall be performed in accordance with one of the three following procedures. The tests must obtain accurate soil moduli for the soils and rock encountered such that the most accurate prediction of the behavior of the dynamically loaded foundations can be calculated by others.

A. Crosshole Test:

The dynamic soil moduli shall be determined using the Crosshole test method. Test(s) shall be conducted at the locations indicated on the boring location plan. The test holes shall be a minimum of 30 feet deep. The modulus of each unique soil (rock) strata shall be determined, but as a minimum, the modulus shall be determined at an interval of 7.5 feet for the depth of the hole, resulting in four (4) calculated moduli for each foundation.

The Crosshole test shall be conducted in general in accordance with ASTM D 4428.

B. Downhole Test:

The dynamic soil moduli shall be determined using the Downhole test method. Test(s) shall be conducted at the locations indicated on the boring location plan. The test holes shall be a minimum of 30 feet deep. The modulus of each unique soil (rock) strata shall be determined, but as a minimum, the modulus shall be determined at an interval of 7.5 feet for the depth of the hole, resulting in four (4) calculated moduli for each foundation.

The Downhole test shall be conducted in general in accordance with ASTM D 7400.

C. Multi-channel Analysis of Surface Waves:

The dynamic soil moduli shall be determined using the Multi-channel Analysis of Surface Waves (MASW) test method. The test shall be conducted to a depth of at least 30 feet for each foundation.

The Provider shall submit written procedures for conducting the MASW test for Engineer's approval.

3.2.6. Upon completion of the work in each area, backfill or otherwise close each boring hole as specified herein, except when specifically instructed by the Geotechnical Engineer to leave a boring hole open for ground water observation or other purposes. Remove all equipment, tools and supplies. Take reasonable precautions to minimize damage to the land or facilities resulting from the use of field exploration equipment and operations.

3.3. Laboratory Testing

3.3.1. Select the appropriate number and type of laboratory tests needed to support recommendations.

3.3.2. Perform testing in accordance with appropriate ASTM standards.

3.3.3. State the number and types of tests anticipated in the proposal. Include transportation costs and the legal disposal of soil, rock and other samples.

3.4. Final Geotechnical Report

The results of the geotechnical investigation shall be analyzed and published in a final Geotechnical Engineering Subsurface Investigation Report. This report shall take into consideration the requirements of the proposed facility. The report shall be in accordance with ASTM D 420, but not be limited to, the following:

A. A discussion of plant site geology.

B. Borehole location drawing showing final borehole locations and elevations.

C. Detailed log of each boring as described in Section 3.2.3.

D. Description of laboratory and field tests performed on soil samples.

E. Discussion of test results and findings that include the following:
   1. Density
   2. Sieve analysis
   3. Plastic limit
   4. Unconfined compression
   5. Moisture content
   6. Hydrometer analysis
   7. Consolidation
   8. Moisture/density relations
   9. Gradation
   10. Liquid limit
   11. Tri-axial compression
   12. Allowable bearing pressure (net and gross values)
   13. Liquefaction potential
   14. Seismic Site Class
   15. Coefficient of friction
   16. Unit weight of soil
   17. Angle of internal friction
   18. Soil resistivity (ohm-cm)
   19. Modulus of subgrade reaction
   20. Poisson’s ratio

21. Coefficient of active soil pressure
22. Coefficient of at rest soil pressure
23. Coefficient of passive soil pressure
24. Modulus of lateral subgrade reaction
25. pH

F. Recommendations for suitable shallow foundations systems to support the various structures and equipment including:

1. Set bottom elevation of foundations, with consideration given for frost depth.
2. Discuss frost susceptibility of soils at the site and foundation recommendations regarding freeze thaw conditions.
3. Allowable bearing pressure values at various recommended depths. Gross and net allowable bearing pressures shall be specified.
4. Increase in allowable net bearing pressure under temporary loading (seismic, wind).
5. Coefficient of sliding friction between soil and bottom of foundation.
6. Estimated total settlement and time rate of settlement for footings of various sizes.
7. Estimate the potential of the soils to undergo differential settlement, and the behavior of the foundations due to unbalanced bearing pressures of footings/mats of different size and in close proximity to each other.
8. Provide the modulus of Subgrade Reaction for mat foundations and slabs on grade.
9. Uplift resistance for foundations.
10. Frost heave and frost jacking considerations, including methods and construction details to minimize frost heave effects. Discuss both heated and cold structures and foundations.
11. Void form recommendations (type, thickness, etc.) based on site conditions and local practice.
12. Structural backfill and foundation base soil compaction and gradation requirements.

G. Recommendations for suitable deep foundations systems to support the various structures and equipment including:

1. Acceptable foundation type, size, and length.
2. Minimum deep foundation spacing and group efficiency considerations.
3. Allowable load capacity for acceptable deep foundation, sizes and lengths tension and compression, and factor of safety for different load combinations.
4. Lateral load capacity curves for different deep foundation types. Having lateral deflections of ¼-inch, ½ inch, ¾ inch and 1 inch for free and fixed head conditions.
5. Minimum penetration into bearing surface or minimum pile or pier length
6. Modulus of lateral subgrade reaction based on depth and change of soil stratum.
7. Capacity reduction for group action.
8. Estimated settlement and time rate.
9. Allowable end bearing and/or skin friction.
10. Allowable uplift.
11. Blow count - capacity relationship and recommended field formula to calculate pile or pier capacities.

12. Recommendation of hammer for pile driving.
13. Consideration of battered piles to take horizontal forces.
14. Down drag considerations.
15. Frost heave or frost jacking considerations.
16. Construction and design considerations due to high water table, if present.
17. A trade-off in costs, constructability, schedule impacts and similar items, between alternate foundation systems shall be included if appropriate.

H. A discussion of construction related recommendations for items such as sub grade preparation, mass excavation, utility trenching, slope protection, compaction, structural fill, dewatering during construction, and any other matters relating to earthwork.

I. Design parameters for retaining wall or buried structure design including active, passive, and at rest lateral pressures, internal angle of friction or repose, coefficient of sliding friction, and similar design parameters. Provide recommendation on backfill material and compaction requirements, excavation and backfill methodology.

J. Recommendations for temporary (during construction) and permanent (after construction) cuts, embankments, and other similar areas, including allowable cut and embankment slopes (both wet and dry as appropriate)

K. Estimates of the amounts of ground water or perched water likely to be encountered during construction and to be disposed of during the excavation for piping, foundations and/or underground structures

L. Recommendations for dewatering methodology and equipment

M. Provide recommendations for compatible type of portland cement.

N. Provide recommendations for excavation slope limitations to satisfy geotechnical and OSHA requirements based on soil types encountered.

O. Recommendations for floor slab construction to mitigate the effects of swelling soil, ground water, etc.

P. Provide values for the dynamic shear modulus, modulus of elasticity, material damping, Poisson's ratio and soil density for the dynamic analysis and design of equipment foundations.

Q. Discuss and provide design recommendations for site specific soil conditions that may impact the proposed project including expansion and collapse of soil, seismic setting, design category and soil site classification as defined in the 2011 Ohio Building Code.

R. Discuss liquefaction potential and mitigation, if applicable.

S. Pavement design recommendations

T. Underground utility recommendations

3.5. Schedule

A.	Pre-drilling Meeting	1/22/2016
B.	Start of Drilling	1/25/2016

C. Preliminary Report 2/4/2016

D. Final Report 2/17/2016

If the Seller cannot meet the intended schedule provide a proposed schedule to the Buyer with the proposal.

3.6. Fees

3.6.1. Include a schedule of fees (invoice rates) for drilling, laboratory, and engineering costs associated for this work, including standard equipment rental rate schedule. Also include breakdown of services and fees including unit prices, estimated quantities, and total prices, as applicable.

3.6.2. Include the duration for which proposal is valid from date of issuance.

3.7. Basis of Payment

A lump sum price shall cover the geotechnical engineering, subsurface investigation, subsurface investigation analysis, laboratory testing, and reports in accordance with the detailed scope of service provided herein. The base bid price shall be based upon the number and depth of borings indicated. Unit prices shall be provided as a basis of payment for additional work authorized by the Buyer. Payment will be made only for items included in the Proposal.

END OF SECTION

Attachment A – Boring Location Plan

(53-71-49.00-P)
130.00
145.17
14.76
180.11
179.17
NORTH AVE
175.5
150.59
68.00
104.23
91.47
BELMONT AVE
(53-71-20.00-P)
EXISTING
YOUNGSTOWN
THERMAL PLANT
126.85
8.09
69.51
R=25
(53-71-20.01-P)
112.63
250.97
41.87
90.00
82.57
B-1
B-2
B-3
B-4
B-5
B-6
B-7
B-8
B-9
B-10
B-11
B-12
B-13
B-14
B-15
(53-71-158.00-P)
CL 61755
415.16
140.65
R=15
(53-71-19)

A-USC Com Test at Youngstown Thermal

Youngstown, OH

PROJECT NUMBER 31609

SPECIFICATION NUMBER 03 20 00

FOR

CONCRETE REINFORCING

PREPARED FOR

Energy Industries of Ohio (EIO)

By

AECOM

1500 W 3rd Street, Suite 200

Cleveland, OH 44113

Revision	Date	Status
A	March 16, 2016	Preliminary

SPECIFICATION REVISION PAGE

Project Name:	A-USC Com Test	Discipline:	Structural
Client:	Energy Industries of Ohio		

Revision Signatures

Jeff Morris	3/16/2016		
Prepared by	Date	Approved by (PEM)	Date
		NA	
Checked by	Date	Approved by (if required) (title)	Date

Status	Rev. No.	Date	Prepared By	Pages	Description of Changes
Prelim.	A	3/16/2016	JJM	All	For FEED use

PART 1 - GENERAL

1.01 SUMMARY

A. Furnish, fabricate and install concrete reinforcement, reinforcement supports, and associated items in accordance with this specification section and other Contract Documents.

B. This specification section supplements Section 3 of ACI 301-10, "Specifications for Structural Concrete", and takes precedence if conflict exists.

1.02 RELATED REQUIREMENTS

A. Work in other sections of the specifications:

1. Section 32 13 00 Rigid Paving (reinforcement for paving, sidewalks, and curbs)
2. Section 03 30 00 Cast-in-Place Concrete
3. Section 04 20 00 Unit Masonry (reinforcement for masonry)
4. Section 05 50 00 Metal Fabrications (anchor rods and other embedments)

1.03 ALTERNATIVES

A. If substitute materials or alternate construction methods are proposed, submit complete technical data to Owner's Representative for review. Information submitted must clearly demonstrate that substitute material or method is equal to or superior in quality or performance to that specified herein and demonstrates substantial savings in time or cost to the Owner.

1.04 REFERENCE STANDARDS

A. Reference to standards of organizations made herein is in accordance with the following abbreviations. All referenced standards and codes contained within this document shall be the latest edition as of the date of contract award.

1. ACI American Concrete Institute
   a. 117 Specifications for Tolerances for Concrete Construction and Materials
   b. 301 Specifications for Structural Concrete
   c. 315 Details and Detailing of Reinforcement
   d. 318 Building Code Requirements for Structural Concrete
2. ASTM American Society for Testing and Materials
   a. A615 Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.

b. 1064 Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement , Plain and Deformed, for Concrete.

3. AWS American Welding Society

a. D1.4 Structural Welding Code - Reinforcing Steel

4. CRSI Concrete Reinforcing Steel Institute

a. Manual of Standard Practice

1.05 SUBMITTALS

A. Requirements: At least 10 days prior to planned start of fabricating this work, submit 3 copies of each submittal to the Owner's Representative for review.

B. Items requiring review:

1. Submittals: Submit all data listed in ACI 301, Section 3.1.1.

2. Shop Drawings: Show complete information necessary for fabrication, bending and placement. Comply with ACI 315, “Details and Detailing of Reinforcement”. Include material, grade, bar schedules, stirrup spacing, bent bar diagrams, arrangements, assemblies, supports, laps and splices. Include special reinforcement required for openings through concrete structures.

3. Product Data: Catalog cuts or standard drawings for each type of manufactured material and product indicated. Include manufacturer's technical data and tested physical and performance properties.

a. Load Transfer Devices

4. Mill Test Reports: Submit certified reports on mill tests of chemical analysis, tensile and bend test for steel reinforcement.

5. Welding: Qualify procedures and personnel according to AWS D1.4, “Structural Welding Code – Reinforcing Steel”.

C. Delivery Tickets: Maintain a record at the project site showing date and delivery time of reinforcing steel. Make the record available to the Owner’s Representative for inspection, upon request. Upon completion of the Work, deliver complete record and delivery tickets to the Owner’s Representative.

D. Permits and Inspection Reports: Furnish to Owner’s Representative as required by governing authorities.

E. Review Procedure for Submittals:

1. Contractor's Review:

a. Submittals to the Owner's Representative must be complete. Review each submittal and check for compliance with the Contract Documents. If deviations from the Contract Documents are necessary, highlight, encircle, or otherwise identify the deviation.

b. Note corrections and field dimensions.

c. Mark each submittal with a stamp that includes name of reviewer, date of Contractor's approval, and statement certifying that submittal has been reviewed, checked, and approved for compliance with the Contract Documents, with deviations, if any, identified.

d. Submittals that are changed after having been reviewed by the Owner's Representative are to be resubmitted for review with changes encircled and identified as revisions.

2. Review by Owner's Representative:

a. Submittals will not be reviewed that do not bare Contractor's approval stamp and will be returned without action. Submittals not required by the Contract Documents will not be reviewed and may be discarded. The Owner's Representative reserves the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

b. Review of submittals will be for conformance with design concept and the Contract Documents. The Contractor is solely responsible for, and this review does not include: confirming and correlating quantities and dimensions, selecting fabrication processes and techniques of construction, and performing work in a safe and proper manner.

c. This review does not relieve the supplier from compliance with supplier's contract obligations. The fact that no exceptions are taken, or that comments and/or markings may have been made on submittals, shall not relieve the Contractor from compliance with the Contract Documents, nor be construed as authorizing departure therefrom, nor constitute either expressly or implied, a change therein, or with the Contractor's responsibilities as listed above.

d. Each submittal will be reviewed, marks made to indicate corrections or modifications if necessary, and returned. Each submittal will stamped and the stamp will be appropriately marked to indicate action taken.

1.06 QUALITY ASSURANCE

A. Codes and Regulations: Conform to the requirements of the Ohio Building Code (IBC 2009) and the governing authorities having jurisdiction at the site.

B. Welding: Qualify procedures and personnel according to AWS D1.4, "Structural Welding Code--Reinforcing Steel."

1.07 DELIVERY, STORAGE AND HANDLING

A. Reference: Follow ACI 301, Section 3.1.2, except as noted.

B. Delivery: Deliver reinforcement to Project Site bundled, tagged and marked. Use metal tags indicating bar size, lengths and other information corresponding to markings shown on placement diagrams. If reinforcing bars do not bear stamped identification, provide certified copies of mill reports for first delivery of bars and for each 15 tons thereafter.

C. Storage: Keep stored materials clear of ground by means of timbers and blocking. Space supports to prevent damage. Keep storage area properly drained. Store materials in accordance with manufacturer's written recommendations and at locations designated by the Owner's Representative.

D. Handling: Handle materials in accordance with manufacturer's recommendations. Assume responsibility for damage resulting from handling or from failure to maintain adequate precautions.

PART 2 - PRODUCTS

2.01 MATERIALS

A. General: Provide only new materials, as specified, unless otherwise shown on the drawings. Provide other materials, not specifically described, but required, for a complete installation.

2.02 STEEL REINFORCEMENT

A. Reinforcing Steel: ASTM A615, Grade 60, deformed steel bars, unfinished.

B. Welding: Welding of A615 bars, including tack welding, is not permitted. If welding of bars is required for construction purposes, obtain approval from Owner’s Representative before proceeding; conform to procedures in AWS D1.4 and use ASTM A706 bars.

C. Welded Wire Fabric: ASTM A1064, plain, cold-drawn wire, gage and spacing of wires as indicated on drawings. Use flat mats instead of rolls of fabric.

2.03 REINFORCEMENT ACCESSORIES

A. Bar Supports: Bolsters, high chairs, and other items required to position reinforcement. Sized and shaped for strength and support of reinforcement and to hold bars in proper position while concrete is being placed. Include load-bearing pad on bottom to prevent vapor barrier puncture. Where concrete surfaces are exposed to weather in the finished structure, the portions of accessories in contact with formwork must be galvanized or made of plastic. Manufacture bar supports according to CRSI’s “Manual of Standard Practice”.

B. Manufactured Items: Use in accordance with manufacturer’s recommendations. If such recommendations differ from requirements herein, call to the attention of the Owner’s Representative before proceeding.

C. Wire Ties: Minimum 16 gage, black annealed type or patented system.

D. Load Transfer Devices: Tapered-shape plate dowels shall be installed where indicated on the drawings. Plates shall be fabricated of ASTM A36 steel, with flat, square and de-burred end edges.

1. Construction Joint Dowels: Diamond-shape dowels with a high density plastic-pocket former that holds the plate in the proper position and creates a void adjacent to the vertical surfaces of the dowel to allow for free horizontal movement within the slab. Acceptable product PNA Diamond Dowel System manufactured by PNA Construction Technologies, www.pna-inc.com; 800-542-0214.

2. Contraction Joint Dowels: Trapezoidal-shaped dowels. Surfaces shall be coated with a factory applied de-bonding agent. Install with alternating orientation of the narrow end of the dowels. Support dowels in a wire basket assembly in a manner that maintains the specified location of the dowels during construction activities and allows free movement of the narrow end of the dowel. Acceptable product PNA PD3 Basket assembly manufactured by PNA Construction Technologies, www.pna-inc.com; 800-542-0214.

2.04 FABRICATION

A. General: Fabricate steel reinforcement in accordance with detail design drawings and as detailed on shop drawings that have been reviewed in accordance with Article 1.04 – "Submittals". Follow ACI 301, Section 3.2.2 and CRSI's "Manual of Standard Practice".

B. Fabrication Tolerances: For bar sizes #3 through #11, follow ACI 117, Figure 2.1(a), summarized below for convenience.

1. Length of Bars: Plus or minus 1 inch

2. Location of Bends: Plus or minus 1 inch

3. Depth of Truss Bars: Plus 0, minus 1/2 inch

4. Stirrups and Ties, Under 12 Feet: Plus or minus 1/2 inch

5. Stirrups and Ties, 12 Feet and Greater: Plus or minus 1 inch

6. Spirals, 30 Inches or Less: Plus or minus 1/2 inch

7. Spirals, Greater than 30 Inches: Plus or minus 1 inch

PART 3 - EXECUTION

3.01 EXAMINATION

A. Inspection: Before starting work, inspect subgrade cross sections, profiles and surfaces receiving concrete reinforcement for compliance with drawings and referenced specification sections.

B. Notification: Notify the Owner's Representative in writing of conditions that would impede

the installation of this work.

3.02 PREPARATION

A. Safeguards: Provide, erect and maintain temporary safeguards, such as barricades, signs, lights etc. for protection of the public, personnel, equipment and materials and as required by governing laws and regulations. Remove them when no longer needed.

B. Base Lines: Preserve principal base lines, bench marks and other reference points. Set and maintain supplementary grades as required.

3.03 PLACEMENT

A. Follow ACI 301 Sections 3.3.1 and 3.3.2, and CRSI's "Manual of Standard Practice", except as noted.

B. Place reinforcing in accordance with detail design drawings and as detailed on shop drawings that have been reviewed in accordance with Article 1.04 – "Submittals". Do not displace or damage vapor retarder. If damaged, repair and reseal in accordance with manufacturer's written instructions.

C. Supporting and Wiring: Tie reinforcing bars securely together and support in position to prevent displacement by construction loads or the placing of concrete. Do not tack weld crossing reinforcing bars. Set tie wires with ends directed into concrete, not toward exposed concrete surfaces. On ground; concrete brickbats may be used to support bars. Provide brickbats that have a compressive strength equal to that of surrounding concrete. Over formwork; use metal or plastic bar chairs and spacers.

D. Bar Splices: Locate splices where shown on the design drawings and conform to requirements in Chapter 12 of ACI 318. Splices not shown on the drawings must be approved by the Owner's Representative.

E. Welded Wire Fabric Splices: Provide lap splices as indicated on the drawings. Make splices so that the overlap measured between outermost cross wires of each fabric sheet is not less than the spacing of the cross wires plus 2 inches. Extend mesh across supporting beams and walls and to within 2 inches of concrete edges. Cut mesh at contraction joints and construction joints unless it will be saw cut. Offset laps of adjoining sheet widths to prevent continuous laps in either direction. Lace overlaps with wire.

F. Safety Caps: Place safety caps on exposed ends of vertical concrete reinforcement bars that pose a danger to life safety.

G. Placing Welded Wire Fabric:

1. Support welded wire fabric in longest practicable lengths on bar supports spaced to minimize sagging.

2. In lieu of high chairs or other supports, welded wire fabric may be laid on freshly placed concrete and "walked-in". The mesh, after completing finishing operations, shall be in its proper final position as indicated on the drawings.

3. An acceptable alternative, to "walking-in" the mesh, is to place and screed the concrete to the reinforcing elevation shown on the drawings. Then, immediately set the mesh reinforcing on the fresh concrete surface and place the remaining concrete without disturbing the position of the mesh. The operation must be conducted in a manner that prevents the formation of cold joints.

4. Setting of welded wire fabric on forms or on grade and subsequent lifting or "hooking it up" through the plastic concrete is not permitted.

H. Bending Embedded Reinforcement: Unless approved by the Owner's Representative do not field bend reinforcement that has been embedded in hardened concrete.

I. Cleaning: Make sure steel reinforcement, at the time concrete is placed around it, is free from loose rust and mill scale, oil, grease, paint, earth, ice, or other coatings that might reduce or destroy bond between steel and concrete. Clean reinforcement as necessary prior to, during and after placement to achieve this result.

J. Placement Tolerances: Install bars to the tolerances given in Section 3.3.2.1 of ACI 301. If interference with other reinforcing steel, conduits, or embedded items cause bars to be moved more than one bar diameter, or enough to exceed ACI tolerances, obtain approval of resulting configuration from the Owner's Representative.

K. Dowel Joints: Install dowel sleeves and dowels or dowel bar and support assemblies at joints where indicated on drawings.

L. Plate Dowels: Install in accordance with manufacturer's written instructions.

3.04 FIELD QUALITY CONTROL

A. Inspection: In-place formwork and reinforcing are subject to inspection by the Owner's Representative for compliance with specified requirements prior to casting concrete. Do not place concrete until formwork, reinforcing, embedments and other miscellaneous embedment items have been inspected and approved and placement cards provided by the Contractor.

B. Correction of Work: If test reports or inspections indicate that Work does not comply with Contract Documents, correct deficiencies in Work until specified requirement are met. Assume costs of correction, including inspection and retesting the corrected work.

END OF SECTION

A-USC Com Test at Youngstown Thermal

Youngstown, OH

PROJECT NUMBER 31609

SPECIFICATION NUMBER 03 30 00

FOR

CAST IN PLACE CONCRETE

PREPARED FOR

Energy Industries of Ohio (EIO)

By

AECOM

1500 W 3rd Street, Suite 200

Cleveland, OH 44113

Revision	Date	Status
A	March 16, 2016	Preliminary

SPECIFICATION REVISION PAGE

Project Name:	A-USC Com Test	Discipline:	Structural
Client:	Energy Industries of Ohio		

Revision Signatures

Jeff Morris	3/16/2016		
Prepared by	Date	Approved by (PEM)	Date
		NA	
Checked by	Date	Approved by (if required) (title)	Date

Status	Rev. No.	Date	Prepared By	Pages	Description of Changes
Prelim.	A	3/16/2016	JJM	All	For FEED use

PART 1 - GENERAL

1.01 SUMMARY

A. This specification section, the reference standards noted herein (namely ACI 301, as described in Article 1.03, "References") and other Contract Documents cover cast-in-place concrete including formwork, mix design, placement, procedures, finishes, curing, grouting of column bases and associated work.

1.02 RELATED REQUIREMENTS

A. Work in other sections of the specifications:

1. Section 31 00 00 Earthwork (excavating, filling, backfilling and compacting)
2. Section 32 13 13 Concrete Paving (concrete for paving, sidewalks and curbs)
3. Section 33 30 00 Sanitary Sewerage Utilities (concrete supports, concrete structures)
4. Section 33 40 00 Storm Drainage Utilities (concrete supports, concrete structures)
5. Section 03 20 00 Concrete Reinforcing (reinforcing steel for concrete)
6. Section 04 20 00 Unit Masonry (constructing cast-in-place items associated with masonry)
7. Section 05 50 00 Metal Fabrications (anchor rods and embedded steel)
8. Miscellaneous items (furnished under other sections) for embedment under this section.

1.03 ALTERNATIVES

A. If substitute materials or alternate construction methods are proposed, submit complete technical data to Owner's Representative for review. Information submitted must clearly demonstrate that substitute material or method is equal to or superior in quality or performance to that specified herein and demonstrates substantial savings in time or cost to the Owner.

1.04 REFERENCE STANDARDS

A. To be complete, this specification section requires the use of American Concrete Institute Standard ACI 301, "Standard Specification for Structural Concrete". This specification section supplements and modifies ACI 301-10, and takes precedence if a conflict exists.

B. Except as modified herein, conform to the referenced standards and cited publications given in Section 1.3 of ACI 301.

C. Reference to standards of organizations made herein is in accordance with the following abbreviations. All referenced standards and codes contained within this document shall be the latest edition as of the date of contract award.

1. ACI American Concrete Institute

a. 117 Specifications for Tolerances for Concrete Construction and Materials

b. 301 Specifications for Structural Concrete

c. 306.1 Standard Specification for Cold Weather Concreting

d. 305R Guide to Hot Weather Concreting

2. ASTM American Society for Testing and Materials

a. C33 Standard Specification for Concrete Aggregates

b. C94 Standard Specification for Ready-Mixed Concrete

c. C125 Standard Terminology Relating to Concrete and Concrete Aggregates

d. C150 Standard Specification for Portland Cement

e. C171 Standard Specification for Sheet Materials for Curing Concrete

f. C260 Standard Specification for Air-Entraining Admixtures for Concrete

g. C309 Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete

h. C311 Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland - Cement Concrete

i. C494 Standard Specification for Chemical Admixtures for Concrete

j. C579 Standard Test Methods for Compressive Strength of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes

k. C618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete

l. C920 Standard Specification for Elastomeric Joint Sealants

m. C1107 Standard Specification for Packaged, Dry, Hydraulic - Cement Grout (Non-Shrink)

n. C1315 Standard Specification for Liquid Membrane - Forming Compounds having Special Properties for Curing and Sealing Concrete

o. D1751 Standard Specification for Preformed Expansion Joint Fillers for Concrete Paving and Structural Concrete (Non-extruding and Resilient Bituminous Types)

p. D4397 Standard Specification for Polyethylene Sheeting for Construction, Industrial, and Agricultural Applications

e. E1745 Standard Specification for Plastic Vapor Retarders Used in Contact with Soil or Granular Fill Under Concrete Slabs

3. NIST National Institute of Standards and Technology

1.05 SUBMITTALS

A. Requirements: Follow ACI 301, Section 1.5.

B. At least 10 days prior to planned placement of concrete, submit the following to the Owner's Representative for review:

1. Concrete mix designs. See Article 2.04, "Concrete Proportioning", herein. Follow ACI 301, Section 4.1.2. See attached “Concrete Mix Design Submittal Form”.

2. Product Data: Standard drawings, manufacturer’s technical data and installation instructions for the following:

a. Admixtures

b. Bonding Agents

c. Curing Materials

d. Grouts and Mortars

e. Joint Fillers

f. Joint Sealants

g. Surface Finish Material

h. Vapor Retarders

i. Waterstops

3. Follow submittal requirements as specified in ACI 301, Section 2.1.2 and Section 5.1.2.

C. Submit to the Owner's Representative concrete test results. See Article 1.05, "Quality Assurance", herein. Follow ACI 301, Section 1.6.

D. Review Procedure for Submittals:

1. Contractor's Review:

a. Submittals to the Owner’s Representative must be complete. Review each submittal and check for compliance with the Contract Documents. If deviations from the

Contract Documents are necessary, highlight, encircle, or otherwise identify the deviation.

b. Note corrections and field dimensions.

c. Mark each submittal with a stamp that includes name of reviewer, date of Contractor's approval, and statement certifying that submittal has been reviewed, checked, and approved for compliance with the Contract Documents, with deviations, if any identified.

d. Submittals that are changed after having been reviewed by the Owner's Representative are to be resubmitted for review with changes encircled and identified as revisions.

2. Review by Owner's Representative:

a. Submittals will not be reviewed that do not bare Contractor's approval stamp and will be returned without action. Submittals not required by the Contract Documents will not be reviewed and may be discarded. The Owner's Representative reserves the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

b. Review of submittals will be for conformance with design concept and the Contract Documents. The Contractor is solely responsible for, and this review does not include: confirming and correlating quantities and dimensions, selecting fabrication processes and techniques of construction, and performing work in a safe and proper manner.

c. This review does not relieve the supplier from compliance with supplier's contract obligations. The fact that no exceptions are taken, or that comments and/or markings may have been made on submittals, shall not relieve the Contractor from compliance with the Contract Documents, nor be construed as authorizing departure therefrom, nor constitute either expressly or implied, a change therein, or with the Contractor's responsibilities as listed above.

d. Each submittal will be reviewed, marks made to indicate corrections or modifications if necessary, and returned. Each submittal will be stamped and the stamp will be appropriately marked to indicate action taken.

1.06 QUALITY ASSURANCE

A. Testing: Follow ACI 301, Section 1.6, except as noted.

B. Testing Agency Designation: The Owner's Representative will employ an independent testing laboratory to perform testing services for purpose of monitoring concrete quality. The selected laboratory will be one that has been inspected by the Cement and Concrete Reference Laboratory at the National Institute of Standards and Technology (NIST), and that meets the requirements of ACI 301, Section 1.6. To comply, the laboratory shall submit to the Owner's Representative a copy of a recent NIST inspection report.

C. Testing Services: Follow ACI 301, Section 1.6.3.2, modified and supplemented as follows:

1. Sampling, Making Specimens, Capping, Handling, Curing and Testing: Conform strictly to referenced ASTM standards, and perform procedures by authorized laboratory personnel only. Tests for slump, air content, temperature, unit weight, and compressive strength are required.

2. Cylinders: Prepare five cylinders for each 100 yards of concrete or part thereof used in one day's placing of concrete. For normal concrete, test 1 cylinder at 7 days, 3 at 28 days, and hold 1 in reserve. For high-early strength concrete, test 2 cylinders at 3 days, 2 at 7 days and hold 1 in reserve. The reserve cylinder may be substituted if another specimen develops an unrealistic test value.

3. Reporting: Laboratory shall report test results to Engineer, to the Owner's Representative, to the Concrete Constructor, and to the Concrete Supplier.

D. Concrete Constructor's Responsibilities: Cooperate with the laboratory to assure proper performance of required testing services. Promptly deliver concrete material samples, and furnish mill test reports of cement. Furnish assistance in obtaining samples and handling specimens, and provide necessary facilities at site for storage and curing.

E. Concrete Products: Follow ACI 301, Section 4.2.1 and 4.2.2.

F. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer’s plant, with each aggregate from one source, and each admixture from the same manufacturer.

G. Concrete Work: Conform to all requirements of ACI 301, “Specifications for Structural Concrete”, except as modified and supplemented herein.

H. Preinstallation Conference: Unless otherwise directed by the Owner’s Representative, at least 30 days prior to the start of the concrete construction schedule, the Contractor shall conduct a meeting to review proposed mixes and discuss the required methods and procedures to achieve the required concrete construction and schedule. Coordinate time and place of meeting with Owner’s Representative. Minutes of meeting shall be recorded, typed, printed, and distributed by the Contractor to all concerned parties within five calendar days of the meeting. The Contractor shall require responsible representatives concerned with the concrete work to attend the meeting, including, but not limited to the following:

1. Contractor’s Superintendent

2. Testing agency responsible for field quality control

3. Concrete subcontractor

4. Ready-mix concrete producer

5. Admixture manufacturer(s)

6. Concrete pumping contractor

7. Owner's Representative

PART 2 - PRODUCTS

2.01 GENERAL

A. Where applicable, reference is made to material requirements given in ACI 301.

B. Use materials in accordance with manufacturer's written instructions. If such recommendations differ from requirements specified herein, notify the Owner's Representative before proceeding for resolution.

2.02 FORMWORK AND FORM ACCESSORIES

A. Follow ACI 301, Section 2.2, except as noted.

B. Forms: Use wood, steel or other approved material based on safety, and quality of finished work. Plywood for forms and form liners used on exposed concrete work shall conform to U.S. Product Standard PS-1, High Density Overlay, stamped with APA grade trademark. Furnish in largest practical sizes to minimize number of joints and to conform to joint system shown on drawings.

C. Form Ties: For exposed work, use type so arranged that when forms are removed, no metal will be closer than 1 inch from a surface. Wire ties may be used where concrete will not be exposed to weather and where discoloration would not be objectionable.

D. Expansion/Isolation Joint System: Follow ACI 301, Section 2.2.1.4.

1. Pre-molded Joint Material: Asphalt impregnated fiber, ASTM D1751. Size 1/2 inch thick x full depth of slab. Provide joint filler in two pieces or scored for easy removal and installation of backer rod and sealant.

2. Foam Joint Backer Rod: Closed cell polyethylene foam rod; Acceptable products are: Sonofoam by Sonneborn Building Products Division, Sealtight Backer Rod by W.R. Meadows, Inc., or Ethafoam by Dow Chemical. Size: 1/8 to 1/4 inch larger (diameter) than joint width.

3. Joint Sealant: Single component polyurethane base structural sealant, gray color meeting the requirements of ASTM C920, Type S, Grade P, Class 25, use T. Provide appropriate primer compatible with sealant. Acceptable product is: Sonolastic SL 1 by Sonneborn used with No. 733 Primer.

E. Contraction Joint Filler: Two-part semi-rigid epoxy with Shore "A" hardness of 80, Shore "D" hardness of 50 and bond strength to concrete of less than 350 psi. Acceptable product is: "MM-80" by Metzger-McGuire Company, P.O. Box 2217, Concord, NH 03302.

F. Waterstops: Follow ACI 301, Section 2.2.1.5, except as noted.

1. Premolded Rubber Waterstop: Size 6 inches x 3/8 inch, dumbbell shape, without center

bulb, plain or split, 2000 psi minimum tensile strength, SBR rubber, with sleeve fittings. Acceptable products are: Everlastic rubber waterstop (DB) by Williams Products, Inc., Troy, Michigan; Greenstreak Plastic Products, Inc., St. Louis, MO.

2. Preformed Plastic Adhesive Applied Waterstops: Size approximately 1 inch x 1 inch cross section preformed plastic waterstop meeting the requirements of FS SS-2-201A, "Sealing Compound for Expansion Joints". Use with manufacturer's primer. Acceptable product is: SYNKO-FLEX waterstop by SYNKO-FLEX Products, Houston, TX (800-231-4551).

3. Bentonite/butyl Rubber Based Waterstops: Size 1 inch by 3/4 inch cross-section, active bentonite/butyl rubber based strip waterstop system. Use with manufacturer's adhesive. Acceptable products are: "Waterstop-RX 101" by Colloid Environmental Technologies Company (CETCO), Buildings Material Group, Arlington Heights, IL (800-527-9948); "Swellstop" by Greenstreak, St. Louis, MO.

4. Premolded PVC Waterstop: Size 6 inches x 3/8 inches polyvinyl chloride (PVC) premolded waterstop, 1500 psi minimum tensile strength, having multi-ribbed profile and preformed corner sections and heat welded jointing. Acceptable manufacturers are: Sealtight PVC Waterstop number 6380 by W.R. Meadows, Inc., Elgin, IL; Style No. 732 by Greenstreak, Plastic Products Company, Inc., St. Louis, MO.

G. Underslab Vapor Retarder: Minimum 10 mil thick fiberglass reinforced paper coated both sides with polyethylene film, meeting ASTM E1745; furnished complete with recommended adhesive or pressure sensitive tape for sealing laps and penetrations. Acceptable products is Moistop manufactured by Fortifiber Corporation.

H. Compressible Form Material: Use a material that is sufficiently rigid to support concrete in smooth plane when placed, and capable of being compressed under force of building expansion. Provide thickness of material as shown on the drawings. Acceptable material is Styrofoam SE (square edge) by Dow Chemical Co.

2.03 CONCRETE MATERIALS

A. Cementitious Materials: Follow ACI 301, Section 4.2.1.1. Use ASTM C150, Type II Portland cement. When such properties as high early strength and air-entrainment are required, use admixtures. For exposed concrete within a single structure, use same brand and source of cement throughout.

B. Aggregates: Follow ACI 301, Section 4.2.1.2, and ASTM C33. Fineness modulus, as defined in ASTM C125, for fine aggregates placed in flatwork shall have a range of 2.3 to 3.1. Provide aggregates from a single source throughout project.

C. Water and Ice: Follow ACI 301, Section 4.2.1.3.

D. Admixtures: Follow ACI 301, Section 4.2.1.4. If using more than one admixture, verify compatibility with manufacturer. If possible, provide admixtures from one manufacturer. Use admixtures with chloride content no greater than in local drinking water. Following are the only admixture materials that will be permitted in concrete:

1. Air-Entraining Admixture: ASTM C260. Acceptable products are: W. R. Grace, Daravair; Master Builders, MB-VR or Micro-Air; Sika, AER; and Euclid Chemical Co; Air Mix.

2. Water Reducing Admixture, Normal Setting: ASTM C494, Type A. Acceptable products are: W.R. Grace WRDA; Master Builders Pozzolith/Polyheed Normal; Sika, Plastocrete 161 and Euclid Chemical Co, Eucon WR-75.

3. Water Reducing and Set Retarding Admixture: ASTM C494, Type D. Acceptable products are: W. R. Grace, Daratard; Master Builders Pozzolith Retarder; Sika, Plastocrete 161-R and Euclid Chemical Co, Eucon Retarder 75.

4. Water Reducing and Set Accelerating Admixture: ASTM C494, Type E, non-chloride formulation. Acceptable products are: W. R. Grace, Darex set accelerator used with WRDA; Master Builders, Pozzutec 20; Sika, Plastocrete 161FL; and Euclid Chemical Co, Accelguard 80.

5. High Range Water Reducer (Superplasticizer): ASTM C494, Type F. Acceptable products are: Eucon 37 by Euclid Chemical Co; and Rheobuild 1000 by Master Builders.

6. Pumping Aid: Where included in design mix to assist in pumping concrete, use a water soluble lubricant that decreases friction in the pipeline and increases flow without interfering with the hydration of cement or the engineering properties of the concrete, such as setting time, volume changes, and compressive strength. Acceptable product is: Darex Pumping Aid by Construction Products Division of W. R. Grace Co.

7. Assistance: A full-time qualified concrete technician employed by the admixture manufacturer shall be available to assist in proportioning concrete mixes and to advise on subsequent adjustments of mixes to suit job conditions.

8. Alternatives: Substitute products will be considered provided they are of similar type, have been proven in field service for at least 10 years, and are capable of producing concrete meeting specified quality requirements with regard to slump, compressive strength, total air content, controlled rate of hardening, improved workability, and improved surface texture. Written approval of the Owner's Representative is required prior to use of a substitute product on the project.

9. Fly Ash: The use of fly ash in foundation concrete will be considered based on the ready-mix plant's past experience with fly ash concrete. Submit current data sheets representative of the material presently in storage, and compare that with the requirements of ASTM C618, including Supplementary Optional Physical Requirements and Supplementary Optional Chemical Requirements. Submit proposed mix designs using fly ash proposed. Fly ash: ASTM C618, Class C, with more than 50 percent SiO_2, Al_2O_3, and Fe_2O_3 combined and less than 5 percent loss on ignition when tested in accordance with ASTM C311. Maximum amount: 20 percent replacement of cement with fly ash by weight.

2.04 CONCRETE PROPORTIONING

A. Follow ACI 301, Section 4.2.2 and 4.2.3, for Exposure Category S1 (Moderate Exposure) except as noted. Maximum w/cm = 0.50.

B. Mix Requirements: Conform to following:

1. Normal setting concrete for foundations and structures below grade: 4,000 psi specified compressive strength at 28 days, 520 pounds per cubic yard of concrete minimum cement content for 1-1/2 inch maximum size aggregate, slump 3 inches, not to exceed 4 inches, total air content not to exceed 3 percent by volume. Water reducing admixture, approved by the Owner's Representative, may be used but is not required. If a water reducing admixture is used, slump shall not exceed 7 inches.

2. High-early strength concrete for foundations, pits, trenches, and other similar work not subject to destructive exposure: 4,000 psi specified compressive strength at 7 days, 520 pound per cubic yard of concrete minimum cement content for 1-1/2 inch maximum size aggregate, slump 4 inches, not to exceed 5 inches, total air content not to exceed 3 percent by volume. Water reducing/set accelerating admixture, approved by the Owner's Representative, is required for early strength. If a water-reducing admixture is used, slump shall not exceed 7 inches.

3. Interior Floor Slab Concrete: 4,000 psi specified compressive strength at 28 days, 540 lbs. per cubic yard of concrete minimum cement content for 3/4 inch maximum size aggregate, slump 3 inches, not to exceed 4 inches, total air content not to exceed 3 percent by volume. Water reducing admixture, approved by the Owner's Representative, is required. Compatible set controlling admixture permitted as weather or job conditions require. If a water-reducing admixture is used, slump shall not exceed 7 inches.

4. High-early strength concrete for interior floor slabs and other structures not subject to severe exposure: 4,000 psi specified compressive strength at 7 days, 540 pounds per cubic yard of concrete minimum cement content for 3/4 inch maximum size aggregate, slump 4 inches, not to exceed 5 inches, total air content not to exceed 3 percent by volume. Water reducing/set accelerating admixture, approved by the Owner's Representative, is required for early strength. If a water-reducing admixture is used, slump shall not exceed 7 inches.

5. Design mixes to be pumpable without addition of more water at the jobsite than allowed in mix design. See Article 2.05, "Production of Concrete", herein.

6. Pumped Concrete: Where concrete is to be pumped, the slumps indicated above are to be measured at the point of deposit, the outlet end of pump hose. As a preliminary measure of slump, tests made at the hopper on the pump may use the following as a guide to provide for loss in the pipeline:

Additional Slump Allowable, Inches	Length of Pipeline Feet
+ 1/4	0- 49
+ 1/2	50- 99
+ 3/4	100-149
+ 1	150-199

C. Air Entrainment: Follow ACI 301, Section 4.2.2.4. Concrete "subject to severe exposure" is defined as exposed horizontal surfaces outdoors or in unheated areas where freezing and thawing may occur. Measure total air content at the point of deposit, and if pumped, at the end of the pump hose.

D. Use of Admixtures: Only the admixtures specified herein under Article 2.03, "Concrete Materials" shall be permitted in concrete. Mix designs shall take into account admixtures required or proposed for use.

1. Use air-entraining admixture, not air-entraining cement, to obtain and control required air content.

2. Use water reducing admixture in concrete for floor slabs and other traffic areas. Water reducing admixture is optional in other concrete. Use set-controlling admixture when conditions require that rate of strength development be controlled.

3. Do not use calcium chloride. Do not use an admixture containing a water-soluble chloride ion content greater than 0.3 of 1 percent by weight of cement in concrete; follow ACI 301, Section 4.2.2.7.

4. Strictly follow recommendations of admixture manufacturer for dosages, addition times, and compatibility.

E. Mix Designs:

1. Submit proposed mix designs for review and furnish data on source of supply for concrete materials and grout at the same time. Submit data of proposed mixes to the Owner's Representative for written approval in accordance with ACI 301, Section 4.2.3, "Proportioning". Do not place structural concrete until authorized by the Owner's Representative.

2. For proposed mix based on previous field experience, submit strength tests records made within the past 12 months in accordance with ACI 301, Section 4.2.3.2. Base required compressive strength on the standard deviation of those tests. Approval of design mixes based on previous field experience will be tentative, pending verification of field cylinder tests.

3. When proposed mixes are based on trial mixtures, the concrete supplier shall engage and pay for the services of a testing laboratory (whose retention is subject to approval of the Owner's Representative to design mixes in accordance with ACI 301, Section 4.2.3.4.b. The required average compressive strength for trial mixtures shall be 1200 psi greater than that specified. Make arrangements for the approved testing laboratory to procure samples for the design of the mixes.

F. Certification: Provide completed delivery ticket for each load of concrete delivered to the site. Include all information noted in paragraph 2.05C., "Delivery Ticket" herein and submit tickets to the Owner's Representative at the site.

G. Verifying Mix Designs: Use one batch of each mix design specified for the project, except

lean concrete, in constructing footings or similar foundation work. Make at least 5 cubic yards for each batch, using proposed cement, aggregates and admixtures, without accelerators or retarders. For each batch the Laboratory shall make tests for unit weight, slump, air content and compressive strength as specified in Article 1.05, "Quality Assurance", herein.

2.05 PRODUCTION OF CONCRETE

A. Follow ACI 301, Section 4.3, except as noted.

B. Production: Use ready-mixed concrete for specified work. If small quantities (not over 1/2 cu. yd.) are needed for isolated or relatively unimportant items, concrete may be batch mixed at site, subject to prior approval of Owner's Representative.

C. Delivery Ticket: In addition to the information required on the delivery ticket in ASTM C94, each batch (truckload) of concrete shall have the following information on the delivery ticket or on an attached batch ticket:

Total water allowed per Mix Design_____gal./yd
Surface moisture on aggregates_____gal./yd
Water (and ice) added at plant mixer_____gal./yd
Total water in batch at Ready-Mix Plant_____gal./yd
(Water permissible = water in mix design less plant water)
Permissible to add at jobsite___gal/yd x ___yd = _____gal.
Time batch mixed at Ready-Mix Plant_____AM/PM
Inspector or Dispatcher at R/M Plant_____
Time R/M truck arrived at jobsite_____AM/PM
Time at start of concrete placement_____AM/PM
Time at finish of concrete placement_____AM/PM
Inspector or Foreman at Jobsite:_____

D. Mixing Time: Do not place concrete that has attained its initial set or has contained water for longer than listed below:

Concrete Temperature at Time of Placement	Maximum Time Before Placement
Under 80°F	1-1/2 hour
80 F - 85°F	1-1/4 hour
86 F - 90°F	1 hour
Over 90°F	1 hour, with Owner's Representative approval dependent on slump and use. Do not use as structural concrete.

2.06 CURING MATERIALS

A. Follow ACI 301, Section 5.2, except as noted.

B. Moisture-retaining cover: ASTM C171, polyethylene film, white burlap-polyethylene sheet, or waterproof paper. Seal laps with pressure sensitive tape, nonstaining mastic, or other effective adhesive recommended by covering manufacturer.

C. Water: Potable

D. Evaporation Retarder: Waterborne, monomolecular film forming, manufactured for application to fresh concrete. Acceptable products are: Confilm by Master Builders Inc.; Eucobar by The Euclid Chemical Co.; E-Con by L & M Construction Chemicals, Inc.

E. Curing and Sealing Compound: Liquid, non-yellowing, membrane-forming type (sodium silicate not approved) meeting the requirements of ASTM C309, Type 1 Clear, or ID, Class B, having a fugitive dye to facilitate visual check of coverage. Instructions on containers of compounds delivered to job shall clearly state the maximum coverage rate that meets ASTM C309 moisture retention requirement of 0.055 gram/sq. cm/72 hr. A compound that performs additional functions (hardening, dustproofing, etc.) may be used provided it meets ASTM C309 and performs the primary function of curing.

F. Curing and Sealing Compound: Liquid, non-yellowing, membrane-forming type (sodium silicate not approved) meeting requirements of ASTM C1315, Type 1 Clear, or II, Class A, having a fugitive dye to facilitate visual check of coverage. Instructions on containers of compounds delivered to job shall clearly state the maximum coverage rate that meets ASTM C1315 moisture retention requirement of 0.030-gram/sq. cm/72 hr. A compound that performs additional functions (hardening, dustproofing, etc.) may be used provided it meets ASTM C1315 and performs the primary function of curing and sealing.

2.07 SURFACE FINISH MATERIALS

A. Follow ACI 301, Section 5.3.4, except as noted.

B. Abrasive-Aggregate Non-Slip Surfacing: Composed of not less than 95 percent pure aluminum oxide and graded from 8 to 16 mesh. Acceptable product is: FRICTEX NS by Sonneborn Building Products, Chemrex Inc. Application rate = 1/4 pound per square foot.

C. Trap Rock Surface Hardener: Premixed floor hardener, requiring no mixing with cement at point of application, containing only graded trap rock and cement; free of iron aggregate, rust particles and other contaminants. Acceptable products are: Iron Mountain Trap Rock Premixed Floor Hardener; Surflex TR of the Euclid Chemical Co. Application rate = 1-1/2 pounds per square foot.

D. Natural Aggregate Surface Hardener: Ready to use, requiring no mixing at point of application, containing mineral aggregate, cementitious binders, plasticizers, water-reducing admixtures, and other proprietary ingredients. Acceptable products are: Mastercron F_F by Master Builders; Surflex by the Euclid Chemical Co. Application rate = 1-1/2 pounds per square foot.

2.08 MISCELLANEOUS ITEMS

A. Nonshrink Cement Grout: ASTM C1107, Type C, at a fluid consistency, in temperatures from 45 degrees F to 90 degrees F, for nonshrink, expansive cement grout. Gas liberating, metal oxidizing or gypsum forming grouts are not permitted. Provide premixed grout, ready-to-use at jobsite with the addition of water only. Grout shall harden without shrinkage or settlement, be free of bleeding, and exceed the strength of a plain cement-sand grout at all ages. Acceptable

products are: Masterflow 928 grout by Master Builders Co, Cleveland, Ohio; F-100 grout by Sauereisen Cements Co, Pittsburgh, Pennsylvania; NS grout by the Euclid Chemical Co.

B. Nonshrink Mortar: Ready-to-use natural aggregate type, similar to nonshrink grout, but graded finer to facilitate featheredging of patches. Acceptable product is: EMACO R300 by Master Builders Co.

C. Fast Setting Cement: Special cement for anchoring rods and other items in hardened concrete, that will set in 15 minutes and have approximately 3000 psi compressive strength in 24 hours. Acceptable product is: Mari-Crete by Atlas Minerals & Chemicals, Inc.

D. Bonding Adhesive: Two component epoxy resin system. Acceptable products are: Sikadur 32 Hi-Mod by Sika Chemical Corp, Lyndhurst, N.J.; Concresive Standard Liquid by Master Builders Co; Euco #452 by the Euclid Chemical Co.

E. Epoxy Grout: Multi-component epoxy resin, hardener, and quartz filler grout with minimum 11,000 psi compressive strength at 7 days per ASTM C579. Grout to be packaged so that correct proportions of resin, hardener and quartz filler can be mixed without requiring field measuring. Acceptable products are: Masterflow 648 CP Plus" by Master Builders Co.; "E^3 Grout" by Euclid Chemical; and "Five Star Epoxy Grout" by Five Star Products, Inc.; "Chockfast" Grouting System by ITW Philadelphia Resins, Montgomeryville, PA.

PART 3 - EXECUTION

3.01 FORMWORK

A. Follow ACI 301, Section 2.3, except as noted.

B. Form Design and Construction: Make forms accurately conforming to required line, grade and shape, and sufficiently tied and braced to maintain proper position and dimensions during concrete placing. Use form molds to produce chamfers at exposed corners and edges of concrete. Arrange forms and supports so they may be readily removed without hammering or prying against concrete. Obtain approval of completed formwork from Owner's Representative before placing concrete.

C. Form and Shore Removal: Adjust the following guidelines for cold or hot weather conditions and if accelerating or retarding admixtures are used:

1. Do not remove forms, and shoring supporting the weight of concrete, in less than 7 days and after test cylinder results indicate 75 percent of the required 28-day compressive strength has been attained. Superimposed construction loads must be restricted to one-half the design live load until full 28 day compressive strengths are achieved.

2. Forms not supporting the weight of concrete may be removed as soon as practical without damaging the concrete by removal of its support, or by the stripping operation. For footings, grade beams, piers less than 3 feet high, slabs on grade and other items, as determined by the Owner's Representative, remove forms after a minimum of 12 hours.

3. If forms are removed prior to total curing time specified, exposed surfaces must be cured and protected from damage.

D. Installing Compressible Form Material: Use where shown on drawings to isolate new concrete from existing construction. Before placing concrete, attach boards of the material firmly in place with spots of adhesive applied on existing construction approximately 2 feet on center in each direction.

3.02 PREPARATION AND PLACING

A. Follow ACI 301, Section 5.3.1 and 5.3.2, except as noted.

B. Preparation Before Placing Concrete:

1. Cleaning Reinforcement and Forms: Remove loose mill scale and rust, dirt and other coatings that would reduce or destroy bond from reinforcing steel. Thoroughly clean forms of hardened concrete, wood chips, shavings and other debris.

2. Placing Underslab Vapor Retarder:

a. Install vapor retarder under ground floor slab areas where shown on the project design drawings.

b. Make sure subbase material beneath vapor retarder is compacted, level, smooth, and free from sharp objects.

c. Place vapor retarder at proper elevation as shown on drawings. Lap joints at least 6 inches and seal with recommended adhesive or tape. Extend vapor retarder to the walls, turn up and terminate 1 inch below top of slab.

d. At penetrations, carefully cut openings no larger than necessary. Provide flashing, cut from vapor retarder material, to extend out at least 12 inches on all sides. Thoroughly seal flashing to vapor retarder and to surface of penetrating item.

e. Perform subsequent work carefully to avoid damaging vapor retarder.

3. Sprinkling Slab Underbed: At slab areas on ground, sprinkle granular underbed sufficiently and uniformly with clean water to eliminate loss of water from concrete.

C. Bonding: For joint surface preparation, see Article 3.03C, "Bonding", herein.

3.03 JOINTS AND EMBEDDED ITEMS

A. Follow ACI 301, Section 5.3.2, except as noted.

B. Construction Joints in Slabs: Construct as shown on drawings. Follow ACI 301, Section 5.3.2.6.

C. Bonding: Where fresh concrete is placed on or against hardened concrete and adhesion is required, obtain bond as specified in ACI 301, Section 5.3.2.6.

D. Expansion/Isolation Joints: Place specified premolded joint filler in joints where ground floor slabs meet walls, columns, equipment foundations and other abutments, as well as other specific locations shown on drawings. Install backer and apply sealant manufacturer's recommended primer to clean, dry surfaces. Compact sealant to provide smooth, straight, and slightly convex or flat surface. Follow ACI 301, Section 2.3.1.13.

E. Contraction Joints: Construct contraction joints accurately and neatly in floor slabs at locations shown on drawings. Follow ACI 301, Section 5.3.5.

1. Protect edges of contraction joints from physical damage; keep cuts clean and free of oil, grease or other contaminants until joint sealant is installed.

2. Delay installation of specified epoxy joint filler as long as possible so that the majority of slab shrinkage will have taken place prior to installing epoxy filler. Allow at least 30 days, with 3 months or longer preferred. If joints open up after epoxy filler is installed and cured, wait until building is a normal temperature, then clean out voids and refill them with same epoxy or manufacturer's recommended filler for thin spaces. Do not remove previously installed epoxy filler.

3. Use either of the following methods:

a. Use early entry or “soff-cut” method for saw cutting joints without the use of water. Perform saw cutting as soon as the slab can support the weight of the saw and operator without disturbing the final finish. Perform saw cutting within sawcut machine manufacturer’s recommended concrete curing window. Replace manufacturer’s patented anti-revel skid plate with each new saw blade to prevent concrete spalling and raveling.

b. Unless otherwise noted on the drawings, make cuts a minimum of ¼ slab thickness. Vacuum joints clean after sawing.

F. Embedments: Position and support sleeves, inserts, anchors, waterstops, and other embedded items prior to placing concrete. Install manufactured items in accordance with manufacturer's printed instructions. Follow ACI 301, Section 2.3.1.

3.04 FINISHING OF FORMED SURFACES

A. Follow ACI 301, Section 5.3.3, except as noted.

B. Selection of Finishes:

1. Grout Cleaned Rubbed Finish: Use for exposed exterior surfaces and interior vertical surfaces not to be painted. Follow ACI 301, Section 5.3.3.4.b.

2. Smooth Form Finish-2.0: Use for equipment foundations, pits, exposed surfaces to be painted, and for exposed interior overhead surfaces whether or not painted. Follow ACI 301, Section 5.3.3.3.b.

3. Rough Form Finish: Follow ACI 301, Section 5.3.3.3.a for surfaces show on detailed

design drawings.

3.05 FINISHING SLABS AND OTHER UNFORMED SURFACES

A. Follow ACI 301, Section 5.3.4, except as noted.

B. Finishes and Tolerances:

1. Scratched Finish: Follow ACI 301, Section 5.3.4.2.a. Use this finish at areas of foundations and pads where non-shrink cementitious grout will be applied.

2. Floated Finish: Follow ACI 301, Section 5.3.4.2.b. Use this finish at top surface of spread footings where top surface is not at floor level with a permissible tolerance of 1/4 inch in 2 feet.

3. Troweled Finish: Follow ACI 301, Section 5.3.4.2.c. Use this finish at interior floor slabs and at top surface of foundations and pads where the top surfaces are at or above floor level. Perform at least 3 trowelings on concrete to be exposed and 2 trowelings where finishes are to be applied.

4. Broom or Belt Finish: Follow ACI 301, Section 5.3.4.2.d. Use a light broom finish or belt finish at exterior walkways and ramps with a permissible tolerance of 5/16 inch in 10 feet. Apply broom finish with lines perpendicular to main traffic pattern.

5. Dry Shake Nonslip Finish: Follow ACI 301, Section 5.3.4.2.e. Use this finish at exterior steps, ramps, landings and platforms with a permissible tolerance of 5/16 inch in 10 feet. Soak and drain specified abrasive aggregate and apply at a rate as specified in Article 2.07.

6. Dry Shake Natural-Aggregate Surface Hardener: Follow ACI 301, Section 5.3.4.2.e. Use this finish at areas shown on the drawings to receive aggregate finished surface with a permissible tolerance of 5/16 inch in 10 feet. Apply specified aggregate surface hardener at rate as specified in Article 2.07.

7. Dry Shake Trap Rock Surface Hardener: Follow ACI 301, Section 5.3.4.2.e. Use this finish at areas shown on the drawings to receive Trap Rock finished surface with a permissible tolerance of 5/16 inch in 10 feet. Follow manufacturer's recommendations. Modify design mix No. 3 in paragraph 2.04B.3. by including approved high range water reducer specified in paragraph 2.03D.5. Follow requirements in paragraph 2.03D. Apply specified Trap Rock surface hardener at a rate as specified in Article 2.07.

C. Floor Flatness/Level Tolerances:

1. Slabs less than 4,000 S.F.: Finish to flatness and levelness that meet or exceed 1/8-inch as measured by a 10-foot straightedge.
2. Slabs larger than 4,000 S.F.:
    a. Measure finished concrete slab on grade for flatness and levelness in accordance with ASTM E1155.
    b. Floor measurements shall be taken by the Testing Agency within 24-hours of placement and reported to the Contractor and the Owner’s Representative within

48-hours and prior to the next slab placement

c. When F numbers are less than the specified composite, adjust the placement operations to assure compliance. Submit adjusted procedures to the Owner's Representative before proceeding with additional slab placements.

d. Where F number for local condition are less than the minimum specified, submit in writing, proposed corrective procedures to the Owner's Representative for approval. Do not proceed with further slab placements without approval from the Owner's Representative.

e. Slab-on-Grade:

i. Trowel Finished Floors: Composite FF30/FL25 value and a minimum FF20/FL17 value for an individual floor section.

ii. Float Finished Floors: Composite FF25/FL20 value and a minimum FF18/FL13 value for an individual floor section.

iii. ASRS Area: Composite FF75/FL50 value and a minimum FF38/FL25 value for an individual floor section.

iv. Measurements shall apply across control joints, but not within 2-feet of construction joints or edge forms. Tolerance for these finished surfaces shall not be less than 1/8-inch in 2-feet.

3.06 CURING AND PROTECTION

A. Follow ACI 301, Section 5.3.6, except as noted.

B. Requirements: Strictly observe procedures specified in ACI 301, with particular emphasis on the following:

1. Initial curing may be accomplished by any of the methods given in ACI 301, Section 5.3.6, except as noted, using materials specified herein. Use specified curing and sealing compound for final curing of slabs, except where a coating will be applied.

2. Maintain initial curing for approximately 12 hours after finishing. Increase this period to 24 hours when air temperature is 75°F and above.

3. Provide total curing period of 7 cumulative days, 3 days for high-early strength concrete, not necessarily consecutive, during which air in contact with concrete is above 50°F.

4. For formed surfaces, keep wood forms in contact with concrete wet, as well as steel forms heated by the sun. After form removal maintain curing for remaining time of required curing period.

C. Weather Requirements:

1. Cold Weather: Follow the recommendations in ACI 306.1. Do not add chemicals, anti-freeze or other foreign materials to concrete to prevent it from freezing. When placing concrete at or below 40°F, heat the mixing water to provide mixed concrete at a minimum temperature of 55° F when placed. If necessary to achieve 55 degree temperature; use other methods such as heating large aggregate, etc. When local weather predictions state that ambient temperature may fall below 40°F during the curing period, protect cast concrete by providing enclosures, insulated tarpaulins or

other Owner's Representative approved coverings and provide artificial heat. Make sure covering contains the heat around all concrete surfaces, including top of slabs. Maintain temperature at minimum of 50°F, for five days after placing and protect from freezing for an additional two days. At the end of this period, remove protection in such a manner that the drop in temperature of the concrete will be gradual and will not exceed a 40-degree drop in 24 hours. Keep exposed surfaces wet during heating period. Replace concrete damaged by freezing.

2. Hot Weather: Follow the recommendations in ACI 305R. Do not allow the concrete to exceed a temperature of 90°F at the time the concrete is placed. Reduce the temperature of aggregate and mixing water with chilled water or ice as required. For limitations of evaporation retarders, see manufacturer's precautions.

3. Warm, Dry, or Windy Weather: Use evaporation reducer specified to reduce moisture evaporation from freshly placed concrete when it is exposed to rapid drying conditions: direct sunlight, low humidity, heated interior, high wind, etc. Prepare solution and spray apply on plastic concrete immediately after screeding, at rate specified by manufacturer. If drying conditions are particularly severe, make additional applications as required following various finishing steps.

D. Use of Curing Methods: Maintain curing protection in good condition during required period. Repair, reapply or replace if necessary.

1. Water: When excessive amounts of water are used for curing, provide means for removal so that harmful effects to other construction and to earth surfaces will be minimized.

2. Waterproof Sheet Materials: These will be permitted for initial curing only. Use largest practicable size sheets. Lap joints not less than 4 inches and seal carefully. Anchor covering securely in place.

3. Curing Compound (Also see paragraph 2.06, "Curing and Sealing Compound", herein): Apply uniformly at a coverage rate not less than that stated by manufacturer that meets specified moisture retention requirement.

4. Reflective Materials: During hot sunny weather (generally 75°F and above) use of white or light colored curing materials is recommended to help keep down concrete surface temperature. Do not use white or gray pigmented curing compound.

3.07 REPAIR OF SURFACE DEFECTS

A. Follow ACI 301, Section 5.3.7, except as noted.

B. Patching: Concrete surfaces not exposed to view upon completion, may be patched with non-shrink mortar specified herein, in lieu of ACI specified mortar.

3.08 INCIDENTAL WORK

A. Non-Shrink Cementitious Grouting:

1. Unless otherwise noted on drawings, use non-shrink cement grout.

2. Mixes: Use a grout mix consisting of nonshrink grout material (specified under Miscellaneous Items) and water only. Use correct amount of water as determined by conditions of placement.

3. Mixing: Mix not less than 3 minutes and in a mortar mixer as close as possible to locations of use. Do not mix more grout than can be placed in 1/2 hour period, and once mixed do not add water to retemper.

4. Forms: Use sufficient form materials and of adequate strength, sufficiently tight to prevent leakage, and securely anchored to withstand applied pressure. Provide access space necessary for grout placement.

5. Preparation: Clean contact surfaces of concrete of lattice, dirt, oil, grease and loose material, then roughen and saturate with water. Remove excess water. Clean metal members and anchor rods of dirt, oil, grease and loose material, and align, level, and maintain them in correct final position during grouting.

6. Placement: Place grout quickly and continuously, avoiding segregation, bleeding or breaking down of initial set. Grout may be poured, or placed by plunger, pump or pressure, as most practicable. Make sure spaces are completely filled and there are no voids.

7. Finishing: After initial set (within 12 to 24 hours), remove forms, cut off exposed edges vertically, and finish neatly. Cure grout with wet burlap for first 48 hours. Do not disturb leveling devices for at least 48 hours after placing grout; if later removed, voids shall be pointed flush.

B. Epoxy Grouting: Mix, place and cure grout in accordance with manufacturer's printed instructions. Strictly adhere to manufacturer's recommendations for surface preparation.

C. Setting Items Into Hardened Concrete: When anchor rods, concrete reinforcing bars and other items are to be set into hardened concrete, drill hole as required, clean hole of loose particles and dampen with water only if required by grout manufacturer. Set items accurately and hold securely in position, and pour in epoxy grout, or fast setting cement mixed with water. Make sure remaining space is completely filled with grout, and finish surface smoothly.

3.09 CLOSEOUT ACTIVITIES

A. Follow ACI 301, Section 1.7 and 1.8. If test reports or inspections indicate that Work does not comply with Contract Documents, correct deficiencies in Work until specified requirements are met. Assume costs of correction including inspection and restesting of corrected work.

END OF SECTION

CONCRETE MIX DESIGN SUBMITTAL FORM

AECOM

1500 W. 3RD STREET

CLEVELAND, OHIO

Project:_____

City:_____State:_____

General Contractor:_____

Concrete Constructor:_____

Concrete Supplier: _____

Specified Concrete Strength (Class):_____

Mixture Identification Description):_____

Design Mix Information:

	Check One
Based on Standard Deviation Analysis……..	☐
Based on Trial Mix Test Data……	☐

Design Characteristics:

Density: _____ pcf
Strength: _____ psi (28-day)
Total Air Content: _____ Percent

If trial mixes are used the Mix Design proportion to achieve f'cr = f'c + 1200 psi
(1400 psi for strengths higher than 5,000 psi @ 28-days

Mix Proportions:

	Class/Type/Source	Specific Gravity	Weight (lbs./CY)	Absolute Volume (CF)
Cement				
Total Water				
Coarse Aggregates SSD				
Fine Aggregates SSD				
Fly Ash				
GGBFS				
Silica Fume				
Air				
Other				
		TOTAL		

Water/Cementitious Materials Ratio = _____Percent

Percent sand of total aggregate = _____Percent

Coarse Aggregate - Dry Rodded Unit Weight: _____ pcf

Fine Aggregate - Fineness Modulus (FM): _____

Admixtures:

	Type/Manufacturer:	Dosage (oz/cwt)
Water Reducer:	_____	_____
	_____	_____
Air Entraining Agent:	_____	_____
	_____	_____
High Range Water Reducer:	_____	_____
	_____	_____
Other:	_____	_____
	_____	_____

Slump before HRWR_____ inches

Slump after HRWR _____ inches

Standard Deviation Analysis (from experience records):

Number of Test Cylinders Evaluated: _____

Standard Deviation: _____

f'cr = f'c + 1.34s or f'cr = f'c + 2.33s – 500

(Refer to ACI 301 for increased deviation factor when less than 30 tests are available)

Laboratory Test Data:

Compressive Strength:

Age (Days)	Mix #1 (psi)	Mix #2 (psi)	Mix #3 (psi)
7			
7			
28			
28			
28 average			

Required Attachments with Submittal:

	Please Check If Included
Coarse Aggregate Gradation Report and Physical Properties	
Fine Aggregate Gradation Report and Physical Properties	
Concrete Compressive Strength Data or Trial Mixture Test Data	
Admixture Compatibility letter	
Cement – Material Certification Report	
Pozzolans – Material Certification Report	

Submitted by:

Name/Title: _____

Address: _____

Phone Number (Office/Cell): _____

Main Plant Location (Address):_____

Miles from Project: _____

Secondary Plant Location (Address):_____

Miles from Project: _____

Date Submitted: _____

End of Form

Cost Estimating

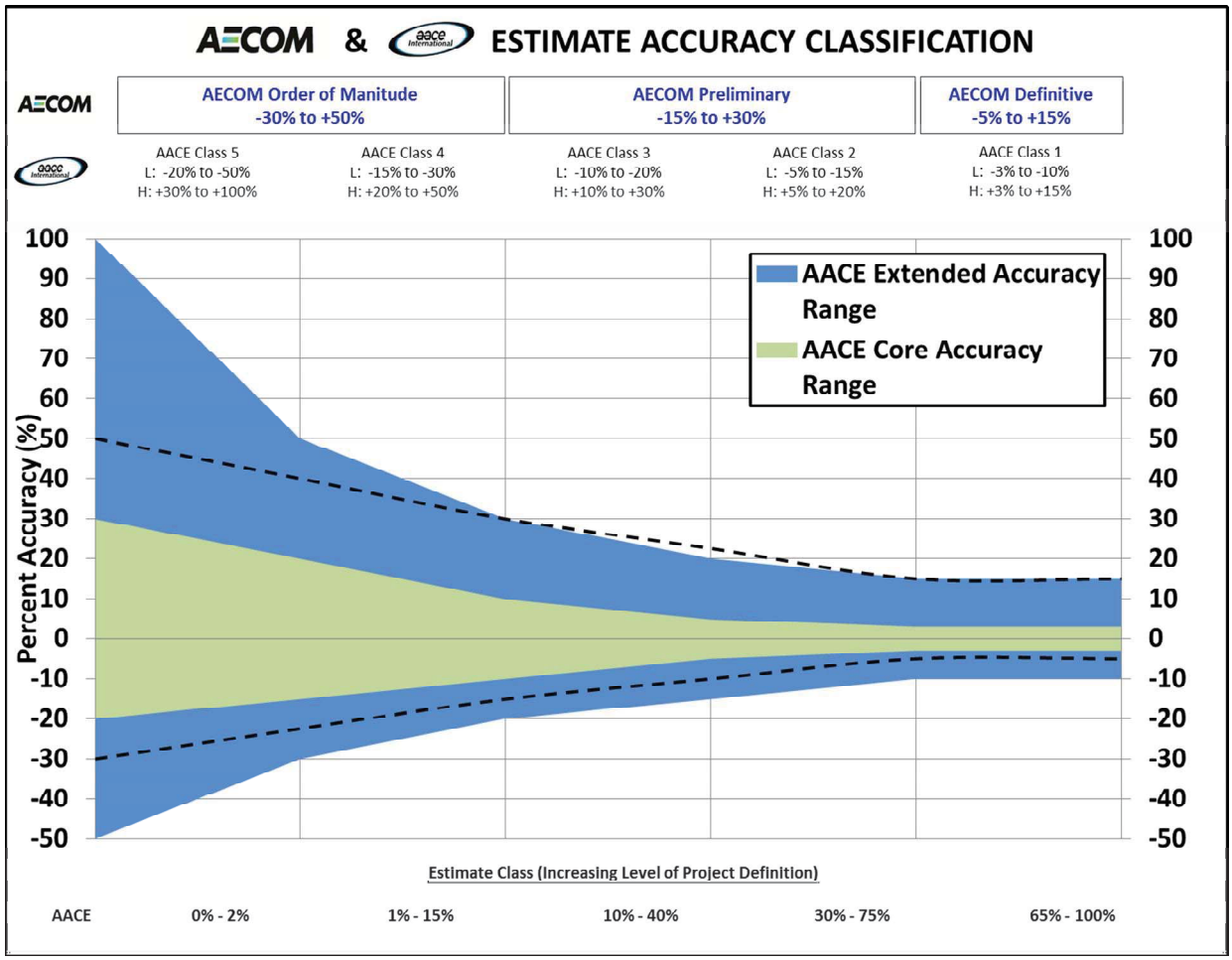
ESTIMATE BASIS

CLIENT:	Energy Industries of Ohio (EIO)	**PROJECT MANAGER:**	Dan Mardovin
PROJECT:	Advanced Ultra-Supercritical Component Test Project (A-USC Comtest)	**ESTIMATOR:**	R Rieser/RA Sheely/W Melton
LOCATION:	Youngstown, OH	**DATE:**	March 31, 2016
JOB NO.:	31609	**REVISION NO:**	0

1.0 PURPOSE

Client (Energy Industries of Ohio, Department of Energy & Ohio Coal Development office) has requested AECOM to prepare a Balance of Plant (BOP) estimate +/- 20-30% accuracy level based on FEED engineering deliverables for Cleveland office client R&D project at Youngstown, OH. This deliverable relates to an AECOM Class 3 estimate with an accuracy range of -20% to +30%.

AECOM uses the Association for the Advancement of Cost Engineers (AACE) cost estimate classification system, see attached AACE estimate accuracy graph.



ESTIMATE BASIS

2.0 BASIS

This FEED estimate includes Engineering, Procurement, Construction (EPC) plus scope and costs by others to represent an EPC Total Installed Cost (TIC) estimate through start-up.

This estimate is based on project deliverables received from the project team as of Thursday, March 24, 2016.

The execution philosophy assumes an open shop EPC contractor responsible for engineering after FEED, and includes procurement and construction of the facility.

The project is identified as the following areas which carry through to drawings, equipment, instrument and line numbering

- Turbine bldg
  - Pre-engineered Metal bldg
    - 2 levels: Level 1 and Lower level
  - Turbine/Dynamometer scope supply and install by GE Power
  - All other scope design, purchase and install by AECOM
- Cooling Tower
  - Deaerator and demineralizer to be rented
  - All other scope design, purchase and install by AECOM
- Boiler area
  - All scope design, purchase and install by AECOM
- Utility area
  - All scope design, purchase and install by AECOM
- Superheater
  - Superheater equipment supply and install by Babcock &Wilcox
  - Superheater piping supply by GE Boiler, install by AECOM
  - Foundation design, purchase and install by AECOM
- Electrical power
  - 600' overhead 23kv power from offsite by Ohio Edison Utility to onsite 35kv ABB switch and transformer inside curb
  - Underground ductbank to switchgear inside turbine bldg.
- Offsite Natural Gas Pipeline
- Decommissioning, demolition and salvage of specific scope excluding equipment, commodities and Turbine bldg to remain place, at completion of test project
- Operational costs are not mixed with the construction costs. Utility costs during the 24 month operations period are reported separately in the FEED study

3.0 SCOPE

This estimate is based on deliverables prepared by the project team including:

- P&IDs

ESTIMATE BASIS

- Equipment list with preliminary definition of Conditions of Service including metallurgy, dimensions, pressure, etc
- Material Take Offs (MTOs)

AECOM/AACE required deliverables for a Class 3 Estimate are:

	AACE ESTIMATE CLASSIFICATION				
	CLASS 5	**CLASS 4**	**CLASS 3**	**CLASS 2**	**CLASS 1**
MATURITY LEVEL OF PROJECT DEFINITION DELIVERABLES	**0% to 2%**	**1% to 15%**	**10% to 40%**	**30% to 75%**	**65% to 100%**
AACE General Project Data:					
Project Scope Description	General	Preliminary	Defined	Defined	Defined
Plant Production/Facility Capacity	Assumed	Preliminary	Defined	Defined	Defined
Plant Location	General	Approximate	Specific	Specific	Specific
Soils & Hydrology	None	Preliminary	Defined	Defined	Defined
Integrated Project Plan	None	Preliminary	Defined	Defined	Defined
Project Master Schedule	None	Preliminary	Defined	Defined	Defined
Escalation Strategy	None	Preliminary	Defined	Defined	Defined
Work Breakdown Structure	None	Preliminary	Defined	Defined	Defined
Project Code of Accounts	None	Preliminary	Defined	Defined	Defined
Contracting Strategy	Assumed	Assumed	Preliminary	Defined	Defined
AACE Engineering Deliverables:					
Block Flow Diagrams	S/P	P/C	C	C	C
Plot Plans		S/P	C	C	C
Process Flow Diagrams (PFDs)		P	C	C	C
Utility Flow Diagrams (UFDs)		S/P	C	C	C
Piping & Instrument Diagrams (P&IDs)		S/P	C	C	C
Heat & Material Balances		S/P	C	C	C
Mechanical & Electrical Equipment List with horsepower's for the process & utilities (with vendor assisted budgetary pricing quotes or recent similar experience)		S/P	C	C	C
Utility Equipment List		S/P	C	C	C
Electrical One-Line Drawings		S/P	C	C	C
Specifications & Datasheets		S	P/C	C	C
General Equipment Arrangement Drawings		S	C	C	C
Spare Parts Listings			P	P	C
Mechanical Discipline Drawings			S/P	P/C	C
Electrical Discipline Drawings			S/P	P/C	C
Instrumentation/Control System Discipline Drawings			S/P	P/C	C
Civil/Structural/Site Discipline Drawings			S/P	P/C	C
Additional URS Engineering Deliverables:					
URS Classifications	**Order of Magnitude**		**Preliminary**		**Definitive**
Piping Line List			P		C
Valve List			MTO from P&ID's will be used		C
Insulation & Heat Trace Requirements			P		C
Area Classification			P		C

ESTIMATE BASIS

Building Envelope & Layouts	General Description	General Description	C
Demolition & Relocation Requirements	General Description	General Description	C
Similar Projects for Reference	If available	If available	If available
Owner Furnished items		P	C

4.0 QUANTITY and COST BASIS

The AECOM Direct Field Cost (DFC) accounts are:

Code of Account (CoA)	Quantity & Pricing Basis
01 Demolition	o By Owner prior to initiation of this project
02/03 Earthwork / Improvements to Site	o Scope and cost based on deliverables o Excavation and backfill for foundations, sewers (sanitary & storm), grounding and ductbank o Aggregate surface per civil dwg o Cut out opening in basement wall o Allowance for hauling excavated soil 5 miles plus dump fees o Sewer manholes o Sheet Piling/ Shoring o Underpinning o Bollards/Guardrails o Unqualified allowance of $100k for identification and removal of underground obstructions
04 Concrete	o Scope and cost based on deliverables o Foundations for equipment including supply and installation of ready-mix concrete, rebar, formwork, embeds, etc o Foundations for F-4, F-5, F-5A, F-6A, F-9, F-10, P-1 Basement, P-1 Piperack, P-1 Piperack at Cooling Pumps Mat, P-1 Cooling Tower, Basement Wall Footing o Drilled Piers, DP-1 and DP-2 at Superheater o Slab on grade for Basement and Connector o Support slabs for Connector Roof, Superheaters, 1st Floor, 1st Floor SOG, and Frost Slab o Grade Beams o Walls for P-2 Basement, Basement Walls, Walls at Tunnel, Saddle Walls at Dump Exchanger, Transformer Containment Walls, Section 2 and 2A/395-002 o Equipment Pads (over slab) for Hotwell

ESTIMATE BASIS

	tanks, Hotwell pumps, Ladder Pad at Cooling Tower o Equipment Foundations for Air Compressor, Turbine Foundation, Cooling Tower Pumps, Cooling Tower Skid-dyno, Ladder, Boilers, Deaerator, OWT System, Dump Exchanger, and Transformers.
05 Structural Steel	o Scope and cost based on deliverables o Structural steel associated with equipment including platforms, ladders, stairs, handrail, etc o Cooling Tower Platform o 1st Floor Building o Piperacks o Misc. Supports
06 Balance of Plant Equipment	o Scope and cost based on deliverables o P&IDs o Process Equipment List with COS o Pricing from suppliers or fabricators, in-house historical unit price information o Supply and Install scope and cost from GE Turbine and B&W is carried as Scope supplied by Owner
11 Piping	o Scope and cost based on deliverables o Small bore and large bore piping and valves based on MTO by dia, spec/metallurgy length. In house models used to incorporate fittings, welds, and hangers o Pricing based on large bore pipe being shop fabricated into spools to be shipped to field for installation and small bore pipe to be 100% field fabricated o Supply only scope and cost from GE Boiler is carried as Scope supplied by Owner. GE Boiler will supply shop fabricated pipe spools with prepared ends that can be shipped on a standard truck. AECOM is responsible for the pipe supports (other than welded attachments), insulation and installation. Assume the piping field joints will be all welded (no flanges). Also, assume the 10” piping and half of the small bore piping will be considered boiler external piping (subject to ASME Sect I stamping and documentation

ESTIMATE BASIS

	requirements). The balance of the piping will be nonboiler piping, fabricated and installed per B31.1. o Onsite sanitary sewer, storm sewer PVC piping per civil drawing o Overall breakdown of process piping based on qty: o **LB vs SB** o 75% Large Bore o 25% Small Bore o **Metallurgy** o 84% CS o 16% Alloy o (88% of Alloy Supplied by GE Boiler) o The existing natural gas service to the Youngstown Thermal site doesn't have adequate capacity for the component test boiler and superheater. This FEED scope therefore requires installation of an offsite new 8,000' natural gas line from offsite tie-in point to the project site. Routing of the natural gas line has to follow a route to avoid the downtown Youngstown area and Youngstown State University campus and also crosses US 422, a 4-lane highway. This estimate, provided by the project team, includes subcontracted costs for the above scope including purchase, install, pipe valves, trenching, backfill, bedding, road crossings, pigging (if applicable), and meter stations. This does not include asphalt paving, resurfacing, or patching.
12 Electrical	o Scope and cost based on deliverables o Ohio Edison has confirmed that there is sufficient power on the existing 23kV utility line that would feed the new power loads. The estimate includes a 600' overhead and one underground road crossing of 23kv power from offsite by Ohio Edison Utility to on site 35kv ABB switch and transformer inside curb o Underground ductbank to 4160V switchgear/MCC inside turbine bldg. o 480V MCCs in turbine bldg. to entire site in tray in piperack o Electrical power and control wire/cable,

ESTIMATE BASIS

	raceway o Grounding, lighting & receptacles including 3 indoor welding receptacles o 13 Cameras with sound for site and superheater structure including monitoring and recording equipment o Allowance for 2,090 feet of electrical heat tracing per the PHA due to potential for water lines to freeze if the facility is down during cold weather. It was recommended for the following instances: boiler feed water lines, low pressure feed water lines, city water lines, condensate lines, cooling water lines and instrument tubing and instruments in heated enclosures. The larger lines won't require tracing.
13 Instrumentation	o Scope and cost based on deliverables o AECOM to furnish and install AECOM instruments and control valves per instrumentation index, RIO cabinets, control room equipment and control room PLC, card readers for turbine bldg. exterior doors and fire detection on both floors of turbine bldg o B&W to furnish and install instruments and control valves per instrumentation index. AECOM to furnish and install instrumentation fiber optic cable to main PLC in turbine bldg. o GE Power to furnish and install instruments and control valves per instrumentation index. AECOM to furnish and install instrumentation fiber optic cable to main PLC in turbine bldg. o GE Boiler to furnish only instruments and control valves per instrumentation index. AECOM install GE Boiler instruments and control valves and to furnish and install instrumentation cabling to RIO cabinet and fiber optic cable to master controller in turbine bldg.
14 Painting	o Touch up of structural steel included
15 Insulation	o Scope and cost based pipe requirements

ESTIMATE BASIS

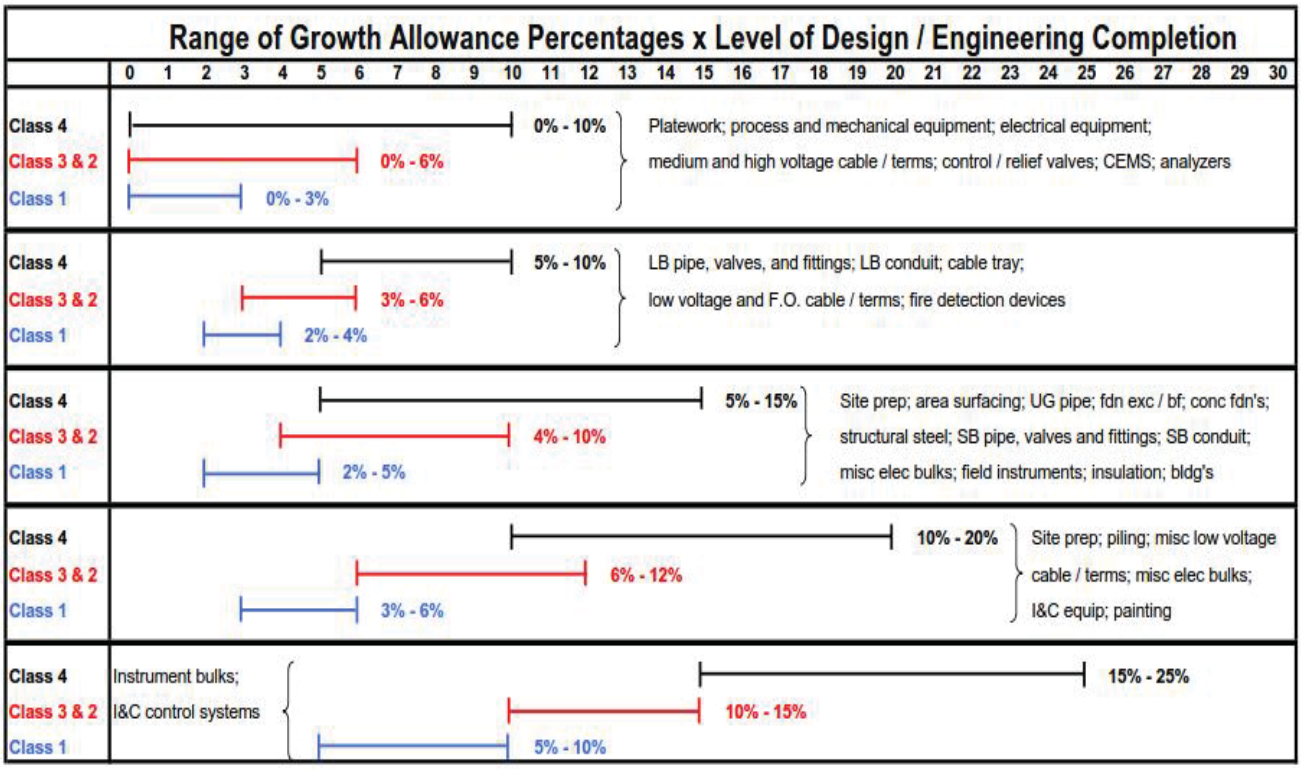
16 Buildings & Architectural	o Scope and cost based on deliverables o Turbine bldg as Pre-Engineered Metal Building (PEMB) supply and install per quotes o HVAC/Plumbing o Fire Detection & Alarms on both levels

Design Development

Material take-off (MTO) allowances are cost provisions for an entire activity (or activities), often identified as a one-line entry expressed in percentages of labor and materials, which at that point in time could not be completely identified in terms of specific scope items. Therefore, an allowance is established which reflects the estimator's best judgment of cost, based on many factors (e.g., degree of engineering completion, estimate methodology, quality and accuracy of material take-offs, etc.). Experience has shown these allowances will be spent. These allowances will decrease as additional scope is identified in detail design, and would be very minimal in an estimate prepared at completion of engineering.

The MTO allowances are based on the estimator's confidence in the commodity take-offs, and are a function of the documents, drawings, sketches, and specifications available to support the take-offs. The MTO allowances are deemed to be for quantities that the estimator was not able to take off, but experience shows will be required. For example, an estimate prepared prior to completion of design and engineering may require MTO allowances. The following is a guideline of Range of Growth Percentages by Level of Design/Engineering Completion.

ESTIMATE BASIS



NOTES: Class 4: Design & Engineering <20% complete
Class 3 & 2: Design & Engineering 20% - 80% complete
Class 1: Design & Engineering >80% complete

For this Class 3 estimate, the following MTO allowance is included:

6% Allowance for Earthwork, Concrete/Masonry, Structural Steel, Piping, Electrical, Instrument & Control, and Building
4% Allowance for Balance of Plant Equipment

5.0 CRAFT LABOR & PRODUCTIVITY

This estimate is based on a general contractor merit / open shop construction execution philosophy with specialty subcontractors, of 50 hours per week to attract skilled craft labor.

Direct Field Cost (DFC) labor rate of $55.00 per hour, includes premium pay for 50 hour work week, is based on recent open shop labor requirements, which includes:

Base labor	o Millwright o Instrument Fitter o Structural Ironworker o Pipefitter/Welder o Combination pipewelder

	o Electrician o Carpenter o Concrete finisher o Rebar ironworker o Operator – Heavy (NCCCO certified) o Operator – Medium o Operator – Light o Mechanic (gas & diesel) o Laborer For all craft: • Journeymen • Helpers • Foreman • General Foreman
Benefits, taxes & insurances	o Medical o Dental o Life o FICA o FUI o SUI o Workers compensation o Training

Estimated labor productivity is based on a typical USGC (US Gulf Coast) labor productivity plus an adjustment to allow for specific project requirements such as:

- Craftsmen experience and availability
- Schedule
- Supervision
- Access & congestion
- Material delivery and engineering
- Weather
- Height and elevation
- Size of project and site conditions

6.0 CONSTRUCTION INDIRECTS

Construction Indirect scope and cost are included based on contracting strategy which assumes an EPC contractor responsible for engineering after Detail Design, and includes procurement, construction, and commissioning of the facility. Construction Indirect scope includes:

ESTIMATE BASIS

Code of Account (CoA)	Scope Included
31 CONST. MANAGEMENT STAFF & SERVICES	Based on AECOM construction management of general contractor reporting to owner. Scope and costs include staff to meet 50 hour work week, per diem, home office support staff, engineering during construction, facilities & site office, computers, vehicles, safety supplies, project recognition and 3rd party inspections.
31 Contractor's Field Staff	Based on amount of Direct Craft Labor allowing for typical organization chart and staffing plan
32 Craft Indirects	o Craft orientation o Craft training o Welder qualifications o Drug testing of construction craft o Safety / tool box meetings o Craft show-up time, onsite downtime, training, incentives o Craft support / Material handling crews o Completion bonus
33 Temporary facilities	The following are included to meet typical project requirements o Temporary power, water and utilities o Contractor office complex/trailers o potable water & ice o construction water o temporary roads & parking o construction laydown area will be prepared by others and these costs are not included in this estimate o weather protection o temporary toilets o site janitorial o general site clean-up o dumpster service o temporary fencing o surveying
41 Construction Equipment	Includes mobilization, rental, maintenance, operation and demobilization for the following types of rental equipment: o Cranes and accessories o Lifting and hoisting equipment o Earthwork, piling and dewatering equipment

	o Concrete and demolition equipment o Compressors, Blowers, HVAC and Pneumatic equipment o Job vehicles o Heavy trucks, tractors and trailers o Miscellaneous equipment o Cutting, welding & sheetmetal equipment
41 Scaffolding	Based on USGC Greenfield site
41 Small tools & consumables	Based on Direct Field Cost (DFC)
49 Construction Camp	Not required
49 Per Diem	Not Included for craft or contractor supervision; included for construction management
51 Startup support	Included as allowance for AECOM professional services, craft support, and vendor representatives

7.0 HOME OFFICE ENGINEERING

Costs for Home Office engineering and support are listed below and includes packaging documents for construction and programming of PLC:

- FEED $ 798,000
- Detailed Engineering $3,100,000
- **TOTAL** **$3,898,000**

8.0 SUMMARY SHEET MARKUPS

- Insurance included as allowance of 1.02% of total Installed cost (TIC)
- Taxes NOT INCLUDED, specific rate and basis by state to be determined as applicable including potential for state tax exemption on permanent equipment and materials
- Freight included as allowance of 8% of total equipment and material
- Contingency excluded per direction from Client
- Escalation Included to meet project schedule at 3.5% per year to midpoint of schedule
- Fee includes AECOM G&A and fee
- Owner's Cost NOT INCLUDED
- Supply & Install costs from GE Power, B&W and GE Boiler
  - o GE Power $29,390,000
  - o B&W $29,019,000

- GE Boiler $ 7,900,000

9.0 DEMOLITION & DECOMMISIONING of BOP PROJECT

Upon completion of the test project (approximately 2 years), an estimate of the costs to demolish BOP scope has been prepared, utilizing demolition specialty subcontractor with direction from engineering deliverables. The execution strategy is for the demolition subcontractor to take all commodities associated with scope below and haul away from site:

- Turbine Building
  - Equipment to remain in-place:
    - 30 Ton Bridge Crane
    - Air Compressor skid in basement
  - Equipment to be removed for salvage:
    - PU-7001-A, B Hot Well Pumps
  - Equipment to be removed and scrapped:
    - TK-7001-A, B Hot Well Tanks
  - Turbine bldg, HVAC, electrical, lighting and plumbing (assuming control room stays)
- Yard Equipment
  - Equipment to remain in-place:
    - CT-7004-A thru F Cooling Towers
    - Cooling Tower Water Treatment System
    - PU-7002-A, B, C Dump Exchanger Feed Pumps
  - Equipment to be removed for salvage:
    - PU-7003-A, B Dynamometer Supply Pumps
    - PU-6002-A, B Condensate Return Pumps
    - B-591 Boiler including Burner, Fan, Fan Motor, Economizer, Stack and interconnecting duct work
    - Rental Deaerator/Pump Skid-return to rental company
    - Demineralizer/Filter Skid-return to rental company
  - Equipment to be removed and scrapped:
    - HE-6001 Dump Exchanger
    - DS-2201 Desuperheater
    - OWT System
- Balance of Pant Scope to remain unchanged
    - Underground scope is unchanged (foundations, ductbanks, sheet piling)
    - Piperack scope (structural steel, pipe, cable tray, cable)

10.0 ASSUMPTIONS & EXCLUSIONS

- Construction is based on 10 months of “Pre-Construction activities (Gas Line and Power into jobsite), and 19 months of hard construction inside of area

ESTIMATE BASIS

footprint. All construction and commissioning is expected to be complete by September 2018. No escalations have been accounted for beyond that date.

- Adjustments to meet MBWE, FBE or DBE are not included
- Project team used soils report, estimating does not have copy. Assume design basis incorporates soils report.
- Assume project team has met Class 3 estimate deliverable requirements.
- Piping specifications were requested but were not received.
- In lieu of specifications, we have included $12/lnft for testing, cleaning, and post weld heat treatment.
- Building does not include fire protection and suppression.
- This project is not subject to affects from existing facilities including hot permits, firewatch, work shut downs, or daily work permits.
- Assume boiler and cooling towers are packaged equipment, i.e. minimal installation.
- No additional isolation from existing building or specials measures, or cost allowed for work inside existing building during construction.
- Sound attenuation not included.
- Insulation of boiler not included.
- Estimating has not received the FEED or detailed design estimates, project schedule, specifications, GE Power, B&W or GE Boiler quotes to determine scope included in each.
- Estimating assumes GE Power, B&W, and GE Boiler quotes include all piping, electrical instruments, insulation, construction installation, and all construction indirect costs. This estimate does not include any management or insurance of these scopes.
- Estimating has incorporated third party construction management
- Estimating does not have project specific basis for insurance requirements and estimate includes liability insurance, excluding scope by others.
- Assume piping length provided is through center line of all piping fittings and valves, and includes all changes in directions.
- Adjustments to meet MBE, FBE, or DBE requirements have not been included
- This FEED estimate represents scoping costs through start up.
- This estimate has not been prepared to comply with DCAA or FAR requirements.
- Estimate includes unqualified allowance for identification and removal of underground obstructions
- Estimate does not include costs for remediation
- Estimate does not include spare parts or first fills.
- Labor productivity has been included to meet specific project requirements in existing operating plant.
- Lead/Asbestos abatement excluded
- No hazardous materials
- Material pricing based on project team quotes and in house database information

ESTIMATE BASIS

- Existing soil can be re-used as backfill
- Area available for laydown
- All areas to be non-classified areas.
- Excludes ARC Flash Protection and VFDs.
- Excludes Gas Detection System.
- Excludes lightning protection, communication systems and PAGA Systems
- Existing 23kV distribution line is within 600' of the site and has sufficient power.

Please note that the cost estimates provided herein are dependent upon the various underlying assumptions, inclusions, and exclusions utilized in developing them. Actual project costs will differ, and can be significantly affected by factors such as changes in the external environment, the manner in which the project is implemented, and other factors which impact the estimate basis or otherwise affect the project. Estimate accuracy ranges are only projections based upon cost estimating methods and are not a guarantee of actual project costs.

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CLIENT:	Energy Industries of Ohio (EIO)								**DATE:**	31-Mar-16				
PROJECT:	Advanced Ultra-Supercritical Component Test Project (A-USC COMTEST)								**PREPARED BY:**	RAS/WCM/RER				
LOCATION:	Youngstown, OH								**FIELD LAB FACT:**	1.20				
JOB NO.:	31609								**FIELD LAB RATE:**	$55.00				
REV NO.:	0													
	FEED Estimate Subcontract Basis													
				LABOR			**SUBCONTRACT**							
ACCT	**DESCRIPTION**	**KEY QUANTITIES**		**FIELD WORKHOURS**	**FIELD LABOR TOTAL COST**	**MATERIAL**	**SUBCONTRACT LABOR HOURS**	**SUBCONTRACT TOTAL COST**	**TOTAL**		**% of DFC**	**% of TIC**	**Equip Fac**	
01	DEMOLITION				$ -	$ -		$ -	NOT INCLUDED					
02	SITEWORK, PREPARATIONS AND IMPROVEMENTS			2,284	$ 125,607	$ 46,913		$ 106,000	$ 278,520		1.2%	0.7%		
03	EARTHWORK			7,498	$ 412,406	$ 269		$ 465,570	$ 878,245		3.9%	2.3%		
04	CONCRETE/ MASONRY	1,288	cy conc	27,048	$ 1,487,652	$ 449,558		$ -	$ 1,937,210		8.6%	5.0%		
05	STRUCTURAL STEEL/ PLATEWORK	144	tons	2,935	$ 161,427	$ 603,722		$ -	$ 765,149		3.4%	2.0%		
06	BALANCE OF PLANT EQUIPMENT	24	each	4,297	$ 236,339	**$ 4,840,623**		$ 72,219	$ 5,149,181		22.8%	13.3%		
11	PIPING	7,626	lft pipe	28,245	$ 1,553,490	$ 1,323,028		$ 104,899	$ 2,981,417		13.2%	7.7%		
	PIPELINE				$ -	**$ -**		$ 4,000,000	$ 4,000,000		17.7%	10.3%		
12	ELECTRICAL	61,324	lft w/c	21,556	$ 1,185,558	$ 1,461,955		$ 147,446	$ 2,794,959		12.4%	7.2%		
13	INSTRUMENTATION	117	ea instr/CV	4,151	$ 228,307	$ 1,760,050		$ 44,848	$ 2,033,205		9.0%	5.2%		
14	PAINTING / COATING / LINING				$ -	$ -		$ 17,780	$ 17,780		0.1%	0.0%		
15	INSULATION				$ -	$ -		$ 261,904	$ 261,904		1.2%	0.7%		
16	BUILDINGS			757	$ 41,658	$ 12,606		$ 610,775	$ 665,039		2.9%	1.7%		
21	SPARE PARTS & FIRST FILLS				$ -	$ -		$ -	NOT INCLUDED					
22	FREIGHT	8.00%			$ -	$ 839,898		$ -	$ 839,898		3.7%	2.2%		
	DIRECT FIELD COST		**$ 55.00**	**98,771**	**$ 5,432,444**	**$ 11,338,622**	**-**	**$ 5,831,441**	**$ 22,602,507**			**58.3%**	**466.9%**	
31	FIELD STAFF & SERVICES		6.07	16,260	$ 1,224,690	$ 333,490		$ -	$ 1,558,180		$15.78			
32	CRAFT LABOR RELATED EXPENSES			10,100	$ 802,018	$ 165,930		$ -	$ 967,948		$9.80			
33	TEMP. CONST. FAC., FURNISHINGS, SERVICES			5,410	$ 276,100	$ 346,160		$ -	$ 622,260		$6.30			
41	CONSTRUCTION EQUIPMENT			1,870	$ 95,640	$ 872,680		$ -	$ 968,320		$9.80			
42	SMALL TOOLS/ CONSUMABLES			-	$ 395,080	$ -		$ -	$ 395,080		$4.00			
43	SCAFFOLDING			9,880	543,404	48,900		$ -	$ 592,304		$6.00			
49	CRAFT SUBSISTENCE - PER DIEM				$ -	$ -	-	$ -	NOT INCLUDED					
	FREIGHT				$ -	$ 141,373	-	$ -	$ 141,373					
	CONTRACTOR INDIRECT FIELD COST			43,520	$ 3,336,932	$ 1,908,533	-	$ -	$ 5,245,465		**$51.68**	**13.5%**		
	TOTAL FIELD COST			**142,291**	**$ 8,769,376**	**$ 13,247,155**	**-**	**$ 5,831,441**	**$ 27,847,972**			**71.8%**	**575.3%**	
31	CONST. MANAGEMENT STAFF & SERVICES		2.67	37,059	$ 5,488,917	$ -	$ -	$ -	$ 5,488,917		$55.57	14.2%		
51	START UP SUPPORT (includes AECOM Professional Services, craft support & vendor representatives)							$ 250,000	$ 250,000		$2.53	0.6%		
61	ENGINEERING HOME OFFICE SERVICES - FEED				798,000				$ 798,000			2.1%		
61	ENGINEERING HOME OFFICE SERVICES - Detailed Engineering				3,100,000				$ 3,100,000			8.0%		
	TOTAL FIELD, HOME OFFICE and OTHER SERVICES				**$ 18,156,293**	**$ 13,247,155**	**-**	**$ 6,081,441**	**$ 37,484,889**			**96.6%**	**774.4%**	
71	INSURANCE, Excluding scope by others	1.02%	of TIC		$ 392,000	$ -	-	$ -	$ 392,000			1.0%		
72	TAXES (STATE TAX ONLY, ALLOWANCE)				$ -	$ -		$ -	NOT INCLUDED					
73	BONDS							$ -	NOT INCLUDED					
74	PERMITS								NOT INCLUDED					
75	FINANCING								NOT INCLUDED					
	SUBTOTAL:				*$ 392,000*	*$ -*	-	*$ -*	*$ 392,000*			*1.0%*		
92	CONTINGENCY, on all costs Excluding scope by others	NOT INCLUDED PER CLIENT DIRECTION							EXCLUDED					
94	ESCALATION	to meet project schedule at 3.5% per year to midpoint of 18 month schedule							$ 910,400			2.3%		
	TOTAL INSTALLED COST				$ 18,548,293	$ 13,247,155	-	$ 6,081,441	$ 38,787,000			**100%**	**801%**	
	PROJECT FEE (includes G&A & fee, excludes Construction mgmt and engineering)								$ 3,828,479					
	OWNER'S COST								NOT INCLUDED					
	Supply & Install Equipment Scope by others: GE Turbine and B&W								$ 58,409,000					
	Supply only Piping scope by others: GE Boiler								$ 7,900,000					
	Decommissioning, demolition and salvage of specific scope excluding equipment, commodities and Turbine bldg to remain place								$ 3,213,000					
	GRAND TOTAL								**$ 112,137,000**				**23.17**	

CLIENT:	Energy Industries of Ohio (EIO)	20-Jan-16	31-Mar-16	31-Mar-16	
PROJECT:	Advanced Ultra-Supercritical Component Test Project (A-USC COMTEST)	RAS	RAS/WCM/RER		
LOCATION:	Youngstown, OH	1.20	1.20		
JOB NO.:	31609	$55.00	$55.00		
REV NO.:	0		rev 0		
	FEED Estimate				

ACCT	DESCRIPTION	PREVIOUS ROM TOTAL	CURRENT FEED TOTAL	DELTA	COMMENT
01	DEMOLITION	NOT INCLUDED	NOT INCLUDED		
02	SITEWORK, PREPARATIONS AND IMPROVEMENTS	$ 5,000	$ 278,520	$ 273,520	based on MTO , now sanitary & storm sewers and aggregate site surfacing
03	EARTHWORK	$ 350,600	$ 878,245	$ 527,645	based on MTO per geotech report
04	CONCRETE/ MASONRY	$ 1,120,500	$ 1,937,210	$ 816,710	based on MTO, equipment now permanent with foundaions, bldg has basement
05	STRUCTURAL STEEL/ PLATEWORK	$ 580,900	$ 765,149	$ 184,249	based on MTO, piperack defined
06	BALANCE OF PLANT EQUIPMENT	$ 979,200	$ 5,149,181	$ 4,169,981	ROM based on more rental equipment ie BOILER NOW PURCHASED $3.1mil
11	PIPING	$ 2,287,200	$ 2,981,417	$ 694,217	based on MTO, definition of metallurgy & wall thk
	PIPELINE	NOT INCLUDED	$ 4,000,000	$ 4,000,000	NEW $4mil OFFSITE NAT GAS LINE
12	ELECTRICAL	$ 2,306,000	$ 2,794,959	$ 488,959	based on MTO, definition of bldg elec PLUS OFFSITE 23kv OH LINE
13	INSTRUMENTATION	$ 1,574,700	$ 2,033,205	$ 458,505	based on MTO, definition & quotes for CV PLUS control system & room
14	PAINTING / COATING / LINING	$ 244,400	$ 17,780	$ (226,620)	now only touch-up
15	INSULATION	$ 339,800	$ 261,904	$ (77,896)	based on pipe MTO
16	BUILDINGS	$ 924,000	$ 665,039	$ (258,961)	Bldg based on supply & install PEMB quote
21	SPARE PARTS & FIRST FILLS	NOT INCLUDED	NOT INCLUDED		
22	FREIGHT	$ 526,000	$ 839,898	$ 313,898	same 8% more mat'l as base
	DIRECT FIELD COST	**$ 11,238,300**	**$ 22,602,507**	**$ 11,364,207**	
31	FIELD STAFF & SERVICES	$ 3,286,800	$ 1,558,180	$ (1,728,620)	direct craft hours reduced to 84k, previously 96k
32	CRAFT LABOR RELATED EXPENSES	$ 939,200	$ 967,948	$ 28,748	
33	TEMP. CONST. FAC., FURNISHINGS, SERVICES	$ 603,800	$ 622,260	$ 18,460	
41	CONSTRUCTION EQUIPMENT	$ 1,147,819	$ 968,320	$ (179,499)	
42	SMALL TOOLS/ CONSUMABLES	$ 383,400	$ 395,080	$ 11,680	
43	SCAFFOLDING	Incl w const equip	$ 592,304	$ 592,304	previously included with construction equipment
49	CRAFT SUBSISTENCE - PER DIEM	NOT INCLUDED	NOT INCLUDED	$ -	
	FREIGHT		$ 141,373	$ 141,373	previously included in freight above
	INDIRECT FIELD COST	$ 6,361,019	$ 5,245,465	$ (1,115,554)	
	TOTAL FIELD COST	**$ 17,599,319**	**$ 27,847,972**	**$ -**	
31	CONST. MANAGEMENT STAFF & SERVICES, Third Party Constructi	NOT INCLUDED	$ 5,488,917	$ 5,488,917	Included Third party CM
51	START UP SUPPORT	NOT INCLUDED	$ 250,000	$ 250,000	Included Start up support
61	ENGINEERING HOME OFFICE SERVICES - FEED	$ 798,000	$ 798,000	$ -	
61	ENGINEERING HOME OFFICE SERVICES - Detailed Engineering	$ 3,100,000	$ 3,100,000	$ -	
	TOTAL FIELD, HOME OFFICE and OTHER SERVICES	**$ 21,497,319**	**$ 37,484,889**	**$ -**	
71	INSURANCE, Excluding scope by others	$ 237,000	$ 392,000	$ 155,000	based on TIC
72	TAXES (STATE TAX ONLY, ALLOWANCE)	NOT INCLUDED	NOT INCLUDED	$ -	
73	BONDS	NOT INCLUDED	NOT INCLUDED	$ -	
74	PERMITS	NOT INCLUDED	NOT INCLUDED	$ -	
75	FINANCING	NOT INCLUDED	NOT INCLUDED	$ -	
	SUBTOTAL:	*$ 237,000*	*$ 392,000*	$ -	
92	CONTINGENCY	$ 3,260,000	EXCLUDED	$ (3,260,000)	per client direction, contingency DELETED
94	ESCALATION	NOT INCLUDED	$ 910,400	$ 910,400	$ -
	TOTAL INSTALLED COST	$ 24,994,000	$ 38,787,000	$ 13,793,000	
	PROJECT FEE	EXCLUDED	$ 3,828,479	$ 3,828,479	
	OWNER'S COST	NOT INCLUDED	NOT INCLUDED	$ -	
	Supply & Install Equipment Scope by others: GE Turbine and B&W	$ 58,409,000	$ 58,409,000	$ -	
	Supply only Piping scope by others: GE Boiler	$ 7,900,000	$ 7,900,000	$ -	
	Decommissoning & demo of above ground scope excluding Turbine Bldg		$ 3,213,000	$ 3,213,000	
	GRAND TOTAL	**$ 91,303,000**	**$ 112,137,000**	**$ 20,834,000**	

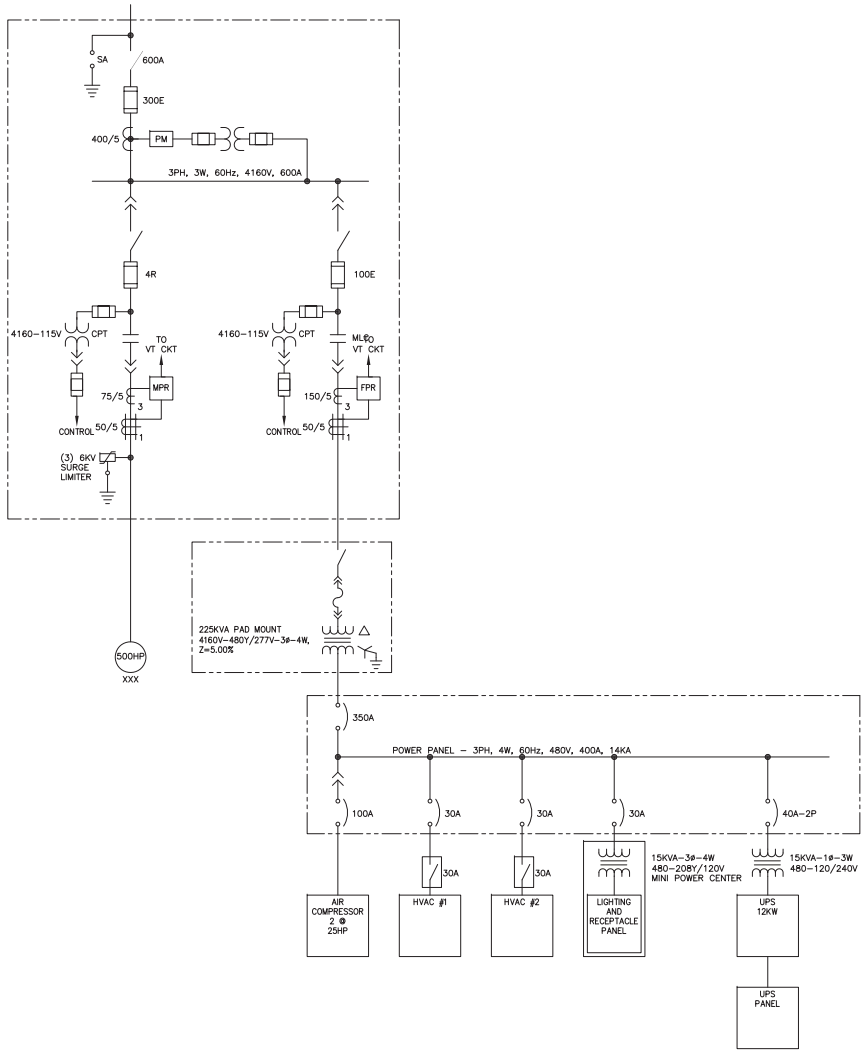
CLIENT:	Energy Industries of Ohio (EIO)								**DATE:**	31-Mar-16		
PROJECT:	**Decommissioning, demolition and salvage of specific scope excluding equipment, commodities and Turbine bldg to remain place**								**PREPARED BY:**	RAS/WCM/RER		
LOCATION:	Youngstown, OH								**FIELD LAB FACT:**	1.20		
JOB NO.:	31609								**FIELD LAB RATE:**	$110.00		
REV NO.:	0											
	FEED Estimate											
				LABOR			**SUBCONTRACT**					
ACCT	**DESCRIPTION**	**KEY QUANTITIES**		**FIELD WORKHOURS**	**FIELD LABOR TOTAL COST**	**MATERIAL**	**SUBCONTRACT LABOR HOURS**	**SUBCONTRACT TOTAL COST**	**TOTAL**	**% of DFC**	**% of TIC**	**Equip Fac**
01	DEMOLITION					$ -	15,977	$ 1,757,448	$ 1,757,448	100.0%	66.4%	
02	SITEWORK, PREPARATIONS AND IMPROVEMENTS	SITEWORK, PREPARATIONS AND IMPROVEMENTS remains in place, demo not applicable										
03	EARTHWORK	EARTHWORK remains in place, demo not applicable										
04	CONCRETE/ MASONRY	CONCRETE/ MASONRY remains in place, demo not applicable										
05	STRUCTURAL STEEL/ PLATEWORK	STRUCTURAL STEEL/ PLATEWORK remains in place, demo not applicable										
06	BALANCE OF PLANT EQUIPMENT	Demo of specified BALANCE OF PLANT EQUIPMENT and demo & salvage of specified BALANCE OF PLANT EQUIPMENT										
11	PIPING	Demo of PIPING supporting GE Boiler, GE Power and B&W scope only										
	NATURAL GAS PIPELINE	NATURAL GAS PIPELINE remains in place, demo not applicable										
12	ELECTRICAL	Demo of specific ELECTRICAL commodities, excluding scope supporting BOP equip remaining in place & Turbine bldg										
13	INSTRUMENTATION	Demo of specific INSTRUMENTATION commodities, excluding scope supporting BOP equip remaining in place & Turbine bldg										
14	PAINTING / COATING / LINING	PAINTING / COATING / LINING remains in place, demo not applicable										
15	INSULATION	Demo of INSULATION supporting GE Boiler, GE Power and B&W scope only										
16	BUILDINGS	BUILDINGS remains in place, demo not applicable										
21	SPARE PARTS & FIRST FILLS											
22	FREIGHT											
	DIRECT FIELD COST		**$ -**	**-**	**$ -**	**$ -**	**15,977**	**$ 1,757,448**	**$ 1,757,448**		**54.7%**	
31	CONST. MANAGEMENT STAFF & SERVICES		2.67	5,995	$ 887,865	$ -	$ -	$ -	$ 887,865			
31	FIELD STAFF & SERVICES			-	$ -	$ -		$ -	INCLUDED ABOVE			
32	CRAFT LABOR RELATED EXPENSES			-	$ -	$ -		$ -	INCLUDED ABOVE			
33	TEMP. CONST. FAC., FURNISHINGS, SERVICES			-	$ -	$ -		$ -	INCLUDED ABOVE			
41	CONSTRUCTION EQUIPMENT			-	$ -	$ -		$ -	INCLUDED ABOVE			
42	SMALL TOOLS/ CONSUMABLES			-	$ -	$ -		$ -	INCLUDED ABOVE			
43	SCAFFOLDING			-				$ -	INCLUDED ABOVE			
49	CRAFT SUBSISTENCE - PER DIEM								NOT INCLUDED			
51	START UP SUPPORT (includes AECOM Professional Services, craft support & vendor representatives)								NOT INCLUDED			
	FREIGHT					$ -			$ -			
	INDIRECT FIELD COST			5,995	$ 887,865	$ -	-	$ -	$ 887,865		**27.6%**	
	TOTAL FIELD COST			**5,995**	**$ 887,865**	**$ -**	**15,977**	**$ 1,757,448**	**$ 2,645,313**		**82.3%**	
61	ENGINEERING HOME OFFICE SERVICES - FEED								$ -			
61	ENGINEERING HOME OFFICE SERVICES - Detailed Engineering				397,000				$ 397,000		12.4%	
	TOTAL FIELD, HOME OFFICE and OTHER SERVICES				**$ 1,284,865**	**$ -**	**15,977**	**$ 1,757,448**	**$ 3,042,313**		**94.7%**	
71	INSURANCE, Excluding scope by others	1.02%	of TIC		$ 34,000				$ 34,000		1.1%	
72	TAXES (STATE TAX ONLY, ALLOWANCE)				$ -	$ -		$ -	NOT INCLUDED			
73	BONDS							$ -	NOT INCLUDED			
74	PERMITS								NOT INCLUDED			
75	FINANCING								NOT INCLUDED			
	SUBTOTAL:				*$ 34,000*	*$ -*	-	*$ -*	*$ 34,000*		*1.1%*	
92	CONTINGENCY, on all costs Excluding scope by others	NOT INCLUDED PER CLIENT DIRECTION							EXCLUDED			
94	ESCALATION	to meet project schedule at 3.5% per year to midpoint after 18 months construction plus 2 years operation							$ 136,400		4.2%	
	TOTAL INSTALLED COST				$ 1,318,865	$ -	15,977	$ 1,757,448	$ 3,213,000		**100%**	
	PROJECT FEE (inludes G&A & fee)								EXCLUDED			
	OWNER'S COST								NOT INCLUDED			
	GRAND TOTAL								**$ 3,213,000**			-

CLIENT:	Energy Industries of Ohio (EIO)								**DATE:**	05-Apr-16			
PROJECT:	Youngstown Thermal Boiler Case YTB								**PREPARED BY:**	RAS/WCM/RER			
LOCATION:	Youngstown, OH								**FIELD LAB FACT:**	1.20			
JOB NO.:	31609								**FIELD LAB RATE:**	$55.00			
REV NO.:	0												
	FEED Estimate YTB												
				LABOR			SUBCONTRACT						
ACCT	**DESCRIPTION**	**KEY QUANTITIES**		**FIELD WORKHOURS**	**FIELD LABOR TOTAL COST**	**MATERIAL**	**SUBCONTRACT LABOR HOURS**	**SUBCONTRACT TOTAL COST**	**TOTAL**	**% of DFC**	**% of TIC**	**Equip Fac**
01	DEMOLITION				$ -	$ -		$ -	NOT INCLUDED			
02	SITEWORK, PREPARATIONS AND IMPROVEMENTS			2,114	$ 116,255	$ 41,088		$ 100,000	$ 257,343	1.9%	0.9%	
03	EARTHWORK			7,000	$ 385,002	$ 254		$ 432,000	$ 817,256	6.0%	2.8%	
04	CONCRETE/ MASONRY	1,168	cy conc	24,796	$ 1,363,802	$ 396,491		$ -	$ 1,760,293	13.0%	6.1%	
05	STRUCTURAL STEEL/ PLATEWORK	144	tons	2,769	$ 152,289	$ 569,549		$ -	$ 721,838	5.3%	2.5%	
06	BALANCE OF PLANT EQUIPMENT	23	each	2,317	$ 127,457	**$ 1,497,445**		$ 69,441	$ 1,694,343	12.5%	5.9%	
11	PIPING	6,366	lft pipe	23,946	$ 1,317,029	$ 1,121,534		$ 99,012	$ 2,537,575	18.7%	8.8%	
	PIPELINE							Provided By Youngstown Thermal				
12	ELECTRICAL	58,366	lft w/c	18,916	$ 1,040,370	$ 1,326,208		$ 139,100	$ 2,505,678	18.4%	8.7%	
13	INSTRUMENTATION	117	ea instr/CV	3,868	$ 212,744	$ 1,655,028		$ 42,309	$ 1,910,081	14.1%	6.6%	
14	PAINTING / COATING / LINING				$ -	$ -		$ 16,774	$ 16,774	0.1%	0.1%	
15	INSULATION				$ -	$ -		$ 205,750	$ 205,750	1.5%	0.7%	
16	BUILDINGS			715	$ 39,303	$ 11,892		$ 576,203	$ 627,398	4.6%	2.2%	
21	SPARE PARTS & FIRST FILLS								NOT INCLUDED			
22	FREIGHT	8.00%				$ 529,559			$ 529,559	3.9%	1.8%	
	DIRECT FIELD COST		**$ 55.00**	**86,441**	**$ 4,754,251**	**$ 7,149,048**	**-**	**$ 1,680,589**	**$ 13,583,888**		**47.1%**	**907.1%**
31	CONST. MANAGEMENT STAFF & SERVICES		2.33	37,059	$ 5,488,917				$ 5,488,917	$63.50		
31	FIELD STAFF & SERVICES		6.07	14,230	$ 1,071,810	$ 291,860		$ -	$ 1,363,670	$15.78		
32	CRAFT LABOR RELATED EXPENSES			8,840	$ 701,903	$ 145,220		$ -	$ 847,123	$9.80		
33	TEMP. CONST. FAC., FURNISHINGS, SERVICES			4,740	$ 241,630	$ 302,950		$ -	$ 544,580	$6.30		
41	CONSTRUCTION EQUIPMENT			1,640	$ 83,700	$ 868,330		$ -	$ 952,030	$11.01		
42	SMALL TOOLS/ CONSUMABLES				$ 345,760	$ -		$ -	$ 345,760	$4.00		
43	SCAFFOLDING			8,640	475,200	42,800		$ -	$ 518,000	$5.99		
49	CRAFT SUBSISTENCE - PER DIEM								NOT INCLUDED			
51	START UP SUPPORT (includes AECOM Professional Services, craft support & vendor representatives)							$ 250,000	$ 250,000	$2.89	0.9%	
	FREIGHT	8.00%				$ 132,093			$ 132,093			
	INDIRECT FIELD COST			75,149	$ 8,408,919	$ 1,783,253	-	$ 250,000	$ 10,442,172	**$55.77**	**36.2%**	
	TOTAL FIELD COST			**161,590**	**$ 13,163,170**	**$ 8,932,301**	**-**	**$ 1,930,589**	**$ 24,026,060**		**83.4%**	**1604.5%**
61	ENGINEERING HOME OFFICE SERVICES - FEED				798,000				$ 798,000		2.8%	
61	ENGINEERING HOME OFFICE SERVICES - Detailed Engineering				3,100,000				$ 3,100,000		10.8%	
	TOTAL FIELD, HOME OFFICE and OTHER SERVICES				**$ 17,061,170**	**$ 8,932,301**	**-**	**$ 1,930,589**	**$ 27,924,060**		**96.9%**	**1864.8%**
71	INSURANCE, Excluding scope by others	1.02%	of TIC		$ 294,000				$ 294,000		1.0%	
72	TAXES (STATE TAX ONLY, ALLOWANCE)				$ -	$ -		$ -	NOT INCLUDED			
73	BONDS							$ -	NOT INCLUDED			
74	PERMITS								NOT INCLUDED			
75	FINANCING								NOT INCLUDED			
	SUBTOTAL:				*$ 294,000*	*$ -*	-	*$ -*	*$ 294,000*		*1.0%*	
92	CONTINGENCY, on all costs Excluding scope by others	NOT INCLUDED PER CLIENT DIRECTION							EXCLUDED			
94	ESCALATION	to meet project schedule at 3.5% per year to midpoint of 18 month schedule							$ 601,700		2.1%	
	TOTAL INSTALLED COST				$ 17,355,170	$ 8,932,301	-	$ 1,930,589	$ 28,820,000		**100%**	**1925%**
	PROJECT FEE (includes G&A & fee, excludes Construction mgmt and engineering)								$ 2,530,576			
	OWNER'S COST								NOT INCLUDED			
	Supply & Install Equipment Scope by others: GE Turbine and B&W								$ 58,409,000			
	Supply only Piping scope by others: GE Boiler								$ 7,900,000			
	Decommissioning, demolition and salvage of specific scope excluding equipment, commodities and Turbine bldg to remain place								$ 2,486,000			
	GRAND TOTAL								**$ 100,146,000**			**66.88**

CLIENT:	Energy Industries of Ohio (EIO)							**DATE:**	05-Apr-16			
PROJECT:	**Decommissioning, demolition and salvage of specific scope excluding equipment, commodities and Turbine bldg to remain place**							**PREPARED BY:**	RAS/WCM/RER			
LOCATION:	Youngstown, OH							**FIELD LAB FACT:**	1.20			
JOB NO.:	31609							**FIELD LAB RATE:**	$110.00			
REV NO.:	0											
	FEED Estimate											
				LABOR			**SUBCONTRACT**					
ACCT	**DESCRIPTION**	**KEY QUANTITIES**		**FIELD WORKHOURS**	**FIELD LABOR TOTAL COST**	**MATERIAL**	**SUBCONTRACT LABOR HOURS**	**SUBCONTRACT TOTAL COST**	**TOTAL**	**% of DFC**	**% of TIC**	**Equip Fac**
01	DEMOLITION					$ -	11,819	$ 1,300,068	$ 1,300,068	100.0%	63.4%	
02	SITEWORK, PREPARATIONS AND IMPROVEMENTS	SITEWORK, PREPARATIONS AND IMPROVEMENTS remains in place, demo not applicable										
03	EARTHWORK	EARTHWORK remains in place, demo not applicable										
04	CONCRETE/ MASONRY	CONCRETE/ MASONRY remains in place, demo not applicable										
05	STRUCTURAL STEEL/ PLATEWORK	STRUCTURAL STEEL/ PLATEWORK remains in place, demo not applicable										
06	BALANCE OF PLANT EQUIPMENT	Demo of specified BALANCE OF PLANT EQUIPMENT **(Excludes Boiler, Deaerator, & Demineralizer)** and demo & salvage of specified BALANCE OF PLANT EQUIPM										
11	PIPING	Demo of PIPING supporting GE Boiler, GE Power and B&W scope only										
	NATURAL GAS PIPELINE	NATURAL GAS PIPELINE remains in place, demo not applicable										
12	ELECTRICAL	Demo of specific ELECTRICAL commodities, excluding scope supporting BOP equip remaining in place & Turbine bldg										
13	INSTRUMENTATION	Demo of specific INSTRUMENTATION commodities, excluding scope supporting BOP equip remaining in place & Turbine bldg										
14	PAINTING / COATING / LINING	PAINTING / COATING / LINING remains in place, demo not applicable										
15	INSULATION	Demo of INSULATION supporting GE Boiler, GE Power and B&W scope only										
16	BUILDINGS	BUILDINGS remains in place, demo not applicable										
21	SPARE PARTS & FIRST FILLS											
22	FREIGHT											
	DIRECT FIELD COST		**$ -**	**-**	**$ -**	**$ -**	**11,819**	**$ 1,300,068**	**$ 1,300,068**		**52.3%**	
31	CONST. MANAGEMENT STAFF & SERVICES		2.33	5,067	$ 750,482	$ -	$ -	$ -	$ 750,482			
31	FIELD STAFF & SERVICES			-	$ -	$ -		$ -	INCLUDED ABOVE			
32	CRAFT LABOR RELATED EXPENSES			-	$ -	$ -		$ -	INCLUDED ABOVE			
33	TEMP. CONST. FAC., FURNISHINGS, SERVICES			-	$ -	$ -		$ -	INCLUDED ABOVE			
41	CONSTRUCTION EQUIPMENT			-	$ -	$ -		$ -	INCLUDED ABOVE			
42	SMALL TOOLS/ CONSUMABLES			-	$ -	$ -		$ -	INCLUDED ABOVE			
43	SCAFFOLDING			-				$ -	INCLUDED ABOVE			
49	CRAFT SUBSISTENCE - PER DIEM								NOT INCLUDED			
51	START UP SUPPORT (includes AECOM Professional Services, craft support & vendor representatives)								NOT INCLUDED			
	FREIGHT					$ -			$ -			
	INDIRECT FIELD COST			5,067	$ 750,482	$ -	-	$ -	$ 750,482		**30.2%**	
	TOTAL FIELD COST			**5,067**	**$ 750,482**	**$ -**	**11,819**	**$ 1,300,068**	**$ 2,050,550**		**82.5%**	
61	ENGINEERING HOME OFFICE SERVICES - FEED								$ -			
61	ENGINEERING HOME OFFICE SERVICES - Detailed Engineering				308,000				$ 308,000		12.4%	
	TOTAL FIELD, HOME OFFICE and OTHER SERVICES				**$ 1,058,482**	**$ -**	**11,819**	**$ 1,300,068**	**$ 2,358,550**		**94.9%**	
71	INSURANCE, Excluding scope by others	1.02%	of TIC		$ 26,000				$ 26,000		1.0%	
72	TAXES (STATE TAX ONLY, ALLOWANCE)				$ -	$ -		$ -	NOT INCLUDED			
73	BONDS							$ -	NOT INCLUDED			
74	PERMITS								NOT INCLUDED			
75	FINANCING								NOT INCLUDED			
	SUBTOTAL:				*$ 26,000*	*$ -*	-	*$ -*	*$ 26,000*		*1.0%*	
92	CONTINGENCY, on all costs Excluding scope by others	NOT INCLUDED PER CLIENT DIRECTION							EXCLUDED			
94	ESCALATION	to meet project schedule at 3.5% per year to midpoint after 18 months construction plus 2 years operation							$ 101,000		4.1%	
	TOTAL INSTALLED COST				$ 1,084,482	$ -	11,819	$ 1,300,068	$ 2,486,000		**100%**	
	PROJECT FEE (inludes G&A & fee)								EXCLUDED			
	OWNER'S COST								NOT INCLUDED			
	Supply & Install Equipment Scope by others: GE Turbine and B&W											
	Supply only Piping scope by others: GE Boiler											
	Decommissioning, demolition and salvage of specific scope excluding equipment, commodities and Turbine bldg to remain place											
	GRAND TOTAL								**$ 2,486,000**			**-**

Electrical

17-11-050-001



PRELIMINARY

LEGEND:

PM POWER METER

REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
A				

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A		EMD	DM
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV.NO.

PROJECT NO.: 31609

DRAWN: GAP DATE:

CHECKED: DATE:

SCALE: NONE

AECOM
1300 East 9th St., Suite 500
Cleveland, OH 44114
(216) 622-2300

AECOM

ENERGY INDUSTRIES of OHIO
6100 Oak Tree Boulevard, Suite 200
Independence, OH 44131
(216) 643-2952

A-USC COMTEST PROJECT
ELECTRICAL
SINGLE LINE DIAGRAM

DWG. NO. 17-11-050-001

REV A

EC_D_Size.dwg

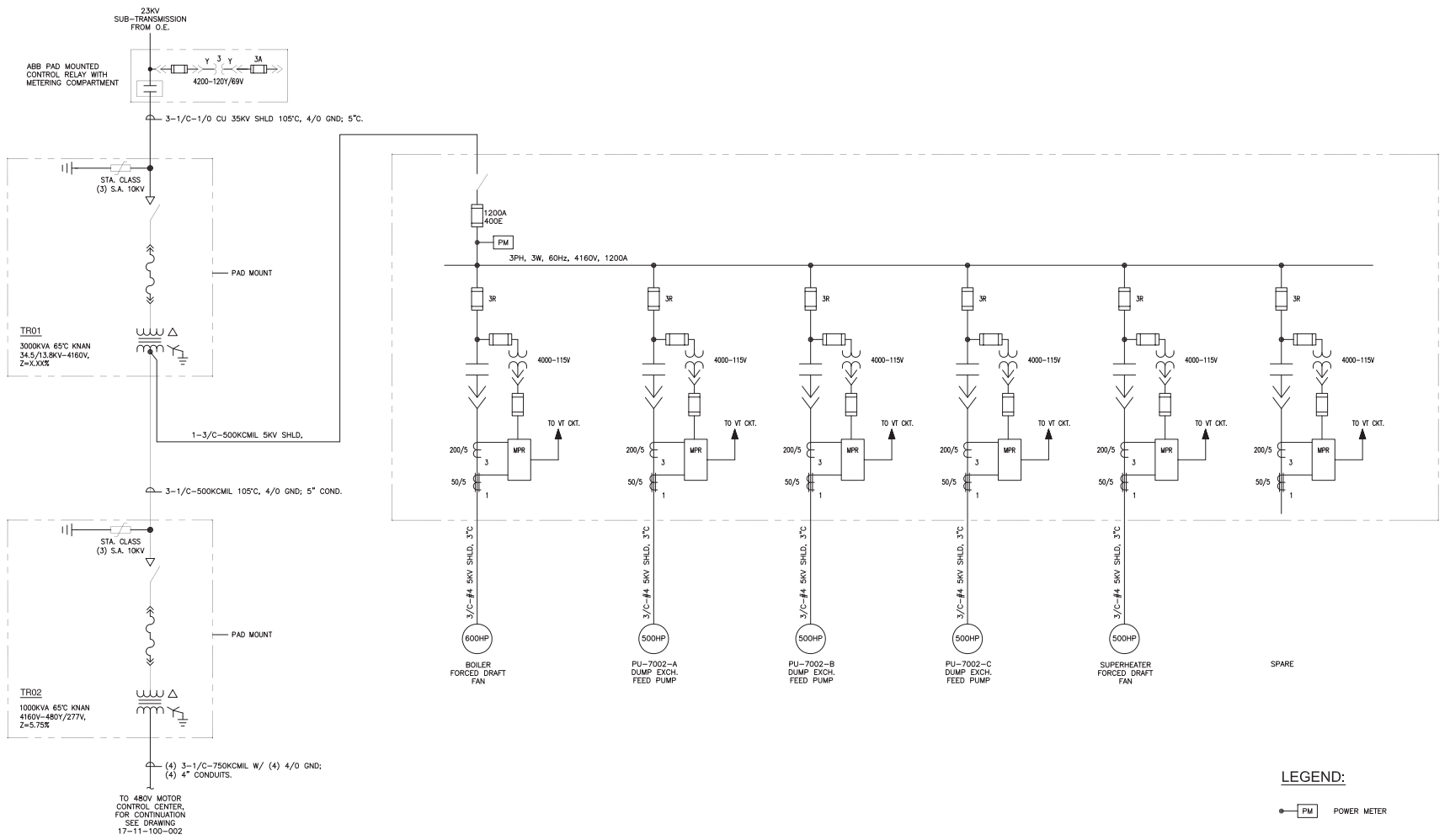
INCHES 1 2

CENTIMETERS 1 2 3 4 5 6

8 7 6 5 4 3 2 1

D C B A

17-11-100-001



LEGEND:

PM — POWER METER

REVISION APPROVAL RECORD						REV NO.	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BLDNG SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C						B	03/31/16	ISSUED FOR FEED	GAP	EMD
						A	02/16/16	ISSUED FOR REVIEW	GAP	EMD

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	B	03/31/16	EMD	DM
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV NO.

PROJECT NO.: 31609
DRAWN: GAP DATE: 2/16/16
CHECKED: DATE:
SCALE: NONE

URS ENERGY & CONSTRUCTION Inc, - an AECOM Company
1500 West 3rd St., Suite 200
Cleveland, OH 44113
(216) 523-5600
AECOM

ENERGY INDUSTRIES of OHIO
6100 Oak Tree Boulevard, Suite 200
Independence, OH 44131
(216) 643-2952

A-USC COMTEST PROJECT
ELECTRICAL
5KV SINGLE LINE DIAGRAM

DWG. NO. 17-11-100-001 REV B

INCHES CENTIMETERS

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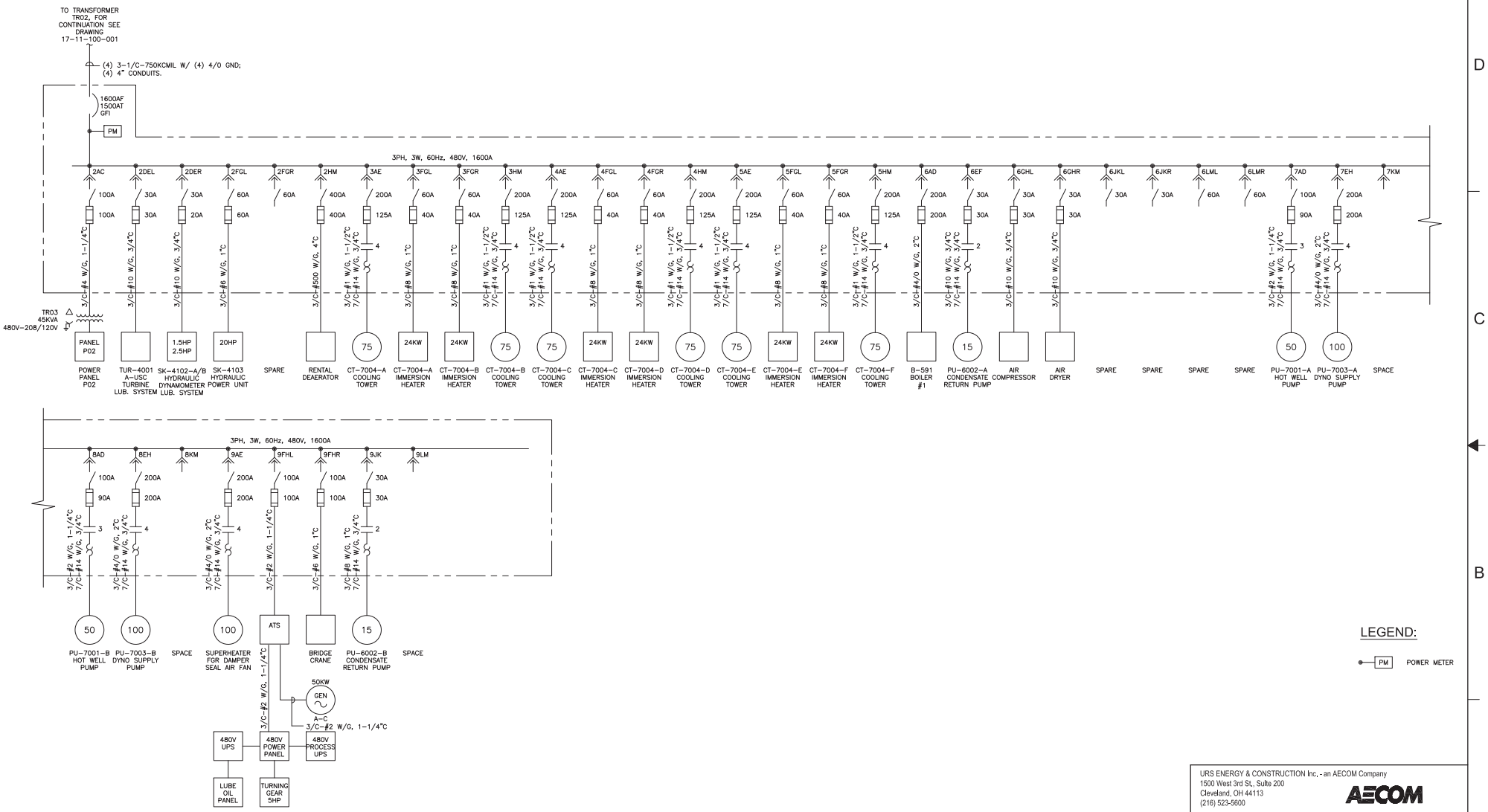
17-11-100-002



LEGEND:

PM POWER METER

REVISION APPROVAL RECORD				REV		REV NO.	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BLDNG SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C						B	03/31/16	ISSUED FOR FEED	GAP	EMD
						A	02/16/16	ISSUED FOR REVIEW	GAP	EMD

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	B	03/31/16	EMD	DM
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV.NO.

PROJECT NO: 31609
DRAWN: GAP DATE: 2/16/16
CHECKED: DATE:
SCALE: NONE

URS ENERGY & CONSTRUCTION Inc, - an AECOM Company
1500 West 3rd St., Suite 200
Cleveland, OH 44113
(216) 523-5600
AECOM

ENERGY INDUSTRIES of OHIO
6100 Oak Tree Boulevard, Suite 200
Independence, OH 44131
(216) 643-2952

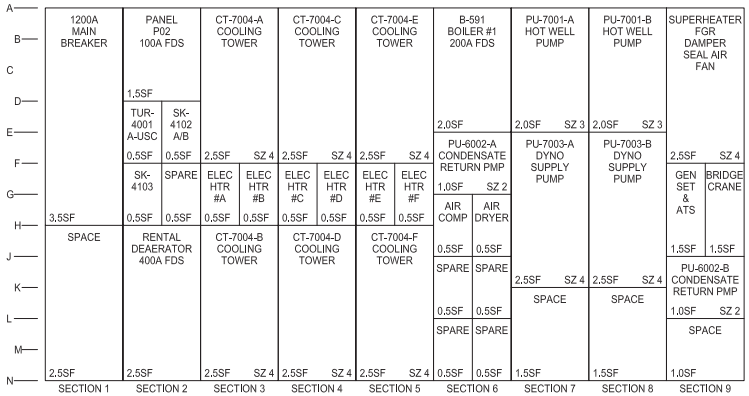
A-USC COMTEST PROJECT
ELECTRICAL
480 VOLT SINGLE LINE DIAGRAM

DWG. NO. 17-11-100-002
REV B

INCHES CENTIMETERS

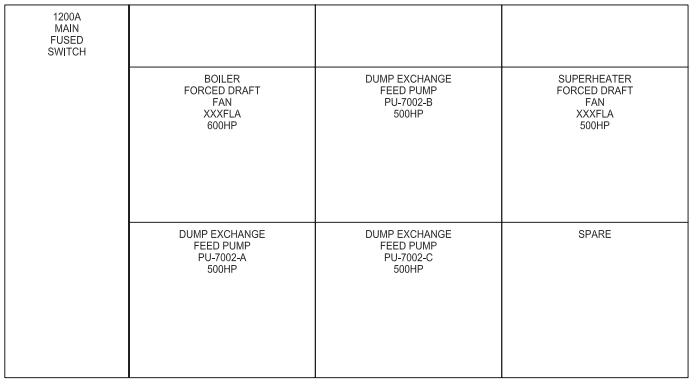
EC_D_Size.dwg

17-11-100-003



480V MOTOR CONTROL CENTER ELEVATION

SEE DRAWING 17-11-100-002



5KV SWITCHGEAR ELEVATION

SEE DRAWING 17-11-100-001

REVISION APPROVAL RECORD				REV		REV NO.	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C										
						A	03/31/16	ISSUED FOR FEED	GAP	EMD

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A	03/31/16	EMD	DM
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV NO.

PROJECT NO.: 31609

DRAWN: GAP DATE: 2/16/16

CHECKED: DATE:

SCALE: NONE

URS ENERGY & CONSTRUCTION Inc, - an AECOM Company
1500 West 3rd St., Suite 200
Cleveland, OH 44113
(216) 523-5600

ENERGY INDUSTRIES of OHIO
6100 Oak Tree Boulevard, Suite 200
Independence, OH 44131
(216) 643-2952

A-USC COMTEST PROJECT
ELECTRICAL
480V & 5KV MCC ELEVATIONS

DWG. NO. 17-11-100-003

REV A

EC_D_Size.dwg

INCHES CENTIMETERS

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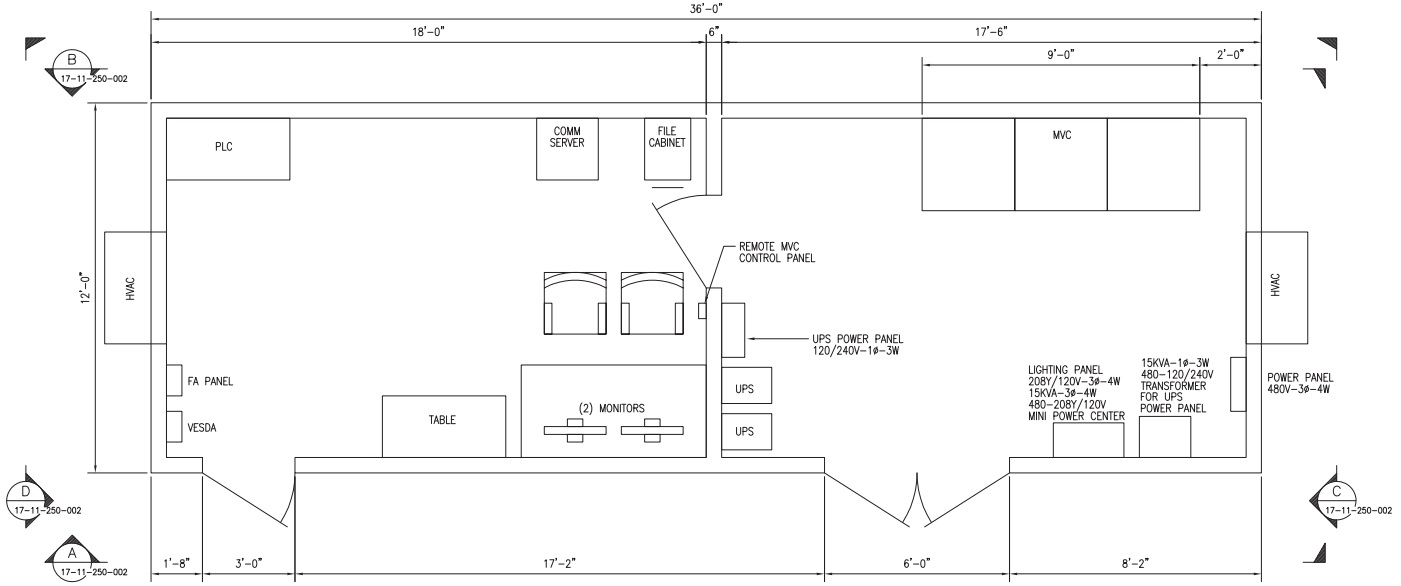
17-11-250-001



NOTES:

1. CONDUIT & WIRE SHALL BE INSTALLED IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE AND LOCAL CODES.

LEGEND:

- 120 VOLT, 1 PHASE, MANUAL MOTOR STARTER WITH OVERLOAD HEATER ELEMENT. NEMA 12 ENCLOSURE, PILOT LIGHT, PROVISIONS FOR PADLOCKING, 3/4" CONDUIT HUB.
- 120 VOLT, 1 PHASE, 1/4 HORSE POWER UNIT HEATER BLOWER MOTOR, SEE HVAC DRAWING 17-11-411-002 FOR DETAILS.

PRELIMINARY

TRUE NORTH

PROJECT NORTH

REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO	DATE	REVISIONS	BY	CHKR
A				

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A		EMD	DM
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV.NO.

PROJECT NO.: 31609

DRAWN: GAP DATE:

CHECKED: DATE:

SCALE: 1/2" = 1'-0"

AECOM
1300 East 9th St., Suite 500
Cleveland, OH 44114
(216) 622-2300

AECOM

ENERGY INDUSTRIES of OHIO
6100 Oak Tree Boulevard, Suite 200
Independence, OH 44131
(216) 643-2952

A-USC COMTEST PROJECT
ELECTRICAL
PDC EQUIPMENT ARRANGEMENT

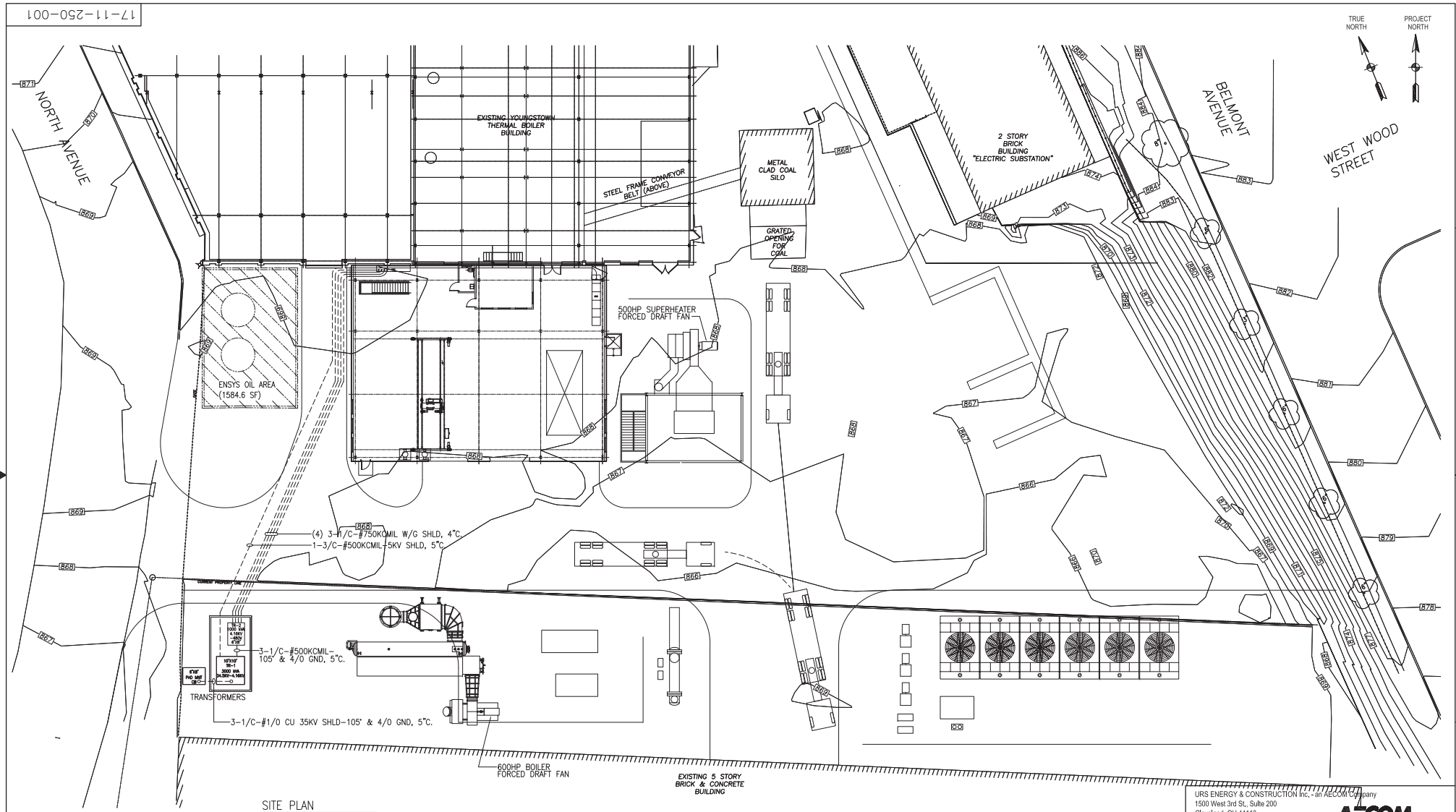
DWG. NO. 17-11-250-001

REV A

INCHES CENTIMETERS

EC_D_Size.dwg

17-11-250-001



SITE PLAN
SCALE: 1/16" = 1'-0"

REVISION APPROVAL RECORD				REV		REV NO.	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BLDNG SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C						B	3/31/16	ISSUED FOR FEED	GAP	EMD
						A	2/16/16	ISSUED FOR REVIEW	GAP	EMD

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	B	3/31/16	EMD	DM
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV.NO.

PROJECT NO.: 31609
DRAWN: GAP DATE: 2/16/16
CHECKED: DATE:
SCALE: AS NOTED

URS ENERGY & CONSTRUCTION Inc., an AECOM Company
1500 West 3rd St., Suite 200
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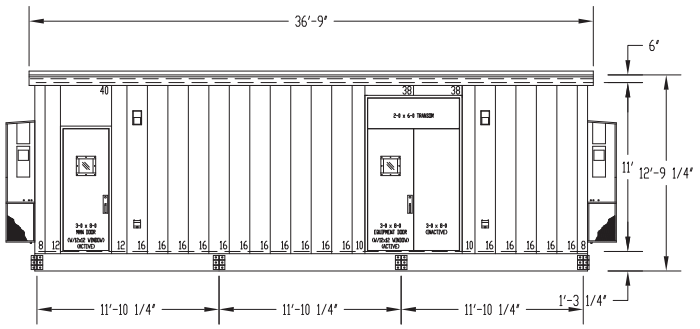
A-USC COMTEST PROJECT
ELECTRICAL
POWER PLAN - SITE LAYOUT

DWG. NO. 17-11-250-001 REV B

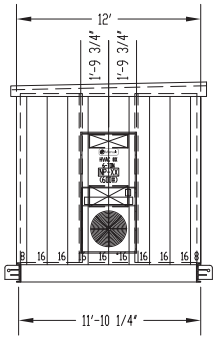
INCHES CENTIMETERS
EC_D_Size.dwg

17-11-250-002



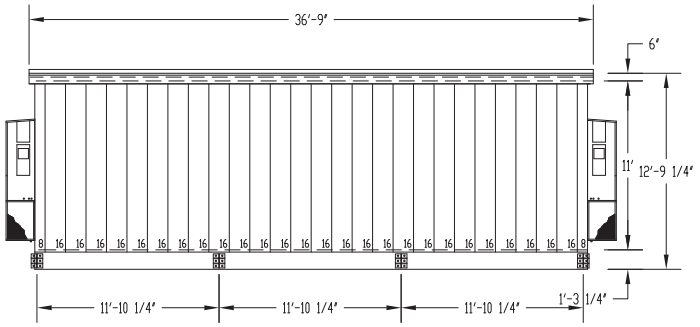
PDC ELEVATION SIDE A

SECTION A
SCALE: 1/4" = 1'-0"
17-11-250-001



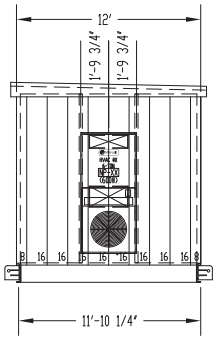
PDC ELEVATION SIDE C

SECTION C
SCALE: 1/4" = 1'-0"
17-11-250-001



PDC ELEVATION SIDE B

SECTION B
SCALE: 1/4" = 1'-0"
17-11-250-001



PDC ELEVATION SIDE D

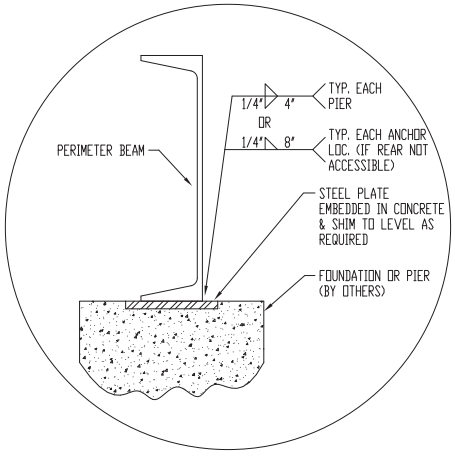
SECTION D
SCALE: 1/4" = 1'-0"
17-11-250-001

NOTES:

1. CONDUIT & WIRE SHALL BE INSTALLED IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE AND LOCAL CODES.

LEGEND:

- 120 VOLT, 1 PHASE, MANUAL MOTOR STARTER WITH OVERLOAD HEATER ELEMENT, NEMA 12 ENCLOSURE, PILOT LIGHT, PROVISIONS FOR PADLOCKING, 3/4" CONDUIT HUB.
- 6 — 120 VOLT, 1 PHASE, 1/4 HORSE POWER UNIT HEATER BLOWER MOTOR, SEE HVAC DRAWING 17-11-411-002 FOR DETAILS.



RECOMMENDED ANCHOR DETAIL

PRELIMINARY

REVISION APPROVAL RECORD				REV		REV NO.	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C										
						A				

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A		EMD	DM
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV.NO.

PROJECT NO.: 31609
DRAWN: GAP DATE:
CHECKED: DATE:
SCALE: 1/2" = 1'-0"

URS ENERGY & CONSTRUCTION Inc, - an AECOM Company
1500 West 3rd St., Suite 200
Cleveland, OH 44113
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AECOM

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Independence, OH 44131
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A-USC COMTEST PROJECT
ELECTRICAL
PDC EXTERIOR ELEVATIONS

DWG. NO. 17-11-250-002
REV A

INCHES 1 2
CENTIMETERS 1 2 3 4 5 6

8 7 6 5 4 3 2 1

D C B A

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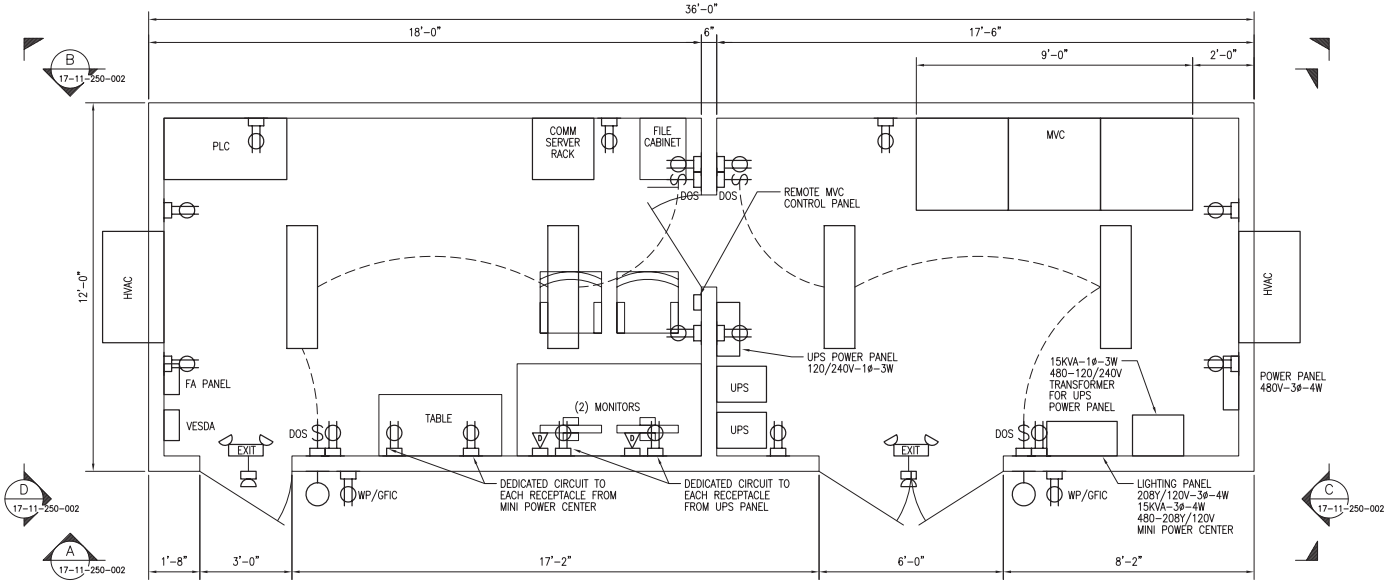
17-11-350-001



NOTES:

1. CONDUIT & WIRE SHALL BE INSTALLED IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE AND LOCAL CODES.
2. INTERIOR LIGHTING ILLUMINATION TO BE AND AVERAGE MAINTAINED 30 FOOT-CANDLES AT 2'-6" ABOVE FINISHED FLOOR BASED ON 80-50-20 REFLECTANCE.

LEGEND:

DOS — 120 VOLT, OCCUPANCY & VACANCY DIMMING WALL SENSOR, 0-10 VOLT, PASSIVE INFRARED (PIR) & ULTRASONIC OCCUPANCY DETECTION DUAL TECHNOLOGY, LEGRAND # DW-311-W OR EQUAL.

120 VOLT, 20 AMP, NEMA 5-20R DUPLEX RECEPTACLE, WHITE, EXTRA HEAVY DUTY INDUSTRIAL GRADE, HUBBELL # HBL5362W OR EQUAL.

WP/GFIC — 120 VOLT, 20 AMP, NEMA 5-20R GROUND FAULT DUPLEX RECEPTACLE, WHITE, EXTRA HEAVY DUTY INDUSTRIAL/HOSPITAL GRADE, HUBBELL # GFR8300SGW OR EQUAL, INSTALLED IN A DIE-CAST ALUMINUM WHILE-IN-USE SINGLE GANG BOX, HUBBELL # WP26E OR EQUAL.

1' X 4' LED SURFACE MOUNTED LIGHT FIXTURE, VOLUMETRIC STYLE, 82 CRI, 3500'K CCT, 0-10 VOLT DIMMING, DIMS TO 1%, 120-277 VOLT DRIVER, LITHONIA # STL4-60L-EZ1-LP835-SC2 OR EQUAL.

LED MINI WALL SCONCE, SURFACE MOUNTED LIGHT FIXTURE, 4000'K CCT, 120 VOLT DRIVER, WHITE FINISH, BUTTON TYPE PHOTOELECTRIC CELL, SUITABLE FOR WET LOCATIONS, LITHONIA # WSTM-2A-40K-120-PE-DWHXD OR EQUAL.

EXIT — LED COMBINATION EXIT-EMERGENCY LIGHTING UNIT, TWO HEADS, SURFACE MOUNTED (TOP-END-BACK), SINGLE FACE, WHITE HOUSING, RED LETTERS, 120/277 VOLT DRIVER, WHITE FINISH, HIGH OUTPUT NI-CAD BATTERY, LITHONIA # LHQM-LED-R-HO OR EQUAL.

SINGLE LED WEATHERPROOF REMOTE HEAD, SURFACE MOUNTED, GRAY FINISH, LITHONIA # ELA-QWP-L0309 OR EQUAL.

CAT 5E DATA JACK, WHITE, TWO (2) PER FACEPLATE, HUBBELL # HXJ5EW, 2 PORT, 1 GANG, STAINLESS STEEL FACEPLATE, HUBBELL # SSF12 OR EQUAL.

PRELIMINARY

TRUE NORTH PROJECT NORTH

REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
A				

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A		EMD	DM
APPROVED FOR CONSTRUCTION				

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PROJECT NO.: 31609
DRAWN: GAP DATE:
CHECKED: DATE:
SCALE: 1/2" = 1'-0"

URS ENERGY & CONSTRUCTION Inc. - an AECOM Company
1500 West 3rd St., Suite 200
Cleveland, OH 44113
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AECOM

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(216) 643-2952

A-USC COMTEST PROJECT
ELECTRICAL
LIGHTING & RECEPTACLE PLAN

DWG. NO. 17-11-350-001 REV A

INCHES / CENTIMETERS

EC_D_Size.dwg

17-11-353-001

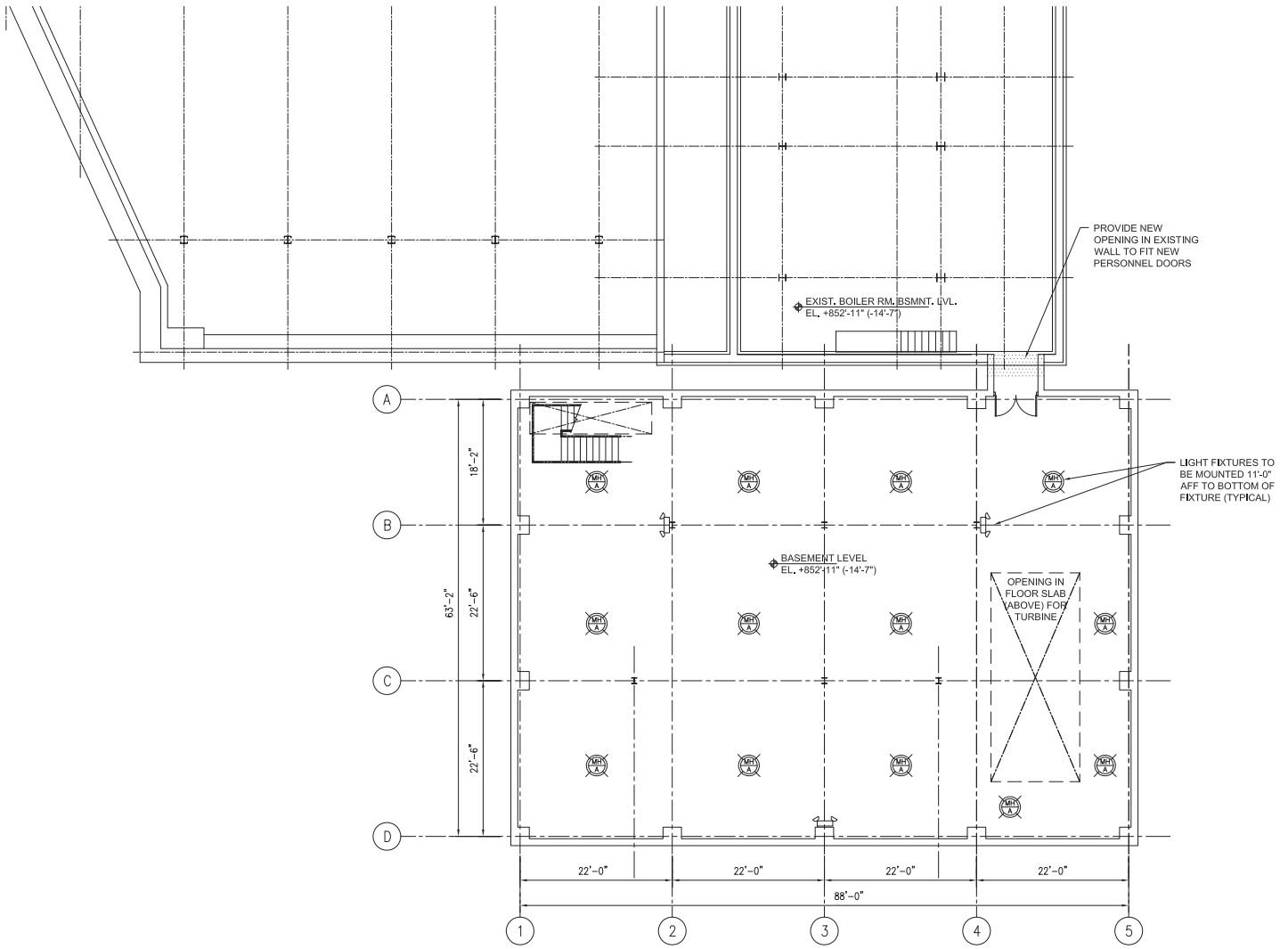
NOTES:

1. LIGHTING SHALL BE INSTALLED IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE AND LOCAL CODES.

LEGEND:

MH A — 250 WATT PULSE START METAL HALIDE LOW BAY INDUSTRIAL LIGHTING FIXTURE, ENCLOSED AND GASKETED, ACRYLIC LENS, PENDANT MOUNTED. LITHONIA #TX 250MP A30 TB SCWA OR EQUAL.

INDUSTRIAL EMERGENCY LIGHTING UNIT, TWO (2) 12V HALOGEN HEADS, REMOTE HEAD CAPABLE, 120/277VAC INPUT, MAINTENANCE FREE LEAD ACID BATTERY, DUAL-LITE #AS-360-12V-I-A31-AHDSB1250-6000 OR EQUAL.



LIGHTING LAYOUT - LOWER LEVEL

SCALE: 1/8" = 1'-0"

TRUE NORTH / PROJECT NORTH

REVISION APPROVAL RECORD				REV		REV NO.	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C						?	03/31/16	ISSUED FOR FEED	GAP	EMD

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A	03/31/16	EMD	DM
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV NO.

PROJECT NO: 31609

DRAWN: GAP DATE: 03-09-16

CHECKED: DATE:

SCALE: AS NOTED

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Cleveland, OH 44113
(216) 523-5600

ENERGY INDUSTRIES of OHIO
6100 Oak Tree Boulevard, Suite 200
Independence, OH 44131
(216) 643-2952

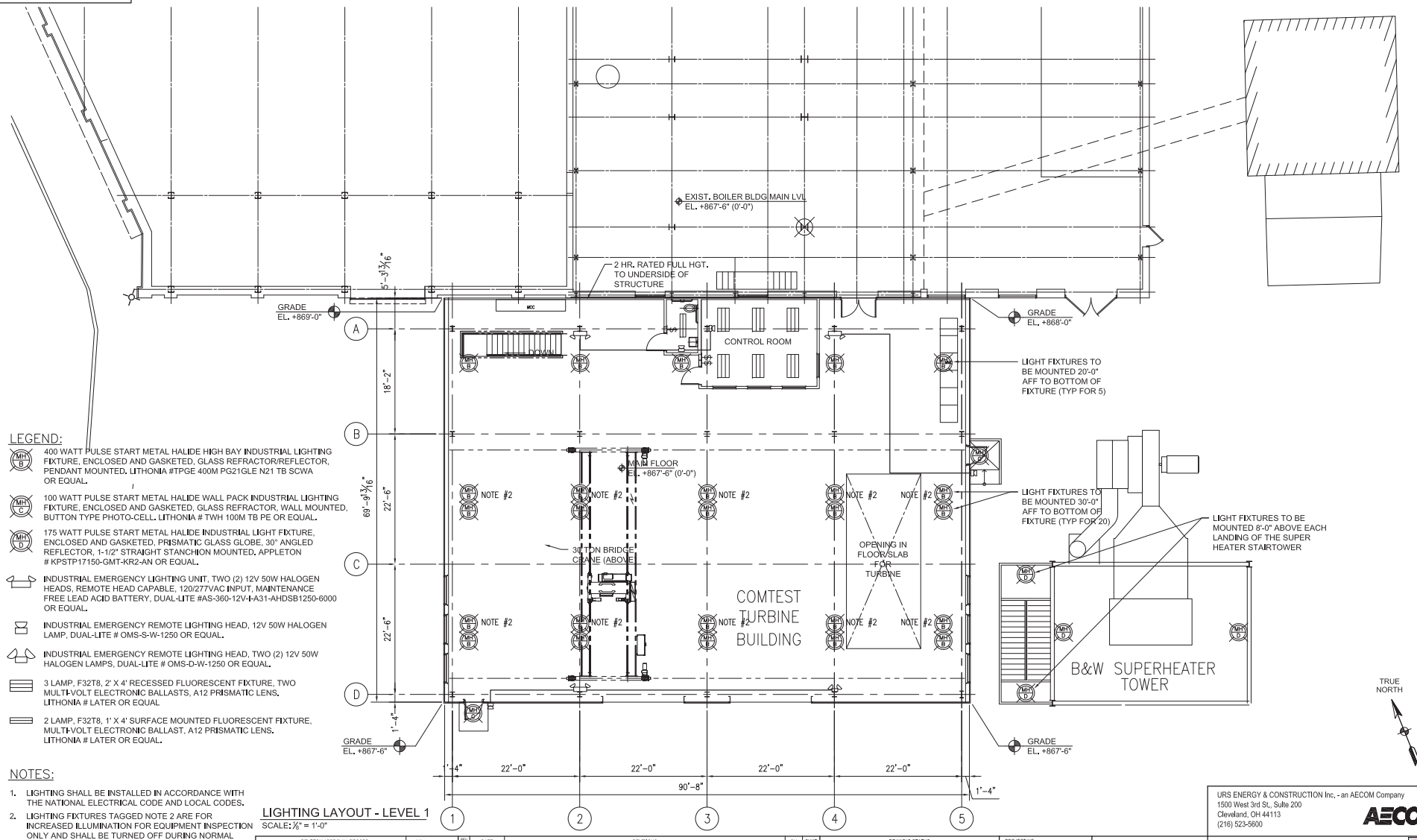
A-USC COMTEST PROJECT
ELECTRICAL
LIGHTING LAYOUT - LOWER LEVEL

DWG. NO. 17-11-353-001 REV A

EC_D_Size.dwg

INCHES / CENTIMETERS

17-11-353-002



LEGEND:

- MH B — 400 WATT PULSE START METAL HALIDE HIGH BAY INDUSTRIAL LIGHTING FIXTURE, ENCLOSED AND GASKETED, GLASS REFRACTOR/REFLECTOR, PENDANT MOUNTED. LITHONIA #TPGE 400M PG21GLE N21 TB SCWA OR EQUAL.
- MH C — 100 WATT PULSE START METAL HALIDE WALL PACK INDUSTRIAL LIGHTING FIXTURE, ENCLOSED AND GASKETED, GLASS REFRACTOR, WALL MOUNTED, BUTTON TYPE PHOTO-CELL. LITHONIA # TWH 100M TB PE OR EQUAL.
- MH D — 175 WATT PULSE START METAL HALIDE INDUSTRIAL LIGHT FIXTURE, ENCLOSED AND GASKETED, PRISMATIC GLASS GLOBE, 30° ANGLED REFLECTOR, 1-1/2" STRAIGHT STANCHION MOUNTED. APPLETON # KPSTP17150-GMT-KR2-AN OR EQUAL.
- INDUSTRIAL EMERGENCY LIGHTING UNIT, TWO (2) 12V 50W HALOGEN HEADS, REMOTE HEAD CAPABLE, 120/277VAC INPUT, MAINTENANCE FREE LEAD ACID BATTERY, DUAL-LITE #AS-360-12V-I-A31-AHDSB1250-6000 OR EQUAL.
- INDUSTRIAL EMERGENCY REMOTE LIGHTING HEAD, 12V 50W HALOGEN LAMP, DUAL-LITE # OMS-S-W-1250 OR EQUAL.
- INDUSTRIAL EMERGENCY REMOTE LIGHTING HEAD, TWO (2) 12V 50W HALOGEN LAMPS, DUAL-LITE # OMS-D-W-1250 OR EQUAL.
- 3 LAMP, F32T8, 2' X 4' RECESSED FLUORESCENT FIXTURE, TWO MULTI-VOLT ELECTRONIC BALLASTS, A12 PRISMATIC LENS. LITHONIA # LATER OR EQUAL
- 2 LAMP, F32T8, 1' X 4' SURFACE MOUNTED FLUORESCENT FIXTURE, MULTI-VOLT ELECTRONIC BALLAST, A12 PRISMATIC LENS. LITHONIA # LATER OR EQUAL.

NOTES:

1. LIGHTING SHALL BE INSTALLED IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE AND LOCAL CODES.
2. LIGHTING FIXTURES TAGGED NOTE 2 ARE FOR INCREASED ILLUMINATION FOR EQUIPMENT INSPECTION ONLY AND SHALL BE TURNED OFF DURING NORMAL PLANT OPERATIONS.

LIGHTING LAYOUT - LEVEL 1

SCALE: 1/8" = 1'-0"

REVISION APPROVAL RECORD						REV NO.	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BLDG SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C						A	03/31/16	ISSUED FOR FEED	GAP	EMD

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A	03/31/16	EMD	DM
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV.NO.

PROJECT NO: 31609

DRAWN: GAP DATE: 03-09-16

CHECKED: DATE:

SCALE: AS NOTED

URS ENERGY & CONSTRUCTION Inc. - an AECOM Company
1500 West 3rd St., Suite 200
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(216) 523-5600
AECOM

ENERGY INDUSTRIES of OHIO
6100 Oak Tree Boulevard, Suite 200
Independence, OH 44131
(216) 643-2952

A-USC COMTEST PROJECT
ELECTRICAL
LIGHTING LAYOUT - LEVEL 1

DWG. NO. 17-11-353-002

REV A

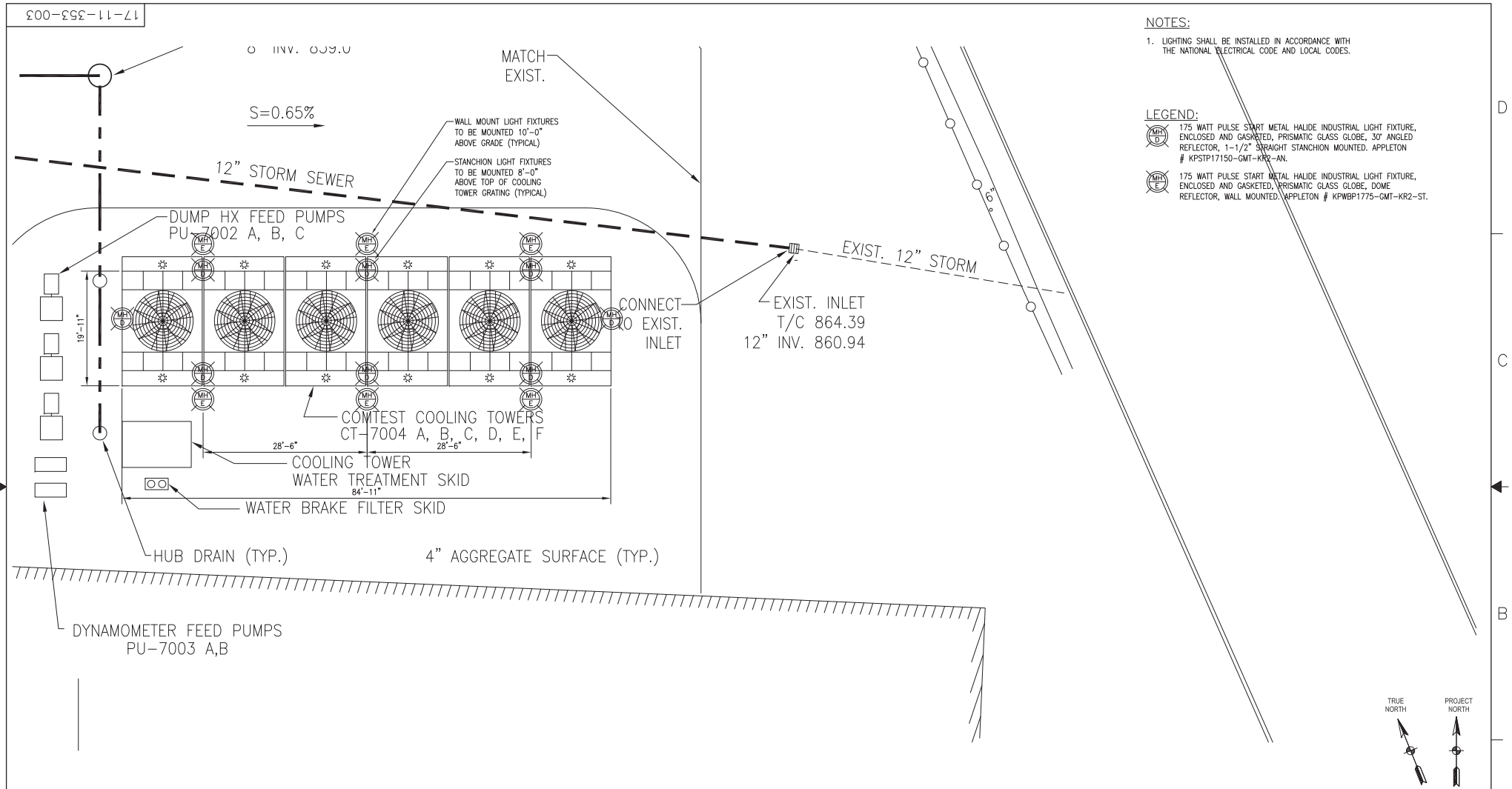
EC_D_Size.dwg

INCHES / CENTIMETERS

8 7 6 5 4 3 2 1

D C B A

17-11-353-003



NOTES:

1. LIGHTING SHALL BE INSTALLED IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE AND LOCAL CODES.

LEGEND:

MH D — 175 WATT PULSE START METAL HALIDE INDUSTRIAL LIGHT FIXTURE, ENCLOSED AND GASKETED, PRISMATIC GLASS GLOBE, 30° ANGLED REFLECTOR, 1-1/2" STRAIGHT STANCHION MOUNTED. APPLETON # KPSTP17150-GMT-KR2-AN.

MH E — 175 WATT PULSE START METAL HALIDE INDUSTRIAL LIGHT FIXTURE, ENCLOSED AND GASKETED, PRISMATIC GLASS GLOBE, DOME REFLECTOR, WALL MOUNTED. APPLETON # KPWBP1775-GMT-KR2-ST.

LIGHTING LAYOUT – COOLING TOWER
SCALE: 1/8" = 1'-0"

REVISION APPROVAL RECORD						REV NO.	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BLDNG SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C										
						A	3/31/16	ISSUED FOR FEED	GAP	EMD

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A	3/31/16	EMD	DM
APPROVED FOR CONSTRUCTION				

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PROJECT NO: 31609
DRAWN: GAP DATE: 03-09-16
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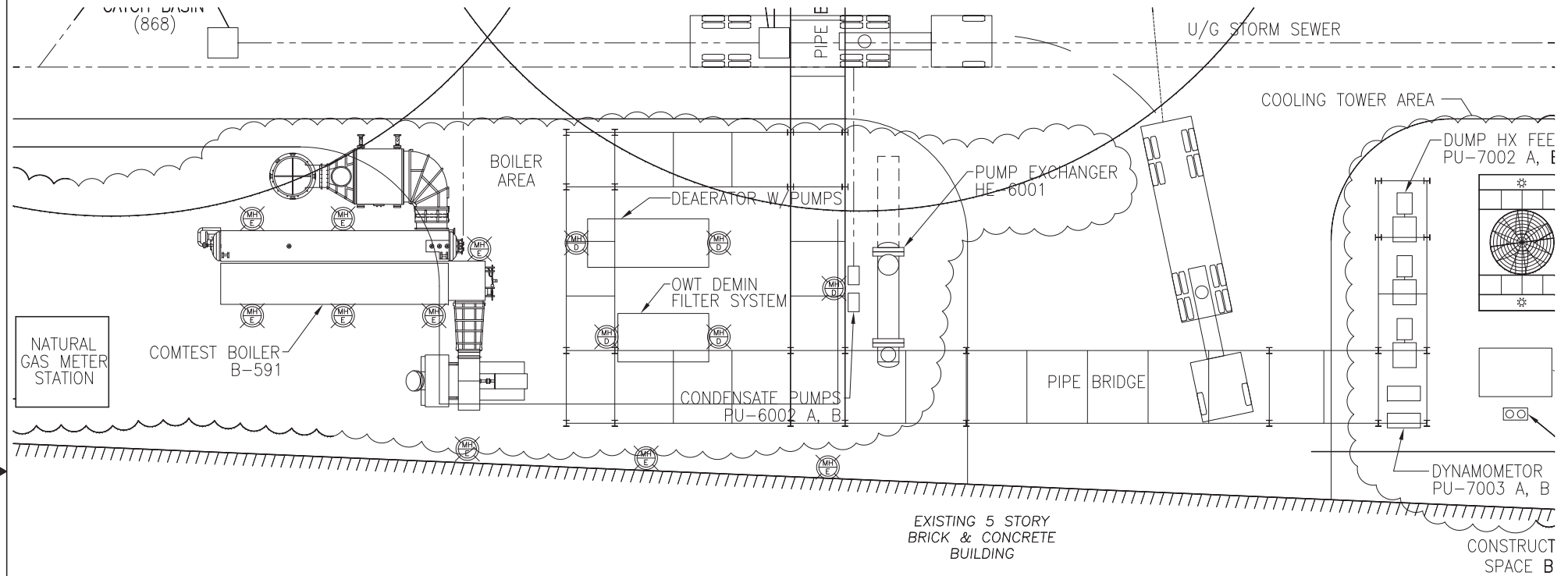
A-USC COMTEST PROJECT
ELECTRICAL
LIGHTING LAYOUT – COOLING TOWER

DWG. NO. 17-11-353-003 REV A

INCHES / CENTIMETERS

EC_D_Size.dwg

17-11-353-004



NOTES:

1. LIGHTING SHALL BE INSTALLED IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE AND LOCAL CODES.

LEGEND:

MH D — 175 WATT PULSE START METAL HALIDE INDUSTRIAL LIGHT FIXTURE, ENCLOSED AND GASKETED, PRISMATIC GLASS GLOBE, 30° ANGLED REFLECTOR, 1-1/2" STRAIGHT STANCHION MOUNTED. APPLETON # KPSTP17150-GMT-KR2-AN.

MH E — 175 WATT PULSE START METAL HALIDE INDUSTRIAL LIGHT FIXTURE, ENCLOSED AND GASKETED, PRISMATIC GLASS GLOBE, DOME REFLECTOR, WALL MOUNTED. APPLETON # KPWBP1775-GMT-KR2-ST.

TRUE NORTH / PROJECT NORTH

LIGHTING LAYOUT – BOILER AREA
SCALE: 1/8" = 1'-0"

REVISION APPROVAL RECORD				REV		REV NO.	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C						A	3/31/16	ISSUED FOR FEED	GAP	EMD

DRAWING STATUS	REV	DATE	SDE	PEM
PRELIMINARY	A	3/31/16	EMD	DM
APPROVED FOR CONSTRUCTION				

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PROJECT NO: 31609
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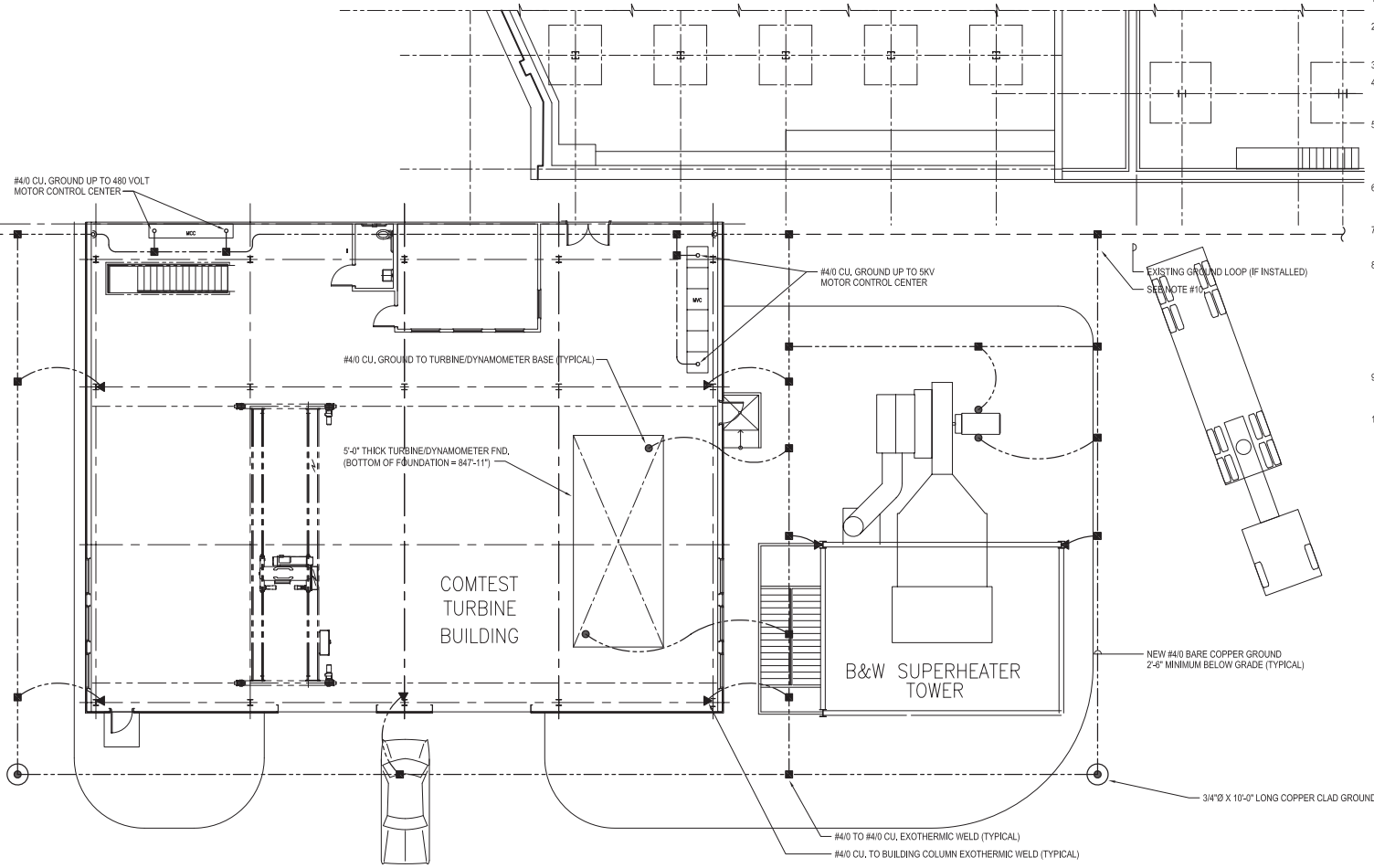
A-USC COMTEST PROJECT
ELECTRICAL
LIGHTING LAYOUT – BOILER AREA

DWG. NO. 17-11-353-004 REV A

INCHES / CENTIMETERS

EC_D_Size.dwg

17-11-503-001



NOTES:

1. GROUNDING SYSTEM SHALL BE INSTALLED IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE AND LOCAL CODES.
2. GROUND CONDUCTORS SHALL BE #4/0 AWG BARE SOFT DRAWN ANNEALED STRANDED BARE COPPER FOR BURIED GROUND WIRE. STUB-UPS SHALL BE PROTECTED IN A PVC CONDUIT SLEEVE.
3. DEPTH OF THE GROUND GRID SHALL BE 30" BELOW GRADE.
4. BURIED CONNECTIONS SHALL BE MADE WITH THERMAL WELDED CONNECTIONS SPECIALLY MADE FOR GROUNDING SYSTEMS. THERMAL WELDING SHALL BE MOLDED FUSION WELDING PROCESS BY CADWELD.
5. GROUND RODS SHALL BE 3/4" DIAMETER 10'-0" LONG (MINIMUM), STEEL CORE WITH COPPER JACKET. GROUNDING RODS EXACT HORIZONTAL SEPARATION TO BE DETERMINED IN THE FIELD, BUT THE HORIZONTAL SEPARATION SHALL BE NO LESS THAN THE DRIVEN DEPTH OF THE RODS.
6. GROUND SYSTEMS ARE SHOWN DIAGRAMMATICALLY ONLY. EXACT LOCATION OF RODS, LOOPS, EQUIPMENT CONNECTION POINTS, ETC. ARE TO BE DETERMINED IN FIELD.
7. CONTRACTOR SHALL MAINTAIN INTEGRITY OF EXISTING GROUND LOOP AND ALL GROUND LOOP CONNECTIONS WHEN REQUIRED TO JOIN AREAS.
8. A RESISTANCE-TO-GROUND OF 5 OHMS OR LESS IS THE OBJECTIVE OF THE EXTERNAL GROUND SYSTEM. THE CONTRACTOR SHALL PERFORM THE THREE POINT (FALL-OF-POTENTIONAL) METHOD FOR GROUND SYSTEM RESISTANCE TESTING, AS DESCRIBED IN IEEE STANDARD 142-2007 GROUNDING OF INDUSTRIAL AND POWER SYSTEMS. THE CONTRACTOR SHALL EMPLOY THE SERVICES OF AN EXPERIENCED TESTING LABORATORY OR ENGINEERING FIRM FAMILIAR WITH THE SPECIFIED TESTING METHOD. IF THE RESISTANCE OF THE ENTIRE SYSTEM EXCEEDS 5 OHMS, NOTIFY THE OWNER'S REPRESENTATIVE FOR FURTHER DIRECTIVE.
9. CONTRACTOR SHALL INSTALL GROUNDING TABS WELDED TO BUILDING COLUMNS. TABS SHALL BE 2" X 2" X 1/4" WITH PREDRILLED WITH ONE (1) 9/16"Ø HOLE IN EACH TAB.
10. CONTRACTOR SHALL CONNECT NEW #4/0 GROUND LOOP TO EXISTING GROUND LOOP (IF FOUND OR PREVIOUSLY INSTALLED). IN EVENT AN EXISTING GROUND LOOP IS NOT FOUND OR INSTALLED, THE NEW #4/0 GROUND LOOP SHALL BE ATTACHED TO THE NEAREST EXISTING STRUCTURAL STEEL COLUMN.

TRUE NORTH / PROJECT NORTH

GROUNDING PLAN
SCALE: 1/8"=1'-0"

REVISION APPROVAL RECORD				REV		REV NO	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C										
						A	3/31/16	ISSUED FOR FEED	GAP	EMD

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A	03/31/16	EMD	DM
APPROVED FOR CONSTRUCTION				

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A-USC COMTEST PROJECT
ELECTRICAL
GROUNDING PLAN - TURBINE BUILDING

DWG. NO. 17-11-503-001 REV A

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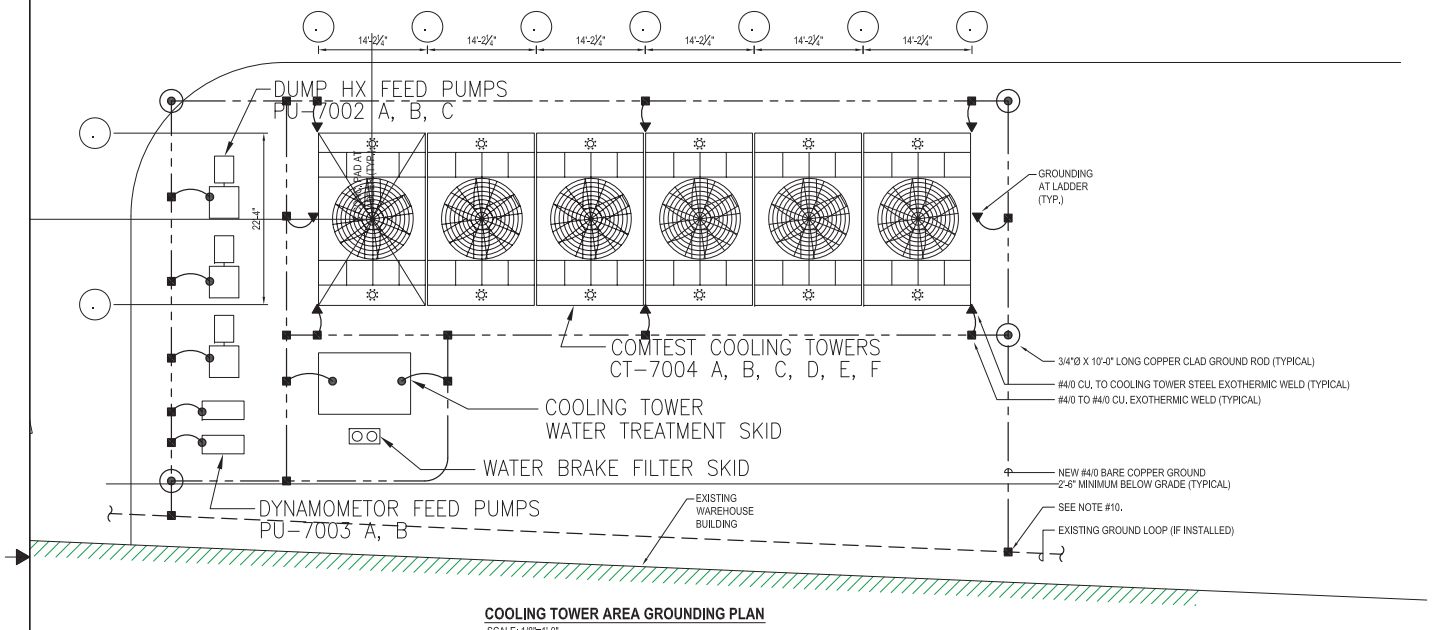
INCHES / CENTIMETERS

8 7 6 5 4 3 2 1

17-11-503-002



COOLING TOWER AREA GROUNDING PLAN
SCALE: 1/8"=1'-0"

NOTES:

1. GROUNDING SYSTEM SHALL BE INSTALLED IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE AND LOCAL CODES.
2. GROUND CONDUCTORS SHALL BE #4/0 AWG BARE SOFT DRAWN ANNEALED STRANDED BARE COPPER FOR BURIED GROUND WIRE. STUB-UPS SHALL BE PROTECTED IN A PVC CONDUIT SLEEVE.
3. DEPTH OF THE GROUND GRID SHALL BE 30" BELOW GRADE.
4. BURIED CONNECTIONS SHALL BE MADE WITH THERMAL WELDED CONNECTIONS SPECIALLY MADE FOR GROUNDING SYSTEMS. THERMAL WELDING SHALL BE MOLDED FUSION WELDING PROCESS BY CADWELD.
5. GROUND RODS SHALL BE 3/4" DIAMETER 10'-0" LONG (MINIMUM), STEEL CORE WITH COPPER JACKET. GROUNDING RODS EXACT HORIZONTAL SEPARATION TO BE DETERMINED IN THE FIELD, BUT THE HORIZONTAL SEPARATION SHALL BE NO LESS THAN THE DRIVEN DEPTH OF THE RODS.
6. GROUND SYSTEMS ARE SHOWN DIAGRAMMATICALLY ONLY. EXACT LOCATION OF RODS, LOOPS, EQUIPMENT CONNECTION POINTS, ETC. ARE TO BE DETERMINED IN FIELD.
7. CONTRACTOR SHALL MAINTAIN INTEGRITY OF EXISTING GROUND LOOP AND ALL GROUND LOOP CONNECTIONS WHEN REQUIRED TO JOIN AREAS.
8. A RESISTANCE-TO-GROUND OF 5 OHMS OR LESS IS THE OBJECTIVE OF THE EXTERNAL GROUND SYSTEM. THE CONTRACTOR SHALL PERFORM THE THREE POINT (FALL-OF-POTENTIONAL) METHOD FOR GROUND SYSTEM RESISTANCE TESTING, AS DESCRIBED IN IEEE STANDARD 142-2007 GROUNDING OF INDUSTRIAL AND POWER SYSTEMS. THE CONTRACTOR SHALL EMPLOY THE SERVICES OF AN EXPERIENCED TESTING LABORATORY OR ENGINEERING FIRM FAMILIAR WITH THE SPECIFIED TESTING METHOD. IF THE RESISTANCE OF THE ENTIRE SYSTEM EXCEEDS 5 OHMS, NOTIFY THE OWNER'S REPRESENTATIVE FOR FURTHER DIRECTIVE.
9. CONTRACTOR SHALL INSTALL GROUNDING TABS WELDED TO THE COOLING TOWER COLUMNS AND LADDERS. TABS SHALL BE 2" X 2" X 1/4" WITH PREDRILLED WITH ONE (1) 9/16"Ø HOLE IN EACH TAB.
10. CONTRACTOR SHALL CONNECT NEW #4/0 GROUND LOOP TO EXISTING GROUND LOOP (IF FOUND OR PREVIOUSLY INSTALLED). IN EVENT AN EXISTING GROUND LOOP IS NOT FOUND OR INSTALLED, THE NEW #4/0 GROUND LOOP SHALL BE ATTACHED TO THE NEAREST EXISTING STRUCTURAL STEEL COLUMN.

TRUE NORTH
PROJECT NORTH

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DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C										
						A	3/31/16	ISSUED FOR FEED	GAP	EMD

DRAWING STATUS				
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A-USC COMTEST PROJECT
ELECTRICAL
GROUNDING PLAN - COOLING TOWER

DWG. NO. 17-11-503-002 REV A

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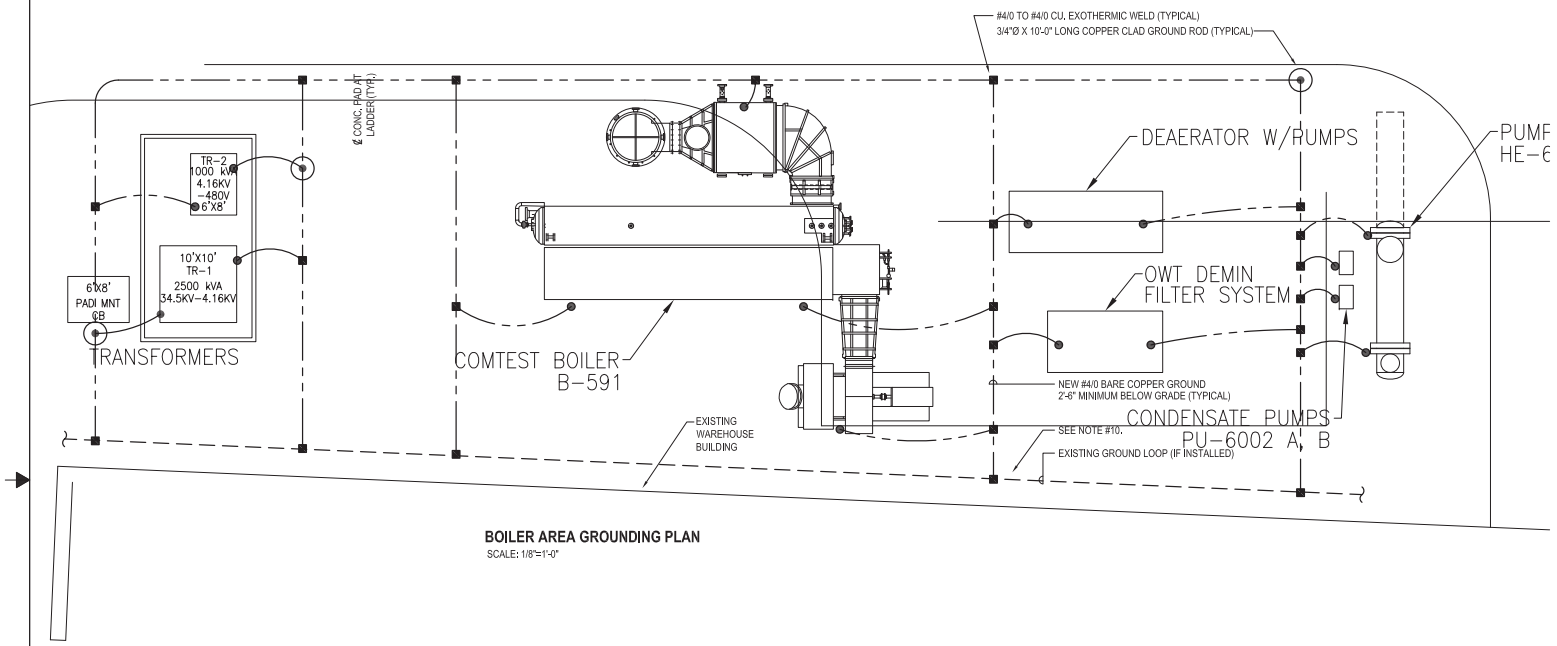
INCHES 1 2
CENTIMETERS 1 2 3 4 5 6

8 7 6 5 4 3 2 1
D C B A

17-11-503-003



BOILER AREA GROUNDING PLAN

SCALE: 1/8"=1'-0"

NOTES:

1. GROUNDING SYSTEM SHALL BE INSTALLED IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE AND LOCAL CODES.
2. GROUND CONDUCTORS SHALL BE #4/0 AWG BARE SOFT DRAWN ANNEALED STRANDED BARE COPPER FOR BURIED GROUND WIRE. STUB-UPS SHALL BE PROTECTED IN A PVC CONDUIT SLEEVE.
3. DEPTH OF THE GROUND GRID SHALL BE 30" BELOW GRADE.
4. BURIED CONNECTIONS SHALL BE MADE WITH THERMAL WELDED CONNECTIONS SPECIALLY MADE FOR GROUNDING SYSTEMS. THERMAL WELDING SHALL BE MOLDED FUSION WELDING PROCESS BY CADWELD.
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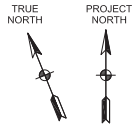

REVISION APPROVAL RECORD				REV	
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ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
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DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
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A-USC COMTEST PROJECT
ELECTRICAL
GROUNDING PLAN - BOILER AREA

DWG. NO. 17-11-503-003 REV A

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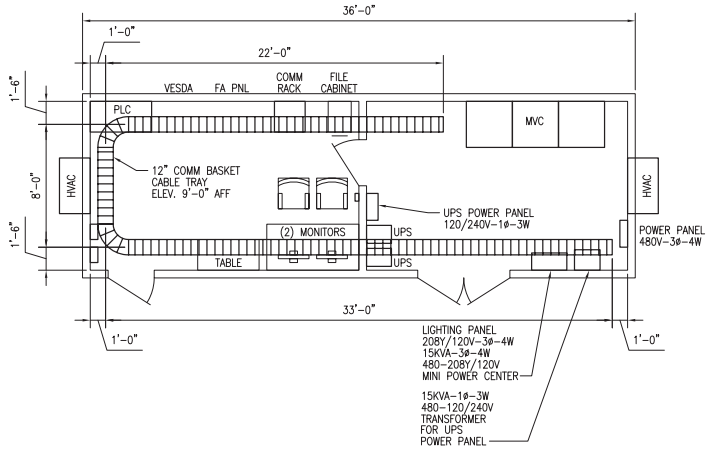
INCHES 1 2 CENTIMETERS 1 2 3 4 5 6

8 7 6 5 4 3 2 1

D C B A

17-11-650-001



NOTES:

1. CONDUIT & WIRE SHALL BE INSTALLED IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE AND LOCAL CODES.

LEGEND:

12" WIDE X 4" DEEP ROUND CROSS-WIRE BASKET TRAY, PRE-GALVANIZED STEEL, HUBBELL CAT. 3 HBT0412 OR EQUAL.

90° HORIZONTAL BEND, 12" WIDE X 4" DEEP ROUND CROSS-WIRE BASKET TRAY, PRE-GALVANIZED STEEL, HUBBELL CAT. 3 HBTR0412 OR EQUAL. (OR CUT STRAIGHT WIRE BASKET TRAY TO FORM A 90° FLAT ELBOW USING ZINC PLATED SPLICE KITS AND HARDWARE, HUBBELL # HBTSK)

PRELIMINARY

TRUE NORTH

PROJECT NORTH

REVISION APPROVAL RECORD				REV		REV NO	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
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ENVIRON.			STRUCTURAL							
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ISSUED	REV	DATE	SDE	PEM
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PROJECT NO.: 31609

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SCALE: 1/4" = 1'-0"

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A-USC COMTEST PROJECT
ELECTRICAL
CABLE TRAY ARRANGEMENT

DWG. NO. 17-11-650-001

REV A

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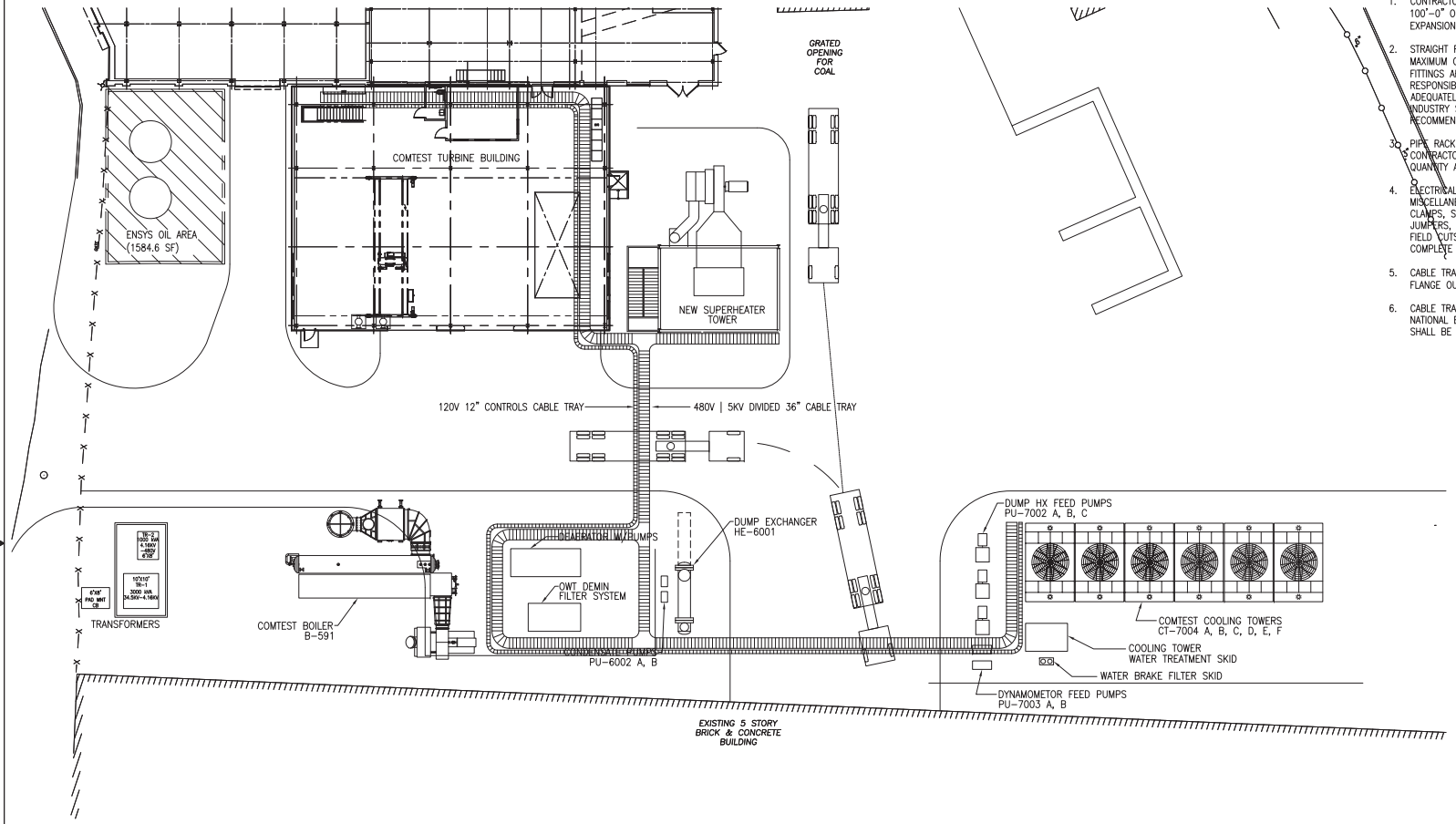
INCHES 1 2

CENTIMETERS 1 2 3 4 5 6

8 7 6 5 4 3 2 1

D C B A

17-11-652-001



NOTES:

1. CONTRACTOR TO INSTALL EXPANSION JOINTS AT A MAXIMUM OF 100'-0" ON STRAIGHT RUNS, OUTDOORS AND AT EVERY BUILDING EXPANSION JOINT LOCATION, INDOORS.
2. STRAIGHT RUNS OF CABLE TRAY SHALL BE SUPPORTED AT A MAXIMUM OF 20'-0". MISCELLANEOUS TRAY SUPPORTS FOR FITTINGS ARE NOT SHOWN. ELECTRICAL CONTRACTOR IS RESPONSIBLE FOR MAKING SURE THAT THE CABLE TRAY IS ADEQUATELY SUPPORTED IN ACCORDANCE WITH ACCEPTED INDUSTRY STANDARDS AND PER MANUFACTURERS RECOMMENDATIONS.
3. PIPE RACK SUPPORTS SHALL BE PROVIDED BY STRUCTURAL CONTRACTOR. REFER TO STRUCTURAL DRAWINGS FOR DETAILS. QUANTITY AND EXACT LOCATIONS.
4. ELECTRICAL CONTRACTOR SHALL FURNISH AND INSTALL ANY MISCELLANEOUS CABLE TRAY ACCESSORIES SUCH AS HOLD DOWN CLAMPS, STEEL SUPPORTS, EXPANSION JOINTS, BONDING JUMPERS, CABLE TIES, TRAY CONNECTORS AS REQUIRED FOR FIELD CUTS AND ANY OTHER MATERIAL REQUIRED TO MAKE A COMPLETE CABLE TRAY SYSTEM.
5. CABLE TRAYS SHALL BE STEEL, 20 FEET IN LENGHT, 6" DEEP, FLANGE OUT, HDGAF, NEMA 20C.
6. CABLE TRAY SHALL BE INSTALLED IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE AND LOCAL CODES. CABLE TRAY SHALL BE SUPPORTED PER NEMA VE2.

TRUE NORTH / PROJECT NORTH

CABLE TRAY ARRANGEMENT PLAN

SCALE: 1/16" = 1'-0"

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ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
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DRAWING STATUS				
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PRELIMINARY	A	3/31/16	EMD	DM
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A-USC COMTEST PROJECT
ELECTRICAL
CABLE TRAY ARRANGEMENT PLAN

DWG. NO. 17-11-652-001 REV A

INCHES / CENTIMETERS

EC_D_Size.dwg

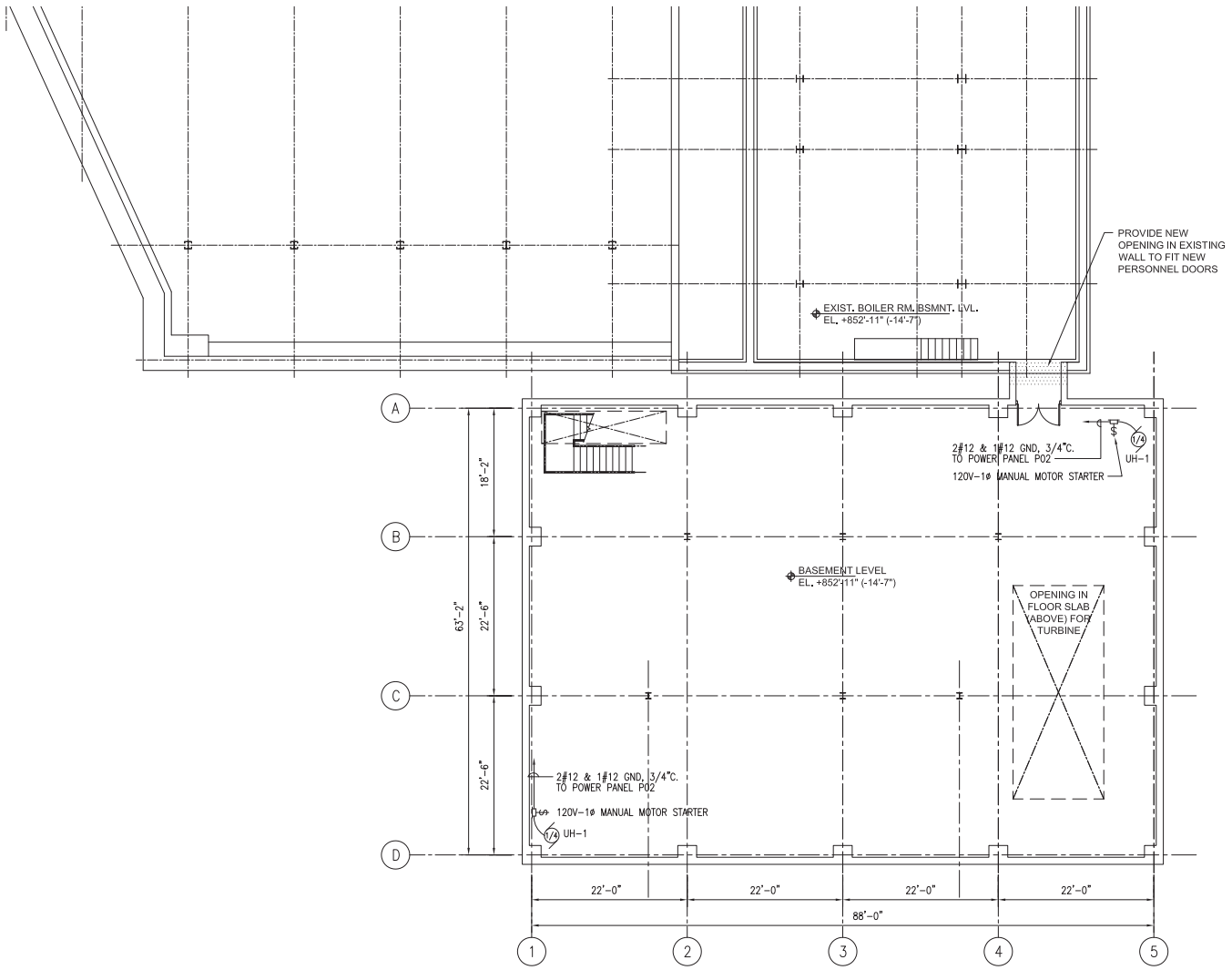
17-11-702-001

NOTES:

1. CONDUIT & WIRE SHALL BE INSTALLED IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE AND LOCAL CODES.

LEGEND:

- $ 120 VOLT, 1 PHASE, MANUAL MOTOR STARTER WITH OVERLOAD HEATER ELEMENT. NEMA 12 ENCLOSURE, PILOT LIGHT, PROVISIONS FOR PADLOCKING, 3/4" CONDUIT HUB.
- ⏀ 120 VOLT, 1 PHASE, 1/4 HORSE POWER UNIT HEATER BLOWER MOTOR, SEE HVAC DRAWING 17-11-411-002 FOR DETAILS.



POWER PLAN - LOWER LEVEL

SCALE: 1/8" = 1'-0"

TRUE NORTH

PROJECT NORTH

REVISION APPROVAL RECORD				REV		REV NO.	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BLDNG SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
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A-USC COMTEST PROJECT
ELECTRICAL
POWER PLAN - LOWER LEVEL

DWG. NO. 17-11-702-001

REV A

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INCHES CENTIMETERS

8 7 6 5 4 3 2 1

D C B A

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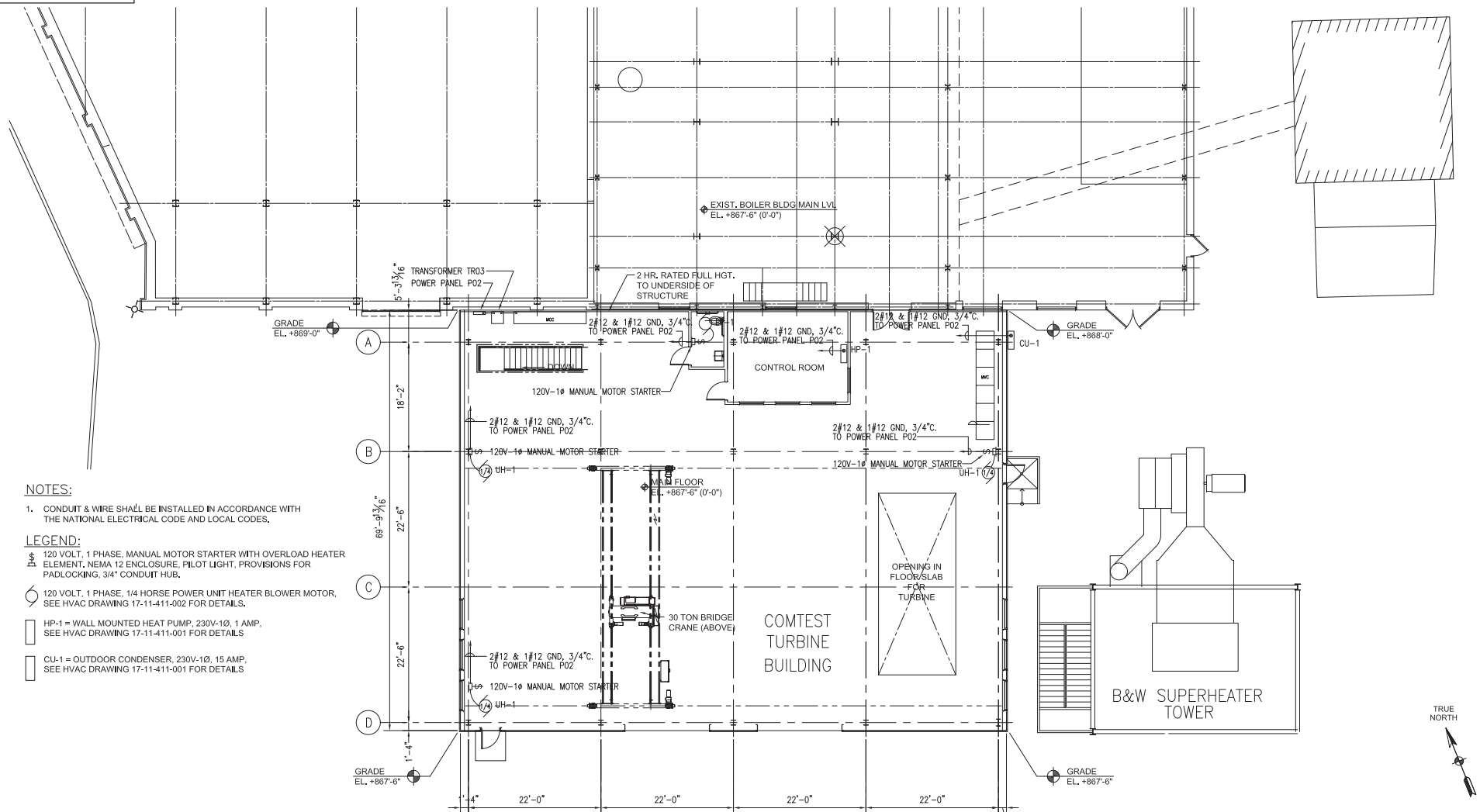

NOTES:

1. CONDUIT & WIRE SHALL BE INSTALLED IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE AND LOCAL CODES.

LEGEND:

- 120 VOLT, 1 PHASE, MANUAL MOTOR STARTER WITH OVERLOAD HEATER ELEMENT. NEMA 12 ENCLOSURE, PILOT LIGHT, PROVISIONS FOR PADLOCKING, 3/4" CONDUIT HUB.
- 120 VOLT, 1 PHASE, 1/4 HORSE POWER UNIT HEATER BLOWER MOTOR, SEE HVAC DRAWING 17-11-411-002 FOR DETAILS.
- HP-1 = WALL MOUNTED HEAT PUMP, 230V-1Ø, 1 AMP, SEE HVAC DRAWING 17-11-411-001 FOR DETAILS
- CU-1 = OUTDOOR CONDENSER, 230V-1Ø, 15 AMP, SEE HVAC DRAWING 17-11-411-001 FOR DETAILS

POWER PLAN - LEVEL 1
SCALE: 1/8" = 1'-0"

REVISION APPROVAL RECORD				REV		REV NO.	DATE	REVISIONS	BY	CHKR
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ARCH.			MECHANICAL							
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CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
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ELECTRICAL
POWER PLAN - LEVEL 1

DWG. NO. 17-11-702-002
REV A

INCHES
CENTIMETERS
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A-USC COMTEST PROJECT

Project Number 31609

Specification Number 26 00 00

FOR

31609-XXX – A-USC COMTEST

ELECTRICAL WORK

PREPARED FOR

Energy Industries of Ohio

by

AECOM
1300 East 9th St. Cleveland, Ohio

Revision: A

Status: Owner Approval

Project Name:	A-USC COMTEST	Discipline:	Electrical
Client :	Electrical Industries of Ohio		

Revision Signatures

Prepared by:	Date	Approved by	Date
Checked by:	Date	Approved by:	Date

Status	Rev. No.	Date	Prepared By	Pages	Description of Changes

PART 1 - GENERAL

1.01 NARRATIVE

A. The purpose of this project is to perform test on a super-heater and cycling header. This specification covers the electrical installation necessary for operations of the super-heater and related ancillary equipment and controls.

B. Install 5kV cable from existing plant switchgear to a pad mounted transformer (4160V to 480V) outside of control building. Install pre-manufactured control building. Install power and control cables from control building to super-heater and accessory equipment. Install communication to control building.

C. Install lighting on super-heater platforms and surrounding area.

D. Install new breaker and protective relay in the existing plant switchgear.

E. Install cable trays and control wiring from control house PLC's and controllers to super-heater and related equipment.

F. Install communications from plant IDF location to control house.

G. Interface planr firealarm system with control house fire alarm system.

1.02 WORK INCLUDED

A. Work in other sections of the specifications:

1.	Section 260513	Medium Voltage Cables
2.	Section 260519	Low Voltage Electrical Power Conductors and Cables
3.	Section 260533	Raceways and Boxes For Electrical Systems
4.	Section 260548	Seismic Controls for Electrical Systems
5.	Section 262419	Motor Control Centers
6.	Section 260923	Lighting Control Devices
7.	Section 260926	Lighting Control Panelboards
8.	Section 263353	Uninterruptible Power Supply & PDU
9.	Section 269000	Electrical Design Completion Requirements

1.03 QUALITY ASSURANCE

A. All electrical items shall be checked for agreement with the project drawings and specifications and shall be visually inspected to assure that equipment is undamaged, is in proper alignment, electrical

connections are tight and properly insulated where required, settings of relays, timers, and circuit breakers are in agreement with coordination study or other instructions, fuses are of proper type and size, and all electrical items in areas classified as hazardous have enclosures of proper NEMA type.

B. Notify AECOM in writing of all discrepancies between drawings/specifications and field installations, or if the visual inspections show damage or improper installation.

C. In addition to the requirements of Division 26, all equipment, materials and work shall be in accordance with the requirements of NEC-2014.

1.04 REFERENCE

A. Organizations whose standards are referenced herein:

1. ANSI American National Standards Institute
2. ASTM American Society for Testing and Materials
3. IEEE Institute of Electrical and Electronics Engineers
4. ICEA Insulated Cable Engineers Association
5. NEC National Electrical Code
6. NEMA National Electrical Manufacturers Association
7. NFPA National Fire Protection Association
8. SSPC Steel Structures Painting Council
9. UL Underwriters Laboratories
10. NESC National Electrical Safety Code

B. Comply with regulations of following governmental authorities:

1. State of Alabama
2. Local Codes

1.05 CONSTRUCTION SUBMITTALS

A. Submit vendor drawings for all contractor furnished equipment.

B. Submit construction submittals in accordance with the project specifications for Electrical.

C. At least 10 days prior to the planned start date of the work; submit the required copies of each submittal for review.

1.07 ELECTRICAL WORK

Design/Build Electrical contractor shall install the following:

A. General:

1. Lighting and Cable Tray layouts are shown diagrammatically based on the preliminary information. Contractor to review and updates the design based on conditions found in field.

2. Inspections and Testing for all Electrical Work.

3. Commissioning of the Electrical System installed by contractor.

B. Power Distribution:

1. Install one 5kV feeder for designated switchgear within the Power Plant to the location of the A-USC Com-test project.

2. Install the new 5kV draw-out style circuit breaker furnished within the designated cell of the switchgear.

3. Install feeder protection relay.

C. Cable Trays

1. Install cable trays as shown on drawings or as required to support tray cables.

D. Cables

1. 5kV tray rated cables

2. Low voltage cables.

3. Communications cables

E. Grounding

1. Install a perimeter ground loop around pre-manufactured control house with ground rods

2. Ground super-heater and related equipment and cable trays as indicated.

3. Install cable trays per drawings.

F. Lightning Protection:

1. Provide an

G. Lighting:

1. Install lighting on platforms and around superheater as indicated on the drawings.
2.

PART 2 - PRODUCTS

2.01 GENERAL

A. Names of approved manufacturers are listed to establish a standard of quality. Products of other manufacturers may be used with the approval of AECOM.

2.02 WIRE AND CABLE

A. All power, control, instrumentation and communication wiring shall meet ICEA, NEMA-WC and NEC standards for material and workmanship unless otherwise specified. See specification section 260513, 260519 and 260523.

B. Approved Manufacturers:

1. Southwire
2. The Okonite Company
3. General Cable; General Cable Corporation
4. Prysmian Power Cables and Systems

2.03 CONDUIT AND CONDUIT FITTINGS

A. Conduit and conduit fittings shall meet ANSI, UL and NEC standards for materials and workmanship. See specification section 260533.

B. Approved Manufacturers:

1. Rigid Steel Conduit:

a. Republic Conduit

b. Allied Tube and Conduit

c. Wheatland Tube Company

d. Western Tube

2. PVC Conduit:

a. Thomas & Betts Corporation

3. Conduit Fittings:

a. Thomas & Betts Corporation

b. B-line

c. O-Z Gedney

4. Outlet Boxes:

a. Crouse-Hinds

b. O-Z/Gedney

c. Appleton

2.04 CABLE TRAYS

A. All cable trays and fittings shall be designed, manufactured and tested in conformance with NEMA VE 1-2009.

B. Cable trays shall be ladder type with 9 inch rung spacing.

C. Communication cable trays shall be capable of supporting 50 lbs/linear foot. Power cable trays shall be capable of supporting 75 lbs/linear foot.

D. Cable trays and fittings shall be manufactured of aluminum or galvanized steel.

E. The tray systems shall be capable of being used as equipment grounding conductors and shall be in compliance with NEC-2014, Article 392.

2.05 SMALL POWER AND LIGHTING TRANSFORMERS

A. Transformers shall be constructed and rated per NEMA Standards, to bear the UL label, copper winding and be dry type. Transformers shall have voltage ratios of 480 volt primary to 240 volt, 3

phase, delta secondary or 208 Y/120, 3 phase, volt secondary.

B. Transformers shall be suitable for indoor use and shall conform to 115 degrees C, average temperature rise above a 40 degree C ambient. Insulating materials shall be in accordance with NEMA standards.

C. Taps: Shall be full capacity, two (2) 2-1/2 percent above and below nominal voltage.

2.06 PANELBOARDS

A. General:

1. Panelboards shall be of the factory assembled, molded case circuit breaker type, as required by the drawings.

2. All panelboards shall be enclosed in safety dead-front steel cabinets painted with manufacturer's grey enamel over a rust inhibitor. Doors shall be capable of being key locked.

3. The quantity and rating of molded case circuit breakers shall be furnished as required by the drawings. It shall be possible to remove these components individually without disturbing the other items.

4. Circuit breakers shall be of the quick make, quick break type, trip free on overloads, with a common trip on multi-pole units, and shall be furnished with thermal long-time and magnetic instantaneous trips.

5. The short circuit rating for all components shall be as required by the drawings.

6. Panelboards and components shall meet the latest applicable UL and NEMA standards.

B. Distribution Panelboards:

1. These items are panelboards where less than 10 percent of the circuits are 30 amperes or less, or that do not have a neutral connection.

2. Panelboards shall be rated for use on 480 volt, 3 phase, 3 wire, or 240 volt, 3 phase, 3 wire, 60 hertz circuits.

3. Main circuit breaker shall be continuously rated as required by the drawings.

4. Molded Case Circuit Breaker Type: Panelboard and components shall be Square D Type, I-Line or approved equal.

C. Lighting and Receptacle Panelboards:

1. These items are panelboards where at least 10 percent of the circuits are 30 amperes or less, with a neutral connection and being limited to 42 overcurrent protective devices.

2. Panelboards shall be rated for use on a 208Y/120 volt, 3 phase, 4 wire, or 240 volt, 3 phase, 3 wire and 60 hertz circuits.

3. The neutral shall be a solid bar containing solderless terminal lugs for each branch circuit with the correct size for the wire used.

4. Molded Case Circuit Breaker Type

a. Breakers shall be of the bolt-on type.

b. Panelboard and components shall be Square D Type NF or NQO - NQOB bolt-on or approved equal.

5. Main and feeder circuit breakers shall be rated as shown on drawings.

2.09 LIGHTING FIXTURES AND LAMPS

A. Luminaires and lighting equipment components shall be as listed in the fixture schedule and shown on the plans. Should the Constructor wish to furnish fixtures of manufacture other than shown in fixture schedule, he shall furnish a complete description of fixtures, with photometric data and computer generated calculations indicating initial and average footcandle levels for the area for approval in accordance with terms of these specifications. Additional information, such as method of support, finishes and/or actual samples of fixtures shall be submitted for approval upon request.

2.10 MOTOR CONTROL CENTER – (MCC)

A. Motor Control Center to meet NEMA ICA 18. See specification section 262419.

B. Approved Manufacturers:

1. Eaton

2. Rockwell/Allen-Bradley

3. Square D

4. Siemens

2.11 INDIVIDUALLY MOUNTED MOTOR STARTERS

A. Fractional Horsepower Manual Starters shall be full-voltage, non-reversing, single-speed, 2-pole, with overload protection for 115/230 volt, single phase, 60 hertz induction motors, single unit with toggle type of operator in NEMA 1 enclosures in office areas, NEMA 12 on plant floor, unless enclosure is designated otherwise on drawings. NEMA size shall be as required by the drawings.

B. Combination Motor Starters shall be full-voltage, non-reversing, single-speed for 480 volt, 3 phase, 60 hertz service complete with electronic overloads, fused disconnect switch, and control transformer (50 VA larger than required), with secondary fuse, rated 480-120 volt. Contactor shall have 120 volt operating coil and a minimum of two normally open, electrically independent contacts wired to terminal blocks. The combination starters shall be in NEMA 12 enclosure unless enclosures are designated otherwise on drawings. NEMA sizes shall be as required by the drawings.

A red "RUN" indicating light, a green "READY" indicating light, and a "START-STOP" pushbutton or hand-off-auto selector switch shall be mounted in the cover as required by the drawings.

2.12 INDIVIDUALLY MOUNTED OPERATOR STATIONS

A. Non-Hazardous Areas: Furnish with heavy duty oiltight control elements, mounted in NEMA Type l3, oil and dust tight enclosures.

B. Hazardous Areas - Class, Division, Group, Locations: Furnish with heavy duty control elements, mounted in NEMA Type 7, hazardous location enclosures.

C. Approved Manufacturers:

1. Eaton
2. General Electric Company
3. Square D Company
4. Allen-Bradley

2.14 FUSES

A. Furnish all fuses, except those specifically excluded.

B. Low voltage fuses, 0-600 volts, shall be UL Class J time delay, unless specified otherwise on drawings.

C. Current limiting, low voltage fuses shall be:

1. 0-600 amps, UL Class J time delay
2. 601-6000 amps, UL Class L

D. Fuse holders shall be specifically designed for these classes and reject all other fuses.

E. High voltage fuses, above 600 volts, shall be as specified on the drawings.

2.15 EMERGENCY LIGHTING UNITS

A. The emergency lighting and emergency lighting units shall be specified on the project drawings.

B. The emergency lighting and emergency lighting units shall provide emergency illumination automatically on failure or interruption of normal electric power.

C: Emergency Lighting and Emergency Lighting Units shall be as follows:

1. In Plant Floor Area:

   a. Specified 480VAC high bay LED luminaires will be wired to emergency lighting panels which are fed from an automatic transfer switch and emergency generator.

   b. Emergency Lighting Units to be 120/277VAC input, wall mounted high capacity industrial style LED emergency lights, black heavy gauge steel housing, 12VDC maintenance free lead acid battery back-up, 360 Watt Capacity with two (2) 50 Watt, 12VDC Halogen adjustable heads. Unit to be plugged into an adjacent mounted 120VAC Single 20 amp receptacle. Use single or double remote 50 Watt, 12VDC heads as necessary.

2. In Offices, Training, Conference, Break, Toilet, Locker, First Aid & Electrical Equipment Rooms utilizing fluorescent lighting:

   a. Fluorescent Fixtures shall be provided with emergency battery ballasts as required to meet the requirements of the NEC and Life Safety Code.

   b. Emergency Lighting Units to be 120/277VAC input, ceiling or wall mounted commercial style LED emergency lights, injected molded high impact thermoplastic white housing with 4.8V Sealed Nickle Cadmium battery back-up and two (2) adjustable lamps.

D. The emergency Lighting Units are to be energized by 120 volt, a-c, single phase, 60 hertz source. It shall contain a “ready/off” switch, a switch for quick testing of the lamps and batteries, and a red light which glows when the unit is on a high rate of charge.

E. From a fully charged condition, the unit shall be capable of furnishing 3.25 hours of light until the batteries discharge to 10.5 volts at 77 degrees F. It shall also be capable of automatically disconnecting the lamps when normal power is restored.

2.16 DISCONNECT SWITCHES

A. Disconnect switches shall be suitable for 480V or 240V, 3 phase, 60 hertz, amperage will be per the load schedule. They shall be fused Class J or RK/L type fuses. Disconnect switches shall be horsepower rated.

B. Disconnect enclosures shall be NEMA 12 unless specified otherwise.

C. Approved Manufacturers:

1. Square "D"
2. Allen-Bradley
3. Eaton
4. Siemens

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2.19 NAMEPLATES

A. Nameplates for panelboards, safety switches, individual motor starters and other electrical equipment, not identified by factory nameplates, shall be furnished and attached. An acceptable nameplate may be made using white laminated phenolic with black engraved letters and adhesive backing. Nameplates on electrical equipment shall include Equipment Number (3/8 inch lettering), Voltage, Phase and where it is fed from (3/16 inch lettering). 120 volt receptacle tags shall include panel and circuit number (3/16 inch lettering). All panel schedule legends shall be type written.

2.20 PAD MOUNTED 15kV SWITCH

A. Provide a S &C type PME 6 or equal pad mounted switch for distributing power to remote locations on site. Provide specialized tools and equipment for operating and maintaining. Fuses shall be provided. Size and type to be determined later.

PART 3 - EXECUTION

3.01 EXCAVATION

A. Perform all excavation, trenching, backfilling, and removal of debris in connection with the work in accordance with the requirements of Division 310 00 00.

3.02 PHASE ROTATION

A. Required order of phase rotation for entire project shall be phase A, phase B, phase C, with voltage reaching maximum value in that order.

B. For switchgear, motor control centers, panelboards and other distribution and motor control equipment, connect phase conductors to terminals in the order A-B-C from left to right, facing

circuit breakers, motor starters, or panelboards. Conductors shall be marked with colored tape at terminations A-Black, B-Red, C-Blue. When not in conflict with the latter, due to standard arrangement, bus bars in this equipment shall be in the order A-B-C from front to back and top to bottom.

3.03.1 EQUIPMENT INSTALLATION

A. Provide all necessary supports for equipment installed under this specification section. Supports shall consist of steel frames, plates, brackets, racks and other shapes of adequate size and fastened with bolts, screws or by welding, to provide rigid support. It is the intent of this specification that drilling and welding of building steel be used for fastening only with approval of Owner's Representative. Mechanical compression type fastening is preferred. Welds shall be continuous and, where exposed, ground smooth. Thoroughly clean metal surfaces and apply one coat of primer as required by SSPC-SP [2] [3] and PAI. All other material to be used for support shall have prior approval.

3.04 WIRE AND CABLE

A. Installation and Hardware:

1. Lubricants used for pulling wire and cable through conduit shall be UL listed.

2. Solderless connectors shall be used for connecting and splicing all wires, where practicable, and shall be used for all stranded wire. For wire up to and including No. 10 AWG connectors shall be similar to "STA-KON" as manufactured by Thomas & Betts. Splices may be made with hand twist wire joints similar to "Piggy" as manufactured by Thomas & Betts, or "Scotchlok" as manufactured by 3M Company. Porcelain wire joints will not be accepted.

3. For wire No. 8 AWG and larger, connectors shall be of the compression type. For copper wire, indenter type of compression connector may be used. Connectors shall be similar to those manufactured by Burndy or Thomas & Betts.

4. All splices and taps shall be made only in headers or junction boxes.

5. All 600 volt or less wiring, where compression type connectors are used, shall be insulated with at least one turn of "Scotchfil" Electrical Insulating Putty and then covered with two half turns of tape similar to 3M Company's "33 Plus" (33+) Plastic Tape.

6. All termination and splices of shielded cable, rated 5 kv and above, shall be stress relieved electrically according to the cable manufacturer's recommendation.

7. Connections to ground conductor shall be made by Cadweld or Thermoweld process unless specified specifically as mechanical connections on drawings.

8. Where possible, No. 6 AWG and smaller wire shall be color coded by the color of the insulation covering. Color coding of wire larger than No. 6 AWG may be by means of self adhesive wrap-around type markers.

B. Wire Identification

1. Power and lighting branch circuits shall be identified at devices services to indicate originating panel and circuit number.

2. Signal and control wires shall be identified at all cabinets, terminal boxes, equipment racks, control panels and consoles.

3. Indoor wiring conductors, No. 8 AWG and smaller, shall be tagged with Brady "Quick-Labels". Permanently mark with cable numbers and fasten to cable, at all terminal ends and pull boxes. All control wire shall be color coded if indicated on drawings, in addition to having identification labels.

4. High voltage feeder cables, No. 6 AWG and larger shall be tagged with belt type plastic wrap-around tags, stamped with feeder number.

3.05 CONDUIT AND CONDUIT FITTINGS

A. General:

1. Field bends and offsets shall be uniform and symmetrical, without conduit flattening or finish scarring. Minimum bend radii shall be as required by NEC.

2. Pipe plugs or caps conforming to accepted construction practice shall be installed in conduit before pouring of concrete. Conduit shall also be kept dry and free of water and debris by means of plugs or caps.

3. Conduit entrances through exterior concrete walls or below grade footings shall be made watertight. Provide pipe sleeves in the concrete with 1/2 inch minimum clearance around the conduit and an entrance seal similar to O.Z. Gedney Type FSK.

4. At all entrances to panelboards, pull boxes, or outlet boxes, conduit runs shall be secured in place with galvanized locknuts and bushings; one locknut inside and one locknut outside the box with the bushing inside the box. Bushings shall be of the insulating type.

5. Field bends shall be made with standard tools and equipment manufactured specifically for conduit bending.

6. Sliding expansion joints with straps and clamps shall be furnished across building expansion joints where conduit is embedded. Where conduit is exposed, provide expansion joints as required by the drawings.

7. Electrical connections to control equipment such as solenoid valves, pressure controls, pneumatic-electric relays, and other devices shall be through flexible conduit, "Sealtite" Type UA, as manufactured by Anaconda Metal Hose, or approved equal.

8. Connectors terminating flexible conduit shall be of the insulated, water-tight type and meet

UL standards for positive ground continuity.

9. All steel bolts, nuts, washers and screws shall be galvanized or cadmium plated.

10. Drawing Layout: Conduit systems shall be installed as close as practicable to indicated locations in order to make all electrical systems complete and workable.

11. Conduit systems shall be installed in conformity with the contract drawings while avoiding interferences with other items and systems and incorporating all necessary boxes, conduit, and/or conduit fittings that may be required to insure a complete and workable system.

12. Secure approval in writing before deviating from the contract drawings.

13. Conduit systems shall be installed in such a manner as to permit ready access to equipment for operation, maintenance and cleaning purposes.

B. Application and Restrictions

1. Rigid or IMC conduit shall be used for exposed exterior locations.

2. Rigid or IMC conduit shall be used for exposed interior locations in manufacturing or production areas from below slab to 15 feet above floors for all sizes.

3. Rigid or IMC conduit shall be used for all interior systems above 600 volts regardless of location.

4. Electrical metallic tubing (EMT) not smaller than 3/4 inch shall be used indoors where rigid conduit is not specified, (such as offices and break room). Use EMT above 15' A.F.F. where not subject to damage.

5. Polyvinyl chloride (PVC) conduit, Schedule 40, shall be used as follows:

   a. Concrete encased ductbanks

   b. Direct buried in earth

   c. Provide a ground wire, sized per NEC in all PVC conduit.

   d. Temporary power skid installations.

6. Liquid-tight flexible conduit with an oil resistant cover shall be used for motor terminations and for equipment terminations where exposed to vibration and/or moisture unless indicated otherwise on drawings. Do not use at transformer connections.

7. Flexible conduit (1 inch maximum) shall be used in concealed areas where required by the limits of installation and above suspended ceilings for final connections to lighting fixtures.

C. Conduit Supports:

1. Exposed conduit shall run parallel or perpendicular to members of the building structure, rigidly maintained and clamped with one-hole malleable iron conduit clamps, or conduit supports similar to those of Steel City Electric Co. or Unistrut Corp. The type of conduit support will depend on the type of construction. Pull boxes shall be rigidly supported with structural steel supports.

2. Ring pipe or trapeze hangers may be used to support conduits, except for the first and last hangers of the conduit run or where a vertical or horizontal direction change occurs. In these cases conduit supports must be rigidly braced so that wire may be pulled without damage to the conduit system. Stud welds, similar to those manufactured by Nelson Stud Welding, may be used for fastening clamps to steel. Flat straps shall not be used to support conduit or boxes. No drilling of building structural members, for supporting conduits, will be allowed. Conduit runs shall be supported as required by NEC unless otherwise noted on the drawings.

3. On vertical conduit runs, which are unsupported from the roof truss to the top of the enclosure, applicable fittings shall be used to fasten the conduit to the top of the enclosure for rigidity.

3. Individual hangers and rods shall be prime coated.

4. Seismic requirement – see Section 260548.

D. Conduit in Duct Banks or Earth:

1. Conduit in contact with earth shall be PVC.

2. A minimum of 6 inch separation between conduit and hot water or steam lines shall be maintained.

3. Conduit stub-up shall be furnished with couplings. Couplings shall be sealed with a flush, threaded pipe plug.

4. Concrete for duct banks shall be in compliance with the requirements of Article 3.13.

5. Duct banks for electrical conduits shall consist of red colored concrete.

3.06 CABLE TRAYS

A. Furnish and install all cable trays, fittings, drop-out accessories, mounting hardware and supports as shown on the project drawings.

B. Installation shall be in compliance with NEMA VE2.

C. Verify the seismic requirements

3.07 SMALL POWER AND LIGHTING TRANSFORMERS

A. KVA and voltage ratings of transformers shall be as required.

3.08 LIGHTING FIXTURES AND LAMPS

A. Luminaire Wiring: All luminaires and lighting equipment shall be wired in accordance with NEC Article 402. No splice or tap shall be located within an arm, stem, or chain. Wire shall be continuous from splice in outlet box of building wiring system to lamp socket or ballast terminal.

B. Lighting fixtures shall be as specified on the drawings. Lighting fixtures will be industrial LED type suitable for the application, elevated temperatures and outdoor.

C. Cleaning: Clean fixtures of dirt and foreign matter before acceptance.

3.09 GROUNDING

A. Grounding system, as required by the drawings, shall be provided with a ground source consisting of a series of driven 3/4 inch x 10 feet copperclad steel ground rods interconnected by bare copper cable.

B. Rods shall be driven to a full 10 foot depth. .

C. Ground cable loop shall be of AWG, 4/0 bare stranded copper cable installed a minimum of 30 inches below grade.

D. All non-current carrying metal parts of electrical equipment and installations shall be connected to the ground loop. These include structural columns, platforms, tanks, wireway, busways, raceways, lightning arresters, switchgear enclosures, transformers, panelboards, pushbutton stations, motors and fences. Refer to vendor information for special requirements for Equipment Numbers 146, 164 and 382.

E. All cable connections shall be exothermic.

F.

3.10 ELECTRONIC OVERLOAD ELEMENTS

A. In motor control centers and some individually mounted motor starters use electronic overload elements.

3.11 DIRECTORIES

A. The directory at each panelboard shall be machine typed showing the destination of each circuit installed.

3.12 FIELD QUALITY ASSURANCE

A. Perform, or have an independent testing organization perform, the test listed in the following paragraphs (where applicable); and notify AECOM in writing of all test results.

B. Cables:

1. Cable Standards:

a. The following table lists applicable ICEA standards for cable tests:

Insulation	ICEA No.	NEMA Pub. No.
Thermoplastic	S-61-402	WC5
Ozone-Resistant	S-68-516	WC8

b. In accordance with ICEA standards, tests shall be made immediately after installation.

c. All voltage tests shall be performed in compliance with ICEA standards, and cable manufacturer's recommended testing procedures and limitations.

2. 600 Perform a circuit continuity test using a simple "ringer" to prove that all conductors are terminated at the correct points and have electrical continuity.

3. 600 Volt Feeder Cables: Perform an insulation resistance test using the one minute dielectric absorption test method for all cables sized 1/0 AWG and larger. The test shall be performed with a 1100 volt megger after cable is in final position and with all splices completed. Test each conductor to ground with other conductors grounded. The resistance shall not measure less than 100 megohms

4. Cables Rated Above 600 Volt: Employ an independent testing organization to perform a dc voltage Hi-pot test on all cables rated above 600 volt. The test shall be performed after cable is in final position with all splices completed, and with all terminations that can withstand the test voltage completed. The test shall comply with paragraph 3.12B.1.c. of this specification.

C. Transformers:

1. General: Inspect the impact resistor gauge on all power transformers that are shipped with such a gauge. If the gauge shows that the transformer received excessively rough handling during shipment, the Constructor shall immediately notify the Engineer.

2. Megger test insulation of primary and secondary windings or dry type transformers 15KVA and above with 1000V meg-ohm meter. Record values.

D. Switchgear:

1. 480 Volt Switchgear: Perform an insulation resistance test of the switchgear bus. Perform a one minute dielectric absorption test using a 1000 volt megger, testing phase-to-phase and phase-to-ground.

3. 4160 Volt and Higher Voltage Rated Switchgear: Employ an independent NETA certified testing organization to perform a dc voltage Hi-pot test on all switchgear and buses.

4. NETA certified testing company shall perform acceptance testing on all medium voltage motor control centers, oil filled transformers above 2MVA, dry type transformers above 1000KVA, and 5kV, 15kV and 480V draw-out switchgear per ANSI/NETA ATS-2009 "Standard for Acceptance Testing".

END OF SECTION

PART 1 GENERAL

1.01 SCOPE

A. This specification covers the design, manufacture and testing of a self-contained pre-engineered custom outdoor walk-in control building containing 480V motor control center (MCC), panel boards, UPS system, PLC system, burner controller and other associated building support equipment as described here-in. The complete integrated unit shall be a completely self contained with a controlled interior environment that will allow the unit to be installed as a one-piece unit or multiple units if shipping splits are required.

B. **Seismic Requirements**: IBC-2016 Seismic Design Category C with a Seismic importance factor of 1.25. Certify the equipment via Calculations performed by a registered engineer.

1.02 RELATED WORK

A. Building Vendor has overall coordination responsibility with any sub-vendors involved with the manufacture of the integrated building.

B. Vendor to provide and install the following equipment:

1. 480 Vol Motor Control Center (MCC) with the number of sections as required per requirements of the one line diagram and components specified herein.

2. Panel boards/power panels, dry type transformers, UPS systems, lighting, receptacles, data outlets, communications cabinet, cable trays, HVAC etc. as indicated on the drawings.

3. Programmable Logic Controller (PLC) in cabinet (see attached drawings).
   a. Includes Allen-Bradley Controllogix system, wire duct, isolated ground, Ethernet switch, power supply, etc.
   b. Refer to attached drawings for PLC components and layout requirements.

C. Building shall be furnished complete with desk, tables, chairs file cabinet etc. as shown on drawings and or specified herein.

1.03 ATTACHMENTS

A. One line diagram, plan and elevation drawings, alarm and communication schematics, AC and DC panelboard schedules, PLC drawings.

B. Instructions to Bidders

1.04 QUALITY ASSURANCE

A. Tests

1. MCC lineup shall have been completely assembled and adjusted at the manufacturer's factory prior to shipping to the building manufacturer.
2. Continuity checks of all wiring installed by the building supplier.
3. Operational check of all building supplier furnished and installed electrical equipment.
4. If the MCC was shipped in more than one shipping piece to the building Vendor, then building Vendor is to re-splice, re-torque all switchgear bus at the shipping section splits. Building Vendor shall reconnect any switchgear control that was disconnected at the switchgear shipping splits.

B. Inspection

1. The Buyer reserves the right to inspect the building during fabrication and assembly. Visual inspection will be made of all equipment prior to shipping. Notify the Buyer not less than 14 days prior to the shipping date.

2. No equipment shall be shipped until visual inspection has been completed by the Buyer or his authorized representative. No equipment shall be shipped until released for shipment by the Buyer or his authorized representative.
3. Witness of building test shall be itemized as a separate cost item in the Vendor's proposal.

C. All electrical equipment supplied in the building shall be UL labeled.

D. Any items removed for shipment shall be plainly marked to facilitate reinstallation in the field.

E. Guarantee

1. All items of equipment shall be fully guaranteed for a period of one year from the date of energization against defective design, material, and workmanship, not to exceed 18 months from date of shipment.
2. Provide a price to extend the guarantee to 2 years after energization.
3. All defects shall be corrected by Vendor or approved party without expense to the Owner, should a defect be discovered or should a failure occur.

1.05 REFERENCE STANDARDS

A. Organizations whose standards are referenced herein:

1.	ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
2.	ASTM and Materials)	ASTM International (formerly American Society for Testing
3.	NEMA	National Electrical Manufacturers Association
4.	NFPA	National Fire Protection Agency
5.	SDI	Steel Deck Institute
6.	SSPC Painting Council)	The Society for Protective Coatings (formerly Steel Structure
7.	UL	Underwriters Laboratories

B. Building:

1. The building shall be designed, manufactured, and tested to the applicable standards listed below including any supplements that are in effect at the time that the Purchase Order is issued.

ASHRAE FUN IP CH30-2005	Nonresidential Cooling and Heating Load Calculations
ASTM A36/A36M-2008	Standard Specification for Carbon Structural Steel
ASTM A572/A572M-2012	Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
ASTM C177-2010	Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus
ASTM C518-2010	Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus
ASTM D2247-2011	Standard Practice for Testing Water Resistance of Coatings in

100 % Relative Humidity

NEMA 250-2008	Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA C80.1-2005	Electrical Rigid Steel Conduit
NFPA 70-2011	National Electrical Code
SDI A250.8-2003 (R2008)	Recommended Specifications for Standard Steel Doors and Frames
SSPC SP 1-1982 (E2004)	Surface Preparation Standards and Specifications (Solvent Cleaning)
SSPC SP 3-1982 (E2004)	Surface Preparation Standards and Specifications (Power Tool Cleaning)
UL 50-2007	UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations - Twelfth Edition; Reprint with revisions through and including APRIL 27,2012
UL 508-1999	UL Standard for Safety Industrial Control Equipment - Seventeenth Edition; Reprint with Revisions Through and Including April 15, 2010

1.06 SUBMITTALS

A. Proposal

1. A statement MUST be submitted that the equipment offered is in complete compliance with this specification, otherwise the Vendor must submit a detailed list of the exceptions being taken. Reference to a specific paragraph number in the specification is required.
2. The following information must be submitted with bid in PDF format.
   a. Descriptive or catalog literature.
   b. Outline drawings complete with dimensions and weights.
   c. Building information such as confirmation of size, operating data, materials and principals of construction, and description of major components.
   d. Dates for furnishing approval drawings and equipment.

B. Approval Drawings:

1. Provide one (1) CD-ROM with drawings in PDF and AutoCAD 2010 or later. Note: E-mailing of approval drawings is acceptable in lieu CD-ROM. Submit within 3 weeks or as per the Vendor's quotation after receipt of the order. Vendor is not authorized to start manufacture of the equipment until the Owner has returned the approval drawings to the Vendor.

2. The Approval Drawings shall include the following as a minimum:
   a. Outline drawings showing front, top and side exterior views of the building with overall dimensions, shipping and installed weights, foundation requirements, base channel dimensions and spacing.
   b. Interior elevations and plans of the building showing the location of all interior mounted equipment
   c. Cross sections
   d. Door details including door hardware and locks

e. HVAC equipment data
f. AC and DC panelboard schedules with breaker sizes
g. Lighting fixture schedule
h. Nameplate legends
i. Details of any specified equipment, such as manual transfer switch, firestopping
j. Building schematics
k. Preliminary bill of material listing major components
l. Purchase Order # and Owner's Equipment ID shall be placed on every drawing.
m. Instructions for handling and installation.
n. Building structural calculations, including seismic and anchoring details.

C. Construction Drawings:
1. Provide Manufacturer's Construction drawings on a CD-ROM with drawings in PDF and AutoCAD 2010 or later. Note: E-mailing of approval drawings is acceptable in lieu of CD-ROM.
2. The Construction Drawings shall include the following as a minimum:
a. All information included in the Approval Drawings.
b. Wiring / connection diagrams.

D. Certified (As-Built) Drawings:
1. Provide three (3) CD-ROMs with drawings in PDF and AutoCAD 2010 or later, as follows: Furnish CD-ROMS two weeks after shipping.
2. The Certified As-Built Drawings shall be updates of the Construction Drawings.

E. Operating and Maintenance Manuals: After submission of certified drawings, provide three (3) sets of manuals hard copies and one (3) CD-ROM copies for all equipment and components furnished. Provide them as follows: Furnish two hard copy sets and the CD-ROM to Owner. Furnish one (1) hard copy set with each building.

F. Certified Building Test Reports: Provide three (3) sets hard copies and one (3) CD-ROM copy after performing routine tests per Manufacturer's standard routine test procedures. Certified copies of the test reports for all routine tests shall be provided. These are to be submitted within two (2) weeks of test completion.

G. Bills of Materials, Spare Parts: Provide three (3) CD-ROMs of:
1. Bills of materials accurately identifying each component in any given equipment assembly.
2. List of recommended spare parts along with their prices and part numbers.
3. List of any special tools along with their prices.
4. Information/Data may be added to CD-ROMs being created above.

1.07 DELIVERY AND HANDLING

A. In addition to manufacturer's normal preparation, packaging and precautions for shipping, this equipment shall be protected by a plastic covering to prevent entrance of moisture, dirt and dust while stored temporarily.

B. Notification of shipment details shall be made to the Owner's representative two working days prior to arrival of the equipment at the job site.

C. Equipment deliveries shall be grouped together on the same truck where possible.

D. Equipment shipping will be FOB destination.

E. Equipment shall be delivered on site to "SHIP-TO ADDRESS" listed on PO, between the weekday hours of 8:00AM and 2:00PM.

1.08 SITE CONDITIONS

A. Outdoor Temperature: Winter Dry Bulb 19.6°F

Summer Dry Bulb 95°F
Summer Wet Bulb 75°F

B. Altitude: less than 1000 feet above mean sea level

PART 2 PRODUCTS

2.01 GENERAL

A. NEMA 3R building shall be factory fabricated by one Vendor complete with the 480V MCC and other items necessary to make the unit complete and workable although all such items may not be listed or described herein and/or as shown on the drawings. Vendor shall identify any sub-vendors supplying over 10 percent of the equipment that he is supplying. If the Vendor is awarded the order, sub-vendor(s) identified in the proposal may not be changed unless the Owner receives a written request from the Vendor and the Owner furnishes a written approval of the change.

B. Devices shall be as shown on the single line diagrams, other included drawings and in this specification, manufactured by the companies as stated. "No substitutions" means that this device should be supplied; the Vendor shall flag critical, functional issues with such specified devices. "Or equal' indicates that an Owner-approved substitution may be made, provided it is approved before supplied.

C. Clean steel work after all welding and fabrication is completed and finish interior and exterior with paint as specified herein.

D. The building and all components mounted thereon shall be designed for and anchored sufficiently for transportation to the job site.

2.02 MATERIALS

A. All materials, equipment, and parts shall be new and unused, of current manufacture, and of highest grade.

B. Provide terminals and terminate wires that are routed between shipping splits (if applicable) in each applicable shipping split to facilitate wiring between shipping splits sections during final assembly at the field installation site.

2.03 BUILDING CONSTRUCTION

A. General
1. Building shall be meet the requirements of a NEMA 3R classification for being rainproof and sleet (ice) resistant.
2. Roof loading shall be 40 PSF or per IBC-2015 whichever is the more stringent requirement. Additional roof snow loading shall requirements are as follows.
    1.) Snow loading shall be calculated in accordance with ASCE 7-10 with the location being Birmingham Alabama.
    2.) Consideration shall be given to partial and unbalanced loading, ponding, instability, additional surcharge loads of rain-on snow, snow sliding off a sloped roof onto a lower roof, drifted snow on lower levels of multi-level roofs, and on roof areas adjacent to projections such as parapet walls, etc
3. Exterior walls shall withstand the wind forces per IBC-2015 for Birmingham Alabama..
4. Structure shall be braced for the specified seismic category of IBC.

B. Base and Floor
1. Base members are ASTM A36 C channels, wide flange, and or angle sections forming a self-supporting grid. All members are continuously welded at all joints. For special applications the base can also be constructed from galvanized materials.

2. The floor is constructed of ASTM A36 1/4" minimum hot rolled steel floor plate and welded to all main structural base members and ground smooth. The floor is flat and free of voids or extrusions.
3. Base shall be of all welded, seamless construction utilizing ASTM-A36 structural steel members, sized and arranged for proper strength, and able to withstand the stress and loads which will result when lifting the complete factory fabricated and equipped assemblies. Welding shall be in accordance with the requirements of AWSD1.1. All welding shall be performed by welders certified through the 4G position. Suppliers shall be prepared to show welders' certificates.
   a. Deflection shall be L/240. The building shall be suitable for installation on a concrete pad.
   b. Base shall be equipped with two (2) external 314 or 316 stainless steel ground pads welded to the base and located at opposite corners of the base. Ground pads shall be supplied with standard NEMA drilling of two holes on 1-3/4 centers tapped for ½" x 13 threads
4. Floor shall be a minimum of 1/4-inch thick H.R. ASTM-A36 smooth steel plate welded to the perimeter and longitudinal and/or transverse structural members of the base. The floor loading shall be not less than 250 PSF.
5. When shown on the attached drawings, the floor shall be provided with floor cutouts where required for power and control cable bottom entry/exit from the switchgear or other equipment. Removable 12 gauge galvanized cover plates shall be supplied to cover the cutouts.

C. Walls, Roof and Ceiling
1. Walls, roof and ceiling shall be fabricated from G90 galvanized steel. Exterior walls, exterior roof and interior ceiling shall be of self-framing, interlocking design, with a maximum panel width of 16 inches. Buildings of framed construction are not acceptable.
2. Exterior walls shall be a minimum of 14-gauge thickness steel, but shall be capable to withstand the wall loading requirements of the installation site.
3. Interior walls shall be a minimum of 14-gauge thickness steel, but rated to withstand the loading requirements of any equipment being mounted on the walls as part of the building requirements.
4. Exterior roof shall be a minimum of 14-gauge thickness, but rated to withstand the roof loading requirements of the installation site. The roof shall be sloped at 1/4-inch minimum per linear foot, and when possible shall be sloped away from the personnel doors. Drip gutters are required over all personnel doors.
5. Interior ceiling shall be minimum of a 14-gauge thickness, but rated to withstand the loading requirements of any building supplier mounted equipment and/or any ceiling mounted equipment as required in this specification.
6. Walls, roof and floor shall be fully insulated, with a minimum of R-11 insulation. The walls and roof shall be provided with fiberglass batt type insulation. The floor shall be provided with polyurethane spray foam insulation.
7. When wall bulkhead penetrations are specified in the building data sheets and/or are shown on the attached building drawings, the cutouts shall be completely framed with 1/4" aluminum cover plates with neoprene gasket. All the penetrations shall be made in the walls prior to bending with the appropriate machinery. No manual cutting of wall penetrations via jigsaw, plasma torch, etc., shall be permitted. All wall bulkhead penetrations require the use of fire stops as specified in paragraph 2.03.D.

D. Fire Stops
1. All firestop products shall be UL 1479, ASTM E 814, or UL 2079 tested for specific fire-rated construction conditions conforming to construction assembly type, penetrating item type, annular space requirements, and fire-rating involved for each separate instance. All tested assemblies that provide a fire rating equal to that of construction being penetrated.

2. Fire-stopping shall be composed of components that are compatible with each other, the substrates forming openings, and the items, if any, penetrating the fire-stopping under conditions of service and application, as demonstrated by the fire-stopping manufacturer based on testing and field experience.
3. Vendor shall use only components specified by the fire-stopping manufacturer and approved by the qualified testing agency for the designated fire-resistance-rated systems.
4. Firestop system shall be supplied with a "F" Rating as determined by UL 1479 or ASTM E 814 which is equal to the time rating of construction being penetrated.
5. Firestop system shall be based on a Hilti system containing the following components. No substitutions are permissible
   a. Hilti FS 657 Fire Block
   b. Hilti FS-ONE High Performance Sealant
   c. Hilti CP-601s Silicone Joint & Penetration Firestop Sealant
   d. Hilti Filler: Mineral Wool
   e. Hilti CP 637 Firestop Mortar

E. Doors
1. Building shall be provided with a minimum of two (2) entrance doors. The doors shall be double wall construction, with stainless steel panic hardware with Best construction core only cylinder lock and thumb latch Magnokrom Cat.#N500-5XOT53-X32 or equal, brushed aluminum automatic closure with built-in hold open device, threshold built into the door frame, neoprene gasket, drip shields/water flashing,. The personnel door shall be 36-inches wide and 84-inches high.
2. Doors shall include viewing windows approximately 12 inches by 12inches.
3. When indicated on the drawings, an equipment door shall be supplied. The door shall be 48 inches wide and 84 inches high with a 12 inch removable transom above the door.
4. A **"DANGER, HIGH VOLTAGE, KEEP OUT"** sign with a minimum of one inch lettering shall be supplied on the doors entering the MCC room.
5. All signs shall be secured with stainless steel screws. Use of glue or adhesive for securing the signs is not acceptable.
6. All external door hardware such as hinges, thumb latch, handles and etc. shall be 314 or 316 stainless steel.

F. Finishing
1. Base shall be sandblasted to all remove rust and scale prior to painting. A 2-3 mil thick application of epoxy iron oxide primer shall be provided.
2. Floor shall be provided with a 2-3 mil application of “Red” epoxy iron oxide primer, followed by a 2-3 mil application of ANSI-61 gray epoxy, with a non-skid finish.
3. The exterior and interior of the building shall be provided with a 0.3-0.6 mil application of a vinyl wash primer. The finish exterior coat shall be a 2-3 mil application of ANSI 70 gray colored epoxy paint. Interior finish shall be manufacture’s standard white.
4. Floor in the control room area shall be covered with an approved vinyl flooring material or commercial grade carpet tile flooring.

2.04 ELECTRICAL

A. General
1. Building shall include all the necessary electrical distribution equipment installed for the proper operation of building services within the building. The operating voltage for larger equipment shall be 480/277, three-phase, 4 wire as indicated on the drawings.

B. Motor Control Center (MCC)

1. Provide a UL listed Motor Control Center (MCC), NEMA 1 enclosure, having a main load break switch with class L fuses. MCC shall be 3 phase, 4 wire and ground bus.
2. MCC shall be suitable for Service Entrance.
3. MCC shall be NEMA Class I, designed, manufactured and tested per NEMA 1B and UL 845 and other applicable NEMA and UL standards.
4. MCC shall be provided with a TVSS protective device near the main disconnecting means.
5. Enclosure shall be free standing steel cabinets NEMA 250 Type 1 with standard manufacturer's finish. Each starter cell, feeder cell, etc. shall have a disconnect handle capable of being locked in the open position.
6. MCC shall be rated 42kAIC minimum with bus bracing or as indicated on drawings.
7. MCC shall be equipped with a power meter to measure all incoming power. Utilize three (3) current transformers that may be placed on the load or line side of the main disconnect switch. Power meter shall be incorporated into a metering compartment that can be inserted and removed similar to a motor starter unit. Power meter shall be an Electro Industries Shark 200 model and include Ethernet the communication options or an engineer approved equivalent.
8. Provide a pull box above the main disconnect compartment for ease of installation of incoming cables (up to four (4) 350 to 500kcmil per phase).
9. Provide motor starters with electronic overload relays as indicated on the drawings. Combination starters shall utilize Motor Circuit Protectors (MCP) or disconnect switch with class J time delay fuses as indicated on the drawings.
10. Feeders from the MCC shall utilize either thermal magnetic circuit breakers or fused switches as shown on drawings. Circuit breakers shall have a interrupting rating of 42kA unless indicated otherwise on drawings. Fused switches shall be designed to accept both Class RK1 and Class J with adjustment of fuse block location within bucket. Provide feeder swtches with Class J time delay fuses unless indicated otherwise on drawings.

11. Variable frequency drives shall be provided for motors indicated on the drawings with the following features:
    a. VFD compartment shall have a main fusible disconnect switch with class J fuses sized per drive requirements or adjustable trip circuit breaker sized for drive requirements.
    b. VFD shall include a tuned passive filter to achieve low harmonics meeting IEEE-519 or other acceptable method.
    c. Provide VFD with and LCD display and communications module to communicate to a PLC control system. Refer to control drawings for further requirements.
    d. VFD shall be suitable for use on a variable torque type motor load (blower).
    e. Provide drive with a 3% output reactor or choke.
    f. VFD control options shall be coordinated with the system control drawings.
    g. Provide bypass motor starter to operate blower motor in the event of a VFD failure.

12. Design shall provide complete front accessibility to all electrical parts. No rear access shall be required for the installation of any of the equipment including termination of the line and load cables.
13. All control and all power (both line and load) shall enter and exit from the top of the enclosure.
14. Each vertical section shall be approximately 90 inches high (excluding mounting channels, external bus enclosure and lifting angles), 20 inches deep and width as required.
15. Install Cat 6 communications cables from the power meter, and the VFD drive unit to the communications server rack in the adjacent control room.
16. MCC will require approved shop drawings prior to manufacture. MCC with VFD shall be manufactured by Eaton, GE, Siemens, or Rockwell.

C. Panelboards
1. Panels shall be UL labeled.
2. Provide each circuit breaker position including the main circuit breaker with an attached lock-out device.

D. Power Centers
1. Provide combinations dry-type transformer with a secondary panelboard such as a Eaton mini-power center, Square D min-power zone or equivalent.
2. Power center shall be 15KVA or as shown on drawings, 480V-120/208V, 3 phase, 4 wire. Power center shall have a secondary main breaker and space for (18) single pole breakers and be supplied with minimum of (6) 20A breakers or as otherwise shown on drawings.
3. Circuit breakers shall be operated by a toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism that is mechanically trip-free. Automatic tripping of the breaker shall be clearly indicated by the handle position. Contacts shall be non-welding silver alloy and arc extinction shall be accomplished by means of arc chutes. A push-to-trip button on the front of the circuit breaker shall provide a local manual means to exercise the trip mechanism.

B. Devices
1. GFCI duplex receptacles shall be supplied indoors at each entry door and two (2) outdoor weatherproof GFCI duplex receptacles shall be supplied near each entry door as shown on the enclosure drawings. GFCI duplex receptacles shall incorporate an integral ground strap for low resistance of fault and a "bypass" contact design incorporating high-conductivity materials that will provide superior spring characteristics for increased force and secure connections. GFCI duplex receptacles shall be rated 125V, 20 amperes, ivory colored face, heavy duty, industrial specification grade type, Hubbell Cat.#GF5362IA or approved equal. Duplex receptacle wall plates shall be stainless steel.
2. Wall switches shall incorporate a steel, nickel plated bridge that is corrosion resistant. Wall switches shall be rated 120V, 20 amperes, single pole, ivory toggle, heavy duty, industrial specification grade, three way, ivory toggle, heavy duty, industrial specification grade.

C. Dry Type Distribution Transformers
1. Dry type distribution transformers shall be supplied with the following ratings.
   a. Primary Nominal Voltage: 480 Primary Connection: Delta
   b. Secondary Nominal Voltage: 240/120 Secondary Connection:
   c. Size (kVA): 15
   d. BIL Ratings (kV): Primary: 30 Secondary: 10
   e. Phases: 1
   f. Frequency (Hz.): 60
2. Transformer efficiency shall meet Public Law 109-58 of the Energy Policy Act of 2015.
3. Transformers shall have a minimum of four (4), 2-½ % full capacity taps with two above nominal voltage and two below nominal voltage.
4. Transformers shall have a 115°C temperature rise above a 40°C ambient. All insulating materials in accordance with NEMA Standard ST20 for a 220°C rise UL component recognized insulation system.
5. Transformers sound levels shall not exceed NEMA standards.
6. Transformers shall be UL listed.
7. Transformers shall be as manufactured by Acme, Square D, Eaton, Sola/Hevi-Duty or General Electric.

D. Lighting

1. Building shall be provided with LED type lighting fixtures, controlled via three-way wall switches to be located at each entry door. Light fixtures shall be surface mounted.
2. Provide light fixtures as shown on drawings or approved equal.
3. Exterior Light fixtures shall be dark sky compliant, photo cell controlled as indicated on drawings.
4. Emergency lighting fixture shall be provided at each entry door to allow for egress in the event of a power loss within the building. Emergency lighting untits shall be as shown on drawings.

E. Wiring

1. Building wiring shall have XHHW-2, 600 volt insulation, #12 AWG minimum conductor size for power circuits and a minimum #14 AWG conductor for control circuits.
   a. Stranded copper conductors only shall be used.
   b. For all control interconnection wiring, both ends of the wire shall be provided with polyolefin sleeve type wire markers.
   c. Building wiring color coding shall conform to the NEC®, phase wire jacket color coding shall be black, blue, red or etc., neutral wire jacket coding shall be white and ground wire jacket color coding shall be green
2. EMT conduit shall be utilized for interior applications only. RGS conduit shall be utilized for medium voltage (4160V) and for all outdoor applications.
3. Provide empty conduits where indicated on the drawings for use by others.
4. Cable tray shall be supplied mounted as shown in the attached drawings.
   a. Power cable tray shall be steel, 6-inch high with a 9-inch rung spacing rated for 75 lbs/ft. All fittings shall have a minimum of an 18-inch radius. Width of the cable shall be a minimum of 36 inches or as shown on the attached building layout drawings.
   b. Control/communication cable tray shall be installed in the control room area as indicated on drawings. Cable tray shall be a wire basket type system, 4-inch depth and 18” width.
   c. Buildings having a cable tray system(s) shall be provided with structural steel channel supports embedded in the ceiling or connected directly to the roof purlins or trusses which is preferred. The use of Unistrut fastened directly to the ceiling for cable tray support is not acceptable. The support from the cable tray channel supports shall be via thread rod (3/8 inch minimum diameter) and Unistrut hangers.
   d. Distance from the top of the switchgear to the bottom of the cable tray shall be a minimum of 24 inches or as shown on the attached building layout drawings.
   e. Distance from the top of the cable tray to the bottom of the ceiling shall be a minimum of 24 inches or as shown on the attached building layout drawings.
   f. All cable tray shall be grounded per the NEC® to the building ground bar.
5. A building copper ground bar (1/4-inch x 2-inch minimum) running the length of the building shall be supplied.
   a. Ground bar shall be mounted approximately 6-inches above the building floor.
   b. At each end of the equipment ground bar, a #4/0 AWG green insulated stranded copper ground cable shall be provided from the ground bar to the exterior base mounted stainless steel ground pads.
   c. A green insulated copper ground wire/cable will be provided from the ground bar to all auxiliary electrical equipment per NEC® Table 250-122.

1.02 HVAC

A. Building shall have an HVAC system supplied and installed by the building Vendor. HVAC system shall be wall mounted.

B. HVAC shall be sized the supplier taking in account the ambient site conditions, the dimensions of the building, the solar heating of the building, and the heat generated by the equipment within the building.

C. The system shall be designed such that the sensible cooling capacity (NOT the total cooling capacity) will maintain an ambient temperature within the building of between 68°F in winter and 72°F in summer at the stated site ambient design conditions.

D. Redundancy of the HVAC system shall be as specified and shall meet the following:
   1. Each of the two HVAC units shall be the same size and shall be capable of heating or cooling the entire building as if the dividing partition was not present.
   2. In the event of a HVAC failure, it will be the responsibility of the tenants to open the door between rooms and provide a space fan if necessary.

E. HVAC system shall be provided with an electronic, automatic changeover thermostat as well as manual override features.

1.03 FIRE AND LIFE SAFETY ALARM SYSTEM

A. Provide a complete fire and Life Safety Alarm System capable of being integrated into any site wide systems. Design and install fire alarm system per requirements of NFPA 72 and NFPA 70 - 2017.

B. Provide plan drawing and riser diagram of system with devices. Provide complete documentation of system installed including battery sizing calculations. Documentation shall be complete and suitable for others to submit for obtaining permits.

C. Provide strobe lights with speakers on interior of the two rooms and strobes and speakers on each exterior wall of structure. Provide pull stations at each exterior door.

D. Provide a VESDA type smoke detection system by Xtralis (or equal) to be connected to the fire alarm panel.

E. Provide any additional enclosures that may be required such as a separate battery enclosure.

F. Provide auxiliary alarm and trouble contacts from a relay that can be supervised by the PLC control system.

1.04 UNITERRUPTABLE POWER SUPPLY (UPS)

A. Provide a complete 9KVA UPS capable of operating at 9KVA for 15 minutes and meet N+1 reliability criteria. UPS shall have (4) 3 KVA modules to achieve the N+1 criteria. UPS shall be expandable to 18KVA.

B. UPS shall have a UL safety marking.

C. Input: 120/240V single phase, 3 Wire, 60Hz. Output: 120/240V single phase, 60Hz +/-0.1Hz

D. UPS shall have modular power modules and battery modules both being able to be changed while energized.

E. UPS to have a hardwired input and a hardwired output.

F. UPS shall include By-Pass Power module to by-pass power modules and connect directly to incoming power source.

G. UPS shall include a Ethernet card for Ethernet communications.

H. UPS shall be an Eaton 9170+ or approved equal.

I. Output of the UPS shall be wired to a 16 circuit 100A, 120/240, 3 phase, 4 wire panelboard with a 100A main breaker, and an isolated ground bus.

1.05 NAMEPLATES/TAGGING

A. Nameplates shall be white with black letters, laminated phenolic engraved with 1/4 inch high letters. All nameplates are to be attached by screws. Screws used to be mount on the exterior of the building shall be stainless steel.

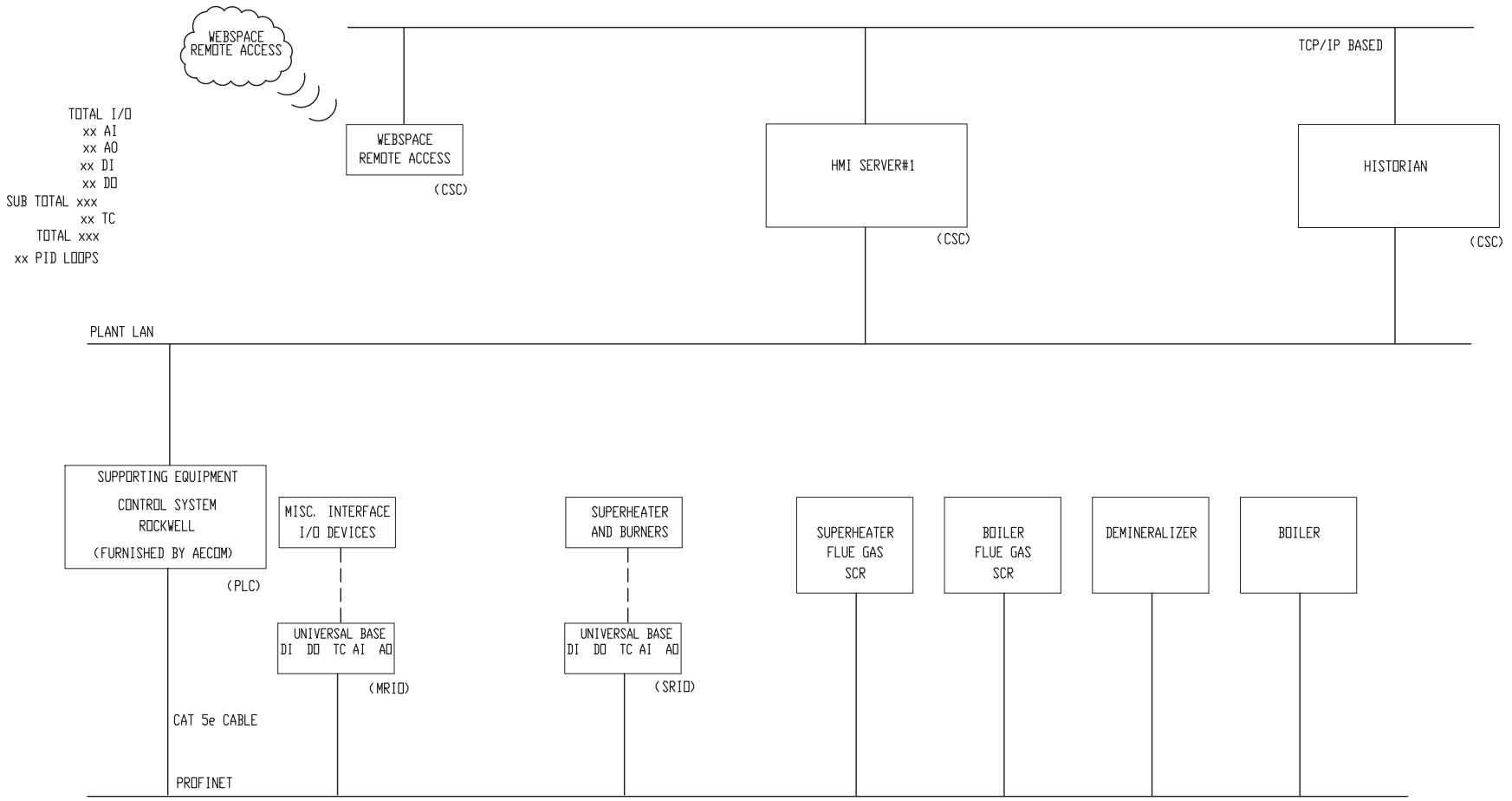
B. Provide building one (1) large nameplate indicating building equipment number and building manufacturer's shop order number.

C. All permanent tagging (wiring or lamacoid) shall be performed with typed or machine-written letters/numbers. (Hand written tagging is not acceptable).

END OF SECTION

Instrumentation and Controls

19-11-200-001



Legend

PLC = PLC Cabinet
CSC = Control System Cabinet
MRIO = Misc. I/O Cabinet
SRIO = Superheater Remore I/O Cab

PRELIMINARY
NOT FOR CONSTRUCTION

REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
C	12/22/17	ISSUE FOR RECORD	DT	DC
B	3/31/16	ISSUED FOR FEED	LH	
A	2/25/16	PRELIMINARY	LH	

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	C	12/22/17	DC	DM
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV. NO.

PROJECT NO: 31609
DRAWN: LAH DATE: 01/29/16
CHECKED: DC DATE: 02/01/16
SCALE: NTS

AECOM
1300 East 9th St., Suite 500
Cleveland, OH 44114
(216) 622 - 2300

ENERGY INDUSTRIES of OHIO
6100 Oak Tree Boulevard, Suite 200
Independence, OH 44131
(216) 643-2952

A-USC COMTEST PROJECT
NETWORK
CONTROL SYSTEM ARCHITECTURE

DWG. NO. 19-11-200-001 REV C

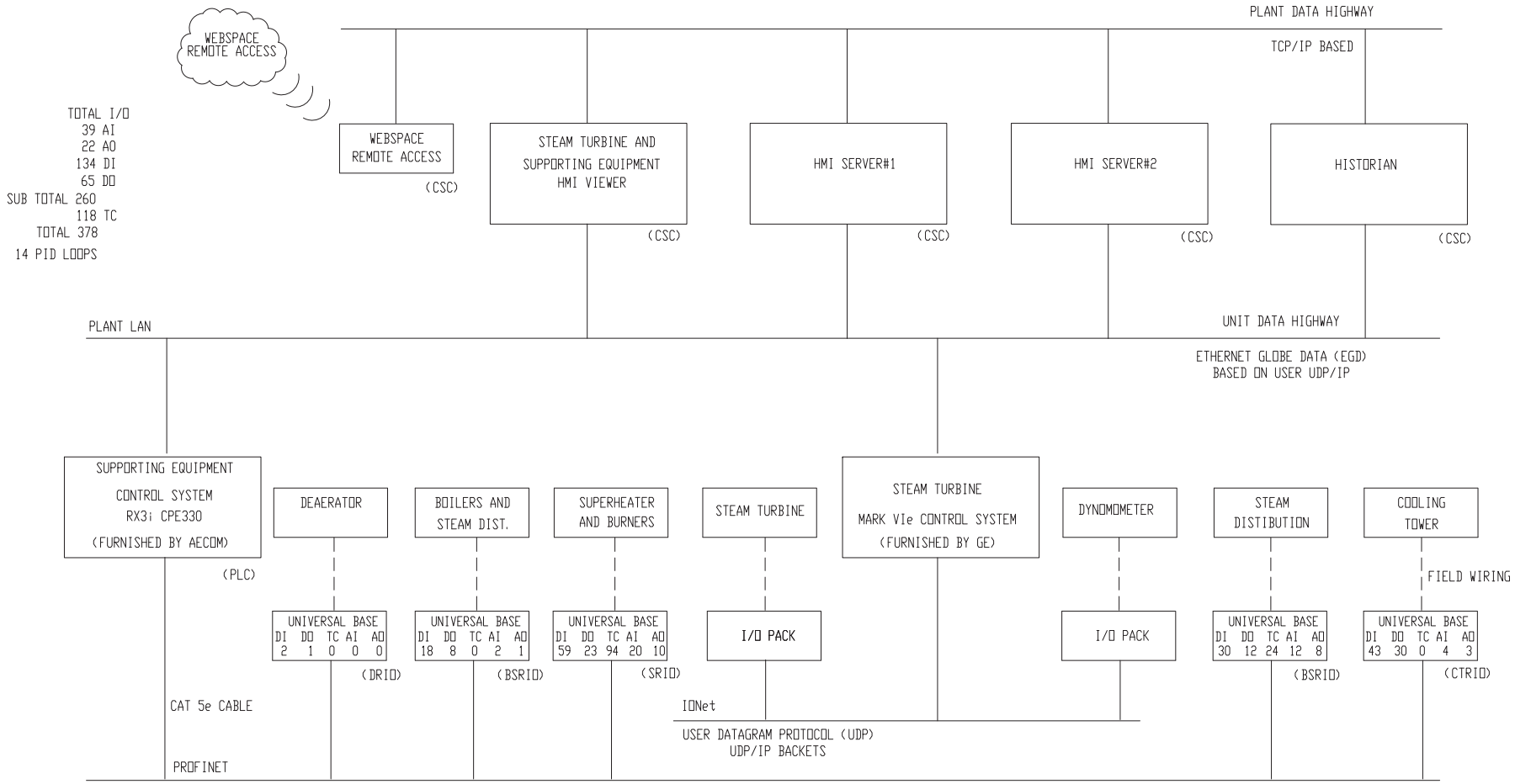
EC_D_Size.dwg

INCHES CENTIMETERS

8 7 6 5 4 3 2 1

D C B A

19-11-250-001



Legend

PLC = PLC Cabinet
CSC = Control System Cabinet
DRIO = Deaerator I/O Cabinet
BSRIO = Boilers-Steam Remote I/O Cab
SRIO = Superheater Remore I/O Cab
CRIO = Cooling Tower Remote I/O Cab

REVISION APPROVAL RECORD				REV		REV NO	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C										
						A	03/31/16	ISSUED FOR FEED	LH	

DRAWING STATUS					
	ISSUED	REV	DATE	SDE	PEM
PRELIMINARY		A	3/31/16	LH	DM
APPROVED FOR CONSTRUCTION					

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED, DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV.NO.

PROJECT NO.: 31609
DRAWN: LH DATE: 01/29/16
CHECKED: DATE:
SCALE: NONE

URS ENERGY & CONSTRUCTION Inc, - an AECOM Company
1500 West 3rd St., Suite 200
Cleveland, OH 44113
(216) 523-5600

ENERGY INDUSTRIES of OHIO
6100 Oak Tree Boulevard, Suite 200
Independence, OH 44131
(216) 643-2952

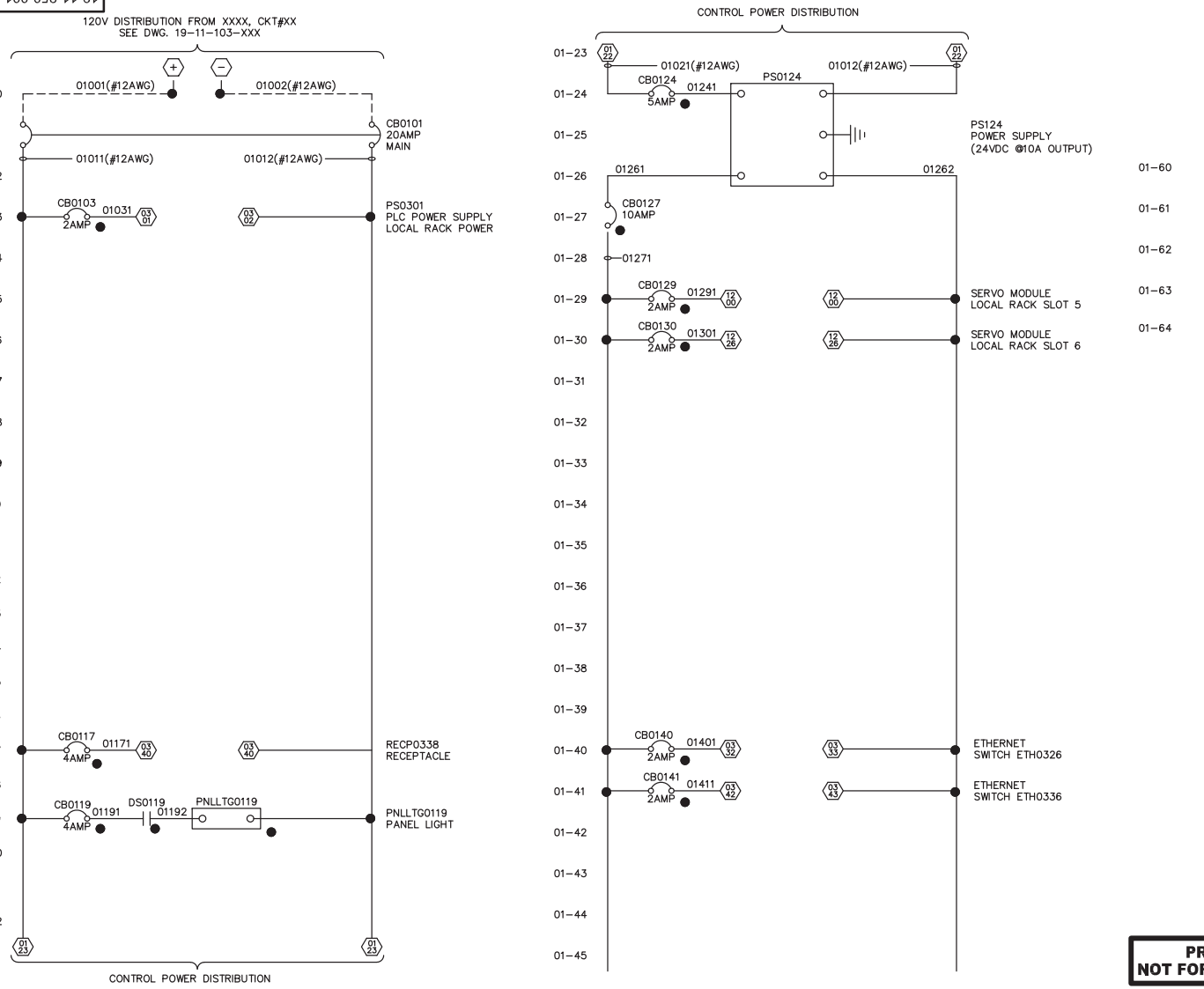
A-USC COMTEST PROJECT
I&C
CONTROL SYSTEM ARCHITECTURE

DWG. NO. 19-11-250-001 REV A

EC_D_Size.dwg

INCHES CENTIMETERS

19-11-250-001



NOTES:

1) ● INDICATES DEVICE LOCATED IN PLC CABINET (PLC)
2) 2AMP F● INDICATES 2 AMP FUSED LOCATED IN PLC CABINET (PLC)
3) ⟨X/YY⟩ XX = SHEET NUMBER, YY = LINE NUMBER
4) – – – – FIELD WIRING
5) –0– – – CUT AND TAPE SHIELD
6) ⏚ GROUND SHIELD

REFERENCE DRAWINGS:

19-11-250-001	CONTROL POWER – PLC CABINET (PLC)
19-11-250-002	SERVO – PLC CABINET (PLC)
19-11-250-003	RACK LAYOUT – PLC CABINET (PLC)
19-11-410-001	PANEL LAYOUT – PLC CABINET (PLC)

PRELIMINARY NOT FOR CONSTRUCTION

AECOM
1300 East 9th St., Suite 500
Cleveland, OH 44114
(216) 622-2300

REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
A	12/22/17	ISSUE FOR RECORD	DRT	DC

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A	12/22/17	DC	DM
APPROVED FOR CONSTRUCTION				

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PROJECT NO.: 31609
DRAWN: GCF DATE: 08/04/2017
CHECKED: DC DATE: 08/04/2017
SCALE: NONE

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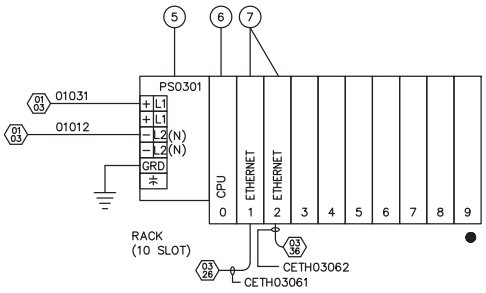
6100 Oak Tree Boulevard, Suite 200
Independence, OH 44131
(216) 643-2952

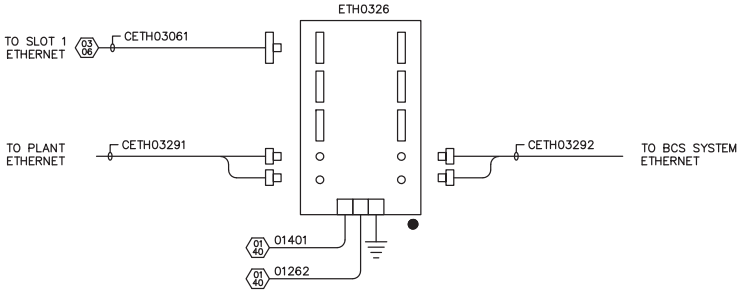
A-USC COMTEST PROJECT
SCHEMATIC DIAGRAM CONTROL POWER
PLC CABINET (PLC)

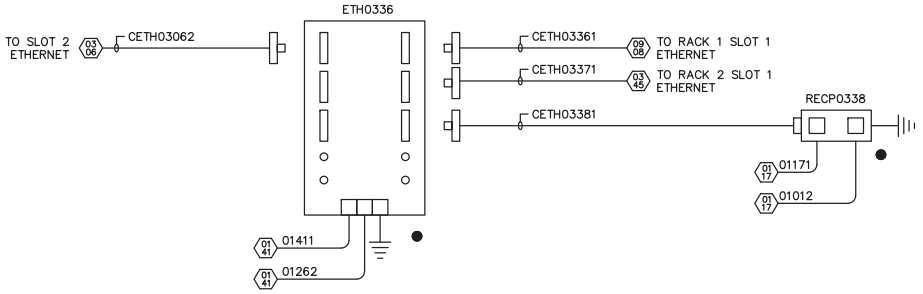
DWG. NO. 19-11-250-001 REV A

EC_D_Size.dwg

19-03-250-003







NOTE:
SEE 19-11-250-001 FOR NOTES
AND REFERENCE DRAWINGS

PRELIMINARY
NOT FOR CONSTRUCTION

REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
A	12/22/17	ISSUE FOR RECORD	DRT	DC

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A	12/22/17	DC	DM
APPROVED FOR CONSTRUCTION				

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PROJECT NO.: 31609
DRAWN: GCF DATE: 08/04/2017
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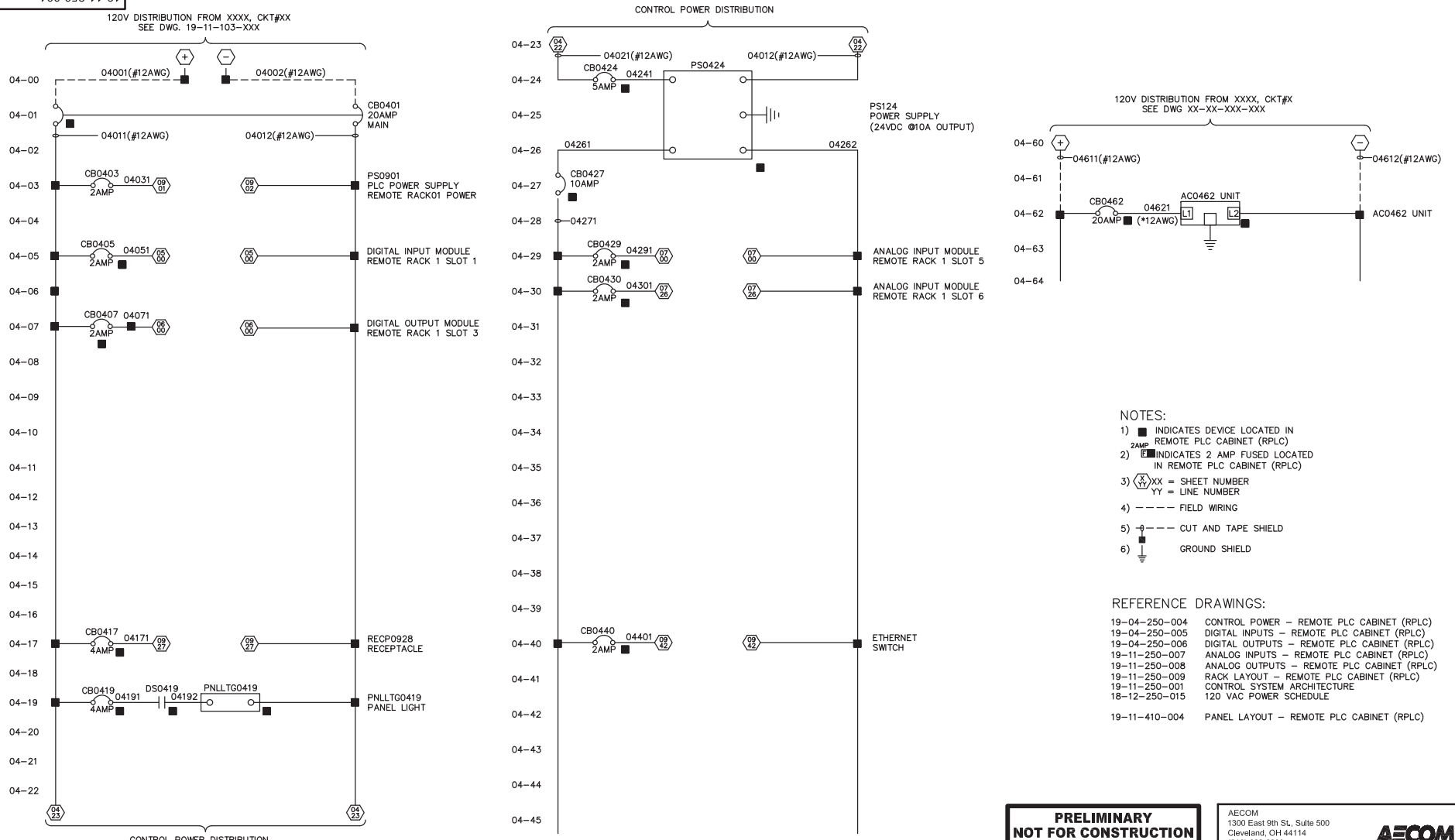
A-USC COMTEST PROJECT
SCHEMATIC DIAGRAM
RACK LAYOUT-PLC CABINET (PLC)

DWG. NO.: 19-11-250-003
REV: A

EC_D_Size.dwg

19-11-250-004



NOTES:

1) ■ INDICATES DEVICE LOCATED IN REMOTE PLC CABINET (RPLC)
2) 2AMP ■ INDICATES 2 AMP FUSED LOCATED IN REMOTE PLC CABINET (RPLC)
3) XX / YY = XX = SHEET NUMBER, YY = LINE NUMBER
4) ———— FIELD WIRING
5) ———— CUT AND TAPE SHIELD
6) GROUND SHIELD

REFERENCE DRAWINGS:

19-04-250-004	CONTROL POWER – REMOTE PLC CABINET (RPLC)
19-04-250-005	DIGITAL INPUTS – REMOTE PLC CABINET (RPLC)
19-04-250-006	DIGITAL OUTPUTS – REMOTE PLC CABINET (RPLC)
19-11-250-007	ANALOG INPUTS – REMOTE PLC CABINET (RPLC)
19-11-250-008	ANALOG OUTPUTS – REMOTE PLC CABINET (RPLC)
19-11-250-009	RACK LAYOUT – REMOTE PLC CABINET (RPLC)
19-11-250-001	CONTROL SYSTEM ARCHITECTURE
18-12-250-015	120 VAC POWER SCHEDULE
19-11-410-004	PANEL LAYOUT – REMOTE PLC CABINET (RPLC)

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REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV	DATE	REVISIONS	BY	CHKR
A	12/22/17	ISSUE FOR RECORD	DRT	DC

DRAWING STATUS					
ISSUED	REV	DATE	SDE	PEM	
PRELIMINARY	A	12/22/17	DC	DM	
APPROVED FOR CONSTRUCTION					

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PROJECT NO.:	31609
DRAWN: GCF	DATE: 11/11/16
CHECKED: DC	DATE: 11/14/16
SCALE:	NONE

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A-USC COMTEST PROJECT
SCHEMATIC DIAGRAM CONTROL POWER
REMOTE PLC CABINET (RPLC)

DWG. NO.	REV
19-11-250-004	A

EC_D_Size.dwg

INCHES / CENTIMETERS

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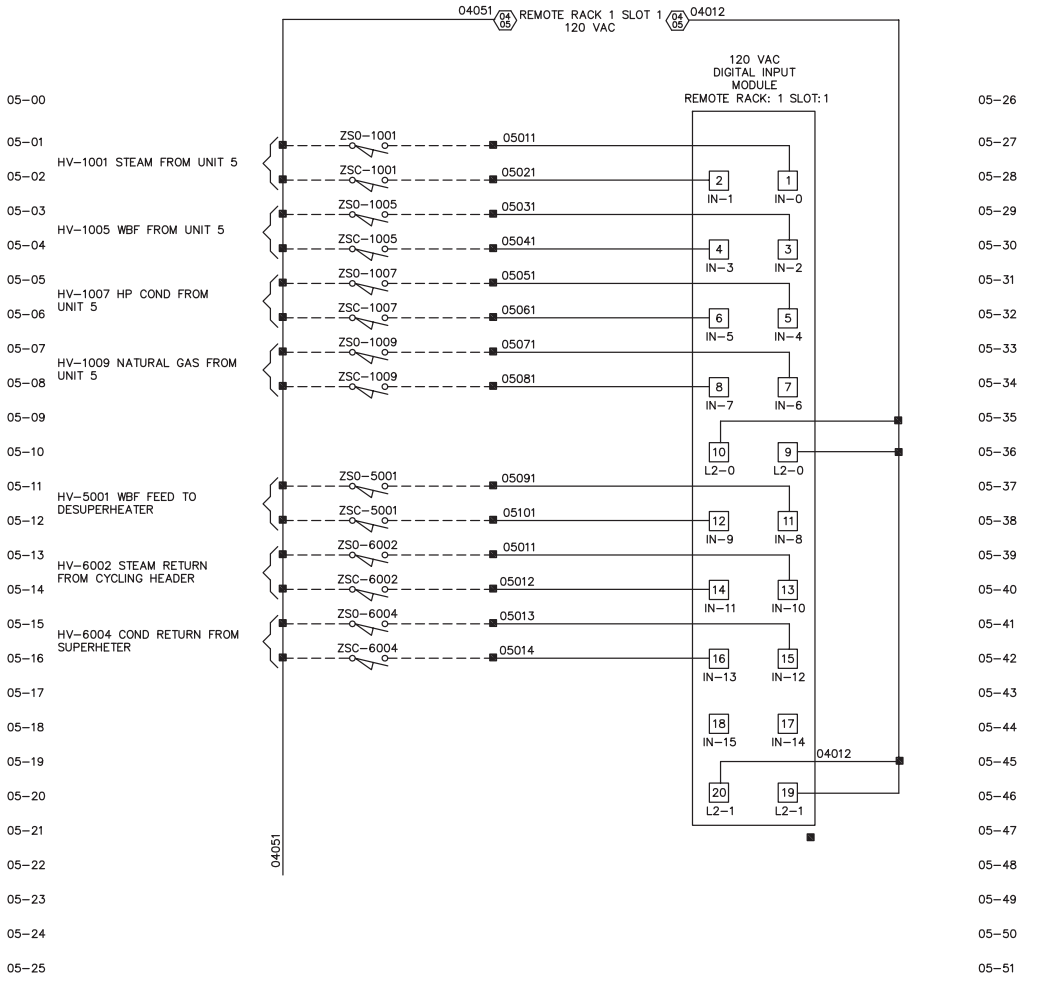
D C B A

19-11-250-005



NOTE:
SEE 19-11-250-004 FOR NOTES AND REFERENCE DRAWINGS.

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REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
A	12/22/17	ISSUE FOR RECORD	DRT	DC

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A	12/22/17	DC	DM
APPROVED FOR CONSTRUCTION				

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PROJECT NO.: 31609
DRAWN: GCF DATE: 11/14/16
CHECKED: DC DATE: 11/14/16
SCALE: NONE

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A-USC COMTEST PROJECT
SCHEMATIC DIAGRAM, DIGITAL INPUTS
REMOTE PLC CABINET (RPLC)

DWG. NO. 19-11-250-005
REV A

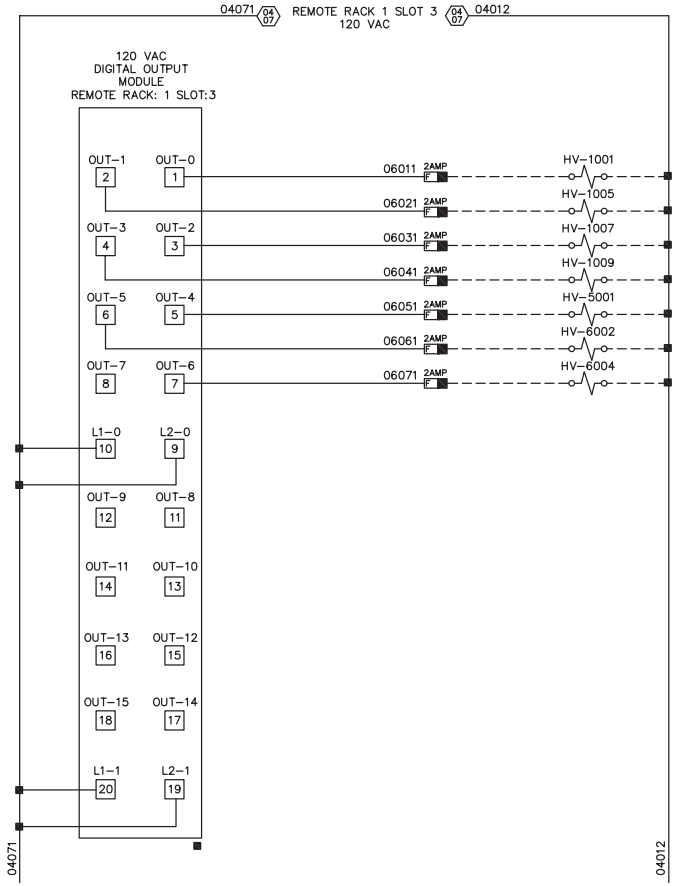
EC_D_Size.dwg

INCHES 1 2 3 4 5 6
CENTIMETERS 1 2 3 4 5 6

8 7 6 5 4 3 2 1

D C B A

19-11-250-006



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06-26 06-27 06-28 06-29 06-30 06-31 06-32 06-33 06-34 06-35 06-36 06-37 06-38 06-39 06-40 06-41 06-42 06-43 06-44 06-45 06-46 06-47 06-48 06-49 06-50 06-51

NOTE:
SEE 19-11-250-004 FOR NOTES AND REFERENCE DRAWINGS.

PRELIMINARY NOT FOR CONSTRUCTION

REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
A	12/22/17	ISSUE FOR RECORD	DRT	DC

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A	12/22/17	DRT	DC
APPROVED FOR CONSTRUCTION				

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PROJECT NO.: 31609
DRAWN: GCF DATE: 07/29/16
CHECKED: DC DATE: 08/03/16
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A-USC COMTEST PROJECT
SCHEMATIC DIAGRAM, DIGITAL OUTPUT REMOTE PLC CABINET (RPLC)

DWG. NO. 19-11-250-006
REV A

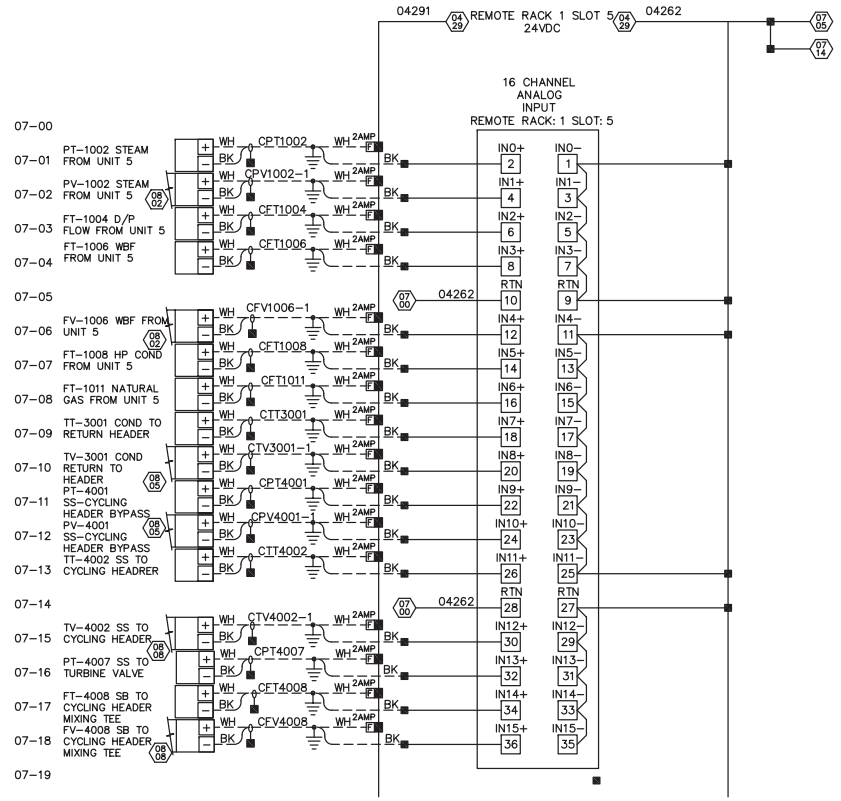
EC_D_Size.dwg

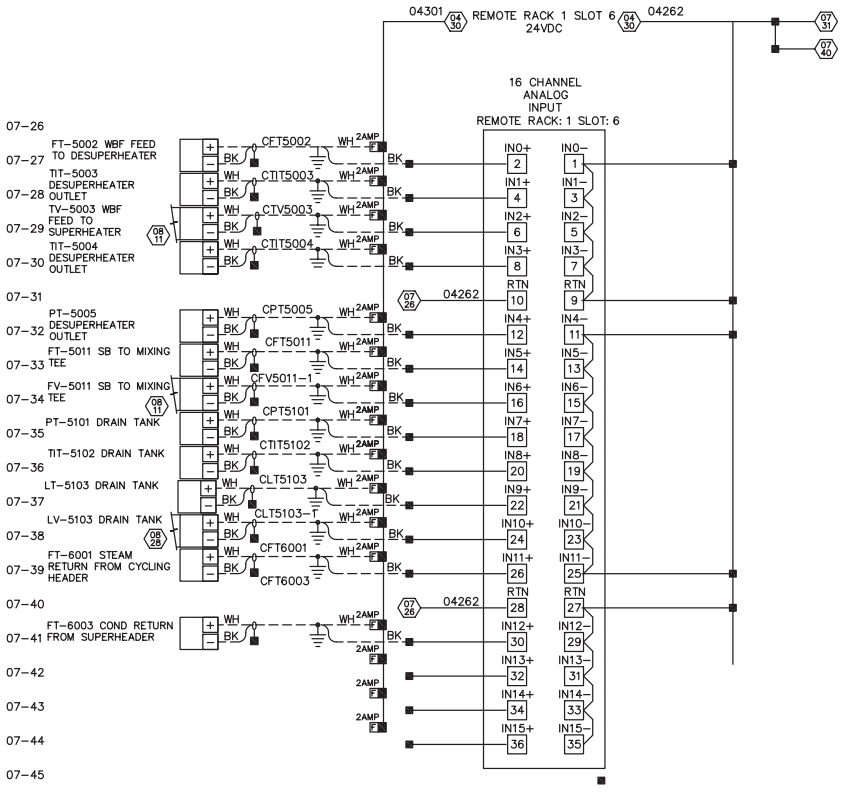
INCHES 1 2 CENTIMETERS 1 2 3 4 5 6

8 7 6 5 4 3 2 1

D C B A

19-11-250-007





NOTE:
SEE 19-11-250-004 FOR NOTES AND REFERENCE DRAWINGS.

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REVISION APPROVAL RECORD					
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV	DATE	REVISIONS	BY	CHKR
A	12/22/17	ISSUE FOR RECORD	DRT	DC

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A	12/22/17	DRT	DC
APPROVED FOR CONSTRUCTION				

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PROJECT NO.: 31609
DRAWN: GCF DATE: 11/15/16
CHECKED: DC DATE: 11/15/16
SCALE: NONE

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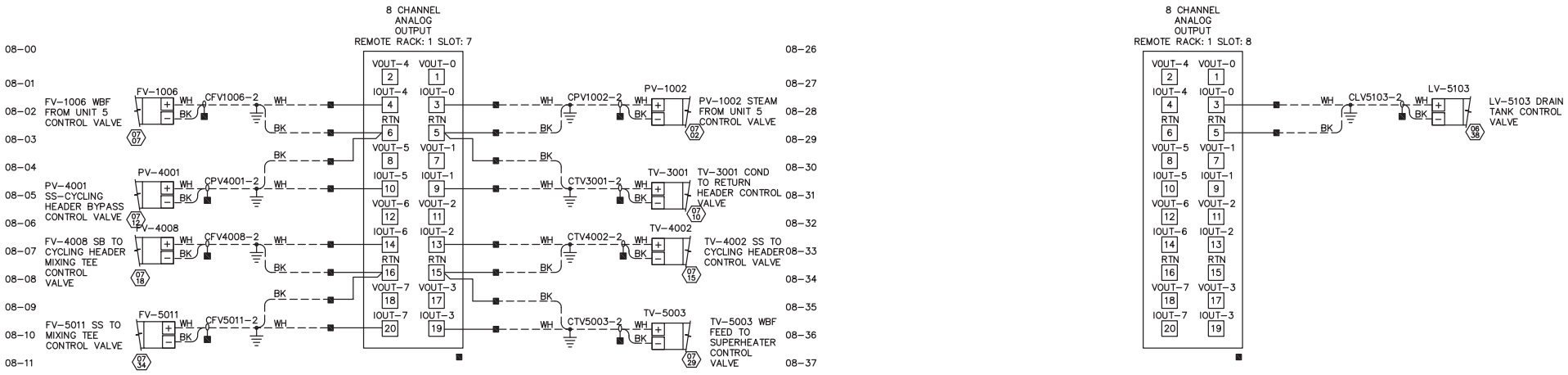
A-USC COMTEST PROJECT
SCHEMATIC DIAGRAM, ANALOG INPUTS
REMOTE PLC CABINET (RPLC)

DWG. NO. 19-11-250-007
REV A

EC_D_Size.dwg

INCHES / CENTIMETERS

19-11-250-008



NOTE:
SEE 19-11-250-004 FOR NOTES AND REFERENCE DRAWINGS.

PRELIMINARY NOT FOR CONSTRUCTION

REVISION APPROVAL RECORD					
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV	DATE	REVISIONS	BY	CHKR
A	12/22/17	ISSUE FOR RECORD	DRT	DC

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ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A	12/22/17	DC	DM
APPROVED FOR CONSTRUCTION				

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PROJECT NO.: 31609
DRAWN: GCF DATE: 6/7/16
CHECKED: DC DATE: 6/14/16
SCALE: NONE

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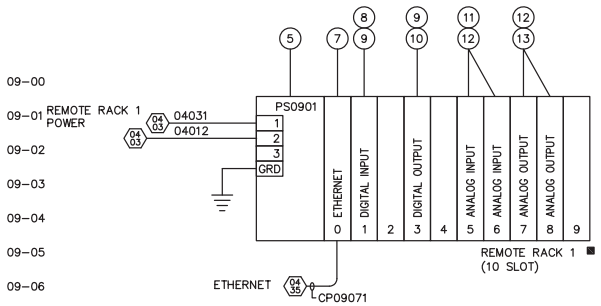
A-USC COMTEST PROJECT
SCHEMATIC DIAGRAM, ANALOG OUTPUT
REMOTE PLC CABINET (RPLC)

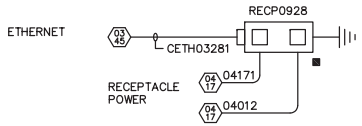
DWG. NO. 19-11-250-008
REV A

EC_D_Size.dwg

INCHES
CENTIMETERS

19-10-250-009





09-00 09-01 09-02 09-03 09-04 09-05 09-06 09-07 09-08 09-09 09-10 09-11 09-12 09-13 09-14 09-15 09-16 09-17 09-18 09-19 09-20 09-21 09-22 09-23 09-24 09-25

09-26 09-27 09-28 09-29 09-30 09-31 09-32 09-33 09-34 09-35 09-36 09-37 09-38 09-39 09-40 09-41 09-42 09-43 09-44 09-45 09-46 09-47 09-48 09-49 09-50 09-51

NOTE:
SEE 19-11-250-004 FOR NOTES
AND REFERENCE DRAWINGS

PRELIMINARY
NOT FOR CONSTRUCTION

REVISION APPROVAL RECORD					
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV	DATE	REVISIONS	BY	CHKR
A	12/22/17	ISSUE FOR RECORD	DRT	DC

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A	12/22/17	DC	DM
APPROVED FOR CONSTRUCTION				

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PROJECT NO.: 31609
DRAWN: GCF DATE: 11/17/16
CHECKED: DC DATE: 11/18/16
SCALE: NONE

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A-USC COMTEST PROJECT
SCHEMATIC DIAGRAM RACK LAYOUT
REMOTE PLC CABINET (RPLC)

DWG. NO. 19-11-250-009
REV A

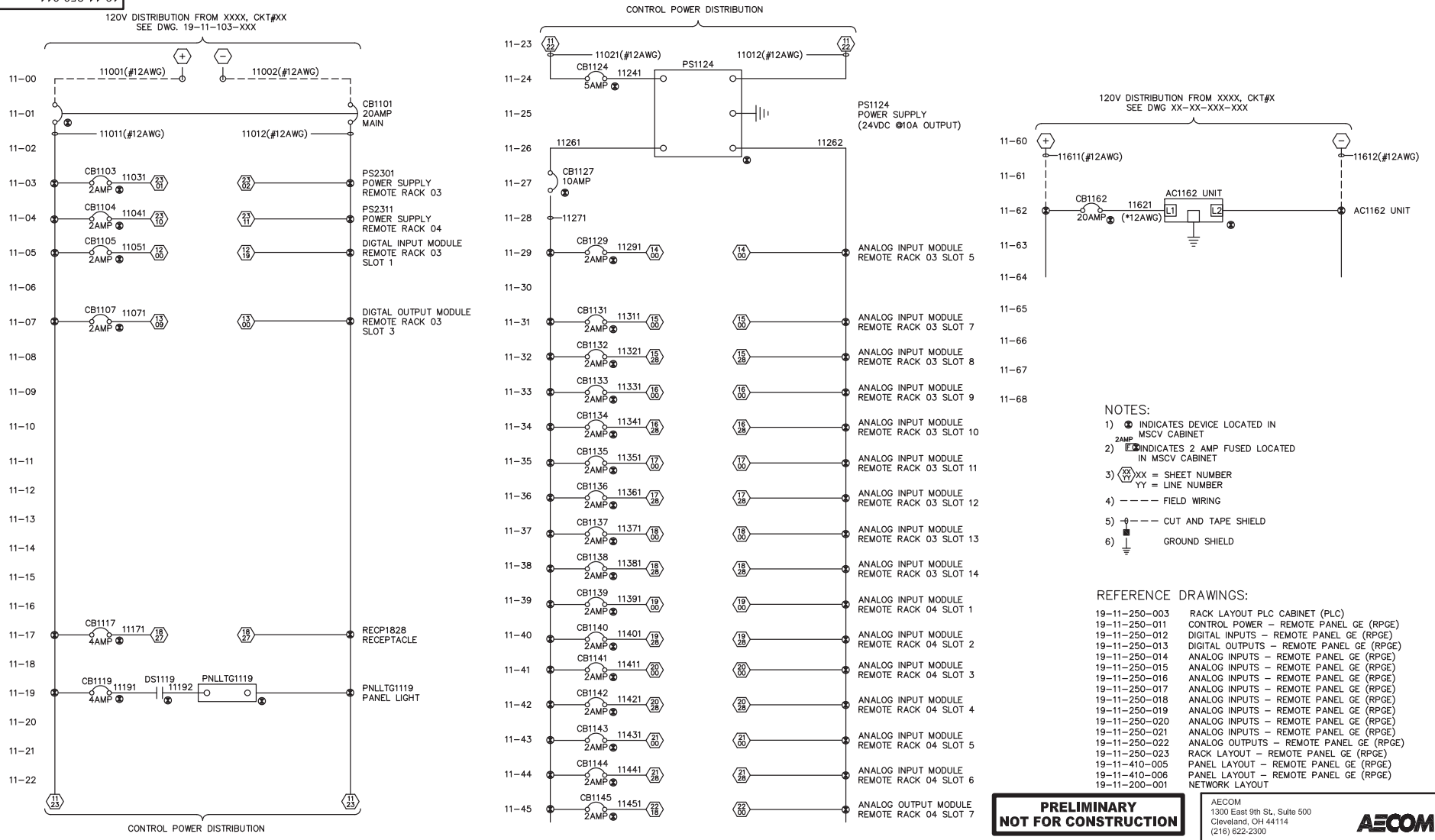
EC_D_Size.dwg

INCHES CENTIMETERS

8 7 6 5 4 3 2 1

D C B A

19-11-250-011



NOTES:

1) ⊗ INDICATES DEVICE LOCATED IN MSCV CABINET
2) 2AMP F⊗ INDICATES 2 AMP FUSED LOCATED IN MSCV CABINET
3) XX/YY XX = SHEET NUMBER, YY = LINE NUMBER
4) ———— FIELD WIRING
5) ———— CUT AND TAPE SHIELD
6) GROUND SHIELD

REFERENCE DRAWINGS:

19-11-250-003	RACK LAYOUT PLC CABINET (PLC)
19-11-250-011	CONTROL POWER – REMOTE PANEL GE (RPGE)
19-11-250-012	DIGITAL INPUTS – REMOTE PANEL GE (RPGE)
19-11-250-013	DIGITAL OUTPUTS – REMOTE PANEL GE (RPGE)
19-11-250-014	ANALOG INPUTS – REMOTE PANEL GE (RPGE)
19-11-250-015	ANALOG INPUTS – REMOTE PANEL GE (RPGE)
19-11-250-016	ANALOG INPUTS – REMOTE PANEL GE (RPGE)
19-11-250-017	ANALOG INPUTS – REMOTE PANEL GE (RPGE)
19-11-250-018	ANALOG INPUTS – REMOTE PANEL GE (RPGE)
19-11-250-019	ANALOG INPUTS – REMOTE PANEL GE (RPGE)
19-11-250-020	ANALOG INPUTS – REMOTE PANEL GE (RPGE)
19-11-250-021	ANALOG INPUTS – REMOTE PANEL GE (RPGE)
19-11-250-022	ANALOG OUTPUTS – REMOTE PANEL GE (RPGE)
19-11-250-023	RACK LAYOUT – REMOTE PANEL GE (RPGE)
19-11-410-005	PANEL LAYOUT – REMOTE PANEL GE (RPGE)
19-11-410-006	PANEL LAYOUT – REMOTE PANEL GE (RPGE)
19-11-200-001	NETWORK LAYOUT

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REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV	DATE	REVISIONS	BY	CHKR
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PRELIMINARY	A	12/22/17	DC	DM
APPROVED FOR CONSTRUCTION				

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PROJECT NO.: 31609
DRAWN: GCF DATE: 08/08/2016
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SCALE: NONE

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A-USC COMTEST PROJECT
SCHEMATIC DIAGRAM CONTROL POWER REMOTE PANEL GE (RPGE)

DWG. NO. 19-11-250-011
REV A

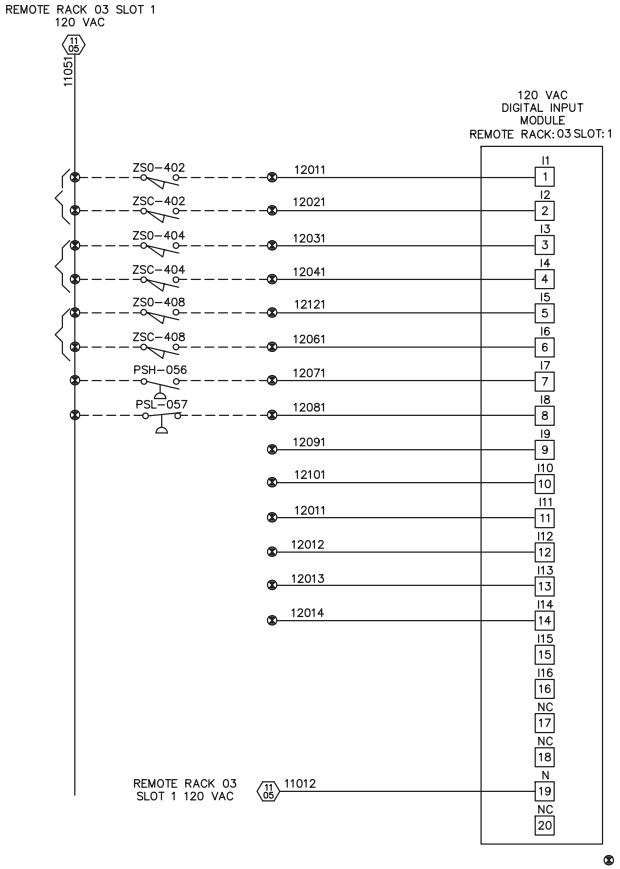
EC_D_Size.dwg

INCHES / CENTIMETERS

8 7 6 5 4 3 2 1

D C B A

19-11-250-012



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12-26 12-27 12-28 12-29 12-30 12-31 12-32 12-33 12-34 12-35 12-36 12-37 12-38 12-39 12-40 12-41 12-42 12-43 12-44 12-45 12-46 12-47 12-48 12-49 12-50 12-51

NOTE:
SEE 19-11-250-011 FOR NOTES AND REFERENCE DRAWINGS.

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REVISION APPROVAL RECORD					
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV	DATE	REVISIONS	BY	CHKR
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PRELIMINARY	A	12/22/17	DC	DM
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PROJECT NO.: 31609
DRAWN: DRT DATE: 09/22/2017
CHECKED: DC DATE: 09/25/2017
SCALE: NONE

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A-USC COMTEST PROJECT
SCHEMATIC DIAGRAM DIGITAL INPUTS
REMOTE PANEL GE (RPGE)

DWG. NO. 19-11-250-012
REV A

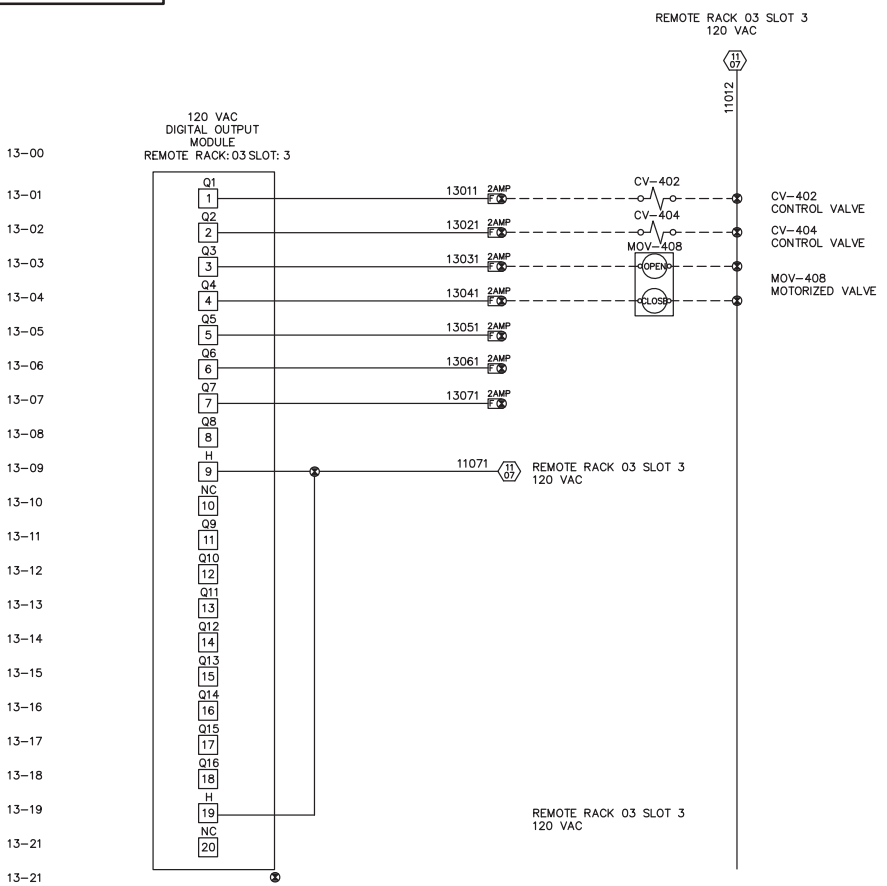
EC_D_Size.dwg

INCHES 1 2 CENTIMETERS 1 2 3 4 5 6

8 7 6 5 4 3 2 1

D C B A

19-11-250-013



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13-26 13-27 13-28 13-29 13-30 13-31 13-32 13-33 13-34 13-35 13-36 13-37 13-38 13-39 13-40 13-41 13-42 13-43 13-44 13-45 13-46 13-47 13-48 13-49 13-50 13-51

NOTE:
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REVISION APPROVAL RECORD				REV		REV NO	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C										
						A	12/22/17	ISSUE FOR RECORD	DRT	DC

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A	12/22/17	DC	DM
APPROVED FOR CONSTRUCTION				

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PROJECT NO.: 31609
DRAWN: GCF DATE: 07/31/2017
CHECKED: DC DATE: 07/31/2017
SCALE: NONE

ENERGY INDUSTRIES of OHIO
6100 Oak Tree Boulevard, Suite 200
Independence, OH 44131
(216) 643-2952

A-USC COMTEST PROJECT
SCHEMATIC DIAGRAM, DIGITAL OUTPUT
REMOTE PANEL GE (RPGE)

DWG. NO. 19-11-250-013
REV A

EC_D_Size.dwg

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CENTIMETERS 1 2 3 4 5 6

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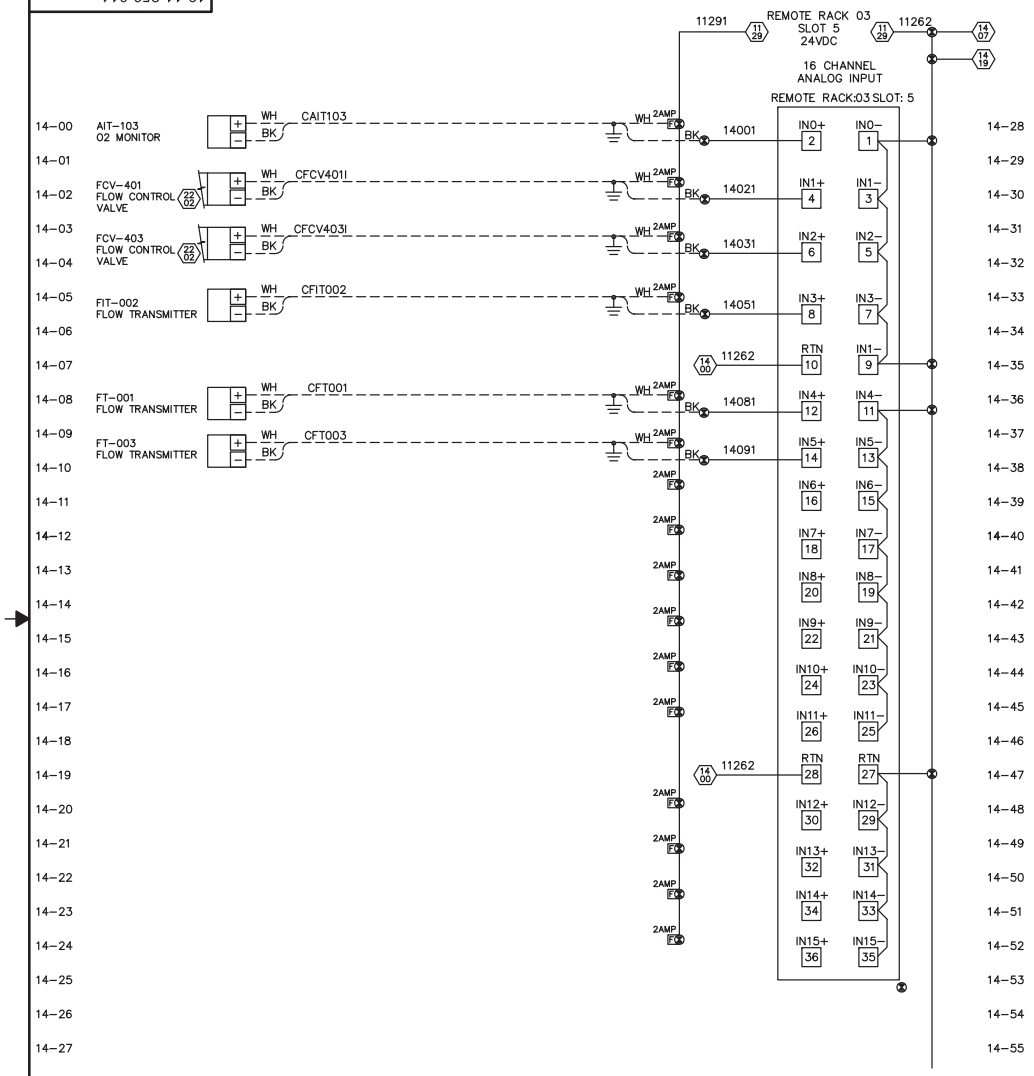
D C B A

19-11-250-014



NOTE:
SEE 19-11-250-011 FOR NOTES
AND REFERENCE DRAWINGS.

PRELIMINARY
NOT FOR CONSTRUCTION

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A-USC COMTEST PROJECT
SCHEMATIC DIAGRAM, ANALOG INPUTS
REMOTE PANEL GE (RPGE)

DWG. NO. 19-11-250-014
REV A

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INCHES
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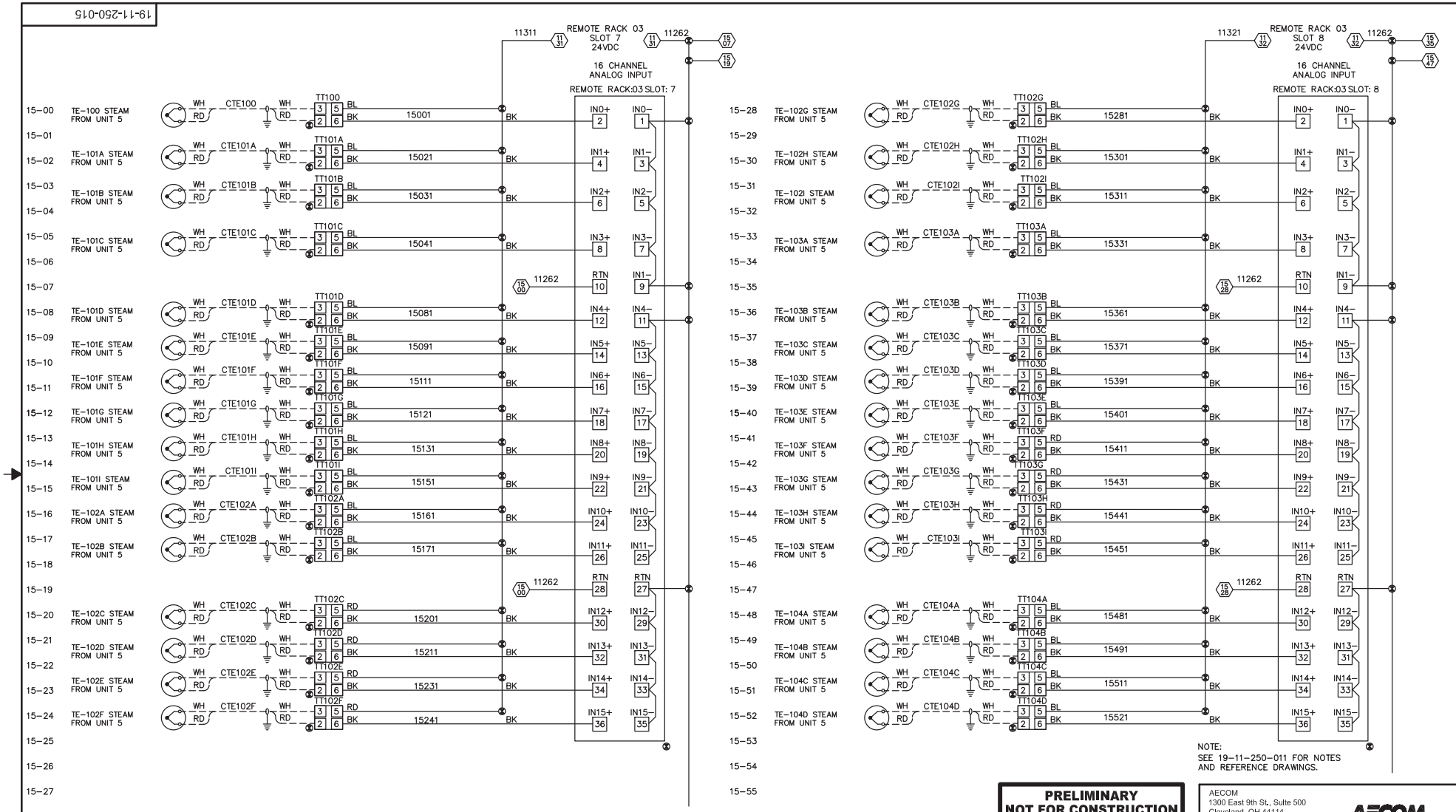

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A-USC COMTEST PROJECT
SCHEMATIC DIAGRAM, ANALOG INPUTS REMOTE PANEL GE (RPGE)

DWG. NO. 19-11-250-015 REV A

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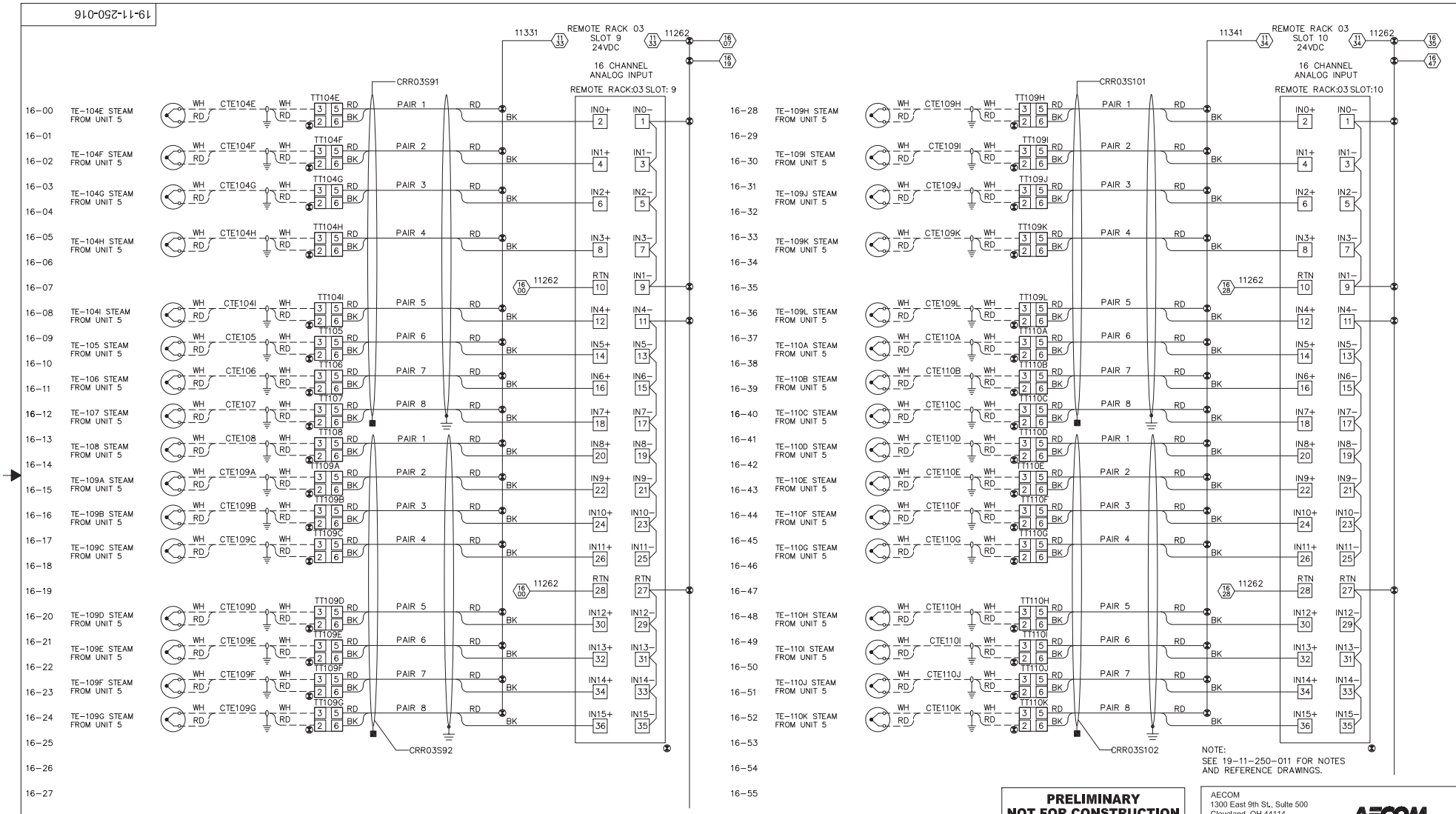

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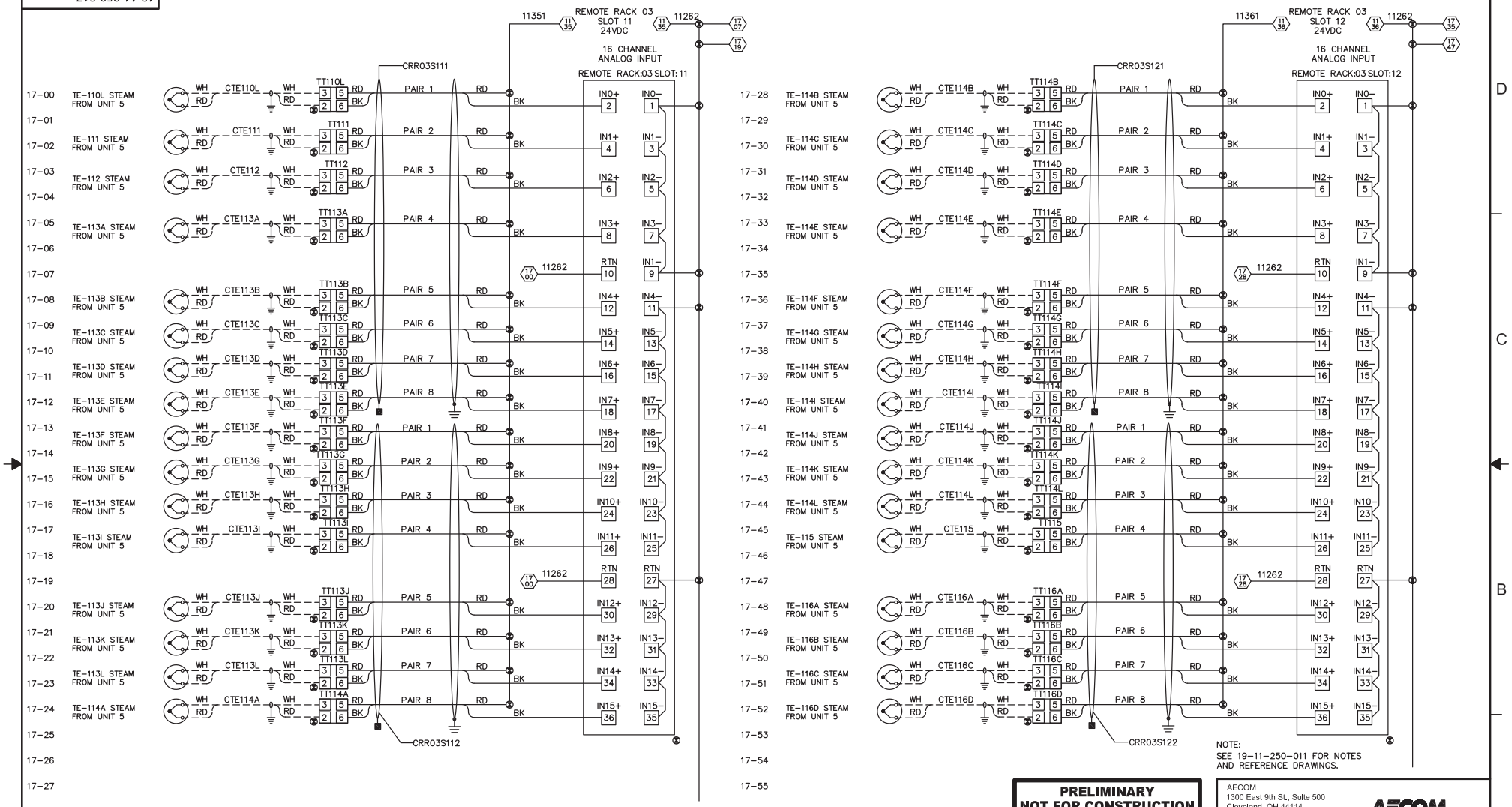
SCHEMATIC DIAGRAM, ANALOG INPUTS REMOTE PANEL GE (RPGE)

DWG. NO. 19-11-250-016 REV A

EC_D_Size.dwg

19-11-250-017



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DWG. NO. 19-11-250-017 REV A

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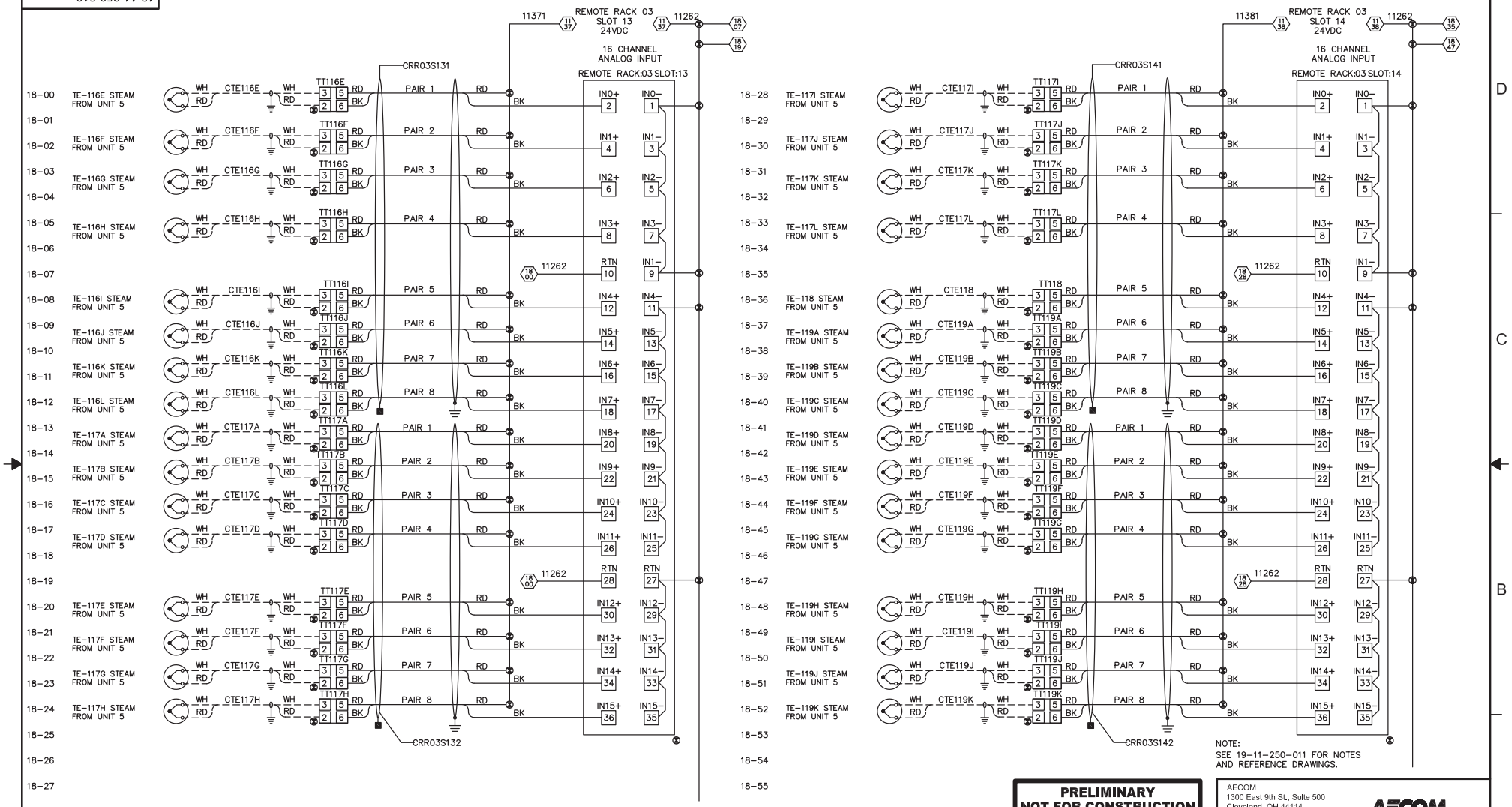

NOTE:
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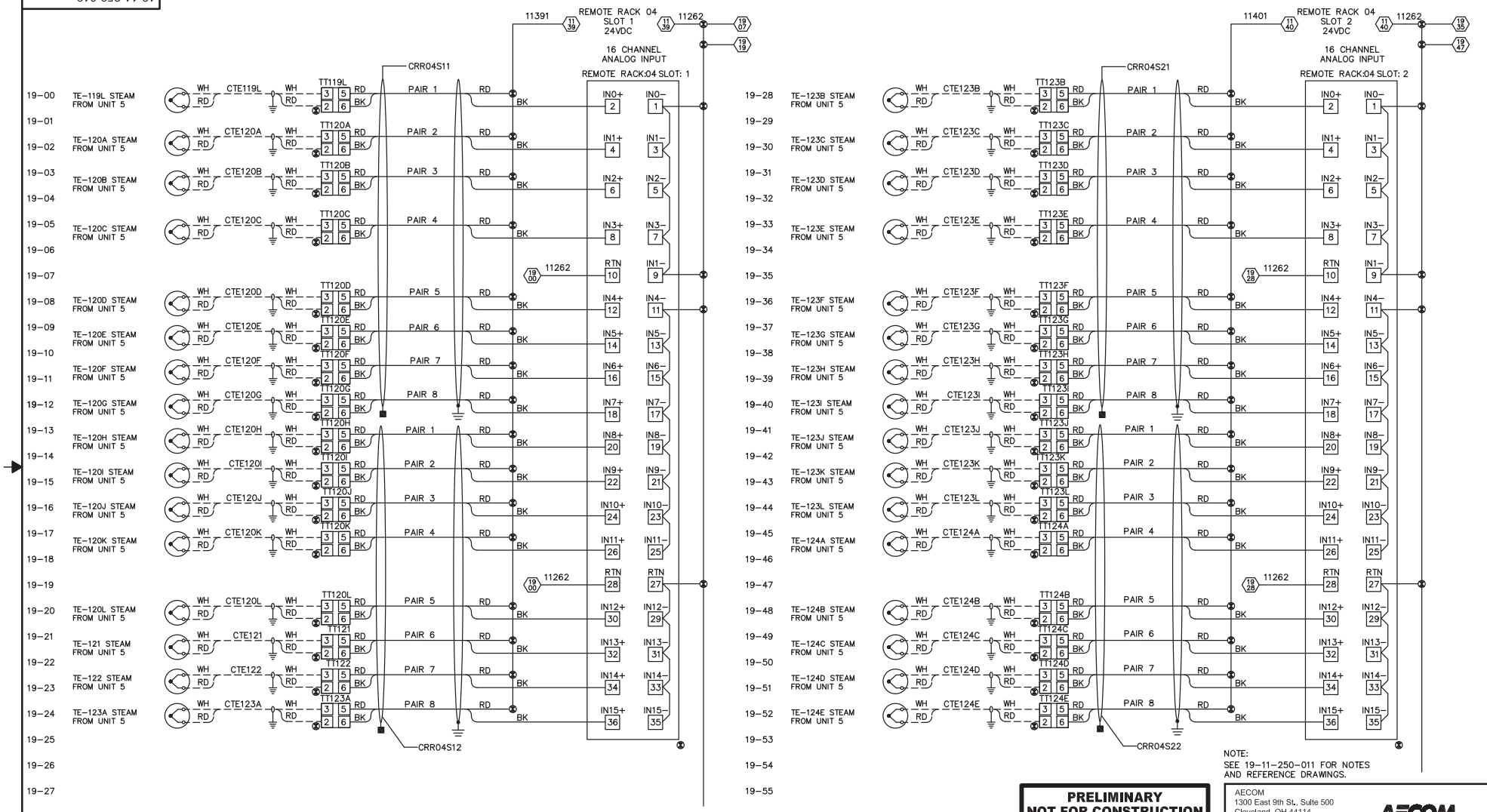
A-USC COMTEST PROJECT
SCHEMATIC DIAGRAM, ANALOG INPUTS REMOTE PANEL GE (RPGE)

DWG. NO. 19-11-250-018
REV A

EC_D_Size.dwg



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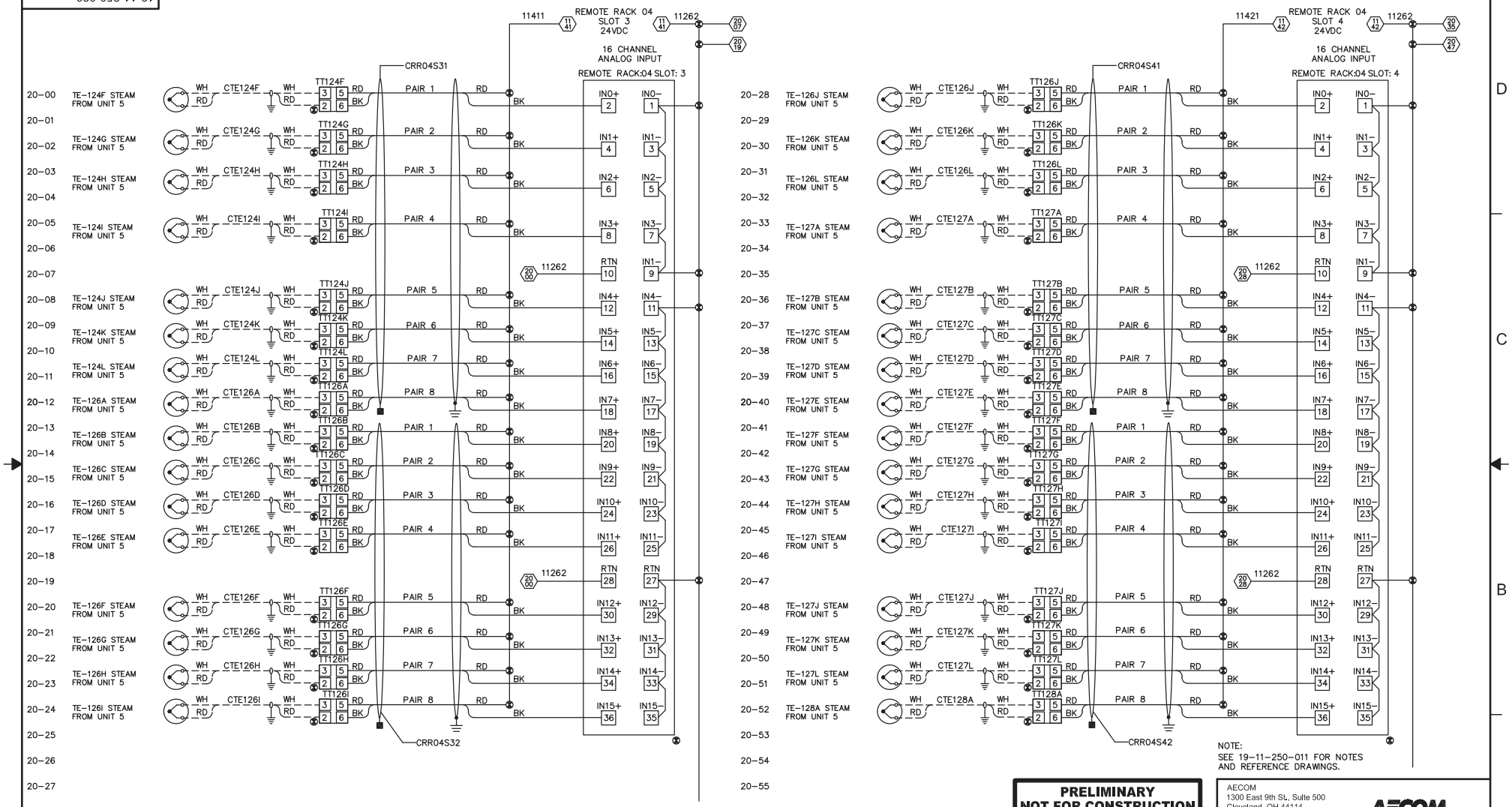
A-USC COMTEST PROJECT
SCHEMATIC DIAGRAM, ANALOG INPUTS REMOTE PANEL GE (RPGE)

DWG. NO. 19-11-250-019
REV A

EC_D_Size.dwg

19-11-250-020



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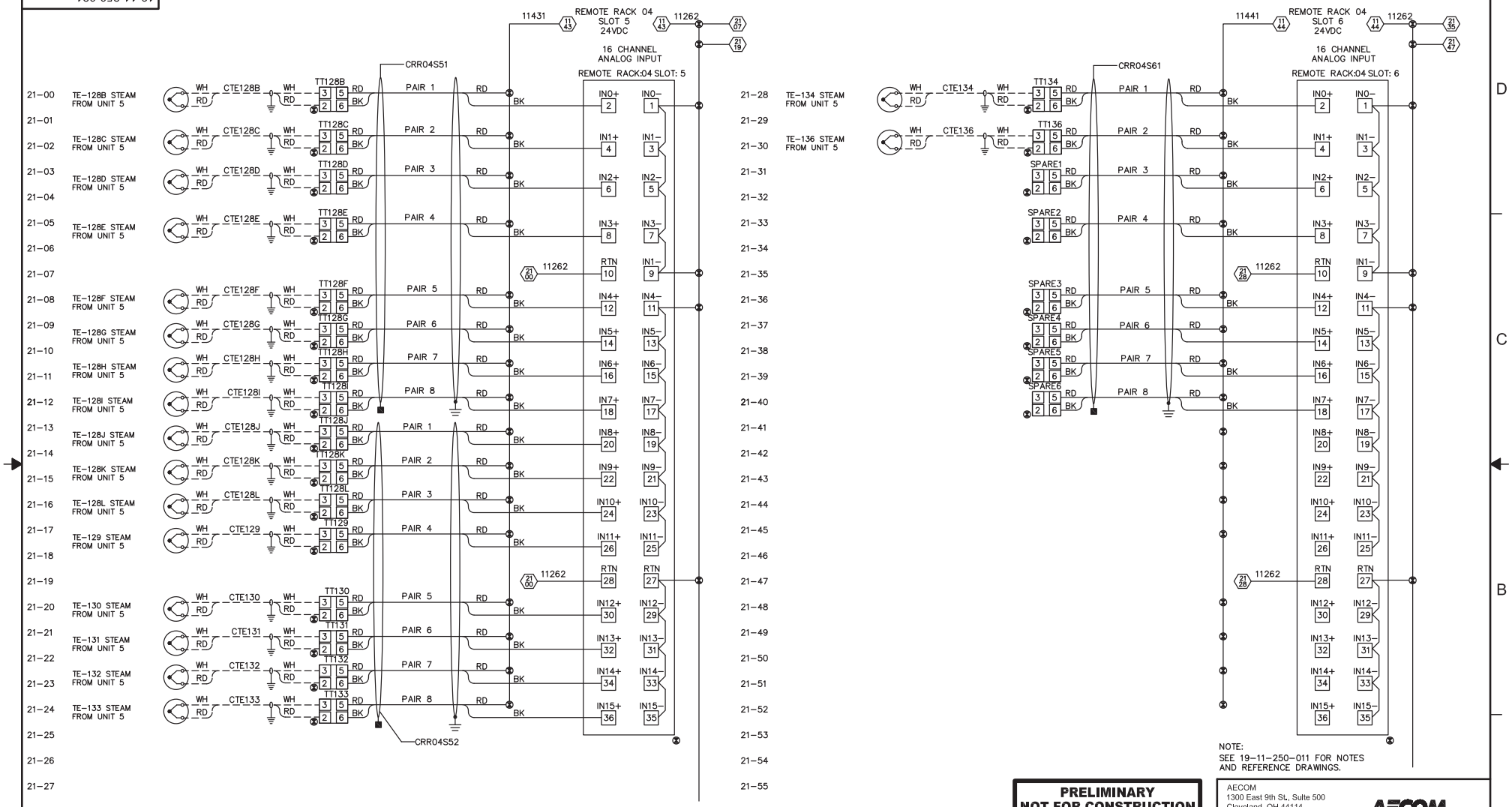
A-USC COMTEST PROJECT
SCHEMATIC DIAGRAM, ANALOG INPUTS
REMOTE PANEL GE (RPGE)

DWG. NO. 19-11-250-020 REV A

EC_D_Size.dwg

19-11-250-021



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A-USC COMTEST PROJECT
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REMOTE PANEL GE (RPGE)

DWG. NO. 19-11-250-021
REV A

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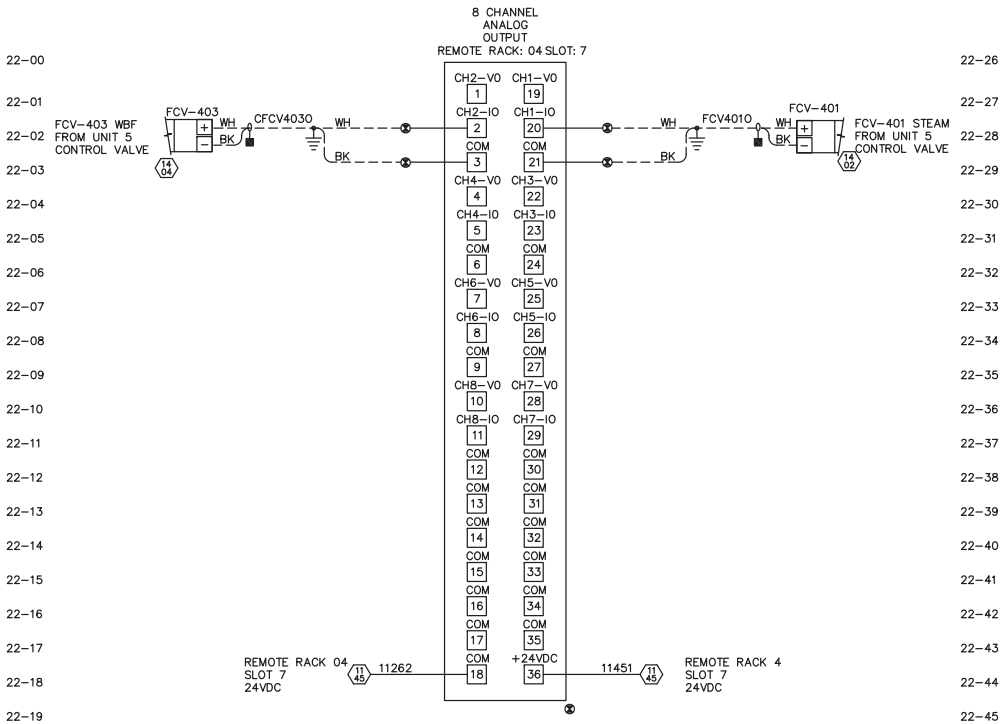
19-11-250-022



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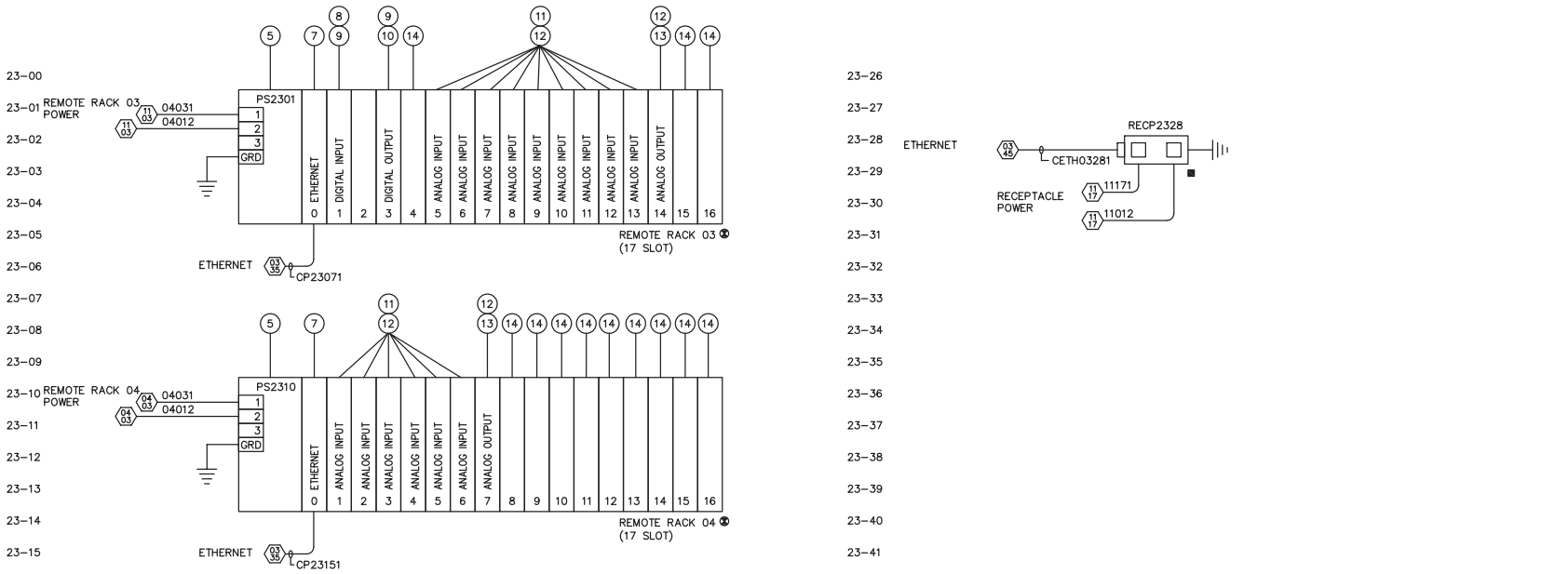
A-USC COMTEST PROJECT
SCHEMATIC DIAGRAM ANALOG OUTPUT
REMOTE PANEL GE (RPGE)

DWG. NO. 19-11-250-022
REV A

EC_D_Size.dwg

INCHES / CENTIMETERS

19-10-250-023



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A-USC COMTEST PROJECT
SCHEMATIC DIAGRAM RACK LAYOUT
REMOTE PANEL GE (RPGE)

DWG. NO. 19-11-250-023
REV A

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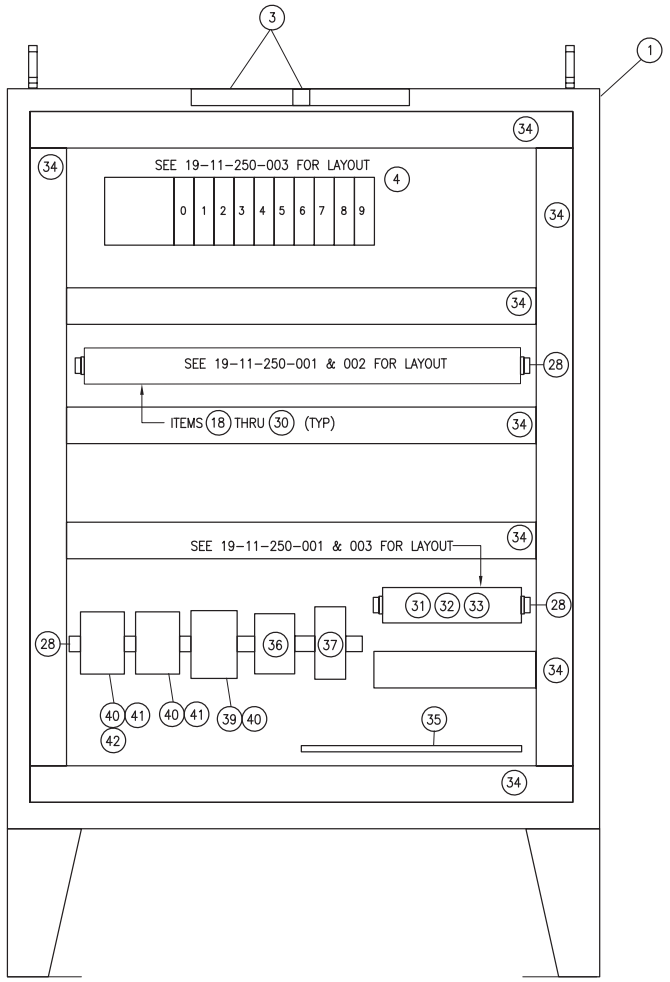
19-11-410-001



BILL OF MATERIAL

ITEM	QTY	MANUFACTURER	CATALOG #	DESCRIPTION
1	1	PENTAIR	A604816LPG A60P48	2–DOOR WITH FLOOR STANDS, TYPE 12 (60X48X16) WITH BACK PANEL
2				
3	1	PENTAIR	LF120V18 ALFSWD	FLOURESCENT ENCLOSURE LIGHT, 120 VAC, 18 INCH WITH REMOTE DOOR SWITCH
4	1	ROCKWELL	1756–A10	CONTROLLOGIX 10 SLOT CHASSIS
5	1	ROCKWELL	1756–PA75	CONTROLLOGIX 85–265 VAC POWER SUPPLY, 13 AMPS
6		ROCKWELL	1756–L82E	CONTROLLOGIX 5580 CONTROLLER WITH 5 MB USER MEMORY
7	2	ROCKWELL	1756–EN2T	ETHERNET 10 –100 MBITS INTERFACE MODULE
8		ROCKWELL	1756–IA16	79–132 VAC DIGITAL INPUT 16 POINT
9		ROCKWELL	1756–TBNH	20 POSITION NEMA SCREW CLAMP BLOCK
10		ROCKWELL	1756–OA16	74–265 VAC DIGITAL OUTPUT MODULE 16 POINT
11		ROCKWELL	1756–IF16H	ANALOG INPUT MODULE – 16 POINT HART
12		ROCKWELL	1756–TBCH	36 PIN SCREW CLAMP BLOCK WITH STANDARD HOUSING
13		ROCKWELL	1756–OF8	ANALOG OUTPUT MODULE – CURRENT/VOLTAGE 8 POINT
14				
15				
16				
17	AS REQ.	ROCKWELL	1492–CA3BL	SINGLE FEED THROUGH TERMINAL BLOCK –SCREW TYPE (BLACK)
18	AS REQ.	ROCKWELL	1492–N16–BL	TERMINAL END BARRIER (BLACK)
19	AS REQ.	ROCKWELL	1492–CA3B	SINGLE FEED THROUGH TERMINAL BLOCK –SCREW TYPE (BLUE)
20	AS REQ.	ROCKWELL	1492–N16–B	TERMINAL END BARRIER (BLUE)
21	AS REQ.	ROCKWELL	1492–CA3GY	SINGLE FEED THROUGH TERMINAL BLOCK –SCREW TYPE (GRAY)
22	AS REQ.	ROCKWELL	1492–N16–GY	TERMINAL END BARRIER (GRAY)
23	AS REQ.	ROCKWELL	1492–CA3	SINGLE FEED THROUGH TERMINAL BLOCK –SCREW TYPE (WHITE)
24	AS REQ.	ROCKWELL	1492–N16	TERMINAL END BARRIER (WHITE)
25	AS REQ.	ROCKWELL	1492–CA3G	SINGLE FEED THROUGH TERMINAL GND. BLOCK –SCREW TYPE (GREEN)
26	AS REQ.	ROCKWELL	1492–N16–G	TERMINAL END BARRIER (GREEN)
27	AS REQ.	ROCKWELL	1492–N23	AND ANCHOR – A–B RAIL – HEAVY DUTY
28	AS REQ.	ROCKWELL	1492–N22	DIN MOUNTING RAIL, RIGID MOUNTING A – B (22.4mm x 6.9mm)
29	AS REQ.	ROCKWELL	1492–FB1M30–L	FUSE HOLDER – 1–1/2" x 13/32" MIDGET FUSE – LED BLOWN FUSE INDICATOR
30	AS REQ.	BUSSMANN	BAF–2	BAF 13/32" X 1–1/2" 25 VAC FAST–ACTING FUSES
31	AS REQ.	ROCKWELL	1489–M1C????	CIRCUIT BREAKER – 1 POLE – SIZE AS REQUIRED XXX AMPS
32	AS REQ.	ROCKWELL	1489–M2C020	CIRCUIT BREAKER – 2 POLE – 20 AMPS
33	AS REQ.	ROCKWELL	1489–AMCL112	12 CIRCUIT BREAKER – 1 PIN BUS BAR
34	AS REQ.	PANDUIT	G3X3LG6, C3LG WR3–C	3 INCH TYPE G SLOT WIRE DUCT WITH COVER AND WIRE DUCT RETAINER (EVERY 2 FT. MAX)
35	1	PENTAIR	EB44	GROUND BUS BAR
36	1	SOLA	SDN 10–24–100P	24 VDC POWER SUPPLY
37	1	LEVITON	GFNT1–DN	DIN–RAIL 15A – 125 V GFCI RECEPTACLE
38		GRACE ENG. PRODUCTS	P–R2–F3RO	SINGLE RECEPTACLE W/ ETHERNET, NEMA 4
39	1	DINSPACE	SNAP–Cu–12	CAT 6 RJ45 PATCH PANEL – 1 PORTS
40	AS REQ.	DINSPACE	LV5EPC02MST–B–BLU	CAT 5 COPPER CUPPER PATCH CABLE – BLUE– 2 METER
41	2	ROCKWELL	1783–BMA10CA	STRATIX 5700 SWITCH, MANAGED, 8 FAST ETHERNET COPPER PORTS, 2 FAST ETHERNET COMBO PORTS & FULL SOFTWARE
42	2	ROCKWELL	1783–SFP100FX	STRATIX FIBER SFP, 100 MBIT CONNECTIVITY OVER MULTI–MODE FIBER

NOTE:
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DRAWING STATUS				
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PROJECT NO.: 31609
DRAWN: DRT DATE: 6/7/16
CHECKED: DC DATE: 6/7/16
SCALE: NONE

A-USC COMTEST PROJECT
PANEL LAYOUT
PLC CABINET (PLC)

DWG. NO. 19-11-410-001
REV A

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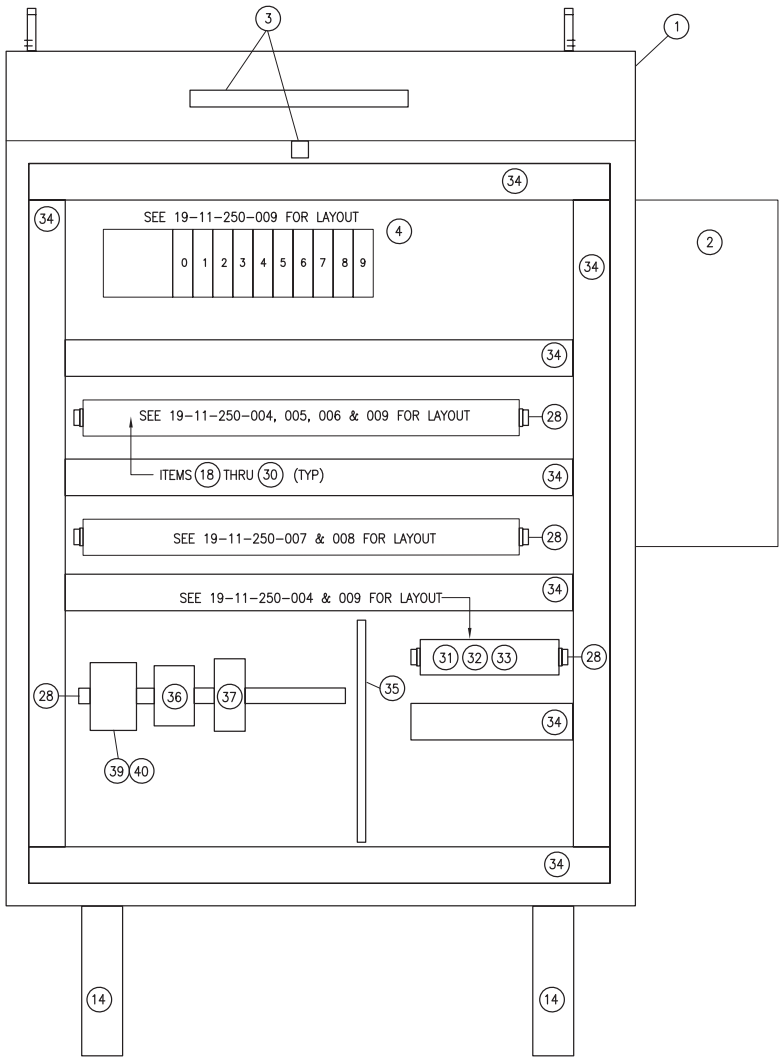
D C B A

19-11-410-004



BILL OF MATERIAL

ITEM	QTY	MANUFACTURER	CATALOG #	DESCRIPTION
1	1	PENTAIR	WS625118SS A60P48	2-DOOR WATERSHED FREE STAND, TYPE 4X STAND ENCLOSURE (62X51X18) WITH BACK PANEL
2	1	PENTAIR	N28041G151	OUTDOOR AIR CONDITIONER 4000 BTU W/ 1300 WATT HEATER,115 VAC
3	1	PENTAIR	LF120V18 ALFSWD	FLOURESCENT ENCLOSURE LIGHT, 120 VAC, 18 INCH WITH REMOTE DOOR SWITCH
4	1	ROCKWELL	1756-A10	CONTROLLOGIX 10 SLOT CHASSIS
5	1	ROCKWELL	1756-PA75	CONTROLLOGIX 85-265 VAC POWER SUPPLY, 13 AMPS
6		ROCKWELL	1756-L82E	CONTROLLOGIX 5580 CONTROLLER WITH 5 MB USER MEMORY
7	1	ROCKWELL	1756-EN2T	ETHERNET 10 -100 MBITS INTERFACE MODULE
8	1	ROCKWELL	1756-IA16	79-132 VAC DIGITAL INPUT 16 POINT
9	2	ROCKWELL	1756-TBNH	20 POSITION NEMA SCREW CLAMP BLOCK
10	1	ROCKWELL	1756-OA16	74-265 VAC DIGITAL OUTPUT MODULE 16 POINT
11	2	ROCKWELL	1756-IF16H	ANALOG INPUT MODULE - 16 POINT HART
12	4	ROCKWELL	1756-TBCH	36 PIN SCREW CLAMP BLOCK WITH STANDARD HOUSING
13	2	ROCKWELL	1756-OF8	ANALOG OUTPUT MODULE - CURRENT/VOLTAGE 8 POINT
14	1	PENTAIR	WSASLKSS	ADJUSTABLE STANTARY LEG KIT
15				
16				
17	AS REQ.	ROCKWELL	1492-CA3BL	SINGLE FEED THROUGH TERMINAL BLOCK -SCREW TYPE (BLACK)
18	AS REQ.	ROCKWELL	1492-N16-BL	TERMINAL END BARRIER (BLACK)
19	AS REQ.	ROCKWELL	1492-CA3B	SINGLE FEED THROUGH TERMINAL BLOCK -SCREW TYPE (BLUE)
20	AS REQ.	ROCKWELL	1492-N16-B	TERMINAL END BARRIER (BLUE)
21	AS REQ.	ROCKWELL	1492-CA3GY	SINGLE FEED THROUGH TERMINAL BLOCK -SCREW TYPE (GRAY)
22	AS REQ.	ROCKWELL	1492-N16-GY	TERMINAL END BARRIER (GRAY)
23	AS REQ.	ROCKWELL	1492-CA3	SINGLE FEED THROUGH TERMINAL BLOCK -SCREW TYPE (WHITE)
24	AS REQ.	ROCKWELL	1492-N16	TERMINAL END BARRIER (WHITE)
25	AS REQ.	ROCKWELL	1492-CA3G	SINGLE FEED THROUGH TERMINAL GND. BLOCK -SCREW TYPE (GREEN)
26	AS REQ.	ROCKWELL	1492-N16-G	TERMINAL END BARRIER (GREEN)
27	AS REQ.	ROCKWELL	1492-N23	AND ANCHOR - A-B RAIL - HEAVY DUTY
28	AS REQ.	ROCKWELL	1492-N22	DIN MOUNTING RAIL, RIGID MOUNTING A - B (22.4mm x 6.9mm)
29	AS REQ.	ROCKWELL	1492-FB1M30-L	FUSE HOLDER - 1-1/2" x 13/32" MIDGET FUSE - LED BLOWN FUSE INDICATOR
30	AS REQ.	BUSSMANN	BAF-2	BAF 13/32" X 1-1/2" 25 VAC FAST-ACTING FUSES
31	AS REQ.	ROCKWELL	1489-M1C????	CIRCUIT BREAKER - 1 POLE - SIZE AS REQUIRED XXX AMPS
32	AS REQ.	ROCKWELL	1489-M2C020	CIRCUIT BREAKER - 2 POLE - 20 AMPS
33	AS REQ.	ROCKWELL	1489-AMCL112	12 CIRCUIT BREAKER - 1 PIN BUS BAR
34	AS REQ.	PANDUIT	G3X3LG6, C3LG WR3-C	3 INCH TYPE G SLOT WIRE DUCT WITH COVER AND WIRE DUCT RETAINER (EVERY 2 FT. MAX)
35	1	PENTAIR	EB44	GROUND BUS BAR
36	1	SOLA	SDN 10-24-100P	24 VDC POWER SUPPLY
37	1	LEVITON	GFNT1-DN	DIN-RAIL 15A - 125 V GFCI RECEPTACLE
38		GRACE ENG. PRODUCTS	P-R2-F3RO	SINGLE RECEPTACLE W/ ETHERNET, NEMA 4
39	1	DINSPACE	SNAP-Cu-12	CAT 6 RJ45 PATCH PANEL - 1 PORTS
40	AS REQ.	DINSPACE	LV5EPC02MST-B-BLU	CAT 5 COPPER CUPPER PATCH CABLE - BLUE- 2 METER

NOTE:
SEE 19-11-250-004 FOR NOTES AND REFERENCE DRAWINGS

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PROJECT NO.: 31609
DRAWN: DRT DATE: 08/21/2017
CHECKED: DC DATE: 08/23/2017
SCALE: NONE

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A-USC COMTEST PROJECT
PANEL LAYOUT
REMOTE PLC CABINET (RPLC)

DWG. NO. 19-11-410-004 REV A

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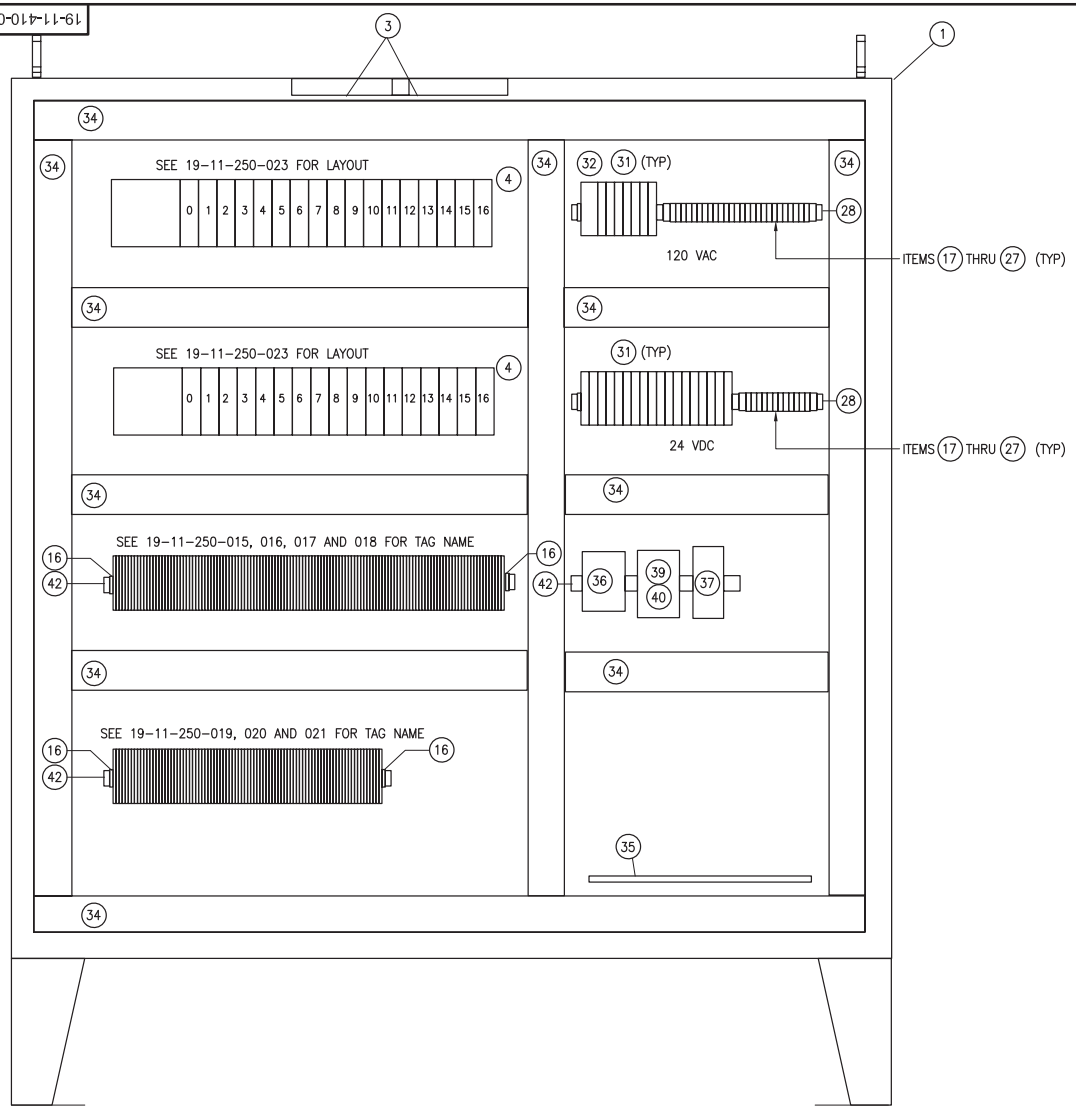
INCHES CENTIMETERS

19-11-410-005



BILL OF MATERIAL

ITEM	QTY	MANUFACTURER	CATALOG #	DESCRIPTION
1	1	PENTAIR	A72H7224SSLPQT A72P72	2-DOOR WITH FLOOR STANDS, TYPE 4X (72X72X24) WITH BACK PANEL
2	1	PENTAIR	A72SMP20	SIDE-MOUNTED PANEL
3	1	PENTAIR	LF120V18 ALFSWD	FLOURESCENT ENCLOSURE LIGHT, 120 VAC, 18 INCH WITH REMOTE DOOR SWITCH
4	2	ROCKWELL	1756-A17	CONTROLLOGIX 10 SLOT CHASSIS
5	2	ROCKWELL	1756-PA75	CONTROLLOGIX 85-265 VAC POWER SUPPLY, 13 AMPS
6		ROCKWELL	1756-L82E	CONTROLLOGIX 5580 CONTROLLER WITH 5 MB USER MEMORY
7	2	ROCKWELL	1756-EN2T	ETHERNET 10 -100 MBITS INTERFACE MODULE
8	1	ROCKWELL	1756-IA16	79-132 VAC DIGITAL INPUT 16 POINT
9	2	ROCKWELL	1756-TBNH	20 POSITION NEMA SCREW CLAMP BLOCK
10	1	ROCKWELL	1756-OA16	74-265 VAC DIGITAL OUTPUT MODULE 16 POINT
11	15	ROCKWELL	1756-IF16H	ANALOG INPUT MODULE - 16 POINT HART
12	16	ROCKWELL	1756-TBCH	36 PIN SCREW CLAMP BLOCK WITH STANDARD HOUSING
13	1	ROCKWELL	1756-OF8	ANALOG OUTPUT MODULE - CURRENT/VOLTAGE 8 POINT
14	12	ROCKWELL	1756-N2	SLOT FILLER MODULE
15	216	PR ELECTRONICS	3331	TEMPERATURE CONVERTER, LOOP POWERED - ISOLATED
16	4	PR ELECTRONICS	9404	MODULE STOP
17	AS REQ.	ROCKWELL	1492-CA3BL	SINGLE FEED THROUGH TERMINAL BLOCK -SCREW TYPE (BLACK)
18	AS REQ.	ROCKWELL	1492-N16-BL	TERMINAL END BARRIER (BLACK)
19	AS REQ.	ROCKWELL	1492-CA3B	SINGLE FEED THROUGH TERMINAL BLOCK -SCREW TYPE (BLUE)
20	AS REQ.	ROCKWELL	1492-N16-B	TERMINAL END BARRIER (BLUE)
21	AS REQ.	ROCKWELL	1492-CA3GY	SINGLE FEED THROUGH TERMINAL BLOCK -SCREW TYPE (GRAY)
22	AS REQ.	ROCKWELL	1492-N16-GY	TERMINAL END BARRIER (GRAY)
23	AS REQ.	ROCKWELL	1492-CA3	SINGLE FEED THROUGH TERMINAL BLOCK -SCREW TYPE (WHITE)
24	AS REQ.	ROCKWELL	1492-N16	TERMINAL END BARRIER (WHITE)
25	AS REQ.	ROCKWELL	1492-CA3G	SINGLE FEED THROUGH TERMINAL GND. BLOCK -SCREW TYPE (GREEN)
26	AS REQ.	ROCKWELL	1492-N16-G	TERMINAL END BARRIER (GREEN)
27	AS REQ.	ROCKWELL	1492-N23	AND ANCHOR - A-B RAIL - HEAVY DUTY
28	AS REQ.	ROCKWELL	1492-N22	DIN MOUNTING RAIL, RIGID MOUNTING A - B (22.4mm x 6.9mm)
29	AS REQ.	ROCKWELL	1492-FB1M30-L	FUSE HOLDER - 1-1/2" x 13/32" MIDGET FUSE - LED BLOWN FUSE INDICATOR
30	AS REQ.	BUSSMANN	BAF-2	BAF 13/32" X 1-1/2" 25 VAC FAST-ACTING FUSES
31	AS REQ.	ROCKWELL	1489-M1C????	CIRCUIT BREAKER - 1 POLE - SIZE AS REQUIRED XXX AMPS
32	AS REQ.	ROCKWELL	1489-M2C020	CIRCUIT BREAKER - 2 POLE - 20 AMPS
33	AS REQ.	ROCKWELL	1489-AMCL112	12 CIRCUIT BREAKER - 1 PIN BUS BAR
34	AS REQ.	PANDUIT	G3X3LG6, C3LG WR3-C	3 INCH TYPE G SLOT WIRE DUCT WITH COVER AND WIRE DUCT RETAINER (EVERY 2 FT. MAX)
35	1	PENTAIR	EB44	GROUND BUS BAR
36	1	SOLA	SDN 10-24-100P	24 VDC POWER SUPPLY
37	1	LEVITON	GFNT1-DN	DIN-RAIL 15A - 125 V GFCI RECEPTACLE
38		GRACE ENG. PRODUCTS	P-R2-F3RO	SINGLE RECEPTACLE W/ ETHERNET, NEMA 4
39	1	DINSPACE	SNAP-Cu-12	CAT 6 RJ45 PATCH PANEL - 1 PORTS
40	AS REQ.	DINSPACE	LV5EPC02MST-B-BLU	CAT 5 COPPER CUPPER PATCH CABLE - BLUE- 2 METER
41	2	ROCKWELL	1783-BMA10CA	STRATIX 5700 SWITCH, MANAGED, 8 FAST ETHERNET COPPER PORTS, 2 FAST ETHERNET COMBO PORTS & FULL SOFTWARE
42	AS REQ.	ROCKWELL	1783-SFP100FX	DIN MOUNTING RAIL, 35mm x 7.5mm DIN Rail, 1 Meter
43	2	ROCKWELL	1783-SFP100FX	STRATIX FIBER SFP, 100 MBIT CONNECTIVITY OVER MULTI-MODE FIBER
44	2	ROCKWELL	1783-SFP100FX	STRATIX FIBER SFP, 100 MBIT CONNECTIVITY OVER MULTI-MODE FIBER
45	2	ROCKWELL	1783-SFP100FX	STRATIX FIBER SFP, 100 MBIT CONNECTIVITY OVER MULTI-MODE FIBER

NOTE:
SEE 19-11-250-011 FOR NOTES AND REFERENCE DRAWINGS

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PROJECT NO.: 31609
DRAWN: DRT DATE: 10/02/2017
CHECKED: DC DATE: 10/04/2017
SCALE: NONE

A-USC COMTEST PROJECT
PANEL LAYOUT
REMOTE PANEL GE (RPGE)

DWG. NO. 19-11-410-005 REV A

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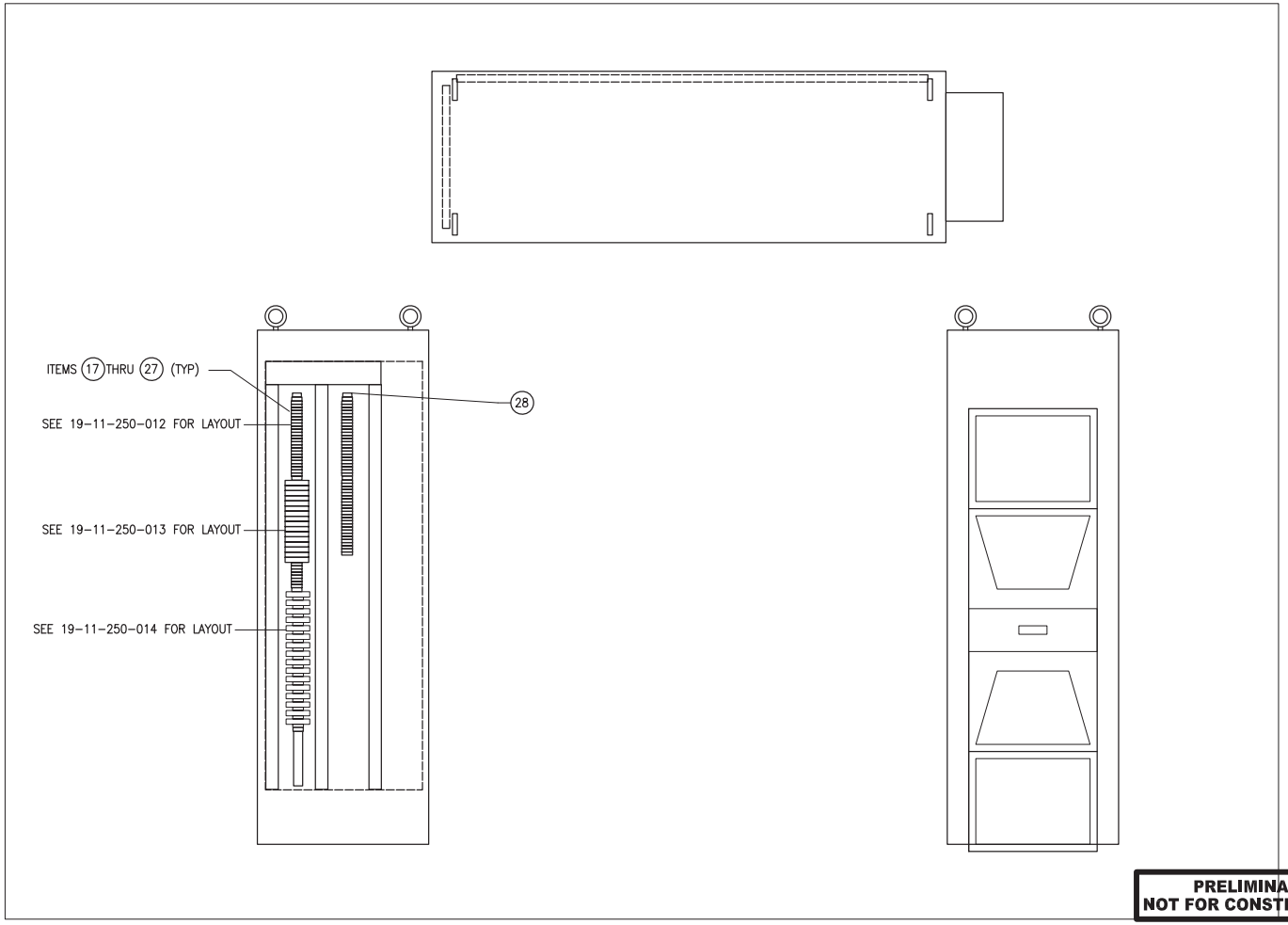
INCHES
CENTIMETERS

19-11-410-006



NOTES:
1. SEE 19-11-250-011 FOR NOTES AND REFERENCE DRAWINGS.
2. FOR ENCIRCLED ITEMS REFER TO BILL OF MATERIAL ON DWG. 19-11-410-005.

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CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C						A	12/22/17	ISSUE FOR RECORD	DRT	DC

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PROJECT NO.: 31609
DRAWN: DRT DATE: 10/2/2017
CHECKED: DC DATE: 10/4/2017
SCALE: NONE

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A-USC COMTEST PROJECT
PANEL LAYOUT
REMOTE PANEL GE (RPGE)

DWG. NO. 19-11-410-006
REV A

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INCHES 1 2 3 4 5 6
CENTIMETERS 1 2 3 4 5 6

8 7 6 5 4 3 2 1

D C B A

A-USC Com Test at Youngstown Thermal

Youngstown, OH

PROJECT NUMBER 31609

SPECIFICATION NUMBER 19-0-001

FOR

Control Systems Sequence of Operation

PREPARED FOR

Energy Industries of Ohio (EIO)

By

AECOM

1500 W 3rd Street, Suite 200

Cleveland, OH 44113

Revision	Date	Status
A	March 31, 2016	Preliminary

SPECIFICATION REVISION PAGE

Project Name:	A-USC Com Test	Discipline:	Instrumentation & Controls
Client:	Energy Industries of Ohio		

Revision Signatures

David Truelsch	3/31/2016		
Prepared by	Date	Approved by (PEM)	Date
		NA	
Checked by	Date	Approved by (if required) (title)	Date

Status	Rev. No.	Date	Prepared By	Pages	Description of Changes
Prelim.	A	3/31/2016	DRT	All	Preliminary – Issued for FEED

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1.0 GENERAL PROCESS AND CONTROLS OVERVIEW

1.1. Purpose

This document's purpose is to communicate to the operating staff and Process Control System integrator how the ComTest A-USC Balance of plant systems will operates and how there are controlled. The purpose of this section is to provide a high level overview of the process and controls.

1.2. Process Overview

Fresh water from the municipal water system will flow to a low pressure pump (if required) before entering a rental once-through water treatment system. The steam entering the turbine would be required to have a quality similar to that found in modern utility steam generation units, and would have to be cleaner than that provided by the city. [Note: GE will provide specification.] The majority of the water used by ComTest would not be returned to the system, so the water treatment system would be sized to handle the full water flow.

The purified water leaving the water treatment system would flow into the rental deaerator. The deaerator would use a combination of 150 psia saturated steam from the Youngstown Thermal boilers and hot water recirculated from the ComTest Superheater/Economizer to strip the dissolved gases from the boiler feedwater before it enters the boilers. A high pressure pump increases the pressure of the boiler feedwater from the deaerator pressure to the boiler operating pressure. This high pressure pump is part of the deaerator skid.

The boiler feedwater would then flow into the packaged boiler. It is anticipated that each these boilers would have a capacity of 75,000 with a design pressure of 750 psia and a steam temperature of 750^{o}F. The boilers would be fired with natural gas at a flowrate required to match the test conditions, and the exhaust from the boilers will be exhausted to atmosphere. [Note: we need to determine if their permit will allow this or will we need to exhaust to the current stack.] Air is supplied to the boilers with a fan that is supplied by the boiler rental company.

Approximately 100,000 lb/hr [Note: this is the previous value – GE may increase to 130,000 lb/hr] of steam at nominally 675 psia and 750^{o}F would leave the boilers and flow to the heat recovery heat exchanger. The steam exhausting the steam turbine has a temperature of approximately 990^{o}F. Since this steam will be delivered to the customers at 150 psia and saturated temperature (358^{o}F), heat can be recovered from this stream to heat the steam to approximately 930^{o}F before it enters the superheater. This will decrease the natural gas flow required by the superheater.

The steam exits the heat recovery heat exchanger and enters a natural gas fired superheater where it is heated to 1400^{o}F before entering the steam turbine. Combustion air is supplied to the superheater through a fan which is included as part of the superheater package. Due to the high exhaust temperature of the flue gas leaving the superheater, an economizer is included as part of the superheater package to cool the flue gas before it is exhausted to atmosphere. A portion of the boiler feedwater exiting the high pressure pump (previously described) flows through the economizer. After heating, this majority of this water returns to the deaerator to decrease the steam requirements. A portion of this water is also used as spray water in the superheater to control the steam temperature.

The 1400^{o}F steam, at approximately 640 psia, flows to the steam turbine where it is exhausted at approximately 170 psia. It is not anticipated that electrical power would be generated by this turbine and a water brake or some other device will be used to absorb the power generated by the turbine. The steam would flow through the heat recovery heat exchanger and be cooled to approximately 800^{o}F before

being desuperheated to saturated conditions with boiler feedwater. This saturated steam at approximately 150 psia is the "product" supplied to the customers of Youngstown thermal.

It is desirable that the flowrate through the ComTest be independent of the flowrate required by Youngtown Thermal's customers. If the steam flow produced by ComTest is greater than that required by Youngtown Thermal's customers, the excess steam would flow to a condenser where it would be cooled and then flow to the deaerator. This condenser would be sized to cool the maximum ComTest steam flowrate. [Note: If Youngstown needs more steam than supplied by ComTest, they would fire additional boilers.]

1.3. Controls Overview

The control system will consist of a Mark VIe Distributed Control System (DCS) for the Steam Turbine System, a The PACSystems RX3i Programmable Automation Controller for the Balance of Plant systems and the package systems will contain standalone controls. The HMI system will have a common database for the Steam Turbine system and the Balance of plant systems and will consists of two workstations.

The Balance of plant systems are:

1. Steam Distribution
2. Superheater
3. Cooling Tower

Standalone Package System are:

1. Deaerator
2. Water Treatment
3. Boiler
4. Condenser Unit

1.3.1. Demand Masters

The following control functions are proposed for the A-USC ComTest Superheater.

Load Demand Master

Load demand and rate of load change is controlled by operator manual input with the Load Demand Master. The mode for turbine and superheater operation may be set by the Load Master. Turbine following (the superheater), superheater following (the turbine), and coordinated mode, may be selected. Load demand controls the Superheater Demand Master in coordination with Steam Turbine Master. The Load Demand Master may be linked to the Youngstown Thermal Steam Plant demand control in some manner to be determined.

Superheater Demand Master

The Superheater Demand Master, with input from the Load Demand Master, controls the Final Superheater Temperature Master, Firing Rate Master, Superheater Steam Flow Master and the Gas Outlet Temperature Control of the exhaust stack inlet from the economizer.

Turbine Demand Master and Turbine Throttle Pressure Control

The Turbine Demand Master, with input from the Load Demand Master, controls the Steam Turbine Throttle Valve and therefore the superheater pressure on setpoint or functional ramp program with Load

Demand.

Turbine Bypass Valve Pressure Control

The Turbine Demand Master permits the Turbine Bypass Valve to control the steam turbine throttle pressure to an upper limit and therefore the superheater upper pressure limit on setpoint or functional ramp program with Load Demand, particularly at start up and turbine trip.

1.3.2. **Superheater**

Final Superheater Temperature Master
Final superheater steam outlet temperature setpoint is provided by the Final Superheater Temperature Master which controls 2nd stage attemperator flow. The 2nd stage spray attemperator flow control trim function is produced by the differential temperature of the 2nd stage attemperator inlet and outlet. The 2nd stage attemperator trim is used to adjust the 1st stage attemperator spray flow demand.

Primary Superheater Temperature Control

Primary superheater outlet temperature is controlled by 1st stage attemperator flow. A Superheater flow control trim function is produced by the differential temperature of the attemperator inlet and outlet. The trim is used to adjust the steam flow demand from the package boiler.

Superheater Steam Flow Control
Superheater steam flow demand from the package boiler is developed as function of the energy pick-up between the enclosure inlet and the 1st stage attemperator inlet in relation to the absorbed energy function to the superheater demand. The 1 stage attemperator differential temperature trim is used to adjust the superheater steam flow demand

Vertical Separator Drain Flow Control

VS level demands drain flow control valve to maintain range of high to low level operation if drains are produced. Superheater steam flow and minimum enclosure flow setpoint provide demand to VS drain flow control valve to open for partial load operation of the steam turbine while protecting the minimum steam flow required in the enclosure walls.

Economizer Discharge Pressure Control
The economizer discharges flow to the deareator and is controlled to the lower deareator pressure. The pressure of the economizer is to be as high as possible to maintain a higher saturation temperature margin.

Spray Water Economizer Outlet Subcooling Enthalpy h (P, T) Control
The spray attemperation water is heated by rows of heating surface that are supplied from the economizer inlet and are situated first in the flue gas path. The smaller amount of flow for attemperation is heated to the subcooled margin allowed. If the demanded spray flow is insufficient to maintain the Subcooling margin, the flow control valve opens to demand additional flow and discharge to the deareator.

Feedwater Flow Control
Maximum economizer outlet water temperature is limited by higher feedwater flow to maintain a subcooled margin to saturation. Also control of outlet flue gas temperature produces a feedwater demand added to the economizer water outlet temperature demand flow. Overflowing the economizer *is* possible because of decoupling from the superheater steam flow.

1.3.3. **Boiler**

Gas Combustion Control

The combustion control is typical boiler system functions. The following functions are proposed:

Firing Rate Master
Air Flow Master
Excess Air (Oxygen)
Gas Recirculation Control (NOx)
Seal Air Fan Control
Water Trough Seal Control
Level
Outlet water temperature

Boiler control system will be furnished by the boiler vendor. The A-USC ComTest Superheater Demand Master controls the package boiler steam flow, Steam flow demand. The following are controlled by the package boiler control system:

Steam temperature
Steam pressure Drum level Feedwater Firing rate Airflow Excess02
Gas recirculation rental Boiler system

Sequences and Interlock Permissives for the A-USC Superheater will include:

Purge, Ignition Light-Off
Master Fuel Trip (MFT)
Start, Load Run-Up, Load Run-Down, Stop
Trips, other

Sequences and Interlock Permissives for the rental Package Boiler will include:

Purge, Ignition Light-Off
Master Fuel Trip (MFT)
Start, Load Run-Up, Load Run-Down, Stop
Trips, other

2.0 NORMAL PROCESS OPERATIONS

2.1. Water Treatment System

2.2. Deaerator

2.3. Boiler

2.4. Superheater

2.5. Turbine

2.6. Condenser Unit

3.0 APPENDICES

3.1. Appendices A – Process Alarms and Setpoints

See Appendix A attached to this document

3.2. Appendices B – Cause and Effect Matrix

See Appendix B attached to this document

A-USC COMTEST INSTRUMENT AND I/O LIST

Tag Number	Instrument Type	Service	Furn. By	P&ID	Budgetary $	Size	Pipe Spec	I/O CABINET	-----I/O----- T/C	AI	AO	DI	DO	Notes
PRV-1001	PRESSURE REGULATOR	WBF TO DEAREATOR	AECOM	PID-YTT-10	$16,207	4"	WBF	-						
FE-1101	FLOW ELEMENT	WBF TO SH-3001	AECOM	PID-YTT-11	$1,845	2"	WBF	-						
FT-1101	D/P FLOW TRANSMITTER	WBF TO SH-3001	AECOM	PID-YTT-11	$4,000			PLC CABINET		1				
FV-1101	FLOW CONTROL VALVE	WBF TO DS-2201	AECOM	PID-YTT-11	$7,614	2"	WBF	PLC CABINET			1	2		
FE-1102	FLOW ELEMENT	WBF TO ECONOMIZER	AECOM	PID-YTT-11	$4,190	4"	WBF	-						
FT-1102	D/P FLOW TRANSMITTER	WBF TO ECONOMIZER	AECOM	PID-YTT-11	$4,000			PLC CABINET		1				
FV-1102	FLOW CONTROL VALVE	WBF TO ECONOMIZER	AECOM	PID-YTT-11	$16,207	4"	WBF	PLC CABINET			1	2		
FE-2001	FLOW ELEMENT	SB TO DISTRIBUTION	AECOM	PID-YTT-20	$4,364	8"	SB	-						
FIT-2001	D/P FLOW TRANSMITTER	SB TO DISTRIBUTION	AECOM	PID-YTT-20	$4,000			BSRIO		1				
FE-2101	FLOW ELEMENT	SB TO DISTRIBUTION	AECOM	PID-YTT-21	$4,364	8"	SB	-						
FIT-2101	D/P FLOW TRANSMITTER	SB TO DISTRIBUTION	AECOM	PID-YTT-21	$4,000			BSRIO		1				
PRV-2201	PRESSURE REGULATOR	SB TO DS-2201	AECOM	PID-YTT-22	$54,195	4"	SB	-						
FE-2202	FLOW ELEMENT	WBF TO DS-2201	AECOM	PID-YTT-22	$1,845	2"	WBF	-						
FT-2202	D/P FLOW TRANSMITTER	WBF TO DS-2201	AECOM	PID-YTT-22	$4,000	-	WBF	PLC CABINET		1				
TIT-2202	TEMP TRANSMITTER	SA STARTUP FROM DS-2201	AECOM	PID-YTT-22	$1,667	-	SA	PLC CABINET		1				
TV-2202	TEMP CONTROL VALVE	WBF TO DS-2201	AECOM	PID-YTT-22	$7,614	2"	WBF	PLC CABINET			1	2		
TW-2202	THERMOWELL	SA STARTUP FROM DS-2201	AECOM	PID-YTT-22	$63	4"	SA	-						
FE-2203	FLOW ELEMENT	SB TO SUPERHEATER	AECOM	PID-YTT-22	$18,000	10"	SB	-						
FT-2203	D/P FLOW TRANSMITTER	SB TO SUPERHEATER	AECOM	PID-YTT-22	$4,000	-	SB	PLC CABINET		1				
PRV-2204	PRESSURE REGULATOR	SB TO DEAERATOR	AECOM	PID-YTT-22	$54,195	6"	SB	-						
FE-2205	FLOW ELEMENT	SB TO BYPASS	AECOM	PID-YTT-22	$4,190	4"	SB	-						
FT-2205	D/P FLOW TRANSMITTER	SB TO BYPASS	AECOM	PID-YTT-22	$4,000	-	SB	PLC CABINET		1				
FV-2205	FLOW CONTROL VALVE	SB TO BYPASS	AECOM	PID-YTT-22	$54,195	4"	SB	PLC CABINET			1	2		
FE-1	FLOW ELEMENT	FRIST ATTEMPERATOR	B&W	PID-YTT-30	-	2"	WLPE	-						
FIT-1	D/P FLOW TRANSMITTER	FRIST ATTEMPERATOR	B&W	PID-YTT-30	-			SRIO		1				
LIT-1	LEVEL TRANSMITTER	ACID CLEANING	B&W	PID-YTT-30	-			SRIO		1				
PIT-1	PRESSURE TRANSMITTER	MAIN STEAM OUTLET	B&W	PID-YTT-30	-			SRIO		1				
FE-2	FLOW ELEMENT	SECOND ATTEMPERATOR	B&W	PID-YTT-30	-	2"	WLPE	-						
FIT-2	D/P FLOW TRANSMITTER	SECOND ATTEMPERATOR	B&W	PID-YTT-30	-			SRIO		1				
LIT-2	LEVEL TRANSMITTER	ACID CLEANING	B&W	PID-YTT-30	-			SRIO		1				
PIT-2	PRESSURE TRANSMITTER	STRINGER TUBES INLET VENT	B&W	PID-YTT-30	-			SRIO		1				
LIT-3	LEVEL TRANSMITTER	ACID CLEANING	B&W	PID-YTT-30	-			SRIO		1				
PIT-6	PRESSURE TRANSMITTER	ECOMIZER OUTLET TO WBF	B&W	PID-YTT-30	-	4"	WLPE	SRIO		1				
PIT-7	PRESSURE TRANSMITTER	ECOMIZER OUTLET TO WBF	B&W	PID-YTT-30	-		WBF	SRIO		1				
TE-101	TUBE THERMOCOUPLE	FRIST ATTEMPERATOR	B&W	PID-YTT-30	-			SRIO	1					
TE-102	TUBE THERMOCOUPLE	FRIST ATTEMPERATOR	B&W	PID-YTT-30	-			SRIO	1					
TE-103	TUBE THERMOCOUPLE	SECOND ATTEMPERATOR	B&W	PID-YTT-30	-			SRIO	1					
TE-104	TUBE THERMOCOUPLE	SECOND ATTEMPERATOR	B&W	PID-YTT-30	-			SRIO	1					
TE-105	TUBE THERMOCOUPLE	ACID CLEANING	B&W	PID-YTT-30	-			SRIO	1					
TE-106	TUBE THERMOCOUPLE	FRIST ATTEMPERATOR	B&W	PID-YTT-30	-			SRIO	1					
TE-107	TUBE THERMOCOUPLE	WFB TO ECOMIZER INLET	B&W	PID-YTT-30	-	2"	WBF	SRIO	1					
TE-113	TUBE THERMOCOUPLE	MAIN STEAM OUTLET	B&W	PID-YTT-30	-			SRIO	1					
TE-114	TUBE THERMOCOUPLE	MAIN STEAM OUTLET	B&W	PID-YTT-30	-			SRIO	1					
TE-115A	TUBE THERMOCOUPLE	STRINGER TUBES OUTLET	B&W	PID-YTT-30	-			SRIO	1					
TE-115B	TUBE THERMOCOUPLE	STRINGER TUBES OUTLET	B&W	PID-YTT-30	-			SRIO	1					
TE-115C	TUBE THERMOCOUPLE	STRINGER TUBES OUTLET	B&W	PID-YTT-30	-			SRIO	1					
TE-115D	TUBE THERMOCOUPLE	STRINGER TUBES OUTLET	B&W	PID-YTT-30	-			SRIO	1					
TE-115E	TUBE THERMOCOUPLE	STRINGER TUBES OUTLET	B&W	PID-YTT-30	-			SRIO	1					
TE-115F	TUBE THERMOCOUPLE	STRINGER TUBES OUTLET	B&W	PID-YTT-30	-			SRIO	1					

Tag Number	Instrument Type	Service	Furn. By	P&ID	Budgetary $	Size	Pipe Spec	I/O CABINET	-----I/O-----					Notes
									T/C	AI	AO	DI	DO	
TE-115G	TUBE THERMOCOUPLE	STRINGER TUBES OUTLET	B&W	PID-YTT-30	-			SRIO	1					
TE-115H	TUBE THERMOCOUPLE	STRINGER TUBES OUTLET	B&W	PID-YTT-30	-			SRIO	1					
TE-115I	TUBE THERMOCOUPLE	STRINGER TUBES OUTLET	B&W	PID-YTT-30	-			SRIO	1					
TE-115J	TUBE THERMOCOUPLE	STRINGER TUBES OUTLET	B&W	PID-YTT-30	-			SRIO	1					
TE-115K	TUBE THERMOCOUPLE	STRINGER TUBES OUTLET	B&W	PID-YTT-30	-			SRIO	1					
TE-115L	TUBE THERMOCOUPLE	STRINGER TUBES OUTLET	B&W	PID-YTT-30	-			SRIO	1					
TE-115M	TUBE THERMOCOUPLE	STRINGER TUBES OUTLET	B&W	PID-YTT-30	-			SRIO	1					
TE-115N	TUBE THERMOCOUPLE	STRINGER TUBES OUTLET	B&W	PID-YTT-30	-			SRIO	1					
TE-115O	TUBE THERMOCOUPLE	STRINGER TUBES OUTLET	B&W	PID-YTT-30	-			SRIO	1					
TE-115P	TUBE THERMOCOUPLE	STRINGER TUBES OUTLET	B&W	PID-YTT-30	-			SRIO	1					
TE-115Q	TUBE THERMOCOUPLE	STRINGER TUBES OUTLET	B&W	PID-YTT-30	-			SRIO	1					
TE-115U	TUBE THERMOCOUPLE	STRINGER TUBES OUTLET	B&W	PID-YTT-30	-			SRIO	1					
TE-115R	TUBE THERMOCOUPLE	STRINGER TUBES OUTLET	B&W	PID-YTT-30	-			SRIO	1					
TE-115S	TUBE THERMOCOUPLE	STRINGER TUBES OUTLET	B&W	PID-YTT-30	-			SRIO	1					
TE-115T	TUBE THERMOCOUPLE	STRINGER TUBES OUTLET	B&W	PID-YTT-30	-			SRIO	1					
TE-115U	TUBE THERMOCOUPLE	STRINGER TUBES OUTLET	B&W	PID-YTT-30	-			SRIO	1					
TE-115V	TUBE THERMOCOUPLE	STRINGER TUBES OUTLET	B&W	PID-YTT-30	-			SRIO	1					
TE-115W	TUBE THERMOCOUPLE	STRINGER TUBES OUTLET	B&W	PID-YTT-30	-			SRIO	1					
TE-117A	TUBE THERMOCOUPLE	SSH OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-117B	TUBE THERMOCOUPLE	SSH OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-117C	TUBE THERMOCOUPLE	SSH OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-117D	TUBE THERMOCOUPLE	SSH OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-117E	TUBE THERMOCOUPLE	SSH OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-117F	TUBE THERMOCOUPLE	SSH OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-117G	TUBE THERMOCOUPLE	SSH OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-117H	TUBE THERMOCOUPLE	SSH OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-117I	TUBE THERMOCOUPLE	SSH OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-117J	TUBE THERMOCOUPLE	SSH OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-117K	TUBE THERMOCOUPLE	SSH OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-117L	TUBE THERMOCOUPLE	SSH OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-118A	TUBE THERMOCOUPLE	PSH OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-118B	TUBE THERMOCOUPLE	PSH OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-118C	TUBE THERMOCOUPLE	PSH OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-118D	TUBE THERMOCOUPLE	PSH OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-118E	TUBE THERMOCOUPLE	PSH OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-118F	TUBE THERMOCOUPLE	PSH OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-118G	TUBE THERMOCOUPLE	PSH OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-118H	TUBE THERMOCOUPLE	PSH OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-118I	TUBE THERMOCOUPLE	PSH OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-118J	TUBE THERMOCOUPLE	PSH OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-118K	TUBE THERMOCOUPLE	PSH OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-118L	TUBE THERMOCOUPLE	PSH OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-119A	TUBE THERMOCOUPLE	ECOMIZER OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-119B	TUBE THERMOCOUPLE	ECOMIZER OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-119C	TUBE THERMOCOUPLE	ECOMIZER OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-119D	TUBE THERMOCOUPLE	ECOMIZER OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-119E	TUBE THERMOCOUPLE	ECOMIZER OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-119F	TUBE THERMOCOUPLE	ECOMIZER OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-119G	TUBE THERMOCOUPLE	ECOMIZER OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					

A-USC COMTEST INSTRUMENT AND I/O LIST

Tag Number	Instrument Type	Service	Furn. By	P&ID	Budgetary $	Size	Pipe Spec	I/O CABINET	-----I/O-----					Notes
									T/C	AI	AO	DI	DO	
TE-119H	TUBE THERMOCOUPLE	ECOMIZER OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-119I	TUBE THERMOCOUPLE	ECOMIZER OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-119J	TUBE THERMOCOUPLE	ECOMIZER OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-120A	TUBE THERMOCOUPLE	ECOMIZER SPRAY OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-120B	TUBE THERMOCOUPLE	ECOMIZER SPRAY OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-120C	TUBE THERMOCOUPLE	ECOMIZER SPRAY OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-120D	TUBE THERMOCOUPLE	ECOMIZER SPRAY OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-120E	TUBE THERMOCOUPLE	ECOMIZER SPRAY OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-120F	TUBE THERMOCOUPLE	ECOMIZER SPRAY OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-120G	TUBE THERMOCOUPLE	ECOMIZER SPRAY OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-120H	TUBE THERMOCOUPLE	ECOMIZER SPRAY OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-120I	TUBE THERMOCOUPLE	ECOMIZER SPRAY OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-120J	TUBE THERMOCOUPLE	ECOMIZER SPRAY OUTLET TUBE	B&W	PID-YTT-30	-			SRIO	1					
TE-121	TUBE THERMOCOUPLE	ACID CLEANING	B&W	PID-YTT-30	-			SRIO	1					
TE-122	TUBE THERMOCOUPLE	ACID CLEANING	B&W	PID-YTT-30	-			SRIO	1					
TE-123	TUBE THERMOCOUPLE	ECOMIZER OUTLET TO WBF	B&W	PID-YTT-30	-		WLPF	SRIO	1					
TE-124	TUBE THERMOCOUPLE	ECOMIZER OUTLET TO WBF	B&W	PID-YTT-30	-		WBF	SRIO	1					
TE-125	TUBE THERMOCOUPLE	ENCLOSURE OUT	B&W	PID-YTT-30	-			SRIO	1					
TE-127	TUBE THERMOCOUPLE	ENCLOSURE OUT	B&W	PID-YTT-30	-			SRIO	1					
FCV-405	PRESSURE CONTROL VALVE	MAIN STEAM TO SPRAY WATER BYPA	GE BOIL	PID-YTT-30	-	10"	SS	SRIO			1	2		
MOV-408	MOTOR OPERATED HAND VALVE	STRINGER TUBES INLET VENT	B&W	PID-YTT-30	-			SRIO				2	2	
CV-409	CONTROL VALVE	FRIST ATTEMPERATOR	B&W	PID-YTT-30	-			SRIO				2	1	
CV-410	CONTROL VALVE	SECOND ATTEMPERATOR	B&W	PID-YTT-30	-			SRIO				2	1	
PCV-411	PRESSURE CONTROL VALVE	MAIN STEAM OUTLET	B&W	PID-YTT-30	-	10"	SS	SRIO			1	2		
PCV-413	PRESSURE CONTROL VALVE	WLPE TO YTT	AECOM	PID-YTT-30	$17,707	4"	WLPF	SRIO			1	2		
MOV-414	MOTOR OPERATED HAND VALVE	STRINGER TUBES INLET VENT	B&W	PID-YTT-30	-			SRIO				2	2	
PRV-416	PRESSURE REGULATOR	MAIN STEAM OUTLET	B&W	PID-YTT-30	-	10"	SS	-						
TCV-419	TEMP CONTROL VALVE	FRIST ATTEMPERATOR	B&W	PID-YTT-30	-			SRIO		1	1			
TCV-420	TEMP CONTROL VALVE	SECOND ATTEMPERATOR	B&W	PID-YTT-30	-			SRIO		1	1			
LIT-4	LEVEL TRANSMITTER	COMBUSTION FURNACE WATER SEA	B&W	PID-YTT-31	-			SRIO		1				
LIT-5	LEVEL TRANSMITTER	COMBUSTION FURNACE WATER SEA	B&W	PID-YTT-31	-			SRIO		1				
FT-6	FLOW TRANSMITTER	FLUE GAS RECIR. FAN INLET FROM A	B&W	PID-YTT-31	-			SRIO		1				
FT-7	FLOW TRANSMITTER	FLUE GAS RECIR. FAN INLET FROM S	B&W	PID-YTT-31	-			SRIO		1				
TE-146W	TUBE THERMOCOUPLE	COMBUSTION FURNACE WATER RET	B&W	PID-YTT-31	-			SRIO	1					
TE-150A	TUBE THERMOCOUPLE	COMBUSTION FURNACE STACK	B&W	PID-YTT-31	-			SRIO	1					
TE-150B	TUBE THERMOCOUPLE	COMBUSTION FURNACE STACK	B&W	PID-YTT-31	-			SRIO	1					
TE-151A	TUBE THERMOCOUPLE	FLUE GAS RECIR. FAN INLET FROM S	B&W	PID-YTT-31	-			SRIO	1					
TE-151B	TUBE THERMOCOUPLE	FLUE GAS RECIR. FAN INLET FROM S	B&W	PID-YTT-31	-			SRIO	1					
TE-152A	TUBE THERMOCOUPLE	FLUE GAS RECIR. FAN INLET FROM A	B&W	PID-YTT-31	-			SRIO	1					
TE-152B	TUBE THERMOCOUPLE	FLUE GAS RECIR. FAN INLET FROM A	B&W	PID-YTT-31	-			SRIO	1					
TE-153A	TUBE THERMOCOUPLE	FLUE GAS RECIR. FAN DSCH	B&W	PID-YTT-31	-			SRIO	1					
TE-153B	TUBE THERMOCOUPLE	FLUE GAS RECIR. FAN DSCH	B&W	PID-YTT-31	-			SRIO	1					
TE-153C	TUBE THERMOCOUPLE	FLUE GAS RECIR. FAN DSCH	B&W	PID-YTT-31	-			SRIO	1					
TE-153D	TUBE THERMOCOUPLE	FLUE GAS RECIR. FAN DSCH	B&W	PID-YTT-31	-			SRIO	1					
MTR-301	VFD FAN MOTOR	FLUE GAS RECIRCULATION FAN	B&W	PID-YTT-31	-			SRIO			1	3	2	
MTR-302	FAN MOTOR	FRG DAMPER SEAL AIR FAN	B&W	PID-YTT-31	-			SRIO				3	2	
DMP-430	DAMPER	FRG DAMPER SEAL AIR DAMPER	B&W	PID-YTT-31	-			SRIO				2	2	
DMP-431	DAMPER FLOW CONTROL	FRG DAMPER SEAL AIR DAMPER	B&W	PID-YTT-31	-			SRIO			1	2		
LCV-432	LEVEL CONTROL VALVE	SEAL WATER INLET	B&W	PID-YTT-31	-			SRIO			1			

A-USC COMTEST INSTRUMENT AND I/O LIST

Tag Number	Instrument Type	Service	Furn. By	P&ID	Budgetary $	Size	Pipe Spec	I/O CABINET	-----I/O-----					Notes
									T/C	AI	AO	DI	DO	
FE-4	FLOW ELEMENT	MAIN GAS INLET	B&W	PID-YTT-32	-			-						
FIT-4	D/P FLOW TRANSMITTER	MAIN GAS INLET	B&W	PID-YTT-32	-			SRIO		1				
PI-20	PRESSURE GAGE	MAIN GAS INLET SUPPLY	B&W	PID-YTT-32	-			-						
PI-21	PRESSURE GAGE	MAIN GAS INLET	B&W	PID-YTT-32	-			-						
PI-22	PRESSURE GAGE	IGNITER GAS INLET	B&W	PID-YTT-32	-			-						
PI-26	PRESSURE GAGE	MAIN GAS INLET	B&W	PID-YTT-32	-			-						
PIT-36	PRESSURE TRANSMITTER	MAIN GAS INLET	B&W	PID-YTT-32	-			SRIO		1				
PIT-39	PRESSURE TRANSMITTER	IGNITER GAS INLET	B&W	PID-YTT-32	-			SRIO		1				
PSL-53	PRESS SWITCH LOW	MAIN GAS INLET	B&W	PID-YTT-32	-			SRIO				1		
PSL-54	PRESS SWITCH LOW	MAIN AIR INLET TO BURNERS	B&W	PID-YTT-32	-			SRIO				1		
PSH-55	PRESS SWITCH HIGH	MAIN GAS INLET	B&W	PID-YTT-32	-			SRIO				1		
PSH-56	PRESS SWITCH HIGH	IGNITER GAS INLET	B&W	PID-YTT-32	-			SRIO				1		
PSL-57	PRESS SWITCH LOW	IGNITER GAS INLET	B&W	PID-YTT-32	-			SRIO				1		
CV-449	CONTROL VALVE	IGNITER GAS INLET TO VENT	B&W	PID-YTT-32	-			SRIO				2	1	
PRV-450	PRESSURE REGULATOR	MAIN GAS INLET	B&W	PID-YTT-32	-			-						
CV-452	CONTROL VALVE	MAIN GAS INLET	B&W	PID-YTT-32	-			SRIO				2	1	
CV-453	CONTROL VALVE	MAIN GAS INLET	B&W	PID-YTT-32	-			SRIO				2	1	
CV-454	CONTROL VALVE	MAIN GAS INLET TO VENT	B&W	PID-YTT-32	-			SRIO				2	1	
FV-455	FLOW CONTROL VALVE	MAIN GAS INLET FLOW	B&W	PID-YTT-32	-			SRIO		1	1			
PRV-456	PRESSURE REGULATOR	IGNITER GAS INLET	B&W	PID-YTT-32	-			-						
CV-457	CONTROL VALVE	IGNITER GAS INLET	B&W	PID-YTT-32	-			SRIO				2	1	
CV-458	CONTROL VALVE	IGNITER GAS INLET	B&W	PID-YTT-32	-			SRIO				2	1	
CV-459	CONTROL VALVE	IGNITER GAS INLET TO BURNER 1	B&W	PID-YTT-32	-			SRIO				2	1	
CV-460	CONTROL VALVE	MAIN GAS INLET TO BURNER 1	B&W	PID-YTT-32	-			SRIO				2	1	
CV-461	CONTROL VALVE	IGNITER GAS INLET TO BURNER 2	B&W	PID-YTT-32	-			SRIO				2	1	
CV-462	CONTROL VALVE	MAIN GAS INLET TO BURNER 2	B&W	PID-YTT-32	-			SRIO				2	1	
CV-463	CONTROL VALVE	IGNITER GAS INLET TO BURNER 3	B&W	PID-YTT-32	-			SRIO				2	1	
CV-464	CONTROL VALVE	MAIN GAS INLET TO BURNER 3	B&W	PID-YTT-32	-			SRIO				2	1	
PI-623	PRESSURE GAGE	MAIN AIR INLET TO BURNERS	B&W	PID-YTT-32	-			-						
BE-630	BURNER ELEMENT	BURNER 1 BURNER ELEMENT	B&W	PID-YTT-32	-			SRIO				1		
BE-631	BURNER ELEMENT	BURNER 1 BURNER ELEMENT	B&W	PID-YTT-32	-			SRIO				1		
BE-632	BURNER ELEMENT	BURNER 2 BURNER ELEMENT	B&W	PID-YTT-32	-			SRIO				1		
BE-633	BURNER ELEMENT	BURNER 2 BURNER ELEMENT	B&W	PID-YTT-32	-			SRIO				1		
BE-634	BURNER ELEMENT	BURNER 3 BURNER ELEMENT	B&W	PID-YTT-32	-			SRIO				1		
BE-635	BURNER ELEMENT	BURNER 3 BURNER ELEMENT	B&W	PID-YTT-32	-			SRIO				1		
HV-4002	HAND VALVE	SS TO TURBINE	GE TURBINE	PID-YTT-40	-	10"	SS	BY GE TURBINE						
SIT-4004	SPEED TRANSMITTER	TURBINE SPEED	GE TURBINE	PID-YTT-40	-			BY GE TURBINE						
SV-4004	SPEED VALVE	SS TO TURBINE	GE TURBINE	PID-YTT-40	-	10"	SS	BY GE TURBINE						
TT-4004	TEMP TRANSMITTER	TUR-4001 AUSC TURBINE	GE TURBINE	PID-YTT-40	-			BY GE TURBINE						
TV-4004	TEMP VALVE	SC TO TURBINE	GE TURBINE	PID-YTT-40	-	6"	SC	BY GE TURBINE						
HV-4005	HAND VALVE	COND TO HE-6001	GE TURBINE	PID-YTT-40	-	2"	COND	BY GE TURBINE						
HV-4006	HAND VALVE	COND TO HE-6001	GE TURBINE	PID-YTT-40	-	2"	COND	BY GE TURBINE						
HV-4007	HAND VALVE	COND TO HE-6001	GE TURBINE	PID-YTT-40	-	2"	COND	BY GE TURBINE						
HV-4008	HAND VALVE	COND TO HE-6001	GE TURBINE	PID-YTT-40	-	2"	COND	BY GE TURBINE						
HV-4009	HAND VALVE	COND TO HE-6001	GE TURBINE	PID-YTT-40	-	2"	COND	BY GE TURBINE						
HV-4010	HAND VALVE	COND TO HE-6001	GE TURBINE	PID-YTT-40	-	2"	COND	BY GE TURBINE						
HV-4011	HAND VALVE	COND TO HE-6001	GE TURBINE	PID-YTT-40	-	2"	COND	BY GE TURBINE						
HV-4012	HAND VALVE	COND TO HE-6001	GE TURBINE	PID-YTT-40	-	2"	COND	BY GE TURBINE						
PI-4101	PRESSURE GAGE	WCS TO DY-4001 DYNAMOMETER	AECOM	PID-YTT-41	$73	10"	WCS	-						

A-USC COMTEST INSTRUMENT AND I/O LIST

Tag Number	Instrument Type	Service	Furn. By	P&ID	Budgetary $	Size	Pipe Spec	I/O CABINET	-----I/O----- T/C	AI	AO	DI	DO	Notes
PRV-4102	PRESSURE REGULATOR	WCS TO COOLING TOWER	AECOM	PID-YTT-41		10"	WCR	PLC CABINET			1	2		
HV-4103	HAND VALVE	WCS TO DY-4001 DYNAMOMETER	GE TURBINE	PID-YTT-41	-	10"	WCS	PLC CABINET						
HV-4104	HAND VALVE	WCR FROM DY-4001 DYNAMOMETER	GE TURBINE	PID-YTT-41	-	12"	WCR	PLC CABINET						
FE-4201	FLOW ELEMENT	WBF TO DS-4201	AECOM	PID-YTT-42	$3,017	3"	WBF	-						
FT-4201	D/P FLOW TRANSMITTER	WBF TO DS-4201	AECOM	PID-YTT-42	$4,000	-	WBF	PLC CABINET		1				
TIT-4201	TEMP TRANSMITTER	SA BYPASS	AECOM	PID-YTT-42	$1,667	-	SA	PLC CABINET		1				
TV-4201	TEMP CONTROL VALVE	WBF TO DS-4201	AECOM	PID-YTT-42	$9,710	3"	WBF	PLC CABINET			1	2		
TW-4201	THERMOWELL	SA BYPASS	AECOM	PID-YTT-42	$149	10.5"	SA	-						
TIT-4202	TEMP TRANSMITTER	SA BYPASS	AECOM	PID-YTT-42	$1,667	-	SA	PLC CABINET		1				
TW-4202	THERMOWELL	SA BYPASS	AECOM	PID-YTT-42	$149	10.5"	SA	-						
FE-5002	FLOW ELEMENT	WBF FROM DISTRIBUTION	AECOM	PID-YTT-50	$3,017	3"	WBF	-						
FT-5002	D/P FLOW TRANSMITTER	WBF FROM DISTRIBUTION	AECOM	PID-YTT-50	$4,000	-	WBF	PLC CABINET		1				
TIT-5002	TEMP TRANSMITTER	SA BYPASS	AECOM	PID-YTT-50	$1,667	-	SA	PLC CABINET		1				
TV-5002	TEMP CONTROL VALVE	WBF FROM DISTRIBUTION	AECOM	PID-YTT-50	$9,710	3"	WBF	PLC CABINET			1	2		
TW-5002	THERMOWELL	SA BYPASS	AECOM	PID-YTT-50	$149	16"	SA	-						
FE-5005	FLOW ELEMENT	SS TO DS-5001	GE BOIL	PID-YTT-50	-	10"	SS	-						
FT-5005	D/P FLOW TRANSMITTER	SS TO DS-5001	GE BOIL	PID-YTT-50	-	-	SS	PLC CABINET		1				
TIT-5006	TEMP TRANSMITTER	SA BYPASS	AECOM	PID-YTT-50	$1,667	-	SA	PLC CABINET		1				
TW-5006	THERMOWELL	SA BYPASS	AECOM	PID-YTT-50	$149	16"	SA	-						
HV-5007	HAND VALVE	SS TO TEST HEADER	GE BOIL	PID-YTT-50	-	10"	SS	PLC CABINET				2	2	
HV-5008	HAND VALVE	SS TO TURBINE	GE BOIL	PID-YTT-50	-	10"	SS	PLC CABINET				2	2	
FE-5103	FLOW ELEMENT	WBF TO DS-5103	AECOM	PID-YTT-51	$3,017	3"	WBF	-						
FT-5103	D/P FLOW TRANSMITTER	WBF TO DS-5103	AECOM	PID-YTT-51	$4,000	-	WBF	PLC CABINET		1				
HV-5103A	MOTOR OPERATED BALL VALVE	WBF TO DS-5103	AECOM	PID-YTT-51	$1,667	3"	WBF	PLC CABINET				2	2	
HV-5103B	MOTOR OPERATED GATE VALVE	WBF TO DS-5103	AECOM	PID-YTT-51	$603	3"	WBF	PLC CABINET				2	2	
TE-5103	TEMP ELEMENT	SA TO DS-4201	AECOM	PID-YTT-51	$150	16"	SA	-						
TT-5103	TEMP TRANSMITTER	SA TO DS-4201	AECOM	PID-YTT-51	$1,667	-	SA	PLC CABINET		1				
TV-5103	TEMP CONTROL VALVE	WBF TO DS-5103	AECOM	PID-YTT-51	$9,710	3"	WBF	PLC CABINET			1	2		
FE-5104	FLOW ELEMENT	SS TO DS-5101	GE BOIL	PID-YTT-51	-	10"	SS	-						
FIT-5104	D/P FLOW TRANSMITTER	SS TO DS-5101	GE BOIL	PID-YTT-51	-	10"	SS	PLC CABINET		1				
FV1-5104	FLOW VALVE	SS TO DS-5101	GE BOIL	PID-YTT-51	-	10"	SS	PLC CABINET			1	2		
FE-5105	FLOW ELEMENT	SB TO DS-5101	AECOM	PID-YTT-51	$18,000	10"	SB	-						
FIT-5105	D/P FLOW TRANSMITTER	SB TO DS-5101	AECOM	PID-YTT-51	$4,000	-	SB	PLC CABINET		1				
FV-5105	FLOW CONTROL VALVE	SB TO DS-5101	AECOM	PID-YTT-51	$259,875	8"	SB	PLC CABINET			1	2		
PT-5106	PRESS TRANSMITTER	SA TO DS-4201	AECOM	PID-YTT-51	$2,360	16"	SA	PLC CABINET		1				
TE-5106	TEMP ELEMENT	SA TO DS-4201	AECOM	PID-YTT-51	$150	16"	SA	-						
TT-5106	TEMP TRANSMITTER	SA TO DS-4201	AECOM	PID-YTT-51	$1,667	-	SA	PLC CABINET		1				
TE-5107A	SKIN MOUNTED THERMOCOUPLE	THICK WALL SECTION DS-5102 TO DS	AECOM	PID-YTT-51	$350		SS	PLC CABINET	1					
TE-5107B	SKIN MOUNTED THERMOCOUPLE	THICK WALL SECTION DS-5102 TO DS	AECOM	PID-YTT-51	$350		SS	PLC CABINET	1					
TE-5107C	SKIN MOUNTED THERMOCOUPLE	THICK WALL SECTION DS-5102 TO DS	AECOM	PID-YTT-51	$350		SS	PLC CABINET	1					
TE-5107D	SKIN MOUNTED THERMOCOUPLE	THICK WALL SECTION DS-5102 TO DS	AECOM	PID-YTT-51	$350		SS	PLC CABINET	1					
TE-5107E	SKIN MOUNTED THERMOCOUPLE	THICK WALL SECTION DS-5102 TO DS	AECOM	PID-YTT-51	$350		SS	PLC CABINET	1					
TE-5107F	SKIN MOUNTED THERMOCOUPLE	THICK WALL SECTION DS-5102 TO DS	AECOM	PID-YTT-51	$350		SS	PLC CABINET	1					
TE-5107G	SKIN MOUNTED THERMOCOUPLE	THICK WALL SECTION DS-5102 TO DS	AECOM	PID-YTT-51	$350		SS	PLC CABINET	1					
TE-5107H	SKIN MOUNTED THERMOCOUPLE	THICK WALL SECTION DS-5102 TO DS	AECOM	PID-YTT-51	$350		SS	PLC CABINET	1					
TE-5107I	SKIN MOUNTED THERMOCOUPLE	THICK WALL SECTION DS-5102 TO DS	AECOM	PID-YTT-51	$350		SS	PLC CABINET	1					
TE-5107J	SKIN MOUNTED THERMOCOUPLE	THICK WALL SECTION DS-5102 TO DS	AECOM	PID-YTT-51	$350		SS	PLC CABINET	1					
TE-5107K	SKIN MOUNTED THERMOCOUPLE	THICK WALL SECTION DS-5102 TO DS	AECOM	PID-YTT-51	$350		SS	PLC CABINET	1					
TE-5107L	SKIN MOUNTED THERMOCOUPLE	THICK WALL SECTION DS-5102 TO DS	AECOM	PID-YTT-51	$350		SS	PLC CABINET	1					

A-USC COMTEST INSTRUMENT AND I/O LIST

Tag Number	Instrument Type	Service	Furn. By	P&ID	Budgetary $	Size	Pipe Spec	I/O CABINET	-----I/O----- T/C	AI	AO	DI	DO	Notes
TE-5108A	TUBE THERMOCOUPLE	THICK WALL SECTION DS-5102 TO DS	GE BOIL	PID-YTT-51	$150		SS	PLC CABINET	1					
TE-5108B	TUBE THERMOCOUPLE	THICK WALL SECTION DS-5102 TO DS	GE BOIL	PID-YTT-51	$150		SS	PLC CABINET	1					
TE-5108C	TUBE THERMOCOUPLE	THICK WALL SECTION DS-5102 TO DS	GE BOIL	PID-YTT-51	$150		SS	PLC CABINET	1					
TE-5108D	TUBE THERMOCOUPLE	THICK WALL SECTION DS-5102 TO DS	GE BOIL	PID-YTT-51	$150		SS	PLC CABINET	1					
TE-5108E	TUBE THERMOCOUPLE	THICK WALL SECTION DS-5102 TO DS	GE BOIL	PID-YTT-51	$150		SS	PLC CABINET	1					
TE-5108F	TUBE THERMOCOUPLE	THICK WALL SECTION DS-5102 TO DS	GE BOIL	PID-YTT-51	$150		SS	PLC CABINET	1					
TE-5108G	TUBE THERMOCOUPLE	THICK WALL SECTION DS-5102 TO DS	GE BOIL	PID-YTT-51	$150		SS	PLC CABINET	1					
TE-5108H	TUBE THERMOCOUPLE	THICK WALL SECTION DS-5102 TO DS	GE BOIL	PID-YTT-51	$150		SS	PLC CABINET	1					
TE-5108I	TUBE THERMOCOUPLE	THICK WALL SECTION DS-5102 TO DS	GE BOIL	PID-YTT-51	$150		SS	PLC CABINET	1					
TE-5108J	TUBE THERMOCOUPLE	THICK WALL SECTION DS-5102 TO DS	GE BOIL	PID-YTT-51	$150		SS	PLC CABINET	1					
TE-5108K	TUBE THERMOCOUPLE	THICK WALL SECTION DS-5102 TO DS	GE BOIL	PID-YTT-51	$150		SS	PLC CABINET	1					
TE-5108L	TUBE THERMOCOUPLE	THICK WALL SECTION DS-5102 TO DS	GE BOIL	PID-YTT-51	$150		SS	PLC CABINET	1					
PT-6001	PRESSURE TRANSMITTER	SA TO HE-6001	AECOM	PID-YTT-60	$2,360	16"	SA	PLC CABINET		1				
PV-6001	CONTROL VALVE	SA TO HE-6001	AECOM	PID-YTT-60	$501,875	12"	SA	PLC CABINET			1			
LT-6002	LEVEL TRANSMITTER	HE-6001 DUMP EXCHANGER	AECOM	PID-YTT-60	$3,328			PLC CABINET		1				
LV-6002	LEVEL VALVE	COND FROM HE-6001 TO DEAREATO	AECOM	PID-YTT-60	$9,710	3"	COND	PLC CABINET			1			
MTR-6002A	PUMP MOTOR	COND FROM HE-6001 TO DEAREATO	AECOM	PID-YTT-60	INCL W/ PUMP $	4"	COND	PLC CABINET				3	2	
MTR-6002B	PUMP MOTOR	COND FROM HE-6001 TO DEAREATO	AECOM	PID-YTT-60	INCL W/ PUMP $	4"	COND	PLC CABINET				3	2	
PI-6003	PRESS GAGE	SA TO HE-6001	AECOM	PID-YTT-60	$73	16"	SA	-						
PI-6004	PRESS GAGE	SA TO HE-6001	AECOM	PID-YTT-60	$73	16"	SA	-						
TI-6005	TEMPERATURE GAGE	SA TO HE-6001	AECOM	PID-YTT-60	$85	16"	SA	-						
TI-6006	TEMPERATURE GAGE	WCS FROM COOLING TOWER TO HE-	AECOM	PID-YTT-60	$85	24"	WCS	-						
TI-6007	TEMPERATURE GAGE	WCR FROM HE-6001 TO COOLING TO	AECOM	PID-YTT-60	$85	24"	WCR	-						
TI-6008	TEMPERATURE GAGE	COND FROM HE-6001 TO DEAREATO	AECOM	PID-YTT-60	$85	8"	COND	-						
PI-6009	PRESS GAGE	PU-6002A COND RETURN PUMP DSC	AECOM	PID-YTT-60	$73	4"	COND	-						
PI-6010	PRESS GAGE	PU-6002B COND RETURN PUMP DSC	AECOM	PID-YTT-60	$73	4"	COND	-						
MOV-6011	MOTOR OPERATED VALVE	COND FROM SUPERHEATER TO HE-6	AECOM	PID-YTT-60	$559	2"	COND	PLC CABINET				2	2	
LCV-6012	LEVEL CONTROL VALVE	COND FROM SUPERHEATER TO HE-6	AECOM	PID-YTT-60	$7,614	2"	COND	PLC CABINET		1	1			
PSV-6013	PRESS SAFETY VALVE	HE-6001 DUMP EXCHANGER	AECOM	PID-YTT-60	$6,500		COND	-						
PSV-6014	PRESS SAFETY VALVE	HE-6001 DUMP EXCHANGER	AECOM	PID-YTT-60	$6,500		COND	-						
HV-7001	CONTROL VALVE	WCR TO COOLING TOWER	AECOM	PID-YTT-70	$1,815	6"	WCR	CRIO				2	1	
LIT-7001	LEVEL TRANSMITTER	CT-7004 A,B,C COOLING TOWER	AECOM	PID-YTT-70	$3,096			CRIO		1				
MTR-7001A	PUMP MOTOR	WCR TO COOLING TOWER	AECOM	PID-YTT-70	INCL W/ PUMP $	10"	WCR	CRIO				3	2	
MTR-7001B	PUMP MOTOR	WCR TO COOLING TOWER	AECOM	PID-YTT-70	INCL W/ PUMP $	10"	WCR	CRIO				3	2	
AIC-7002	ANALYZER CONTROLLER	CT-7004 A,B,C COOLING TOWER	AECOM	PID-YTT-70	$2,500			CRIO		1			2	
AIT-7002	ANALYZER TRANSMITTER	CT-7004 A,B,C COOLING TOWER	AECOM	PID-YTT-70	$2,136			CRIO		1				
HV-7002	CONTROL VALVE	WCR TO DRAIN	AECOM	PID-YTT-70	$3,099	10"	WCR	CRIO				2	1	
MTR-7002A	VFD PUMP MOTOR	WCS TO HE-6001 DUMP EXCHANGER	AECOM	PID-YTT-70	INCL W/ PUMP $	24"	WCR	CRIO			1	3	2	
MTR-7002B	VFD PUMP MOTOR	WCS TO HE-6001 DUMP EXCHANGER	AECOM	PID-YTT-70	INCL W/ PUMP $	24"	WCR	CRIO			1	3	2	
MTR-7002C	VFD PUMP MOTOR	WCS TO HE-6001 DUMP EXCHANGER	AECOM	PID-YTT-70	INCL W/ PUMP $	24"	WCR	CRIO			1	3	2	
LIT-7003	LEVEL TRANSMITTER	WCR LEVEL	AECOM	PID-YTT-70	$3,096			CRIO		1				
LV-7003	LEVEL VALVE	WCR TO COOOLING TOWER	AECOM	PID-YTT-70		8"	WCR	CRIO			1			
MTR-7003A	PUMP MOTOR	WCS TO DY-4001 DYNAMOMETER	AECOM	PID-YTT-70	INCL W/ PUMP $	24"	WCR	CRIO				3	2	
MTR-7003B	PUMP MOTOR	WCS TO DY-4001 DYNAMOMETER	AECOM	PID-YTT-70	INCL W/ PUMP $	24"	WCR	CRIO				3	2	
MTR-7004A	COOLING TOWER FAN	COOLING TOWER FAN MOTOR	AECOM	PID-YTT-70	INCL W/ CT $			CRIO				3	2	
MTR-7004B	COOLING TOWER FAN	COOLING TOWER FAN MOTOR	AECOM	PID-YTT-70	INCL W/ CT $			CRIO				3	2	
MTR-7004C	COOLING TOWER FAN	COOLING TOWER FAN MOTOR	AECOM	PID-YTT-70	INCL W/ CT $			CRIO				3	2	
MTR-7004D	COOLING TOWER FAN	COOLING TOWER FAN MOTOR	AECOM	PID-YTT-70	INCL W/ CT $			CRIO				3	2	
MTR-7004E	COOLING TOWER FAN	COOLING TOWER FAN MOTOR	AECOM	PID-YTT-70	INCL W/ CT $			CRIO				3	2	

A-USC COMTEST INSTRUMENT AND I/O LIST

Tag Number	Instrument Type	Service	Furn. By	P&ID	Budgetary $	Size	Pipe Spec	I/O CABINET	-----I/O-----					Notes
									T/C	AI	AO	DI	DO	
MTR-7004F	COOLING TOWER FAN	COOLING TOWER FAN MOTOR	AECOM	PID-YTT-70	INCL W/ CT $			CRIO				3	2	
TI-7004	TEMPERATURE GAGE	WCR TO PU-7001A & PU-7001B	AECOM	PID-YTT-70	$85	12"	WCR	-						
PI-7005	PRESS GAGE	WCR FROM PU-7001A COOLING TOW	AECOM	PID-YTT-70	$73	10"	WCR	-						
PI-7006	PRESS GAGE	WCR FROM PU-7001B COOLING TOW	AECOM	PID-YTT-70	$73	10"	WCR	-						
TI-7007	TEMPERATURE GAGE	WCS TO PU-7002A & PU-7002B	AECOM	PID-YTT-70	$85	12"	WCS	-						
TI-7008	TEMPERATURE GAGE	WCS TO PU-7003A & PU-7003B	AECOM	PID-YTT-70	$85	12"	WCS	-						
PI-7009	PRESS GAGE	WCS FROM PU-7002A TO HE-6001	AECOM	PID-YTT-70	$73	12"	WCS	-						
PI-7010	PRESS GAGE	WCS FROM PU-7002B TO HE-6001	AECOM	PID-YTT-70	$73	12"	WSC	-						
PI-7011	PRESS GAGE	WCS FROM PU-7003A TO DY-4101	AECOM	PID-YTT-70	$73	10"	WCS	-						
PI-7012	PRESS GAGE	WCS FROM PU-7003B TO DY-4101	AECOM	PID-YTT-70	$73	10"	WSC	-						
PI-7013	PRESS GAGE	WCS FROM PU-7002C TO HE-6001	AECOM	PID-YTT-70	$73	12"	WSC	-						
LIT-7014	LEVEL TRANSMITTER	CT-7004 A,B,C COOLING TOWER	AECOM	PID-YTT-70	$3,096			CRIO		1				
-														
-														
									118	48	26	138	68	

Tag Number	Instrument Type	Service	Spec'd. By	P&ID	Mfg.	Model No.	Pipe Size	Pipe Spec	-----I/O-----					----COMM I/O---				SIS		Notes
									T/C	AI	AO	DI	DO	AI	AO	DI	DO	AI	DO	
PT-0301	PRESSURE TRANSMITTER	RIVER WATER PUMP DISCHARGE	AECOM	PID-AUSC-03			8"	011		1										
HV-0302	ON/OFF VALVE	NATURAL GAS SUPPLY	AECOM	PID-AUSC-03			6"	011				2	1							
FE-0303	FLOW ELEMENT	NATURAL GAS SUPPLY	AECOM	PID-AUSC-03			6"	011												
FT-0303	FLOW TRANSMITTER	NATURAL GAS SUPPLY	AECOM	PID-AUSC-03						1										
PRV-0304	PRESSURE REGULATOR	NATURAL GAS SUPPLY	AECOM	PID-AUSC-03			6"	011												
PSV-0305	PRESSURE RELIEF VALVE	NATURAL GAS SUPPLY	AECOM	PID-AUSC-03			6"	011												
FE-1006	FLOW ELEMENT	WBF TO DESUPERHEATER DSH-1	GE-BLR	PID-AUSC-10			2"	091												
FT-1006	D/P FLOW TRANSMITTER	WBF TO DESUPERHEATER DSH-1	AECOM	PID-AUSC-10				091		1										
FV-1006	FLOW CONTROL VALVE	WBF TO DESUPERHEATER DSH-1	GE-BLR	PID-AUSC-10			1"	091		1	1									
FE-1012	FLOW ELEMENT	WBF TO DESUPERHEATER DSH-2	GE-BLR	PID-AUSC-10			2"	091												
FT-1012	D/P FLOW TRANSMITTER	WBF TO DESUPERHEATER DSH-2	AECOM	PID-AUSC-10				091		1										
FV-1012	FLOW CONTROL VALVE	WBF TO DESUPERHEATER DSH-2	GE-BLR	PID-AUSC-10			1"	091		1	1									
HV-1017	ON/OFF VALVE	WBF TO DESUPERHEATER DSH-1	GE-BLR	PID-AUSC-10			1"	091				2	1							
HV-1018	ON/OFF VALVE	WBF TO DESUPERHEATER DSH-1	GE-BLR	PID-AUSC-10			1"	153				2	1							
HV-1019	ON/OFF VALVE	WBF TO DESUPERHEATER DSH-2	GE-BLR	PID-AUSC-10			1"	091				2	1							
HV-1020	ON/OFF VALVE	WBF TO DESUPERHEATER DSH-2	GE-BLR	PID-AUSC-10			1"	999				2	1							
TE-1201	TEMPERATURE ELEMENT	SPRAY WATER HEATER CONDENSATE TEMPERATURE	AECOM	PID-AUSC-12																
TIT-1201	TEMPERATURE TRANSMITTER	SPRAY WATER HEATER CONDENSATE TEMPERATURE	AECOM	PID-AUSC-12						1										
TV-1201	TEMPERATURE CONTROL VALVE	SPRAY WATER HEATER TEMPERATURE CONTROL	AECOM	PID-AUSC-12			4"	153		1	1									
TW-1201	THERMOWELL	SPRAY WATER HEATER CONDENSATE TEMPERATURE	AECOM	PID-AUSC-12			4"	091												
TI-1202	TEMPERATURE INDICATOR	ATTENUATED STEAM TO SPRAY WATER HEATER	AECOM	PID-AUSC-12			4"	153												
PI-1203	PRESSURE INDICATOR	ATTENUATED STEAM TO SPRAY WATER HEATER	AECOM	PID-AUSC-12			4"	153												
PSV-1204	PRESSURE RELIEF VALVE	SPRAY WATER HEATER	AECOM	PID-AUSC-12																
PSV-1205	PRESSURE RELIEF VALVE	WBF TO DESUPERHEATERS	AECOM	PID-AUSC-12			3"	091												
TE-1206	TEMPERATURE ELEMENT	WBF TO DESUPERHEATERS	AECOM	PID-AUSC-12																
TIT-1206	TEMPERATURE TRANSMITTER	WBF TO DESUPERHEATERS	AECOM	PID-AUSC-12						1										
TW-1206	THERMOWELL	WBF TO DESUPERHEATERS	AECOM	PID-AUSC-12			3"	091												
TE-1207	TEMPERATURE ELEMENT	WBF FROM DEAERATOR PUMPS	AECOM	PID-AUSC-12																
TIT-1207	TEMPERATURE TRANSMITTER	WBF FROM DEAERATOR PUMPS	AECOM	PID-AUSC-12						1										
TW-1207	THERMOWELL	WBF FROM DEAERATOR PUMPS	AECOM	PID-AUSC-12			3"	091												
LT-1208	LEVEL TRANSMITTER	SPRAY WATER HEATER LEVEL	AECOM	PID-AUSC-12						1										
LV-1208	LEVEL CONTROL VALVE	SPRAY WATER HEATER LEVEL CONTROL	AECOM	PID-AUSC-12			4"	091		1	1									
PT-1209	PRESSURE TRANSMITTER	HPC TO CONDENSER	AECOM	PID-AUSC-12			4"	091		1										
PT-2501	PRESSURE TRANSMITTER	STEAM FROM BOILER TO SUPERHEATER	AECOM	PID-AUSC-25			8"	152		1										
HV-2503	ON/OFF VALVE	STEAM FROM BOILER TO SUPERHEATER BYPASS	AECOM	PID-AUSC-25			6"	153				2	1							
HV-2504	ON/OFF VALVE	STEAM FROM BOILER TO SUPERHEATER	AECOM	PID-AUSC-25			8"	152				2	1							
TV-3061	TEMPERATURE CONTROL VALVE	GAS COOLING WATER TO SUPERHEATER	AECOM	PID-AUSC-41			6"	031		1	1									
PI-4102	PRESSURE INDICATOR	GAS COOLING WATER EXPANSION TANK	AECOM	PID-AUSC-41			3"	031												
PT-4104	PRESSURE TRANSMITTER	GAS COOLING WATER FROM SUPERHEATER	AECOM	PID-AUSC-41			6"	031		1										
PSV-4105	PRESSURE RELIEF VALVE	GAS COOLING WATER EXCHANGER	AECOM	PID-AUSC-41																
PSV-4106	PRESSURE RELIEF VALVE	COOLING WATER RETURN TO COOLING TOWER	AECOM	PID-AUSC-41				011												
TE-4107	TEMPERATURE ELEMENT	COOLING WATER RETURN TO COOLING TOWER	AECOM	PID-AUSC-41																
TIT-4107	TEMPERATURE TRANSMITTER	COOLING WATER RETURN TO COOLING TOWER	AECOM	PID-AUSC-41						1										
TW-4107	THERMOWELL	COOLING WATER RETURN TO COOLING TOWER	AECOM	PID-AUSC-41			10"	011												
TE-4108	TEMPERATURE ELEMENT	COOLING WATER SUPPLY FROM COOLING TOWER	AECOM	PID-AUSC-41																
TIT-4108	TEMPERATURE TRANSMITTER	COOLING WATER SUPPLY FROM COOLING TOWER	AECOM	PID-AUSC-41						1										
TW-4108	THERMOWELL	COOLING WATER SUPPLY FROM COOLING TOWER	AECOM	PID-AUSC-41			10"	011												
TE-4109	TEMPERATURE ELEMENT	GAS COOLING WATER PUMP SUCTION	AECOM	PID-AUSC-41																
TIT-4109	TEMPERATURE TRANSMITTER	GAS COOLING WATER PUMP SUCTION	AECOM	PID-AUSC-41						1										
TW-4109	THERMOWELL	GAS COOLING WATER PUMP SUCTION	AECOM	PID-AUSC-41				031												
PT-4110	PRESSURE TRANSMITTER	GAS COOLING WATER PUMP DISCHARGE	AECOM	PID-AUSC-41						1										
RO-4111	RESTRICTION ORIFICE	GAS COOLING WATER PUMP RECIRC	AECOM	PID-AUSC-41				031												
FE-4112	FLOW ELEMENT	GAS COOLING WATER TO SUPERHEATER	AECOM	PID-AUSC-41			6"	031												
FIT-4112	FLOW TRANSMITTER	GAS COOLING WATER TO SUPERHEATER	AECOM	PID-AUSC-41				031		1										
TE-4901A	TEMPERATURE ELEMENT	STEAM TO DESUPERHEATER DSH-3	GE-BLR	PID-AUSC-49																
TE-4901B	TEMPERATURE ELEMENT	STEAM TO DESUPERHEATER DSH-3	GE-BLR	PID-AUSC-49																

Tag Number	Instrument Type	Service	Spec'd. By	P&ID	Mfg.	Model No.	Pipe Size	Pipe Spec	-----I/O----- T/C	AI	AO	DI	DO	----COMM I/O--- AI	AO	DI	DO	SIS AI	DO	Notes
TIT-4901A	TEMPERATURE TRANSMITTER	STEAM TO DESUPERHEATER DSH-3	GE-BLR	PID-AUSC-49						1										
TIT-4901B	TEMPERATURE TRANSMITTER	STEAM TO DESUPERHEATER DSH-3	GE-BLR	PID-AUSC-49						1										
TW-4901A	THERMOWELL	STEAM TO DESUPERHEATER DSH-3	GE-BLR	PID-AUSC-49				999												
TW-4901B	THERMOWELL	STEAM TO DESUPERHEATER DSH-3	GE-BLR	PID-AUSC-49				999												
FE-4902	FLOW ELEMENT	WBF FEED TO DESUPERHEATER 3	GE-BLR	PID-AUSC-49			2"	091												
FT-4902	D/P FLOW TRANSMITTER	WBF FEED TO DESUPERHEATER 3	AECOM	PID-AUSC-49				091		1										
TE-4903	TEMPERATURE ELEMENT	STEAM FROM DESUPERHEATER DSH-3	GE-BLR	PID-AUSC-49																
TIT-4903	TEMPERATURE TRANSMITTER	STEAM FROM DESUPERHEATER DSH-3	GE-BLR	PID-AUSC-49						1										
TV-4903	TEMPERATURE CONTROL VALVE	WBF TO DESUPERHEATER DSH-3	GE-BLR	PID-AUSC-49				091		1	1									
TW-4903	THERMOWELL	STEAM FROM DESUPERHEATER DSH-3	GE-BLR	PID-AUSC-49			8"	999												
TE-4904	TEMPERATURE ELEMENT	STEAM FROM DESUPERHEATER DSH-3	GE-BLR	PID-AUSC-49																
TIT-4904	TEMPERATURE TRANSMITTER	STEAM FROM DESUPERHEATER DSH-3	GE-BLR	PID-AUSC-49						1										
TW-4904	THERMOWELL	STEAM FROM DESUPERHEATER DSH-3	GE-BLR	PID-AUSC-49			8"	999												
HV-4905	ON/OFF VALVE	WBF TO DESUPERHEATER DSH-3	GE-BLR	PID-AUSC-49			1.25"	091				2	1							
HV-4906	ON/OFF VALVE	WBF TO DESUPERHEATER DSH-3	GE-BLR	PID-AUSC-49			1.25"	999				2	1							
HV-4907	VENT VALVE	STEAM TO DESUPERHEATER DSH-3	GE-BLR	PID-AUSC-49			8"	999				2	1							
PSV-4908	PRESSURE RELIEF VALVE	STEAM TO DESUPERHEATER DSH-3	GE-BLR	PID-AUSC-49			8"	999												
PARV-4909	PRESSURE ACTUATED RELIEF VALVE	STEAM TO DESUPERHEATER DSH-3	GE-BLR	PID-AUSC-49			8"	999		1	1		1							I/O TO BE CONFIRMED UPON VALVE SELECTION
FE-5002	FLOW ELEMENT	WBF FEED TO DESUPERHEATER DSH-4	GE-BLR	PID-AUSC-50			3"	091												
FT-5002	D/P FLOW TRANSMITTER	WBF FEED TO DESUPERHEATER DSH-4	AECOM	PID-AUSC-50				091		1										
TE-5003A	TEMPERATURE ELEMENT	STEAM FROM DESUPERHEATER DSH-4	GE-BLR	PID-AUSC-50				-												
TE-5003B	TEMPERATURE ELEMENT	STEAM FROM DESUPERHEATER DSH-4	GE-BLR	PID-AUSC-50				-												
TIT-5003A	TEMPERATURE TRANSMITTER	STEAM FROM DESUPERHEATER DSH-4	GE-BLR	PID-AUSC-50				-		1										
TIT-5003B	TEMPERATURE TRANSMITTER	STEAM FROM DESUPERHEATER DSH-4	GE-BLR	PID-AUSC-50				-		1										
TW-5003A	THERMOWELL	STEAM FROM DESUPERHEATER DSH-4	GE-BLR	PID-AUSC-50			10"	153												
TW-5003B	THERMOWELL	STEAM FROM DESUPERHEATER DSH-4	GE-BLR	PID-AUSC-50			10"	153												
HV-5004	ON/OFF VALVE	WBF TO DESUPERHEATER DSH-4	GE-BLR	PID-AUSC-50			1.25"	091				2	1							
TE-5006	TEMPERATURE ELEMENT	STEAM FROM DESUPERHEATER DSH-4	GE-BLR	PID-AUSC-50																
TIT-5006	TEMPERATURE TRANSMITTER	STEAM FROM DESUPERHEATER DSH-4	GE-BLR	PID-AUSC-50						1										
TV-5006	TEMPERATURE CONTROL VALVE	WBF TO DESUPERHEATER DSH-4	GE-BLR	PID-AUSC-50			1.25"	091		1	1									
TW-5006	THERMOWELL	STEAM FROM DESUPERHEATER DSH-4	GE-BLR	PID-AUSC-50			10"	153												
HV-5007	ON/OFF VALVE	WBF TO DESUPERHEATER DSH-4	GE-BLR	PID-AUSC-50			1.25"	999				2	1							
PSV-5009	PRESSURE RELIEF VALVE	ATTENUATED STEAM TO DESUPERHEATER DSH-5	GE-BLR	PID-AUSC-50			10"	153												
PARV-5010	PRESSURE ACTUATED RELIEF VALVE	ATTENUATED STEAM TO DESUPERHEATER DSH-5	GE-BLR	PID-AUSC-50			10"	153		1	1		1							I/O TO BE CONFIRMED UPON VALVE SELECTION
FE-5101	FLOW ELEMENT	WBF FEED TO DESUPERHEATER DSH-5	AECOM	PID-AUSC-51			3"	091												
FT-5101	D/P FLOW TRANSMITTER	WBF FEED TO DESUPERHEATER DSH-5	AECOM	PID-AUSC-51						1										
HV-5102	ON/OFF VALVE	WBF FEED TO DESUPERHEATER DSH-5	AECOM	PID-AUSC-51			3"	091				2	1							
TE-5103	TEMPERATURE ELEMENT	STEAM FROM DESUPERHEATER DSH-5	AECOM	PID-AUSC-51																
TIT-5103	TEMPERATURE TRANSMITTER	STEAM FROM DESUPERHEATER DSH-5	AECOM	PID-AUSC-51						1										
TV-5103	TEMPERATURE CONTROL VALVE	WBF FEED TO DESUPERHEATER DSH-5	w/ DSH-5	PID-AUSC-51			3"	091		1	1									
TW-5103	THERMOWELL	STEAM FROM DESUPERHEATER DSH-5	AECOM	PID-AUSC-51			26"	031												
HV-5104	ON/OFF VALVE	WBF TO DESUPERHEATER DSH-5	AECOM	PID-AUSC-51			3"	033				2	1							
PT-5105	PRESSURE TRANSMITTER	STEAM TO DESUPERHEATER DSH-5	AECOM	PID-AUSC-51			26"	153		1										
PV-5105	PRESSURE CONTROL VALVE	STEAM TO DESUPERHEATER DSH-5	w/ DSH-5	PID-AUSC-51				153		1	1									
TE-5106	TEMPERATURE ELEMENT	STEAM FROM DESUPERHEATER DSH-5	AECOM	PID-AUSC-51																
TIT-5106	TEMPERATURE TRANSMITTER	STEAM FROM DESUPERHEATER DSH-5	AECOM	PID-AUSC-51						1										
TW-5106	THERMOWELL	STEAM FROM DESUPERHEATER DSH-5	AECOM	PID-AUSC-51			26"	031												
PT-5107	PRESSURE TRANSMITTER	ATTENUATED STEAM TO CONDENSER	AECOM	PID-AUSC-51			26"	031		1										
PSV-6101	PRESSURE RELIEF VALVE	CONDENSER	AECOM	PID-AUSC-61																
TI-6102	TEMPERATURE INDICATOR	ATTENUATED STEAM TO CONDENSER	AECOM	PID-AUSC-61			26"	031												
PI-6103	PRESSURE INDICATOR	ATTENUATED STEAM TO CONDENSER	AECOM	PID-AUSC-61			26"	031												
TI-6104	TEMPERATURE INDICATOR	COOLING WATER RETURN TO COOLING TOWER	AECOM	PID-AUSC-61			24"	011												
PSV-6105	PRESSURE RELIEF VALVE	COOLING WATER RETURN TO COOLING TOWER	AECOM	PID-AUSC-61				011												
LT-6106	LEVEL TRANSMITTER	CONDENSER	AECOM	PID-AUSC-61						1										
LV-6106	LEVEL CONTROL VALVE	CONDENSER	AECOM	PID-AUSC-61			6"	031		1	1									
TI-6107	TEMPERATURE INDICATOR	COOLING WATER SUPPLY FROM COOLING TOWER	AECOM	PID-AUSC-61				011												

Tag Number	Instrument Type	Service	Spec'd. By	P&ID	Mfg.	Model No.	Pipe Size	Pipe Spec	-----I/O-----					----COMM I/O---				SIS		Notes
									T/C	AI	AO	DI	DO	AI	AO	DI	DO	AI	DO	
TI-6108	TEMPERATURE INDICATOR	CONDENSATE RETURN PUMP SUCTION	AECOM	PID-AUSC-61				031												
PT-6109	PRESSURE TRANSMITTER	CONDENSATE RETURN PUMP DISCHARGE	AECOM	PID-AUSC-61			6"	031		1										
RO-6110	RESTRICTION ORIFICE	CONDENSATE RETURN PUMP RECIRC	AECOM	PID-AUSC-61			4"	031												
HV-6401	ON/OFF VALVE	LIQUID AMMONIA FROM TRUCK	AECOM	PID-AUSC-64				011				2	1							
HV-6402	ON/OFF VALVE	PRESSURE EQUALIZATION TO TRUCK	AECOM	PID-AUSC-64				011				2	1							
HV-7001	ON/OFF VALVE	TREATED WATER TO COOLING TOWER	AECOM	PID-AUSC-70			6"	011				2	1							
LIT-7001	LEVEL TRANSMITTER	COOLING TOWER LEVEL	AECOM	PID-AUSC-70						1										
AT-7002	CONDUCTIVITY TRANSMITTER	COOLING TOWER CONDUCTIVITY	AECOM	PID-AUSC-70						1										
HV-7002	ON/OFF VALVE	COOLING WATER RETURN TO SEWER	AECOM	PID-AUSC-70				011				2	1							
LIT-7003	LEVEL TRANSMITTER	COOLING TOWER LEVEL	AECOM	PID-AUSC-70						1										
TI-7004	TEMPERATURE INDICATOR	COOLING WATER SUPPLY TEMPERATURE	AECOM	PID-AUSC-70				011												
PI-7005	PRESSURE INDICATOR	COOLING WATER SUPPLY PUMP A DISCHARGE PRESSURE	AECOM	PID-AUSC-70				011												
PI-7006	PRESSURE INDICATOR	COOLING WATER SUPPLY PUMP B DISCHARGE PRESSURE	AECOM	PID- AUSC-70				011												
PI-7007	PRESSURE INDICATOR	COOLING WATER SUPPLY PUMP C DISCHARGE PRESSURE	AECOM	PID-AUSC-70				011												

TAG	TAG_FN	TAG_NO	DESCR	PRELIMINARY VALVE LIST	DEV_TYPE	SERVICE_DESCR	PID	FLUID	DESIGN_TI	PIPE_DIA	PIPE_WALL	PIPE_MTL
FV-1012	FV	1012	SPRAY WATER DSH 2 FLOW CV	PRELIMINARY VALVE LIST	VALVE							
FV-1019	FV	1019	SPRAY WATER DSH 2 FLOW BLOCK VALVE	PRELIMINARY VALVE LIST	VALVE							
PSV-4908	PSV	4908	SH7 OUTLET LINK SAFETY VALVE CLOSED	PRELIMINARY VALVE LIST	VALVE				1430	12.75	1.1024	IN 740H
PSV-5009	PSV	5009	SH7 OUTLET HEADER PRV	PRELIMINARY VALVE LIST	VALVE				1430	12.75	1.1024	IN 740H
HV-4907	HV	4907	SH7 OUTLET LINK VENT MOV	PRELIMINARY VALVE LIST	VALVE				1430			
HV-3068	HV	3068	SH1 OUTLET MANIFOLD VENT MOV	PRELIMINARY VALVE LIST	VALVE				964			
HV-3002	HV	3002	SH1 INLET MANIFOLD MOV DRAIN VALVE	PRELIMINARY VALVE LIST	VALVE				1430			
HV-4906	HV	4906	SPRAY WATER DSH 3 FLOW STOP VALVE	PRELIMINARY VALVE LIST	VALVE							
HV-5007	HV	5007	SPRAY WATER DSH 4 FLOW STOP VALVE	PRELIMINARY VALVE LIST	VALVE							
FV-1006	FV	1006	SPRAY WATER DSH 1 FLOW CV	PRELIMINARY VALVE LIST	VALVE							
FV-1017	FV	1017	SPRAY WATER DSH 1 FLOW BLOCK VALVE	PRELIMINARY VALVE LIST	VALVE							
HV-1020	HV	1020	SPRAY WATER DSH 2 FLOW STOP VALVE	PRELIMINARY VALVE LIST	VALVE				1430			
FV-5005	FV	5005	MAIN STEAM OUTLET CV	PRELIMINARY VALVE LIST	VALVE							
HV-1018	HV	1018	SPRAY WATER DSH 1 FLOW STOP VALVE	PRELIMINARY VALVE LIST	VALVE				1430			
TV-4903	TV	4903	SPRAY WATER DSH 2 FLOW CV	PRELIMINARY VALVE LIST	VALVE							
HV-4905	HV	4905	SPRAY WATER DSH 3 FLOW BLOCK VALVE	PRELIMINARY VALVE LIST	VALVE							
TV-5008	TV	5008	SPRAY WATER DSH 2 FLOW CV	PRELIMINARY VALVE LIST	VALVE							
HV-5004	HV	5004	SPRAY WATER DSH 4 FLOW BLOCK VALVE	PRELIMINARY VALVE LIST	VALVE							
MV-3001	MV	3001	SH1 INLET MANIFOLD DRAIN VALVE	PRELIMINARY VALVE LIST	VALVE				1430			
HV-3066	HV	3066	SPRAY WATER DSH 2 FLOW CV	PRELIMINARY VALVE LIST	VALVE							
HV-3067	HV	3067	SPRAY WATER DSH 2 FLOW CV	PRELIMINARY VALVE LIST	VALVE							
HV-3068	HV	3068	SPRAY WATER DSH 2 FLOW CV	PRELIMINARY VALVE LIST	VALVE							
HV-3069	HV	3069	SPRAY WATER DSH 2 FLOW CV	PRELIMINARY VALVE LIST	VALVE							
HV-3070	HV	3070	SPRAY WATER DSH 2 FLOW CV	PRELIMINARY VALVE LIST	VALVE							
HV-3071	HV	3071	SPRAY WATER DSH 2 FLOW CV	PRELIMINARY VALVE LIST	VALVE							
HV-3072	HV	3072	SPRAY WATER DSH 2 FLOW CV	PRELIMINARY VALVE LIST	VALVE							
HV-3073	HV	3073	SPRAY WATER DSH 2 FLOW CV	PRELIMINARY VALVE LIST	VALVE							
MV-4910	MV	4910	SH7 OUTLET LINK VENT MANUAL VALVE	PRELIMINARY VALVE LIST	VALVE				1430			
HV-3070	HV	3070	SH1 OUTLET MANIFOLD VENT MOV	PRELIMINARY VALVE LIST	VALVE				964			
HV-3072	HV	3072	SH1 OUTLET MANIFOLD VENT MOV	PRELIMINARY VALVE LIST	VALVE				964			
HV-3074	HV	3074	SH1 OUTLET MANIFOLD VENT MOV	PRELIMINARY VALVE LIST	VALVE				964			
MV-3067	MV	3067	SH1 OUTLET MANIFOLD VENT MOV	PRELIMINARY VALVE LIST	VALVE				964			
MV-3069	MV	3069	SH1 OUTLET MANIFOLD VENT MOV	PRELIMINARY VALVE LIST	VALVE				964			
MV-3071	MV	3071	SH1 OUTLET MANIFOLD VENT MOV	PRELIMINARY VALVE LIST	VALVE				964			
MV-3073	MV	3073	SH1 OUTLET MANIFOLD VENT MOV	PRELIMINARY VALVE LIST	VALVE				964			
MV-3075	MV	3075	SH1 OUTLET MANIFOLD VENT MOV	PRELIMINARY VALVE LIST	VALVE				964			
MV-3076	MV	3076	SH1 OUTLET MANIFOLD VENT MOV	PRELIMINARY VALVE LIST	VALVE				964			
MV-3078	MV	3078	SH1 OUTLET MANIFOLD VENT MOV	PRELIMINARY VALVE LIST	VALVE				964			
MV-3077	MV	3077	SH1 OUTLET MANIFOLD VENT MOV	PRELIMINARY VALVE LIST	VALVE				964			
HV-3124	HV	3124	IGN GAS HDR SHUTOFF VALVE	PRELIMINARY VALVE LIST	VALVE							
HV-3122	HV	3122	IGN GAS HDR SUTOFF VALVE	PRELIMINARY VALVE LIST	VALVE							
HV-3110	HV	3110	MAN GAS SHUTOFF VALVE	PRELIMINARY VALVE LIST	VALVE							
FV-3111	FV	3111	MAN GAS FLOW CV	PRELIMINARY VALVE LIST								
HV-3123	HV	3123	IGN GAS VENT VALVE	PRELIMINARY VALVE LIST	VALVE							
HV-3109	HV	3109	MAIN GAS VENT VALVE	PRELIMINARY VALVE LIST	VALVE							
HV-3108	HV	3108	MAN GAS SHUTOFF VALVE	PRELIMINARY VALVE LIST	VALVE							
HV-3116	HV	3116	BURNER 1 SHUTOFF VALVE	PRELIMINARY VALVE LIST	VALVE							
HV-3117	HV	3117	BURNER 2 SHUTOFF VALVE	PRELIMINARY VALVE LIST	VALVE							
HV-3118	HV	3118	BURNER 3 SHUTOFF VALVE	PRELIMINARY VALVE LIST	VALVE							
HV-3131	HV	3131	IGNITOR 3 SHUTOFF VALVE	PRELIMINARY VALVE LIST	VALVE							
HV-3130	HV	3130	IGNITOR 2 SHUTOFF VALVE	PRELIMINARY VALVE LIST	VALVE							
HV-3129	HV	3129	IGNITOR 1 SHUTOFF VALVE	PRELIMINARY VALVE LIST	VALVE							
MV-3119	MV	3119	IGN GAS MANUAL SHUTOFF VALVE	PRELIMINARY VALVE LIST	VALVE							
MV-3114	MV	3114	MAIN GAS MANUAL SHUTOFF VALVE	PRELIMINARY VALVE LIST	VALVE							

GENERAL	1	Tag Number	P&ID Number		FT-0303		PID-AUSC-03	
	2	Service			NATURAL GAS SUPPLY			
	3	Line Number	Line Material		6"-011-NG-0307		CS	
	4	Line Size	Line Sch	Line Spec	6"	STD		011
	5	Equipment Number	Area Classification					
	6	Ambient Temperature Range						
	7							
PROCESS CONDITIONS	8	Fluid	State		NATURAL GAS		GAS	
	9	Fluid Comments						
	10	Design Pressure	Design Temperature		260 PSIG		150°F	
	11				Units	Minimum	Normal	Maximum
	12	Flow Rate			lb/hr		12304	
	13	Pressure			PSIA		190	
	14	Temperature			°F		77	
	15	Maximum Velocity						
	16	Minimum Conductivity						
	17	Maximum Vacuum Expected						
	18							
	19							
METERING ELEMENT	20	Connection Size	Type & Rating				RF - 150#	
	21	Connection Materials						
	22	Tube Material			*			
	23	Liner Material			*			
	24	Electrode Type			*			
	25	Electrode Material			*			
	26	Power Supply						
	27	Grounding: Type	Material					
	28	Electrical Enclosure Class						
	29	Electrical Connection						
	30							
PIPING DATA	31	Face to Face Dimension			*			
	32	Min. Pie Runs:	Downstream					
	33	Approximate Weight			*			
TRANSMITTER	34	Tag Number			FT-0303			
	35	Integral Display						
	36	Mounting			DIRECT			
	37	Electrical Enclosure Class						
	38	Vendor Supplied Signal Cable Length			*			
	39	Power Supply						
	40	Output			4-20 mAdc			
	41	Calibration						
	42	Zero Flow Cut Off Switch						
	43							
PURCHASE	44	Manufacturer						
	45	Model: Flowtube			*			
	46	Model: Transmitter			*			
	47	Purchase Order Number						
	48	Price	Item Number					
	49	Serial Number	Flowtube	Transmitter	*		*	

Notes: 1. (*) - Final data provided by Supplier
2. Provide Stainless Steel Tag attached to Instrument engraved with the Instrument Tag No.

PRELIMINARY
NOT FOR CONSTRUCTION

INSTRUMENT SPECIFICATION
FLOWMETER
ULTRASONIC

AECOM

No.	By	Chk	App	Date	Description
A	DC			12/22/2017	Issue for Record

Project: AUSC Com Test
W.O. No. 31609

Sheet 1 of 1

Code: 204 | Dwg . No.: FT-0303 | Rev.: A

GENERAL	1	Tag Number			P&ID Number		HV-0302			PID-AUSC-03									
	2	Service					NATURAL GAS SUPPLY												
	3	Line Number			Line Material		6"-011-NG-0307			CS									
	4	Line Size		Line Sch		Line Spec	6"			STD				011					
	5	Equipment Number			Area Classification														
	6	Ambient Temperature Range																	
	7																		
PROCESS CONDITIONS	8	Fluid			State		NATURAL GAS			VAPOR									
	9	Fluid Comments																	
	10	Design Pressure			Design Temperature		260 PSIG			150°F									
	11	Shut Off Differential Pressure					260 PSI												
	12						Units			Minimum			Normal			Maximum			
	13	Flow Rate					lb/hr						12304						
	14	Inlet Pressure					PSIA						190						
	15	Pressure Drop					PSI												
	16	Inlet Temperature					°F						77						
	17	Inlet Density			Inlet Sp. G.		lb/ft3						0.59						
	18	Inlet Compressibility Factor					-												
	19	Inlet Viscosity					cP						0.0116						
	20	Inlet Specific Heat Ratio					-												
	21	Inlet Vapor Pressure					PSIA												
	22																		
CALCULATE RESULTS	23	Flow Coefficient Cv					-			*			*			*			
	24	Travel					%			*			*			*			
	25	Sound Pressure Level					dBA			*			*			*			
	26	Full Stroke (sec): Calc			Actual		*						*						
	27																		
BODY AND TRIM	28	Manufacturer			Model Number		*						*						
	29	Body Type		Material		Size	FIRE-RATED												
	30	End Conn: Size			Type & Rating		6"						150# RF FLANGE						
	31	Plug/Ball/Disk Material			Stem Material		*						*						
	32	Trim Type			Material		*						*						
	33	Seat Material			Packing		*						*						
	34	Bonnet Type			Material														
	35	Shutoff Classification			Bolting		*												
	36	Lubricator			Isol valve														
	37	Rated Cv			Rated Travel		*						*						
ACTUATOR	38	Mfr		Model	*	*	AIR SET	55	Mfr		Model		*		*				
	39	Type		Size	*	*		56	Set Pressure						*				
	40	Material		Orient.	*	*		57	Filter		Gauge								
	41	Area		Fail Pos.	*	CLOSE		58											
	42	Air Supply Pressure					SWITCH	59	Mfr		Model		*		*				
	43	Handwheel Location						60	Type		Quantity					2			
	44	Position Indicator			MFR. STD.			61	Rating		Load		*						
	45							62	Action 1		Action 2		LSO						
SOLENOID VALVE	46	Mfr		Model	*	*		63	Action 3		Action 4		LSC						
	47	Type	Energize To:					64											
	48	Size		Material	*	*	OPTIONS	65	Hydro Test										
	49	Rating: Encl		Coil				66	Leak Test										
	50	Voltage		Hertz				67											
	51	Power (W)			*		PURCHASE	68	Mfr		Model					*			
	52	VA-Hold		VA-Inrush	*	*		69	PO Number										
PIPE DATA	53	F-F Dim		Weight	*	*		70	Price		Item								
	54							71	Serial Number				*						

Notes: 1. (*) - Final data provided by Supplier
2. Provide Stainless Steel Tag attached to Instrument engraved with the Instrument Tag No.

PRELIMINARY
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INSTRUMENT SPECIFICATION
Automated On/Off Valve

AECOM

No.	By	Chk	App	Date	Description
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GENERAL	1	Tag Number			P&ID Number			HV-2503			PID-AUSC-25								
	2	Service						BOILER STEAM TO SUPERHEATER BYPASS											
	3	Line Number			Line Material			6"-153-SA-2501-II			9CR-2W								
	4	Line Size		Line Sch		Line Spec		6"		SCH 160			153						
	5	Equipment Number			Area Classification														
	6	Ambient Temperature Range																	
	7																		
PROCESS CONDITIONS	8	Fluid			State			STEAM			VAPOR								
	9	Fluid Comments																	
	10	Design Pressure			Design Temperature			1500 PSIG			1050°F								
	11	Shut Off Differential Pressure						1500 PSI											
	12							Units		Minimum		Normal		Maximum					
	13	Flow Rate						lb/hr				114000							
	14	Inlet Pressure						PSIA				1300							
	15	Pressure Drop						PSI											
	16	Inlet Temperature						°F				877							
	17	Inlet Density			Inlet Sp. G.			lb/ft3				1.79							
	18	Inlet Compressibility Factor						-											
	19	Inlet Viscosity						cP				0.0275							
	20	Inlet Specific Heat Ratio						-											
	21	Inlet Vapor Pressure						PSIA											
	22																		
CALCULATE RESULTS	23	Flow Coefficient Cv						-		*		*		*					
	24	Travel						%		*		*		*					
	25	Sound Pressure Level						dBA		*		*		*					
	26	Full Stroke (sec): Calc			Actual			*				*							
	27																		
BODY AND TRIM	28	Manufacturer			Model Number			*				*							
	29	Body Type		Material		Size													
	30	End Conn: Size			Type & Rating			6"											
	31	Plug/Ball/Disk Material			Stem Material			*				*							
	32	Trim Type			Material			*				*							
	33	Seat Material			Packing			*				*							
	34	Bonnet Type			Material														
	35	Shutoff Classification			Bolting			*											
	36	Lubricator			Isol valve														
	37	Rated Cv			Rated Travel			*				*							
ACTUATOR	38	Mfr		Model	*		*	AIR SET	55	Mfr		Model		*		*			
	39	Type		Size	*		*		56	Set Pressure				*					
	40	Material		Orient.	*		*		57	Filter		Gauge							
	41	Area		Fail Pos.	*				58										
	42	Air Supply Pressure						SWITCH	59	Mfr		Model		*		*			
	43	Handwheel Location							60	Type		Quantity				2			
	44	Position Indicator			MFG. STD.				61	Rating		Load		*					
	45								62	Action 1		Action 2		LSO					
SOLENOID VALVE	46	Mfr		Model	*		*		63	Action 3		Action 4		LSC					
	47	Type	Energize To:						64										
	48	Size		Material	*		*	OPTIONS	65	Hydro Test									
	49	Rating: Encl		Coil					66	Leak Test									
	50	Voltage		Hertz					67										
	51	Power (W)			*			PURCHASE	68	Mfr		Model				*			
	52	VA-Hold		VA-Inrush	*		*		69	PO Number									
PIPE DATA	53	F-F Dim		Weight	*		*		70	Price		Item							
	54								71	Serial Number				*					

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PRELIMINARY
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INSTRUMENT SPECIFICATION
Automated On/Off Valve

AECOM

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GENERAL	1	Tag Number			P&ID Number		HV-2504			PID-AUSC-25									
	2	Service					BOILER STEAM TO SUPERHEATER												
	3	Line Number			Line Material		8"-152-SB-2001-II			2 1/4Cr-1Mo									
	4	Line Size		Line Sch		Line Spec	8"			SCH 160			152						
	5	Equipment Number			Area Classification														
	6	Ambient Temperature Range																	
	7																		
PROCESS CONDITIONS	8	Fluid			State		STEAM			VAPOR									
	9	Fluid Comments																	
	10	Design Pressure			Design Temperature		1500 PSIG			930°F									
	11	Shut Off Differential Pressure					1500 PSI												
	12						Units			Minimum			Normal			Maximum			
	13	Flow Rate					lb/hr						114000						
	14	Inlet Pressure					PSIA						1300						
	15	Pressure Drop					PSI												
	16	Inlet Temperature					°F						877						
	17	Inlet Density			Inlet Sp. G.		lb/ft3						1.79						
	18	Inlet Compressibility Factor					-												
	19	Inlet Viscosity					cP						0.0275						
	20	Inlet Specific Heat Ratio					-												
	21	Inlet Vapor Pressure					PSIA												
	22																		
CALCULATE RESULTS	23	Flow Coefficient Cv					-			*			*			*			
	24	Travel					%			*			*			*			
	25	Sound Pressure Level					dBA			*			*			*			
	26	Full Stroke (sec): Calc			Actual		*						*						
	27																		
BODY AND TRIM	28	Manufacturer			Model Number		*						*						
	29	Body Type		Material		Size													
	30	End Conn: Size			Type & Rating		8"												
	31	Plug/Ball/Disk Material			Stem Material		*						*						
	32	Trim Type			Material		*						*						
	33	Seat Material			Packing		*						*						
	34	Bonnet Type			Material														
	35	Shutoff Classification			Bolting		*												
	36	Lubricator			Isol valve														
	37	Rated Cv			Rated Travel		*						*						
ACTUATOR	38	Mfr		Model	*	*	AIR SET	55	Mfr		Model		*		*				
	39	Type		Size	*	*		56	Set Pressure						*				
	40	Material		Orient.	*	*		57	Filter		Gauge								
	41	Area		Fail Pos.	*			58											
	42	Air Supply Pressure					SWITCH	59	Mfr		Model		*		*				
	43	Handwheel Location						60	Type		Quantity				2				
	44	Position Indicator			MFG. STD.			61	Rating		Load		*						
	45							62	Action 1		Action 2		LSO						
SOLENOID VALVE	46	Mfr		Model	*	*		63	Action 3		Action 4		LSC						
	47	Type	Energize To:					64											
	48	Size		Material	*	*	OPTIONS	65	Hydro Test										
	49	Rating: Encl		Coil				66	Leak Test										
	50	Voltage		Hertz				67											
	51	Power (W)			*		PURCHASE	68	Mfr		Model				*				
	52	VA-Hold		VA-Inrush	*	*		69	PO Number										
PIPE DATA	53	F-F Dim		Weight	*	*		70	Price		Item								
	54							71	Serial Number				*						

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2. Provide Stainless Steel Tag attached to Instrument engraved with the Instrument Tag No.

PRELIMINARY
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INSTRUMENT SPECIFICATION
Automated On/Off Valve

AECOM

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GENERAL	1	Tag Number			P&ID Number		HV-5102			PID-AUSC-51								
	2	Service					WBF TO DESUPERHEATER 5											
	3	Line Number			Line Material		3"-091-WBF-1006-II			CS								
	4	Line Size	Line Sch		Line Spec		3"	SCH 160		091								
	5	Equipment Number			Area Classification													
	6	Ambient Temperature Range																
	7																	
PROCESS CONDITIONS	8	Fluid			State		WATER			LIQUID								
	9	Fluid Comments																
	10	Design Pressure			Design Temperature		1500 PSIG			575°F								
	11	Shut Off Differential Pressure					1500 PSI											
	12						Units	Minimum		Normal		Maximum						
	13	Flow Rate					lb/hr			17500								
	14	Inlet Pressure					PSIA			1360								
	15	Pressure Drop					PSI											
	16	Inlet Temperature					°F			253								
	17	Inlet Density			Inlet Sp. G.		lb/ft3			59.02								
	18	Inlet Compressibility Factor					-											
	19	Inlet Viscosity					cP			0.2287								
	20	Inlet Specific Heat Ratio					-											
	21	Inlet Vapor Pressure					PSIA			31.8								
	22																	
CALCULATE RESULTS	23	Flow Coefficient Cv					-	*		*		*						
	24	Travel					%	*		*		*						
	25	Sound Pressure Level					dBA	*		*		*						
	26	Full Stroke (sec): Calc			Actual		*			*								
	27																	
BODY AND TRIM	28	Manufacturer			Model Number		*			*								
	29	Body Type	Material		Size													
	30	End Conn: Size			Type & Rating		3"			900# RF FLANGE								
	31	Plug/Ball/Disk Material			Stem Material		*			*								
	32	Trim Type			Material		*			*								
	33	Seat Material			Packing		*			*								
	34	Bonnet Type			Material													
	35	Shutoff Classification			Bolting		*											
	36	Lubricator			Isol valve													
	37	Rated Cv			Rated Travel		*			*								
ACTUATOR	38	Mfr	Model		*	*	AIR SET	55	Mfr	Model		*	*					
	39	Type	Size		*	*		56	Set Pressure			*						
	40	Material	Orient.		*	*		57	Filter	Gauge								
	41	Area	Fail Pos.		*	CLOSE		58										
	42	Air Supply Pressure					SWITCH	59	Mfr	Model		*	*					
	43	Handwheel Location						60	Type	Quantity			2					
	44	Position Indicator			MFG. STD.			61	Rating	Load		*						
	45							62	Action 1	Action 2		LSO						
SOLENOID VALVE	46	Mfr	Model		*	*		63	Action 3	Action 4		LSC						
	47	Type	Energize To:					64										
	48	Size	Material		*	*	OPTIONS	65	Hydro Test									
	49	Rating: Encl	Coil					66	Leak Test									
	50	Voltage	Hertz					67										
	51	Power (W)			*		PURCHASE	68	Mfr	Model			*					
	52	VA-Hold	VA-Inrush		*	*		69	PO Number									
PIPE DATA	53	F-F Dim	Weight		*	*		70	Price	Item								
	54							71	Serial Number			*						

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PRELIMINARY
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INSTRUMENT SPECIFICATION
On/Off Valve

AECOM

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GENERAL	1	Tag Number			P&ID Number		HV-5104			PID-AUSC-51								
	2	Service					WBF TO DESUPERHEATER 5											
	3	Line Number			Line Material		3"-033-WBF-1006-II			9CR-2W								
	4	Line Size	Line Sch		Line Spec		3"	STD		033								
	5	Equipment Number			Area Classification													
	6	Ambient Temperature Range																
	7																	
PROCESS CONDITIONS	8	Fluid			State		WATER			LIQUID								
	9	Fluid Comments																
	10	Design Pressure			Design Temperature		100 PSIG			1050°F								
	11	Shut Off Differential Pressure					100 PSI											
	12						Units	Minimum		Normal		Maximum						
	13	Flow Rate					lb/hr			17500								
	14	Inlet Pressure					PSIA			80								
	15	Pressure Drop					PSI											
	16	Inlet Temperature					°F			253								
	17	Inlet Density			Inlet Sp. G.		lb/ft3			59.02								
	18	Inlet Compressibility Factor					-											
	19	Inlet Viscosity					cP			0.2287								
	20	Inlet Specific Heat Ratio					-											
	21	Inlet Vapor Pressure					PSIA			31.8								
	22																	
CALCULATE RESULTS	23	Flow Coefficient Cv					-	*		*		*						
	24	Travel					%	*		*		*						
	25	Sound Pressure Level					dBA	*		*		*						
	26	Full Stroke (sec): Calc			Actual		*			*								
	27																	
BODY AND TRIM	28	Manufacturer			Model Number		*			*								
	29	Body Type	Material		Size													
	30	End Conn: Size			Type & Rating		3"			300# RF								
	31	Plug/Ball/Disk Material			Stem Material		*			*								
	32	Trim Type			Material		*			*								
	33	Seat Material			Packing		*			*								
	34	Bonnet Type			Material													
	35	Shutoff Classification			Bolting		*											
	36	Lubricator			Isol valve													
	37	Rated Cv			Rated Travel		*			*								
ACTUATOR	38	Mfr	Model		*	*	AIR SET	55	Mfr	Model		*	*					
	39	Type	Size		*	*		56	Set Pressure			*						
	40	Material	Orient.		*	*		57	Filter	Gauge								
	41	Area	Fail Pos.		*	CLOSE		58										
	42	Air Supply Pressure					SWITCH	59	Mfr	Model		*	*					
	43	Handwheel Location						60	Type	Quantity			2					
	44	Position Indicator			MFG. STD.			61	Rating	Load		*						
	45							62	Action 1	Action 2		LSO						
SOLENOID VALVE	46	Mfr	Model		*	*		63	Action 3	Action 4		LSC						
	47	Type	Energize To:					64										
	48	Size	Material		*	*	OPTIONS	65	Hydro Test									
	49	Rating: Encl	Coil					66	Leak Test									
	50	Voltage	Hertz					67										
	51	Power (W)			*		PURCHASE	68	Mfr	Model			*					
	52	VA-Hold	VA-Inrush		*	*		69	PO Number									
PIPE DATA	53	F-F Dim	Weight		*	*		70	Price	Item								
	54							71	Serial Number			*						

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On/Off Valve

AECOM

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A	DC			12/22/2017	Issue for Record

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GENERAL	1	Tag Number			P&ID Number		HV-6401			PID-AUSC-64									
	2	Service					AMMONIA TRUCK UNLOADING TO STORAGE VESSEL												
	3	Line Number			Line Material		X"-011-NH3-6403			CS									
	4	Line Size		Line Sch		Line Spec						011							
	5	Equipment Number			Area Classification														
	6	Ambient Temperature Range																	
	7																		
PROCESS CONDITIONS	8	Fluid			State		NH3			LIQUID									
	9	Fluid Comments																	
	10	Design Pressure			Design Temperature		250 PSIG			150°F									
	11	Shut Off Differential Pressure					250 PSI												
	12						Units			Minimum			Normal			Maximum			
	13	Flow Rate					lb/hr												
	14	Inlet Pressure					PSIA												
	15	Pressure Drop					PSI												
	16	Inlet Temperature					°F												
	17	Inlet Density			Inlet Sp. G.		lb/ft3												
	18	Inlet Compressibility Factor					-												
	19	Inlet Viscosity					cP												
	20	Inlet Specific Heat Ratio					-												
	21	Inlet Vapor Pressure					PSIA												
	22																		
CALCULATE RESULTS	23	Flow Coefficient Cv					-			*			*			*			
	24	Travel					%			*			*			*			
	25	Sound Pressure Level					dBA			*			*			*			
	26	Full Stroke (sec): Calc			Actual		*						*						
	27																		
BODY AND TRIM	28	Manufacturer			Model Number		*						*						
	29	Body Type		Material		Size													
	30	End Conn: Size			Type & Rating								150# RF FLANGE						
	31	Plug/Ball/Disk Material			Stem Material		*						*						
	32	Trim Type			Material		*						*						
	33	Seat Material			Packing		*						*						
	34	Bonnet Type			Material														
	35	Shutoff Classification			Bolting		*												
	36	Lubricator			Isol valve														
	37	Rated Cv			Rated Travel		*						*						
ACTUATOR	38	Mfr		Model	*	*	AIR SET	55	Mfr		Model	*	*						
	39	Type		Size	*	*		56	Set Pressure				*						
	40	Material		Orient.	*	*		57	Filter		Gauge								
	41	Area		Fail Pos.	*	CLOSE		58											
	42	Air Supply Pressure					SWITCH	59	Mfr		Model	*	*						
	43	Handwheel Location						60	Type		Quantity		2						
	44	Position Indicator			MFG. STD.			61	Rating		Load	*							
	45							62	Action 1		Action 2	LSO							
SOLENOID VALVE	46	Mfr		Model	*	*		63	Action 3		Action 4	LSC							
	47	Type	Energize To:					64											
	48	Size		Material	*	*	OPTIONS	65	Hydro Test										
	49	Rating: Encl		Coil				66	Leak Test										
	50	Voltage		Hertz				67											
	51	Power (W)			*		PURCHASE	68	Mfr		Model		*						
	52	VA-Hold		VA-Inrush	*	*		69	PO Number										
PIPE DATA	53	F-F Dim		Weight	*	*		70	Price		Item								
	54							71	Serial Number			*							

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PRELIMINARY
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INSTRUMENT SPECIFICATION
Automated On/Off Valve

AECOM

No.	By	Chk	App	Date	Description
A	DC			12/22/2017	Issue for Record

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Code: 412 | Dwg. No.: HV-6401 | Rev.: A

GENERAL	1	Tag Number			P&ID Number			HV-6402				PID-AUSC-64							
	2	Service						AMMONIA TRUCK UNLOADING PRESSURE EQUALIZATION											
	3	Line Number			Line Material			X"-011-NH3-6404				CS							
	4	Line Size		Line Sch		Line Spec								011					
	5	Equipment Number			Area Classification														
	6	Ambient Temperature Range																	
	7																		
PROCESS CONDITIONS	8	Fluid			State			NH3				LIQUID							
	9	Fluid Comments																	
	10	Design Pressure			Design Temperature			250 PSIG				150 °F							
	11	Shut Off Differential Pressure						250 PSI											
	12							Units		Minimum		Normal		Maximum					
	13	Flow Rate						lb/hr											
	14	Inlet Pressure						PSIA											
	15	Pressure Drop						PSI											
	16	Inlet Temperature						°F											
	17	Inlet Density			Inlet Sp. G.			lb/ft3											
	18	Inlet Compressibility Factor						-											
	19	Inlet Viscosity						cP											
	20	Inlet Specific Heat Ratio						-											
	21	Inlet Vapor Pressure						PSIA											
	22																		
CALCULATE RESULTS	23	Flow Coefficient Cv						-		*		*		*					
	24	Travel						%		*		*		*					
	25	Sound Pressure Level						dBA		*		*		*					
	26	Full Stroke (sec): Calc			Actual			*				*							
	27																		
BODY AND TRIM	28	Manufacturer			Model Number			*				*							
	29	Body Type		Material		Size													
	30	End Conn: Size			Type & Rating							150# RF FLANGE							
	31	Plug/Ball/Disk Material			Stem Material			*				*							
	32	Trim Type			Material			*				*							
	33	Seat Material			Packing			*				*							
	34	Bonnet Type			Material														
	35	Shutoff Classification			Bolting			*											
	36	Lubricator			Isol valve														
	37	Rated Cv			Rated Travel			*				*							
ACTUATOR	38	Mfr		Model	*		*	AIR SET	55	Mfr		Model		*		*			
	39	Type		Size	*		*		56	Set Pressure				*					
	40	Material		Orient.	*		*		57	Filter		Gauge							
	41	Area		Fail Pos.	*				58										
	42	Air Supply Pressure						SWITCH	59	Mfr		Model		*		*			
	43	Handwheel Location							60	Type		Quantity				2			
	44	Position Indicator			MFG. STD.				61	Rating		Load		*					
	45								62	Action 1		Action 2		LSO					
SOLENOID VALVE	46	Mfr		Model	*		*		63	Action 3		Action 4		LSC					
	47	Type	Energize To:						64										
	48	Size		Material	*		*	OPTIONS	65	Hydro Test									
	49	Rating: Encl		Coil					66	Leak Test									
	50	Voltage		Hertz					67										
	51	Power (W)			*			PURCHASE	68	Mfr		Model				*			
	52	VA-Hold		VA-Inrush	*		*		69	PO Number									
PIPE DATA	53	F-F Dim		Weight	*		*		70	Price		Item							
	54								71	Serial Number				*					

Notes: 1. (*) - Final data provided by Supplier
2. Provide Stainless Steel Tag attached to Instrument engraved with the Instrument Tag No.

PRELIMINARY
NOT FOR CONSTRUCTION

INSTRUMENT SPECIFICATION
Automated On/Off Valve

AECOM

No.	By	Chk	App	Date	Description
A	DC			12/22/2017	Issue for Record

Project: AUSC Com Test
W.O. No.: 31609

Sheet 1 of 1

Code: 412 | Dwg. No.: HV-6402 | Rev.: A

GENERAL	1	Tag Number			P&ID Number		HV-7001			PID-AUSC-70									
	2	Service					TREATED WATER TO COOLING TOWER												
	3	Line Number			Line Material		6"-011-WC-7101			CS									
	4	Line Size		Line Sch		Line Spec	6"		STD			011							
	5	Equipment Number			Area Classification														
	6	Ambient Temperature Range																	
	7																		
PROCESS CONDITIONS	8	Fluid			State		WATER			LIQUID									
	9	Fluid Comments																	
	10	Design Pressure			Design Temperature		100 PSIG			140°F									
	11	Shut Off Differential Pressure					100 PSI												
	12						Units		Minimum		Normal		Maximum						
	13	Flow Rate					GPM				22600								
	14	Inlet Pressure					PSIA				55								
	15	Pressure Drop					PSI												
	16	Inlet Temperature					°F				110								
	17	Inlet Density			Inlet Sp. G.		lb/ft3				61.86								
	18	Inlet Compressibility Factor					-												
	19	Inlet Viscosity					cP												
	20	Inlet Specific Heat Ratio					-												
	21	Inlet Vapor Pressure					PSIA				1.27								
	22																		
CALCULATE RESULTS	23	Flow Coefficient Cv					-		*		*		*						
	24	Travel					%		*		*		*						
	25	Sound Pressure Level					dBA		*		*		*						
	26	Full Stroke (sec): Calc			Actual		*				*								
	27																		
BODY AND TRIM	28	Manufacturer			Model Number		*				*								
	29	Body Type		Material		Size													
	30	End Conn: Size			Type & Rating						150# RF FLANGE								
	31	Plug/Ball/Disk Material			Stem Material		*				*								
	32	Trim Type			Material		*				*								
	33	Seat Material			Packing		*				*								
	34	Bonnet Type			Material														
	35	Shutoff Classification			Bolting		*												
	36	Lubricator			Isol valve														
	37	Rated Cv			Rated Travel		*				*								
ACTUATOR	38	Mfr		Model	*	*	AIR SET	55	Mfr		Model		*		*				
	39	Type		Size	*	*		56	Set Pressure				*						
	40	Material		Orient.	*	*		57	Filter		Gauge								
	41	Area		Fail Pos.	*	CLOSE		58											
	42	Air Supply Pressure					SWITCH	59	Mfr		Model		*		*				
	43	Handwheel Location						60	Type		Quantity				2				
	44	Position Indicator			MFG. STD.			61	Rating		Load		*						
	45							62	Action 1		Action 2		LSO						
SOLENOID VALVE	46	Mfr		Model	*	*		63	Action 3		Action 4		LSC						
	47	Type	Energize To:					64											
	48	Size		Material	*	*	OPTIONS	65	Hydro Test										
	49	Rating: Encl		Coil				66	Leak Test										
	50	Voltage		Hertz				67											
	51	Power (W)			*		PURCHASE	68	Mfr		Model				*				
	52	VA-Hold		VA-Inrush	*	*		69	PO Number										
PIPE DATA	53	F-F Dim		Weight	*	*		70	Price		Item								
	54							71	Serial Number				*						

Notes: 1. (*) - Final data provided by Supplier
2. Provide Stainless Steel Tag attached to Instrument engraved with the Instrument Tag No.

PRELIMINARY
NOT FOR CONSTRUCTION

INSTRUMENT SPECIFICATION
Automated On/Off Valve

AECOM

No.	By	Chk	App	Date	Description
A	DC			12/22/2017	Issue for Record

Project: AUSC Com Test
W.O. No.: 31609

Sheet 1 of 1

Code: 412 | Dwg. No.: HV-7001 | Rev.: A

GENERAL	1	Tag Number			P&ID Number		HV-7002			PID-AUSC-70									
	2	Service					COOLING WATER RETURN TO DRAIN												
	3	Line Number			Line Material		4"-011-WCR-7011			CS									
	4	Line Size	Line Sch		Line Spec		4"	STD		011									
	5	Equipment Number			Area Classification														
	6	Ambient Temperature Range																	
	7																		
PROCESS CONDITIONS	8	Fluid			State		WATER			LIQUID									
	9	Fluid Comments																	
	10	Design Pressure			Design Temperature		100 PSIG			175°F									
	11	Shut Off Differential Pressure					100 PSI												
	12						Units	Minimum		Normal		Maximum							
	13	Flow Rate					GPM												
	14	Inlet Pressure					PSIA												
	15	Pressure Drop					PSI												
	16	Inlet Temperature					°F												
	17	Inlet Density			Inlet Sp. G.		lb/ft3												
	18	Inlet Compressibility Factor					-												
	19	Inlet Viscosity					cP												
	20	Inlet Specific Heat Ratio					-												
	21	Inlet Vapor Pressure					PSIA												
	22																		
CALCULATE RESULTS	23	Flow Coefficient Cv					-	*		*		*							
	24	Travel					%	*		*		*							
	25	Sound Pressure Level					dBA	*		*		*							
	26	Full Stroke (sec): Calc			Actual		*			*									
	27																		
BODY AND TRIM	28	Manufacturer			Model Number		*			*									
	29	Body Type	Material		Size														
	30	End Conn: Size			Type & Rating					150# RF FLANGE									
	31	Plug/Ball/Disk Material			Stem Material		*			*									
	32	Trim Type			Material		*			*									
	33	Seat Material			Packing		*			*									
	34	Bonnet Type			Material														
	35	Shutoff Classification			Bolting		*												
	36	Lubricator			Isol valve														
	37	Rated Cv			Rated Travel		*			*									
ACTUATOR	38	Mfr	Model		*	*	AIR SET	55	Mfr	Model		*	*						
	39	Type	Size		*	*		56	Set Pressure			*							
	40	Material	Orient.		*	*		57	Filter	Gauge									
	41	Area	Fail Pos.		*	CLOSE		58											
	42	Air Supply Pressure					SWITCH	59	Mfr	Model		*	*						
	43	Handwheel Location						60	Type	Quantity			2						
	44	Position Indicator			MFG. STD.			61	Rating	Load		*							
	45							62	Action 1	Action 2		LSO							
SOLENOID VALVE	46	Mfr	Model		*	*		63	Action 3	Action 4		LSC							
	47	Type	Energize To:					64											
	48	Size	Material		*	*	OPTIONS	65	Hydro Test										
	49	Rating: Encl	Coil					66	Leak Test										
	50	Voltage	Hertz					67											
	51	Power (W)			*		PURCHASE	68	Mfr	Model			*						
	52	VA-Hold	VA-Inrush		*	*		69	PO Number										
PIPE DATA	53	F-F Dim	Weight		*	*		70	Price	Item									
	54							71	Serial Number			*							

Notes: 1. (*) - Final data provided by Supplier
2. Provide Stainless Steel Tag attached to Instrument engraved with the Instrument Tag No.

PRELIMINARY NOT FOR CONSTRUCTION																			
A	DC			12/22/2017	Issue for Record														
No.	By	Chk	App	Date	Description														

INSTRUMENT SPECIFICATION
Automated On/Off Valve

Project: AUSC Com Test
W.O. No.: 31609

Code: 412 | Dwg. No.: HV-7002 | Rev.: A

Sheet 1 of 1

GENERAL	1	Tag Number		P&ID Number		LV-1208				PID-AUSC-12					
	2	Service				SPRAY WATER HEATER LEVEL									
	3	Line Number		Line Material		4"-091-HPC-1203-II				CS					
	4	Line Specification				091									
	5	Equipment Number		Area Classification											
	6	Ambient Temperature Range													
	7														
PIPE LINE	8	Line Size		Line Schedule		4"				SCH 160					
	9	Pipe Material				CS									
	10	Pipe Insulation													
PROCESS CONDITIONS	11	Fluid		State		CONDENSATE				LIQUID					
	12	Fluid Comments													
	13	Design Pressure		Design Temperature		1100 PSIG				575°F					
	14	Shut Off Differential Pressure				1100 PSI									
	15					Units		Minimum		Normal		Maximum			
	16	Flow Rate				lb/hr		2460		8200		9020			
	17	Inlet Pressure				PSIA		1000		1000		1000			
	18	Pressure Drop				PSI		900		900		900			
	19	Inlet Temperature				°F		530		530		530			
	20	Inlet Density		Inlet Sp. G.		lb/ft3		47.3		47.3		47.3			
	21	Inlet Compressibility Factor				-									
	22	Inlet Viscosity				cP		0.0951		0.0951		0.0951			
	23	Inlet Specific Heat Ratio				-									
	24	Inlet Vapor Pressure													
	25	Molecular Mass				18.02									
	26														
CALC RESULTS	27	Flow Coefficient Cv				-						*			
	28	Travel				%									
	29	Sound Pressure Level				dBA									
	30														
BODY AND TRIM	31	Mfr	Model			POSITIONER	55	Tag Number			LY-1208				
	32	Body Type					56	Mfr	Model	*	*				
	33	End Conn. & Rating		900# RF FLANGE			57	Input Increase							
	34	Body Material					58	Input Signal:		4-20mA					
	35	Body Size	Trim Size		*		59	Bypass	Gauges						
	36	Bonnet Type	Material				60	Position Feedback		4-20mA					
	37	Rated Cv	Character.	*	*		61								
	38	Guiding	No. of Ports				62								
	39	Trim Type		*		AIR SET	63	Mfr	Model	*	*				
	40	Flow Direction					64	Set Pressure		*					
	41	Shutoff Classification		*			65	Filter Gauge							
	42	Lubricator	Isol Valve				66								
	43	Rated Travel		*			67								
	44	Plug/ Ball/ Disk Matl		*			68								
	45	Seat Material		*			69								
	46	Cage Matl	Stem Matl	*	*	DATA	70	Face to Face		*					
	47	Gasket Material		*			71	Approx Weight		*					
	48	Packing	Type Matl	*	*		72								
ACTUATOR	49	Mfr	Model	*	*		73								
	50	Type	Fail Act.	*	CLOSE	PURCHASE	74	Manufacturer							
	51	Size	Area	*	*		75	Model		*					
	52	Air Supply Pressure					76	Purchase Order No.							
	53	Orientation	Handwheel				77	Price	Item						
	54	Valve Fail Pos.					78	Serial Number		*					

Notes: 1. (*) - Final data provided by Supplier

2. Provide Stainless Steel Tag attached to Instrument engraved with the Instrument Tag No.

PRELIMINARY
NOT FOR CONSTRUCTION

INSTRUMENT SPECIFICATION
Control Valve

AECOM

No.	By	Chk	App	Date	Description
A	DC			12/22/2017	Issue for Record

Project: AUSC Com Test
W.O. No.: 31609

Sheet 1 of 1

Code: | Dwg. No.: LV-1208 | Rev.: A

GENERAL	1	Tag Number		P&ID Number		LV-6106			PID-AUSC-61						
	2	Service				CONDENSER LEVEL									
	3	Line Number		Line Material		6"-031-COND-6104-II			CS						
	4	Line Specification				031									
	5	Equipment Number		Area Classification											
	6	Ambient Temperature Range													
	7														
PIPE LINE	8	Line Size		Line Schedule		6"			STD						
	9	Pipe Material				CS									
	10	Pipe Insulation													
PROCESS CONDITIONS	11	Fluid		State		CONDENSATE			LIQUID						
	12	Fluid Comments													
	13	Design Pressure		Design Temperature		100 PSIG			750°F						
	14	Shut Off Differential Pressure				100 PSI									
	15					Units		Minimum		Normal		Maximum			
	16	Flow Rate				lb/hr		48750		162500		178750			
	17	Inlet Pressure				PSIA		65		65		65			
	18	Pressure Drop				PSI		10		10		10			
	19	Inlet Temperature				°F		220		220		220			
	20	Inlet Density		Inlet Sp. G.		lb/ft3		59.63		59.63		59.63			
	21	Inlet Compressibility Factor				-									
	22	Inlet Viscosity				cP		0.269		0.269		0.269			
	23	Inlet Specific Heat Ratio				-									
	24	Inlet Vapor Pressure													
	25	Molecular Mass				18.02									
	26														
CALC RESULTS	27	Flow Coefficient Cv				-						*			
	28	Travel				%									
	29	Sound Pressure Level				dBA									
	30														
BODY AND TRIM	31	Mfr	Model			POSITIONER	55	Tag Number		LY-6106					
	32	Body Type					56	Mfr	Model	*	*				
	33	End Conn. & Rating		300# RF FLANGE			57	Input Increase							
	34	Body Material					58	Input Signal:		4-20mA					
	35	Body Size	Trim Size		*		59	Bypass	Gauges						
	36	Bonnet Type	Material				60	Position Feedback		4-20mA					
	37	Rated Cv	Character.	*	*		61								
	38	Guiding	No. of Ports				62								
	39	Trim Type		*		AIR SET	63	Mfr	Model	*	*				
	40	Flow Direction					64	Set Pressure		*					
	41	Shutoff Classification		*			65	Filter Gauge							
	42	Lubricator	Isol Valve				66								
	43	Rated Travel		*			67								
	44	Plug/ Ball/ Disk Matl		*			68								
	45	Seat Material		*			69								
	46	Cage Matl	Stem Matl	*	*	DATA	70	Face to Face		*					
	47	Gasket Material		*			71	Approx Weight		*					
	48	Packing	Type Matl	*	*		72								
ACTUATOR	49	Mfr	Model	*	*		73								
	50	Type	Fail Act.	*	CLOSE	PURCHASE	74	Manufacturer							
	51	Size	Area	*	*		75	Model		*					
	52	Air Supply Pressure					76	Purchase Order No.							
	53	Orientation	Handwheel				77	Price	Item						
	54	Valve Fail Pos.					78	Serial Number		*					

Notes: 1. (*) - Final data provided by Supplier

2. Provide Stainless Steel Tag attached to Instrument engraved with the Instrument Tag No.

PRELIMINARY
NOT FOR CONSTRUCTION

INSTRUMENT SPECIFICATION
Control Valve

AECOM

No.	By	Chk	App	Date	Description
A	DC			12/22/2017	Issue for Record

Project: AUSC Com Test
W.O. No.: 31609

Sheet 1 of 1

Code: | Dwg. No.: LV-6106 | Rev.: A

GENERAL	1	Tag Number		P&ID Number		TV-1201				PID-AUSC-12					
	2	Service				SPRAY WATER HEATER TEMPERATURE									
	3	Line Number		Line Material		4"-153-SA-5002-II				9CR-2W					
	4	Line Specification				153									
	5	Equipment Number		Area Classification											
	6	Ambient Temperature Range													
	7														
PIPE LINE	8	Line Size		Line Schedule		4"				SCH 160					
	9	Pipe Material				9CR-2W									
	10	Pipe Insulation													
PROCESS CONDITIONS	11	Fluid		State		STEAM				VAPOR					
	12	Fluid Comments													
	13	Design Pressure		Design Temperature		1500 PSIG				1050°F					
	14	Shut Off Differential Pressure				1500 PSI									
	15					Units		Minimum		Normal		Maximum			
	16	Flow Rate				lb/hr		2460		8200		9020			
	17	Inlet Pressure				PSIA		1038		1038		1038			
	18	Pressure Drop				PSI									
	19	Inlet Temperature				°F		1023		1023		1023			
	20	Inlet Density		Inlet Sp. G.		lb/ft3		1.23		1.23		1.23			
	21	Inlet Compressibility Factor				-									
	22	Inlet Viscosity				cP		0.0308		0.0308		0.0308			
	23	Inlet Specific Heat Ratio				-									
	24	Inlet Vapor Pressure													
	25	Molecular Mass													
	26														
CALC RESULTS	27	Flow Coefficient Cv				-						*			
	28	Travel				%									
	29	Sound Pressure Level				dBA									
	30														
BODY AND TRIM	31	Mfr	Model			POSITIONER	55	Tag Number			TY-1201				
	32	Body Type					56	Mfr	Model	*	*				
	33	End Conn. & Rating					57	Input Increase							
	34	Body Material					58	Input Signal:			4-20mA				
	35	Body Size	Trim Size		*		59	Bypass	Gauges						
	36	Bonnet Type	Material				60	Position Feedback			4-20mA				
	37	Rated Cv	Character.	*	*		61								
	38	Guiding	No. of Ports				62								
	39	Trim Type		*		AIR SET	63	Mfr	Model	*	*				
	40	Flow Direction					64	Set Pressure		*					
	41	Shutoff Classification		*			65	Filter Gauge							
	42	Lubricator	Isol Valve				66								
	43	Rated Travel		*			67								
	44	Plug/ Ball/ Disk Matl		*			68								
	45	Seat Material		*			69								
	46	Cage Matl	Stem Matl	*	*	DATA	70	Face to Face		*					
	47	Gasket Material		*			71	Approx Weight		*					
	48	Packing	Type Matl	*	*		72								
ACTUATOR	49	Mfr	Model	*	*		73								
	50	Type	Fail Act.	*	CLOSE	PURCHASE	74	Manufacturer							
	51	Size	Area	*	*		75	Model		*					
	52	Air Supply Pressure					76	Purchase Order No.							
	53	Orientation	Handwheel				77	Price	Item						
	54	Valve Fail Pos.					78	Serial Number		*					

Notes: 1. (*) - Final data provided by Supplier

2. Provide Stainless Steel Tag attached to Instrument engraved with the Instrument Tag No.

PRELIMINARY
NOT FOR CONSTRUCTION

INSTRUMENT SPECIFICATION
Control Valve

AECOM

No.	By	Chk	App	Date	Description
A	DC			12/22/2017	Issue for Record

Project: AUSC Com Test
W.O. No.: 31609

Sheet 1 of 1

Code: | Dwg. No.: TV-1201 | Rev.: A

GENERAL	1	Tag Number		P&ID Number		TV-3061				PID-AUSC-41					
	2	Service				GAS COOLING WATER									
	3	Line Number		Line Material		6"-031-WGC-4101-II				CS					
	4	Line Specification				031									
	5	Equipment Number		Area Classification											
	6	Ambient Temperature Range													
	7														
PIPE LINE	8	Line Size		Line Schedule		6"				STD					
	9	Pipe Material				CS									
	10	Pipe Insulation													
PROCESS CONDITIONS	11	Fluid		State		WATER				LIQUID					
	12	Fluid Comments													
	13	Design Pressure		Design Temperature		525 PSIG				380°F					
	14	Shut Off Differential Pressure				525 PSI									
	15					Units		Minimum		Normal		Maximum			
	16	Flow Rate				lb/hr		61836		206120		226732			
	17	Inlet Pressure				PSIA		165		165		165			
	18	Pressure Drop				PSI		10		10		10			
	19	Inlet Temperature				°F		207		207		207			
	20	Inlet Density		Inlet Sp. G.		lb/ft3		59.9		59.9		59.9			
	21	Inlet Compressibility Factor				-									
	22	Inlet Viscosity				cP		0.29		0.29		0.29			
	23	Inlet Specific Heat Ratio				-									
	24	Inlet Vapor Pressure													
	25	Molecular Mass				18.02									
	26														
CALC RESULTS	27	Flow Coefficient Cv				-						*			
	28	Travel				%									
	29	Sound Pressure Level				dBA									
	30														
BODY AND TRIM	31	Mfr	Model			POSITIONER	55	Tag Number			TY-3061				
	32	Body Type					56	Mfr	Model	*	*				
	33	End Conn. & Rating		300# RF FLANGE			57	Input Increase							
	34	Body Material					58	Input Signal:		4-20mA					
	35	Body Size	Trim Size		*		59	Bypass	Gauges						
	36	Bonnet Type	Material				60	Position Feedback		4-20mA					
	37	Rated Cv	Character.	*	*		61								
	38	Guiding	No. of Ports				62								
	39	Trim Type		*		AIR SET	63	Mfr	Model	*	*				
	40	Flow Direction					64	Set Pressure		*					
	41	Shutoff Classification		*			65	Filter Gauge							
	42	Lubricator	Isol Valve				66								
	43	Rated Travel		*			67								
	44	Plug/ Ball/ Disk Matl		*			68								
	45	Seat Material		*			69								
	46	Cage Matl	Stem Matl	*	*	DATA	70	Face to Face		*					
	47	Gasket Material		*			71	Approx Weight		*					
	48	Packing	Type Matl	*	*		72								
ACTUATOR	49	Mfr	Model	*	*		73								
	50	Type	Fail Act.	*	CLOSE	PURCHASE	74	Manufacturer							
	51	Size	Area	*	*		75	Model		*					
	52	Air Supply Pressure					76	Purchase Order No.							
	53	Orientation	Handwheel				77	Price	Item						
	54	Valve Fail Pos.					78	Serial Number		*					

Notes: 1. (*) - Final data provided by Supplier

2. Provide Stainless Steel Tag attached to Instrument engraved with the Instrument Tag No.

PRELIMINARY
NOT FOR CONSTRUCTION

INSTRUMENT SPECIFICATION
Control Valve

AECOM

No.	By	Chk	App	Date	Description
A	DC			12/22/2017	Issue for Record

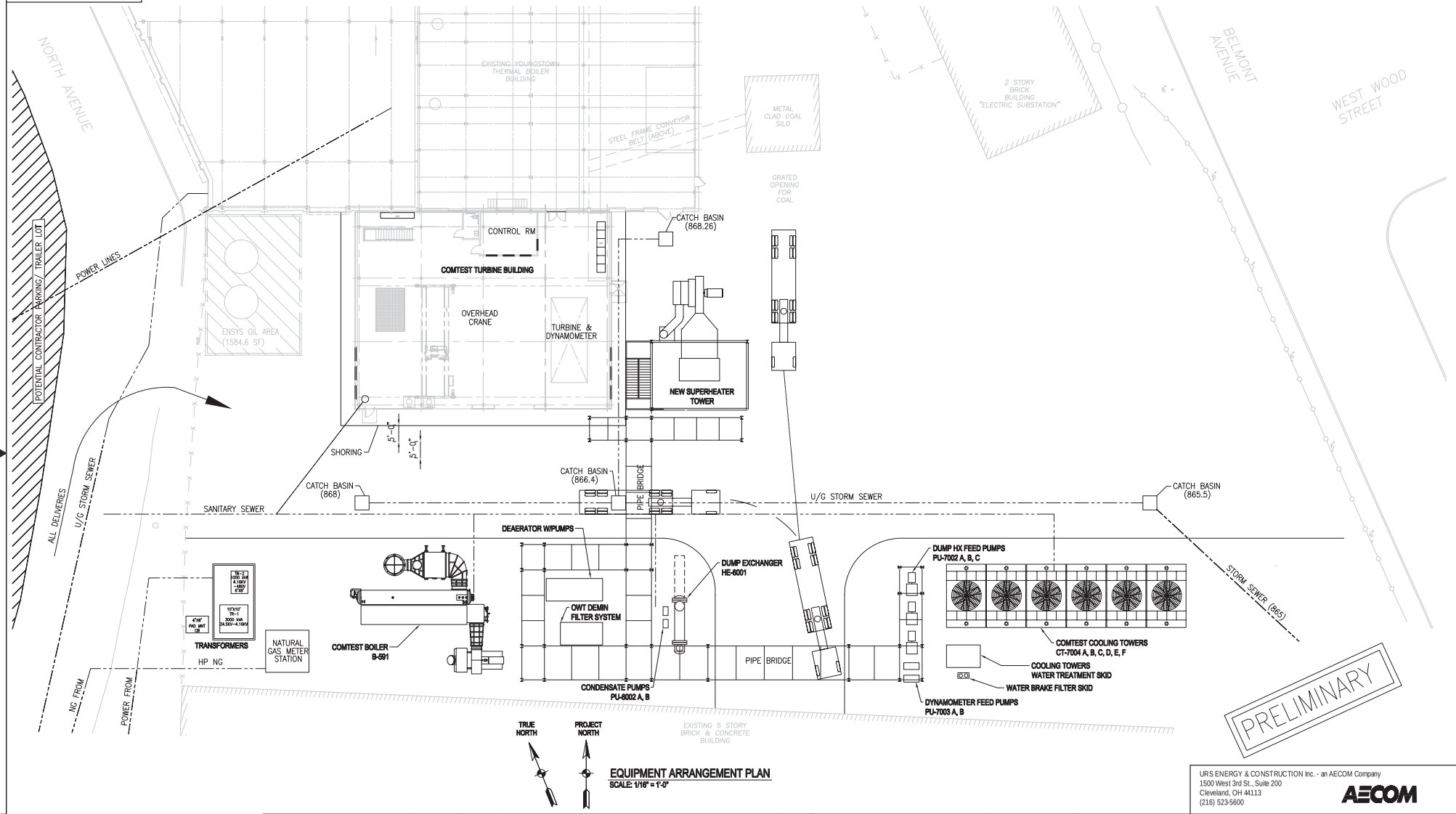
Project: AUSC Com Test
W.O. No.: 31609

Sheet 1 of 1

Code: | Dwg. No.: TV-3061 | Rev.: A

Mechanical

15-11-405-001



PRELIMINARY

EQUIPMENT ARRANGEMENT PLAN
SCALE: 1/16" = 1'-0"

REVISION APPROVAL RECORD				REV		REV NO	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C						A	3/31/16	ISSUED FOR FEED	BD	RG

DRAWING STATUS				
ISSUED	REV	DATE	SCE	PEM
PRELIMINARY	A	3/31/16	RG	DM
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV.NO.

PROJECT NO.: 31609
DRAWN: BD DATE: 03-07-16
CHECKED: DATE:
SCALE: AS NOTED

URS ENERGY & CONSTRUCTION Inc. - an AECOM Company
1500 West 3rd St., Suite 200
Cleveland, OH 44113
(216) 523-5600
AECOM

ENERGY INDUSTRIES of OHIO
6100 Oak Tree Boulevard, Suite 200
Independence, OH 44131
(216) 643-2952

A-USC COMTEST PROJECT
MECHANICAL
EQUIPMENT ARRANGEMENT PLAN

DWG. NO. 15-11-405-001 REV A

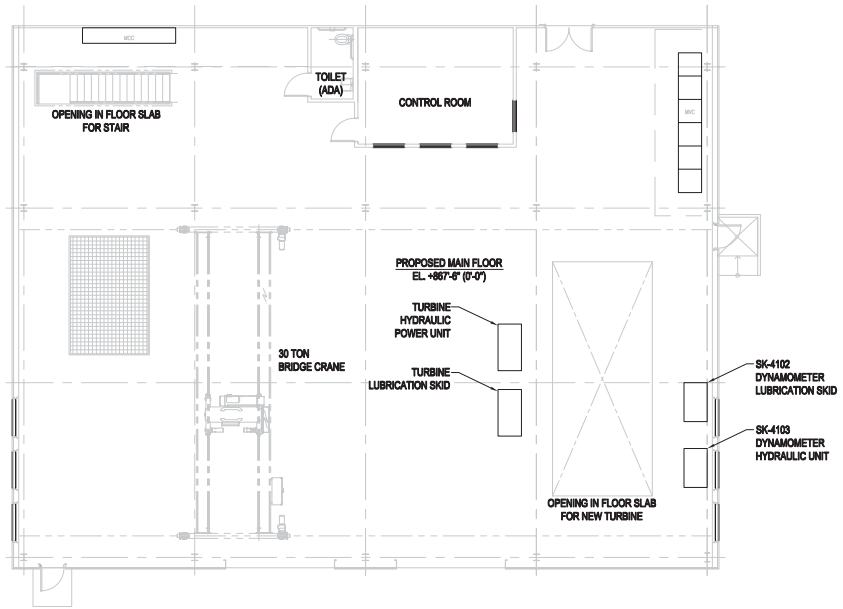
EC_D_Size.dwg

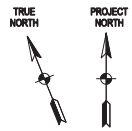
INCHES CENTIMETERS

8 7 6 5 4 3 2 1

D C B A

15-11-405-002





LEVEL 1 FLOOR PLAN

SCALE: ⅛" = 1'-0"

PRELIMINARY

REVISION APPROVAL RECORD				REV		REV NO	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C						A	3/31/16	ISSUED FOR FEED	BD	RG

DRAWING STATUS				
ISSUED	REV	DATE	SCE	PEM
PRELIMINARY	A	3/31/16	RG	DM
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV.NO.

PROJECT NO.: 31609

DRAWN: BD DATE: 03-07-16

CHECKED: DATE:

SCALE: AS NOTED

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Cleveland, OH 44113
(216) 523-5600

AECOM

ENERGY INDUSTRIES of OHIO
6100 Oak Tree Boulevard, Suite 200
Independence, OH 44131
(216) 643-2952

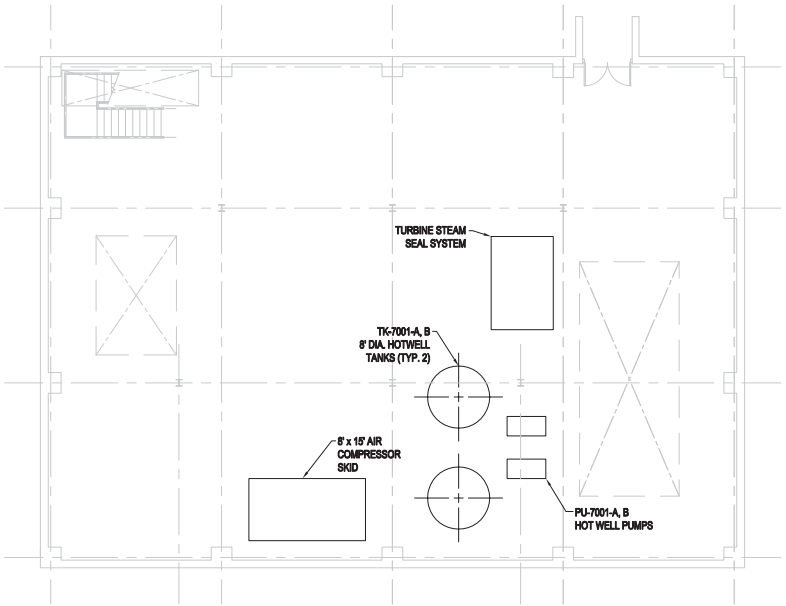
A-USC COMTEST PROJECT
MECHANICAL EQUIPMENT LAYOUT
LEVEL 1 FLOOR PLAN

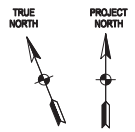
DWG. NO. 15-11-405-002 REV A

INCHES CENTIMETERS

EC_D_Size.dwg

15-11-405-003





BASEMENT FLOOR PLAN
SCALE: 1/8" = 1'-0"

PRELIMINARY

REVISION APPROVAL RECORD				REV		REV NO	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C						A	3/31/16	ISSUED FOR FEED	BD	RG

DRAWING STATUS				
ISSUED	REV	DATE	SCE	PEM
PRELIMINARY	A	3/31/16	RG	DM
APPROVED FOR CONSTRUCTION				

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DRAWN: BD DATE: 03-07-16
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A-USC COMTEST PROJECT
MECHANICAL EQUIPMENT LAYOUT
LOWER LEVEL FLOOR PLAN

DWG. NO. 15-11-405-003 REV A

EC_D_Size.dwg

INCHES CENTIMETERS

15-11-411-001

EQUIPMENT NOTES:

EF-1

CEILING EXHAUST FAN

GREENHECK MODEL SP-B110
90 CFM AT 0.5" S.P.
115/1/60

HP-1/CU-1

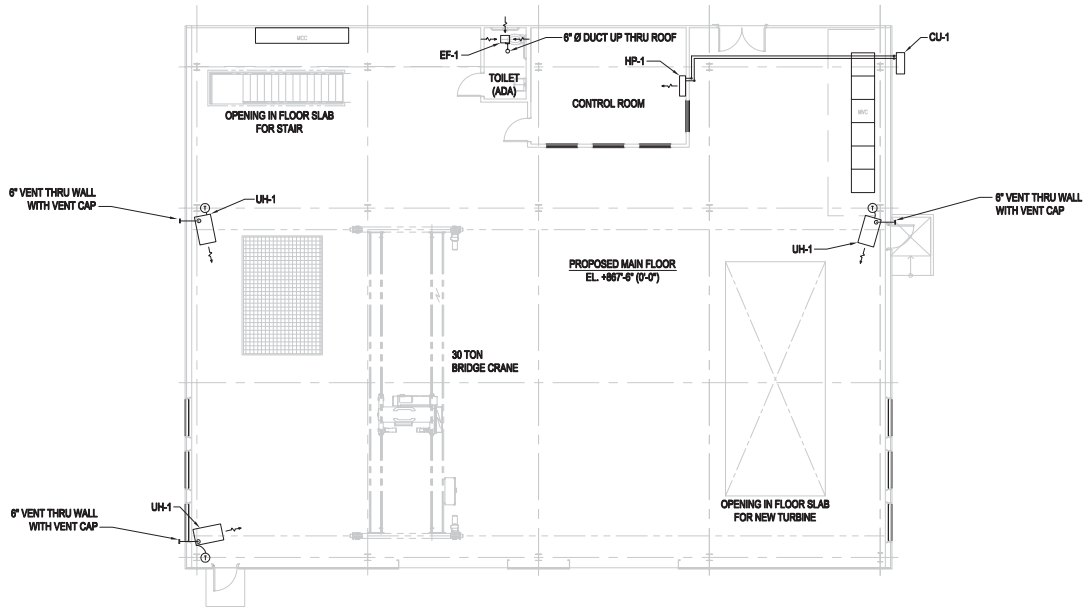
DUCTLESS HEAT PUMP SYSTEM - WALL MOUNTED

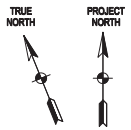
17,200 BTUH COOLING CAPACITY
21,600 BTUH HEATING CAPACITY
POWER CONSUMPTION 1,900 WATTS (HEATING)
MITSUBISHI M-SERIES
MODEL MUZ-GE18NA-1 OUTDOOR CONDENSER (CU-1)
MODEL MSZ-GE18NA-9 WALL MOUNTED UNIT (HP-1)

UH-1

GAS FIRED UNIT HEATER

150,000 BTUH (INPUT) 120,000 BTUH (OUTPUT)
TRANE MODEL GHNE015AT
115V POWER SUPPLY 1/4 HP MOTOR WITH POWER VENTER,
DIRECT SPARK IGNITION AND SINGLE STAGE ROOM THERMOSTAT





LEVEL 1 FLOOR PLAN

SCALE: 1/8" = 1'-0"

PRELIMINARY

REVISION APPROVAL RECORD				REV		REV NO	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C						A	3/31/16	ISSUED FOR FEED	BD	RG

DRAWING STATUS				
ISSUED	REV	DATE	SCE	PEM
PRELIMINARY	A	3/31/16	RG	DM
APPROVED FOR CONSTRUCTION				

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PROJECT NO.: 31609
DRAWN: BD DATE: 03-10-16
CHECKED: DATE:
SCALE: AS NOTED

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A-USC COMTEST PROJECT
HVAC EQUIPMENT LAYOUT
LEVEL 1 FLOOR PLAN

DWG. NO. 15-11-411-001 REV A

INCHES CENTIMETERS

EC_D_Size.dwg

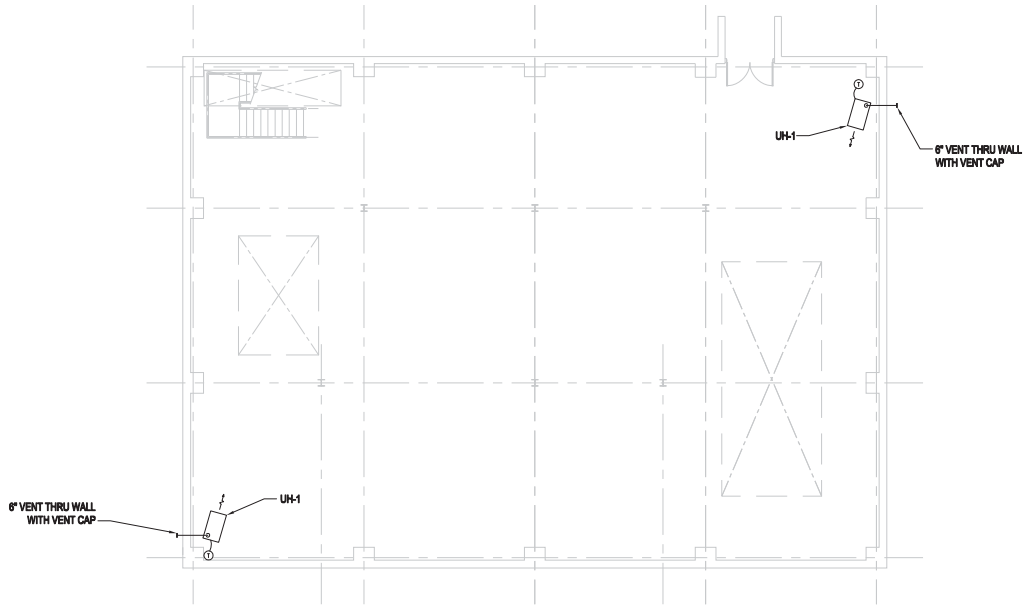
15-11-411-002

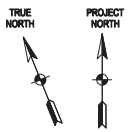
EQUIPMENT NOTES:

UH-1

GAS FIRED UNIT HEATER

150,000 BTUH (INPUT) 120,000 BTUH (OUTPUT)
TRANE MODEL GHNE015AT
115V POWER SUPPLY 1/4 HP MOTOR WITH POWER VENTER,
DIRECT SPARK IGNITION AND SINGLE STAGE ROOM THERMOSTAT





BASEMENT FLOOR PLAN

SCALE: 1/8" = 1'-0"

PRELIMINARY

REVISION APPROVAL RECORD				REV		REV NO	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
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CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C						A	3/31/16	ISSUED FOR FEED	BD	RG

DRAWING STATUS				
ISSUED	REV	DATE	SCE	PEM
PRELIMINARY	A	3/31/16	RG	DM
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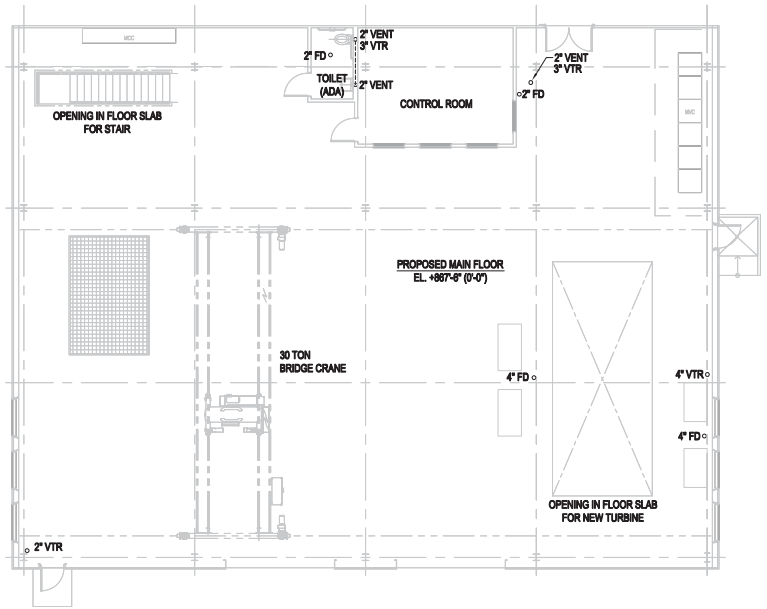
A-USC COMTEST PROJECT
HVAC EQUIPMENT LAYOUT
LOWER LEVEL FLOOR PLAN

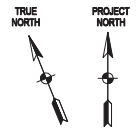
DWG. NO. 15-11-411-002 REV A

INCHES CENTIMETERS

EC_D_Size.dwg

15-11-432-001





LEVEL 1 FLOOR PLAN
SCALE: 1/8" = 1'-0"

PRELIMINARY

REVISION APPROVAL RECORD				REV		REV NO	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C						A	3/31/16	ISSUED FOR FEED	BD	RG

DRAWING STATUS				
ISSUED	REV	DATE	SCE	PEM
PRELIMINARY	A	3/31/16	RG	DM
APPROVED FOR CONSTRUCTION				

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SCALE: AS NOTED

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A-USC COMTEST PROJECT
PLUMBING LAYOUT
LEVEL 1 FLOOR PLAN

DWG. NO. 15-11-432-001 REV A

INCHES 1 2 CENTIMETERS 1 2 3 4 5 6

8 7 6 5 4 3 2 1

D C B A

EC_D_Size.dwg

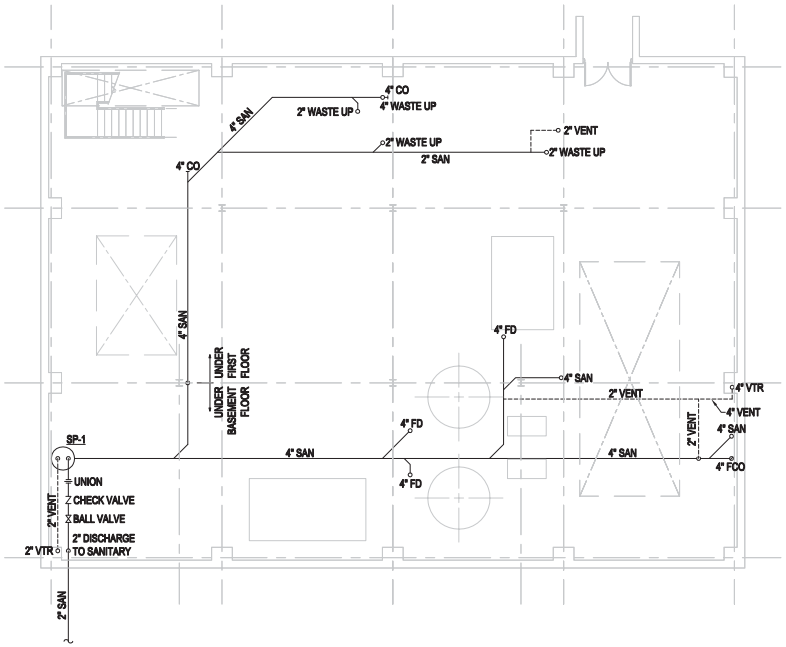
15-11-432-002

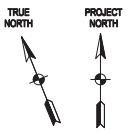
EQUIPMENT NOTES:

SP-1

SUMP PUMP

SUBMERSIBLE SHREDDER SEWAGE PUMP
AMT MODEL 5769-95, 60 GPM @ 20 FT HD
460V/3/60 2" NPT DISCHARGE
W/ FLOAT SWITCH
SEWAGE BASIN 24" DIA X 36" DEEP
W/STEEL BASIN COVER





BASEMENT FLOOR PLAN
SCALE: 1/8" = 1'-0"

PRELIMINARY

REVISION APPROVAL RECORD				REV		REV NO	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C						A	3/31/16	ISSUED FOR FEED	BD	RG

DRAWING STATUS				
ISSUED	REV	DATE	SCE	PEM
PRELIMINARY	A	3/31/16	RG	DM
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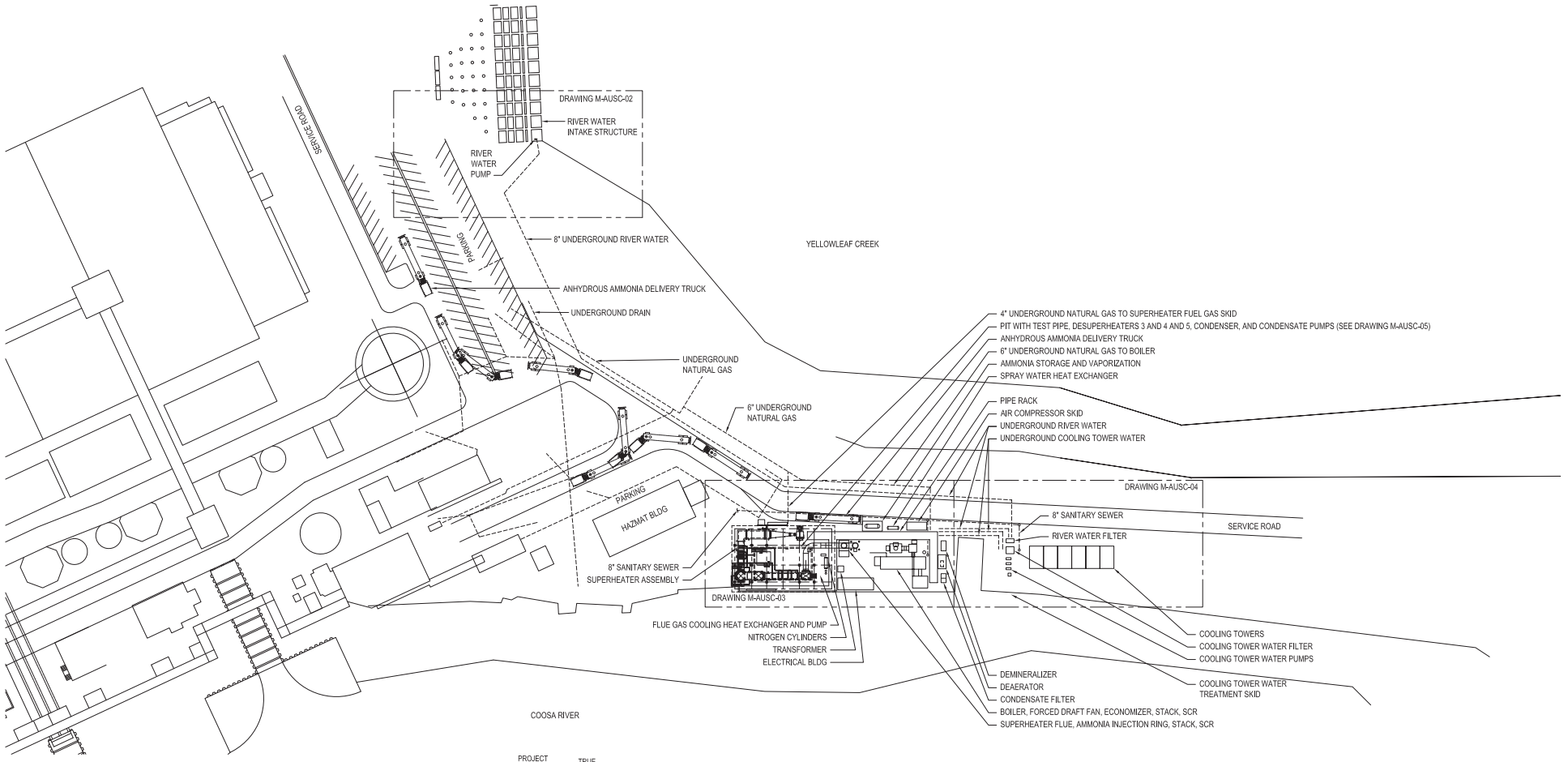
A-USC COMTEST PROJECT
PLUMBING LAYOUT
LOWER LEVEL FLOOR PLAN

DWG. NO. 15-11-432-002 REV A

EC_D_Size.dwg

INCHES CENTIMETERS

M-AUSC-01



PROJECT NORTH

TRUE NORTH

MECHANICAL EQUIPMENT ARRANGEMENT OVERALL PLAN

SCALE: 1" = 50'-0"

0' 50' 100'
SCALE

PRELIMINARY NOT FOR CONSTRUCTION

REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
A	12/22/17	ISSUE FOR RECORD	JK	

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY				
APPROVED FOR CONSTRUCTION				

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PROJECT NO.: 31609
DRAWN: JK DATE: 12-18-17
CHECKED: DATE:
SCALE: 1" = 50'-0"

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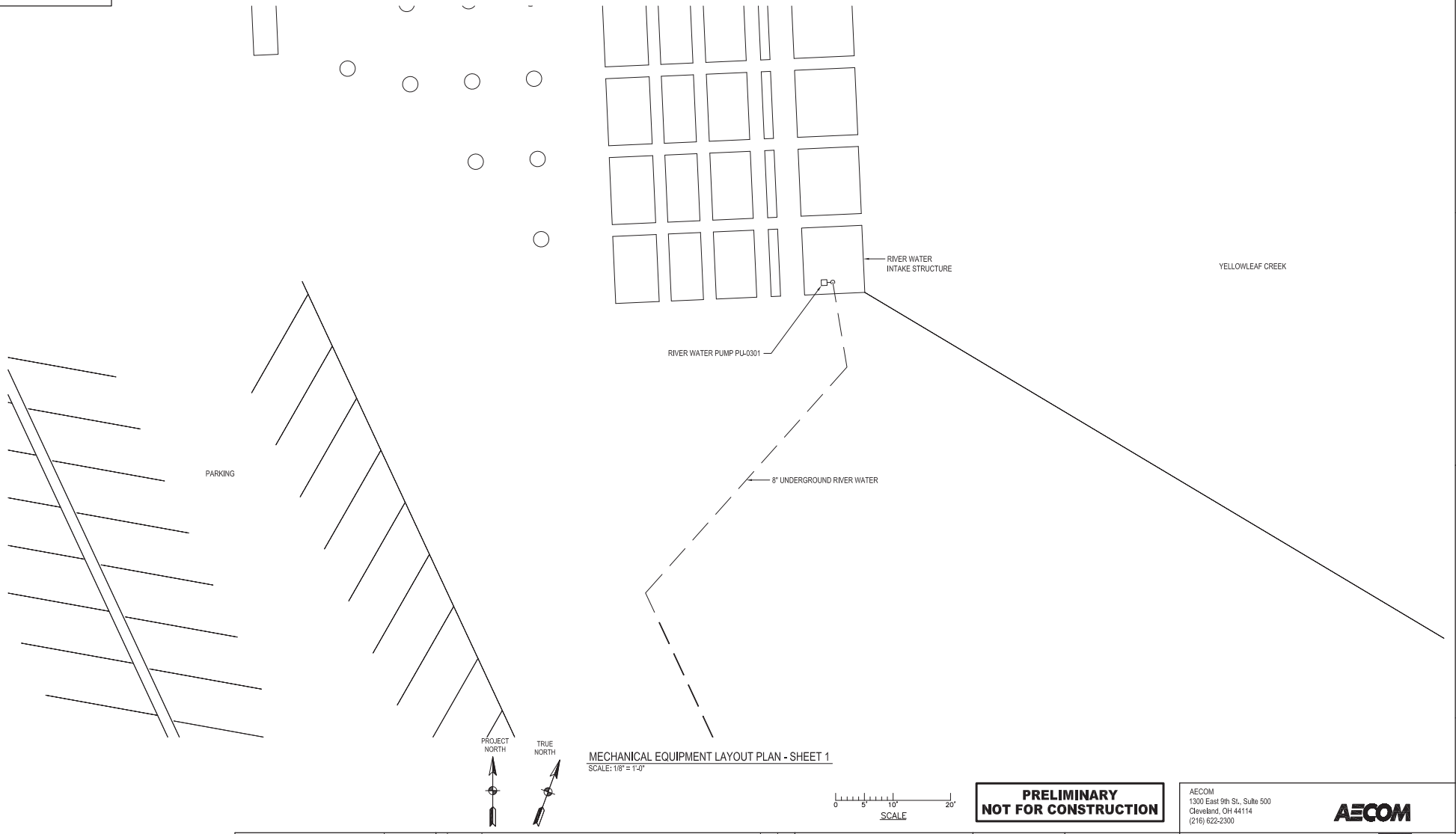
A-USC COMTEST PROJECT
MECHANICAL EQUIPMENT ARRANGEMENT OVERALL PLAN

DWG. NO. M-AUSC-01 REV A

INCHES / CENTIMETERS

EC_D_Size.dwg

M-AUSC-02



MECHANICAL EQUIPMENT LAYOUT PLAN - SHEET 1
SCALE: 1/8" = 1'-0"

0 5' 10' 20'
SCALE

PRELIMINARY
NOT FOR CONSTRUCTION

REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
A	12/22/17	ISSUE FOR RECORD	JK	

DRAWING STATUS

ISSUED	REV	DATE	SDE	PEM
PRELIMINARY				
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PROJECT NO.: 31609
DRAWN: JK DATE: 12-18-17
CHECKED: DATE:
SCALE: 1/8" = 1'-0"

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A-USC COMTEST PROJECT
MECHANICAL EQUIPMENT LAYOUT PLAN – SHEET 1

DWG. NO. M-AUSC-02 REV A

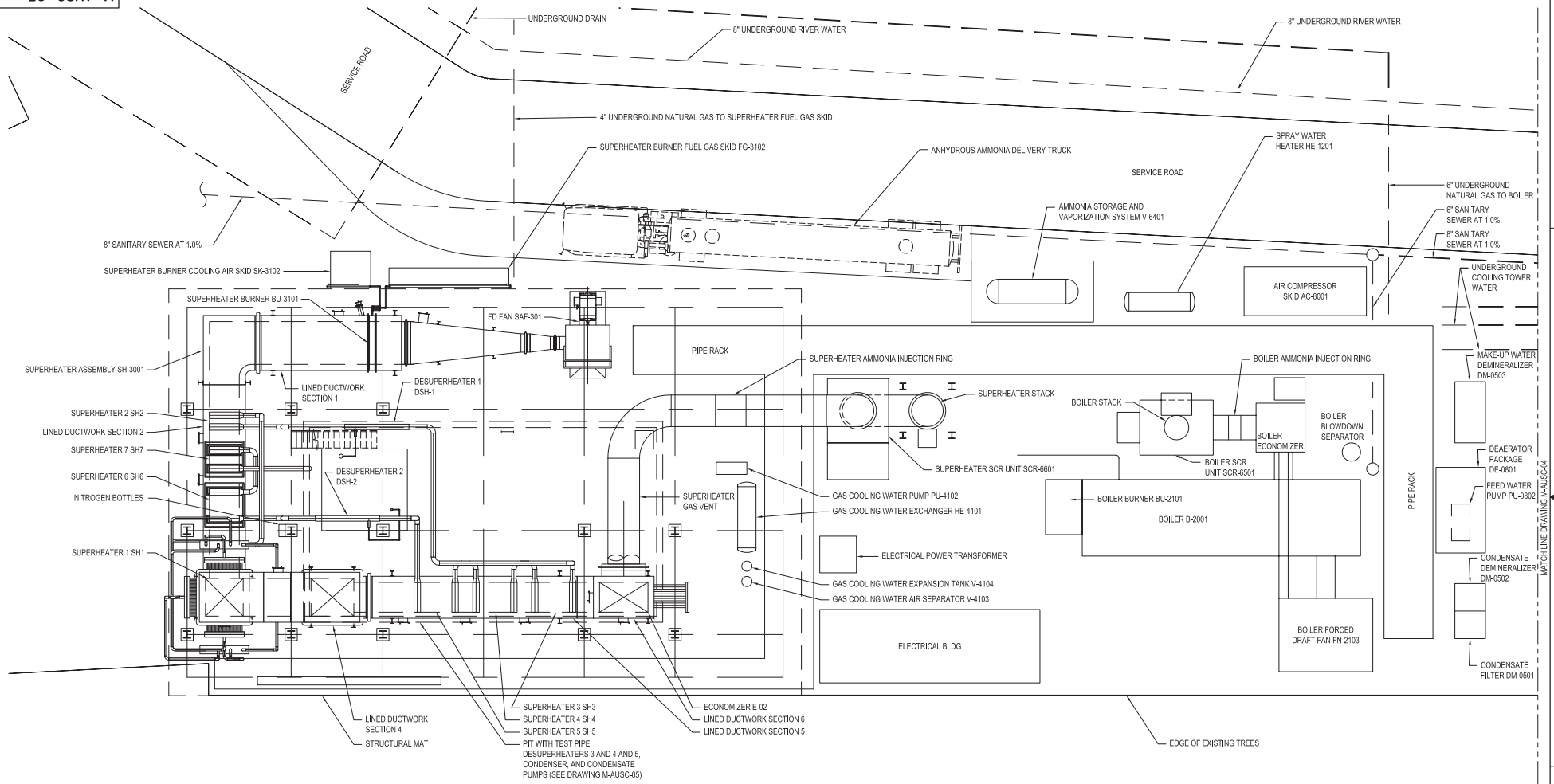
INCHES 1 2
CENTIMETERS 1 2 3 4 5 6

8 7 6 5 4 3 2 1

D C B A

EC_D_Size.dwg

M-AUSC-03



PROJECT NORTH

TRUE NORTH

MECHANICAL EQUIPMENT LAYOUT PLAN - SHEET 2

SCALE: 1/8" = 1'-0"

0 5' 10' 20'
SCALE

PRELIMINARY NOT FOR CONSTRUCTION

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REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
A	12/22/17	ISSUE FOR RECORD	JK	

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY				
APPROVED FOR CONSTRUCTION				

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PROJECT NO.: 31609
DRAWN: JK DATE: 12-18-17
CHECKED: DATE:
SCALE: 1/8" = 1'-0"

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A-USC COMTEST PROJECT MECHANICAL EQUIPMENT LAYOUT PLAN – SHEET 2

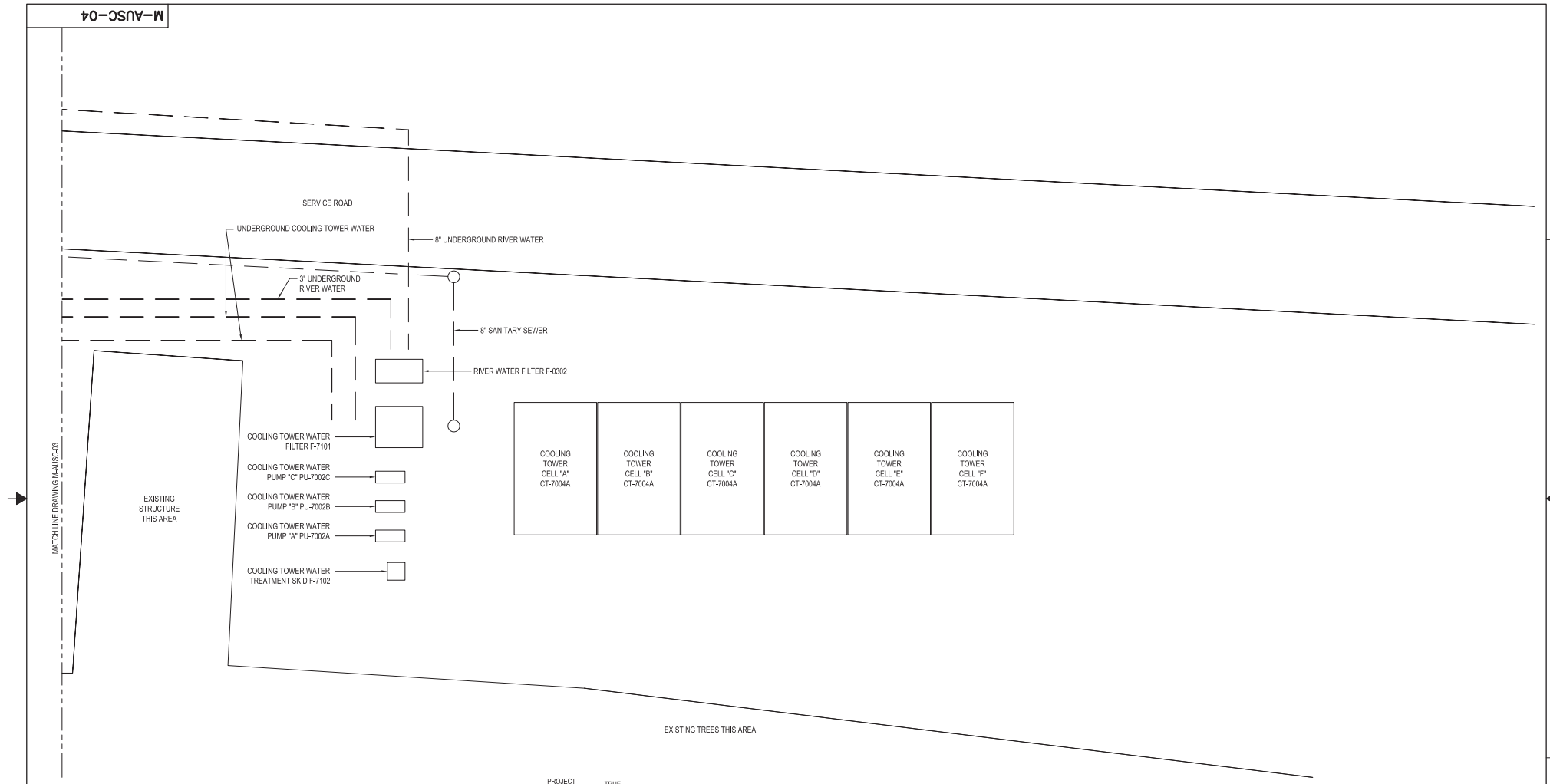
DWG. NO. M-AUSC-03 REV A

INCHES 1 2
CENTIMETERS 1 2 3 4 5 6

8 7 6 5 4 3 2 1

D C B A

EC_D_Size.dwg



MECHANICAL EQUIPMENT LAYOUT PLAN - SHEET 3

SCALE: 1/8" = 1'-0"

PRELIMINARY NOT FOR CONSTRUCTION

REVISION APPROVAL RECORD				REV		REV NO.	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C										
						A	12/22/17	ISSUE FOR RECORD	JK	

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY				
APPROVED FOR CONSTRUCTION				

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PROJECT NO.: 31609

DRAWN: JK DATE: 12-18-17

CHECKED: DATE:

SCALE: 1/8" = 1'-0"

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A-USC COMTEST PROJECT
MECHANICAL EQUIPMENT LAYOUT PLAN - SHEET 3

DWG. NO. M-AUSC-04

REV A

EC_D_Size.dwg

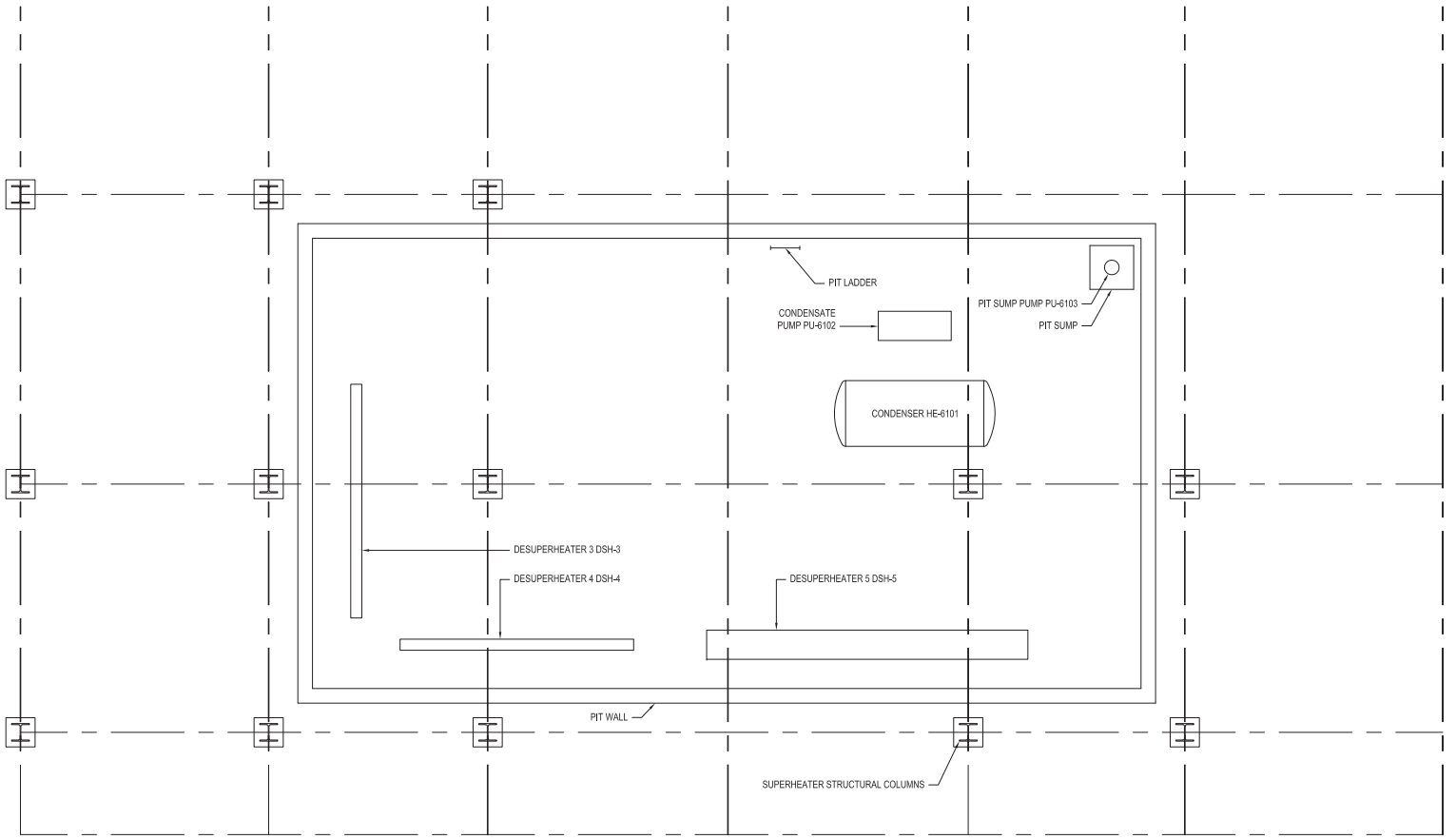
INCHES 1 2

CENTIMETERS 1 2 3 4 5 6

8 7 6 5 4 3 2 1

D C B A

M-AUSC-05



PROJECT NORTH

TRUE NORTH

MECHANICAL EQUIPMENT LAYOUT PLAN - SHEET 4

SCALE: 1/4" = 1'-0"

0 5' 10"

SCALE

PRELIMINARY NOT FOR CONSTRUCTION

REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
A	12/22/17	ISSUE FOR RECORD	JK	

DRAWING STATUS				
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PRELIMINARY				
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PROJECT NO.: 31609

DRAWN: JK DATE: 12-18-17

CHECKED: DATE:

SCALE: 1/4" = 1'-0"

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(216) 643-2952

A-USC COMTEST PROJECT MECHANICAL EQUIPMENT LAYOUT PLAN – SHEET 4

DWG. NO. M-AUSC-05

REV A

INCHES 1 2

CENTIMETERS 1 2 3 4 5 6

8 7 6 5 4 3 2 1

D C B A

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A-USC Component Test Project
Balance of Plant Equipment List

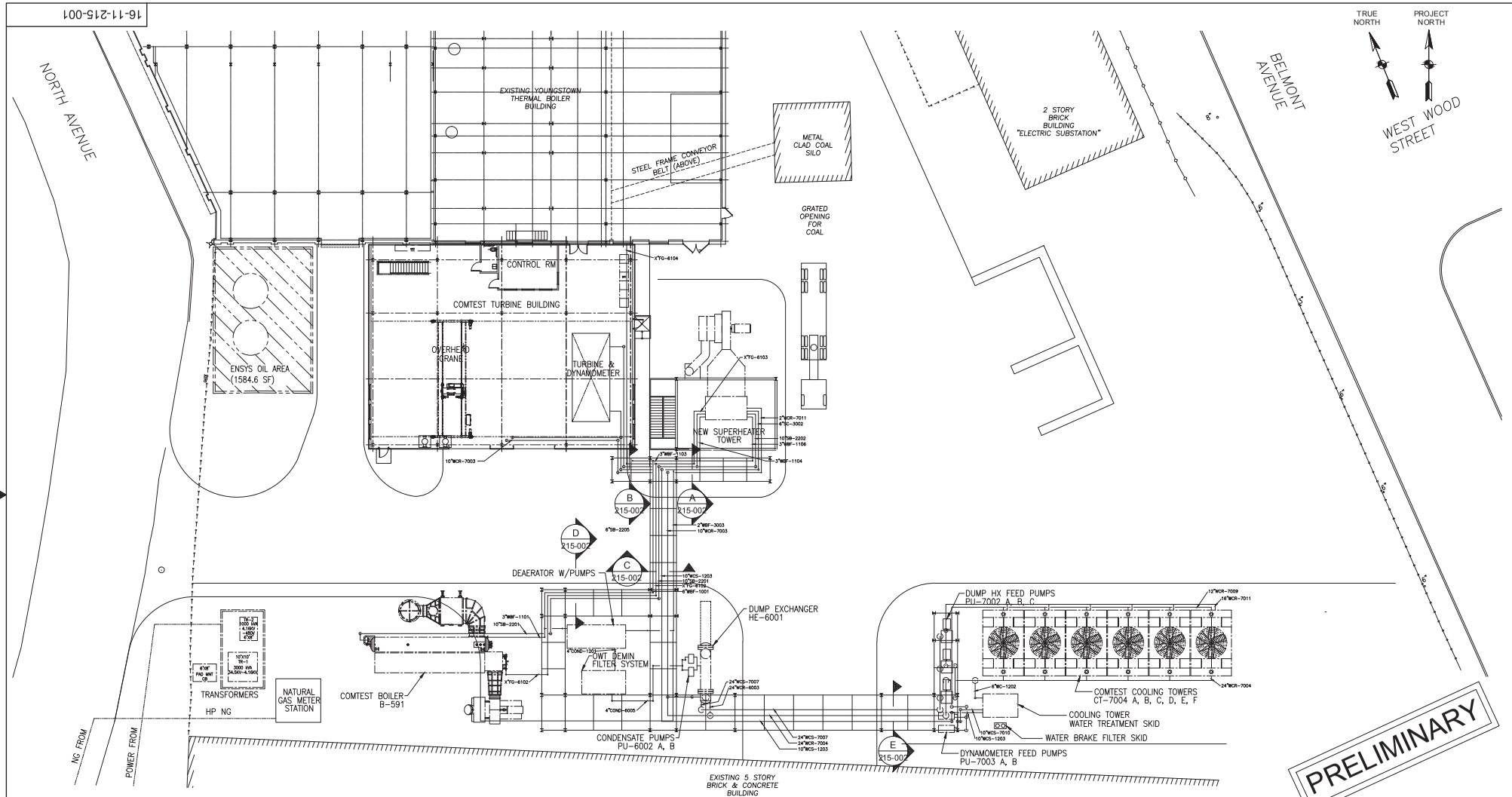
Tag Number	Equipment Name	P&ID Number	Design Pressure (psig)	Design Temperature (°F)	Operating Process Condition (psig and °F)						Capacity	Tag Number	Materials of Construction	Motor Brake (HP, kW or kVA)	Non-Motor Nameplate (kW or kVA)	Non-Motor Operating (kW or kVA)	Speed (RPM)	Drive Requirements	Power	Current (FLA)	Compressed Air (SCFM / PSIG)	Boiler Feed Water (GPM)
					Operating Pressure (Maximum)	Operating Temperature (Maximum)	Operating Pressure (Normal)	Operating Temperature (Normal)	Operating Pressure (Minimum)	Operating Temperature (Minimum)												
TBD	Rental Deaerator Skid w/Pumps	PID-YTT-10	50	TBD	-	-	-	-	-	-	150,000 LB/HR	TBD	Carbon Steel	4 x 50 HP	-	-	-	-	460/3/60	400	TBD	TBD
TBD	Demineralizer / Filter Skid	PID-YTT-12	-	-	-	-	-	-	-	-	TBD	TBD	-	-	-	-	-	-	TBD	TBD	-	-
TBD	Cooling Tower Water Treatment	PID-YTT-12	-	-	-	-	-	-	-	-	TBD		-	-	-	-	-	-	120/1/60	6.3	-	-
TBD	OWT System	PID-YTT-12	-	-	-	-	-	-	-	-	TBD		-	-	-	-	-	-	TBD	TBD	-	-
B-591	Boiler	PID-YTT-20	1100	850	-	-	950	750	-	-	150,000 LB/HR	B-591	-	-	-	-	-	-	460/3/60	200	TBD (Instrument)	459
BNR-591	Burner	PID-YTT-20	-	-	-	-	-	-	-	-	-	BNR-591	-	-	-	-	-	-	-	-	-	-
F-591	Centrifugal Fan	PID-YTT-20	-	-	-	-	30.0 in. wc	103	-	-	50,455 ACFM	F-591	Carbon Steel	-	-	-	TBD	TBD	-	-	-	-
FM-591	Centrifugal Fan Motor	PID-YTT-20	-	-	-	-	-	-	-	-	-	FM-591	-	600 HP	-	-	TBD	TBD	4160/3/60	TBD	-	-
DS-2201	Desuperheater	PID-YTT-22	750	850	TBD	TBD	50	674	TBD	TBD	30,000 LB/HR	DS-2201	A-335 Grade P11	-	-	-	-	-	-	-	-	4.9
TBD	Superheater	PID-YTT-30	-	-	-	-	-	-	-	-	-	TBD	-	-	-	-	-	-	-	-	-	-
TBD	FD & Flue Gas Recirculation Fan	PID-YTT-31	-	-	-	-	-	-	-	-	-	TBD	-	500 HP	-	-	-	-	4160/3/60	TBD	-	-
TBD	FGR Damper Seal Air Fan	PID-YTT-31										TBD		100 HP					460/3/60	TBD		
TUR-4001	A-USC Turbine	PID-YTT-40									10.0 MW	TUR-4001										
TBD	Oil Pump	PID-YTT-40	-	-	-	-	-	-	-	-	TBD	TBD	-	15 HP	-	-	TBD	TBD	460/3/60	TBD	-	-
TBD	Oil Pump	PID-YTT-40	-	-	-	-	-	-	-	-	TBD	TBD	-	15 HP	-	-	TBD	TBD	460/3/60	TBD	-	-
TBD	Turning Gear Oil Pump	PID-YTT-40	-	-	-	-	-	-	-	-	TBD	TBD	-	5 HP	-	-	TBD	TBD	460/3/60	TBD	-	-
DY-4101	Hydraulic Dynamometer	PID-YTT-41	-	-	-	-	-	-	-	-	10.0 MW	DY-4101	Carbon Steel	-	-	-	-	-	N/A	N/A	5.0 SCFM @ 15-20 PSIG, 5µ filter	-
SK-4102	Lubrication System	PID-YTT-41	-	-	-	-	-	-	-	-	5 - 6.5 GPM	SK-4102	Carbon Steel	TBD	N/A	N/A	-	-	460/3/60	1.5 / 2.5	-	-
SK-4103	Hydraulic Power Unit	PID-YTT-41	-	-	-	-	-	-	-	-	12 GPM	SK-4103	Carbon Steel	20 HP	N/A	N/A	-	-	460/3/60	25	-	-
DS-4201	Desuperheater	PID-YTT-42	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	DS-4201	Inconel Alloy 740H	-	-	-	-	-	-	-	-	-
DS-5001	Desuperheater	PID-YTT-50	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	DS-5001	Inconel Alloy 740H	-	-	-	-	-	-	-	-	TBD
TBD	Header Thick Wall Section	PID-YTT-51	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD		Inconel Alloy 740H	-	-	-	-	-	-	-	-	-
DS-5103	Desuperheater	PID-YTT-51	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	DS-5103	Inconel Alloy 740H	-	-	-	-	-	-	-	-	TBD
HE-6001	Dump Exchanger	PID-YTT-60	250 / FV	800	TBD	TBD	TBD	TBD	TBD	TBD	191.2 MM Btu/H	HE-6001	SA-213-304L SS	-	-	-	-	-	-	-	-	-
PU-6002-A	Condensate Return Pump	PID-YTT-60	TBD	TBD	TBD	TBD	155	200	TBD	TBD	350 GPM	PU-6002-A	Cast Iron w/bronze impeller	15 HP	-	-	1750	-	460/3/60	TBD	-	-
PU-6002-B	Condensate Return Pump	PID-YTT-60	TBD	TBD	TBD	TBD	155	220	TBD	TBD	350 GPM	PU-6002-B	Cast Iron w/bronze impeller	15 HP	-	-	1750	-	460/3/60	TBD	-	-
CT-7004-A	Cooling Tower	PID-YTT-70	-	-	-	-	-	-	-	-	1201 Tons	CT-7004-A	Galvanized/Stainless Steel	75 HP	-	24 kW-Basin Heater	1750	-	460/3/60	TBD	-	-
CT-7004-B	Cooling Tower	PID-YTT-70	-	-	-	-	-	-	-	-	1201 Tons	CT-7004-A	Galvanized/Stainless Steel	75 HP	-	24 kW-Basin Heater	1750	-	460/3/60	TBD	-	-
CT-7004-C	Cooling Tower	PID-YTT-70	-	-	-	-	-	-	-	-	1201 Tons	CT-7004-A	Galvanized/Stainless Steel	75 HP	-	24 kW-Basin Heater	1750	-	460/3/60	TBD	-	-
CT-7004-D	Cooling Tower	PID-YTT-70	-	-	-	-	-	-	-	-	1201 Tons	CT-7004-A	Galvanized/Stainless Steel	75 HP	-	24 kW-Basin Heater	1750	-	460/3/60	TBD	-	-
CT-7004-E	Cooling Tower	PID-YTT-70	-	-	-	-	-	-	-	-	1201 Tons	CT-7004-A	Galvanized/Stainless Steel	75 HP	-	24 kW-Basin Heater	1750	-	460/3/60	TBD	-	-
CT-7004-F	Cooling Tower	PID-YTT-70	-	-	-	-	-	-	-	-	1201 Tons	CT-7004-A	Galvanized/Stainless Steel	75 HP	-	24 kW-Basin Heater	1750	-	460/3/60	TBD	-	-
TK-7001-A	Hot Well Tank A	PID-YTT-70	ATM	140	-	-	-	-	-	-	5,500 Gallons		FRP	-	-	-	-	-	-	-	-	-
TK-7001-B	Hot Well Tank B	PID-YTT-70	ATM	140	-	-	-	-	-	-	5,500 Gallons		FRP	-	-	-	-	-	-	-	-	-
PU-7001-A	Hot Well Pump	PID-YTT-70	TBD	TBD	-	-	0	130	-	-	1,850 GPM	PU-7001-A	Cast Iron w/bronze impeller	50 HP	-	-	1750	-	460/3/60	TBD	-	-
PU-7001-B	Hot Well Pump	PID-YTT-70	TBD	TBD	-	-	0	130	-	-	1,850 GPM	PU-7001-B	Cast Iron w/bronze impeller	50 HP	-	-	1750	-	460/3/60	TBD	-	-
PU-7002-A	Dump Exchanger Feed Pump	PID-YTT-70	TBD	TBD	-	-	50	98	-	-	10,000 GPM	PU-7002-A	Cast Iron w/si brz impeller	500 HP	-	-	1750	-	4160/3/60	TBD	-	-
PU-7002-B	Dump Exchanger Feed Pump	PID-YTT-70	TBD	TBD	-	-	50	98	-	-	10,000 GPM	PU-7002-B	Cast Iron w/si brz impeller	500 HP	-	-	1750	-	4160/3/60	TBD	-	-
PU-7002-C	Dump Exchanger Feed Pump	PID-YTT-70	TBD	TBD	-	-	50	98	-	-	10,000 GPM	PU-7002-C	Cast Iron w/si brz impeller	500 HP	-	-	1750	-	4160/3/60	TBD	-	-
PU-7003-A	Dynamometer Supply Pump	PID-YTT-70	TBD	TBD	-	-	50	90	-	-	1,675 GPM	PU-7003-A	Cast Iron w/cast iron impeller	100 HP	-	-	1750	-	460/3/60	TBD	-	-
PU-7003-B	Dynamometer Supply Pump	PID-YTT-70	TBD	TBD	-	-	50	90	-	-	1,675 GPM	PU-7003-B	Cast Iron w/cast iron impeller	100 HP	-	-	1750	-	460/3/60	TBD	-	-
TBD	Air Compresssor Package	TBD	125	120	-	-	≤ 110	≤ 90	≥ 80	≥ 45	≤ 50 SCFM	TBD	Carbon Steel	2 x 10 HP	-	-	1750	-	460/3/60	TBD	-	-
TBD	Bridge Crane	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	30 TONS	TBD	Carbon Steel	Trolley: 2 x 0.75 HP Endtruck: 2 x 2.0 HP Hoist: 1 x 20.4/3.4 HP	N/A	N/A	-	-	460/3/60	-	-	-
MV-1	Roof Ventilator	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	47,905 CFM		Galvalume, HDG frame	1/3 HP	-	-	1725	-	460/3/60	TBD	-	-

A-USC Component Test Project
Balance of Plant Equipment List

Tag Number	Boiler Feed Water (Low Pressure) (GPM)	Supply / Make-Up Water (GPM)	Drain	Natural Gas	Location in Facility	Supplier Data			Physical Data			Estimated Cost (USD)	Remarks
						Supplier	Manufacturer	Model Number	Shipping Weight (lbs)	Operating Weight (lbs)	Operating/Envelope Dimensions (LxWxH)		
TBD	TBD	50	TBD	-	Yard	AECOM	Rental	-	54,000	90,200	53'-0" x 8'-7" x 13'-5"	$ 46,000	Estimated monthly rental cost for deaerator, pumps, demineralized water and filter skids. Per verbal quote on currently available equipment at Powerhouse Boiler Equipment 3/29/16.
TBD	-	TBD	-	-	Yard	AECOM	Rental	-	TBD	-	TBD	$ -	Rental cost included with deaerator unit above.
	-	-	-	-	Yard	AECOM	Evapco	Pulse-Pure P-10	TBD	-	TBD	$ 124,235	Budgetary quoted via email dated 3/15/16.
	-	-	-	-	Yard	AECOM	TBD	-	TBD	-	TBD	$ 30,000	Budgetary allowance.
B-591	-	-	TBD	221,580 CFH	Yard	AECOM	Babcock & Wilcox	FM120-124	216,000	274,000	38'-0" x 12'-6" x 16'-10"	$ 3,111,000	Purchased boiler w/1100 psig design pressure and 850 deg. F design temp per B&W budgetary quote dated 03/03/16 (+/- 20%).
BNR-591	-	-	-	-	Yard	AECOM	B&W / Todd	Variflame	-	-	-	$ -	Estimated rental cost = $80,500 per month
F-591	-	-	-	-	Yard	AECOM	B&W / Buffalo Forge	-	-	-	TBD	$ -	
FM-591	-	-	-	-	Yard	AECOM	Babcock & Wilcox	-	-	-	TBD	$ -	
DS-2201	TBD	-	-	-	Yard	AECOM	Schutte & Koerting	Type 6953-D	120	-	10" x 6" x 10" Sch. 80 tee w/6" flanged side entry	$ 8,345	Schutte & Koerting budgetary quote dated 3/17/16.
TBD	-	-	TBD	113,400 CFH	Yard	B&W	Babcock & Wilcox	-	-	-	34'-0" x 33'-0" x 92'-10"	$ 29,019,000	B&W budgetary cost to furnish and install.
TBD	-	-	-	-	Yard	B&W	Babcock & Wilcox	-	-	-	-	$ -	
TBD					Yard	B&W	Babcock & Wilcox						
TUR-4001					Turbine Bldg.	GE Turbine	GE Turbine					$ 29,390,000	Includes Hydraulic Dynamometer costs
TBD	-	-	-	-	Turbine Bldg.	GE Turbine	TBD	TBD	TBD	-	TBD	$ -	Supplied with turbine
TBD	-	-	-	-	Turbine Bldg.	GE Turbine	TBD	TBD	TBD	-	TBD	$ -	Supplied with turbine
TBD	-	-	-	-	Turbine Bldg.	GE Turbine	TBD	TBD	TBD	-	TBD	$ -	Supplied with turbine
DY-4101	-	1640 GPM @ 50 PSIG, 340µ filter	-	-	Turbine Bldg.	GE Turbine	Kahn Industries	Model 406-080	30,000	-	77" x 61" x 88"	$ -	Furnished and installed by GE-Turbine. Cost included w/TUR-4001.
SK-4102	-	TBD (1/2" NPT)	TBD (1/2" NPT?)	-	Turbine Bldg.	GE Turbine	Kahn Industries	Series 506	450	-	45" x 33" x 36"	$ -	Locate unit within 10 ft. of dynamometer. Cost included w/TUR-4001.
SK-4103	-	TBD (3/8" NPT?)	TBD (3/8" NPT?)	-	Turbine Bldg.	GE Turbine	Kahn Industries	Series 525	870	-	50" x 35" x 42"	$ -	Locate unit within 20 ft. of dynamometer. Cost included w/TUR-4001.
DS-4201	TBD	-	-	-	Turbine Bldg.	GE Boiler (Alstom)	Flowserve	-	TBD	-	TBD	$ -	Cost included w/GE Boiler (Alstom) cost estimate.
DS-5001	-	-	-	-	Turbine Bldg.	GE Boiler (Alstom)	Flowserve	-	TBD	-	TBD	$ -	Cost included w/GE Boiler (Alstom) cost estimate.
	-	-	-	-	TBD	GE Boiler (Alstom)	TBD	-	TBD	TBD	TBD	$ 7,900,000	ROM cost estimate from GE Boiler (Alstom), supply only.
DS-5103	-	-	-	-	Turbine Bldg.	GE Boiler (Alstom)	Flowserve	-	TBD	-	TBD	$ -	Cost included w/GE Boiler (Alstom) supply cost estimate.
HE-6001	-	-	-	-	Yard	AECOM	Gaspar, SHECO	-	33,800	43,494	58" diameter x 132" OAL	$ 275,000	SHECO budgetary quotation dated 3/4/16.
PU-6002-A	-	-	-	-	Yard	AECOM	Peerless	4PV10B	576	-	22" x 12" x 37"	$ 6,890	North Shore Pump & Equipment quote dated 02/26/16.
PU-6002-B	-	-	-	-	Yard	AECOM	Peerless	4PV10B	576	-	22" x 12" x 37"	$ 6,890	North Shore Pump & Equipment quote dated 02/26/16.
CT-7004-A	-	70 GPM @ 40 psig	4" NPTF	-	Yard	AECOM	SPX/Marley	NC8414WAS	25,109	51,365	13'-10-3/4" x 22'-5" x 27'-1-1/8"	$ 553,965	Purchase price for six (6) cell unit per SPX quotation dated 2/12/16. Price includes options: Galv access door platform, galv plenum walkway, galv/frp interior mech platform, VFD's, control safety switches, temp. sensors and ss cold water basins.
CT-7004-A	-	70 GPM @ 40 psig	4" NPTF	-	Yard	AECOM	SPX/Marley	NC8414WAS	25,109	51,365	13'-10-3/4" x 22'-5" x 27'-1-1/8"	$ -	Cooling Tower rental cost = $94,125 per month
CT-7004-A	-	70 GPM @ 40 psig	4" NPTF	-	Yard	AECOM	SPX/Marley	NC8414WAS	25,190	51,365	13'-10-3/4" x 22'-5" x 27'-1-1/8"	$ -	
CT-7004-A	-	70 GPM @ 40 psig	4" NPTF	-	Yard	AECOM	SPX/Marley	NC8414WAS	25,109	51,365	13'-10-3/4" x 22'-5" x 27'-1-1/8"	$ -	
CT-7004-A	-	70 GPM @ 40 psig	4" NPTF	-	Yard	AECOM	SPX/Marley	NC8414WAS	25,109	51,365	13'-10-3/4" x 22'-5" x 27'-1-1/8"	$ -	
CT-7004-A	-	70 GPM @ 40 psig	4" NPTF	-	Yard	AECOM	SPX/Marley	NC8414WAS	25,109	51,365	13'-10-3/4" x 22'-5" x 27'-1-1/8"	$ -	
	-	-	-	-	Turbine Bldg.	AECOM	Corrosion Resistant Tech.	-			8'-0" DIA x 10'-0" OAH	$ 6,000	Budgeary estimate from recent project.
	-	-	-	-	Turbine Bldg.	AECOM	Corrosion Resistant Tech.	-			8'-0" DIA x 10'-0" OAH	$ 6,000	Budgeary estimate from recent project.
PU-7001-A	-	-	-	-	Turbine Bldg.	AECOM	Peerless	14HH	2,483	-	24" x 21" x 80" (above sump)	$ 53,890	North Shore Pump & Equipment quote dated 02/26/16.
PU-7001-B	-	-	-	-	Turbine Bldg.	AECOM	Peerless	14HH	2,483	-	24" x 21" x 80" (above sump)	$ 53,890	North Shore Pump & Equipment quote dated 02/26/16.
PU-7002-A	-	-	-	-	Yard	AECOM	PACO	1415-3/4 KP	2,784	-	46" x 44" x 40" (without motor)	$ 93,600	North Shore Pump & Equipment quote dated 02/26/16.
PU-7002-B	-	-	-	-	Yard	AECOM	PACO	1415-3/4 KP	2,784	-	46" x 44" x 40" (without motor)	$ 93,600	North Shore Pump & Equipment quote dated 02/26/16.
PU-7002-C	-	-	-	-	Yard	AECOM	PACO	1415-3/4 KP	2,784	-	46" x 44" x 40" (without motor)	$ 93,600	North Shore Pump & Equipment quote dated 02/26/16.
PU-7003-A	-	-	-	-	Yard	AECOM	Peerless	F31660M	2,080	-	66" x 29" x 31" (with motor)	$ 18,270	North Shore Pump & Equipment quote dated 02/26/16.
PU-7003-B	-	-	-	-	Yard	AECOM	Peerless	F31660M	2,080	-	66" x 29" x 31" (with motor)	$ 18,270	North Shore Pump & Equipment quote dated 02/26/16.
TBD	-	-	-	-	Yard	AECOM	APO	TBD	TBD	TBD	TBD	$ 55,000	Budgetary quote from recent project.
TBD	-	-	-	-	Turbine Bldg.	AECOM	Engineered Material Handling	ZLK	20,880	-	44'-0" x 10'-11" x 6'-6"	$ 69,441	Double girder top running bridge crane. Budgetary quote from EMH, Inc. dated 3/1/16. Price includes optional test weights, rotating red light and hand held radio control; ASCE #60 runway rail, runway conductor and installation (mechanical and electrical).
	-	-	-	-	Turbine Bldg.	AECOM	PEMB Contractor/Moffitt Vent	MV-48	-	95 LB/FT	80'-0" x 9'-5" x 5'-2"	$ -	Furnished and installed by pre-engineered building contractor. Motorized operator for vent damper requires a reversing starter supplied and installed by electrical contractor.

Piping

16-11-215-001



PIPE RACK PLAN

SCALE: 1/16"=1'-0"

NOTES:

1. THIS DRAWING IS A GENERAL SCHEMATIC OF ROUTING WITHIN THE PIPE RACK AND IS NOT INTENDED TO SHOW EXACT LOCATIONS. FOR EXACT POSITIONS OF LINES WITHIN THE PIPE RACK REFER TO REFERENCED SECTION VIEWS.

REVISION APPROVAL RECORD				REV		REV NO	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C						A	3/31/16	ISSUED FOR FEED		

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A	3/31/16	JC	DM
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV.NO.

PROJECT NO.: 31609

DRAWN: JC DATE: 3/30/16

CHECKED: DATE:

SCALE: AS NOTED

URS ENERGY & CONSTRUCTION Inc. - an AECOM Company
1500 West 3rd St., Suite 200
Cleveland, OH 44113
(216) 523-5600

ENERGY INDUSTRIES of OHIO
6100 Oak Tree Boulevard, Suite 200
Independence, OH 44131
(216) 643-2952

A-USC COMTEST PROJECT
PIPING
PIPE RACK PLAN

DWG. NO. 16-11-215-001 REV A

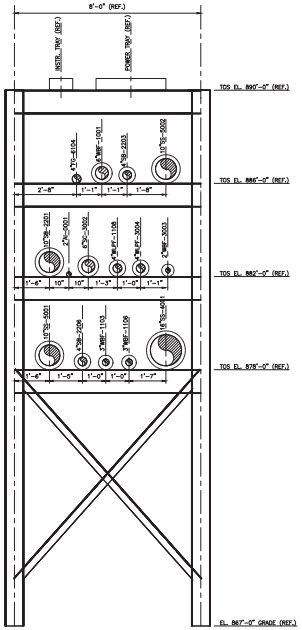
EC_D_Size.dwg

INCHES / CENTIMETERS

8 7 6 5 4 3 2 1

D C B A

16-11-215-002



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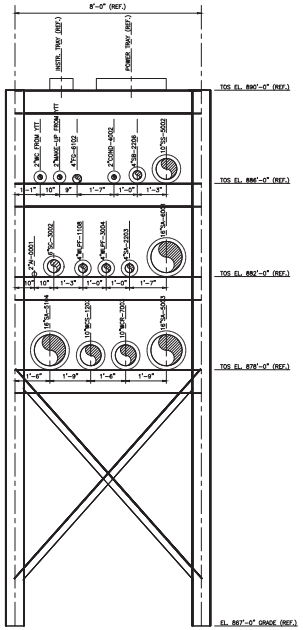
LOOKING EAST



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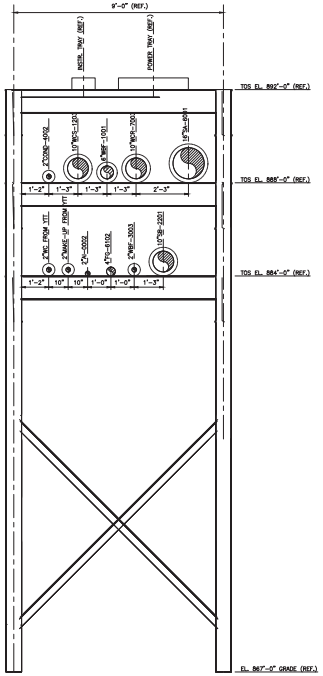
LOOKING EAST



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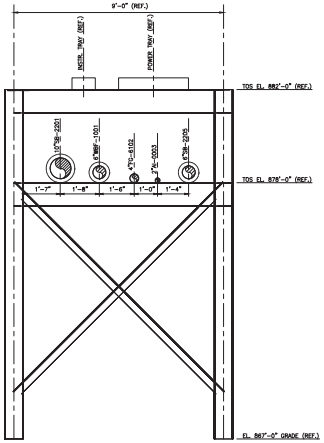
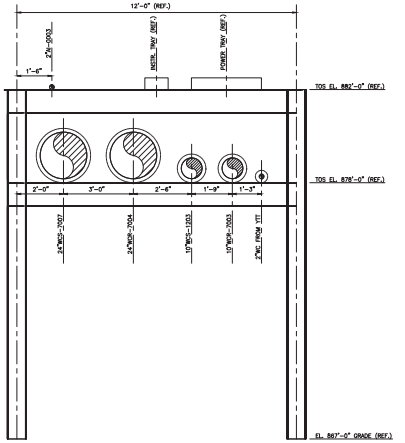
LOOKING NORTH



SECTION 'D-D'
LOOKING EAST



SECTION 'E-E'
LOOKING EAST

PRELIMINARY

REVISION APPROVAL RECORD				REV		REV NO.	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C						A	3/31/16	ISSUED FOR FEED		

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A	3/31/16	JC	DM
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV.NO.

PROJECT NO.: 31609
DRAWN: JC DATE: 3/30/16
CHECKED: DATE:
SCALE: 3/8" = 1'-0"

URS ENERGY & CONSTRUCTION Inc. - an AECOM Company
1500 West 3rd St., Suite 200
Cleveland, OH 44113
(216) 523-5600

ENERGY INDUSTRIES of OHIO
6100 Oak Tree Boulevard, Suite 200
Independence, OH 44131
(216) 643-2952

A-USC COMTEST PROJECT
PIPING
PIPE RACK SECTIONS

DWG. NO. 16-11-215-002
REV A

EC_D_Size.dwg

INCHES
CENTIMETERS

8 7 6 5 4 3 2 1

D C B A

A-USC COMTEST PROJECT

YOUNGSTOWN, OH

PROJECT NUMBER 31609-FEED

SPECIFICATION NUMBER 16-0-400

FOR

BALANCE OF PLANT PIPING

PREPARED FOR

ENERGY INDUSTRIES OF OHIO

URS ENERGY & CONSTRUCTION INC. – AN AECOM COMPANY

1500 WEST 3RD ST

CLEVELAND, OH 44113

Revision: A Status: Preliminary

Project Name:	A-USC COMTEST PROJECT	Discipline :	Piping
Client :	ENERGY INDUSTRIES OF OHIO		

Revision Signatures

J Christensen	3/28/16	D Mardovin	3/28/16
Prepared by	Date	Approved by	Date
Checked by	Date	Approved by	Date

Status	Rev. No.	Date	Prepared By	Pages	Description of Changes
PRE	A	03/28/16	JC	ALL	PRELIMINARY

PART 1 - GENERAL

1.1 SUMMARY OF WORK

A. This section of the Specifications, together with the Contract Documents and the applicable Design Drawings, covers process and utility piping as required by the drawings and specified herein.

B. The word "piping" as used herein means complete systems installed in place including pipe, flanges, valves, supports, gasketing, and other accessory items.

C. All work shall comply with OSHA, all local codes and all applicable codes, specifications, and standards. Applicable dates for all codes, specifications and standards will be the dates of the latest revision in effect at the time of contract award.

1.2 RELATED WORK

A. Items furnished by others: Pressure control valves, temperature control valves, pressure relief valves, and other specialty items identified by instrumentation symbols and classification letters.

1.3 QUALITY ASSURANCE

A. The latest edition of applicable federal, state and local codes in effect at the time of Contract award as applied to process and utility piping shall apply to materials, fabrication and installation of the entire piping system.

B. The Contractor shall have available for reference all the latest editions of federal, state, and local codes in effect at the time of Contract execution which are referred to or apply to process and utility piping materials, welding, testing, fabrication, and installation of the entire piping system.

C. The fabrication, erection and testing of piping shall be in accordance with the requirements of ASME B31.1 Code for Pressure Piping - Power Piping, hereafter referred to as the "Code".

D. Materials and Equipment:

1. All materials and equipment shall be free from defects and imperfections, of recent manufacture, new and unused and per specifications cited.

2. A certification of compliance with specified codes and standards shall be provided for all materials and equipment except those whose manufacturer is listed by name in this specification. The testing laboratory certifying compliance shall be approved by Owner.

1.4 REFERENCE STANDARDS

A. The latest editions or revisions of the industry standards of the following organizations are part of this specification as they are applicable:

1. ANSI American National Standards Institute
2. ASME American Society of Mechanical Engineers
3. ASTM American Society for Testing and Materials
4. MSS Manufacturers' Standardization Society

B. Organizations referenced herein without mention of a specific standard:

1. PFI Pipe Fabrication Institute

1.5 SUBMITTALS

A. Contractor to furnish all necessary inspection reports, approvals, certificates, labels, stamps or nameplates required by the specific reference standards cited in the individual specifications for materials, and equipment or component parts.

B. The Contractor is responsible for preparing shop drawings (as-built drawings) for field changes, spooling details, and manufacturer catalog cuts. As-built drawings are especially important for underground installations.

1.6 DELIVERY, STORAGE AND HANDLING

A. All pipe, valves and fittings shall be new, free of rust inside and out, show no sign of deterioration from pitting inside and out and shall be free of foreign objects.

B. After delivery to the site all materials shall be stored out of the weather in a building or a temporary shelter and shall be maintained in good condition.

C. Pipe not stored in a building shall be kept on blocking to prevent contact with ground. Protect threads from rust and physical damage.

D. Handle pipe, fittings and accessories carefully to avoid damage to coatings and in accordance with manufacturer's recommendations.

1.7 SUBSTITUTIONS

A. Furnish all materials and equipment as specified except where substitutions were proposed and approved by the Construction Manager prior to award of the contract.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Materials shall be new, clean, of first class commercial quality.

C. Materials shall be equal to those specified in the attached Pipe Construction Specifications, and the following unless otherwise shown on drawings:

1. Pipe sizes 3-1/2 and 5 inches are not to be used except to match manufacturer's equipment connections, in which case lengths are to be kept to a minimum.

2. Welding Elbows: Long radius type unless otherwise indicated.

3. Instrument Connection Points: Use Bonney Forge or equal "Thredolets", "Sockolets", "Elbolets", "Latrolets" or "Nipolets" where possible in lieu of tees.

4. Flanges: Bore of weld-neck flanges shall match that of the pipe. Flange face finishes shall range from 125 to 600 AARH unless otherwise specified.

5. Block Valves for dissimilar services shall be selected for the more severe service.

6. The use of asbestos as gasket, seating material or piping material is prohibited.

7. Block valves for hazardous material shall be provided with lockout capability.

2.2 ACCESSORIES

A. Chain Wheels or Extension Stems: Provide when center of the valve handwheel is over 6 feet-9 inches above floor or as otherwise noted.

B. Steam Traps: Provide the following types at locations indicated and as specified on the Trap List.

1. Armstrong float and thermostatic trap.

2. Yarway impulse trap with integral strainer and blowdown valve.

3. Spirax – Sarco Thermodynamic Trap.

C. Pipe Strainers: "Y" type, Yarway No. 921, with blow-off gate valve.

D. Cone Type Temporary Strainers: Mack Iron Works Company, Series PC-R/FF, Style PCL to match pipe material.

E. Flat Type Temporary Strainers: Flat screen inserts, 40 mesh stainless steel for

lines 1-1/2 inches or smaller.

2.3 SUPPORTS

A. Except as otherwise noted, use Grinnell adjustable clevis, Figure 65 or Elcen Figure 12B or equal for 2 inches and smaller pipe, and Grinnell adjustable clevis, Figure 260 or Elcen Figure 12 or equal for 3 inches and larger pipe. For copper tubing use Grinnell Figure CT-269 and CT-65 copper plated hangers. Approved hangers and supports by other manufacturers are acceptable.

B. For insulated pipe use "thermal-hanger-shields" as manufactured by Pipe Shields Incorporated, Power Piping Company, or approved manufacturer, design and tested in accordance with ASTM B31.1 and MSS-SP-58/MSS-SP-89.

PART 3 - EXECUTION

3.1 WELDING, FABRICATING AND INSPECTING

A. Welding, fabricating and inspecting requirements of piping systems shall be in accordance with the code specified on the Index for Piping Services.

B. Provide 6 inches of additional length on carbon steel pipe and 3 inches on stainless or alloy pipe for make-up purposes at all field weld locations indicated on the piping shop drawings. Where a field weld occurs at a flange, tack weld the flange in position.

B. Shop fabrication of pipe shall conform to PFI recommendations and with the Code specified on the Index for Piping Services.

3.2 INSTALLATION

A. Install piping at locations shown. Notify Construction Manager when any conflicts arise. No improvising or field changes will be permitted without Construction Manager's prior written approval.

B. Use full lengths of pipe wherever possible, short lengths with couplings will not be permitted. Cut pipe to exact measurement and install without springing or forcing, except where cold springing is specified on drawings.

C. Avoid tool marks and unnecessary pipe threads. Remove burrs formed when cutting pipe. Remove weld spatter and slag from welded joints by chipping and wire brushing.

D. Slope: Maintain an accurate and uniform slope where lines are pitched for drainage. No lines shall have pockets due to changes in elevation unless indicated on drawings. Provide drain valves at low points of piping systems.

E. Changes in Direction: Use fittings.

F. Expansion Loops: Construct bends with long radius welding fittings unless otherwise indicated.

G. Flanged Connections: Use flat faced flanges and full face gaskets for connections to Class 125 cast iron flanged valves or fittings.

1. Use proper length bolts for each size flange. Bolts with excessive length of exposed threads will not be permitted, and shall be replaced or cut to correct length.

2. Use Class 150 flat faced flanges with full face gaskets to mate with Class 125 flanges at valves, fittings or equipment connections.

3. Use Class 300 raised face flanges to mate with Class 250 flanges at valves, fittings or equipment connections.

4. Slip-on type flanges shall be welded both inside and outside.

H. Unions: Install in all piping connections to equipment, regulating valves and wherever necessary for dismantling of piping or removal of valves and other items requiring maintenance. Flanges on equipment may be considered as unions. Provide di-electric unions at connections of dissimilar metals.

J. Temporary Strainers: Install at pump and compressor suction for initial startup whenever permanent strainers have not been provided. Remove after run-in of equipment, and leak testing the system.

K. Vents and Drains:

1. All high and low points of all pipe rack runs and branch runs shall have manual valve at high point vents and low point drains. Branch runs open end terminations may serve as vent or drain depending on its elevation. Hazardous process lines shall not have vents and drains except as shown on the drawings.

2. For high point vents for hydrostatic testing purposes only, omit the valve and substitute a back-welded cap .

3. Provide all equipment vents and drains with block valve, plug or cap. Materials and construction shall be appropriate for the service.

4. The minimum size vent, drain and sample connection in piping shall be 3/4 inch unless otherwise limited by pipe size or equipment connections.

L. Pipe Sleeves:

1. Provide sleeves where pipe lines pass through floors and walls. Where possible, make sleeves available before floors and walls are constructed. Where sleeves are not provided in the original construction, satisfactorily perform cutting and patching as required.

2. Sleeves shall be standard weight carbon steel pipe inside, galvanized pipe outside, having minimum internal diameter 2 inches larger than OD of bare pipe or 2 inches larger than OD of pipe insulation, unless otherwise indicated. Wall sleeves shall be flush on both sides of wall, and floor sleeves flush on ceiling side and extend 1 inch above floor, except where otherwise indicated or necessary to suit location and piping function.

3. Pack sleeves in fire wall with Dow Corning 3-6548 RTV foam or approved fire stopping material. Fire stop material to be same fire rating of wall..

N. Pipe Hangers and Supports:

1. Pipe support design shall be as shown on drawings. Any changes from indicated design, shall have Engineer's prior approval.

2. Use of building steel for supporting hangers will be permitted only where indicated on drawings or approved by Engineer. Do not weld transversely across the flange of any member under stress; use bracing and other secondary members for support.

4. Support vertical piping with steel brackets to prevent swaying, sagging, vibration and resonance; however, it shall not be so restrained as to cause lines to snake or buckle between supports or anchors. Do not use flat steel strap hangers.

5. For horizontal insulated hot and cold lines, all sizes, use pipe clamps as indicated on drawing PSDET-1027. Install type as specified on the drawings.

6. For vertical insulated piping 4 inches and larger, provide angle or plate type insulation supports welded to pipe at approximately 12 foot intervals. Fabricate supports of same material as pipe to which they are attached, and of widths less than thickness of insulation covering.

7. Rigid pipe support shall be provided at each change of direction. Pipes shall be guided with U-bolts or as otherwise indicated on the contract drawings. Exception being stress analyzed lines.

8. Locate hangers as close as possible to concentrated loads and horizontal changes in direction. If this is not possible, reduce spans turning a corner by 25 percent.

9. For first hanger off equipment shall be within 1/2 span of the equipment.

10. The selection and location of riser supports shall take into consideration the entire weight of the riser and adjacent piping, hydrostatic test load condition, line temperature and the available supporting structure. On a riser subject to expansion, only one support of the rigid type shall be used.

11. Risers shall be supported independently of adjacent horizontal hangers. All risers passing through a floor structure shall be supported at the floor by riser clamps. Supports shall be installed as required over the entire length of riser to provide stability to the riser.

12. Riser clamps shall have a positive means of engagement between the pipe and the clamp. Riser clamps are to be Grinnell Figure 261, or approved manufacturer.

O. Cleaning and Protecting: Prevent entry of foreign matter during handling, assembling and erecting. Use compressed air, wire brush, solvent and other means to remove residual scale, dirt and other foreign matter from interior of piping before final connections are made. Protect open ends of pipe by capping or plugging.

P. Provide and install temporary identification tags on pipe lines after lines are erected, tested and approved so that insulation or painting can be completed.

3.3 TESTING

A. Before insulation or paint is applied to piping or piping is covered by backfilling, the Contractor shall perform tests described herein at pressure given in the Index

for Piping Services. The Contractor shall perform these tests on every pipe, tube, fitting and joint after fabrication and installation in the field, unless otherwise indicated by the Owner.

B. Test piping when ambient air conditions are approximately constant. Before testing, remove nonpressure parts of traps, instruments and specialties. Use spool pieces or blank flanges to replace or isolate instruments and control valves to protect them against overpressure or contamination when testing piping systems.

C. During hydrostatic or pneumatic testing, pipe, tube, fittings and joints shall withstand test pressure without failure, leakage or distortion for a period of 30 minutes. There shall be no loss of test pressure during this period.

D. Where pressure testing with air or gas, leakage shall be located by means of soap bubble test or by using American Gas & Chemicals Inc, Leak-Tec, Formula 372, or snoop leak detector.

E. Where a portion of the piping system is to be concealed before completion of the system, this portion shall be tested separately in the same manner as specified for the entire system.

F. Supplementary equipment, fittings, valves and labor required to perform these tests shall be furnished, installed and removed upon satisfactory completion of tests at no additional cost to the Owner.

G. These tests shall be witnessed and approved by the Owner.

H. The Contractor shall repair defects and repeat the test procedure until a satisfactory test is obtained at no additional cost to the Owner.

I. Air used for pneumatic tests shall be free of oil, water or other foreign materials.

J. All test instruments shall be calibrated with indicated calibration requirements.

K. Records shall be made for each piping installation during the testing. These records shall include:

1. Date of test
2. Identification of piping tested
3. Test medium
4. Test pressure
5. Approval by inspector

L. Any joints (welded, brazed, soldered, threaded or flanged) inspected and found not acceptable by the Owner shall be repaired, replaced or corrected to the satisfaction of the Owner. The Contractor shall bear the cost of correcting any rejected joints.

M. Replace nonpressure parts after initial test and retest piping at operating pressure with steam, water or instrument air, as appropriate, until joints are proven tight to satisfaction of the Construction Manager.

3.4 FINAL CLEANING

A. General:

1. Contractor shall take precautions during fabrication and erection to prevent entrance of foreign matter into piping or equipment. Contractor shall remove loose rust, slag, weld splatter, dirt, oil, grease or other foreign substances from interior surfaces of piping prior to connecting piping to equipment. Prior to fabrication in shop or field, Contractor shall remove scale or foreign materials present in pipe. After fabrication and during erection, open ends of pipelines shall be capped or plugged by Contractor to keep out dirt and other materials until pipelines are connected to equipment. Contractor shall clean completed piping with air, steam or water flushed to the satisfaction of Owner before final connection to the equipment.

2. After completion of any test, where non-potable solutions are used, Contractor shall clean all parts of the installation. Sewer stoppage or discoloration to adjacent structures, equipment, or other damage shall be corrected by Contractor.

3. Contractor shall not combine cleaning and testing. These are separate operations.

4. Thoroughly remove any foreign fluids used for testing. When flushing with water, establish flow from high to low points and drain completely, separating flanges and removing spool pieces where necessary. Gas systems shall be blown dry with air. Disposal of effluent streams from cleaning operations shall be in accordance with environmentally safe procedures.

5. Sterilization: Unless otherwise directed by Owner, Contractor shall be responsible for the sterilization of domestic water piping system(s). Piping shall be sterilized by Contractor with a solution containing not less than 50 parts per million of approved chlorine. Chlorinating material shall be liquid chlorine and shall be introduced into systems by Contractor in a manner approved by Health Authorities and Owner. Sterilization shall conform to the latest revision of AWWA's Standard for Disinfecting Water Mains, and local codes (reference Technical Provision 53). Sterilizing solution shall be allowed to remain in systems for a period of 24 hours during which time all valves shall be opened and closed several times. After sterilization, solution shall be flushed from system by Contractor with clean water until residual chlorine content is identical to the incoming potable city water used for flushingare not acceptable.

6. Provide all required flanges, nuts, bolts, gaskets.

7. Temporary Strainers for Equipment Protection: Contractor shall provide, install, and remove temporary strainers on inlet side of major pieces of

equipment and pumps, where permanent strainers are not provided. Strainers may be the type that slips between flanges of the equipment, with mesh having approximately ⅛" openings. Material shall be the same as the piping and of sufficient thickness to prevent distortion. Strainers shall remain in place until their removal is approved by Owner. Contractor shall maintain a log of temporary strainers installed and removed. Where rigid pipe supports are furnished adjacent to strainers, such supports shall accommodate removal of the strainers. Contractor shall install cone strainers with the cone pointed upstream of the normal flow.

8. Replacement and Temporary Items:

   a. Replace removed items with spool pieces, plugs or blind flanges.

   b. Install new gaskets and thread lubricant when removed flanges or threaded components are replaced after cleaning.

   c. Install temporary piping as needed to complete cleaning procedures.

9. Protection:

   a. Disconnect piping to be flushed from equipment or install temporary strainers directly upstream of equipment if permanent strainers are not provided.

   b. Provide means to protect all piping and connected equipment from overpressure, collapse from vacuum and hydraulic shock.

   c. Disconnect or completely isolate all air piping from connected equipment during flushing and cleaning.

B. Application:

1. General Piping Systems:

   a. Fill headers slowly with clean water until air is expelled from system.

   b. Flush, clean and disinfect piping to satisfaction of Construction Manager and Owner.

   c. Remove, clean and reinstall strainer screens after flushing, cleaning and disinfection; remove temporary strainers and retighten connections.

   d. After cleaning, verify that valves, traps, controls and related equipment are operable; remove dirt and debris accumulated at these and other points in system.

   e. Clean all threads and joining surfaces before installing pipe.

f. When flushing and cleaning are complete for a system or part of system, reconnect all vessels, equipment, piping, instruments, fittings and accessories with new gaskets or thread lubricant as applicable.

g. Where flushing rates are not specified for particular system, flush at approximately 5 feet per second (fps).

h. If pressure testing following cleaning, do not reinstall items subject to damage from test pressure.

i. For systems requiring hydrostatic testing and drying, hydrostatic test may be performed prior to cleaning and drying.

j. Clean pipe at completion of pipe installation.

k. Seal open ends of cleaned piping material with plastic caps.

l. Contractor shall submit additional procedures for vacuum and hydraulic piping.

3.5 STERILIZING POTABLE WATER LINES

A. Follow the governing Plumbing Code for disinfection of potable water system piping. As a minimum requirement lines shall be filled with a solution containing 50 ppm of available chlorine, and solution be retained in lines for 24 hours before flushing and placing in service. Open and close all valves in the lines being chlorinated several times during contact period.

3.6 IDENTIFICATION OF PIPE LINES

A. Mark lines after completion of painting and insulation, by means of self-sticking pipe markers..

B. Install a label identifying pipe contents at each valve, at each point of entry or exit where pipe passes through a wall or ceiling, at each riser and tee joint, and at intervals of 50 ft on long continuous runs.

3.7 ACCEPTANCE

A. Obtain and furnish to the Construction Manager, certificates of inspection and approval from authorities having jurisdiction.

3.8 IDENTIFICATION OF MANUAL VALVES

A. Every valve shall be distinctly marked with brass tags designating the function of the valve. Tags shall be 1 inch in diameter and attached to valve stem by ring and chain.

PART 4 - PAINTING

4.1 REQUIREMENTS

A. This section specifies the requirements for the painting of piping, piping supports, pipe hangers, instrument stands and brackets, and field touch-up.

B. The painting requirements for each pipeline are listed on the construction line list in each Scope of Work Specification.

C. Any surface preparation, prime coat and/or intermediate/finish painting will be referred to as painting in this section.

D. The statement "Owner Furnished Painter" applies if the Owner contracts the Painter. The statement "Contractor Furnished Painter" applies if painting is part of the General Contract. Section 4.1.E specifies the requirements for work using "Owner Furnished Painter". Section 4.1.F applies to work using the "Contractor Furnished Painter".

E. Owner Furnished Painter

1. Sections 4.2 through 4.12 are the responsibility of the Owner and Painter. The General Contractor's responsibilities include:

   a. Transport of all piping, support brackets, pipe hangers, equipment (when applicable), etc. to and from painting contractor's designated work area.
   b. Coordinate with the designated painting contractor as to the timing of when piping, equipment, support brackets, pipe hangers, etc. need to be painted and what painting specification should be followed for each respective component.
   c. Pipe rack lines shall be labeled per _____
   d. Coordinate finish painting with the designated painting contractor prior to installing tracing and covering (When required).
   e. Coordinate with the designated painting contractor to ensure that painting of piping, equipment, support brackets, pipe hangers, etc. is completed.
   f. Coordinate with the designated painting contractor on any touch-up painting of any equipment scratched during shipment or installation as well as any other mechanical or instrumentation components which require field touch-up painting.
   g. Coordinate with the designated painting contractor to ensure that all piping (including fittings) is sandblasted in the painting area.
   h. Pipe ends need to be taped with 2” black 3M electrical tape prior to fabrication.

F. Contractor Furnished Painter

1. Furnish all supervision, labor, materials, and equipment necessary to complete all surface preparation, prime, intermediate, finish painting, and touch-up painting after installation of all piping, pipe supports, and pipe hangers as specified herein and on the line list.

2. Sections 4.2 through 4.12 are the Contractor's responsibility.

4.2 WORK INCLUDED

A. Furnish all supervision, labor, materials, and equipment necessary to complete all surface preparation, prime, intermediate, finish painting, and touch up painting after installation of all piping, pipe supports, and pipe hangers as specified herein and on the Construction Line List.

B. Provide internal surface profiling, periodic inspection of mill thickness and inside cleanliness.

C. Paint pipe hangers and supports prior to installation.

D. Paint instrument brackets and support structures.

E. Coordinate timing with Piping Contractor.

1. Apply a primer coating to field welds as soon as possible. Do not finish paint field welds until after the piping has been pressure tested.

2. After testing is complete, clean the primed areas and apply the finish coating.

4.3 WORK NOT INCLUDED

A. Do not sandblast or paint gasket seat facings.

B. Do not sandblast or paint studs and nuts.

C. Do not sandblast or paint any instrumentation.

D. Do not sandblast or paint nameplates or tags.

4.4 STORAGE AND PROTECTION

A. All coating materials are to be delivered to the job site in original unopened containers with labels attached. A space will be designated for storage of materials, MSDS and equipment.

B. Containers in storage must be covered at all times.

C. Remove oily and paint filled rags, wastes, etc. from the job site every night. Take adequate precautions to prevent fire. Keep all painting equipment such as brushes, spraying devices, thinners, pails, and coatings in an orderly fashion with all materials properly covered when not in use.

D. All paint used in field must be held in a container, and not on the ground. Containers other than the can, must be supplied by the contractor. Cleanup of any paint spilled on the ground is the contractor's responsibility.

4.5 PAINTER FURNISHED PRODUCTS

A. All labor, materials, and equipment necessary to complete surface preparation, prime, intermediate, and finish painting of items specified herein.

4.6 MATERIALS

A. PAINT SPEC APPLICATION

LATER

4.7 EXAMINATION

A. Thoroughly examine surfaces scheduled to be painted prior to commencement of work. Correct any deficiencies or defects which may adversely affect the work of this section.

4.8 PROCEDURES AND WORKMANSHIP

A. Floors and areas adjacent to painting operations shall be kept free from paint drops, spatters, and smears. All overlapping on unpainted surfaces, or adjacent paints of a different color shall be cleaned to the satisfaction of the Owner's Representative.

B. Furnish flame resistant protective coatings (drop cloths). No flammable or asbestos material is permitted.

C. Prior to sandblasting, waterblasting, or spray painting, it is necessary to mask or provide other means of protection which will preserve the identification and operating condition of items against unwarranted surface damage. In addition to the following specific items that require protection, protect any items as directed by the Owner's Representative.

1. Glass

    a. Pressure gauges
    b. Rotometers

2. Nameplates and tags

    a. Equipment numbers
    b. Manufacturer's name plates
    c. Instrument tags

3. Machine surfaces: Typically

    a. Control valve stems
    b. Flange faces

D. After painting is complete, all means of protection shall be removed, including ground coverage for highlines.

4.9 SURFACE PREPARATION PROCEDURES

A. SP-1: Solvent Cleaning and degreasing in accordance with SSPC SP-1: All surfaces to be painted prior to blast cleaning or hand cleaning.

B. SP-2: Hand Tool Cleaning in accordance with SSPC SP-2. To be the minimum surface preparation for areas designated as “non-corrosive areas”. SP-1 required as a first step.

C. SP-3: Power Tool Cleaning in accordance with SSPC SP-3. Required to remove hard rust wherever simple hand tool cleaning is not adequate. Designated for use in “non-corrosive areas” only. SP-1 required as a first step.

D. SP-5: White Metal Blast Cleaning in accordance with SSPC SP-5. For high temperature and lining service surface areas. SP-1 required prior to blasting and thorough removal of all abrasive and foreign matter after cleaning is required. Vacuum cleaning vessels is mandatory before lining is begun.

E. SP-6: Commercial Blast Cleaning in accordance with SSPC SP-6. This specification requires total removal of all mill scale, rust, oxides and foreign matter. SP-1 required prior to blast cleaning. Color of steel shall be gray to near-white.

F. SP-7: Brush-Off Blast Cleaning in accordance with SSPC SP-7. May be performed to remove hard rust to sound surface condition. This specification is ideal for laitance removal from concrete surfaces prior to coating for lining surface. SP-1 required as first step.

G. SP-10: Near-White Metal Blast Cleaning in accordance with SSPC SP-10. Blast cleaning nearly to white metal cleanliness until at least 95% of each element of surface area is free of all visible residues. SP-1 required as first step.

4.10 APPLICATION/EXECUTION

A. Prepare, prime, and finish paint all newly constructed surfaces and those existing surfaces damaged during the course of construction.

B. Coat all surfaces immediately after surface preparations are complete.

C. Apply coating materials evenly. Finished surfaces are to be free from sags, runs, crawls, and other film defects.

D. Ensure that each coat is thoroughly dry prior to application of succeeding coats.

E. Follow paint manufacturer's directions in mixing, thinning, and applying coats.

F. Tint intermediate coats of two or more successive applications of the same color sufficiently to produce enough contrast to indicate complete coverage. The tinting material is to be compatible with the coating and not detrimental to its service life.

G. After installation touch-up field welds and scratched or damaged surfaces incurred during installation with primer and finish paint.

4.11 COLOR SCHEDULE

LATER

4.12 INSPECTION

A. Inspections, as necessary, are the responsibility of the Owner's Representative.

INDEX FOR PIPING SERVICES

Line Symbol	Service	Spec. No.	Operating Conditions PSIG/TEMP (ºF)	Design Conditions PSIG/TEMP (ºF)	Code	Test Pressure PSIG	Exam Required
AI	INSTRUMENT AIR	011	100/90	150/140	B31.1	225	HYDRO
COND	CONDENSATE	011	50/150	150/150	B31.1	225	HYDRO
FG	FUEL GAS	011	60/60	150/110	B31.1/ NFPA 54	225	HYDRO
SA	ATTENUATED STEAM	031	191/670	215/720	B31.1	380	HYDRO
SB	BOILER STEAM	152	950/750	1045/800	B31.1	1568	HYDRO
SC	COOLING STEAM	153	640/1100	700/1100	B31.1	1050	HYDRO
SS	SUPERHEATED STEAM	999	625/1400	1150/1415	B31.1	1725	HYDRO
VENT	VENT	011	ATM/AMB	150/110	B31.1	225	HYDRO
WBF	BOILER FEED WATER	061	1075/250	1180/300	B31.1	1770	HYDRO
WC	CITY WATER	011	45/90	150/110	B31.1	225	HYDRO
WCR	COOLING WATER RETURN	011	60/125	100/175	B31.1	150	HYDRO
WCS	COOLING WATER SUPPLY	011	60/90	100/140	B31.1	150	HYDRO
WLPF	LOW PRESSURE FEED WATER	061	395/250	435/300	B31.1	655	HYDRO

Notes:

PIPING SPECIFICATIONS

SPECIFICATION 011	Material:	Carbon Steel	Maximum Allowable Limits		Issue Date		
	Rating:	150	Temp °F	Press. PSIG	Revision	By	Date
	Design Code:	ASME B31.1 – 2014	100	285	A	JC	03/28/16
	Size Range:	1/2" – 24"	200	260			
	Corrosion Allowance:	0.0625"	300	230			
	Design Factor:	N/A	400	200			
	Design Temperature:	400°F					
	Design Pressure:	200 PSIG					

Material	Nominal Size		Sch/Rating	Description	Notes
	From	To			
PIPE	1/2"	2"	XS	SMLS, A106-B, B36.10, PLAIN ENDS	
	3"	24"	STD	ERW, A53-B TYPE E, B36.10, BEVELED ENDS	
NIPPLES	1/2"	2"	XS	SMLS, A106-B, B36.10, A733, MTE	1
FITTINGS	1/2"	2"	CL3000	SOCKET WELD, A105, B16.11	7
	1/2"	2"	CL3000	THD, A105, B16.11	1,7
	3"	24"	STD	SMLS, BUTT WELD, A234-WPB, B16.9	6,8
PLUGS	1/2"	2"	-	THD, A105, ROUND HEAD, ASME B16.11	1
BRANCHES	1/2"	2"	CL3000	SOCKOLET, A105, MSS-SP97	
	3"	24"		WELDOLET, A105, MSS-SP97	8
UNIONS	1/2"	2"	CL3000	SOCKET WELD, A105, INTEGRAL SEAT, MSS-SP-79	
FLANGES	1/2"	2"	CL150	SOCKET WELD, RF, A105, B16.5	4,5
	3"	24"	CL150	WELD NECK, RF, A105, B16.5, BORE TO MATCH PIPE WALL	
	1/2"	24"	CL150	BLIND, RF, A105, B16.5	4
	3"	24"	CL300	PAIR WELD NECK ORIFICE, RF, A105, B16.5	
VALVES	REFER TO VALVE LIST AND SPECIFICATIONS				
GASKETS	1/2"	24"	CL150	SPIRAL WOUND, B16.20, LOW STRESS, 1/8" COMPRESSED THICKNESS, TYPE316 STAINLESS STEEL WITH GRAFOIL TYPE GTB FILLER OR EQUIVALENT, FLEXITALLIC STYLE LSI OR EQUIVALENT	
BOLTS	1/2"	24"	CL150	STUD BOLT A193-B7 WITH (2) A194-2H HEAVY HEX NUTS	2,3

Notes:

1. THREADED CONNECTIONS ARE ONLY PERMITTED AT VENT/DRAIN VALVE OUTLETS, INSTRUMENT CONNECTIONS AND TO MATCH EQUIPMENT CONNECTIONS.
2. FULLY COAT ALL THREADS WITH NEVER SEEZ OR APPROVED EQUIVALENT PRIOR TO ASSEMBLY. DO NOT
3. STUD SIZE AND LENGTH SHALL BE SELECTED PER ASME B16.5 .
4. USE FLAT FACE FLANGES FOR CONNECTIONS TO CAST IRON VALVES OR EQUIPMENT WITH FLAT FACE FLANGE CONNECTIONS.
5. SLIP-ON FLANGES ARE NOT PERMITTED UNLESS SPECIFICALLY APPROVED OR SHOWN ON DRAWINGS OR PIPING ISOMETRICS. ALL SLIP-ON FLANGES SHALL BE DOUBLE WELDED.
6. TEE, CROSS, REDUCING BRANCH TEE, 90LR ELBOW, 45 LR ELBOW, CAP
7. TEE, CROSS, COUPLING, REDUCING COUPLING, REDUCING INSERT, 90 ELBOW, 45 ELBOW, CAP
8. ALL BUTT WELD FITTINGS SHALL MATCH PIPE THICKNESS.

BRANCH CONNECTION TABLE

HEADER SIZE

½	¾	1	1 ½	2	3	4	6	8	10	12	14	16	18	20	24	**BRANCH SIZE**
ST	SRT	SRT	STI	STI	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	½
	ST	SRT	SRT	STI	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	¾
		ST	SRT	SRT	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	1
			ST	SRT	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	1 ½
				ST	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	2
					ST	WRT	WRT	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL	3
						ST	WRT	WRT	WOL	WOL	WOL	WOL	WOL	WOL	WOL	4
							ST	WRT	WRT	WOL	WOL	WOL	WOL	WOL	WOL	6
								ST	WRT	WRT	WOL	WOL	WOL	WOL	WOL	8
									ST	WRT	WRT	WOL	WOL	WOL	WOL	10
										ST	WRT	WRT	WOL	WOL	WOL	12
											ST	WRT	WRT	WOL	WOL	14
												ST	WRT	WRT	WOL	16
													ST	WRT	WRT	18
														ST	WRT	20
															ST	24

SYMBOLS

ST	=	STRAIGHT TEE
SOL	=	SOCKOLET
WOL	=	WELDOLET
WRT	=	BUTT WELDED REDUCING TEE
SRT	=	SOCKET REDUCING TEE
STI	=	SOCKET WELD TEE WITH SW REDUCING INSERT

Notes:

1. UNREINFORCED STUB-IN CONNECTIONS SHALL NOT BE USED.
2. BRANCH CONNECTIONS DESIGNATED ON DRAWINGS OR PIPING ISOMETRICS SHALL SUPERCEDE VALUES IN THIS TABLE.

SPECIFICATION 031	Material:	Carbon Steel	Maximum Allowable Limits		Issue Date		
	Rating:	300	Temp °F	Press. PSIG	Revision	By	Date
	Design Code:	ASME B31.1 – 2014	100	740	A	JC	03/28/16
	Size Range:	1/2" – 24"	200	680			
	Corrosion Allowance:	0.0625"	300	655			
	Design Factor:	N/A	400	635			
	Design Temperature:	750°F	600	570			
	Design Pressure:	505 PSIG	750	505			

Material	Nominal Size		Sch/Rating	Description	Notes
	From	To			
PIPE	1/2"	2"	XS	SMLS, A106-B, B36.10, PLAIN ENDS	
	3"	16"	STD	SMLS, A106-B, B36.10, BEVELED ENDS	
	18"	24"	XS	SMLS, A106-B, B36.10, BEVELED ENDS	
NIPPLES	1/2"	1 1/2"	XS	SMLS, A106-B, B36.10, A733, MTE	1
FITTINGS	1/2"	2"	CL3000	SOCKET WELD, A105, B16.11	7
	1/2"	1 1/2"	CL3000	THD, A105, B16.11	1,7
	3"	16"	STD	SMLS, BUTT WELD, A234-WPB, B16.9	6,8
	18"	24"	XS	SMLS, BUTT WELD, A234-WPB, B16.9	6,8
PLUGS	1/2"	1 1/2"	-	THD, A105, ROUND HEAD, ASME B16.11	1
BRANCHES	1/2"	2"	CL3000	SOCKOLET, A105, MSS-SP97	
	3"	24"		WELDOLET, A105, MSS-SP97	8
UNIONS	1/2"	1 1/2"	CL3000	SOCKET WELD, A105, INTEGRAL SEAT, MSS-SP-79	
FLANGES	1/2"	2"	CL300	SOCKET WELD, RF, A105, B16.5	4,5
	3"	24"	CL300	WELD NECK, RF, A105, B16.5, BORE TO MATCH PIPE WALL	
	1/2"	24"	CL300	BLIND, RF, A105, B16.5	4
	3"	24"	CL300	PAIR WELD NECK ORIFICE, RF, A105, B16.5	
VALVES	REFER TO VALVE LIST AND SPECIFICATIONS				
GASKETS	1/2"	24"	CL300	SPIRAL WOUND, B16.20, LOW STRESS, 1/8" COMPRESSED THICKNESS, TYPE316 STAINLESS STEEL WITH GRAFOIL TYPE GTB FILLER OR EQUIVALENT, FLEXITALLIC STYLE LSI OR EQUIVALENT	
BOLTS	1/2"	24"	CL300	STUD BOLT A193-B7 WITH (2) A194-2H HEAVY HEX NUTS	2,3

Notes:

1. THREADED CONNECTIONS ARE ONLY PERMITTED AT VENT/DRAIN VALVE OUTLETS, INSTRUMENT CONNECTIONS AND TO MATCH EQUIPMENT CONNECTIONS.
2. FULLY COAT ALL THREADS WITH NEVER SEEZ OR APPROVED EQUIVALENT PRIOR TO ASSEMBLY. DO NOT
3. STUD SIZE AND LENGTH SHALL BE SELECTED PER ASME B16.5 .
4. USE FLAT FACE FLANGES FOR CONNECTIONS TO CAST IRON VALVES OR EQUIPMENT WITH FLAT FACE FLANGE CONNECTIONS.
5. SLIP-ON FLANGES ARE NOT PERMITTED UNLESS SPECIFICALLY APPROVED OR SHOWN ON DRAWINGS OR PIPING ISOMETRICS. ALL SLIP-ON FLANGES SHALL BE DOUBLE WELDED.
6. TEE, CROSS, REDUCING BRANCH TEE, 90LR ELBOW, 45 LR ELBOW, CAP
7. TEE, CROSS, COUPLING, REDUCING COUPLING, REDUCING INSERT, 90 ELBOW, 45 ELBOW, CAP
8. ALL BUTT WELD FITTINGS SHALL MATCH PIPE THICKNESS.

BRANCH CONNECTION TABLE

BRANCH SIZE	HEADER SIZE															
	½	¾	1	1 ½	2	3	4	6	8	10	12	14	16	18	20	24
½	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	ST
¾	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SRT	ST
1	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SRT	SRT	ST
1 ½	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SRT	SRT	ST
2	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SRT	SRT	ST
3	WOL	WOL	WOL	WOL	WOL	WOL	WRT	WRT	WOL	WOL	WOL	WOL	WOL	WOL	WOL	ST
4	WOL	WOL	WOL	WOL	WOL	WOL	WRT	WRT	WOL	WOL	WOL	WOL	WOL	WOL	WOL	ST
6	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WRT	WRT	WOL	WOL	WOL	WOL	WOL	WOL	ST
8	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WRT	WRT	WOL	WOL	WOL	WOL	WOL	ST
10	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WRT	WRT	WOL	WOL	WOL	WOL	ST
12	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WRT	WRT	WOL	WOL	WOL	ST
14	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WRT	WRT	WOL	WOL	ST
16	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WRT	WRT	WOL	ST
18	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WRT	WRT	ST
20	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WRT	ST
24	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL	ST

SYMBOLS

ST	=	STRAIGHT TEE
SOL	=	SOCKOLET
WOL	=	WELDOLET
WRT	=	BUTT WELDED REDUCING TEE
SRT	=	SOCKET REDUCING TEE
STI	=	SOCKET WELD TEE WITH SW REDUCING INSERT

Notes:

1. UNREINFORCED STUB-IN CONNECTIONS SHALL NOT BE USED.
2. BRANCH CONNECTIONS DESIGNATED ON DRAWINGS OR PIPING ISOMETRICS SHALL SUPERCEDE VALUES IN THIS TABLE.

SPECIFICATION 061	Material:	Carbon Steel	Maximum Allowable Limits		Issue Date		
	Rating:	600	Temp °F	Press. PSIG	Revision	By	Date
	Design Code:	ASME B31.1 – 2014	100	1480	A	JC	03/28/16
	Size Range:	1/2" – 24"	200	1360			
	Corrosion Allowance:	0.0625"	300	1310			
	Design Factor:	N/A	400	1265			
	Design Temperature:	750°F	600	1135			
	Design Pressure:	1015 PSIG	750	1015			

Material	Nominal Size		Sch/Rating	Description	Notes
	From	To			
PIPE	1/2"	2"	XS	SMLS, A106-B, B36.10, PLAIN ENDS	
	3"	8"	XS	SMLS, A106-B, B36.10, BEVELED ENDS	
	10"	24"	SCH-80	SMLS, A106-B, B36.10, BEVELED ENDS	
NIPPLES	1/2"	3/4"	SCH-160	SMLS, A106-B, B36.10, A733, MTE	1
FITTINGS	1/2"	2"	CL3000	SOCKET WELD, A105, B16.11	6
	1/2"	3/4"	CL3000	THD, A105, B16.11	1,6
	3"	8"	XS	SMLS, BUTT WELD, A234-WPB, B16.9	5,7
	10"	24"	SCH-80	SMLS, BUTT WELD, A234-WPB, B16.9	5,7
PLUGS	1/2"	3/4"	-	THD, A105, ROUND HEAD, ASME B16.11	1
BRANCHES	1/2"	2"	CL3000	SOCKOLET, A105, MSS-SP97	
	3"	24"		WELDOLET, A105, MSS-SP97	7
UNIONS	1/2"	3/4"	CL3000	SOCKET WELD, A105, INTEGRAL SEAT, MSS-SP-79	
FLANGES	1/2"	2"	CL600	SOCKET WELD, RF, A105, B16.5	
	3"	24"	CL600	WELD NECK, RF, A105, B16.5, BORE TO MATCH PIPE WALL	4
	1/2"	24"	CL600	BLIND, RF, A105, B16.5	
	3"	24"	CL600	PAIR WELD NECK ORIFICE, RF, A105, B16.5	
VALVES	REFER TO VALVE LIST AND SPECIFICATIONS				
GASKETS	1/2"	24"	CL600	SPIRAL WOUND, B16.20, 1/8" COMPRESSED THICKNESS, TYPE316 STAINLESS STEEL WITH GRAFOIL TYPE GTB FILLER OR EQUIVALENT, FLEXITALLIC STYLE CGI OR EQUIVALENT	
BOLTS	1/2"	24"	CL600	STUD BOLT A193-B7 WITH (2) A194-2H HEAVY HEX NUTS	2,3

Notes:

1. THREADED CONNECTIONS ARE ONLY PERMITTED AT VENT/DRAIN VALVE OUTLETS, INSTRUMENT CONNECTIONS AND TO MATCH EQUIPMENT CONNECTIONS.
2. FULLY COAT ALL THREADS WITH NEVER SEEZ OR APPROVED EQUIVALENT PRIOR TO ASSEMBLY. DO NOT
3. STUD SIZE AND LENGTH SHALL BE SELECTED PER ASME B16.5 .
4. SLIP-ON FLANGES ARE NOT PERMITTED
5. TEE, CROSS, REDUCING BRANCH TEE, 90LR ELBOW, 45 LR ELBOW, CAP
6. TEE, CROSS, COUPLING, REDUCING COUPLING, REDUCING INSERT, 90 ELBOW, 45 ELBOW, CAP
7. ALL BUTT WELD FITTINGS SHALL MATCH PIPE THICKNESS.

BRANCH CONNECTION TABLE

BRANCH SIZE	HEADER SIZE															
	½	¾	1	1 ½	2	3	4	6	8	10	12	14	16	18	20	24
½	ST	SRT	SRT	STI	STI	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL
¾		ST	SRT	SRT	STI	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL
1			ST	SRT	SRT	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL
1 ½				ST	SRT	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL
2					ST	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL
3						ST	WRT	WRT	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL
4							ST	WRT	WRT	WOL	WOL	WOL	WOL	WOL	WOL	WOL
6								ST	WRT	WRT	WOL	WOL	WOL	WOL	WOL	WOL
8									ST	WRT	WRT	WOL	WOL	WOL	WOL	WOL
10										ST	WRT	WRT	WOL	WOL	WOL	WOL
12											ST	WRT	WRT	WOL	WOL	WOL
14												ST	WRT	WRT	WOL	WOL
16													ST	WRT	WRT	WOL
18														ST	WRT	WRT
20															ST	WRT
24																ST

SYMBOLS

ST	=	STRAIGHT TEE
SOL	=	SOCKOLET
WOL	=	WELDOLET
WRT	=	BUTT WELDED REDUCING TEE
SRT	=	SOCKET REDUCING TEE
STI	=	SOCKET WELD TEE WITH SW REDUCING INSERT

Notes:

1. UNREINFORCED STUB-IN CONNECTIONS SHALL NOT BE USED.
2. BRANCH CONNECTIONS DESIGNATED ON DRAWINGS OR PIPING ISOMETRICS SHALL SUPERCEDE VALUES IN THIS TABLE.

SPECIFICATION 152	Material:	Carbon Steel	Maximum Allowable Limits		Issue Date		
	Rating:	1500	Temp °F	Press. PSIG	Revision	By	Date
	Design Code:	ASME B31.1 – 2014	100	1200	A	JC	03/28/16
	Size Range:	1/2" – 24"	200	1200			
	Corrosion Allowance:	0.0625"	300	1200			
	Design Factor:	N/A	400	1200			
	Design Temperature:	800°F	600	1200			
	Design Pressure:	1200 PSIG	800	1200			

Material	Nominal Size		Sch/Rating	Description	Notes
	From	To			
PIPE	1/2"	2"	SCH-160	SMLS, A106-C, B36.10, PLAIN ENDS	
	3"	8"	SCH-160	SMLS, A106-C, B36.10, BEVELED ENDS	
NIPPLES	1/2"	3/4"	SCH-160	SMLS, A106-C, B36.10, A733, MTE	1
FITTINGS	1/2"	2"	CL3000	SOCKET WELD, A105, B16.11	6
	1/2"	3/4"	CL3000	THD, A105, B16.11	1,6
	3"	8"	SCH-160	SMLS, BUTT WELD, A234-WPC, B16.9	5,7
PLUGS	1/2"	3/4"	-	THD, A105, ROUND HEAD, ASME B16.11	1
BRANCHES	1/2"	2"	CL3000	SOCKOLET, A105, MSS-SP97	
	3"	8"		WELDOLET, A105, MSS-SP97	7
UNIONS	1/2"	3/4"	CL3000	SOCKET WELD, A105, INTEGRAL SEAT, MSS-SP-79	
FLANGES	1/2"	2"	CL1500	SOCKET WELD, RF, A105, B16.5	4
	3"	8"	CL1500	WELD NECK, RF, A105, B16.5, BORE TO MATCH PIPE WALL	
	1/2"	8"	CL1500	BLIND, RF, A105, B16.5	
	3"	8"	CL1500	PAIR WELD NECK ORIFICE, RF, A105, B16.5	
VALVES	REFER TO VALVE LIST AND SPECIFICATIONS				
GASKETS	1/2"	8"	CL1500	SPIRAL WOUND, B16.20, 1/8" COMPRESSED THICKNESS, TYPE316 STAINLESS STEEL WITH GRAFOIL TYPE GTB FILLER OR EQUIVALENT, FLEXITALLIC STYLE CGI OR EQUIVALENT	
BOLTS	1/2"	8"	CL1500	STUD BOLT A193-B7 WITH (2) A194-2H HEAVY HEX NUTS	2,3

Notes:

1. THREADED CONNECTIONS ARE ONLY PERMITTED AT VENT/DRAIN VALVE OUTLETS, INSTRUMENT CONNECTIONS AND TO MATCH EQUIPMENT CONNECTIONS.
2. FULLY COAT ALL THREADS WITH NEVER SEEZ OR APPROVED EQUIVALENT PRIOR TO ASSEMBLY. DO NOT
3. STUD SIZE AND LENGTH SHALL BE SELECTED PER ASME B16.5 .
4. SLIP-ON FLANGES ARE NOT PERMITTED.
5. TEE, CROSS, REDUCING BRANCH TEE, 90LR ELBOW, 45 LR ELBOW, CAP
6. TEE, CROSS, COUPLING, REDUCING COUPLING, REDUCING INSERT, 90 ELBOW, 45 ELBOW, CAP
7. ALL BUTT WELD FITTINGS SHALL MATCH PIPE THICKNESS.

BRANCH CONNECTION TABLE

BRANCH SIZE	HEADER SIZE															
	½	¾	1	1 ½	2	3	4	6	8	10	12	14	16	18	20	24
½	ST	SRT	SRT	STI	STI	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL
¾		ST	SRT	SRT	STI	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL
1			ST	SRT	SRT	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL
1 ½				ST	SRT	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL
2					ST	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL
3						ST	WRT	WRT	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL
4							ST	WRT	WRT	WOL	WOL	WOL	WOL	WOL	WOL	WOL
6								ST	WRT	WRT	WOL	WOL	WOL	WOL	WOL	WOL
8									ST	WRT	WRT	WOL	WOL	WOL	WOL	WOL
10										ST	WRT	WRT	WOL	WOL	WOL	WOL
12											ST	WRT	WRT	WOL	WOL	WOL
14												ST	WRT	WRT	WOL	WOL
16													ST	WRT	WRT	WOL
18														ST	WRT	WRT
20															ST	WRT
24																ST

SYMBOLS

ST	=	STRAIGHT TEE
SOL	=	SOCKOLET
WOL	=	WELDOLET
WRT	=	BUTT WELDED REDUCING TEE
SRT	=	SOCKET REDUCING TEE
STI	=	SOCKET WELD TEE WITH SW REDUCING INSERT

Notes:

1. UNREINFORCED STUB-IN CONNECTIONS SHALL NOT BE USED.
2. BRANCH CONNECTIONS DESIGNATED ON DRAWINGS OR PIPING ISOMETRICS SHALL SUPERCEDE VALUES IN THIS TABLE.

SPECIFICATION 153	Material:	9CR-2W	Maximum Allowable Limits		Issue Date		
	Rating:	1500	Temp °F	Press. PSIG	Revision	By	Date
	Design Code:	ASME B31.1 – 2014	100	700	A	JC	03/28/16
	Size Range:	1/2" – 8"	400	700			
	Corrosion Allowance:	0.0625"	600	700			
	Design Factor:	N/A	800	700			
	Design Temperature:	1100°F	1100	700			
	Design Pressure:	700					

Material	Nominal Size		Sch/Rating	Description	Notes
	From	To			
PIPE	1/2"	2"	XS	SMLS, A335-P92, B36.10, PLAIN ENDS	
	3"	8"	XS	SMLS, A335-P92, B36.10, BEVELED ENDS	
FITTINGS	1/2"	2"	CL3000	SOCKET WELD, A182-F92, B16.11	5
	3"	8"	STD	SMLS, BUTT WELD, A234-WP92, B16.9	4,6
BRANCHES	1/2"	2"	CL3000	SOCKOLET, A182-F92, MSS-SP97	
	3"	8"		WELDOLET, A182-F92, MSS-SP97	6
FLANGES	1/2"	2"	CL1500	SOCKET WELD, RF, A182-F92, B16.5	3
	3"	8"	CL1500	WELD NECK, RF, A182-F92, B16.5, BORE TO MATCH PIPE WALL	
	1/2"	8"	CL1500	BLIND, RF, A182-F92, B16.5	
VALVES	REFER TO VALVE LIST AND SPECIFICATIONS				
GASKETS	1/2"	8"	CL1500	SPIRAL WOUND, B16.20, 1/8" COMPRESSED THICKNESS, TYPE316 STAINLESS STEEL WITH THERMICULITE 835 FILLER OR EQUIVALENT, FLEXITALLIC STYLE CGI OR EQUIVALENT	
BOLTS	1/2"	8"	CL1500	STUD BOLT A193-B16 WITH (2) A194-3 HEAVY HEX NUTS	1,2,7

General Notes:

A. CERTIFIED MATERIAL TEST REPORTS REQUIRED FOR ALL MATERIAL

B. ALL MATERIAL SHALL BE SUPPLIED TO B31 CODE CASE 183-1. PWHT IS MANDATORY AND SHALL MEET B31.1 2014 ED. REQUIREMENTS FOR P-NO. 15E.

C. THREADED CONNECTIONS ARE NOT PERMITTED.

Specific Notes:

1. FULLY COAT ALL THREADS WITH NEVER SEEZ OR APPROVED EQUIVALENT PRIOR TO ASSEMBLY. DO NOT
2. STUD SIZE AND LENGTH SHALL BE SELECTED PER ASME B16.5.
3. SLIP-ON FLANGES ARE NOT PERMITTED.
4. TEE, CROSS, REDUCING BRANCH TEE, 90LR ELBOW, 45 LR ELBOW, CAP
5. TEE, CROSS, COUPLING, REDUCING COUPLING, REDUCING INSERT, 90 ELBOW, 45 ELBOW, CAP
6. ALL BUTT WELD FITTINGS SHALL MATCH PIPE THICKNESS.
7. MATERIAL MUST BE CERTIFIED TO UNS 08800; IT MUST BE ANNEALD, SOLUTION ANNEALED OR HOT FINISHED. FORGING QUALITY MATERIAL IS NOT PERMITTED

BRANCH CONNECTION TABLE

BRANCH SIZE	HEADER SIZE															
	½	¾	1	1 ½	2	3	4	6	8	10	12	14	16	18	20	24
½	ST	SRT	SRT	STI	STI	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL
¾		ST	SRT	SRT	STI	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL
1			ST	SRT	SRT	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL
1 ½				ST	SRT	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL
2					ST	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL
3						ST	WRT	WRT	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL
4							ST	WRT	WRT	WOL	WOL	WOL	WOL	WOL	WOL	WOL
6								ST	WRT	WRT	WOL	WOL	WOL	WOL	WOL	WOL
8									ST	WRT	WRT	WOL	WOL	WOL	WOL	WOL
10										ST	WRT	WRT	WOL	WOL	WOL	WOL
12											ST	WRT	WRT	WOL	WOL	WOL
14												ST	WRT	WRT	WOL	WOL
16													ST	WRT	WRT	WOL
18														ST	WRT	WRT
20															ST	WRT
24																ST

SYMBOLS

ST	=	STRAIGHT TEE
SOL	=	SOCKOLET
WOL	=	WELDOLET
WRT	=	BUTT WELDED REDUCING TEE
SRT	=	SOCKET REDUCING TEE
STI	=	SOCKET WELD TEE WITH SW REDUCING INSERT

Notes:

1. UNREINFORCED STUB-IN CONNECTIONS SHALL NOT BE USED.
2. BRANCH CONNECTIONS DESIGNATED ON DRAWINGS OR PIPING ISOMETRICS SHALL SUPERCEDE VALUES IN THIS TABLE.

SPECIFICATION 999	Material:	INCONEL 740H	Maximum Allowable Limits		Issue Date		
	Rating:	-	Temp °F	Press. PSIG	Revision	By	Date
	Design Code:	ASME B31.1 – 2014	1415	1150	A	JC	03/28/16
	Size Range:	1/2" – 16"					
	Corrosion Allowance:	0.0"					
	Design Factor:	N/A					
	Design Temperature:	1415°F					
	Design Pressure:	1150 PSIG					

Material	Nominal Size		Sch/Rating	Description	Notes
	From	To			
PIPE	1/2"	6"	SCH-160	SMLS, B983-N07740, SOLUTION HEAT TREATED AND AGED, B36.10/B36.19, BEVELED ENDS, ASME B31.1 CODE CASE 190-12	
	8"	8"	0.625"		
	10"	10"	0.75"		
	16"	16"	1.125"		
FITTINGS	1/2"	2"	CL3000	SOCKET WELD, B564-N07740, B16.11	2
	3"	24"	STD	SMLS, BUTT WELD, B366-N07740, B16.9	1,3
BRANCHES	1/2"	2"	CL3000	SOCKOLET, B564-N07740, MSS-SP97	
	3"	24"		WELDOLET, B564-N07740, MSS-SP97	3
VALVES	REFER TO VALVE LIST AND SPECIFICATIONS				

General Notes:

A. CERTIFIED MATERIAL TEST REPORTS REQUIRED FOR ALL MATERIAL

B. ALL MATERIAL SHALL BE SUPPLIED TO B31 CODE CASE 190. SOLUTION ANNEALING, AGING AND PWHT IS MANDATORY AND SHALL CONFORM TO THE REQUIREMENTS OF B31 CODE CASE 190.

C. FLANGES OR THREADED CONNECTIONS ARE NOT PERMITTED.

Specific Notes:

1. TEE, CROSS, REDUCING BRANCH TEE, 90LR ELBOW, 45 LR ELBOW, CAP
2. TEE, CROSS, COUPLING, REDUCING COUPLING, REDUCING INSERT, 90 ELBOW, 45 ELBOW, CAP
3. ALL BUTT WELD FITTINGS SHALL MATCH PIPE THICKNESS.

BRANCH CONNECTION TABLE

HEADER SIZE → / BRANCH SIZE ↓	½	¾	1	1 ½	2	3	4	6	8	10	12	14	16	18	20	24
½	ST	SRT	SRT	STI	STI	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL
¾		ST	SRT	SRT	STI	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL
1			ST	SRT	SRT	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL
1 ½				ST	SRT	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL
2					ST	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL	SOL
3						ST	WRT	WRT	WOL	WOL	WOL	WOL	WOL	WOL	WOL	WOL
4							ST	WRT	WRT	WOL	WOL	WOL	WOL	WOL	WOL	WOL
6								ST	WRT	WRT	WOL	WOL	WOL	WOL	WOL	WOL
8									ST	WRT	WRT	WOL	WOL	WOL	WOL	WOL
10										ST	WRT	WRT	WOL	WOL	WOL	WOL
12											ST	WRT	WRT	WOL	WOL	WOL
14												ST	WRT	WRT	WOL	WOL
16													ST	WRT	WRT	WOL
18														ST	WRT	WRT
20															ST	WRT
24																ST

SYMBOLS

ST	=	STRAIGHT TEE
SOL	=	SOCKOLET
WOL	=	WELDOLET
WRT	=	BUTT WELDED REDUCING TEE
SRT	=	SOCKET REDUCING TEE
STI	=	SOCKET WELD TEE WITH SW REDUCING INSERT

Notes:

1. UNREINFORCED STUB-IN CONNECTIONS SHALL NOT BE USED.
2. BRANCH CONNECTIONS DESIGNATED ON DRAWINGS OR PIPING ISOMETRICS SHALL SUPERCEDE VALUES IN THIS TABLE.

VALVE SELECTION INDEX

SERVICE	SPECIFICATION	SIZE	VALVE TYPE	VALVE CODE
COND	011	1/2”-2”	BALL	BA01
		1/2”-2”	GATE	GT01
		3”-12”	GATE	GT02
		14”-24”	GATE	GT03
		3”-24”	SWING CHECK	CK01
SA	031	1/2”-2”	GATE	GT01
		3”-6”	GATE	GT04
		8”-12”	GATE	GT05
		14”-24”	GATE	GT06
SB	152	1/2”-2”	BALL	BA02
		1/2”-2”	GATE	GT07
		3”-6”	GATE	GT08
		8”-12”	GATE	GT09
SC	153	3”-24”	TILTING DISC CHECK	CK04
SS	999	1/2”	BALL	BA99
		1/2”	GATE	GT98
		16”	GATE	GT99
WBF	061	1/2”-2”	BALL	BA01
		1/2”-2”	GATE	GT10
		3”-6”	GATE	GT11
		8”-24”	GATE	GT12
		1/2”-2”	GLOBE	GL01
		1/2”-2”	SWING CHECK	CK02
		3”-24”	SWING CHECK	CK03
WC	011	4”	BACKFLOW PREVENTER	BP01
		6“	BACKFLOW PREVENTER	BP01
		3”-24”	SWING CHECK	CK01
WCR	011	1/2”-2”	BALL	BA01
		3”-6”	BUTTERFLY	BF01
		8”-12”	BUTTERFLY	BF02
		14”-24”	BUTTERFLY	BF03
		3”-24”	SWING CHECK	CK01
WCS	011	1/2”-2”	BALL	BA01
		3”-6”	BUTTERFLY	BF01
		8”-12”	BUTTERFLY	BF02
		14”-24”	BUTTERFLY	BF03
		1/2”-2”	GATE	GT01
		3”-24”	SWING CHECK	CK01
WLPF	061	1/2”-2”	BALL	BA01
		3”	BALL	BA03
		1/2”-2”	GATE	GT01
		3”-6”	GATE	GT11
		8”-24”	GATE	GT12
		1/2”-2”	GLOBE	GL01
		1/2”-2”	SWING CHECK	CK02
		3”-24”	SWING CHECK	CK03

Notes:

BALL VALVES

VALVE NO.	SIZE	MANUFACTURER	MODEL NUMBER	RATING		SPECIFICATIONS	
				°F	PSIG		
BA01	1/2"-2"	WORCESTER	XX-4446XGSW	300	1480	TYPE PORT STANDARD/RTG TRIM END TYPE/STD BODY MAT'L BALL SEATS STEM PACKING/SEALS BONNET OPERATOR TESTING MARKING REMARKS	BALL STANDARD ASME B16.34 SW (ASME B16.11) A105 A479-316 HIGH-PER FILL A479-316 GRAPHITE COATED SS LIVE LOADED LEVER MFR STD MSS SP25
BA02	1/2"-2"	VELAN	WXX-C2Q02-AGSA	800	4252	TYPE PORT STANDARD/RTG TRIM END TYPE/STD BODY MAT'L BALL SEATS STEM PACKING/SEALS BONNET OPERATOR TESTING MARKING REMARKS	BALL STANDARD ASME B16.34 CL3100 SW (ASME B16.11) A105 13CR HARDFACED 13CR HARDFACED 13CR HARDFACED FLEXIBLE GRAPHITE LIVE LOADED SLIDE HANDLE API 598 MSS SP25
BA03	3"	VELAN	FXX-20402-CRCA	300	700	TYPE PORT STANDARD/RTG TRIM END TYPE/STD BODY MAT'L BALL SEATS STEM PACKING/SEALS BONNET OPERATOR TESTING MARKING REMARKS	BALL STANDARD ASME B16.34 CL600 RF (ASME B16.5) A216-WCB 316 FLOATING CR PLATED C-RPTFE 316 SS INHIBITED GRAPHITE, SW GASKET LIVE LOADED EXT. HANDLE API 598 MSS SP25
BA99	1/2"	-	-	1415	1100	TYPE PORT STANDARD/RTG END TYPE/STD BODY MAT'L REMARKS	BALL STANDARD SPECIAL DESIGN BW (ASME B16.25) N07740 SPECIAL DESIGN, SUPPLIED BY GE BOILER

BUTTERFLY VALVES

VALVE NO.	SIZE	MANUFACTURER	MODEL NUMBER	RATING		SPECIFICATIONS	
				°F	PSIG		
BF01	3”-6”	KEYSTONE	222 SERIES	200	250	TYPE PORT STANDARD/RTG TRIM END TYPE/STD BODY MAT’L DISC LINER STEM PACKING/SEALS BONNET OPERATOR TESTING MARKING REMARKS	BUTTERFLY STANDARD CL150 FF (ASME B16.5) A126-B ALUMINUM BRONZE EPDM 416 SS EPDM NBR LOCKING LEVER MFR STD MFR STD LUGGED BODY, DOUBLE DEAD END SERVICE
BF02	8”-12”	KEYSTONE	222 SERIES	200	250	TYPE PORT STANDARD/RTG TRIM END TYPE/STD BODY MAT’L DISC LINER STEM PACKING/SEALS BONNET OPERATOR TESTING MARKING REMARKS	BUTTERFLY STANDARD CL150 FF (ASME B16.5) A126-B ALUMINUM BRONZE EPDM 416 SS EPDM NBR ENCL. GEAR MFR STD MFR STD LUGGED BODY, DOUBLE DEAD END SERVICE
BF03	14”-24”	KEYSTONE	XXX60LDAS1U2	200	200	TYPE PORT STANDARD/RTG TRIM END TYPE/STD BODY MAT’L DISC LINER STEM PACKING/SEALS BONNET OPERATOR TESTING MARKING REMARKS	BUTTERFLY STANDARD CL150 FF (ASME B16.5) A536-65/15/12 ALUMINUM BRONZE EPDM 416 SS EPDM NBR ENCL. GEAR MFR STD MFR STD LUGGED BODY, DEAD END SERVICE

BACKFLOW PREVENTERS

VALVE NO.	SIZE	MANUFACTURER	MODEL NUMBER	RATING		SPECIFICATIONS	
				°F	PSIG		
BP01	4"-6"	CONBRACO	40-200 SERIES	140	350	TYPE PORT STANDARD/RTG TRIM END TYPE/STD BODY MAT'L DISC LINER STEM PACKING/SEALS BONNET OPERATOR TESTING MARKING REMARKS	TOP ENTRY REDUCED PRESSURE DOUBLE BACKFLOW PREVENTER STANDARD 125 BRONZE FF (ASME B16.1) DUCTILE IRON, EPOXY COATED INTERIOR

GLOBE VALVES

VALVE NO.	SIZE	MANUFACTURER	MODEL NUMBER	RATING		SPECIFICATIONS	
				°F	PSIG		
GL01	1/2"-2"	BONNEY FORGE	HL-61-SW	800	1100	TYPE PORT STANDARD/RTG TRIM END TYPE/STD BODY MAT'L DISC SEAT STEM PACKING/SEALS BONNET OPERATOR TESTING MARKING REMARKS	GLOBE STANDARD API 602 CL800 API NO. 8 SW (ASME B16.11) A105 LOOSE SOLID DISC 13CR HF 13CR HF SEAL WELDED 13CR HARDFACED INHIBITED GRAPHITE, SW GASKET BOLTED OS&Y HANDWHEEL API 598 MSS SP25

CHECK VALVES

VALVE NO.	SIZE	MANUFACTURER	MODEL NUMBER	RATING		SPECIFICATIONS	
				°F	PSIG		
CK01	3”-24”	CRANE	XX-147-XUF	400	200	TYPE PORT STANDARD/RTG TRIM END TYPE/STD BODY MAT’L DISC SEAT STEM PACKING/SEALS BONNET TESTING MARKING REMARKS	SWING CHECK STANDARD ASME B16.34 CL150 API NO. 8 RF (ASME B16.5) A216-WCB 13CR HF 13CR HF INTEGRAL INHIBITED GRAPHITE BOLTED COVER MFR STD MSS SP25
CK02	1/2”-2”	BONNEY FORGE	HL-61-SW	800	1100	TYPE PORT STANDARD/RTG TRIM END TYPE/STD BODY MAT’L DISC SEAT STEM PACKING/SEALS BONNET TESTING MARKING REMARKS	SWING CHECK STANDARD API 602 CL800 API NO. 8 SW (ASME B16.11) A105 13CR HF 13CR HF INTEGRAL INHIBITED GRAPHITE, SW GASKET BOLTED COVER API 598 MSS SP25
CK03	3”-24”	CRANE	XX-175 1/2-XUF	300	1310	TYPE PORT STANDARD/RTG TRIM END TYPE/STD BODY MAT’L DISC SEAT STEM PACKING/SEALS BONNET TESTING MARKING REMARKS	SWING CHECK STANDARD ASME B16.34 CL600 API NO. 8 BW (ASME B16.25) A216-WCB 13CR HF 13CR HF SEAL WELDED INHIBITED GRAPHITE BOLTED COVER API 598 MSS SP25
CK04	3”-24”	VELAN	BXX-3344P-34TS	1100	700	TYPE PORT STANDARD/RTG TRIM END TYPE/STD BODY MAT’L DISC SEAT STEM PACKING/SEALS BONNET TESTING MARKING REMARKS	SWING CHECK STANDARD ASME B16.34 CL1500 API NO. 5 BW (ASME B16.25) A182-F91 A182-F91 HF HARDFACED A182-F91 HF INHIBITED GRAPHITE BOLTED COVER API 598 MSS SP25

GATE VALVES

VALVE NO.	SIZE	MANUFACTURER	MODEL NUMBER	RATING		SPECIFICATIONS	
				°F	PSIG		
GT01	1/2"-2"	BONNEY FORGE	HL-11-SW	800	1100	TYPE PORT STANDARD/RTG TRIM END TYPE/STD BODY MAT'L DISC SEATS STEM PACKING/SEALS BONNET OPERATOR TESTING MARKING REMARKS	GATE STANDARD API 602 CL800 API NO. 8 SW (ASME B16.11) A105 SOLID WEDGE 13CR HF 13CR HF SEAL WELDED 13CR HARDFACED INHIBITED GRAPHITE, SW GASKET BOLTED OS&Y HANDWHEEL API 598 MSS SP25
GT02	3-12"	CRANE	XX-47XUF	400	200	TYPE PORT STANDARD/RTG TRIM END TYPE/STD BODY MAT'L DISC SEATS STEM PACKING/SEALS BONNET OPERATOR TESTING MARKING REMARKS	GATE STANDARD ASME B16.34 CL150 API NO. 8 RF (ASME B16.5) A216-WCB FLEXIBLE WEDGE 13CR HF 13CR HF SEAL WELDED 13CR HARDFACED INHIBITED GRAPHITE BOLTED OS&Y HANDWHEEL API 598 MSS SP25
GT03	14"-24"	CRANE	XX-47XUF-OV	400	200	TYPE PORT STANDARD/RTG TRIM END TYPE/STD BODY MAT'L DISC SEATS STEM PACKING/SEALS BONNET OPERATOR TESTING MARKING REMARKS	GATE STANDARD ASME B16.34 CL150 API NO. 8 RF (ASME B16.5) A216-WCB FLEXIBLE WEDGE 13CR HF 13CR HF SEAL WELDED 13CR HARDFACED INHIBITED GRAPHITE BOLTED OS&Y ENCL. GEAR API 598 MSS SP25

GATE VALVES (CONTINUED)

VALVE NO.	SIZE	MANUFACTURER	MODEL NUMBER	RATING		SPECIFICATIONS	
				°F	PSIG		
GT04	3”-6”	CRANE	XX-33XUF	800	410	TYPE PORT STANDARD/RTG TRIM END TYPE/STD BODY MAT’L DISC SEATS STEM PACKING/SEALS BONNET OPERATOR TESTING MARKING REMARKS	GATE STANDARD ASME B16.34 CL300 API NO. 8 RF (ASME B16.5) A216-WCB FLEXIBLE WEDGE 13CR HF 13CR HF SEAL WELDED 13CR HARDFACED INHIBITED GRAPHITE BOLTED OS&Y HANDWHEEL API 598 MSS SP25
GT05	8-12”	CRANE	XX-33XUF	800	410	TYPE PORT STANDARD/RTG TRIM END TYPE/STD BODY MAT’L DISC SEATS STEM PACKING/SEALS BONNET OPERATOR TESTING MARKING REMARKS	GATE STANDARD ASME B16.34 CL300 API NO. 8 RF (ASME B16.5) A216-WCB FLEXIBLE WEDGE 13CR HF 13CR HF SEAL WELDED 13CR HARDFACED INHIBITED GRAPHITE BOLTED OS&Y HANDWHEEL API 598 MSS SP25 W/DRAIN
GT06	14”-24”	CRANE	XX-33XUF-OV	800	410	TYPE PORT STANDARD/RTG TRIM END TYPE/STD BODY MAT’L DISC SEATS STEM PACKING/SEALS BONNET OPERATOR TESTING MARKING REMARKS	GATE STANDARD ASME B16.34 CL300 API NO. 8 RF (ASME B16.5) A216-WCB FLEXIBLE WEDGE 13CR HF 13CR HF SEAL WELDED 13CR HARDFACED INHIBITED GRAPHITE BOLTED OS&Y ENCL. GEAR API 598 MSS SP25 W/DRAIN AND BYPASS

GATE VALVES (CONTINUED)

VALVE NO.	SIZE	MANUFACTURER	MODEL NUMBER	RATING		SPECIFICATIONS	
				°F	PSIG		
GT07	1/2"-2"	BONNEY FORGE	9WL-11-SW	800	2055	TYPE PORT STANDARD/RTG TRIM END TYPE/STD BODY MAT'L DISC SEATS STEM PACKING/SEALS BONNET OPERATOR TESTING MARKING REMARKS	GATE STANDARD API 602 CL1500 API NO. 8 SW (ASME B16.5) A105 SOLID WEDGE 13CR HF 13CR HF SEAL WELDED 13CR HARDFACED INHIBITED GRAPHITE WELDED OS&Y HANDWHEEL API 598 MSS SP25
GT08	3-6"	VELAN	BXX-3054P-02TS	800	2055	TYPE PORT STANDARD/RTG TRIM END TYPE/STD BODY MAT'L DISC SEATS STEM PACKING/SEALS BONNET OPERATOR TESTING MARKING REMARKS	GATE STANDARD ASME B16.34 CL1500 API NO. 5 BW (ASME B16.25) A105 FLEXIBLE WEDGE HF HARDFACED 13CR HARDFACED INHIBITED GRAPHITE PRESSURE SEAL HANDWHEEL API 598 MSS SP25 W/DRAIN
GT09	8"-24"	VELAN	BXX-3054P-02TS	800	2055	TYPE PORT STANDARD/RTG TRIM END TYPE/STD BODY MAT'L DISC SEATS STEM PACKING/SEALS BONNET OPERATOR TESTING MARKING REMARKS	GATE STANDARD ASME B16.34 CL1500 API NO. 5 BW (ASME B16.25) A105 FLEXIBLE WEDGE HF HARDFACED 13CR HARDFACED INHIBITED GRAPHITE PRESSURE SEAL ENCL. GEAR API 598 MSS SP25 W/DRAIN AND BYPASS

GATE VALVES (CONTINUED)

VALVE NO.	SIZE	MANUFACTURER	MODEL NUMBER	RATING		SPECIFICATIONS	
				°F	PSIG		
GT10	1/2"-2"	BONNEY FORGE	HL-11-SW	800	1100	TYPE PORT STANDARD/RTG TRIM END TYPE/STD BODY MAT'L DISC SEATS STEM PACKING/SEALS BONNET OPERATOR TESTING MARKING	GATE STANDARD API 602 CL800 API NO. 8 SW (ASME B16.11) A105 SOLID WEDGE 13CR HF 13CR HF SEAL WELDED 13CR HARDFACED INHIBITED GRAPHITE, SW GASKET BOLTED OS&Y HANDWHEEL API 598 MSS SP25
GT11	3-6"	CRANE	XX-76 1/2XUF	300	1310	TYPE PORT STANDARD/RTG TRIM END TYPE/STD BODY MAT'L DISC SEATS STEM PACKING/SEALS BONNET OPERATOR TESTING MARKING	GATE STANDARD ASME B16.34 CL600 API NO. 8 BW (ASME B16.25) A216-WCB FLEXIBLE WEDGE 13CR HF 13CR HF SEAL WELDED 13CR HARDFACED INHIBITED GRAPHITE BOLTED OS&Y HANDWHEEL API 598 MSS SP25
GT12	8"-24"	CRANE	XX-76 1/2XUF-OV	300	1310	TYPE PORT STANDARD/RTG TRIM END TYPE/STD BODY MAT'L DISC SEATS STEM PACKING/SEALS BONNET OPERATOR TESTING MARKING	GATE STANDARD ASME B16.34 CL600 API NO. 8 BW (ASME B16.25) A216-WCB FLEXIBLE WEDGE 13CR HF 13CR HF SEAL WELDED 13CR HARDFACED INHIBITED GRAPHITE BOLTED OS&Y ENCL. GEAR API 598 MSS SP25
GT98	1/2"			1415	1100	TYPE PORT STANDARD/RTG END TYPE/STD BODY MAT'L REMARKS	GATE STANDARD SPECIAL DESIGN BW (ASME B16.25) N07740 SPECIAL DESIGN, SUPPLIED BY GE BOILER
GT99	16"			1415	1100	TYPE PORT STANDARD/RTG END TYPE/STD BODY MAT'L REMARKS	GATE STANDARD SPECIAL DESIGN BW (ASME B16.25) N07740 SPECIAL DESIGN, SUPPLIED BY GE BOILER

PART 5 - INSULATION

5.1 SCOPE

A. This section, together with the Contract Documents and the applicable design drawings, covers furnishing and installing insulation for piping services, complete with required surface finishes, as specified herein. All items that are not specifically excluded and are necessary to make the insulation systems complete are a part of this insulation Work.

B. Work shall comply with OSHA requirements and all applicable federal, state, and local codes, specifications, and standards. Applicable dates for all codes, specifications, and standards will be the dates of the latest revision in effect on the effective date of the Contract.

5.2 REFERENCE STANDARDS

A. Organization whose standards are referenced herein:

1. ASTM American Society for Testing and Materials

5.3 ALTERNATES

A. It is not intended that this specification section prohibits the use of materials by manufacturers other than those specified. All requests for substitutions must be made in writing and approved by Engineer prior to award of Contract.

B. Requests for substitutions shall include the following information:

1. Exact names of products and their manufacturers.

2. Descriptive and technical data sufficient for evaluation.

3. Thickness of insulation to be furnished.

5.4 MATERIALS

A. Materials shall be as specified on the attached Data Sheets.

B. Where specific manufacturers and/or products are specified, these products shall be used. Alternates must be approved in writing by Owner.

C. Material manufacturer's application instructions shall be followed when installing materials. If this Technical Provision is in conflict with manufacturer's instructions, the conflict shall be brought to the attention of Owner.

D. Only insulation materials certified to be asbestos free may be used.

E. Insulation manufacturers shall certify that thermal conductivities and densities of insulation materials to be used in Work.

F. Metal jacketing shall be applied over all insulated pipe, fittings, and specialties. The only exception is Class III insulation used in protected areas.

G. Contractor shall submit samples of materials for Owner's review and acceptance prior to installation.

5.5 INSPECTION

A. Inspect piping installation to make sure that pipelines are permanently installed with all hangers, supports, saddles and sleeves in place.

B. Pipe testing, cleaning, and painting will be performed by Others, prior to application of insulation. Any scale, rust or pipe leakage shall be brought to the attention of Owner for correction. Insulation shall not be applied until such conditions have been corrected unless Contractor notified by Owner must authorize in writing if otherwise.

5.6 INSTALLATION

A. Apply insulation and accessory materials in accordance with manufacturer's recommendations, data sheets and the following:

1. All components of the pipe line are to be insulated in accordance with the requirements of the adjoining piping.

2. Furnish and install insulation supports required on vertical piping four (4) inches and larger that have not been provided with the piping. Use steel angle or plate type supports having a width of approximately ½-inch less than insulation thickness.

3. If necessary to block or shore up pipe, or to displace or remove hangers, restore pipe and hangers to original locations and alignment after insulation is installed.

4. For piping supported by hangers installed outside insulation or set on racks, install hanger rod rain shields secured with stainless steel screws.

5. When multi-layer insulation is required to attain specified thicknesses, apply each layer independently with all joints staggered.

6. At flanged connections, neatly bevel exposed ends of insulation down to pipe with insulating cement or vapor seal cement, leaving sufficient clearance for removal or tightening of bolts. Removable flange insulation (blanket) shall be installed after piping is tested and completed.

7. Prior to application of final surface finishes, fill all voids and open joints and neatly point with insulating cement, sealing compound, or other coating material as appropriate for type of insulation involved.

8. Apply insulation at expansion joints to permit free operation of the expansion joints.

9. On normally uninsulated pipe such as relief vents which may operate above 125°F insulate for personnel protection in locations where contact by personnel is probable. In general, contact by personnel may be considered probable near walkways up to seven (7) feet above the elevation of the walkway, and within two (2) feet of handrails.

10. Provide removable insulation (rigid or bagged) over all valves and flanges which must be accessible for maintenance or inspection. The sections shall be secured with lacing, snaps or other reusable fastening devices.

11. Only insulation exposed to weather shall be covered with aluminum sheet metal.

12. Insulation on piping with temperatures below ambient shall have a vapor barrier.

13. All insulation shall be covered with fire-resistant material or coating.

14. Insulation shall not be installed on hand wheels, hand levers and unions.

B. Insulation shall be handled and applied in a manner that shall not adversely affect its insulating or structural properties. If insulation becomes wet, it shall be replaced. The use of insulation previously wetted is prohibited.

C. Insulation materials shall be protected from weather, Polystyrene foam and polyisocyanurate foam insulation shall be protected from exposure to direct sunlight. All insulation shall be protected from water and materials generated by other construction activity.

D. Insulation installed each day shall have permanent jacket installed before contractor leaves the site for the day (indoor and outdoor). Any exposed or partially completed ends left temporarily exposed shall be protected from weather or other contaminates with plastic wrap and tape at the end of each shift.

5.7 FIELD QUALITY CONTROL

A. Workmanship shall be first class in every respect.

B. Carefully examine insulation applied to surfaces subject to sweating, as work progresses and after completion, to assure vapor barrier is complete and unbroken throughout.

C. Contractor shall be responsible for the following at no additional cost to Owner.

D. Daily cleaning of the affected work area and clean-up upon final completion of Work.

E. Repair of damages caused directly or indirectly by its workers to structures, buildings, equipment, piping and clearing of obstructed sewers.

5.8 PROTECTION

A. Protect from weather all insulating materials stored on the project site, and incomplete insulation work. If insulation becomes wet, it shall be replaced. The use of insulation previously wetted is prohibited.

END OF SECTION

AECOM

A-USC Component Test Project
Piping Line List

REVISION: A - 3/31/16
STATUS: PRELIMINARY

PREFIX	LINE NO.	SERVICE INFORMATION		PIPE SIZE (INCH)	PIPE SPEC	P&ID NUMBER PID-YYT-	BUILDING NUMBER	STRESS ANAL. REQ'D? (Y/N)	OPERATING			INSULATION			TESTING						COMMENTS
		EQUIPMENT (LINE) NO.							TEMP °F	PRESSURE (PSIG)	FLUID DENSITY	THICK (INCH)	SPEC	CODE	PAINT SPEC	TEST TYPE	TEST PRESSURE	DURATION (MIN)	TIE-IN NUMBER	
		FROM	TO																		
WBF	1001	WBF PUMPS	WBF DISTRIBUTION	6.00	YY	10	6		250	1030				II							
WBF	1101	6"WBF-1001-II	RENTAL BOILER #1	3.00	YY	11	2		250	1030				II							
WBF	1102	6"WBF-1001-II	RENTAL BOILER #2	3.00	YY	11	2		250	1030				II							
WLPF	1103	WBF DISTRIBUTION	SUPER HEATED STEAM DISTRIBUTION	3.00	YY	11	6							II							
WBF	1104	6"WBF-1001-II	SUPERHEATER STEAM SIDE	2.00	YY	11	3		250	1030				II							
WLPF	1105	WBF DISTRIBUTION	EXHAUST STEAM	3.00	YY	11	6							II							
WBF	1106	6"WBF-1001-II	SUPERHEATER GAS SIDE	3.00	YY	11	5		250	1030				II							
WLPF	1107	WBF DISTRIBUTION	BOILER STEAM DISTRIBUTION	2.00	YY	11	2		250	1030				II							
WLPF	1108		SUPERHEATER STEAM SIDE	4.00	YY	11	6							II							
COND	1201	OWT DEMIN FILTER SYSTEM	DEAREATOR	4.00	YY	12								II							
WC	1202	OWT DEMIN FILTER SYSTEM	COOLING TOWER	6.00	YY	12			90	90				II							
WCS	1203	OWT DEMIN FILTER SYSTEM	DY- 4101 DYNOMOMETER	10.00	YY	12			90	90				II							
SB	2001	RENTAL BOILER #1	BOILER STEAM DISTRIBUTION	8.00	YY	20	2		850	960				II							
SB	2101	RENTAL BOILER #2	BOILER STEAM DISTRIBUTION	8.00	YY	21	2		850	980				II							
SB	2201	8"SB-2001-II AND 8"SB-2101-II	DS-2201	10.00	YY	22	2		850	980				II							
SB	2202	10"-SB2201-II	SUPERHEATER - STEAM SIDE	10.00	YY	22	3		850	980				II							
SB	2203	DS-2201	TUR-4001 AUSC TURBINE	10.00	YY	22	5		850	980				II							
SA	2204	10"SB-2201-II	10"SB-5001-II	10.00	YY	22	4		1000	980				II							
SB	2205	BOILER STEAM DISTRIBUTION	DEAREATOR	6.00	YY	22			850	980				II							
SB	2206	BOILER STEAM DISTRIBUTION	SB BYPASS	4.00	YY	22			850	980				II							
SS	3001	SUPERHEATER - STEAM SIDE	DS-5001	10.00	YY	30	3		1400	1100				II							
SC	3002	SUPERHEATER - STEAM SIDE	TUR-4001 AUSC TURBINE	6.00	YY	30	4		1100	655				II							
WBF	3003	SUPERHEATER	DEAREATOR	2.00	YY	30	1		250	1030				II							
WLPF	3004	SUPERHEATER - STEAM SIDE	TO YTT	4.00	YY	30	3							II							
COND	3005	SUPERHEATER - STEAM SIDE	HE-6001 DUMP EXCHANGER	2.00	YY	30	3							II							
SS	4001	TUR-4001 AUSC TURBINE	DS-4201	16.00	YY	40	4		1400	1100				II							
COND	4002	TUR-4001 AUSC TURBINE	2"COND-3005-II	2.00	YY	40								II							
COND	4003	10"SS-5002-II	2"COND-4002-II	2.00	YY	40								II							
WCS	4004	2"WCS-4104	TURBINE LUBRICATION SKID	2.00	~~YY~~	40			90	90				-							
WCS	4005	2"WCS-4104	TURBINE HYDRAULICPOWER UNIT	2.00	YY	40			90	90				-							
WCR	4006	TURBINE LUBRICATION SKID	6"WCR-4008	2.00	YY	40			60	90				-							
WCR	4007	TURBINE HYDRAULICPOWER UNIT	6"WCR-4008	2.00	YY	40			60	90				-							
WCR	4008	TURBINE STEAM SEAL SYSTEM	HOT WELL	2.00	YY	40			60	90				-							
WCS	4101	10"WCS-7010	DY- 4101 DYNOMOMETER	16.00	YY	41	7		90	90				-							
WCR	4102	10"WCS-7010	HOT WELL	10.00	YY	41	7		125	90				-							
WCR	4103	DY- 4101 DYNOMOMETER	HOT WELL	12.00	YY	41	7		125	90				-							
WCS	4104	10"WCS-1203-II	TURBINE STEAM SEAL SYSTEM	2.00	YY	41			90	90				-							
WCS	4105	10"WCS-1203-II	DYNOMOMETER HYDRAULIC POWER SKID	2.00	YY	41			90	90				-							
WCS	4106	10"WCS-1203-II	DYNOMOMETER LUBRICATION SKID	2.00	YY	41			90	90				-							
WCR	4107	DYNOMOMETER HYDRAULIC POWER SKID	12"WCR-4103	2.00	YY	41			60	90				-							
WCR	4108	DYNOMOMETER LUBRICATION SKID	2"WCR-4107	2.00	YY	41			60	90				-							
SA	4201	DS-4201	16"SA-6001-II	16.00	YY	42	6		1000	980				II							
SS	5001	10"SS-3001-II	DS-5103 DESUPERHEATER	10.00	YY	50	5		1400	1100				II							
SS	5002	10"SS-3001-II	TUR-4001 AUSC TURBINE	10.00	YY	50	4		1400	1100				II							
SA	5003	DS-5001	16"SA-4201-II	24.00	YY	50	6		1000	980				II							
SA	5104	DS-5103 DESUPERHEATER	16"SA-4201-II	16.00	YY	51	6		1000	980				II							
SA	6001	16"SA-4201-II	HE-6001 DUMP EXCHANGER	16.00	YY	60	4		1000	980				II							
SA	6002	16"SA-6001-II	TO YTT	16.00	YY	60			1000	980				II							
WCR	6003	HE-6001 DUMP EXCHANGER	24"WCR-7004	24.00	YY	60	7		125	90				-							
COND	6004	HE-6001 DUMP EXCHANGER	CONDENSATE RETURN PUMPS	6.00	YY	60	7							II							

3/31/2016 11:05 AM

AECOM

A-USC Component Test Project
Piping Line List

REVISION: A - 3/31/16
STATUS: PRELIMINARY

PREFIX	LINE NO.	SERVICE INFORMATION		PIPE SIZE (INCH)	PIPE SPEC	P&ID NUMBER PID-YYT-	BUILDING NUMBER	STRESS ANAL. REQ'D? (Y/N)	OPERATING			INSULATION			TESTING					COMMENTS
		EQUIPMENT (LINE) NO.							TEMP °F	PRESSURE (PSIG)	FLUID DENSITY	THICK (INCH)	SPEC	CODE	PAINT SPEC	TEST TYPE	TEST PRESSURE	DURATION (MIN)	TIE-IN NUMBER	
		FROM	TO																	
COND	6005	CONDENSATE RETURN PUMPS	OWT DEMIN FILTER SYSTEM	4.00	YY	60	1							II						
COND	6006	HE-6001 DUMP EXCHANGER	4"COND-6005-II	4.00	YY	60	4							II						
COND	6007	4"COND-6005-II	4"COND-6005-II	4.00	YY	60								II						
VENT	6008	HE-6001 DUMP EXCHANGER	ATMOSPHERE		YY	60								-						
VENT	6009	HE-6001 DUMP EXCHANGER	ATMOSPHERE		YY	60								-						
FG	6101	FROM YTT	FLOW METER (VENDOR PACKAGE)		YY	61								II						
FG	6102	FLOW METER (VENDOR PACKAGE)	RENTAL BOILER 1		YY	61								II						
FG	6103	X"FG-6102-II	RENTAL BOILER 2		YY	61								II						
FG	6104	X"FG-6102-II	SUPERHEATER 3		YY	61								II						
WCR	7001	HOT WELL	COOLING TOWER PUMPS	12.00	YY	70	7		125	90				-						
WCR	7002	12"WCR-7002	COOLING TOWER PUMPS	12.00	YY	70	7		125	90				-						
WCR	7003	COOLING TOWER PUMPS	24"WCR-7004	10.00	YY	70	7		125	90				-						
WCR	7004	10"WCR-7003	COOLING TOWER	24.00	YY	70	7		125	90				-						
WCS	7005	COOLING TOWER	COOLING TOWER PUMPS	18.00	YY	70	7		90	90				-						
WCS	7006	18"WCR-7005	COOLING TOWER PUMPS	18.00	YY	70	7		90	90				-						
WCS	7007	COOLING TOWER PUMPS	HE-6001 DUMP EXCHANGER	18.00	YY	70	7		90	90				-						
WCS	7008	COOLING TOWER	COOLING TOWER PUMPS	12.00	YY	70	7		90	90				-						
WCS	7009	12"WCR-7008	COOLING TOWER PUMPS	12.00	YY	70	7		90	90				-						
WCS	7010	COOLING TOWER PUMPS	10"WCS-7010	10.00	YY	70	7		90	90				-						
WCR	7011	18"WCR-7006	COOLING TOWER PUMPS	18.00	YY	70	7		60	90				-						
WCR	7012	10"WCR-7003	SUPERHEATER - GAS SIDE	2.00	YY	70			60	90				-						

AECOM

A-USC Component Test Project
Piping Line List

REVISION: B DATE: 8/15/2017
STATUS: FOR REVIEW
DOCUMENT NO.: 31609-16-LST-0001

LINE AND SERVICE INFORMATION						P&ID NUMBER PID-AUSC-	INSULATION			TESTING					COMMENTS
PIPE SIZE (INCH)	PIPE SPEC	PREFIX	LINE NO.	DESTINATION			THICK (INCH)	SPEC	CODE	PAINT SPEC	TEST TYPE	TEST PRESSURE	DURATION (MIN)	TIE-IN NUMBER AUSC-	
				FROM	TO										
8	011	WR	0301	RIVER WATER FILTER F-0302	MAKE UP WATER TO COOLING TOWER CT-7004	03									
2	011	WR	0302	8"-011-WR-0301	MAKE UP WATER TO DEAERATOR DE-0801	03									
6	011	NG	0303	PRV-0304	SUPERHEATER BURNER	03									
6	011	NG	0304	6"-011-NG-0303	TO BOILER BURNER	03									
8	011	WR	0305	RIVER WATER PUMP P-0301	RIVER WATER FILTER F-0302	03									
3	011	WR	0306	8"-011-WR-0301	MAKE UP WATER TO GCW EXP. TK. V-4104	03									
6	011	NG	0307	TIE-IN 02	PRV-0304	03								02	
6	031	COND	0501	BOILER FEED WATER TREATMENT DM-0502	TO DEAERATOR DE-0801	05			II						
3	011	WR	0502	DEMIN SYSTEM DM-0503	MAKE UP WATER TO DEAERATOR DE-0801	05									
6	091	WBF	0801	DEAERATOR DE-0801	WBF DISTRIBUTION AND BOILER B-2001	08			II						
3	091	WBF	1001	6"-091-WBF-0801-II	SPRAY WATER HEATER HE-1201	10			II						
1	999	WBF	1003	2"-091-WBF-1010-II	DESUPERHEATER 2 DSH-2	10			II						
1	153	WBF	1004	2"-091-WBF-1009-II	DESUPERHEATER 1 DSH-1	10			II						
2	091	WBF	1005	3"-091-WBF-1201-II	DESUPERHEATER 3 DSH-3	10			II						
3	091	WBF	1006	6"-091-WBF-0801-II	DESUPERHEATER 5 DSH-5	10			II						
2	091	WBF	1009	3"-091-WBF-1201-II	1"-153-WBF-1004-II	10			II						
2	091	WBF	1010	3"-091-WBF-1201-II	1"-999-WBF-1003-II	10			II						
3	091	WBF	1201	SPRAY WATER HEATER HE-1201	DESUPERHEATER 4 DSH-4	12			II						
6	091	HPC	1202	LV-1208	CONDENSATE CONDENSER HE-6101	12			II						
4	091	HPC	1203	SPRAY WATER HEATER HE-1201	LV-1208	12			II						
8	152	SB	2001	BOILER B-2001	SB DISTRIBUTION	20			II						
6	153	SA	2501	8"-152-SB-2001-II	10"-153-SA-5001-II	25			II						SUPERHEATER BYPASS
6	031	WGC	3001	SUPERHEATER ECONOMIZER	GAS COOLING WATER EXCHANGER HE-4101	30			II						
8	999	SS	3002	SUPERHEATER SH-3001	CONDENSATE CONDENSER HE-6101	30			II						
x	031	COND	3003	SUPERHEATER SH-3001	CONDENSATE CONDENSER HE-6101	30			II						
6	031	WGC	4101	GAS COOLING WATER PUMP PU-4102	SUPERHEATER SH-3001	41			II						
6	031	WGC	4102	GAS COOLING WATER EXCHANGER HE-4101	GAS COOLING WATER PUMP PU-4102	41			II						
10	011	WGC	4103	GAS COOLING WATER EXCHANGER HE-4101	COOLING TOWERS CT-7004	41									
8	999	SS	4901	DESUPERHEATER 3 DSH-3	DESUPERHEATER 4 DSH-4	49			II						
10	153	SA	5001	DESUPERHEATER 4 DSH-4	DESUPERHEATER 5 DSH-5	50			II						
4	153	SA	5002	10"-153-SA-5001-II	SPRAY WATER HEATER HE-1201	50			II						

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A-USC Component Test Project
Piping Line List

REVISION: B DATE: 8/15/2017
STATUS: FOR REVIEW
DOCUMENT NO.: 31609-16-LST-0001

LINE AND SERVICE INFORMATION						P&ID NUMBER PID-AUSC-	INSULATION			TESTING					COMMENTS
PIPE SIZE (INCH)	PIPE SPEC	PREFIX	LINE NO.	DESTINATION			THICK (INCH)	SPEC	CODE	PAINT SPEC	TEST TYPE	TEST PRESSURE	DURATION (MIN)	TIE-IN NUMBER AUSC-	
				FROM	TO										
26	032	SA	5101	DESUPERHEATER 5 DSH-5	CONDENSATE CONDENSER HE-6101	51			II						
6	032	SA	5102	26"-031-SA-5101-II	DEAERATOR DE-0801	51			II						
6	031	COND	6101	CONDENSATE CONDENSER HE-6101	CONDENSATE RETURN PUMP PU-6102	61			II						
4	031	COND	6102	CONDENSATE CONDENSER HE-6101	6"-031-COND-6104-II	61			II						
24	011	WCR	6103	CONDENSATE CONDENSER HE-6101	COOLING TOWERS CT-7004	61									
6	031	COND	6104	CONDENSATE RETURN PUMP PU-6102	BOILER FEED WATER TREATMENT	61			II						
2	011	NH3	6401	AMMONIA STORAGE TANK V-6401	BOILER SCR	64									
1	011	NH3	6402	x"-011-NH3-6401	SUPERHEATER SCR	64									
x	011	NH3	6403	TRUCK UNLOADING	AMMONIA STORAGE TANK V-6401	64									
x	011	NH3	6404	AMMONIA STORAGE TANK V-6401	TRUCK UNLOADING	64									
18	011	WCS	7003	SUPPLY PUMP PU-7002B	24"-011-WCS-7004	70									
18	011	WCS	7004	SUPPLY PUMP PU-7002C	24"-011-WCS-7007	70									
20	011	WCS	7005	28"-011-WCS-7008	SUPPLY PUMP PU-7002A	70									
20	011	WCS	7006	28"-011-WCS-7008	SUPPLY PUMP PU-7002B	70									
24	011	WCS	7007	SUPPLY PUMP PU-7002A	CONDENSATE CONDENSER HE-6101	70									
28	011	WCS	7008	COOLING TOWERS CT-7004	SUPPLY PUMP PU-7002C	70									
10	011	WCS	7010	18"-011-WCS-7004	GAS COOLING WATER EXCHANGER HE-4101	70									
6	011	WR	7101	COOLING TOWER WATER TREATMENT SK-7102	COOLING TOWERS CT-7004	71									
x	011	AI	8001	AIR COMPRESSOR SKID AC-8001	AIR DISTRIBUTION HEADER	80									
2	011	AI	8002	x"-011-AI-8001	SUPERHEATER SH-3001	80									
2	011	AI	8003	x"-011-AI-8001	SUPERHEATER SH-3001	80									

AECOM

A-USC Component Test Project
Piping Line List

REVISION: B DATE: 8/15/2017
STATUS: FOR REVIEW
DOCUMENT NO.: 31609-16-LST-0001

LINE AND SERVICE INFORMATION						P&ID NUMBER PID-AUSC-	INSULATION			TESTING					COMMENTS
PIPE SIZE (INCH)	PIPE SPEC	PREFIX	LINE NO.	DESTINATION			THICK (INCH)	SPEC	CODE	PAINT SPEC	TEST TYPE	TEST PRESSURE	DURATION (MIN)	TIE-IN NUMBER AUSC-	
				FROM	TO										

AECOM

A-USC Component Test Project
Piping Line List

REVISION: B DATE: 8/15/2017
STATUS: FOR REVIEW
DOCUMENT NO.: 31609-16-LST-0001

LINE AND SERVICE INFORMATION						P&ID NUMBER PID-AUSC-	BUILDING NUMBER	STRESS ANALYSIS REQ'D? (Y/N)	OPERATING			INSULATION			TESTING					COMMENTS
PIPE SIZE (INCH)	PIPE SPEC	PREFIX	LINE NO.	DESTINATION					TEMP °F	PRESSURE (PSIG)	FLUID DENSITY	THICK (INCH)	SPEC	CODE	PAINT SPEC	TEST TYPE	TEST PRESSURE	DURATION (MIN)	TIE-IN NUMBER AUSC-	
				FROM	TO															
6 *	451	SB	1001	TIE-IN 01 - UNIT 5 MAIN STEAM HEADER	8"-152-SB-1002-II	10			1000	3485	4.9			II					01	
8	152	SB	1002	X"-451-SB-1001-II	STEAM SUPERHEATER	10			877	1285	1.8			II					-	
6	152	SB	1003	8"-152-SB-1002-II	STEAM CYCLING HEADER	10			877	1285	1.8			II					-	
3	251	WBF	1004	TIE-IN 02 - UNIT 5 #7A/7B HEATER	SUPERHEATER SPRAY STATION #2	10			500	3735	44.9			II					02	
3	251	WBF	1005	3"-251-WBF-1004-II	DESUPERHEATER	10			500	2985	44.9			II					-	
6	031	COND	1006	TIE-IN 03 - UNIT 5 #2 HEATER	SUPERHEATER GAS COOLER	10			207	465	57.5			II					03	
3	011	NG	1007	TIE-IN 04 - SITE NATURAL GAS HEADER	SUPERHEATER	10			77	175	0.59		-	-					04	
6	031	COND	3001	SUPERHEATER	TIE-IN 06 - UNIT 5 DEAERATOR	30			322	445	53.3			II					06	
8 *	999	SS	3002	SUPERHEATER	STEAM CYCLING HEADER	30			1400	1028	0.95			II					-	
2	251	WBF	3003	2"-251-WBF-1004-II	SUPERHEATER SPRAY STATION #1	30			500	2985	44.9			II					-	
TBD	152	COND	3004	SUPERHEATER DRAINS	DRAIN TANK	30			-	-	-			II					-	START UP DRAIN
8 *	999	SS	4001	X"-999-SS-3002-II	X"-999-SS-4003-II	40			1400	1028	0.95			II					-	STEAM CYCLING HEADER BYPASS
6	152	SB	4002	6"-152-SB-1003-II	X"-999-SS-3002-II	40			877	1285	1.8			II					-	
10 *	999	SS	4003	STEAM CYCLING HEADER	DESUPERHEATER	40			1400	1000	0.93			II					-	
12	152	SA	5001	DESUPERHEATER	TIE-IN-05 - UNIT 5 HOT REHEAT HEADER	50			1005	665	0.81			II					05	
2	011	COND	5102	DRAIN TANK	DRAIN	51			212	ATM	-			II					-	
4	011	AI	8001	AIR COMPRESSOR SKID	AIR DISTRIBUTION HEADER	80			115	90	0.65		-	-					-	
2	011	AI	8002	4"-011-AI-8001	SUPERHEATER	80			115	90	0.65		-	-					-	
2	011	AI	8003	4"-011-AI-8001	SUPERHEATER	80			115	90	0.65		-	-					-	

* = PIPE ID

3/5/2018

AECOM

A-USC Component Test Project
Automated Valve List

REVISION: D DATE: 8/14/2017

STATUS: FOR REVIEW

DOCUMENT NO.: 31609-16-LST-0003

TAG NO.	SIZE (INCH)	TYPE	SCOPE	LINE NUMBER	PIPE SPEC	P&ID PID-AUSC-	SERVICE	VENDOR	LEAD TIME	REMARKS
HV-0302	6	ON/OFF	AECOM	6"-011-NG-0307	011	03	NG			
FV-1006	1	MODULATING	AECOM	1"-153-WBF-1004-II	153	10	WBF			
FV-1012	1	MODULATING	AECOM	1"-153-WBF-1004-II	999	10	WBF			
HV-1009		ON/OFF	GE	-	011	10	NG			
HV-1017	1	ON/OFF	AECOM	1"-153-WBF-1004-II	153	10	WBF			
HV-1018	1	ON/OFF	AECOM	1"-153-WBF-1004-II	153	10	WBF			
HV-1019	1	ON/OFF	AECOM	1"-153-WBF-1004-II	999	10	WBF			
HV-1020	1	ON/OFF	AECOM	1"-153-WBF-1004-II	999	10	WBF			
LV-1208	4	MODULATING	AECOM	4"-091-HPC-1203-II	091	12	HPC			
TV-1201	4	MODULATING	AECOM	4"-153-SA-5002-II	153	12	SA			
FCV-805	6	ON/OFF	NATIONWIDE	6"-091-WBF-0801-II	091	20	WBF			
BSV-504	6	ON/OFF	NATIONWIDE	6"-011-NG-0304	011	21	NG			
BSV-506	6	ON/OFF	NATIONWIDE	6"-011-NG-0304	011	21	NG			
BSV-508	6	ON/OFF	NATIONWIDE	6"-011-NG-0304	011	21	NG			
BSV-511	6	ON/OFF	NATIONWIDE	6"-011-NG-0304	011	21	NG			
HV-2503	6	ON/OFF	AECOM	6"-153-SA-2501-II	153	25	SA			
HV-2504	8	ON/OFF	AECOM	8"-152-SB-2001-II	152	25	SB			
HV-3002	1	ON/OFF	GE	-	SA-335-P91	30	STEAM			
HV-3068	1	ON/OFF	GE	-	SA-335 P91	30	STEAM			
HV-3070	1	ON/OFF	GE	-	SA-335 P91	30	STEAM			
HV-3072	1	ON/OFF	GE	-	SA-335 P91	30	STEAM			
HV-3074	1	ON/OFF	GE	-	SA-335 P91	30	STEAM			
HV-3080	1	ON/OFF	GE	-	SA-335-P91	30	STEAM			
HV-3082	1	ON/OFF	GE	-	SA-335-P91	30	STEAM			

AECOM

A-USC Component Test Project
Automated Valve List

REVISION: D DATE: 8/14/2017
STATUS: FOR REVIEW
DOCUMENT NO.: 31609-16-LST-0003

TAG NO.	SIZE (INCH)	TYPE	SCOPE	LINE NUMBER	PIPE SPEC	P&ID PID-AUSC-	SERVICE	VENDOR	LEAD TIME	REMARKS
HV-3084	1	ON/OFF	GE	-	SA-335-P91	30	STEAM			
HV-3086	1	ON/OFF	GE	-	SA-335-P91	30	STEAM			
MV-3001	1	ON/OFF	GE	-	SA-335-P91	30	STEAM			
MV-3067	1	ON/OFF	GE	-	SA-335 P91	30	STEAM			
MV-3069	1	ON/OFF	GE	-	SA-335 P91	30	STEAM			
MV-3071	1	ON/OFF	GE	-	SA-335 P91	30	STEAM			
MV-3073	1	ON/OFF	GE	-	SA-335 P91	30	STEAM			
MV-3075	1	ON/OFF	GE	-	SA-335 P91	30	STEAM			
MV-3076	1	ON/OFF	GE	-	SA-335 P91	30	STEAM			
MV-3077	1	ON/OFF	GE	-	SA-335 P91	30	STEAM			
MV-3078	1	ON/OFF	GE	-	SA-335 P91	30	STEAM			
MV-3079	1	ON/OFF	GE	-	SA-335-P91	30	STEAM			
MV-3081	1	ON/OFF	GE	-	SA-335-P91	30	STEAM			
MV-3083	1	ON/OFF	GE	-	SA-335-P91	30	STEAM			
MV-3085	1	ON/OFF	GE	-	SA-335-P91	30	STEAM			
FV-3111	X	ON/OFF	GE	-	011	31	NG			
HV-3108	X	ON/OFF	GE	-	011	31	NG			
HV-3109	X	ON/OFF	GE	-	011	31	NG			
HV-3110	X	ON/OFF	GE	-	011	31	NG			
HV-3116	X	ON/OFF	GE	-	011	31	NG			
HV-3117	X	ON/OFF	GE	-	011	31	NG			
HV-3118	X	ON/OFF	GE	-	011	31	NG			
HV-3122	X	ON/OFF	GE	-	011	31	NG			
HV-3123	X	ON/OFF	GE	-	011	31	NG			

AECOM

A-USC Component Test Project
Automated Valve List

REVISION: D DATE: 8/14/2017
STATUS: FOR REVIEW
DOCUMENT NO.: 31609-16-LST-0003

TAG NO.	SIZE (INCH)	TYPE	SCOPE	LINE NUMBER	PIPE SPEC	P&ID PID-AUSC-	SERVICE	VENDOR	LEAD TIME	REMARKS
HV-3124	X	ON/OFF	GE	-	011	31	NG			
HV-3129	X	ON/OFF	GE	-	011	31	NG			
HV-3130	X	ON/OFF	GE	-	011	31	NG			
HV-3131	X	ON/OFF	GE	-	011	31	NG			
MV-3114	X	ON/OFF	GE	-	011	31	NG			
MV-3119	X	ON/OFF	GE	-	011	31	NG			
MV-3135	X	ON/OFF	GE	-	011	31	NG			
MV-3136	X	ON/OFF	GE	-	011	31	NG			
MV-3137	X	ON/OFF	GE	-	011	31	NG			
MV-3138	X	ON/OFF	GE	-	011	31	NG			
MV-3139	X	ON/OFF	GE	-	011	31	NG			
MV-3140	X	ON/OFF	GE	-	011	31	NG			
TV-3061	6	MODULATING	AECOM	6"-031-WGC-4101-II	031	41	WGC			
FV-4903	1.5	MODULATING	GE	2"-091-WBF-1005-II	091	49	WBF			
HV-4905	1.25	ON/OFF	AECOM	2"-091-WBF-1005-II	091	49	WBF			
HV-4906	1.25	ON/OFF	AECOM	2"-091-WBF-1005-II	091	49	WBF			
HV-4907	X	ON/OFF	GE	8"-999-SS-3002-II	999	49	SS			
MV-4910	X	ON/OFF	GE	8"-999-SS-3002-II	999	49	SS			
PARV-4908	X	ON/OFF	GE	8"-999-SS-3002-II	999	49	SS			
TV-4903	1.25	MODULATING	AECOM	2"-091-WBF-1005-II	091	49	WBF			
FV-5005	8	MODULATING	GE	-	999	50	STEAM			
FV-5008	1.5	MODULATING	GE	3"-091-WBF-1008-II	091	50	WBF			
HV-5004	1.25	ON/OFF	AECOM	3"-091-WBF-1008-II	091	50	WBF			
HV-5007	1.25	ON/OFF	AECOM	3"-091-WBF-1008-II	091	50	WBF			

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A-USC Component Test Project
Automated Valve List

REVISION: D DATE: 8/14/2017
STATUS: FOR REVIEW
DOCUMENT NO.: 31609-16-LST-0003

TAG NO.	SIZE (INCH)	TYPE	SCOPE	LINE NUMBER	PIPE SPEC	P&ID PID-AUSC-	SERVICE	VENDOR	LEAD TIME	REMARKS
PARV-5010	X	ON/OFF	GE	10"-153-SA-5001-II	153	50	SA			
TV-5006	1.25	MODULATING	AECOM	3"-091-WBF-1008-II	091	50	WBF			
HV-5102	3	ON/OFF	AECOM	3"-091-WBF-1006-II	091	51	WBF			
HV5104	2	ON/OFF	AECOM	3"-091-WBF-1006-II	091	51	WBF			
PV-5105	8	MODULATING	AECOM	10"-153-SA-5001-II	153	51	SA			
TV-5103	2	MODULATING	AECOM	3"-091-WBF-1006-II	091	51	WBF			
LV-6106	6	MODULATING	AECOM	6"-031-COND-6104-II	031	61	COND			
HV-6401	X	ON/OFF	AECOM	X"-011-NH3-6403	011	64	NH3			
HV-6402	X	ON/OFF	AECOM	X"-011-NH3-6403	011	64	NH3			
PV-64XX	2	MODULATING	GE	VENDOR PACKAGE	011	64	NH3			
XV-65XX	1	ON/OFF	GE	SUPERHEATER SCR	011	65	NH3			
XV-65XX	1	MODULATING	GE	SUPERHEATER SCR	011	65	NH3			
XV-66XX	1	ON/OFF	GE	SUPERHEATER SCR	011	66	NH3			
XV-66XX	1	MODULATING	GE	SUPERHEATER SCR	011	66	WCR			
HV-7001	6	MODULATING	AECOM	6"-011-WC-7101	011	70	WC			
HV-7002	4	MODULATING	AECOM	4"-011-WCR-7011	011	70	WCR			

AECOM

A-USC Component Test Project
Automated Valve List

REVISION: D DATE: 8/14/2017
STATUS: FOR REVIEW
DOCUMENT NO.: 31609-16-LST-0003

TAG NO.	SIZE (INCH)	TYPE	SCOPE	LINE NUMBER	PIPE SPEC	P&ID PID-AUSC-	SERVICE	VENDOR	LEAD TIME	REMARKS

AECOM

A-USC Component Test Project
Manual Valve List

REVISION: B DATE: 8/14/2017
STATUS: FOR REVIEW
DOCUMENT NO.: 31609-16-Ist-0002

DRAWING NO. PID-AUSC-	TYPE	SPEC	SERVICE	VENDOR	LEAD TIME	SIZE (INCH)																
						0.5	0.75	1	1.5	2	3	4	6	8	10	12	14	16	18	20	22	24	26
03	BALL	011	NG					3				1	3										
03	GATE	011	WR			1				1	1		1	3									
08	GATE	031	COND										1										
08	GATE	091	WBF										1										
10	BALL	091	WBF			8		8		3													
10	CHECK	091	WBF							3	2		1										
10	GATE	091	WBF								3		1										
12	CHECK	091	HPC			2		2			1	1											
12	GATE	091	WBF								2												
12	GATE	091	WBF					2															
12	GATE	153	SA			2						2											
25	GATE	152	SB			2																	
41	B'FLY	011	WCS/WCR												2								
41	BALL	031	WGC						2														
41	GATE	031	WGC			4		6			1		7										
49	BALL	091	WBF			4																	
49	GATE	091	WBF			4																	
50	BALL	091	WBF			4																	
50	GATE	091	WBF			4																	
50	CHECK	153	SA												2								
51	GATE	032	SA			2																	
51	GATE	033	SA			2																	
51	BALL	091	WBF			4																	
51	GATE	091	WBF			4																	
61	B'FLY	011	WCS/WCR																			2	
61	CHECK	031	COND										1										
61	GATE	031	COND					2				2											
61	GATE	031	COND			1		2					7										
61	GATE	032	SA			2																	1
61	GATE	091	HPC										1										
64	BALL	011	NH3							2													
64	GATE	011	NH3					2															

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A-USC Component Test Project
Manual Valve List

REVISION: B DATE: 8/14/2017
STATUS: FOR REVIEW
DOCUMENT NO.: 31609-16-Ist-0002

DRAWING NO. PID-AUSC-	TYPE	SPEC	SERVICE	VENDOR	LEAD TIME	SIZE (INCH)																	
						0.5	0.75	1	1.5	2	3	4	6	8	10	12	14	16	18	20	22	24	26
65	BALL	011	NH3					1															
66	BALL	011	NH3					1															
70	BALL	011	WCS			3		3															
70	B'FLY	011	WCS																3	3			
70	CHECK	011	WCS																3				
71	GATE	011	WR										1										
80	GATE	011	AI			38				10													

3/5/2018

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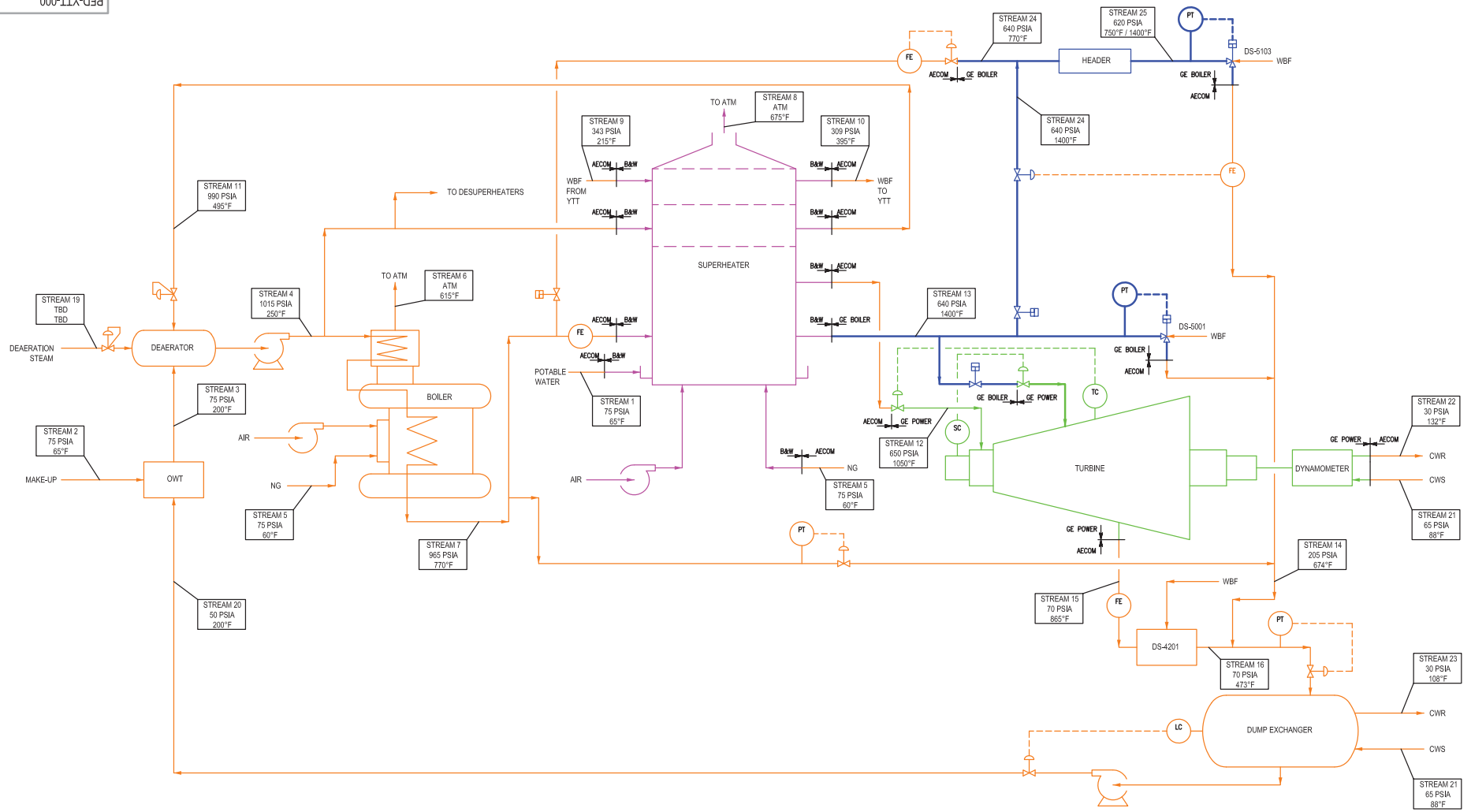
A-USC Component Test Project
Manual Valve List

REVISION: B DATE: 8/14/2017
STATUS: FOR REVIEW
DOCUMENT NO.: 31609-16-Ist-0002

DRAWING NO. PID-AUSC-	TYPE	SPEC	SERVICE	VENDOR	LEAD TIME	SIZE (INCH)																
						0.5	0.75	1	1.5	2	3	4	6	8	10	12	14	16	18	20	22	24	26

Process

PFD-YTT-000



LEGEND:

- B&W
- GE BOILER
- GE POWER
- AECOM

NOTES:

1. STREAM NUMBERS REFERENCE STREAM PROPERTIES LISTED IN INTERFACE DEFINITIONS DOCUMENT.
2. BOLD LINES DESIGNATE HIGH NICKEL ALLOY PIPING.

REVISION APPROVAL RECORD				REV		REV	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C						A	08/05/16	ISSUED FOR REVIEW	GG	

DRAWING STATUS				
ISSUED	REV.	DATE	SDE	PEM
PRELIMINARY	A	08/05/16	CB	DM
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV.NO.

PROJECT NO.: 31609
DRAWN: GG DATE: 07/26/16
CHECKED: CB DATE:
SCALE: NTS

URS ENERGY & CONSTRUCTION Inc. - an AECOM Company
1500 West 3rd St., Suite 200
Cleveland, OH 44113
(216) 523-5600
AECOM

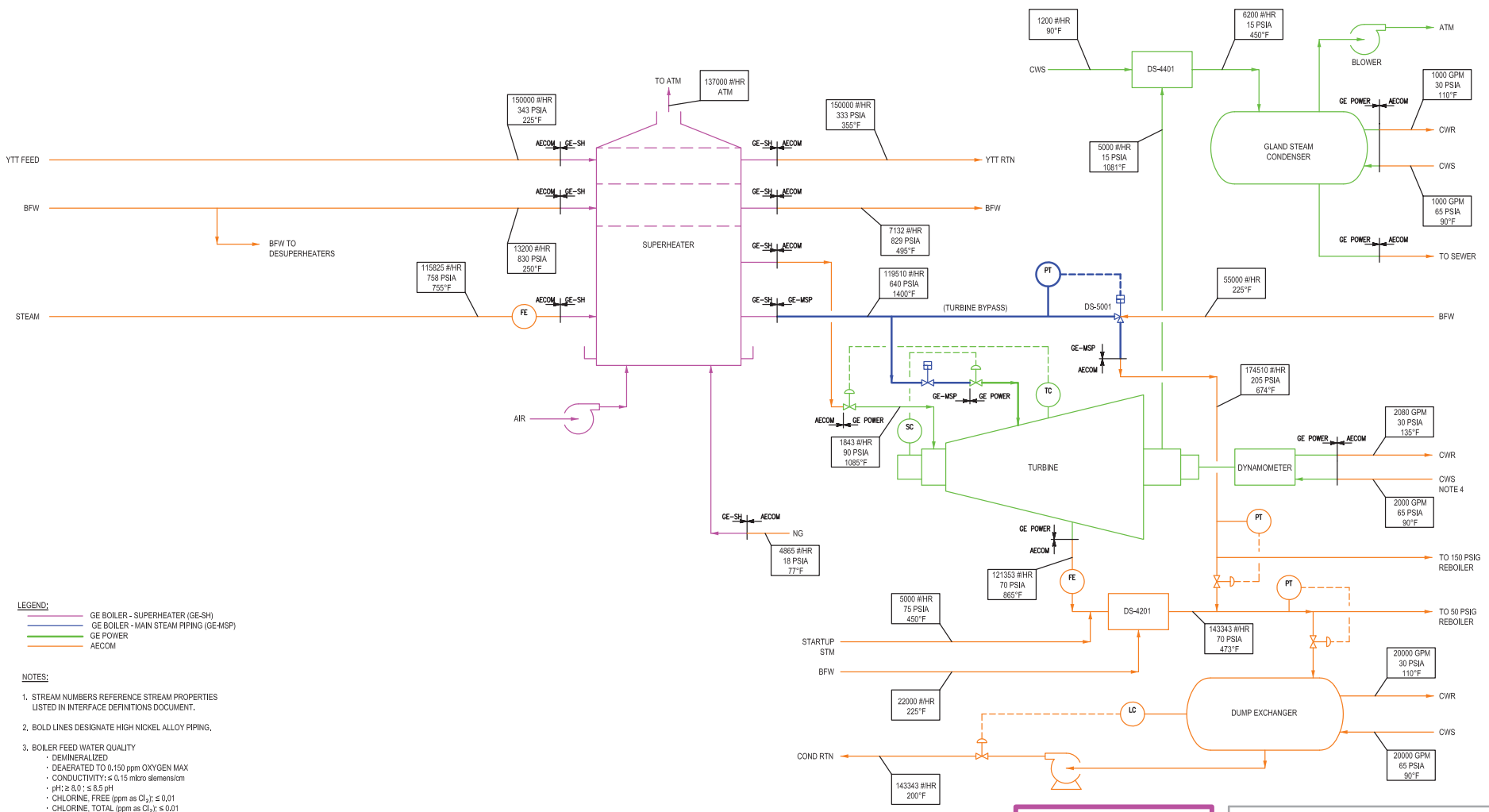
ENERGY INDUSTRIES of OHIO
6100 Oak Tree Boulevard, Suite 200
Independence, OH 44131
(216) 643-2952

A-USC COMTEST PROJECT
PROCESS FLOW DIAGRAM

DWG. NO. PFD-YTT-000 REV A

EC_D_Size.dwg

PFD-AUSC-000-YTT



LEGEND:

- GE BOILER - SUPERHEATER (GE-SH)
- GE BOILER - MAIN STEAM PIPING (GE-MSP)
- GE POWER
- AECOM

NOTES:

1. STREAM NUMBERS REFERENCE STREAM PROPERTIES LISTED IN INTERFACE DEFINITIONS DOCUMENT.
2. BOLD LINES DESIGNATE HIGH NICKEL ALLOY PIPING.
3. BOILER FEED WATER QUALITY
   - DEMINERALIZED
   - DEAERATED TO 0.150 ppm OXYGEN MAX
   - CONDUCTIVITY: ≤ 0.15 mIcro siemens/cm
   - pH: ≥ 8.0 ; ≤ 8.5 pH
   - CHLORINE, FREE (ppm as Cl_2): ≤ 0.01
   - CHLORINE, TOTAL (ppm as Cl_2): ≤ 0.01
   - IRON, TOTAL (ppm as Fe): ≤ 0.005 ppm IRON MAX
   - SILICA (ppm as SiO_2): ≤ 0.01
   - SODIUM: ≤ 0.003 ppm
   - COPPER (AS Cu): ≤ 0.002 ppm
   - OWT WATER TREATMENT
4. COOLING WATER QUALITY
   - FILTERED
   - pH ≥ 7.0 ≤ 8.8
   - CONDUCTIVITY ≤ 120 mS/m
   - HARDNESS ≤ 50 ppm (as $CaCo_3$)
   - TOTAL SOLIDS ≤ 750 ppm
   - CHLORIDE CONTENT ≤ 50 ppm

PRELIMINARY
NOT FOR CONSTRUCTION

REVISION APPROVAL RECORD				REV		REV	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C						A	XX	ISSUED FOR REVIEW	GG	

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY				
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV NO.

PROJECT NO.: 31609
DRAWN: GG DATE: 12/18/16
CHECKED: CB DATE:
SCALE: NTS

URS ENERGY & CONSTRUCTION Inc, - an AECOM Company
1300 East 9th St., Suite 500
Cleveland, OH 44114
(216) 622-2300

ENERGY INDUSTRIES of OHIO
6100 Oak Tree Boulevard, Suite 200
Independence, OH 44131
(216) 643-2952

A-USC COMTEST PROJECT
PROCESS FLOW DIAGRAM

DWG. NO. PFD-AUSC-000-YTT REV A

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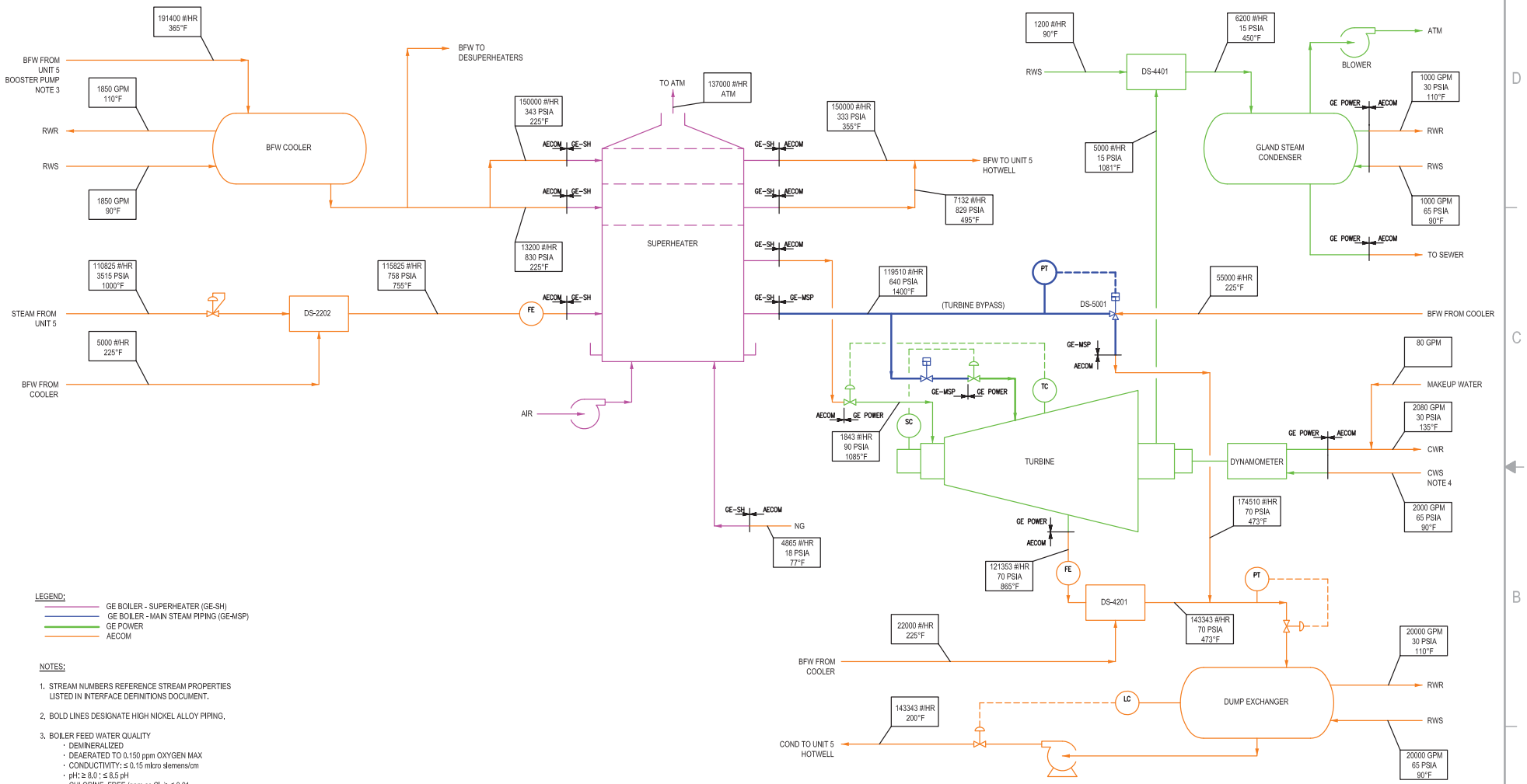
PFD-AUSC-000



LEGEND:

- GE BOILER - SUPERHEATER (GE-SH)
- GE BOILER - MAIN STEAM PIPING (GE-MSP)
- GE POWER
- AECOM

NOTES:

1. STREAM NUMBERS REFERENCE STREAM PROPERTIES LISTED IN INTERFACE DEFINITIONS DOCUMENT.
2. BOLD LINES DESIGNATE HIGH NICKEL ALLOY PIPING.
3. BOILER FEED WATER QUALITY
   - DEMINERALIZED
   - DEAERATED TO 0.150 ppm OXYGEN MAX
   - CONDUCTIVITY: ≤ 0.15 mIcro siemens/cm
   - pH: ≥ 8.0 ; ≤ 8.5 pH
   - CHLORINE, FREE (ppm as Cl_2): ≤ 0.01
   - CHLORINE, TOTAL (ppm as Cl_2): ≤ 0.01
   - IRON, TOTAL (ppm as Fe): ≤ 0.005 ppm IRON MAX
   - SILICA (ppm as SiO_2): ≤ 0.01
   - SODIUM: ≤ 0.003 ppm
   - COPPER (AS Cu): ≤ 0.002 ppm
   - OWT WATER TREATMENT
4. COOLING WATER QUALITY
   - FILTERED
   - pH ≥ 7.0 ≤ 8.8
   - CONDUCTIVITY ≤ 120 mS/m
   - HARDNESS ≤ 50 ppm (as $CaCo_3$)
   - TOTAL SOLIDS ≤ 750 ppm
   - CHLORIDE CONTENT ≤ 50 ppm

REVISION APPROVAL RECORD				REV		REV NO.	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C						A	XX	ISSUED FOR REVIEW	GG	

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY				
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV NO.

PROJECT NO.: 31609
DRAWN: GG DATE: 12/12/16
CHECKED: CB DATE:
SCALE: NTS

PRELIMINARY NOT FOR CONSTRUCTION

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1300 East 9th St., Suite 500
Cleveland, OH 44114
(216) 622-2300
AECOM

ENERGY INDUSTRIES of OHIO
6100 Oak Tree Boulevard, Suite 200
Independence, OH 44131
(216) 643-2952

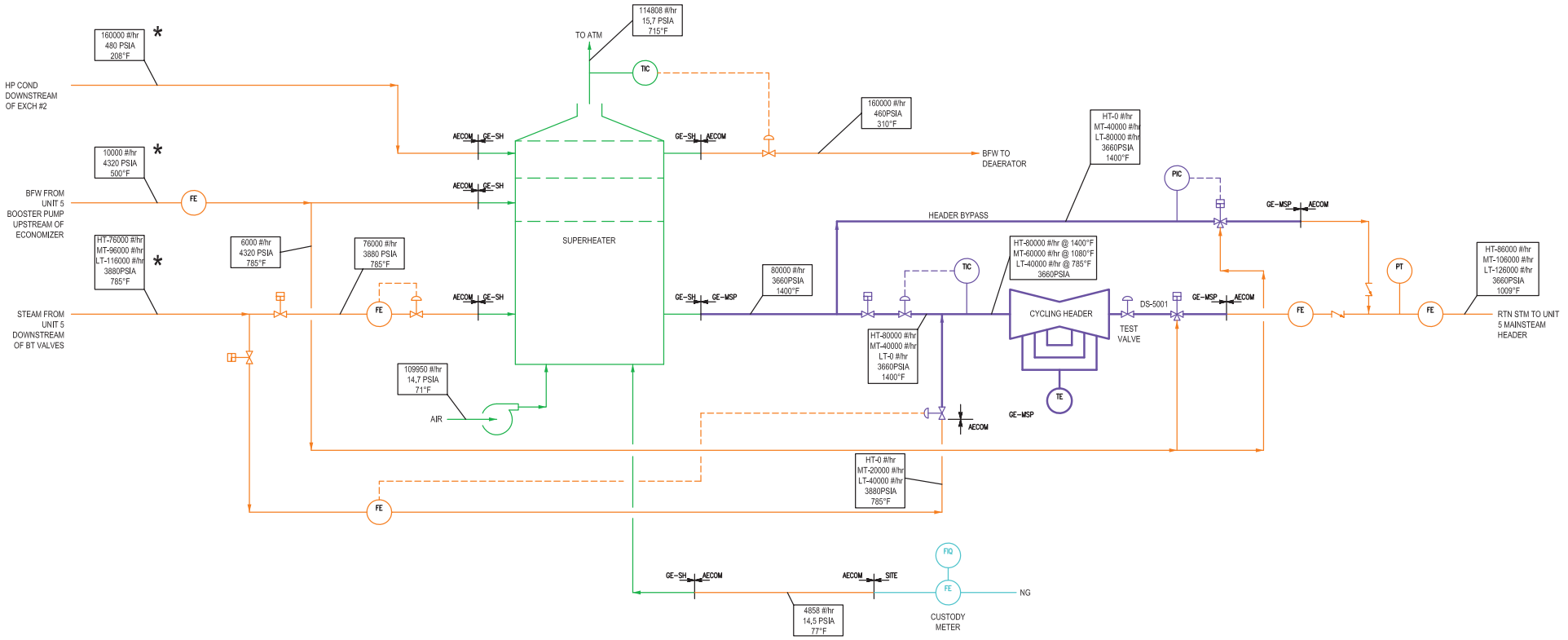
A-USC COMTEST PROJECT
PROCESS FLOW DIAGRAM

DWG. NO. PFD-AUSC-000 REV A

EC_D_Size.dwg

INCHES CENTIMETERS

PFD-AUSC-000-REVISED



LEGEND:

- GE BOILER - SUPERHEATER (GE-SH)
- GE BOILER - MAIN STEAM PIPING (GE-MSP) -HIGH TEMP PIPING
- SITE
- AECOM

* ASSUMED CONDITIONS AT TIE POINTS

HT- HIGH TEMPERATURE CASE 80000 /hr @ 1400°F
MT- MEDIUM TEMPERATURE CASE 60000 #/hr @ 1080°F
LT- LOW TEMPERATURE CASE 40000 # hr @ 785°F

REVISION APPROVAL RECORD				REV		REV	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C						A	XX	ISSUED FOR REVIEW	GG	

DRAWING STATUS

ISSUED	REV	DATE	SDE	PEM
PRELIMINARY				
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV.NO.:

PROJECT NO.: 31609
DRAWN: GG DATE: 04/05/17
CHECKED: CB DATE:
SCALE: NTS

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1300 East 9th St., Suite 500
Cleveland, OH 44114
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6100 Oak Tree Boulevard, Suite 200
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A-USC COMTEST PROJECT
PROCESS FLOW DIAGRAM

DWG. NO. PFD-AUSC-000-REVISED REV A

EC_D_Size.dwg

INCHES CENTIMETERS

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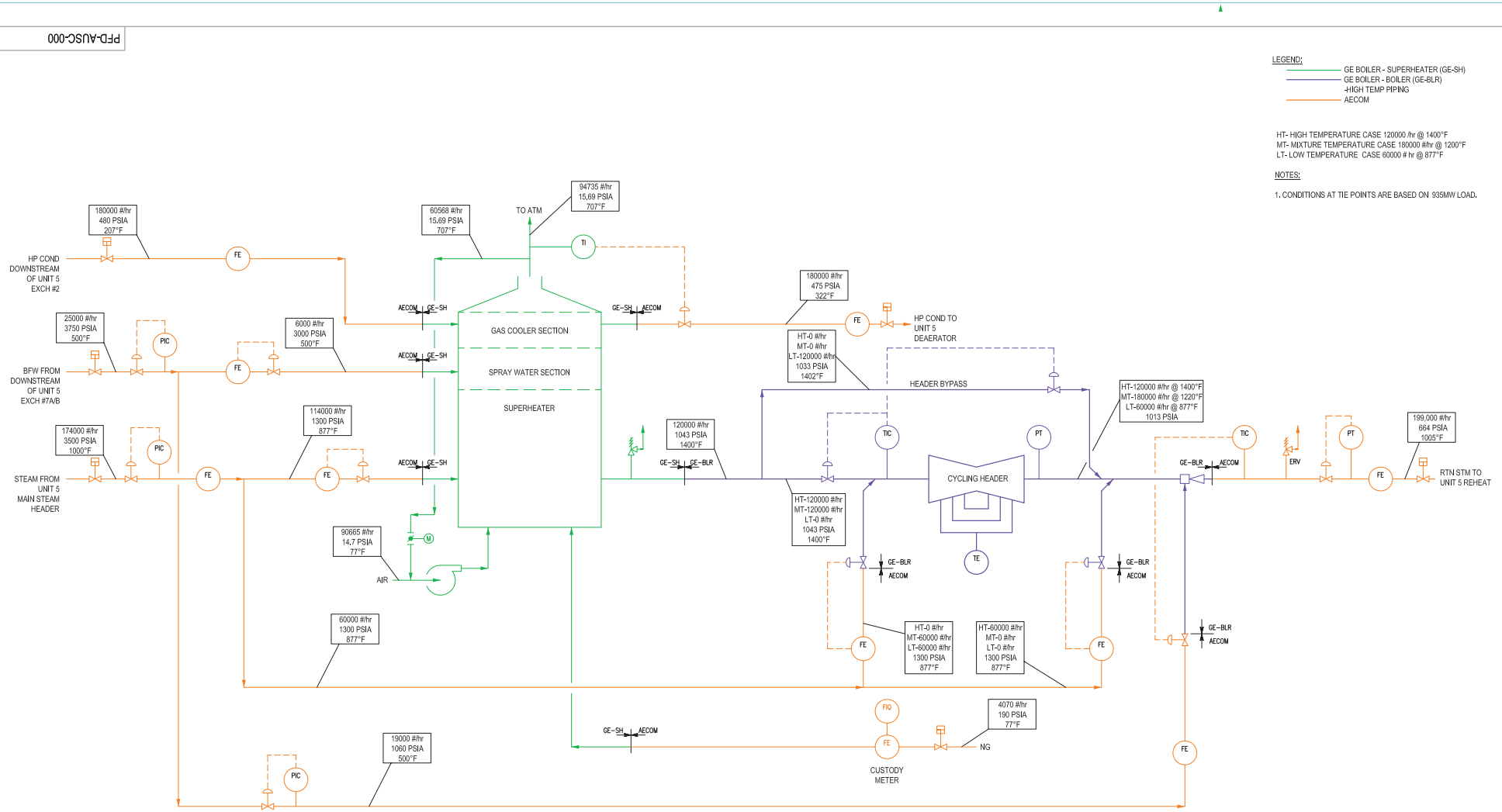
D C B A

PFD-AUSC-000



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REVISION APPROVAL RECORD				REV		REV NO	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C						A	08-14-17	ISSUED FOR REVIEW	BLT	CB

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A	08-14-17	CB	DM
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED, DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV.NO.

PROJECT NO.: 31609
DRAWN: GG DATE: 04-05-17
CHECKED: CB DATE: 04-07-17
SCALE: NTS

ENERGY INDUSTRIES of OHIO
6100 Oak Tree Boulevard, Suite 200
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(216) 643-2952

A-USC COMTEST PROJECT
PROCESS FLOW DIAGRAM

DWG. NO. PFD-AUSC-000 REV A

EC_D_Size.dwg

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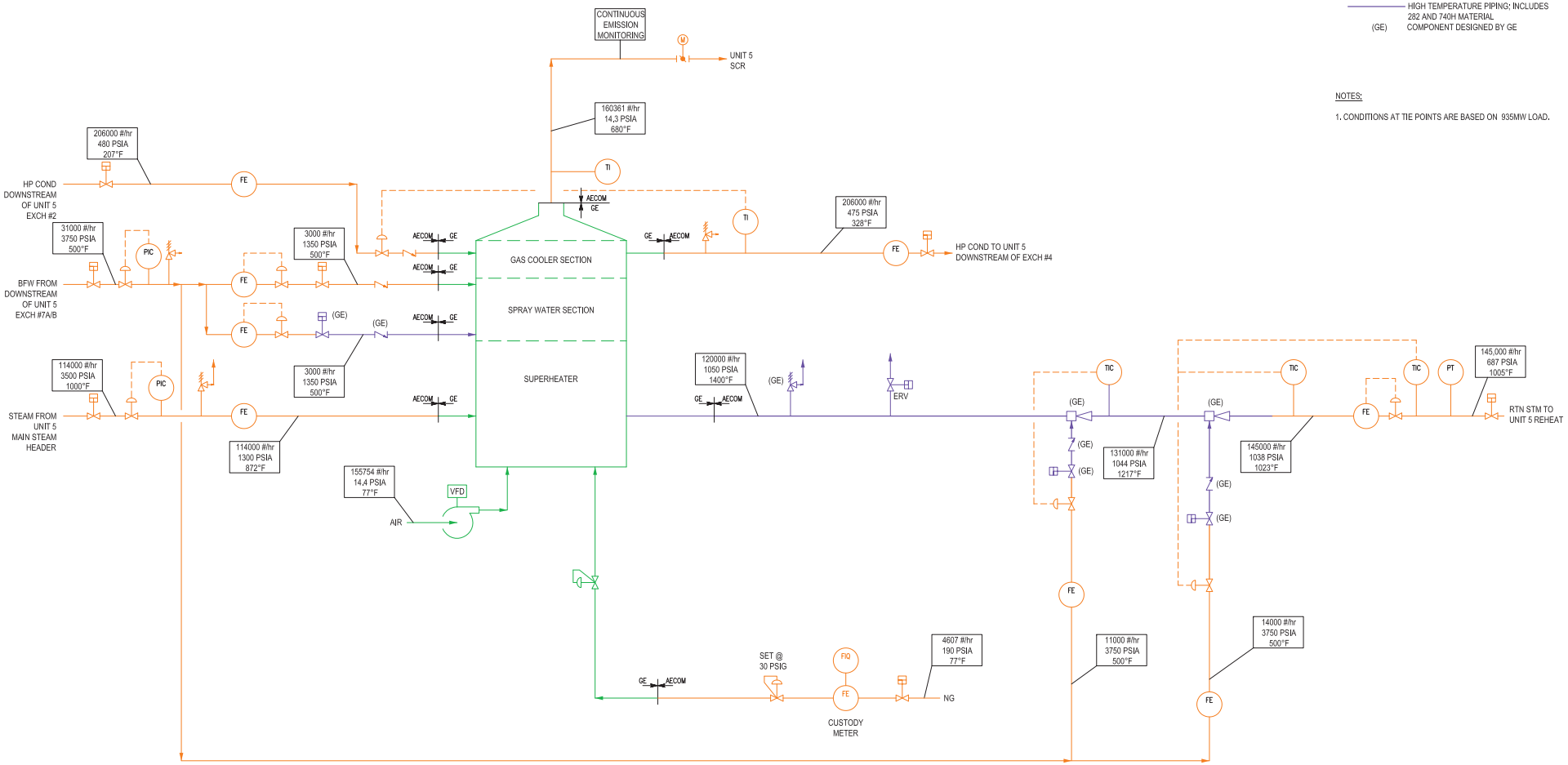
8 7 6 5 4 3 2 1

D C B A

PFD-AUSC-000



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1300 East 9th St., Suite 500
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REVISION APPROVAL RECORD				REV		REV NO	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C						B	09-25-17	INTERNAL ISSUE	JK	CB
						A	08-14-17	ISSUED FOR REVIEW	BLT	CB

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	B	09-25-17	CB	DM
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED, DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV.NO.

PROJECT NO.: 31609
DRAWN: GG DATE: 04-05-17
CHECKED: CB DATE: 04-07-17
SCALE: NTS

ENERGY INDUSTRIES of OHIO
6100 Oak Tree Boulevard, Suite 200
Independence, OH 44131
(216) 643-2952

A-USC COMTEST PROJECT
PROCESS FLOW DIAGRAM

DWG. NO. PFD-AUSC-000 REV B

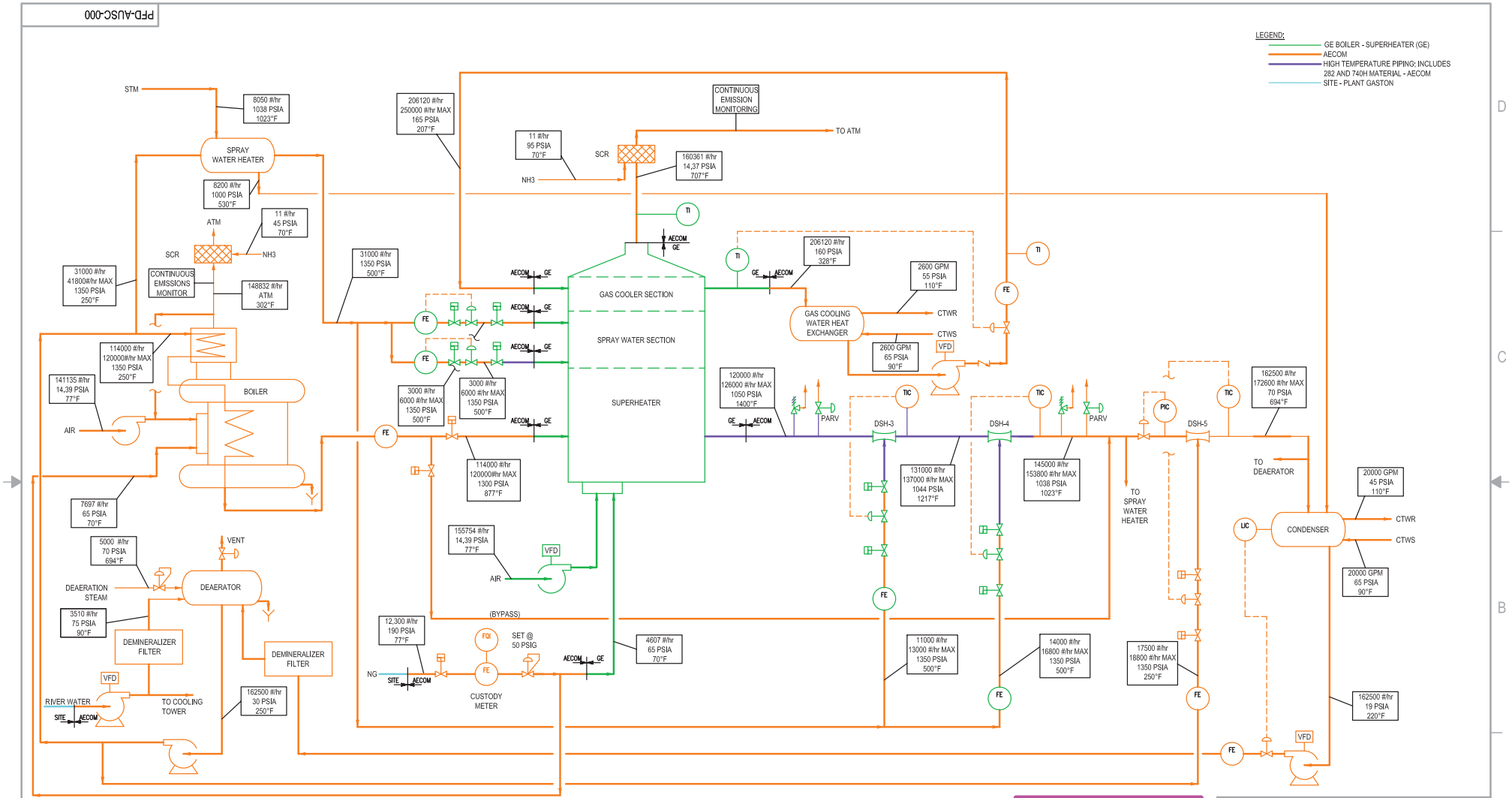
EC_D_Size.dwg

INCHES 1 2 CENTIMETERS 1 2 3 4 5 6

8 7 6 5 4 3 2 1

D C B A

PFD-AUSC-000



PRELIMINARY
NOT FOR CONSTRUCTION

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1300 East 9th St., Suite 500
Cleveland, OH 44114
(216) 622-2300

AECOM

REVISION APPROVAL RECORD					
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
C	12-22-17	ISSUE FOR RECORD	DC	CB
B	09-25-17	INTERNAL ISSUE	JK	CB
A	08-14-17	ISSUED FOR REVIEW	BLT	CB

DRAWING STATUS

ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	C	12/22/17	CB	DM
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV NO.

PROJECT NO.: 31609
DRAWN: GG DATE: 04-05-17
CHECKED: CB DATE: 04-07-17
SCALE: NTS

ENERGY INDUSTRIES of OHIO
6100 Oak Tree Boulevard, Suite 200
Independence, OH 44131
(216) 643-2952

A-USC COMTEST PROJECT
PROCESS FLOW DIAGRAM

DWG. NO. PFD-AUSC-000 REV C

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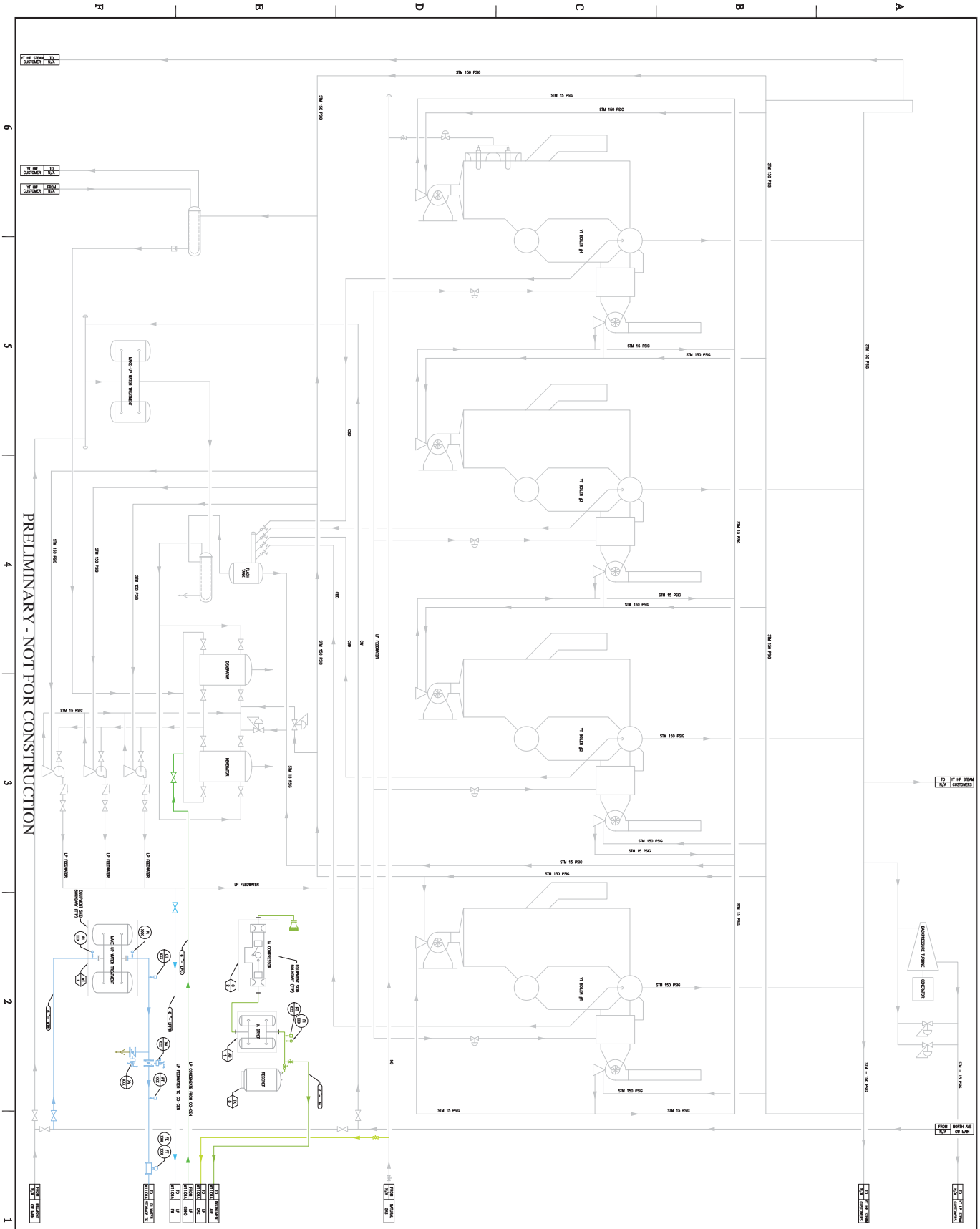
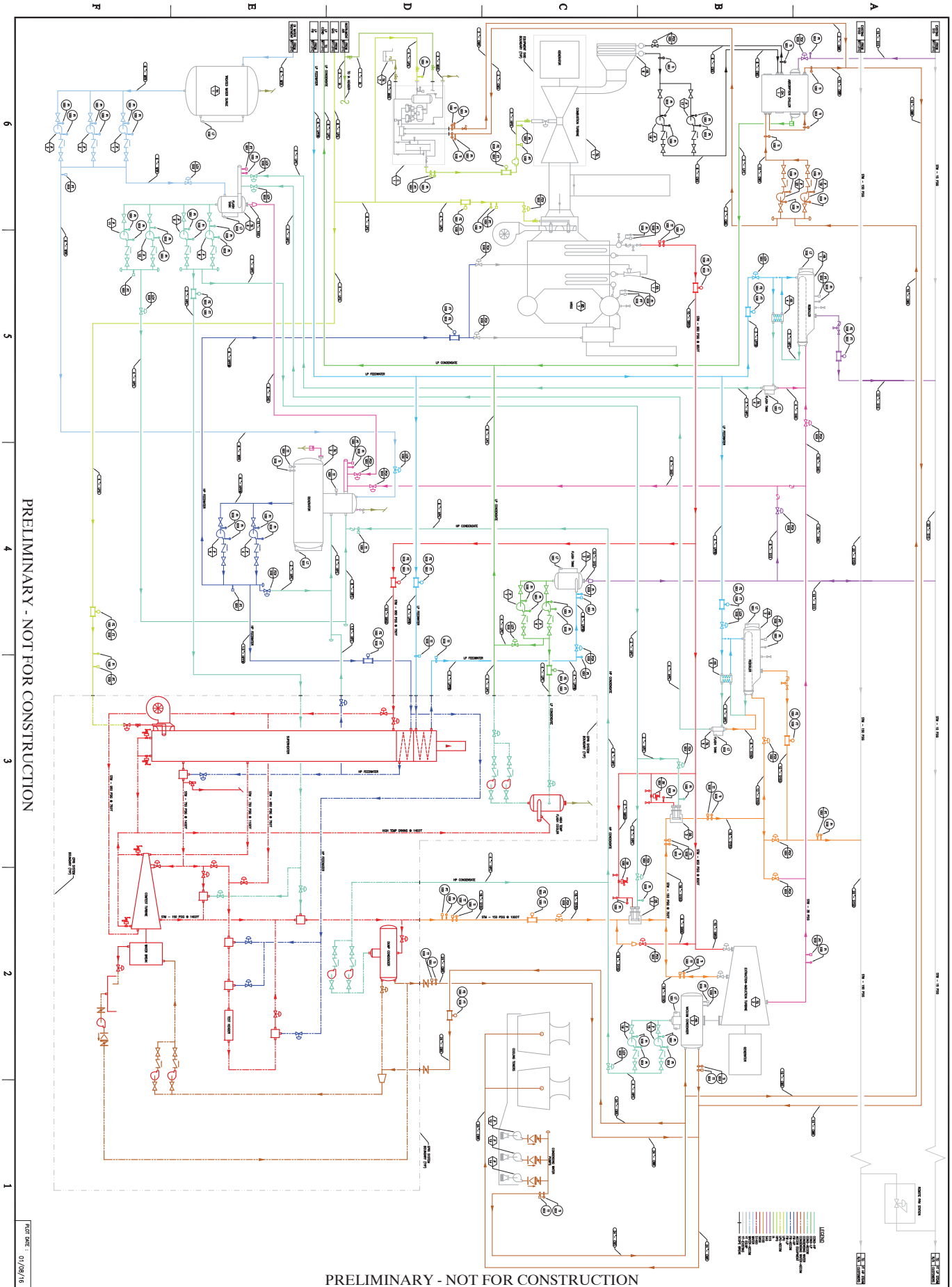
INCHES CENTIMETERS

8 7 6 5 4 3 2 1

D C B A


PRELIMINARY - NOT FOR CONSTRUCTION
YT HP STEAM TO CUSTOMER
YT HRH TO CUSTOMER
YT HRH FROM N/A
STM 150 PSIG
STM 15 PSIG
HRH 150 PSIG
CRH 150 PSIG
CRH 15 PSIG
CRD
HRH
YT BOILER #4
YT BOILER #3
YT BOILER #2
YT BOILER #1
MAKE-UP WATER TREATMENT
FLASH TANK
DEAERATOR
LP FEEDWATER
EQUIPMENT SKID BOUNDARY (TYP)
N. COMPRESSOR
S. BOOSTER
RECEIVER
LP CONDENSATE FROM CO2 HEX
LP CONDENSATE TO CO2 HEX
TURBOGENERATOR
CONDENSER
TO YT HP STEAM N/A CUSTOMERS
FROM NORTH AVE N/A OR MAIN
TO YT HP STEAM N/A CUSTOMERS
TO YT LP STEAM N/A CUSTOMERS
FROM N/A BOILER
TO YT LP STEAM N/A CUSTOMERS
TO YT HRH N/A CUSTOMERS
TO YT LP STEAM N/A CUSTOMERS
TO YT HP STEAM



PRELIMINARY - NOT FOR CONSTRUCTION

PRELIMINARY - NOT FOR CONSTRUCTION

PLOT DATE : 01/08/16

DRAWING NO.	M11.02A
PROJECT NO.	672
DRAWN BY:	DATE: 11/10/15
CHKD:	DATE:
APP'D BY:	DATE:

REVISIONS

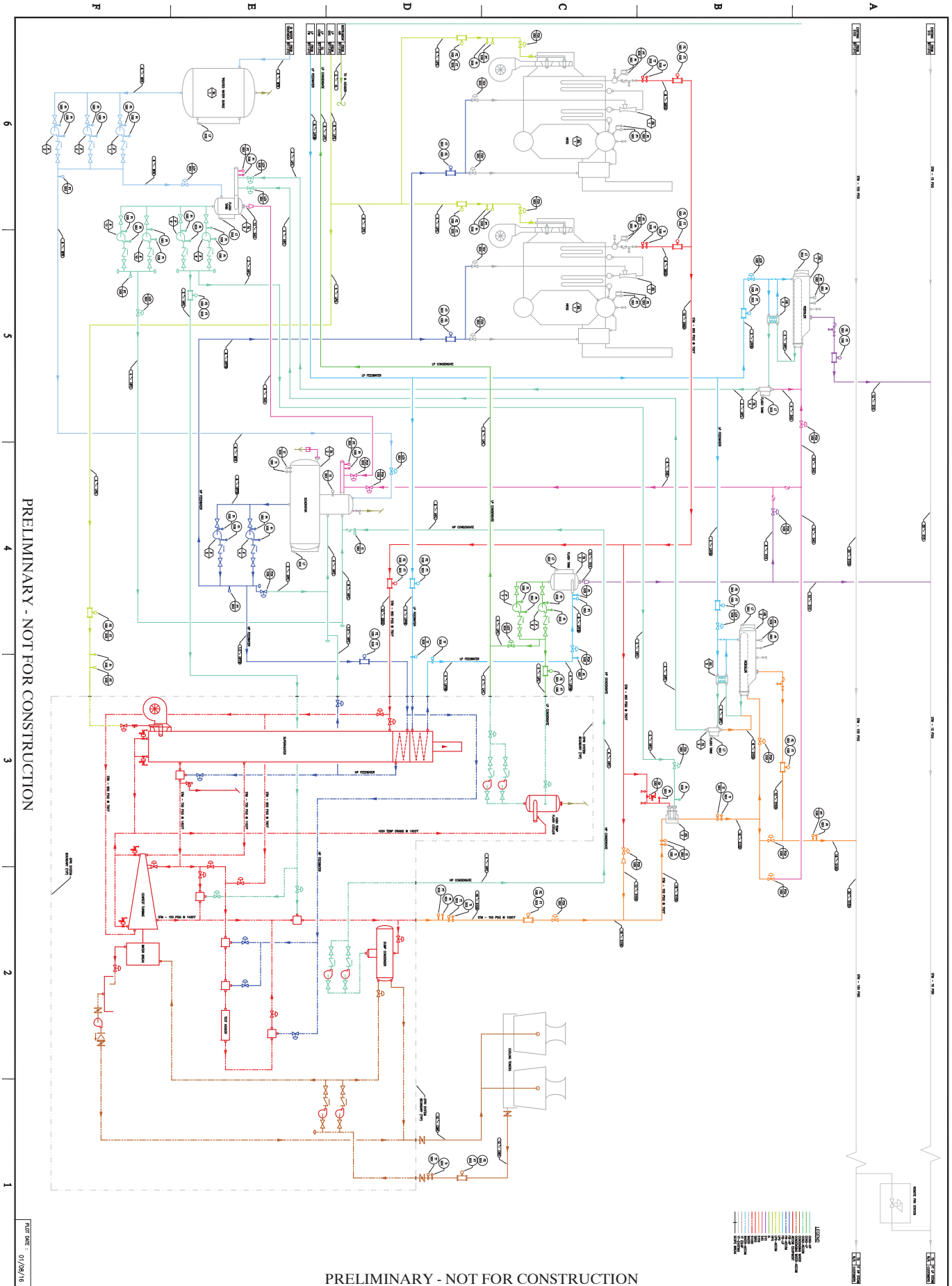
NO.	DATE	DESCRIPTION

youngstown thermal
A Youngstown Thermal Holdings, LLC Company
205 NORTH AVENUE
YOUNGSTOWN, OHIO 44502
TEL. (330) 743-7712
FAX (866) 250-3036

AUSC COMTEST

OVERALL SCHEMATIC
YT CO-GEN OPTION

THERMAL ENGINEERING GROUP, INC.
P.O. BOX 396 • HENDERSONVILLE, TN 37075



PRELIMINARY - NOT FOR CONSTRUCTION

PRELIMINARY - NOT FOR CONSTRUCTION

PLOT DATE : 01/28/16

DRAWING NO.	M11.02B
PROJECT NO.	672
DRAWN BY: DPC	DATE: 11/10/15
APP'D BY:	DATE:
CHECKED:	DATE:

REVISIONS

NO.	DATE	DESCRIPTION

youngstown thermal
A Youngstown Thermal Holdings, LLC Company
205 NORTH AVENUE
YOUNGSTOWN, OHIO 44502
TEL. (330) 743-7712
FAX (866) 250-3036

AUSC COMTEST

OVERALL SCHEMATIC BASE SCOPE

THERMAL ENGINEERING GROUP, INC.
P.O. BOX 396 • HENDERSONVILLE, TN 37075

PID-AUSC-00

VALVE SYMBOLS

- GATE (OR GENERIC)
- CHECK
- STOP CHECK
- GLOBE
- BUTTERFLY
- NEEDLE
- NON RETURN
- BALL
- GENERIC ROTARY (1/4 TURN)
- PLUG
- DIAPHRAGM
- 3-WAY
- 4-WAY
- PINCH
- ANGLE
- KNIFE
- PRESSURE RELIEF OR SAFETY VALVE
- VACUUM BREAK
- FIRE WATER VALVE
- PRESSURE REGULATOR
- BACKFLOW PREVENTER

PIPING FITTINGS

- FLANGE
- WELDED CONNECTION
- CAP
- CONCENTRIC (OR GENERIC) REDUCER
- ECCENTRIC REDUCER
- HOSE CONNECTION
- SPACER
- BLANK
- OPEN FIGURE 8 BLIND
- CLOSED FIGURE 8 BLIND
- PLUG
- BLIND FLANGE
- WELDOLET

PIPING SPECIALTY ITEMS

- Y-TYPE STRAINER
- CONE STRAINER
- DUPLEX STRAINER
- BASKET STRAINER
- TEMPORARY STRAINER
- FILTER
- DETONATION ARRESTOR
- FLAME ARRESTOR
- STEAM TRAP
- EJECTOR / EDUCTOR
- PULSATION DAMPER
- INLINE SILENCER
- VENT SILENCER
- REMOVABLE SPOOL
- FLEXIBLE HOSE
- EXPANSION JOINT
- DAMPER
- BREATHER
- VENT COVER
- INLINE MIXER
- EXCESS FLOW VALVE
- RUPTURE DISC
- CHEMICAL SEAL
- RAIN CAP
- DRAIN
- RESTRICTION ORIFICE
- VENTURI FLOW METER
- DRIP POCKET

ACTUATOR SYMBOLS

- MANUAL OPERATOR
- DIAPHRAGM
- PRESSURE BALANCED DIAPHRAGM
- CYLINDER / PISTON
- MOTOR OPERATOR
- ELECTRO-HYDRAULIC OPERATOR
- SINGLE SOLENOID

NOMENCLATURE & NUMBERING

FUNCTIONAL AREAS
- 1 - FEED STREAMS
- 2 - FEED DISTRIBUTION
- 3 - SUPERHEATER
- 4 - DELETED
- 5 - HEADER & HT PIPING
- 6 - SITE / INTEGRATION
- 7 - DELETED

DRAWING NUMBERS PID-AUSC-AN
- A - FUNCTIONAL AREA (1-7)
- N - SEQUENCE NUMBER (0-9)

EQUIPMENT NUMBERS TTT-ANNN
- TTT- EQUIPMENT TYPE (TWO OR THREE CHARACTERS)
- AN - ORIGINATING DRAWING NUMBER
- NN - ITEM NUMBER (01-99)

INSTRUMENT NUMBERING TTT-ANNN
- TTT - INSTRUMENT TYPE (TWO OR THREE CHARACTERS)
- AN - ORIGINATING DRAWING NUMBER
- NN - ITEM NUMBER (01-99)

LINE NUMBERING XX"-YYY-ZZZ-ANNN-II-T
- XX - NOMINAL DIAMETER (INCHES)
- YYY - SPEC
- ZZZ - SERVICE
- AN - ORIGINATING DRAWING NUMBER
- NN - SEQUENCE NUMBER (01-99)
- II - INSULATION CODE
- T - TRACING CODE

SERVICES

WATERS	PSIA	F	SPEC
COND - CONDENSATE	70	700	031
WBF - BOILER FEED WATER	1350	500	091
WGC - GAS COOLING WATER	475	333	031
HPC - HIGH PRES CONDENSATE	1000	530	091
WR - RIVER WATER	90	90	011
WC3 - COOLING WATER SUPPLY	65	90	011
WCR - COOLING WATER RETURN	55	110	011
STEAMS			
SB - BOILER STEAM	1300	877	152
SS - SUPERHEATED STEAM	1050	1400	999
SA - ATTENUATED STEAM	1038	1023	153
SA - ATTENUATED STEAM	70	700	032
SA - ATTENUATED STEAM	70	1023	033
GASES			
NG - NATURAL GAS	190	80	011
AI - INSTRUMENT AIR	140	100	011
N2 - NITROGEN	140	100	011
NH3 - ANHYDROUS AMMONIA	95	70	011

OPERATING CONDITIONS

CONTRACTOR DESIGNATIONS

AECOM - AECOM
SITE - PLANT GASTON
GE - GENERAL ELECTRIC

DRAWING LIST

PFD-AUSC-000	PROCESS FLOW DIAGRAM
PID-AUSC-00	LEGEND
PID-AUSC-01	SUPERHEATER LEGEND #1
PID-AUSC-02	SUPERHEATER LEGEND #2
PID-AUSC-03	FEED STREAMS
PID-AUSC-05	BOILER FEEDWATER TREATMENT
PID-AUSC-08	DEAERATOR
PID-AUSC-10	WBF DISTRBUTION
PID-AUSC-12	SPRAY WATER HEATER
PID-AUSC-20	AUX, BOILER
PID-AUSC-21	AUX, BOILER BURNER
PID-AUSC-25	BOILER STEAM DISTRIBUTION
PID-AUSC-30	SUPERHEATER
PID-AUSC-31	SUPERHEATER BURNER
PID-AUSC-41	GAS COOLING WATER EXCHANGER
PID-AUSC-49	DESUPERHEATER #3
PID-AUSC-50	DESUPERHEATER #4
PID-AUSC-51	DESUPERHEATER #5
PID-AUSC-61	CONDENSER
PID-AUSC-64	ANNHYDROUS AMMONIA STORAGE
PID-AUSC-65	BOILER SCR UNIT
PID-AUSC-66	SUPERHEATER SCR UNIT
PID-AUSC-70	COOLING TOWER
PID-AUSC-71	COOLING TOWE WATER TREATMENT
PID-AUSC-80	COMPRESSED AIR SYSTEM

PIPE SPECIFICATIONS

PIPE SPEC	CLASS / MATERIAL
011	150 / CS
031	300 / CS
032	300 / CS
033	300 / P92
091	900 / CS
152	1500 / P22
153	1500 / P92
999	1500/ 740H / 282

MISCELLANEOUS

- REF. DRAWING / DESCRIPTION — OFF PAGE CONNECTOR
- TG1 TG2 / TG1 TG2 — POINT OF CHANGE FOR: RESPONSIBILITY, PIPE CLASS / SPEC, INSULATION, ABOVE / BELOW GROUND
- SP-XXXX — PIPING SPECIALTY ITEM
- LINE BREAK
- FLOW ARROW
- PACKAGED EQUIPMENT LIMITS
- BATTERY LIMITS OR MATCH LINE
- T XXX — TIE POINT
- DEMOLITION

	FIELD MOUNTED	PRIMARY LOCATION NORMALLY ACCESSIBLE TO OPERATOR	PRIMARY LOCATION NORMALLY INACCESSIBLE OR BEHIND PANEL DEVICES	AUXILIARY LOCATION OR PANEL NORMALLY ACCESSIBLE TO OPERATOR	AUXILIARY LOCATION OR PANEL NORMALLY INACCESSIBLE OR BEHIND PANEL DEVICES
DISCRETE INSTRUMENTS (END DEVICES OR STAND-ALONE CONTROLLER)	○	⊖ IP1*	⊖	⊖	⊖
SHARED DISPLAY, SHARED CONTROL, DISTRIBUTED CONTROL (OR VIDEO DISPLAY)	□	▭	▭	▭	▭
COMPUTER FUNCTION FLOW	⬡	⬡	⬡	⬡	⬡
PROGRAMMABLE LOGIC CONTROL	◇	◇	◇	◇	◇

PIPING LINE SYMBOLS

- PRIMARY
- SECONDARY / UTILITY
- FUTURE OR EXISTING
- FINNED
- JACKETED OR DOUBLE CONTAINMENT
- OUT OF SERVICE OR ABANDONED
- PIPE INSULATION
- PIPE INSULATION & STEAM TRACING
- PERSONNEL PROTECTION (P)
- PIPE INSULATION & ELECTRICAL TRACING E
- COVERED PIPE C

PRELIMINARY NOT FOR CONSTRUCTION

REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
B	12-22-17	ISSUE FOR RECORD	DC	CB
A	08-14-17	ISSUED FOR REVIEW	BLT	CB

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	B	12-22-17	CB	DM
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV.NO.

PROJECT NO.: 31609
DRAWN: GG DATE: 03/29/17
CHECKED: CB DATE: 04/04/17
SCALE: NTS

AECOM
1300 East 9th St., Suite 500
Cleveland, OH 44114
(216) 622-2300

AECOM

ENERGY INDUSTRIES of OHIO
6100 Oak Tree Boulevard, Suite 200
Independence, OH 44131
(216) 643-2952

A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
LEGEND

DWG. NO. PID-AUSC-00 REV B

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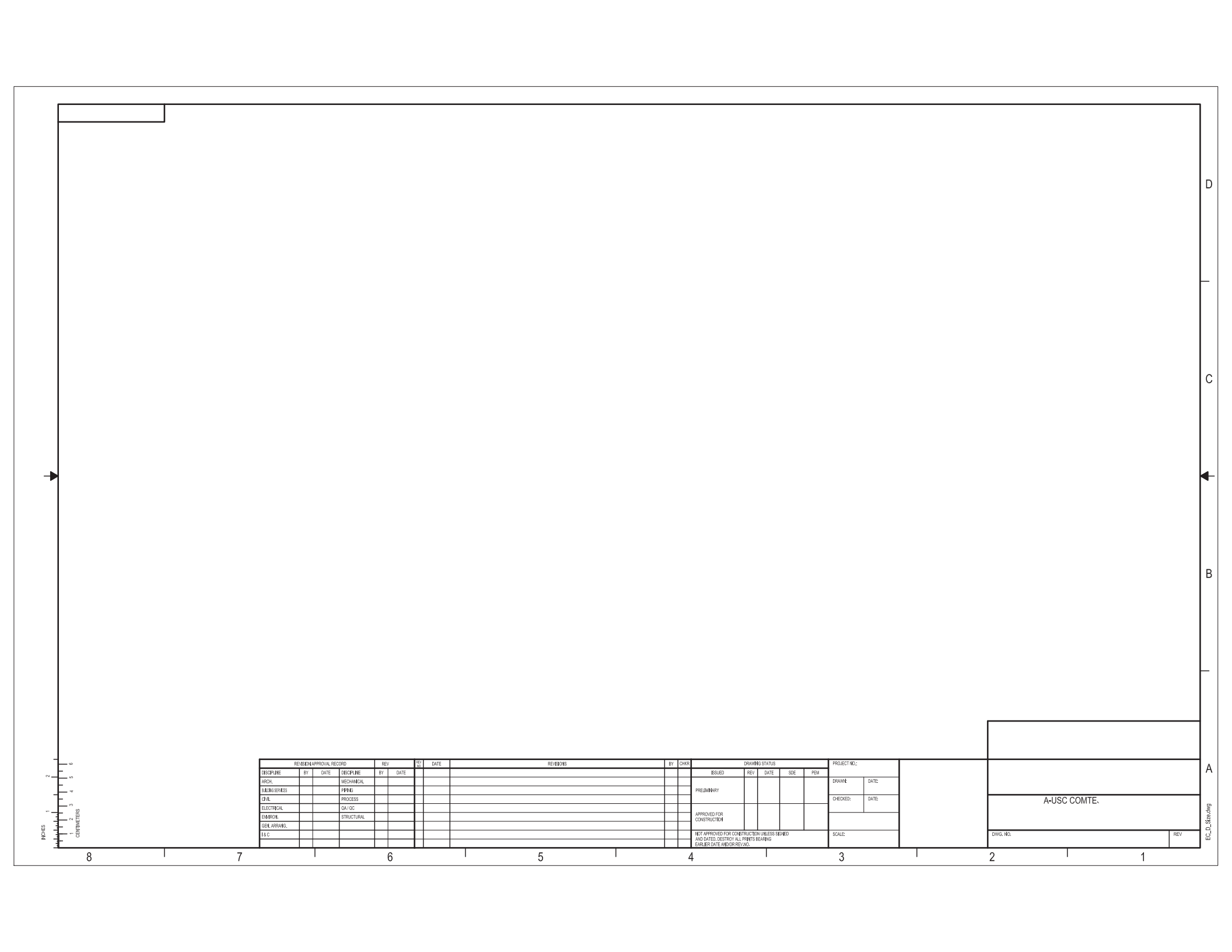
INCHES / CENTIMETERS

8 7 6 5 4 3 2 1

D C B A


D
C
B
A
8
7
6
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2
1
INCHES
CENTIMETERS
REVISION APPROVAL RECORD
REV
DISCIPLINE
BY
DATE
ARCH.
BUILDING SERVICES
CIVIL
ELECTRICAL
ENVIRON.
GEN. ARRANG.
I & C
MECHANICAL
PIPING
PROCESS
QA / QC
STRUCTURAL
REV NO.
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NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV NO.
PROJECT NO.:
DRAWN:
CHECKED:
SCALE:
A-USC COMTE.
DWG. NO.
EC_D_Site.dwg

PID-AUSC-02

E2B-025064-1E8503 REVISIONS

VALVES

- GATE VALVE (NORMALLY OPEN)
- GATE VALVE (NORMALLY CLOSED)
- BALL VALVE (NORMALLY OPEN)
- BALL VALVE (NORMALLY CLOSED)
- GLOBE VALVE (NORMALLY OPEN)
- GLOBE VALVE (NORMALLY CLOSED)
- PINCH VALVE (NORMALLY OPEN)
- PINCH VALVE (NORMALLY CLOSED)
- BUTTERFLY VALVE (NORMALLY OPEN)
- BUTTERFLY VALVE (NORMALLY CLOSED)
- NEEDLE VALVE (NORMALLY OPEN)
- NEEDLE VALVE (NORMALLY CLOSED)
- ECCENTRIC DISK VALVE (NORMALLY OPEN)
- ECCENTRIC DISK VALVE (NORMALLY CLOSED)
- KNIFE-GATE VALVE (NORMALLY OPEN)
- KNIFE-GATE VALVE (NORMALLY CLOSED)
- PLUG VALVE (NORMALLY OPEN)
- PLUG VALVE (NORMALLY CLOSED)
- DIAPHRAGM VALVE (NORMALLY OPEN)
- DIAPHRAGM VALVE (NORMALLY CLOSED)
- RAM VALVE (NORMALLY OPEN)
- RAM VALVE (NORMALLY CLOSED)
- DART VALVE (NORMALLY OPEN)
- DART VALVE (NORMALLY CLOSED)
- ANGLE VALVE (NORMALLY OPEN)
- ANGLE VALVE (NORMALLY CLOSED)
- THREE WAY VALVE (NORMALLY OPEN)
- FOUR WAY VALVE (NORMALLY OPEN)
- RUPTURE DISK (VACUUM RELIEF)
- RUPTURE DISK (PRESSURE RELIEF)
- PRESSURE RELIEF VALVE
- VACUUM PRESSURE RELIEF VALVE
- THREE WAY SAFETY VALVE
- RELIEF VALVE
- CHECK VALVE
- SLIDE GATE VALVE
- DAMPER (SINGLE)
- DAMPER (DOUBLE)
- POPPET DAMPER
- GUILLOTINE DAMPER
- SOLENOID VALVE
- DIVERTER VALVE
- SLIDE DIVERTER VALVE
- FLAPPER VALVE
- PRESSURE REDUCING VALVE SELF CONTAINED
- BACK PRESSURE VALVE SELF CONTAINED
- PRESSURE REDUCING VALVE WITH EXTERNAL PIPE TAPS
- BACK PRESSURE VALVE WITH EXTERNAL PIPE TAPS
- TEMPERATURE REGULATING VALVE

INSTRUMENTS

	FIELD MOUNTED	PRIMARY LOCATION NORMALLY ACCESSIBLE TO OPERATOR	AUXILIARY LOCATION NORMALLY ACCESSIBLE TO OPERATOR	PRIMARY LOCATION NORMALLY INACCESSIBLE TO OPERATOR	AUXILIARY LOCATION NORMALLY INACCESSIBLE TO OPERATOR
DISCRETE INSTRUMENTS	○	⊖	⊖	⊖	⊖
SHARED DISPLAY, SHARED CONTROL	□	⊟	⊟	⊟	⊟
PROGRAMMABLE LOGIC CONTROL	◇	⊠	⊠	⊠	⊠

- ALARM, LOCAL VISUAL
- ALARM, LOCAL AUDIBLE
- ORIFICE PLATE
- MAGNETIC FLOW METER
- CORIOLIS FLOW METER
- VORTEX FLOW METER
- V-CONE FLOW METER
- TURBINE METER
- FLOW NOZZLE
- PITOT TUBE
- AVERAGING PITOT TUBE
- VENTURI TUBE
- FLUME
- WEIR
- FLOW STRAIGHTENING VANE
- POSITIVE-DISPLACEMENT FLOW METER
- ROTAMETER
- ULTRASONIC FLOW METER
- NUCLEAR DENSITY METER
- FLAME DETECTOR

ACTUATORS

- CYLINDER (PISTON), PNEUMATIC
- MOTOR ACTUATOR
- SOLENOID ACTUATOR
- HYDRAULIC ACTUATOR
- DIAPHRAGM

VALVE FAILURE MODE ABBREVIATIONS

GLOBE, GATE, BALL OR OTHER VALVE TYPE SYMBOL

- FO FAIL OPEN
- FC FAIL CLOSED
- FIP FAIL IN PLACE
- LIP LOCK IN PLACE
- LOA LOSS OF AIR
- LOS LOSS OF SERVICE

LINE LEGEND

- PROCESS LINE
- INSTRUMENT SUPPLY CONNECTION TO PROCESS OR AUXILIARY
- EQUIPMENT BOUNDARY OR SKID
- ELECTRICAL
- FUTURE
- BY OTHERS
- FLEX HOSE
- ELECTRIC HEAT TRACED & INSULATED PROCESS LINE
- PERSONNEL PROTECTION INSULATED PROCESS LINE
- PROCESS LINE WITH INSULATION (NOT HEAT TRACED)
- STEAM TRACED & INSULATED
- PNEUMATIC SIGNAL OR INSTRUMENT AIR SIGNAL
- CAPILLARY TUBING
- PID-XXXX-YY CONTINUATION REFERENCE NUMBER
- SPLIT OF RESPONSIBILITIES
- ASME CODE BOUNDARY
  - BP – BOILER PIPING
  - BEP – BOILER EXTERNAL PIPING
  - NBEP – NONBOILER EXTERNAL PIPING

EQUIPMENT

- CENTRIFUGAL PUMP
- POSITIVE DISPLACEMENT PUMP
- PROPORTIONING PUMP
- SUMP PUMP
- AXIAL FAN
- POSITIVE-DISPLACEMENT BLOWER
- CENTRIFUGAL BLOWER OR FAN
- CENTRIFUGAL COMPRESSOR
- RECIPROCATING COMPRESSOR
- VFD VARIABLE FREQUENCY DRIVE
- VSD DC VARIABLE SPEED DRIVE
- MFC MASS FLOW CONTROLLER
- MAGNETIC SEPARATOR
- PICK-UP TEE
- CLOSED CIRCUIT TV
- MICROPHONE
- CONVEYOR
- SCREW CONVEYOR/FEEDER
- ROTARY FEEDER
- ACCUMULATOR
- MOTOR
- HEAT EXCHANGER
- ELECTRIC HEATER
- AIR FOIL
- AGITATOR/MIXER
- AMMONIA/AIR MIXER
- AMMONIA INJECTION GRID
- STATIC MIXING DEVICE
- EDUCTOR
- LOAD CELL
- MILL
- PRESSURE/VACUUM RELIEF MANWAY
- AIR TO AIR HEAT EXCHANGER

PIPING SPECIALTIES

- CAP
- SCREWED CAP
- QUICK DISCONNECT
- HOSE CONNECTION
- FLANGE
- D REDUCER
- DRAIN TO TRENCH
- V VENT
- S SAMPLE
- T TRAP
- F PNEUMATIC FILTER
- L LUBRICATOR
- Y OPEN DRAIN
- TYPE STRAINER
- EXPANSION JOINT
- DUPLEX STRAINER
- SIGHT FLOW INDICATOR
- STRAINER
- DIAPHRAGM SEAL
- SIPHON TUBE
- CERAMIC SPOOL
- ISO SPOOL
- FILTER
- SILENCER
- ATTEMPERATOR
- VENT STACK
- SAFETY VENT SILENCER
- SPECTACLE BLIND
- LPA LARGE PARTICLE ASH SCREEN

NOTES:

1. FOR PROCESS & INSTRUMENTATION DIAGRAM – DRAWING INDEX, SEE DRAWING –1E8501
2. FOR PROCESS & INSTRUMENTATION DIAGRAM – IDENTIFICATION & TAGGING, SEE DRAWING –1E8502

CONTRACT NO. E2B-025064 UNIT NO.

PROCESS & INSTRUMENTATION DIAGRAM
SYMBOLS & NOMENCLATURE
AUSC COMPONENT TEST FACILITY
COMTEST-760

GE POWER

SCALE : NONE
DRAWN BY : VDK DATE : 11-22-17
CHECKED BY : JPG DATE : 11-22-17
APPROVED BY : JPG DATE : 11-22-17
NEW CODE :

DRAWING NO. E2B-025064-1E8503 REV. 00

IF FILE NAME : E2B-025064-1E8503
IF DIRECTORY : E2B-025064

PRELIMINARY NOT FOR CONSTRUCTION

REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV	DATE	REVISIONS	BY	CHKR
A	12-22-17	ISSUE FOR RECORD	DC	CB

DRAWING STATUS	REV	DATE	SDE	PEM
ISSUED				
PRELIMINARY	A	12/22/17	CB	DM
APPROVED FOR CONSTRUCTION				

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PROJECT NO.: 31609
DRAWN: DC DATE: 12/14/17
CHECKED: CB DATE: 12/18/17
SCALE: NTS

AECOM
1300 East 9th St., Suite 500
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AECOM

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Independence, OH 44131
(216) 643-2952

A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
SUPERHEATER LEGEND #2

DWG. NO. PID-AUSC-02 REV A

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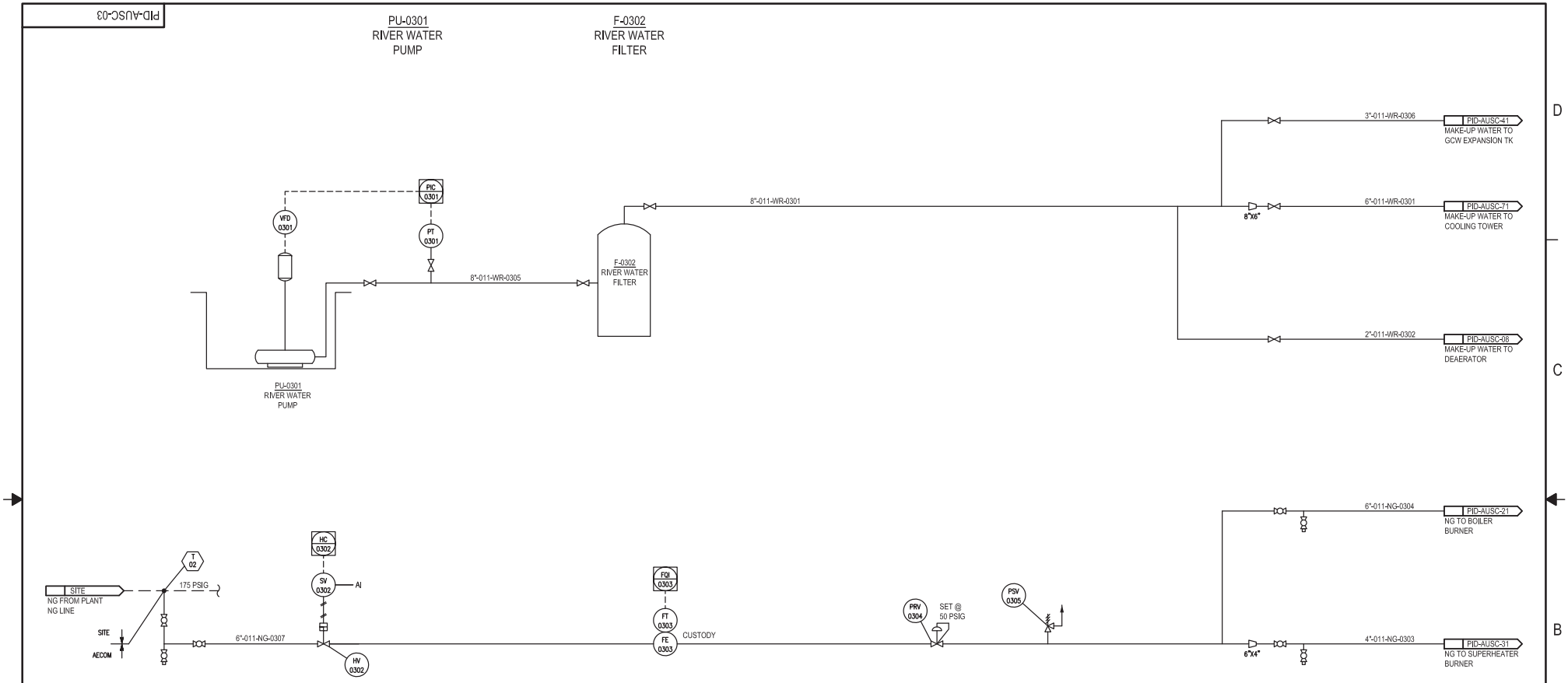
INCHES CENTIMETERS



PRELIMINARY
NOT FOR CONSTRUCTION

REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
A	12-22-17	ISSUE FOR RECORD	DC	CB

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A	12/22/17	CB	DM
APPROVED FOR CONSTRUCTION				

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PROJECT NO.: 31609
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AECOM
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Cleveland, OH 44114
(216) 622-2300

ENERGY INDUSTRIES of OHIO
6100 Oak Tree Boulevard, Suite 200
Independence, OH 44131
(216) 643-2952

A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
FEED STREAMS

DWG. NO. PID-AUSC-03 REV A

EC_D_Size.dwg

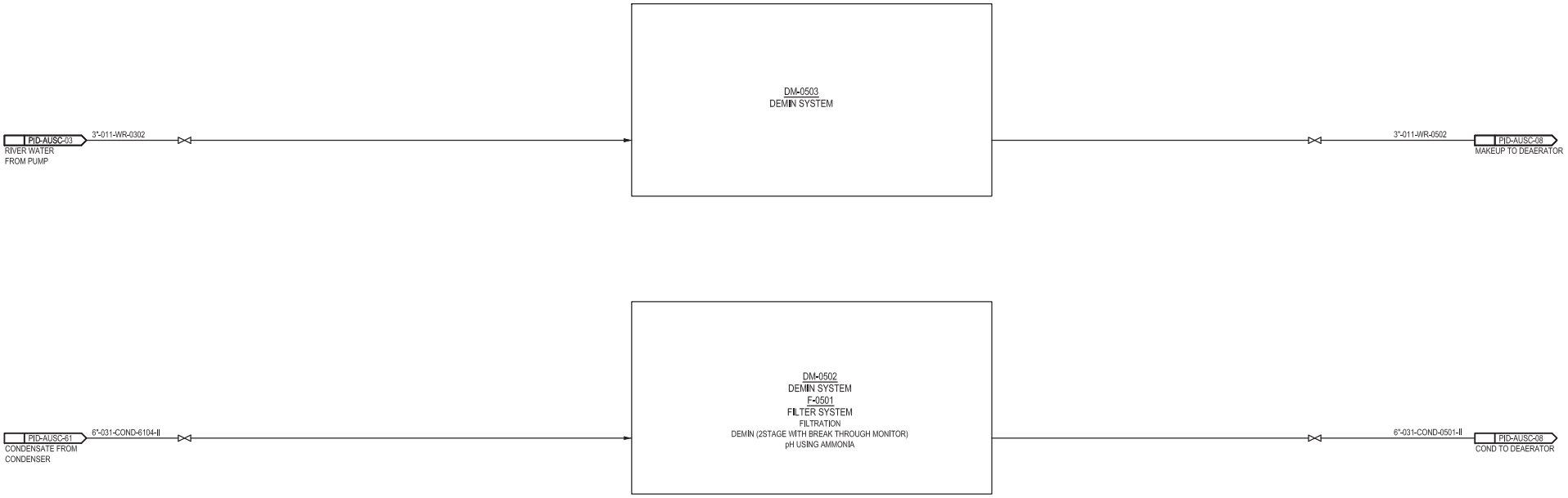
INCHES CENTIMETERS

PID-AUSC-05

F-0501
CONDENSATE FILTER SYSTEM

DM-0502
CONDENSATE DEMIN SYSTEM

DM-0503
MAKEUP WATER DEMIN SYSTEM



PRELIMINARY
NOT FOR CONSTRUCTION

URS ENERGY & CONSTRUCTION Inc, - an AECOM Company
1500 West 3rd St., Suite 200
Cleveland, OH 44113
(216) 523-9600
AECOM

REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
C/ML			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN'L ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
A	12/22/17	ISSUE FOR RECORD	DC	CB

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A	12/22/17	CB	DM
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV.NO.

PROJECT NO.: 31609
DRAWN: DC DATE: 12/14/17
CHECKED: CB DATE: 12/18/17
SCALE: NTS

ENERGY INDUSTRIES of OHIO
6100 Oak Tree Boulevard, Suite 200
Independence, OH 44131
(216) 643-2952

A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
BOILER FEED WATER TREATMENT

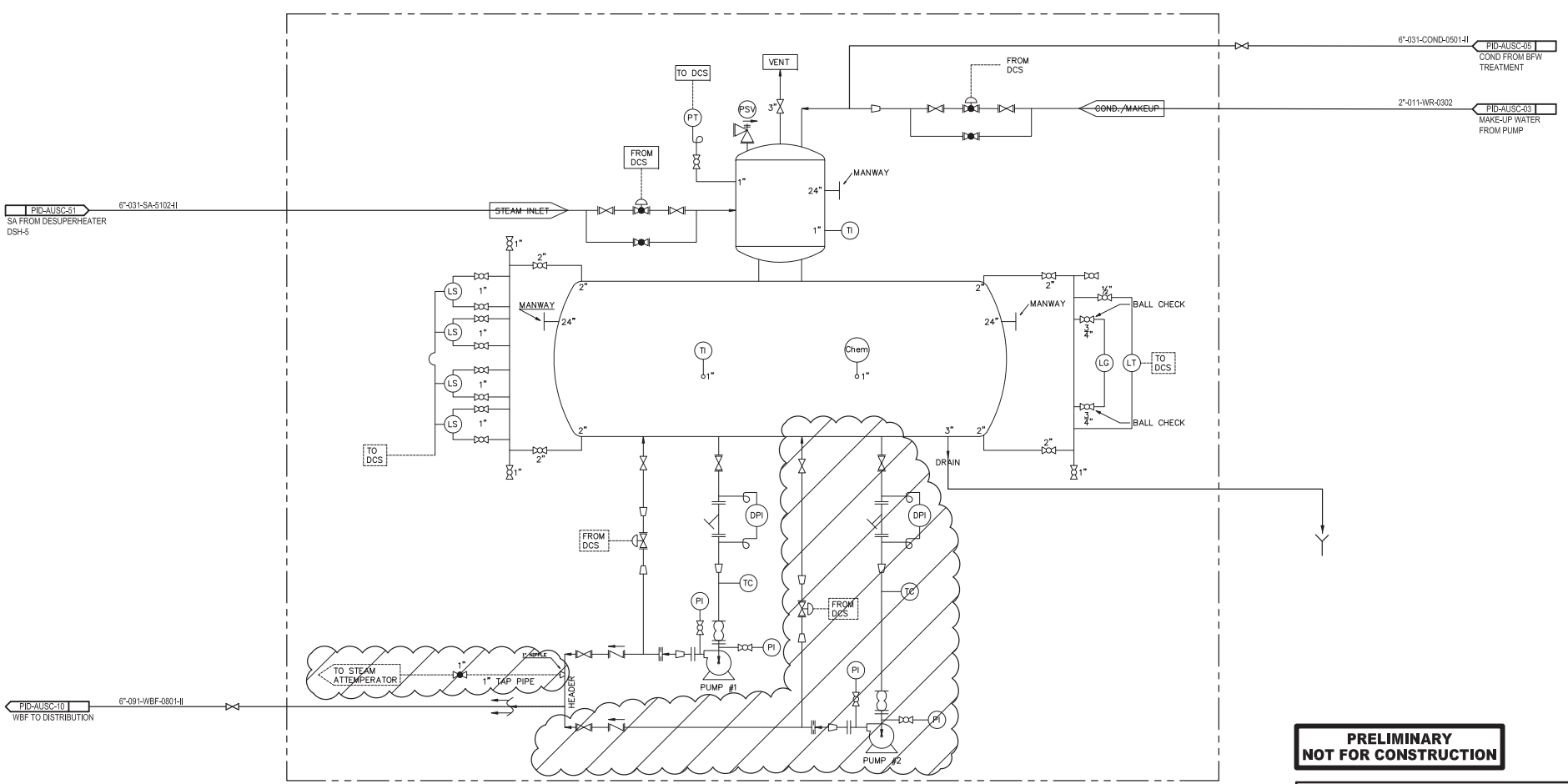
DWG. NO. PID-AUSC-05 | A

INCHES
CENTIMETERS
EC_D_Size.dwg

PID-AUSC-08

DE-0801
DEAERATOR

PU-0802
BFW PUMP



PRELIMINARY
NOT FOR CONSTRUCTION

REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
A	12/22/17	ISSUE FOR RECORD	DC	CB

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A	12/22/17	CB	DM
APPROVED FOR CONSTRUCTION				

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PROJECT NO.: 31609
DRAWN: DC DATE: 12/14/17
CHECKED: CB DATE: 12/18/17
SCALE: NTS

AECOM
1300 East 9th St., Suite 500
Cleveland, OH 44114
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Independence, OH 44131
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A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
DEAERATOR

DWG. NO. PID-AUSC-08 REV A

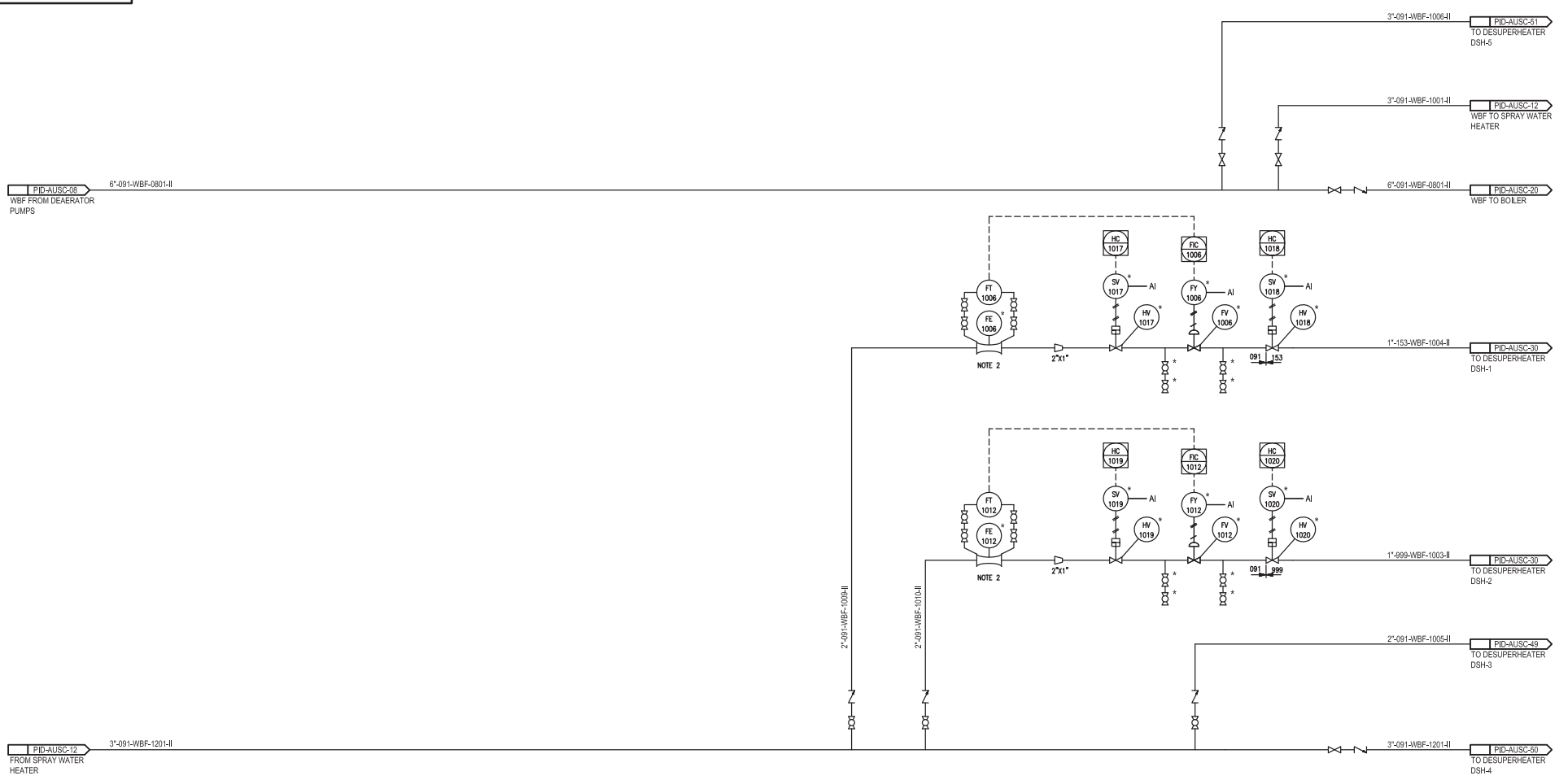
EC_D_Size.dwg

INCHES 1 2 CENTIMETERS 1 2 3 4 5 6

8 7 6 5 4 3 2 1

D C B A

PID-AUSC-10



NOTES:
1. ALL INSTRUMENTATION AND PIPING COMPONENTS WITH * NOTATION ARE SPECIFIED BY GE.
2. 30D STRAIGHT RUN REQUIRED UPSTREAM AND 10D STRAIGHT RUN REQUIRED DOWNSTREAM.

PRELIMINARY NOT FOR CONSTRUCTION

REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
C	12-22-17	ISSUE FOR RECORD	DC	CB
B	10-04-17	INTERNAL ISSUE	JK	CB
A	08-14-17	ISSUED FOR REVIEW	BLT	CB

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	C	12-22-17	CB	DM
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV NO.

PROJECT NO.: 31609
DRAWN: GG DATE: 03/30/17
CHECKED: CB DATE: 04/04/17
SCALE: NTS

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Cleveland, OH 44114
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Independence, OH 44131
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A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
WBF DISTRIBUTION

DWG. NO. PID-AUSC-10 REV C

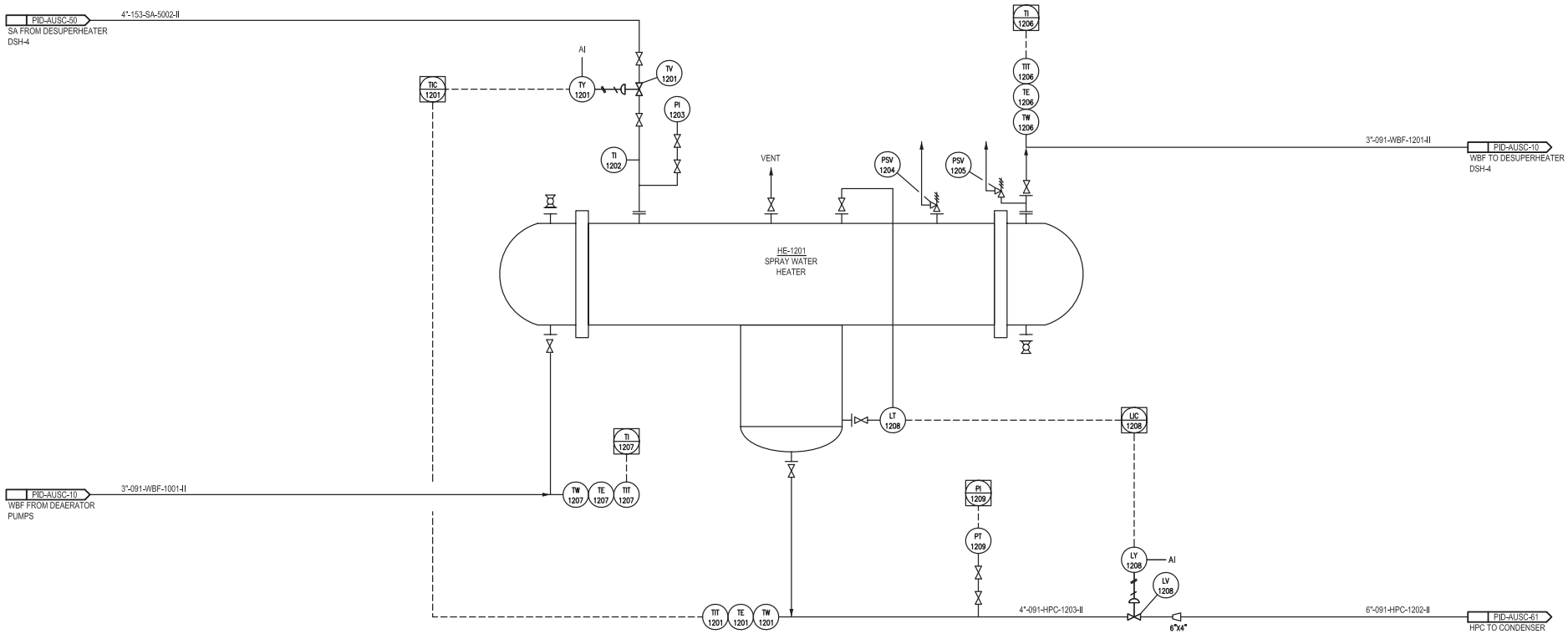
EC_D_Size.dwg

INCHES CENTIMETERS

PID-AUSC-12

HE-1201
SPRAY WATER HEATER

____BTU/HR
SHELL: ____PSIG @ ____DEG F
TUBE: ____PSIG @ ____DEG F



PRELIMINARY
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REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
A	12-22-17	ISSUE FOR RECORD	DC	CB

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A	12-22-17	CB	DM
APPROVED FOR CONSTRUCTION				

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PROJECT NO.: 31609
DRAWN: DC DATE: 12/14/17
CHECKED: CB DATE: 12/18/17
SCALE: NTS

ENERGY INDUSTRIES of OHIO
6100 Oak Tree Boulevard, Suite 200
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A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
SPRAY WATER HEATER

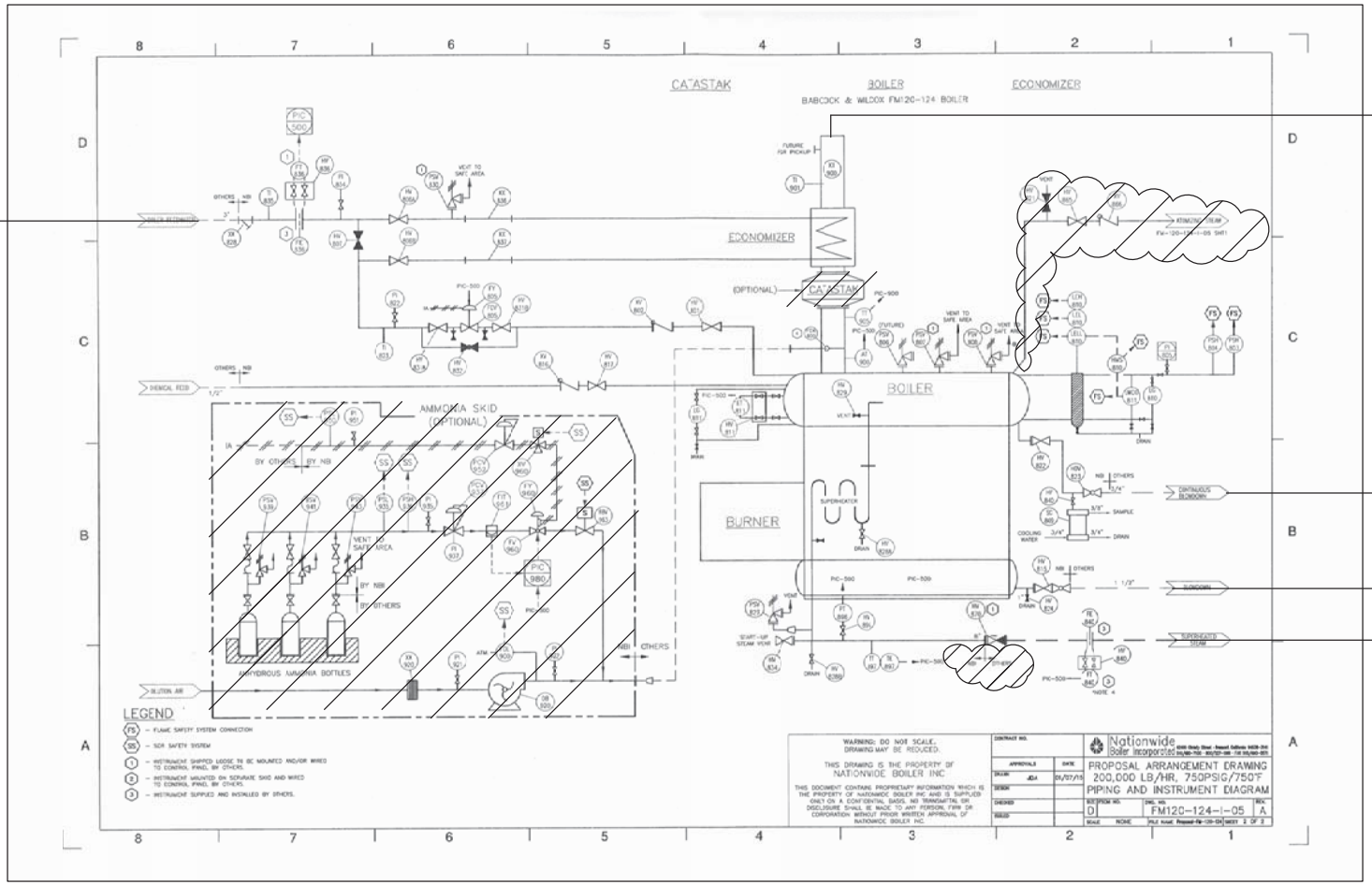
DWG. NO. PID-AUSC-12
REV A

EC_D_Size.dwg

INCHES
CENTIMETERS

PID-AUSC-20

B-2001
AUXILIARY BOILER



PRELIMINARY
NOT FOR CONSTRUCTION

REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
A	12-22-17	ISSUE FOR RECORD	DC	CB

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A	12/22/17	CB	DM
APPROVED FOR CONSTRUCTION				

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PROJECT NO.: 31609
DRAWN: DC DATE: 12/14/17
CHECKED: CB DATE: 12/18/17
SCALE: NTS

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A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
AUXILIARY BOILER

DWG. NO. PID-AUSC-20 REV A

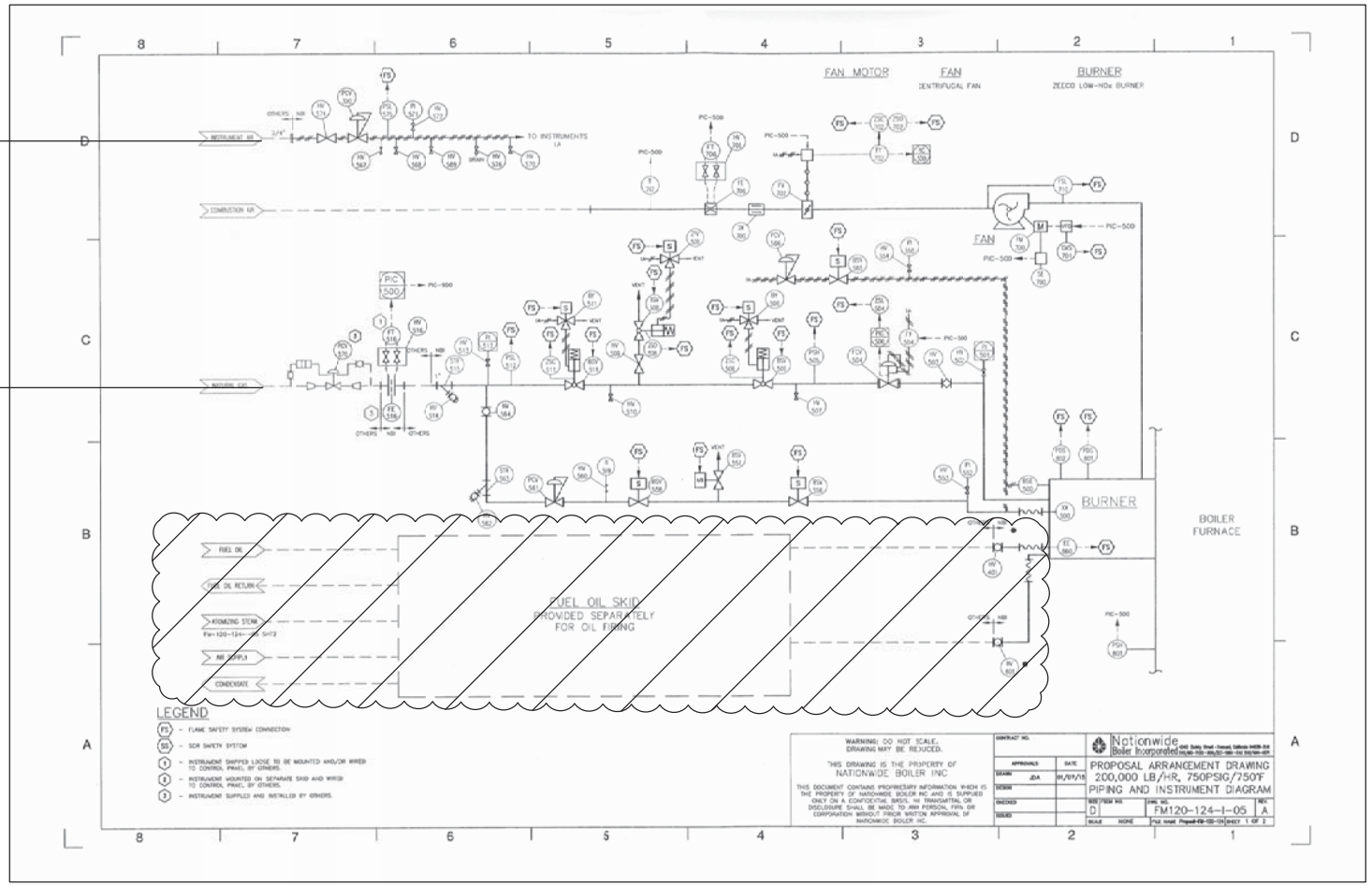
EC_D_Size.dwg

PID-AUSC-21

BU-2101
BOILER BURNER

FG-2102
FUEL GAS SKID

FG-2103
COMBUSTION AIR FAN



PRELIMINARY
NOT FOR CONSTRUCTION

REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
A	12-22-17	ISSUE FOR RECORD	DC	CB

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A	12/22/17	CB	DM
APPROVED FOR CONSTRUCTION				

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PROJECT NO.: 31609
DRAWN: DC DATE: 12/14/17
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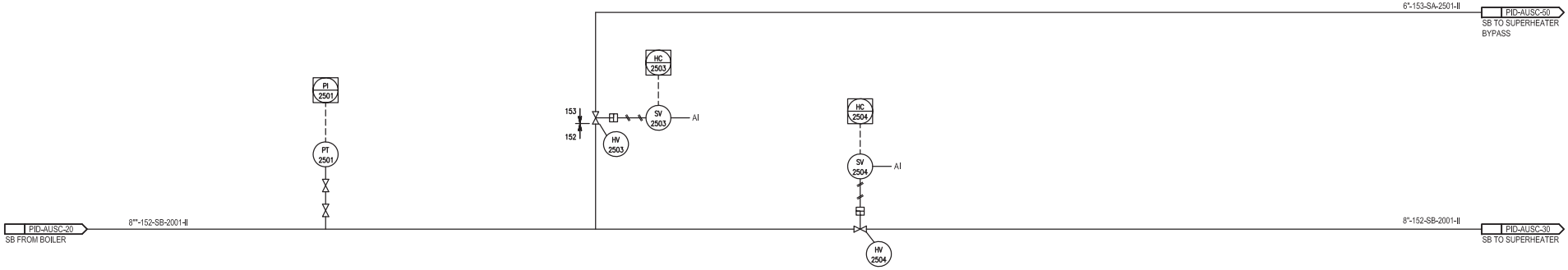
A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
AUXILIARY BOILER BURNER

DWG. NO. PID-AUSC-21 REV A

EC_D_Size.dwg

PID-AUSC-25



PRELIMINARY NOT FOR CONSTRUCTION

REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
A	12-22-17	ISSUE FOR RECORD	DC	CB

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A	122217	CB	DM
APPROVED FOR CONSTRUCTION				

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PROJECT NO.: 31609

DRAWN: DC DATE: 12-14-17

CHECKED: CB DATE: 12-18-17

SCALE: NTS

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A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
BOILER STEAM DISTRIBUTION

DWG. NO. PID-AUSC-25 REV A

INCHES CENTIMETERS

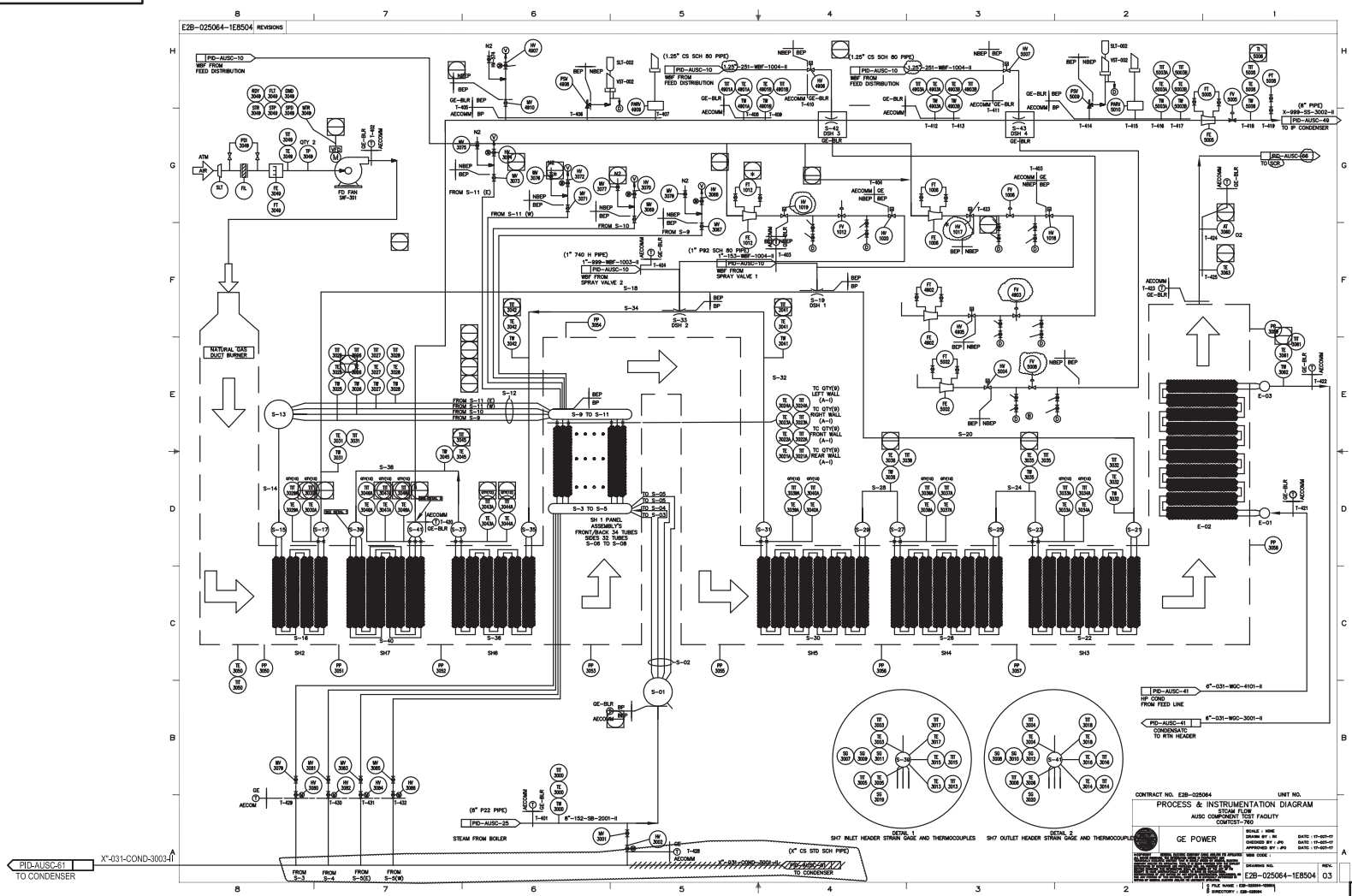
8 7 6 5 4 3 2 1

D C B A

EC_D_Size.dwg

PID-AUSC-03

SH-3001
SUPERHEATER
ASSEMBLY



PRELIMINARY
NOT FOR CONSTRUCTION

REVISION APPROVAL RECORD				REV		REV NO.	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.										
I & C						B	12-22-17	ISSUE FOR RECORD	DC	CB
						A	08-14-17	ISSUED FOR REVIEW	BLT	CB

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	B	12/22/17	CB	DM
APPROVED FOR CONSTRUCTION				

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PROJECT NO: 31609
DRAWN: GC DATE: 03/31/17
CHECKED: CB DATE: 04-04-17
SCALE: NTS

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A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
SUPERHEATER

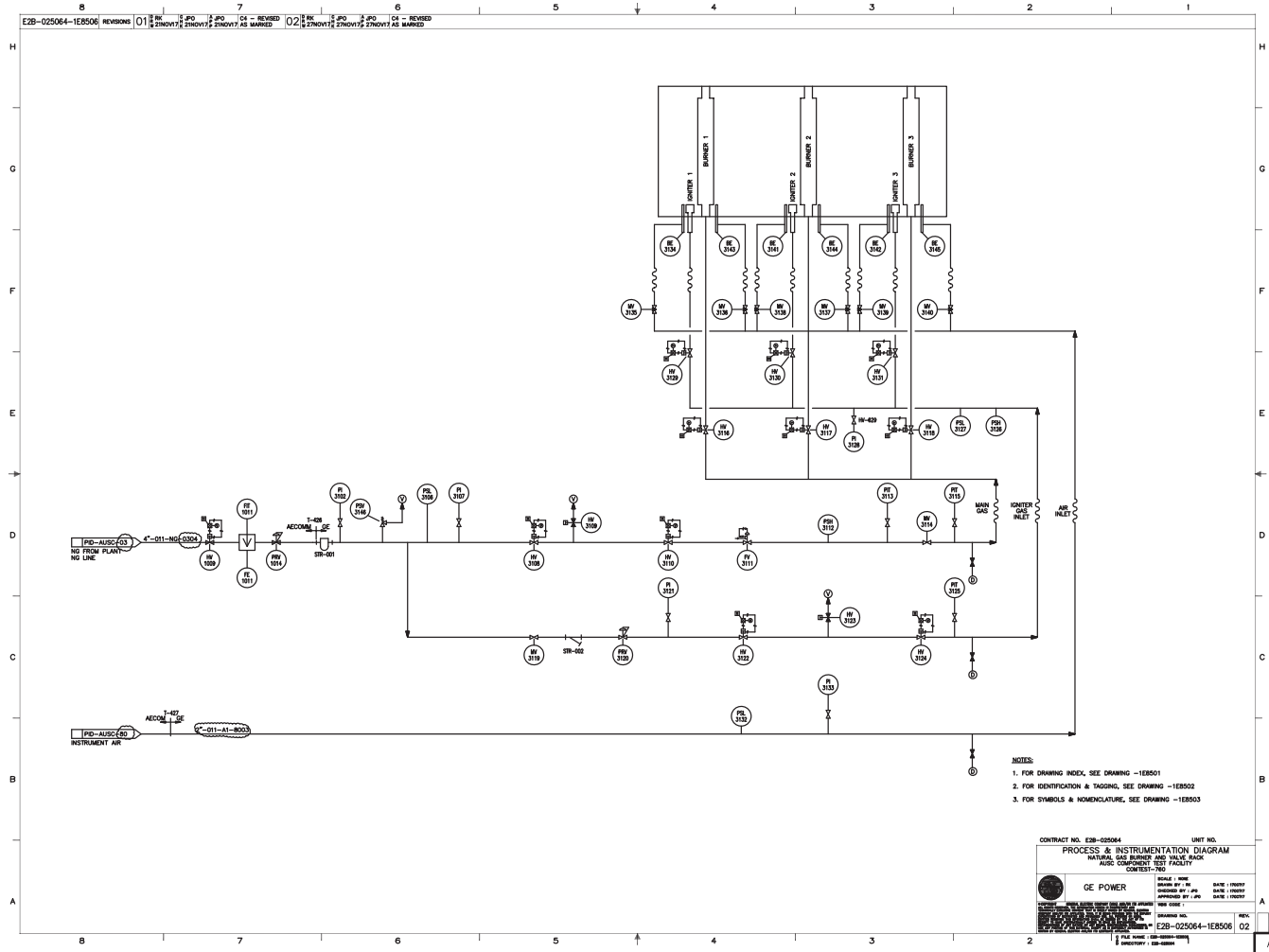
DWG. NO. PID-AUSC-30 REV B

EC_D_Size.dwg

PID-AUSC-31

BU-3101
SUPERHEATER
BURNER

FG-3102
BURNER FUEL
GAS SKID



PRELIMINARY
NOT FOR CONSTRUCTION

REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
A	12-22-17	ISSUE FOR RECORD	DC	CB

DRAWING STATUS					
ISSUED	REV	DATE	SDE	PEM	
PRELIMINARY	A	12/22/17	CB	DM	
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SCALE: NTS

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Independence, OH 44131
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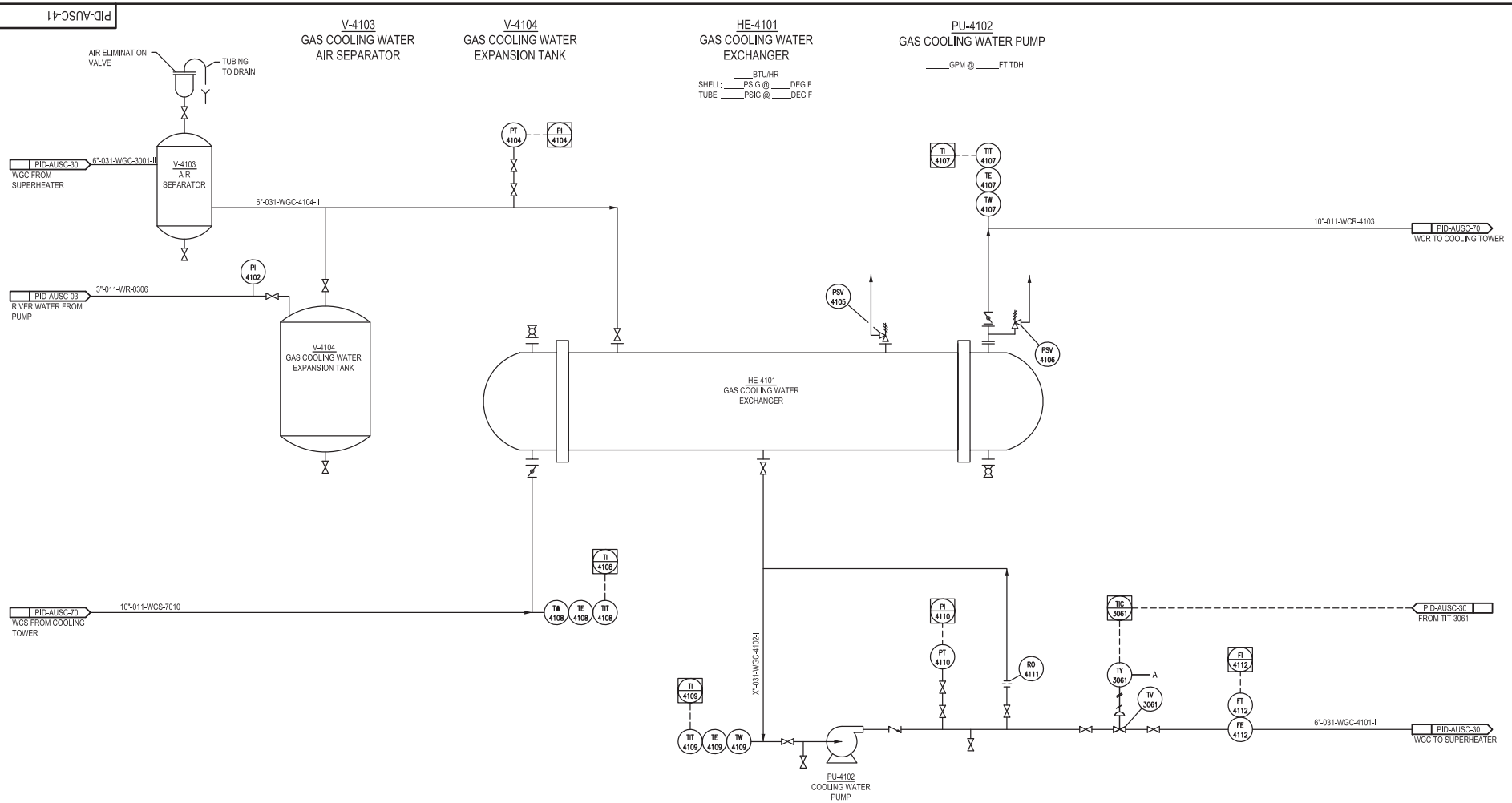
A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
SUPERHEATER BURNER AND VALVE RACK

DWG. NO. PID-AUSC-31
REV A

EC_D_Size.dwg

PID-AUSC-41



PRELIMINARY NOT FOR CONSTRUCTION

REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN'L ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
A	12-22-17	ISSUED FOR RECORD	DC	CB

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	A	12-22-17	CB	DM
APPROVED FOR CONSTRUCTION				

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PROJECT NO: 31609
DRAWN: DC DATE: 12/14/17
CHECKED: CB DATE: 12/18/17
SCALE: NTS

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Independence, OH 44131
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A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
GAS COOLING WATER EXCHANGER

DWG. NO. PID-AUSC-41
REV A

EC_D_Size.dwg

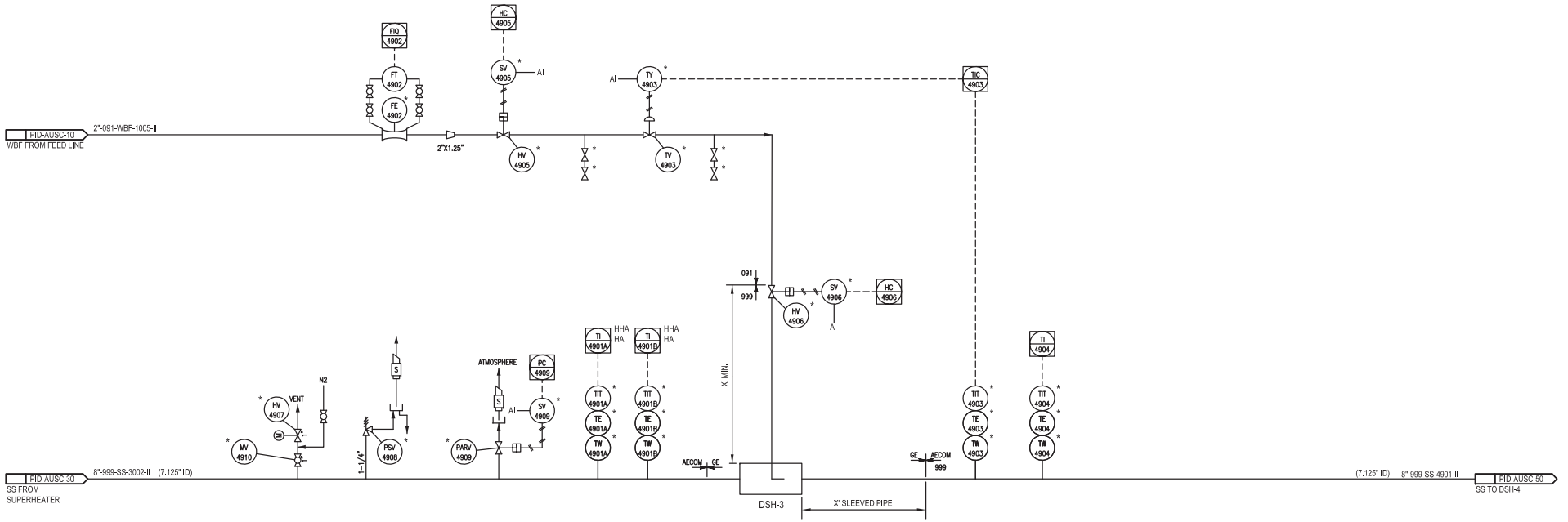
INCHES 1 2 3 4 5 6
CENTIMETERS 1 2 3 4 5 6

8 7 6 5 4 3 2 1

D C B A

PID-AUSC-49

DSH-3
DESUPERHEATER #3



NOTES:
1. ALL INSTRUMENTATION AND PIPING COMPONENTS WITH * NOTATION ARE SPECIFIED BY GE.

PRELIMINARY NOT FOR CONSTRUCTION

REVISION APPROVAL RECORD				REV		REV NO.	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN'L ARRANG.										
I & C						B	12-22-17	ISSUE FOR RECORD	DC	CB
						A	09-29-17	INTERNAL ISSUE	BLT	CB

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	B	12-22-17	CB	DM
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV.NO.

PROJECT NO: 31609
DRAWN: BLT DATE: 09/27/17
CHECKED: CB DATE: 09/27/17
SCALE: NTS

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A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
DESUPERHEATER #3

DWG. NO. PID-AUSC-49 REV B

EC_D_Size.dwg

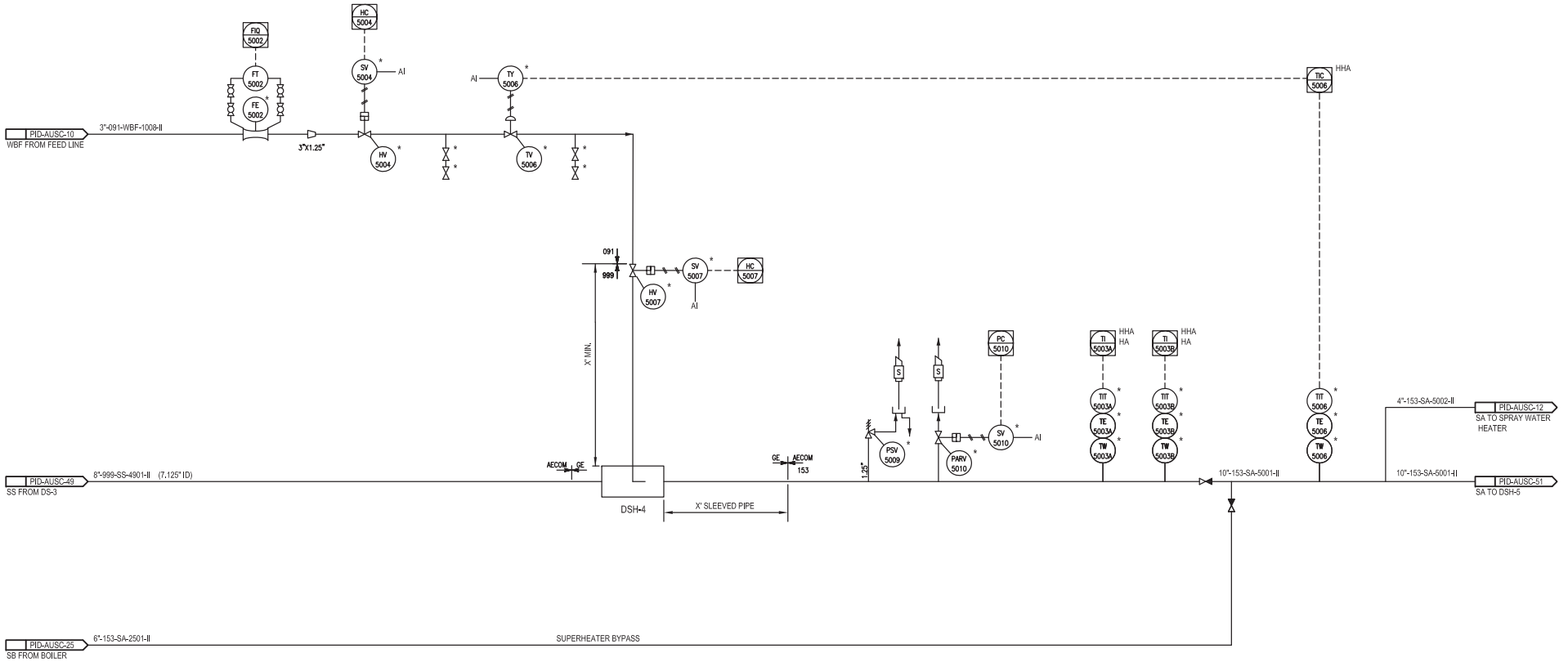
INCHES 1 2 3 4 5 6
CENTIMETERS 1 2

8 7 6 5 4 3 2 1

D C B A

PID-AUSC-50

DSH-4
DESUPERHEATER #4



NOTES:
1. ALL INSTRUMENTATION AND PIPING COMPONENTS WITH * NOTATION ARE SPECIFIED BY GE.

PRELIMINARY NOT FOR CONSTRUCTION

REVISION APPROVAL RECORD				REV		REV NO.	DATE	REVISIONS	BY	CHKR
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE					
ARCH.			MECHANICAL							
BUILDING SERVICES			PIPING							
CIVIL			PROCESS							
ELECTRICAL			QA / QC							
ENVIRON.			STRUCTURAL							
GEN. ARRANG.						C	12-22-17	ISSUE FOR RECORD	DC	CB
I & C						B	09-29-17	INTERNAL ISSUE	BLT	CB
						A	08-14-17	ISSUED FOR REVIEW	BLT	CB

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	C	12/22/17	CB	DM
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV.NO.

PROJECT NO: 31609
DRAWN: GG DATE: 08-16-17
CHECKED: CB DATE: 08-16-17
SCALE: NTS

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A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
DESUPERHEATER #4

DWG. NO. PID-AUSC-50 REV C

EC_D_Size.dwg

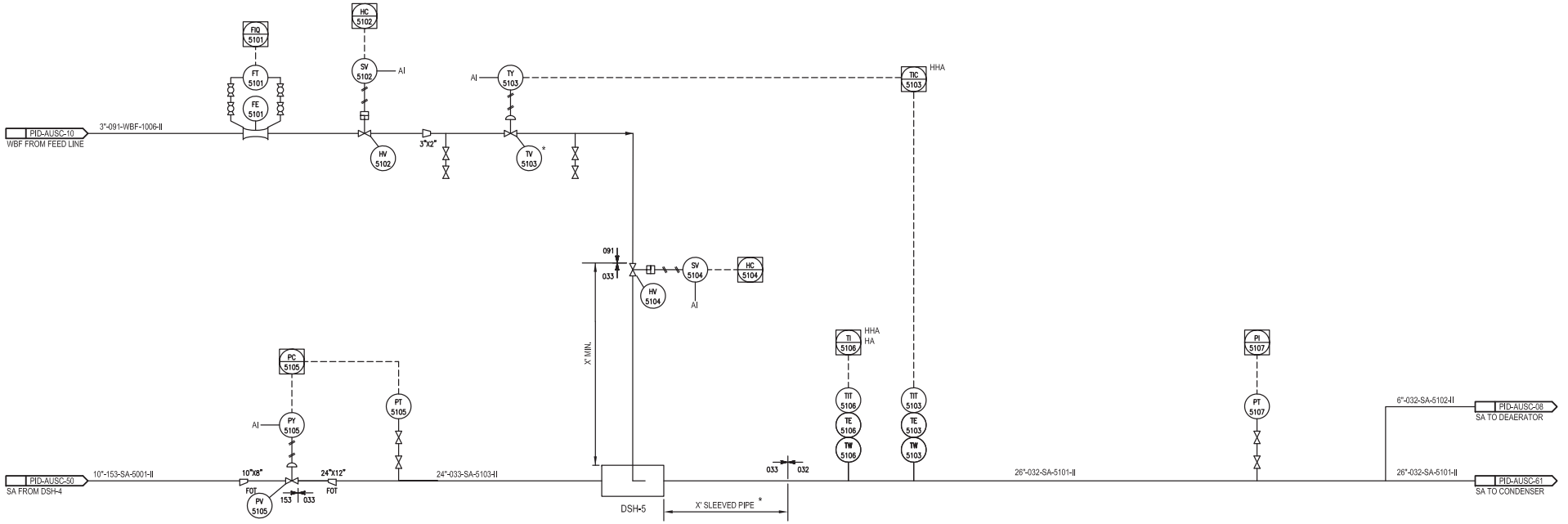
INCHES 1 2 3 4 5 6
CENTIMETERS 1 2

8 7 6 5 4 3 2 1

D C B A

PID-AUSC-51

DSH-5
DESUPERHEATER #5



NOTES:

1. INSTRUMENTS AND COMPONENTS WITH * NOTATION ARE PROVIDED WITH DESUPERHEATER EQUIPMENT.

PRELIMINARY
NOT FOR CONSTRUCTION

REVISION APPROVAL RECORD				REV	
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE
ARCH.			MECHANICAL		
BUILDING SERVICES			PIPING		
CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
B	12-22-17	ISSUE FOR RECORD	DC	CB
A	08-14-17	ISSUED FOR REVIEW	BLT	CB

DRAWING STATUS					
ISSUED	REV	DATE	SDE	PEM	
PRELIMINARY	B	12/22/17	CB	DM	
APPROVED FOR CONSTRUCTION					

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PROJECT NO: 31609
DRAWN: BLT DATE: 08-28-17
CHECKED: CB DATE: 08-28-17
SCALE: NTS

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A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
DESUPERHEATER #5

DWG. NO. PID-AUSC-51 REV B

EC_D_Size.dwg

INCHES 1 2 CENTIMETERS 1 2 3 4 5 6

8 7 6 5 4 3 2 1

D C B A

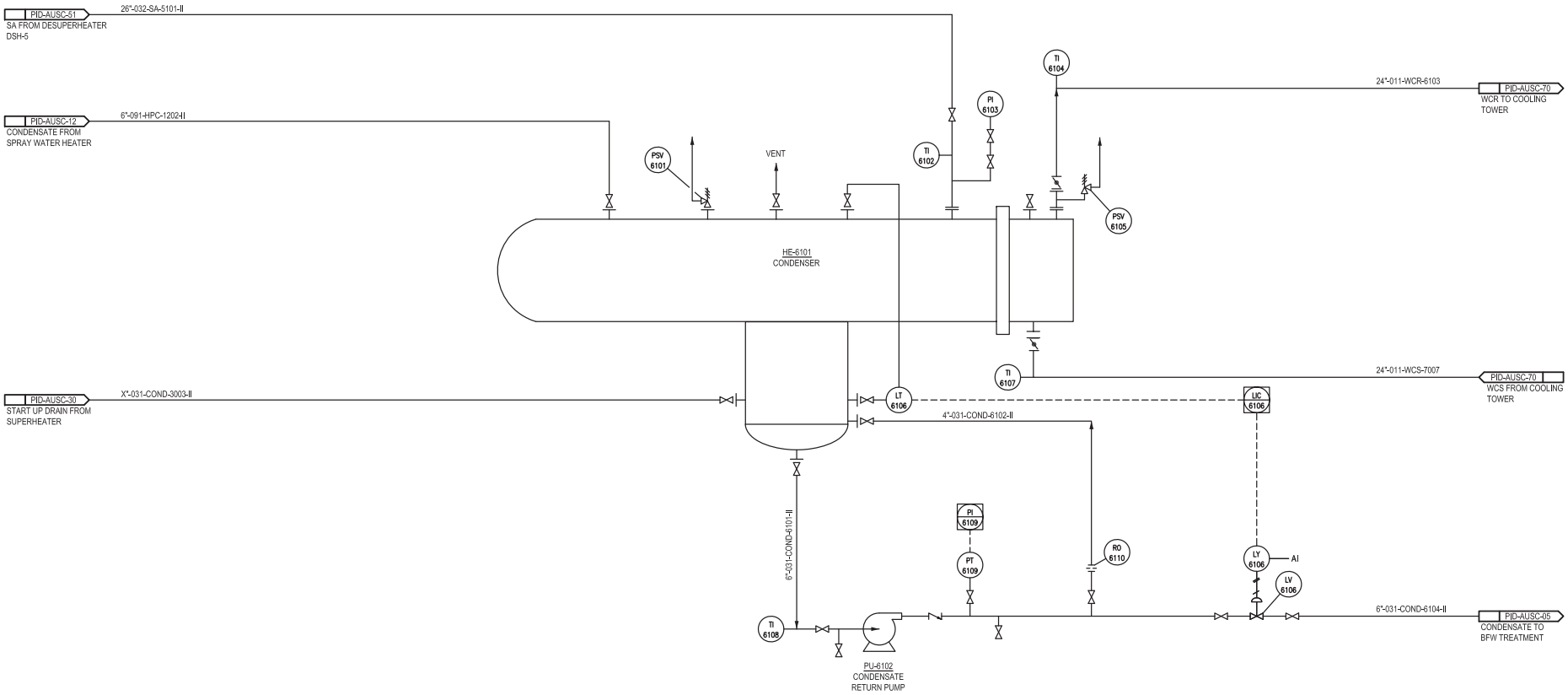
PID-AUSC-61

HE-6101
CONDENSER

_____BTU/HR
SHELL: _____PSIG / FV @ _____DEG F
TUBE: _____PSIG @ _____DEG F

PU-6102
CONDENSATE RETURN PUMP

_____GPM @ _____FT TDH



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A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
CONDENSER

DWG. NO. PID-AUSC-61
REV A

EC_D_Size.dwg

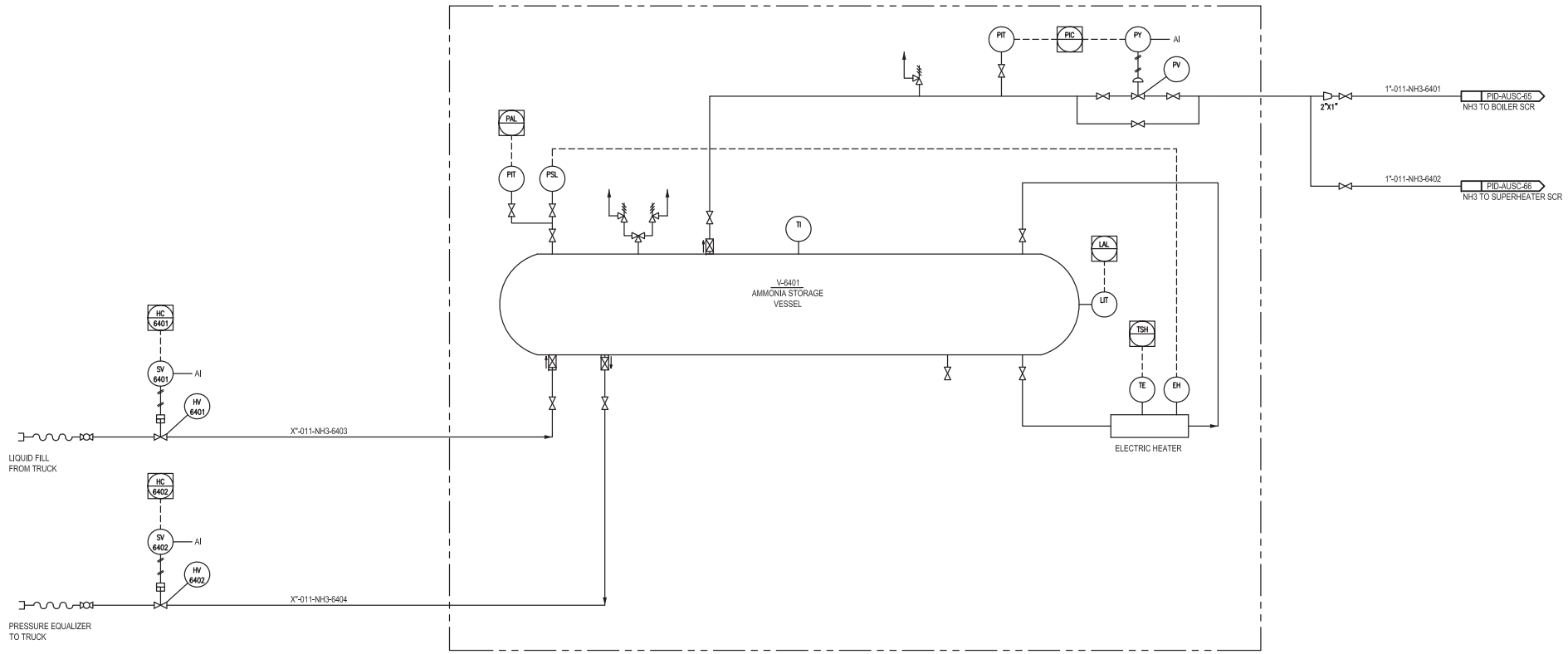
INCHES 1 2 3 4 5 6
CENTIMETERS 1 2 3 4 5 6

8 7 6 5 4 3 2 1

D C B A

PID-AUSC-64

V-6401
ANHYDROUS AMMONIA
SYSTEM



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A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
ANHYDROUS AMMONIA SYSTEM

DWG. NO. PID-AUSC-64 REV A

INCHES CENTIMETERS

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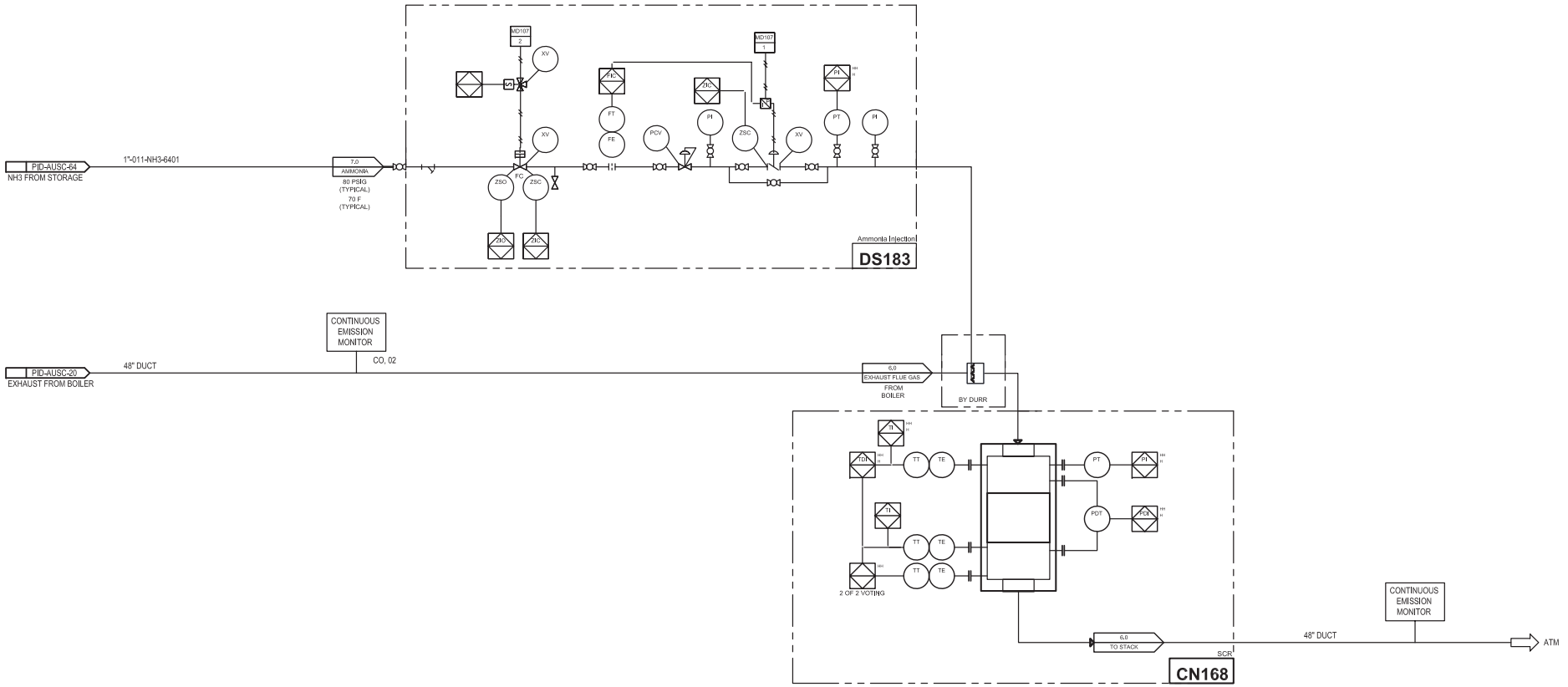
PID-AUSC-65

SCR-6501
BOILER SCR UNIT



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A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
BOILER SCR UNIT

DWG. NO. PID-AUSC-65 REV A

EC_D_Size.dwg

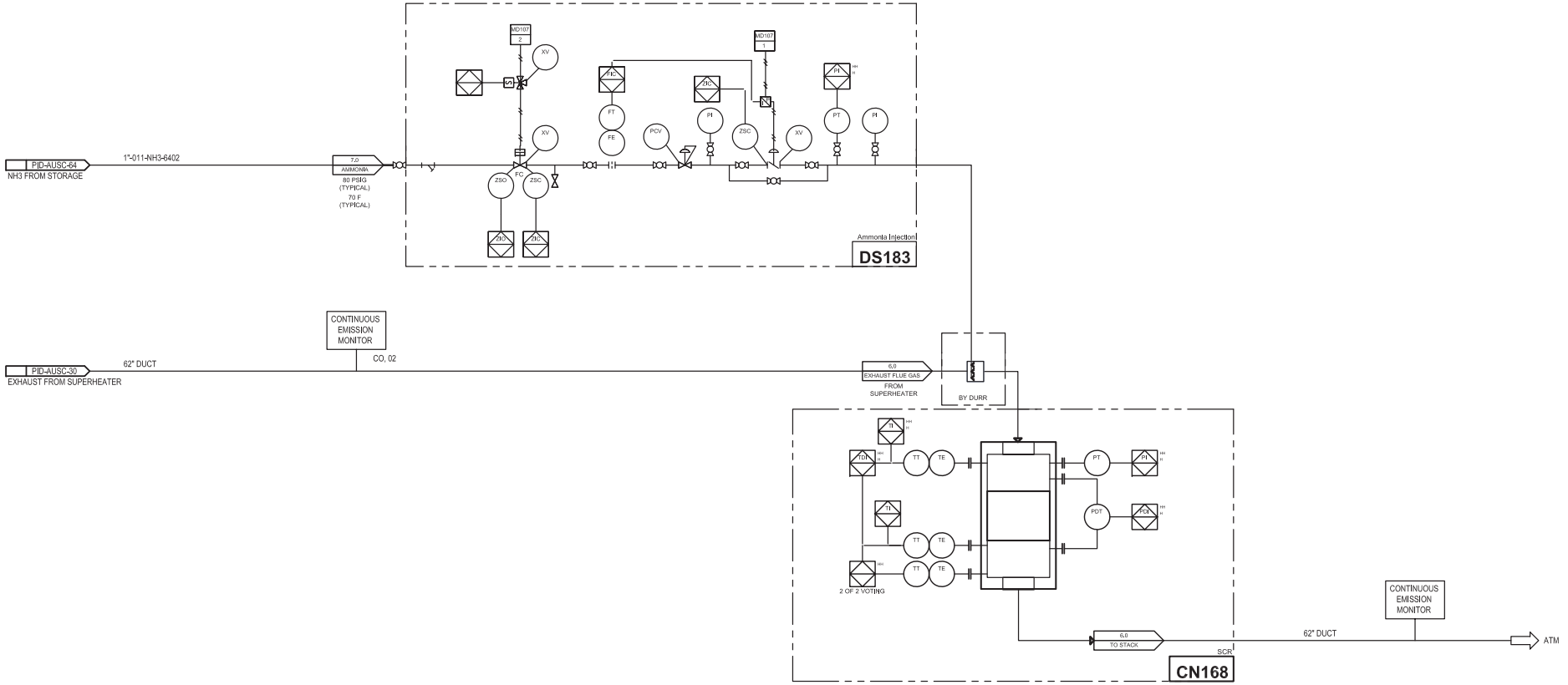
INCHES 1 2 3 4 5 6
CENTIMETERS 1 2 3 4 5 6

8 7 6 5 4 3 2 1

D C B A

PID-AUSC-66

SCR-6601
SUPERHEATER SCR UNIT



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A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
SUPERHEATER SCR UNIT

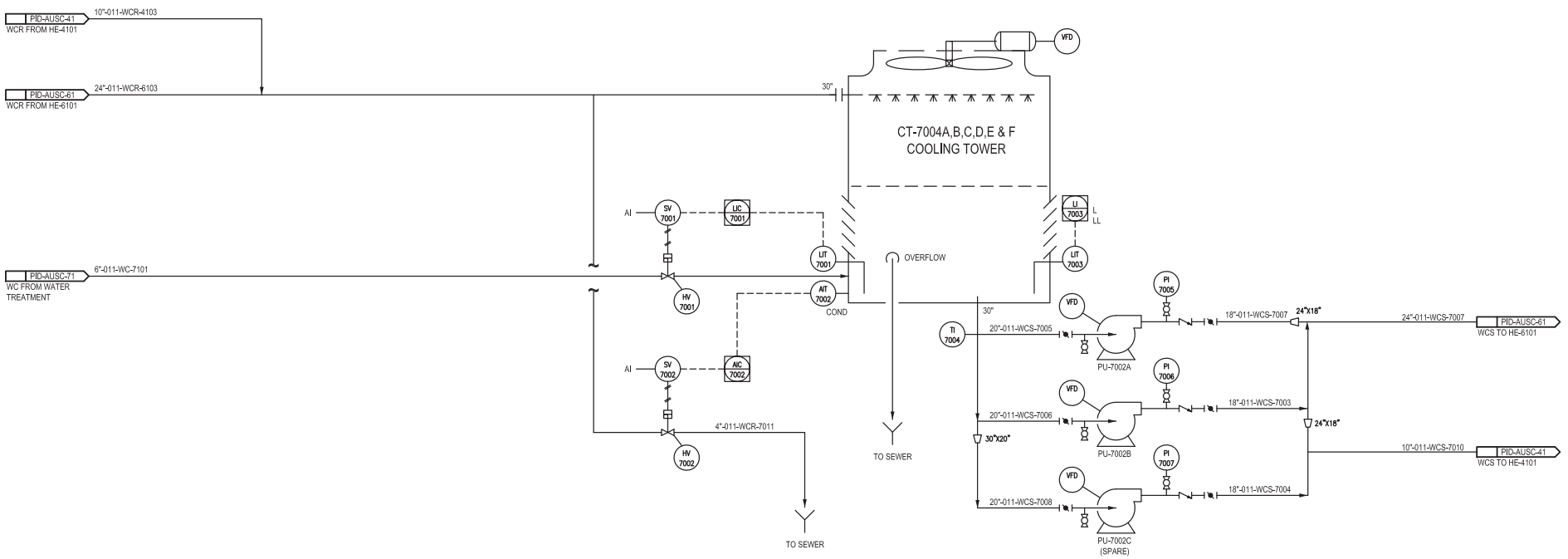
DWG. NO. PID-AUSC-66
REV A

INCHES CENTIMETERS
8 7 6 5 4 3 2 1
D C B A
EC_D_Size.dwg

PID-AUSC-70

CT-7004A,B,C,D,E & F
COOLING TOWER
23000 GPM

PU-7002A,B & C
SUPPLY PUMP
11500 GPM
25 PSIG



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A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
COOLING TOWER

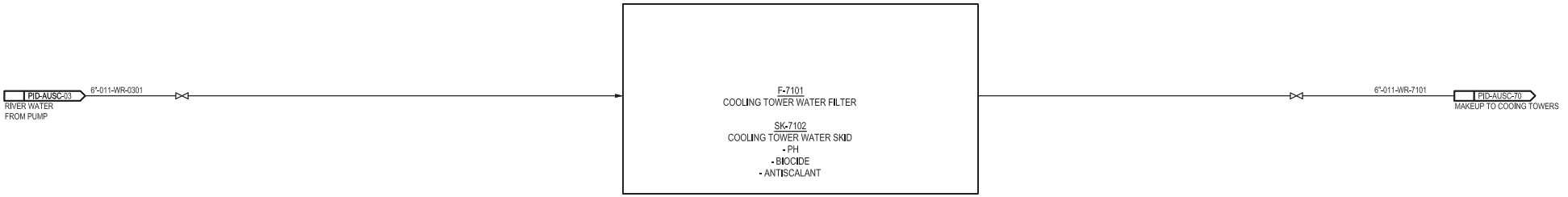
DWG. NO. PID-AUSC-70
REV A

INCHES
CENTIMETERS
EC_D_Size.dwg

PID-AUSC-71

F-7101
COOLING TOWER WATER FILTER

SK-7102
COOLING TOWER WATER SKID



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URS ENERGY & CONSTRUCTION Inc, - an AECOM Company
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AECOM

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A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
COOLING TOWER WATER TREATMENT

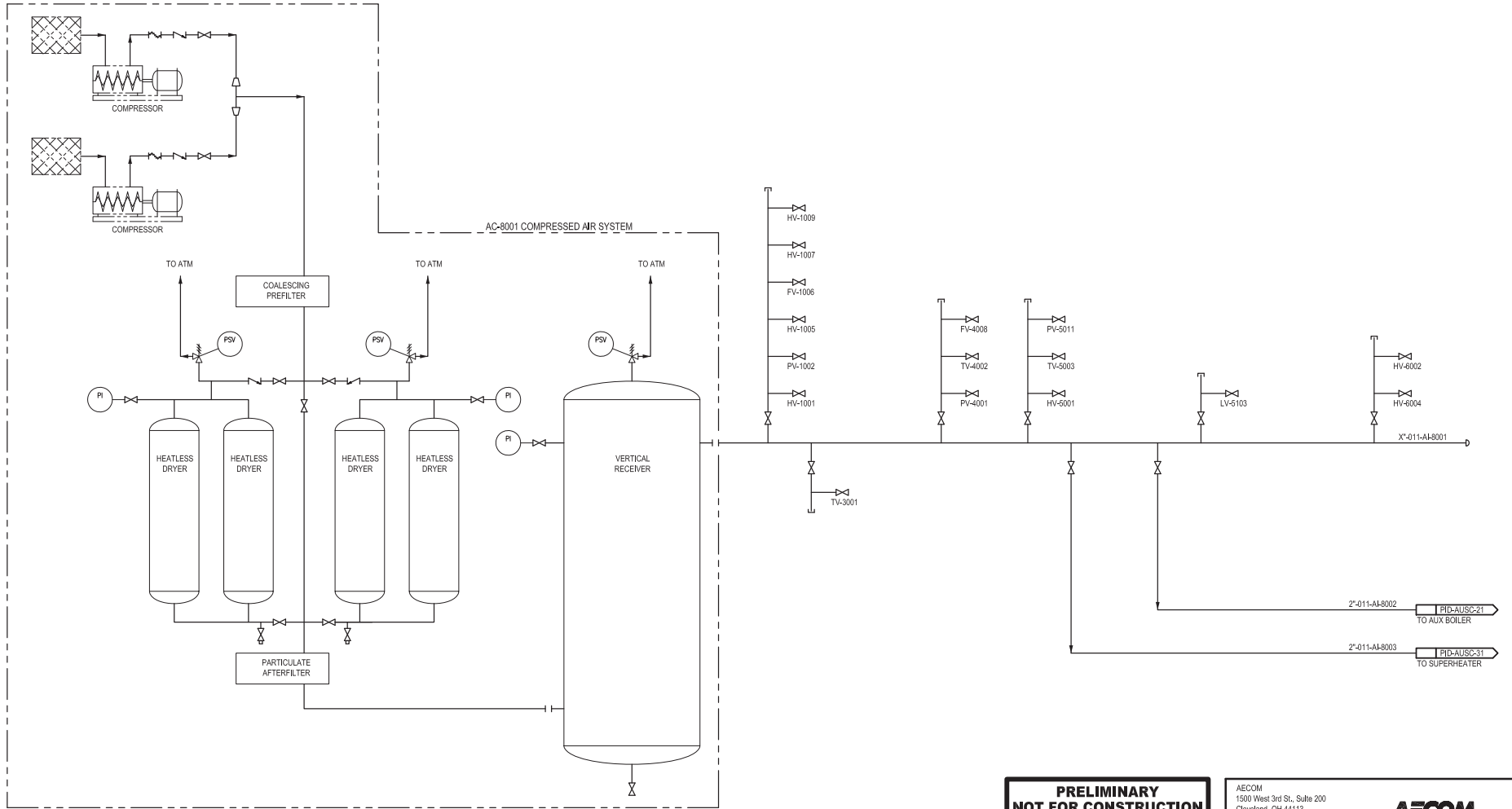
DWG. NO. PID-AUSC-71 | A

INCHES CENTIMETERS

EC_D_Size.dwg

PID-AUSC-80

COMPRESSOR	COALESCING PREFILTER	HEATLESS DESEICANT DRYER	PARTICULATE AFTERFILTER	VERTICAL RECEIVER	AC-8001 COMPRESSED AIR SYSTEM
65,0 ACFM 25 HP	2 MICRON	40 ACFM DEW PT QUALITY 2 MICRON CLASS 2 -40°F		240 GALLON 200 PSI	



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CIVIL			PROCESS		
ELECTRICAL			QA / QC		
ENVIRON.			STRUCTURAL		
GEN. ARRANG.					
I & C					

REV NO.	DATE	REVISIONS	BY	CHKR
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A	08-14-17	ISSUED FOR REVIEW	BLT	CB

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A-USC COMTEST PROJECT
PIPING & INSTRUMENTATION DIAGRAM
COMPRESSED AIR SYSTEM

DWG. NO. PID-AUSC-80 REV B

INCHES CENTIMETERS

EC_D_Size.dwg

Structural

A-USC ComTest at Youngstown Thermal

Youngstown, OH

PROJECT NUMBER 31609

SPECIFICATION NUMBER 31609-13-03-200-001

FOR

STRUCTURAL DESIGN CRITERIA

PREPARED FOR

Energy Industries of Ohio

By

AECOM

1500 W 3rd Street, Suite 200

Cleveland, OH 44113

Revision	Date	Status
A	March 31, 2016	Preliminary

SPECIFICATION REVISION PAGE

Project Name:	A-USC ComTest at Youngstown Thermal	Discipline:	Structural
Client:	Energy Industries of Ohio		

Revision Signatures

Jeff Morris	2/24/2016		
Prepared by	Date	Approved by (title)	Date
John Kropp	3/1/2016		
Checked by	Date	Approved by (if required) (title)	Date

Status	Rev. No.	Date	Prepared By	Pages	Description of Changes
Prelim.	A	3/31/16	JJM	All	Issued for FEED use

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1.0 GENERAL

1.1. Scope of Work

This document sets forth the structural design criteria requirements to be used as a guide for all AECOM designed steel structures, reinforced concrete structures, masonry and foundations.

1.2. Codes and Standards

Design shall conform to the requirements of the issues in effect as of October 30, 2015 of the following Codes, Standards, and Specifications including applicable supplements and revisions. All discrepancies or conflicts between Codes, Standards, Specifications, and this Design Criteria shall be referred to the Supervising Structural Engineer for resolution.

1.2.1. Ohio Building Code 2011 (Revised January 2016) (Based on IBC 2009)

1.2.2. American Concrete Institute (ACI)

Building Code Requirements for Structural Concrete, ACI 318-08.

Building Code Requirements for Masonry Structures, ACI 530-08

1.2.3. American Institute of Steel Construction, Inc. (AISC)

Specification for Structural Steel Buildings (AISC 360-05)

Code of Standard Practice for Steel Buildings and Bridges

Seismic Provisions for Structural Steel Buildings (AISC 341-05)

Steel Construction Manual, Thirteenth Edition, 2005

Seismic Design Manual, 1nd Edition, 2005

1.2.4. Research Council on Structural Connections (RCSC)

Specification for Structural Joints Using High-Strength Bolts 2009

1.2.5. American Iron and Steel Institute (AISI)

North American Specification for the Design of Cold-Formed Steel Structural Members (S100-07)

1.2.6. American Society for Civil Engineers (ASCE)

Minimum Design Loads for Buildings and Other Structures, ASCE 7-05

1.2.7. American Society for Testing and Materials (ASTM)

1.2.8. American Nationals Standards Institute (ANSI)

1.2.9. American Welding Society (AWS)

Structural Welding Code - Steel, AWS D1.1/D1.1M (1998)

Structural Welding Code - Reinforcing Steel, AWS D1.4/D1.4M (1998)

1.2.10. Code of Federal Regulations (CFR)

Title 29 - Labor, Part 1910-Occupational Safety and Health Standards

Title 29 - Labor, Part 1926-Safety and Health Regulations for Construction

Title 40 - Protection of Environment

1.2.11. International Code Council (ICC)

International Building Code 2009

1.2.12. Metal Building Manufacturer's Association (MBMA)

Metal Building Systems Manual 2006 Edition, with 2010 Supplements

Metal Roofing Systems Design Manual 2002 Edition

1.2.13. Factory Mutual, Johnston, RI. Property Loss Prevention Data Sheets

A. Roof system and attachment to conform to FM requirements per data sheets 1-28 and 1-29.

B. Wind loads applied to structure, both roof and walls, per Ohio Building Code, not FM.

1.2.14. Geotechnical Report

Geotechnical Engineering Report by CTL Engineering, Inc. dated March 7, 2016

1.2.15. SSPC: The Society for Protective Coatings

Standards and Publications

1.2.16. AECOM Engineering Standards

1.2.17. Submittals

A. Upon request, Design Calculations, Drawings, and Specifications shall be submitted to the Engineer for review.

B. All Calculations and Design Drawings shall be prepared under the supervision of and sealed by a Professional Engineer registered in the State of Ohio

1.3. Seller Documentation (Not Used)

1.4. Quality Assurance (Not Used)

1.5. Site and Utility Data

The site is located in Mahoning County, Youngstown, Ohio 44502 at 205 North Ave.

Latitude: 41.1052 N; Longitude: 80.6566 W

1.5.1. Occupancy Category III (IBC Table 1604.5)

1.5.2. Seismic IBC 2009

A. Mapped Spectral Accelerations (Site Class B)

0.2 Second Spectral Response Accel., S_s = 0.152 (USGS Design Maps)

1.0 Second Spectral Response Accel. S_1 = 0.049 (USGS Design Maps)

B. Site Class C per Geotechnical Report of section 1.2.14.

C. S_{ds} = 0.121; S_{d1} = 0.056

D. Importance Factor 1.25 (ASCE Table 11.5-1)

E. Seismic Design Category A

F. New Turbine Building Structure: By Pre-Engineered Building Vendor

G. Steel Pipe Racks and Supports: “Steel Systems Not Specifically Detailed for Seismic Resistance” (ASCE 7-05, Table 12.2-1, Item “H”); R=3

1.5.3. Climatic

A. Temperatures:

Design Minimum Ambient	0 F
Design Maximum Ambient	100 F

B.	Ambient Pressure	14.0 PSIA
C.	Wind:	
	Basic Wind Speed	90 Miles/Hour*
	* Three (3) second gust wind speed at 33 feet above ground	
	Exposure Category	B
	Importance Factor	1.15 (ASCE Table 6.1)
D.	Rainfall:	
	Design 1-Hour Period (100 yr)	2.75 inches (OBC Figure 1611.1)
E.	Snowfall: Annual Average	62 inches
	Ground Snow, p_g	20 psf (ASCE 7-05; Fig 7-1)
	Importance Factor	1.1 (ASCE 7-05; Table 7-4)
	Rain-on-snow surcharge load	5 psf (ASCE 7-05; Sec 7.10)
F.	Frost Depth:	42 inches (per section 1.2.14).
	Install Foundation Footings (Minimum Depth)	42 inches
G.	Plant Finish Floor Elevation:	867.49 feet +/- above mean sea level

2.0 PRODUCTS

2.1. Design Criteria

2.1.1. Design Loads

A. Dead Load (D) shall be considered as the weight of all materials forming a permanent part of the structure. It shall include the total weight of all equipment, structure, roofing and siding, ductwork, fireproofing, insulation, piping, conduits, and other attachments.

B. Equipment and Piping Loads (D_o, D_t)

1. The Operating dead load is the maximum weight of the contents (fluid load) during normal operation (D_o).
2. The Test dead load is the weight of the test medium contained in the system (D_t).

C. Live Load (L) shall include uniform floor area loads, equipment handling loads, truck wheel loads, and other similar loads. The floor area live load shall be omitted from areas occupied by equipment who's weight has been included in the dead load - unless the floor area live load is larger, in which case it shall be used. Live loads not specified below shall be in accordance with the Ohio Building Code.

1. Platform/Floor Areas

Electrical Equipment Rooms	250 psf, or 2,000 lb concentrated load at any point
Storage – Light	125 psf
Storage – Heavy	250 psf
Miscellaneous Platforms and Walkways	100 psf
Stairs	100 psf or 1000 lb. concentrated load at any point
Turbine Laydown Area	350 psf

2. Truck Traffic Areas

Forklift in Turbine Building	5 ton lift capacity

3. Building Roof Areas (L_R): 20 psf (ASCE 7-05 Table 4-1)
4. Ladders 300 lb at 10'-0" vertical c/c or 200 lb at 6'-0" vertical c/c
5. Handrail and Guards Systems, Posts and attachment devices 200 lbs or 50 lb/ft applied in any direction

No reduction in live load shall be made based on either tributary areas or ratio of dead loads to live loads.

D. Snow Load (S)

1. Snow loading shall be calculated in accordance with the Ohio Building Code, and ASCE 7-05. Ground snow loading = 20 psf

2. Consideration shall be given to partial and unbalanced loading, ponding, instability, additional surcharge loads of rain-on snow, snow sliding off a sloped roof onto a lower roof, drifted snow on lower levels of multi-level roofs, and on roof areas adjacent to projections such as parapet walls, etc.

E. Seismic Load (E)

1. Seismic loading shall be calculated in accordance with the Ohio Building Code and ASCE 7-05 using the data in paragraph 1.5.2.
2. Crane seismic loading:
   - Crane seismic loading shall consist of the dead weight of the crane bridge, trolley and cab.
   - The crane shall be considered in the parked or stored position.

F. Wind Load (W)

1. Wind loading shall be calculated in accordance with the ASCE 7-05.
2. For calculating wind loads on large, freestanding vessels and equipment, add 2'-0" to the diameter or width and 3'-0" to the height (to account for platforms, caged ladders, pipes, etc.). Use the appropriate shape factor.

G. Contingency Load (C)

1. Actual vendor supplied or engineered loads for major piping, ductwork, chutes, electrical trays and equipment should be used for final design.
2. In the absence of definition of the magnitude and location of such loads and to account for other unknown loads, assumed contingency loads shall be applied as concentrated loads at the midspan of all beams, girders and trusses as noted below. These loads are not to be carried as end reactions to other members, but each member's connection shall account for its contingency load.

Floor Beams	2 kips
Roof Beams (excluding purlins)	2 kips
Primary Girders	3 kips

Columns shall be designed to include the following minimum contingency loads. These loads are to be carried to the foundations.

Columns with axial load less than 200 kips	10% of column vertical load
Columns with axial load greater than 200 kips	5% of column vertical load not less than 20 kips

H. Crane and Hoist Load (C_D, C_L)

Vertical loads for cranes and hoists shall be as specified by the equipment manufacturer. Crane load shall be considered as the crane in an operating mode with maximum wheel loads and vertical and horizontal impact loadings occurring simultaneously.

I. Impact Loads (I)

1. The increase in the design live loads which induce impact shall have the following minimum values:

Equipment	Factor	Notes
Monorails	25%	1
Cab operated or remotely operated cranes, powered	25%	1,3
Pendant operated hoists	10%	1
Bridge cranes or monorail cranes with hand-geared bridge, trolley and hoist	0%	1,3
Light rotating machinery	20%	2
Reciprocating machinery	50%	2
Floor support hangers	33%	2

Notes:

1. ASCE 7-05, section 4.10.2
2. IBC 2009, section 1607.8.2
3. Live loads on crane support girders shall be taken as the maximum crane wheel loads.

2. Lateral impact forces and longitudinal forces for crane runways shall be as follows:
   - Lateral force shall be 20% of the sum of the lifted load and the weight of the crane trolley applied on each side of the runway, with due regard for lateral stiffness of the supporting structure.
   - Longitudinal forces shall be 10% of the maximum wheel loads.
   - Forces shall be applied at the top of the rail for top running cranes and at the bottom flange for under running cranes.
3. Lateral impact forces and longitudinal forces for monorail crane runways shall be as follows:
   - Lateral force shall be 10% of the maximum wheel load.
   - Longitudinal force shall be 10% of the maximum wheel load.
   - Forces shall be applied at the bottom flange for monorails.

J. Thermal Load and Movement (T)

1. Design of structures shall take into consideration fabrication, erection, and ambient and operating temperatures.
   - Unheated or exterior structures exposed to ambient temperatures shall be designed for the following overall temperature differentials:

     Erection to winter: -70F

     Erection to summer: +50F

2. Structures and foundations supporting equipment that operates at a high temperature shall be designed for the additional thermal loads and

displacements. Reduction of modulus of elasticity and yield stress shall be considered.

3. Adequate provisions shall be made to accommodate the movement of equipment or structural members so that such movements do not create physical interference of the supporting structure with equipment, ducts, pipes or other structures to which it may adjoin, or be attached. Structural members and their end connections shall be analyzed and properly designed for stresses caused by thermal gradients across the members.

4. The following coefficients of static friction shall be used to determine forces at sliding surfaces:

   - Teflon on Stainless Steel Slide Bearing 0.10
   - Steel on steel 0.40
   - Steel on concrete 0.33

5. If stress analysis loads for pipelines are not available, use 20% of the operating vertical pipe load as lateral expansion/contraction forces for the design of individual support beams. Cumulative longitudinal pipe rack loads shall be 10% of the total vertical pipe load on the rack.

6. Thermal movements will be calculated based on the assumption that the ambient dry bulb temperature during fabrication is 70° F. Induced thermal loads (i.e. thermal loads induced by equipment operating temperatures) will be considered in design of applicable structural elements.

K. Vibration Loads

The design of foundations and structures supporting machinery or equipment shall take into consideration the vibration and related disturbing forces that may be present at start-up, shut-down or during normal operation. Structural design for vibration amplitude shall be to limitations provided by vendors, and fatigue shall be considered in the design.

L. Earth Pressure and Hydrostatic Loads (H)

1. Earth pressure loads due to lateral earth pressures and ground water hydrostatic pressure. Where lateral earth pressure provides resistance to structural actions from other forces, it shall not be included in (H) but shall be included in the design resistance.
2. Foundations and below grade structures shall be designed for applicable earth/water pressure plus an appropriate surcharge load (which shall not be less than a construction surcharge load of 500 psf). Lateral earth pressure should be based on the soil parameters listed in Geotechnical Engineering Investigation.
3. Hydrostatic Loads and Buoyancy shall be considered when a structure or equipment extends below water level, either temporarily or long term as follows:
   - Structure or equipment shall be considered as empty when evaluating impact of buoyancy.

M. Notional Loads for Stability Design Requirements (N)

1. Notional loads shall be developed and applied in accordance AISC 360-05.

N. Consideration of effects of blasts or explosions <u>is not</u> included in the scope of work.

2.1.2. Load Combinations

A. Load Combinations and Permissible Stresses shall be per ASCE 7-05.

1. Reduction in nominal stresses for structural steel shall be considered at elevated temperatures to reflect a decrease in yield strength.
2. No increase in nominal design stresses shall be made for anchor rods or elements of structural steel connections.
3. Load combinations for foundation stability and soil bearing pressure are based on service loads.
4. Load combinations for steel, concrete and masonry design are based on Load and Resistance Factored Design (LRFD).
5. Where the requirements of AISC 360-05, Appendix 7.3, are met the notional loads (N) need not be included in those combinations that include wind or seismic loads.
6. It is permitted to omit a load combination from analysis if it can be shown that it is bounded by another load combination for the effect under consideration.
7. The thermal piping loads normally are an envelope of various load cases and are provided by Pipe Stress/Support Engineer as numeric values without a positive or negative sign. Since thermal loads may be self-balancing, a sign could be assigned (if feasible) to the anchor thermal loads using engineering judgment by reviewing individual load cases to remove/reduce conservatism in design.
8. Friction loads, including the friction component of anchor loads, shall be considered temporary and shall not be combined with wind or earthquake loads.
9. Anchor and guide loads shall be considered permanent loads combined with wind or earthquake.

B. Symbols and Notations:

D	=	Dead load including equipment weight.
D_o	=	Vertical component of piping operating load (Dead Load) including conduit, and cable tray loads.
D_t	=	Pipe Load During Hydro-Test.
F	=	Loads due to fluids with well-defined pressure and maximum heights in tanks (weight and lateral pressure). Note that F should be considered zero for empty tank condition.
C_D	=	Crane dead weight including trolley weight.
T	=	Thermal loads due to self-straining force of the structure
T_o	=	Thermal Friction Forces
A_f	=	Pipe Anchor and Guide Forces
L	=	Live Load
C_L	=	Crane live (lifted) load including crane lateral and longitudinal effects.
H	=	Load due to the weight and lateral pressure of soil and water in soil.

L_R = Roof Live Load

S = Snow load

R = Rain Load

W = Wind Load

W_i = Wind Load on Ice (ASCE 7-05, Chapter 6)

E = Earthquake loads, vertical and horizontal effect.

N = Stability Load (Steel framing only)

C = Contingency Load

C. Load Combinations for Steel and Concrete Design

Load combinations, using the Load and Resistance Factor Design (LRFD) based on Section 1605.2 of IBC 2009 are as follows:

1. Typical Condition:
   - EQ 16-1: $1.4(D + D_o + C_D + F) + 1.4N$
   - EQ 16-2: $1.2(D + D_o + C_D + F + A_f + T_o + T) + 1.6(L + C_L + H + C) + 0.5(L_r$ or S or R) + 1.2N
   - EQ 16-3: $1.2(D + D_o + C_D + A_f + T_o) + 1.6(L_r$ or S or R) + $L + C_L + C + 1.2N$
   - EQ 16-3: $1.2(D + D_o + C_D + A_f) + 1.6(L_r$ or S or R) + $0.8W + C + 1.2N$
   - EQ 16-4: $1.2(D + D_o + C_D + A_f) + 1.6W + L + C_L + 0.5(L_r$ or S or R) + C + 1.2N
   - EQ 16-5: $1.2(D + D_o + C_D + A_f) + 1.0E + L + C_L + 0.2S + C + 1.2N$
   - EQ 16-6: $0.9(D + D_o + C_D + A_f) + 1.6W + 1.6H + 0.9N$
   - EQ 16-6: $0.9(D + C_D + A_f) + 1.6W + 1.6H + 0.9N$ Empty Pipes
   - EQ 16-7: $0.9(D + D_o + C_D + A_f) + 1.0E + 1.6H + 0.9N$
   - EQ 16-7: $0.9(D + C_D + A_f) + 1.0E + 1.6H + 0.9N$ Empty Pipes
2. Erection Condition:
   - EQ 16-1: $1.4(D+ C_D)+ 1.4N$
   - EQ 16-4: $1.2(D + C_D) + 1.6W + 0.5(L_r$ or S or R) + C + 1.2N
   - EQ 16-6: $0.9D + 1.6W + 1.6H + 0.9N$
3. Test Condition:
   - EQ 16-2: $1.2(D + D_t + T) + 1.6L + 0.5(L_r$ or S or R) + 1.6C + 1.2N
   - EQ 16-3: $1.2(D + D_t) + 1.6(L_r$ or S or R) + L + C + 1.2N
   - EQ 16-3: $1.2(D + D_t) + 1.6(L_r$ or S or R) + 0.8W + C + 1.2N
4. Upset Condition:
   - $1.2(D + D_o + A_f + T) + 1.6S + C + 1.2N$

D. Load Combinations for Soil and Foundation Design

Load combinations, using the Allowable Stress Design (ASD) based on Section 1605.3 of IBC 2009 are as follows:

1. Operating Condition:

- EQ 16-8: $D + D_o + C_D + F + N$
- EQ 16-9: $D + D_o + C_D + H + F + A_f + T_o + T + L + C_L + C + N$
- EQ 16-10: $D + D_o + C_D + H + F + A_f + T_o + (L_r \text{ or } S \text{ or } R) + C + N$
- EQ 16-11: $D + D_o + C_D + H + F + A_f + T_o + 0.75(L + T + C_L) + 0.75(L_r \text{ or } S \text{ or } R) + C + N$
- EQ 16-12: $D + D_o + C_D + H + F + A_f + (W \text{ or } 0.7E) + C + N$
- EQ 16-13: $D + D_o + C_D + H + F + A_f + 0.75(W \text{ or } 0.7E) + 0.75(L + C_L) + 0.75(L_r \text{ or } S \text{ or } R) + C + N$
- EQ 16-14: $0.6(D + D_o + C_D + A_f) + W + H + 0.6N$
- EQ 16-14: $0.6(D + C_D + A_f) + W + H + 0.6N$ Empty Pipes
- EQ 16-15: $0.6(D + D_o + C_D + A_f) + 0.7E + H + 0.6N$
- EQ 16-15: $0.6(D + C_D + A_f) + 0.7E + H + 0.6N$ Empty Pipes

2. Erection Condition:

- EQ 16-8: $D + C_D + N$
- EQ 16-12: $D + C_D + H + W + C + N$
- EQ 16-14: $0.6D + W + H + 0.6N$

3. Test Condition:

- EQ 16-8: $D + D_t + C_D + C + N$
- EQ 16-9: $D + D_t + C_D + H + F + L + T + C + N$
- EQ 16-13: $D + D_t + C_D + H + F + 0.75W + C + N$

4. Upset Condition:

- $D + D_o + A_f + T + S + C + N$

2.1.3. General Stability Considerations

For purposes of design, stability loading with regard to uplift, overturning and sliding shall be investigated in accordance with standard engineering practice as governed by applicable codes and standards.

A. Listed below are the minimum factors of safety against overturning and sliding:

	Condition	**Factor of Safety**
1.	Load combination with 0.6D	1.1
2.	All other load combinations	1.5

B. Friction and passive pressure resistances shall be considered to act in combination.

C. Safety Factor against Flotation (FS) is defined as the weight of structure including equipment and soil plus weight of confined water within structure plus surcharge divided by total uplift force on the base.

2.2. Materials and Fabrication

2.2.1. Structural Steel

A. All structural steel shapes, bars, and plates shall conform to Table 1 unless noted on the Design Drawings.

Table 1 - Structural Shapes and Their ASTM Specifications

Structural Shapes	ASTM Specification	Min. F_Y (ksi)	Min. F_U (ksi)
W shapes	A 992	50	65
M and S shapes	A 36	36	58
HP shapes	A 572, Grade 50	50	65
Channels	A 36	36	58
Angles	A 36	36	58
Steel Pipe	A 53, Grade B	35	60
Round HSS	A 500, Grade C	46	52
Square and Rectangular HSS	A 500, Grade C	50	62
Structural Plates	A 36	36	58
Handrails, Guards, Ladder, and Stairs	As indicated in their respective Specifications.		

B. Cold-formed structural members shall be designed in conformance with AISI Specifications.

C. High strength bolts shall conform to ASTM A 325 Type 1 with ASTM A 563, Grade DH heavy hex nuts, ASTM F 436 hardened washers and ASTM F 959 direct tension indicators.

D. Secondary connections (stair treads) shall be bolted with ASTM A 307, Grade A bolts.

E. Welds shall be designed utilizing E 70 series electrodes.

2.2.2. Flooring

A. All interior and exterior grating shall be ASTM A 1011, Commercial Steel (CS Type B) welded with 1-1/4-inch deep by 3/16-inch bearing bars spaced 1-3/16-inch on center and cross bars spaced four (4) inches on center. Exterior grating shall be galvanized, in accordance with ASTM A 123, and shall be serrated (unless noted otherwise on drawings). Serrated grating strength shall be checked including the effects of the serrations. Use manufacture's data for serrated grating or one size smaller bearing bars.

B. Steel floor plate shall be rolled from ASTM A 36 material, minimum thickness of 1/4-inch, and shall conform to the requirements of ASTM A 786, Pattern #4, or Engineer-Approved equal. Floor plate for exterior use shall be hot-dip galvanized in accordance with ASTM A 123 after fabrication.

C. Metal decking shall be manufactured from steel conforming to A 653, SS Grade 33 and galvanized in accordance with ASTM A 924, G60 coating.

D. Fiberglass Reinforced Plastic (FRP) grating shall be molded 1-1/2-inch deep by 1-1/2-inch square mesh, vinyl ester resin.

2.2.3. Reinforced Concrete

A. Concrete

Concrete shall be mixed using ASTM C 150, Type II cement and shall develop the following twenty-eight (28) day strengths:

Foundations	4,000 psi
Slabs and Pavements	4,000 psi
Containment Structures	4,000 psi
Large Rotating or Vibrating Equipment Foundations	4,000 psi
All other structures	4,000 psi
Lean Concrete	2,000 psi

B. Reinforcing

1. Reinforcing bars shall be in accordance with ASTM A 615, Grade 60.
2. Welded wire fabric shall be in accordance with ASTM A 185 or ASTM A 497 and furnished in flat sheets.

C. Embedded Items

1. Unless otherwise noted on the Design Drawing(s), anchor rods shall be fabricated in accordance with ASTM F 1554, Grade 36 with aa hot-dipped galvanized finish per ASTM A123. Nuts shall be ASTM A 563, Grade A, heavy hex. Washers shall conform to ASTM F 436 and plate washers shall be ASTM A 36 material.
2. Structural steel embedments shall be fabricated from ASTM A 36 plate, bars, and shapes unless noted otherwise on Design Drawings.

D. Grout

1. Grout shall be non-shrink, non-metallic type conforming to ASTM C 1107, unless noted otherwise on the Design Drawings.
2. Nominal grout thickness under large base plates (least width of twelve (12) inches to thirty-six (36) inches) shall be 1-1/2 inches and under smaller base plates (least width of twelve (12) inches or less) one (1)-inch.
3. Grout thickness under all equipment shall be a minimum of one (1)-inch.
4. Epoxy grout shall be used for grouting equipment as specified by the equipment vendor. The extent of the epoxy grout shall be shown on the Design Drawings.

2.3. Testing and Inspection (Not Used)

2.4. Cleaning and Painting (Not Used)

2.5. Tagging and Marking (Not Used)

2.6. Packaging and Shipping (Not Used)

3.0 EXECUTION

3.1. Design of Steel Structure

3.1.1. Steel structures shall be designed in accordance with the AISC 360-05, “Specification for Structural Steel Buildings”

3.1.2. Stability Design Requirements

Stability shall be provided for the structure and each element. The preferred method is the Direct Analysis Method, of the 13th Edition of the Steel Construction Manual. This approach addresses stability provisions that include: second-order effects, flexural shear and axial deformations, geometric imperfections and member stiffness.

3.1.3. Minimum Design Clearances

A. Vertical Clearances

Slab to top of crane runway beam (excluding crane rail)	24’-6”
Above major roads open to unrestricted traffic	20’-0”
Above internal roadways provided for access of maintenance and firefighting equipment	16’-0”
Above walkways and elevated operating platforms	7’-0”
Mandoors	7’-0”

B. Horizontal Clearances

Width of primary walkways and stairs	3’-0”
Width of secondary walkways and stairs	2’-6”
Minimum clearance from equipment	2’-6”
All main personnel doors	3’-0”
Road edge and structure	4’-0”
Centerline of ladder rungs to any front and back obstruction	2’-6” in back (climbing side) 0’-7” in front
Centerline of ladder to any side obstruction	1’-3”

3.1.4. Platforms and Walkways

A. All platforms and walkways shall conform to the Ohio Building Code, OSHA and AECOM standards. Platforms shall be provided for safe access to equipment as indicated or at approximately 3'-6" below centerline of manhole, equip. operation level, etc.

B. Rectangular platforms that will be shop assembled shall include horizontal bracing for rigidity during shipping and erection.

3.1.5. Guards and Handrail

A. Guards and Handrail shall be to Ohio Building Code requirements and shall be standard two (2) rail type per OSHA and AECOM standards. It shall be provided at all landings and stairs where four (4) or more risers exist.

B. Self-closing safety gates shall be provided across ladder openings at all landings and shall conform to OSHA and AECOM standards.

C. Kickplates shall be provided continuously at all platforms and walkway edges, and openings through platforms, except at access openings. The maximum vertical gap between kickplate and floor grating or plate shall be 1/4-inch.

D. Materials used shall be as indicated on the design drawings.

3.1.6. Stairways

A. Stairways shall conform to the Ohio Building Code and AECOM standards.

B. Tread runs shall be 11 inches maximum.

C. Risers shall be no more than 7 inches. Riser openings cannot exceed 4 inches.

D. Maximum vertical distance between landings shall be 12 feet.

E. Stair runs over 12 feet in slope length shall be laced with in accordance with the design drawings.

F. Stair runs shall have a landing, measured in the direction of travel, equal to the stair width and a minimum of 3’-0”.

G. Three (3)-inch handrail clearance shall be maintained in layout of stairwells and adjacent obstructions.

H. Materials used shall be as indicated on the design drawings.

3.1.7. Ladders and Cages

A. Ladders and cages must conform to OSHA and AECOM standards. Access to vessels, platforms and equipment for infrequent process, inspection, and maintenance operations shall be provided by ladders. Side entry ladders are preferred.

B. Cages shall be provided on all ladders accessing platforms which are over 20 feet above grade. All ladders originating from elevated platforms in an exposed position shall be caged.

C. Maximum vertical run of ladders shall be 30 feet. For ladder runs in excess of 30 feet, intermediate platforms or landings are required at a spacing not exceeding 30 feet.

D. Secondary exits from platforms may be accessed by ladders. Such exits shall be located so that no point on the platform is horizontally more than 100 feet walking distance from the exit and the length of dead end platforms is no greater than 25 feet.

E. The top edge of all ladder rungs adjacent to step off surfaces shall coincide with platform walking surface.

F. Ladders shall be 16-inch clear width between side rails with 3/4-inch diameter rungs equally spaced at twelve (12)-inch maximum centers.

G. A seven (7)-inch minimum clearance from the centerline of the ladder rung to any object for foot clearance (such as vessel shell, insulations, stiffeners, fireproofing, piping, etc.) shall be maintained.

H. Materials used shall be as indicated on the design drawings.

3.1.8. Connections

A. All design forces for steel connection design will be shown on the Design Drawings. Connection design and detailing will be by steel fabricator.

B. Connections for structural members shall be shop welded and field bolted as much as possible.

C. Primary field connections shall be made using ASTM A 325, Type 1 bolts, ASTM A 563, Grade DH heavy hex nuts, ASTM F 436 hardened washers, and Direct Tension Indicator washers conforming to ASTM F959. Unless otherwise noted, field connections for primary members (i.e., columns, struts, bracing, beams and girders) shall be bearing-type connections with threads included in shear plane, using 3/4 inch diameter high-strength bolts with one (1) hardened washer, one (1) direct tension indicator, and heavy hex nut. All high-strength bolts shall be tensioned to the full pre-tension requirements of the RCSC Specification for Structural Joints Using ASTM A325 or A490 Bolts.

D. When slip-critical (SC) connections are noted on the drawings, faying surfaces are assumed to have a Class “A” finish.

E. Field connections with long slotted holes for adjustment shall be provided as shown on drawings. Plate washer must be provided for such connections as specified in RCSC Specification for Structural Joints Using ASTM A325 or A490 Bolts.

F. Working points of the bracing system on columns, beams and trusses shall be concentric, whenever practical. Moments and forces due to eccentric connections shall be considered.

G. For beams and girders with a depth greater than 24 inches use work points at the top and bottom of the beam or girder. Bending stresses due to eccentricities shall be taken into consideration for the design of members.

H. Secondary connections (stair treads) shall use 3/8-inch diameter ASTM A 307, Grade A bolts.

I. Gusset plates shall be a minimum of 3/8-inch thickness, unless otherwise specified on the Design Drawings. Any cross-section of the gusset, weld or bolt group shall be designed to develop the axial loads plus any bending due to eccentricity.

J. The minimum thickness of connection angles shall be 5/16-inch.

3.1.9. Vibration

A. Special consideration shall be given to the design of structural elements which are subject to vibration caused by operating machinery.

B. Fatigue shall be considered when vibration is present in accordance with the provisions of Appendix 3 of the AISC specification.

C. Primary connections, subject to fatigue loading, shall be designed and installed as slip-critical.

D. The natural frequency of structural steel framing directly affected by the vibratory load shall not be within the range of 0.70 to 1.50 times the forcing frequency.

E. Members directly supporting machinery shall be designed as simple span members to the greatest extent possible.

F. No member shall directly support more than one machine unless consideration is given to the possible phase relationships of the machines.

3.1.10. Base Plates

Bracing work points shall be at the intersection of neutral axis of framing member and the top of column base plate.

A. Major Structures

The horizontal component of bracing forces, or other lateral load at the column base plate, shall be transferred to the column pedestal by friction on the bottom of the base plate or by anchor rods.

1. If the column is not subject to net uplifting loads, shear forces may be transferred via friction using a friction coefficient of μ = 0.33. The allowable shear force developed by friction is V = 0.33 x (net downward load).
2. If the total shear force cannot be developed by friction, anchor rods shall be used to resist the force.
3. Anchor rods
   - Structural columns shall have their base-plates designed to accept, as a minimum, four (4) anchor rods to provide stability during erection. Each column anchor rod assembly, including the column-to-baseplate weld and the column foundation, shall be designed to resist a minimum eccentric gravity load of 300 pounds located eighteen (18) inches from the extreme outerface of the column in each direction at the top of the column shaft.
   - Secondary columns, or posts weighing less than 300 pounds, may have two (2) anchor rods as a minimum.
   - Use minimum 3/4-inch diameter anchor rods unless equipment vendor indicates otherwise.

B. Minor Structures, Pre-engineered Metal Buildings, Utility Racks and Stair Tower

1. Lateral shear forces may be transferred to the footings by the anchor rods and/or by friction between the base plate and the grout.
2. Structural columns shall have their baseplates designed to accept, as a minimum, four (4) anchor rods to provide factor during erection. Each column anchor rod assembly, including the column-to-baseplate weld and the column foundation, shall be designed to resist a minimum eccentric gravity load of 300 pounds located eighteen (18) inches from the extreme outerface of the column in each direction at the top of the column shaft.
3. Secondary columns, or posts weighing less than 300 pounds, may have two (2) anchor rods as a minimum.
4. Use minimum 3/4-inch diameter anchor rods.

3.1.11. Additional Design Considerations

A. A double connection is defined as an attachment method where the connection point is intended for two (2) pieces of steel which share common bolts on either side of a central piece.

1. Double connections through column webs or at beams that frame over the tops of columns shall be designed and detailed to have at least one (1) installed bolt remain in place to support the first beam while the second beam is being erected.
2. If a seat or equivalent device is used, it shall be designed to support the load during the double connection process. The seat shall be adequately bolted or welded to both a supporting member and the first member before the nuts on the shared bolts are removed to make the double connection.

B. Column splices shall be located a minimum of 4’-0” above the finished floor or as shown on the Design Drawings.

Each column splice shall be designed to resist a minimum eccentric gravity load of 300 pounds located eighteen (18) inches from the extreme outer face of the column in each direction at the top of the column shaft. Unless otherwise indicated on the drawings.

C. Shear connectors (weldable studs, reinforcing bars, deformed anchors, or threaded studs) shall not be shop attached to the top flanges of beams, joists, or beam attachments so as to project vertically from or horizontally across the top flange of the member.

Shear connectors shall be field attached to the top flange of steel after decking or flooring has been installed.

D. Beam members shall have a nominal depth of eight (8) inches or 1/24th of the span, whichever is greater, unless:

1. Clearances require a smaller member.
2. Low tuning requires a lesser moment of inertia.

E. Floor bracing connections to columns shall be avoided.

F. Maximum clear span for 1-1/4-inch serrated grated shall be 4'-0".

G. Maximum sag rod spacing shall be 8'-0".

H. Serviceability Limits

1. Deflection (Δ) limits, when subjected to live, wind and other superimposed loads shall not exceed the following:

Description	**vertical Δ**	**horizontal Δ**
Under-Running CMAA Class A, B & C crane girders and monorails	L/450	
Floor or roof framing members where deflection could damage architectural features	L/360	
Floor or roof framing members where deflection will not damage architectural features	L/240	
Floor plate and grating	L/180, but not to exceed ¼-inch	
Purlins	L/180	
Girts		L/180
Roof cladding (un-insulated sheet metal)	L/120	
Wall cladding (un-insulated sheet metal)		L/120
Roof cladding (sandwich panel)	L/180	
Wall cladding (sandwich panel)		L/180
Where: L = span length of the member being considered.		

2. Structural sway (drift) limits due to wind load shall not exceed the following:

Structure Type	Max. sway
Pipe racks and supports	H/200
Pre-Engineered Building	H/200
Conventional Steel Structures	H/240
Where: H is the sway height	

The sway (drift) limits for seismic load shall conform to the ASCE 7-05 limitations.

3.2. Design of Concrete Structures

3.2.1. Reinforced concrete structures and foundations shall be designed in accordance with the ACI 318-08, "Building Code Requirements for Structural Concrete."

A. Unless otherwise noted on the Design Drawings, maintain a two (2)-inch minimum concrete cover over reinforcing steel.

3.2.2. Anchor Rods

A. Locate all anchor rods and anchor rod sleeves so that there is a minimum clear concrete cover of 6 inches and they are within the main reinforcing or ties.

B. Anchor rod projections shall be from top of rough concrete and shall be based on the following:

1. Single Nut: Grout + base plate thickness + washer + 2 Rod Diameters.
2. Double Nut: Grout + base plate thickness + washer + 3 Rod Diameters.

C. Use double nuts on all anchor rods subject to significant vibration or where a net uplift force exists at the column base plate.

D. Where practical, use a square pattern of four (4) anchor rods.

3.2.3. Floor Slabs

A. Ground floor slabs shall be a minimum of four (4) inches thick in office areas and six (6) inches thick in all other areas. Slope slabs in spill areas and heavy wash-down areas 1/4-inch per foot to trenches or drains. In other areas where drainage is required slope slabs 1/8-inch per foot to drains except areas indicated to be flat by owner.

B. Elevated slabs shall be poured on metal decking and shall be a minimum of four (4) inches thick including the depth of decking. Decking shall not be considered as reinforcing. Slabs in wash-down areas shall be sloped to drains at 1/8-inch per foot minimum (increase slab thickness as required). In areas requiring minimum wash-down, depress the floor drain one (1)-inch and slope the slab within a twelve (12)-inch radius to the drain.

3.3. Foundation Design

3.3.1. The foundation system(s) shall be based on the recommendations stipulated in the Geotechnical Report by CTL Engineer, Inc. (CTL). (Sec 1.2.14)

3.3.2. Heavy Machinery Foundations

A. Heavy machinery shall be defined as any equipment having reciprocating or rotary masses as the major moving parts, and having a gross plan area of more than thirty (30) square feet or a total weight greater than 5,000 pounds.

B. Soil bearing pressure should not exceed 50% of the allowable values for static loads.

C. The ratio of foundation to heavy machinery weight should not be less than 5 to 1 for reciprocating machinery and 3 to 1 for centrifugal machinery, unless a dynamic analysis is done and warrants less.

D. Foundations for heavy machinery, supported at grade, shall have a minimum width at the base equal to the vertical distance from the foundation base to the machine centerline.

E. Reciprocating machinery and associated pulsation bottles shall be supported directly on a single rigid foundation.

F. Where practical and where the result is a reduction in amplitudes of vibration, several machines of like type (centrifugal or reciprocating) may be mounted on a common rigid mat. Consideration shall be given to possible phase relationships of the equipment when placing multiple machines on one foundation.

G. The horizontal eccentricity, in any direction, between the centroid of the mass of the machine-foundation system and the centroid of the base contact area, should not exceed 5% of the respective base dimension.

H. Foundations for heavy machinery should have a frequency ratio outside the range of 0.7 to 1.4 if practicable. Where second-order unbalanced forces or couples are present, the same frequency ratio restriction should apply in the second order if practicable.

3.3.3. Light Machinery Foundations

A minimum mass ratio of concrete mass (weight) to equipment mass (weight) is required for light machinery supported on individual foundations.

A. Small reciprocating machinery: 5 to 1

B. Small centrifugal machinery: 3 to 1

END OF SECTION

A-USC Com Test at Youngstown Thermal

Youngstown, OH

PROJECT NUMBER 33609

SPECIFICATION NUMBER 05 12 00

FOR

STRUCTURAL STEEL

PREPARED FOR

Energy Industries of Ohio (EIO)

By

AECOM

1500 W 3rd Street, Suite 200

Cleveland, OH 44113

Revision	Date	Status
A	March 16, 2016	Preliminary

SPECIFICATION REVISION PAGE

Project Name:	A-USC Com Test	Discipline:	Structural
Client:	Energy Industries of Ohio		

Revision Signatures

Jeff Morris	3/16/2016		
Prepared by	Date	Approved by (PEM)	Date
		NA	
Checked by	Date	Approved by (if required) (title)	Date

Status	Rev. No.	Date	Prepared By	Pages	Description of Changes
Prelim.	A	3/16/2016	JJM	All	For FEED use

PART 1- GENERAL

1.01 DESCRIPTION:

A. The term "Structural Steel" is used as defined in accordance with the AISC Code of Standard Practice.

B. Provide structural steel as specified and as shown on contract drawings.

1.02 REFERENCES:

A. American Institute of Steel Construction (AISC):

1. 303: Code of Standard Practice for Steel Buildings and Bridges

2. 325: Manual of Steel Construction, Thirteenth Edition

3. 326: Structural Steel Detailing Manual

4. 348: Specification for Structural Joints using ASTM A 325 or A 490 Bolts

5. 360-05: Specification for Structural Steel Buildings

B. American Society for Testing and Materials International (ASTM):

1. A6/A6M: Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling.

2. A36/A36M: Specification for Carbon Structural Steel.

3. A53: Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

4. A108: Standard Specification for Steel Bars, Carbon and Alloy, Cold-Finished

5. A123: Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

6. A143: Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedures for Detecting Embrittlement.

7. A153: Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

8. A194/A194M: Specification for Carbon and Alloy-Steel Nuts for Bolts for High-Pressure and High-Temperature Service.

9. A307: Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.

10. A325: Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.

11. A384: Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies.

12. A385: Practice for Providing High Quality Zinc Coatings (Hot-Dip).

13. A449: Specification for Quenched and Tempered Steel Bolts and Studs.

14. A500: Standard Specification for Steel for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.

15. A563: Specification for Carbon and Alloy Steel Nuts.

16. A572: Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel.

17. A780: Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.

18. A992: Standard Specification for Steel for Structural Shapes for Use in Building Framing.

19. B695: Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel.

20. F436: Specification for Hardened Steel Washers.

21. F1554: Standard Specification For Anchor Bolts, Steel, 36, 55, and 105 ksi Yield.

C. American Welding Society (AWS):

1. D1.1: Structural Welding Code – Steel

D. Society for Protective Coatings (SSPC).

E. Occupational Safety and Health Administration (OSHA):

1. Safety and Health Standards for the Construction Industry, 29 CFR 1926 Subpart R Safety Standards for Steel Erection.

F. Governing Building Code:

1. Ohio Building Code (IBC 2009)

1.03 DESIGN CRITERIA:

A. Structural Connections: AISC Specification for Structural Steel Buildings. Design connections not fully detailed on the Drawings to resist the loads shown on the Contract Drawings or specified.

B. Where beam end reactions are not shown, design the connection for one-half the total allowable uniform load in kips for beams laterally supported at the given span, as

determined by the tables for allowable loads on beams in the AISC Manual of Steel Construction, in addition to any axial loads identified on the Drawings.

C. Unless otherwise noted on Contract Drawings, design connections for ASTM A325 bolts, bearing-type connection with threads included in shear plane.

1.04 SUBMITTALS:

A. Submit the following shop drawings in accordance with Section 01 33 00.

1. Submit in advance of fabrication complete information necessary for the fabrication of each component and part of the structural steel framing. Include the following:

a. Member size and length.

b. Bill of materials.

c. Material specifications.

d. Bolt hole size and bolt size.

e. Cuts, copes, and bevels.

f. Piece marks for field assembly.

g. Detail of each connection or typical connection.

h. Splices.

2. Submit erection drawings showing complete information necessary for the erection of each component part of the structural steel framing. Include the following:

a. Dimensions for alignment and elevations of each member.

b. Location of members and attachments by match-marking of piece numbers.

c. Type and location of each field connection.

d. Number of shear connectors on each member.

e. Detail of each field connection or typical connection.

f. Anchor blots and setting plans.

3. Do not develop shop drawings by using reproductions of contract drawings. Identify each shop drawing detail by contract drawing detail title.

4. Indicate both shop and field welding and the required nondestructive testing by welding symbols and nondestructive testing symbols as shown in the latest edition of AWS A2.4.

a. Fully explain special conditions with notes or details.

b. Welding symbols for groove welds shall indicate the groove depth required to obtain the specified effective throat thickness for the welding process and position of welding to be used.

c. The details of groove welds, joints, and preparation of base material shall be referenced to prequalified joints specified in AWS Figures 3.2 through 3.11 and shall clearly distinguish between complete joint penetration and partial joint penetration.

d. Fillet weld symbols shall indicate required weld size to obtain the specified effective throat thickness and effective length. For fillet weld lengths not specified provide a continuous weld.

5. Welding Procedures: Prepare written welding procedures for both shop and field welds, which are deemed prequalified in accordance with AWS Code Section 3, and make the procedures available to the testing agency at the fabricator's plant. Prior to use of submit other for review procedures along with tests required to qualify the procedure in accordance with AWS Code Section 3.2.3.

6. Submit sequence-of-welding outline.

7. Submittals for Evidence of Conformity to Specifications: Certified mill test reports containing results of chemical and mechanical test as specified by ASTM A6 for the following material:

   a. Structural steel shapes.

   b. Structural steel bars.

   c. Structural steel plates.

   In addition to the certified mill test reports, the fabricator shall provide an affidavit stating that the structural steel furnished meets the requirements of ASTM specification for the grade furnished. Test any of the members not represented by certified mill test reports by the testing laboratory in accordance with ASTM specification for chemical and physical properties. The contractor is responsible for the cost of sampling and testing.

8. Submit manufacturer's certification and test data that the following items furnished conform to the following specifications:

   a. High-strength bolts including nuts and washers. Provide Connection type N per the AISC handbook unless otherwise noted in the drawings.

   b. Shear Connectors: ASTM A108, stud base qualification requirements in accordance with AWS Code Section 7.6.

9. Proposed Substitutions: Submit for review in sketch form prior to submittal of shop drawings substitutions of members or modifications of details, if proposed by the Contractor. Make such substitutions or corrections only when permitted by the Engineer.

10. Qualification test reports bearing witness certification by an independent testing laboratory for each welder, welding operator and tacker to be employed in the work.

1.05 QUALITY ASSURANCE:

A. Provide structural steel in accordance with AISC Standard for Structural Steel Buildings and the Code of Standard Practice for Steel Buildings and Bridges, unless otherwise specified herein.

B. Design connections not detailed on the Drawings under direct supervision of a Professional Structural Engineer experienced in design of this work and licensed in the State where the Project is located.

C. Use connections shown or, if not shown, select connections to support half the AISC maximum uniform load for the indicated beam size and span.

D. Steel fabricator shall have 5 years' experience minimum in structural steel fabrications.

E. Steel erector shall have 5 years' experience minimum in structural steel erection.

F. Welding Qualification and Certification:

1. Furnish written welding procedure for welds in conformance with the AWS D 1.1.

2. Each welder, welding operator and tack welder shall be certified by test to perform type of work required in conformance with AWS D 1.1.

3. If a welder or welding operator has not been engaged in a specific welding process for a period of six months or more, that individual shall be deemed unqualified and shall not perform work on the project until the individual has been qualified again by testing in conformance with AWS D 1.1.

4. Maintain duplicate qualification and certification records at the job site readily available for examination.

G. Tolerances:

1. Maintain tolerances conforming to AISC Code of Standard Practice.

2. Permissible variation tolerances conforming to ASTM A6.

H. Tension Calibrator:

1. Provide certification by an independent testing laboratory confirming the accuracy of the tension-measuring device when slip-critical connections and connections subject to direct tension are being used. Confirm accuracy not more than 30 days prior to use on project and at intervals not more than six months thereafter.

2. Provide tension calibrator measuring device at the job site when high-strength bolts in slip-critical connections and connections subject to direct tension are being installed and tightened.

3. Conform to the AISC Specification for Structural Joints for frequency and of number confirmation tests to be performed and the test procedure.

4. Return tension calibrator measuring device to the independent testing laboratory for certification if Engineer or Construction Manager questions its accuracy.

1.06 DELIVERY, STORAGE AND HANDLING:

A. Load structural members in such a manner that they may be transported and unloaded without being over-stressed, deformed or otherwise damaged.

B. Protect structural steel members and packaged materials from corrosion and deterioration. Store material in a dry area.

C. Support materials stored outdoors above ground surfaces on wood runners and protected with acceptable effective and durable covers.

D. Do not place materials on the structure in a manner that might cause distortion or damage to the members or the supporting structures. Repair or replace damaged materials or structures as recommended by the Engineer.

1.07 FIELD MEASUREMENTS:

A. Verify dimensions and make any field measurements necessary and be fully responsible for accuracy and layout of the work.

B. Review the Contract Drawings and report any discrepancies to the Engineer for clarification prior to starting fabrication.

PART 2 - PRODUCTS

2.01 STRUCTURAL STEEL:

A. W shapes in conformance with ASTM A992 unless otherwise indicated or specified.

B. C, M, S and HP shapes in conformance with ASTM A572, Grade 50, unless otherwise specified or shown on contract drawings.

C. Angles, plates and bars in conformance with ASTM A36.

D. Round, square and rectangular structural tube members (HSS) in conformance with ASTM A500, Grade B.

E. Steel pipe in conformance with ASTM A53, Grade B.

F. Hot-Dip Galvanized Carbon Steel in conformance with ASTM A123.

G. Shear studs in conformance with ASTM A449.

2.02 FASTENERS:

A. Carbon Steel Bolts, Nuts and Washers: ASTM A307, Grade A.

B. High-strength fasteners in conformance with ASTM A325, Type 1.

C. Nuts and washers ASTM A563 and F 436.

D. Hot-dip Galvanized Bolts, nuts and washers in conformance with ASTM A153.

E. Mechanically Galvanized Bolts, nuts and washers in conformance with ASTM B695.

2.03 ANCHOR BOLTS:

A. Steel anchor bolts in conformance with ASTM F1554, grade 36.

2.04 WELDED STUDS:

A. Weld studs in conformance with the requirements of ASTM A108, Grade 1015 or 1020.

2.05 CRANE RAILS:

A. Provide in conformance with crane manufacturer's requirements and as indicated or specified. Provide materials needed for fabrication and construction of crane rails, including:

1. Joint bar bolts: ASTM A449 or ASTM A325.

2. Joint bar nuts: ASTM A563, Grade B or ASTM A325.

2.06 WELDING:

A. Class E70XX electrodes.

B. Provide equipment for welding, electrodes, welding wire and fluxes capable of producing indicated welds when used by certified welders under AWS welding procedures. Provide welding materials that comply with requirements of AWS Structural Welding Code.

2.07 SHOP FABRICATION:

A. Fabricate each element and connection as indicated on the fabrication shop drawings accepted by the Engineer and Construction Manager. Fabricate and shop assemble work to the greatest extent practical in conformance with following publications:

1. AISC Manual of Steel Construction

2. AISC Specification for Structural Joints

3. AISC Detailing Manual

4. AWS Structural Welding Code

2.08 CONNECTIONS:

A. Connect members with ASTM A325 high strength bolts unless otherwise specified or shown on contract drawings. Provide clean-cut holes without torn or ragged edges and remove outside burrs.

B. Provide high-strength bolted construction assembly in accordance with AISC Specifications for Structural Joints. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible material. Free joint surfaces burrs and foreign materials. Score hot-dipped galvanized contact surfaces with a wire brush or blasted prior to assembly. Grinding of surfaces is not permitted. If the thickness of the material is not greater than the normal diameter of the bolt plus 1/8 inch, the holes may be punched. If the thickness of the material is greater than the normal diameter of the bolt plus 1/8 inch, drill it full size or subpunched 1/16 inch smaller than the bolt diameter and reamed to full size. Provide holes for work to be secured to structural steel framing and for the passage of work through steel framing members. Provide threaded nuts, threaded units, or other items welded to framing, which receive other work. Provide normal bolt hole diameters not more than 1/16 inch in excess of the normal bolt diameter unless otherwise specified in contract drawings. Provide required slotted or oversize bolt holes as specified in the AISC Specification for Structural Joints Section 3.3. Tighten each bolt to provide the minimum tension shown in Table 8.1 of AISC Specification for Structural Joints for the size and grade of bolts used. Tighten bolts in accordance with the manufacturer's specifications.

C. Provide full cross section bearing on milled ends of columns, crane rails, monorails, and bearing stiffeners.

D. Welded Connections:

1. Weld connections indicated or specified.

E. Make connections with ASTM A307 carbon steel bolts when specified or shown in contract drawings.

F. Provide anchor rods with washer and heavy hex nuts. Provide hot-dip galvanized anchor rods, washers and heavy hex nuts with galvanized steel.

2.09 SHOP PAINTING:

A. Apply shop prime coat to structural steel, except to members or portions of members to be embedded in concrete or masonry, surfaces and edges to be field welded, and galvanized surfaces, unless otherwise specified. Provide surface preparation to the standard of SSPC-SP2 or as described for the specified coating system.

B. Apply primer immediately after surface preparation. Use painting methods that will result in full coverage of joints, corners, edges, and exposed surfaces.

C. Structural steel incased in masonry or which will be inaccessible in the finished work, receive two shop coats of primer.

D. Provide prime coats compatible with fire proofing system.

2.10 GALVANIZE:

A. Provide hot-dip galvanizing in conformance with ASTM A123, Grade 100 to steel indicated or specified to be galvanize coated.

B. Provide hot-dip galvanizing, in conformance with ASTM A153, to bolts, nuts and washers that will be used with galvanized steel.

C. Complete fabrication and prepare surfaces of steel by removing weld spatter, flux, residue, burrs and metal surface defects before galvanizing. Clean weldments with power wire brush prior to galvanizing.

D. Provide steel dipped into solution of zinc chloride plus ammonium chloride immediately prior to galvanizing.

E. Tap bolt nuts after hot-dip galvanizing in conformance with ASTM A563.

F. Inspect galvanized material for compliance with these specifications. Mark the material with a clearly visible stamp indicating the name of the galvanizer, the ASTM number and the weight of zinc coating in ounces per sq. ft.

2.11 GALVANIZE TOUCH-UP:

A. Galvanize Touch-Up: Where galvanizing is damaged, touch-up abraded areas, using brushed-on method, with zinc-rich coating. Touch-up repair with zinc-rich coating of not less than 3 mil and not more than 6 mil dry film thickness.

B. Touch-up damaged galvanized surfaces with one of the following zinc rich coatings:

1. Endupor, zinc-rich coating by Dampney Manufacturing Co., Everett, MA

2. ZiRP, zinc-rich coating by Duncan Galvanizing Corp., Everett, MA

3. ZRC Cold Galvanizing Compound or ZRC Galvilite by ZRC Worldwide, Division of Norfolk Corp., Marshfield, MA;

4. Or acceptable equivalent product.

PART 3 - EXECUTION

3.01 ERECTION OF STRUCTURAL STEEL:

A. Conform to the Ohio Building Code (IBC 2009) and referenced AISC standards. Brace and secure work until permanent connections are completed. Provide accessories and fasteners to secure the work in place whether or not shown or specified. Comply with OSHA requirements.

B. Erect structural steel with qualified, experienced personnel. Plan and lay out steel to require minimum of cutting. Erect work plumb, square, and true to line and level and in precise positions. Provide temporary bracing and guys to counteract loads and stresses to which

structure may be subjected, including those due to erection equipment and its operation. Do not encumber premises with material or equipment.

C. Splice members only where shown or specified. On exposed welded connections, remove erection bolts, fill holes with plug welds, and grind smooth at exposed surfaces. Comply with AISC specifications for bearing, adequacy of temporary connections, alignment, and the removal of paint on surfaces adjacent to field welds. Do not enlarge holes in members by burning or the use of drift pins, except in secondary bracing members. Ream holes that must be enlarged to place bolts. Do not use gas-cutting torches in the field for correcting fabrication errors in the structural framing.

D. Erect, plumb, level, and align each individual member within the tolerance defined in Section 7 and Commentary of the AISC Code of Standard Practice, allowing for weld shrinkage during erection for assurance that the end product is within specified tolerance. Establish and maintain the building line for use in plumbing the exterior columns.

3.02 DAMAGED MEMBERS:

A. During erection, straighten or replace members that are bent, twisted, or damaged. If heating is required in straightening, perform heating by methods that ensure uniform temperature throughout entire member. When required by the Engineer, remove members that are impaired strength and replace with new members at no additional cost to Owner.

3.03 MISFITS AT BOLTED CONNECTIONS:

A. Immediately notify the Construction Manager where misfits in erection bolting are encountered. Then Submit a method to remedy the misfit for review by the Engineer. The Engineer will determine whether the remedy is acceptable or if the member must be refabricated.

B. Do not enlarge incorrectly sized or misaligned holes in members by burning or by the use of drift pins. Notify the Construction Manager immediately and submit a proposed method of remedy for review by the Engineer.

3.04 ANCHOR BOLTS:

A. Install anchor bolts by using templates, setting drawings, and instructions provided by the fabricator. Verify positions of bolts prior to delivery of steel; report errors or deviation for adjustment. After anchor bolts have been embedded, protect threads by applying grease and by having the nuts screwed on until the metalwork is installed.

3.05 COLUMN BASEPLATES AND BEARING PLATES:

A. Set columns with base plates attached and bearing plates for beams and similar structural members to their proper alignment and elevation using shim packs. Set loose column bases level to their proper alignment and elevation by use of shim packs or as shown in the contract drawings. Tighten anchor bolts after members have been positioned and plumbed. Do not remove protruding wedges, shims, or other leveling devices but cut off flush with the baseplate prior to packing with grout.

3.06 CONNECTIONS:

A. Securely bolt members to maintain steel in position during field welding and final bolting and accommodate dead loads, wind, and erection stresses.

B. Tighten high-strength bolted connections in accordance with AISC Specification for Structural Joints using ASTM A325 or A490 Bolts and manufacturer's specifications.

C. Perform shop-welded construction in accordance with AWS D1.1 Sections 2 through 6, whichever is applicable. Use only welded joints deemed as being prequalified in accordance with AWS Code Section 4, which are selected from AWS Code Figures 3.2 through 3.11.

D. Common Bolts: Tighten ASTM A307 and nonslip critical bolts to snug tight plus one-quarter turn with upset bolt threads to preclude loosening, or use self-locking nuts.

E. Do not reuse galvanized high-strength bolts, nuts and washers.

3.07 CRANE RAILS:

A. Installation: Provide in conformance with crane manufacturer's printed instructions and as specified or as shown on contract drawings.

B. Fasten crane rails to runway beam with rail clamps, in pairs, one each side of rail, spaced not more than 30 inch centers. Bolt each clamp to runway beam top flange with two bolts and self-locking nuts. Allow 1/32-inch clearance between clamp plate and top of rail flange and 1/4-inch clearance between clamp plate and edge of rail flange to provide a "floating rail" in conformance with AISC Manual. Do not use hook bolts. Center crane rail on the runway beam. In no case shall the crane rail eccentricity be greater than three-fourths of the runway beam web thickness. The entire assembly will be rejected if the crane rail eccentricity exceeds the three-fourths limitation. Replace and remove entire rejected assembly from job site at no additional cost to the Owner.

C. Install crane rails with milled ends and tight joints at splices. Use bolted splice bars to maintain joint alignment in conformance with AISC Manual. Do not use welded butt joints.

D. Retighten splice bolts within 30 days and in conformance with AISC Manual.

3.08 CLEAN-UP:

A. Upon completion of the work, remove surplus materials, rubbish, and debris resulting from the operations, including disused equipment and implements of service, and leave the entire structure and site, insofar as the work of this section is concerned, in a neat, clean condition.

3.09 CLOSEOUT ACTIVITIES:

A. Provide in accordance with Section 01 77 00

END OF SECTION

AECOM

CALCULATION COVER SHEET

Calculation No.			
YT-13-05-201-001			
Prel	**Final**	**Void**	**Revision**
X			A

CLIENT	Energy Industries of Ohio (EIO)	**Discipline** Structural
PROJECT TITLE	A-USC Com Test	**Project No.** 31609
SUBJECT/FEATURE	FEED Design	**No. of Sheets** 22

CALCULATION OBJECTIVE

Perform structural design for the new building and equipment support for the A-USC ComTest project at Youngstown Thermal. The new building houses the steam turbine and is a pre-engineered steel building with a basement and bridge crane.

This calculation is for the preliminary design of the steel frames for the purpose of preliminary sizing and reactions for the concrete design. Also this calculation is for the steel pipe racks and supports.

Preliminary Foundation design is also include for the turbine building, pipe racks, cooling tower, and other equipment.

<u>The final calculation of the PEMB turbine building is by the PEMB manufacturer.</u>

RESULTS / CONCLUSIONS

See section 8.0.

ASSUMPTIONS / OPEN ITEMS

This is a FEED calculation. Also inputs and assumptions will be verified during detailed engineering.

DESIGN CRITERIA / DESIGN BASIS (With Reference to Source of Data)

1. **Structural Design Criteria – 13-03-200-001 Rev 0**
    a. **Risk Category of Building : III**

REFERENCES / SOURCE DOCUMENTS

1. **Ohio Building Code 2011 (Revised January 2016)**
2. **IBC 2009**
3. **ASCE 7-05**
4. **AISC 360-05**
5. **ACI 318-05**

URS

Sheet 01

Project YOUNGSTOWN THERMAL | Contract No. | File No.

Feature SUPER HEATER | Designed BILL ENGLE | Date 3-15-16

Item FOUNDATION | Checked | Date

DESIGNING FOUNDATION FOR SUPER HEATER TOWER

STRUCTURAL SLAB SUPPORTING GRADE LEVEL EQUIPMENT ON GRADE BEAMS, ON DRILLED PIERS. THIS SYSTEM WILL ASSURE CONTINUITY OF MOVEMENT OF THE TOWER AND THE SLAB SUPPORTED EQUIPMENT

DESIGN LOADS

DEAD LOAD (ASSUMED)

10" SLAB = 125 PSF

8" CONC SLAB $\frac{8}{12}(150) = 100$ PSF

36"x24" GRADE BEAMS $(2\times3)150 = 0.9$ KLF

SLAB LIVE LOAD 100 PSF (FOR SLAB DESIGN)

50 PSF (FOR D.P. LOADING)

DRILLED PIERS

ALLOWABLE NET END BEARING = 130 KSF
SOCKETED 3'-5' INTO ROCK)

$A = \frac{\phi^2 \pi}{4}$

ALLOWABLE AXIAL LOAD

ϕ	AREA BRG (ft^2)	P_{ALLOW} (k)
24"	3.14	408
30"	4.91	638
36"	7.07	919
42"	9.62	1,250
48"	12.57	1,634

URS

Sheet 02

Project YOUNGSTOWN THERMAL | Contract No. | File No.

Feature SUPER HEATER | Designed BILL EAGLE | Date 3-16-4

Item FOUNDATION | Checked | Date

SLABS L=24'

1' STRIP $W_u = 1.2(100) + 1.6(100) = 0.28$ KLF

$M_u = \frac{1}{8} W_u L^2 = 20.2$ FK

IF 8" SLABS $h = 8" \rightarrow d = 6$ $q_u = 4.2$

$A_s = \frac{M_u}{q_u \cdot d} = \frac{20.2}{(4.2)(6)} = 0.80 \text{ in}^2/\text{ft}$ #6@6"

IF 10" SLABS $h = 10 \rightarrow d = 8"$ $M_u = 22.3$

$W_u = 1.2(125) + 1.6(100) = 0.31$ KLF

$A_s = 0.66 \text{ in}^2/\text{ft}$ #6@8 T&B

USE 10" SLABS W/ #6@8 T&B

TEMP STEEL $A_s = 0.0018(10 \times 12) = 0.22 \text{ in}^2/\text{ft}$ #4@12 T&B

FOR ADD'L LOAD TRANSFER CAPACITY

GRADE BEAM

ON ① FROM Ⓑ TO Ⓒ L=34'

G.B SLABS

DL LL

$W_u = 1.2(0.9) + \frac{48}{2}[(1.2 \times 125) + (1.6 \times 50)]$

$= 6.6$ KLF

$M_u = \frac{1}{8} W_u L^2 = 954$ FK

$h = 36 \rightarrow d = 32" \rightarrow A_s = \frac{M_u}{q_u \times d} = 7.1 \text{ in}^2$ 7 #9

$q_u = 4.2$

TRY GB 36x48 → $GB_{WT} = 3 \times 4 \times 150 = 1.8$ KLF $h = 48 \rightarrow d = 44$

$W_u = 7.68$ KLF → $M_u = 1110$ FK

$A_s = \frac{1110}{4.2(44)} = 6.0 \text{ in}^2 \rightarrow$ 6-#9 — USE W 36x48" GB W/ #4 TIES @ 18"

URS

Project YOUNGSTOWN THERMAL | Contract No. | Sheet 03
Feature SUPER HEATER | Designed BILL ENGLE | File No. | Date 3-16-16
Item FOUNDATION | Checked | Date

ON (D) W/ CANTI SUPPORTING STAIR TOWER

$P_u = 1.5(45) = 68^k$

$L = 9'$

$w_u = \left(\frac{24}{2} + 6\right)\left(1.2(125) + 1.6(50)\right) = 4.14$ KLF

$M_u = \frac{1}{2}(4.14)(9)^2 + (68 \times 9) = 780 < 1110$

∴ 3"x48" W/ 6-#4 OK

GRADE BEAM (0.5) FROM (B) TO (C) $L = 34'$ $h = 48$, $d = 44$

$w_u = \frac{24}{2}\left((1.2 \times 125) + (1.6 \times 50)\right) + 1.2(1800) = 4.92$ KLF

$M_u = \frac{1}{8}(4.92)(34)^2 = 711$ FK

$A_s = \frac{711}{4.2(44)} = 3.84$ USE 4-#9

GB 48" x 24"-30" W/ #4 TIES @ 18

URS

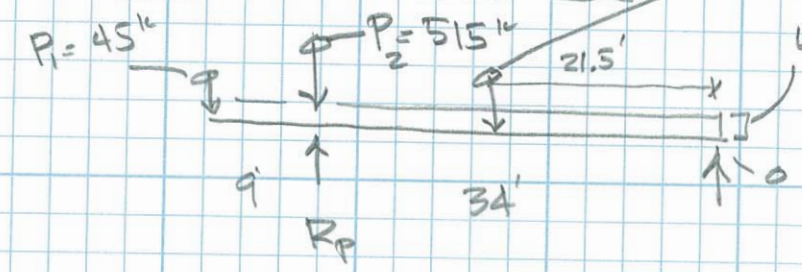
Project YOUNGSTOWN THERMAL | Contract No. | Sheet 04
Feature SUPER HEATER | Designed BILL ENGLE | File No. | Date 3-16-11
Item FOUNDATION | Checked | Date

DRILLED PIERS — ASD

WORST CASE LOAD AT B-1

$R_D = (9+34)(6) = 258^K$

$W = 1800 + \frac{48}{2}(125+50) = 6 KLF$

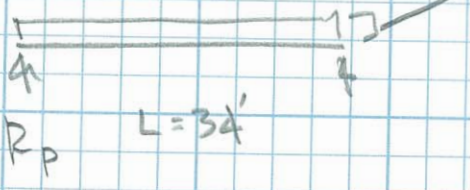


$\circlearrowleft + \Sigma M_0 = 0 = +(43 \times 45) + (34 \times 515) + (21.5 \times 258) - (34 \times R_P)$

$R_P = 735^K \rightarrow$ 36" ϕ DP, $P_{ALLOW} = 919$ ← USE AT B-1, B-2, C-1 & C-2

30" ϕ $P_{ALLOW} = 633$

LEAST LOAD AT (B) & (C) - 0.5



$W = \frac{34}{2}(125+50) + 1800$

$= 3.9 KLF$

$R_P = \frac{34}{2}(3.9) = 66.3^K$

USE 24" ϕ $P_{ALLOW} = 408^K$

URS

Project YOUNGSTOWN THERMAL | Contract No. | File No. | Sheet D 5

Feature SUPER HEATER | Designed BILL ENGLE | Date 3.16.16

Item FOUNDATIONS | Checked | Date

LATERAL LOADS ON DRILLED PIERS

FROM B&W LOAD TABLES → WORST CASE LATERAL LOADING NORTH/SOUTH WIND LOAD

ΣP_L = TOTAL WIND AT COLUMN BASES = 120+106+1+1 = 228 K

DISTRIBUTED THROUGH GRADE BEAM & SLAB TO (4) 36"ϕ DRILLED PIERS WITH FIXED TOPS. CONSERVATIVELY IGNORING THE LATERAL RESTRAINT OF THE GRADE BEAMS PUSHING AGAINST THE SURROUNDING SOIL.

LATERAL LOAD AT THE TOP OF EACH PILE $Q_g = \frac{228}{4} = 57$ K

FROM GAYLORD & GAYLORD

BEARING LOAD ON SOIL (lb/ft) $w = \frac{C_w \times Q_{hg}}{T}$ (46)

MOMENT IN PIER (in.lbs) $M = C_m \times Q_{hg} \times T$ (48)

FROM FIG 49 FIXED HEAD $C_{w_{max}} = 0.65$

FROM FIG 51 FIXED HEAD $C_{m_{max}} = 0.25$

FROM TABLE 19 SAND, N = 10~30, DRY → $n_h = 28$

$T = \sqrt[5]{EI/n_h}$

$= 55$

$f'_c = 3000$

$E = \sqrt{f'_c} \times 57{,}000$

$= 3.12E6$

$I = \frac{\pi r^4}{4}$ $r = \frac{36}{2} = 18"$

$= 4{,}580 \text{ in}^4$

LATERAL LOADING OF D.P's CONT'

BEARING LOAD $W_{MAX} = \frac{C_{W_{MAX}} \times Q_{hg}}{T}$

$= \frac{0.65 \times 57000}{55} = 673.6$ lb/ft

MAXIMUM BEARING PRESSURE CONSIDERING 3' WIDE FACE OF PIER

$\sigma = \frac{673}{3} = 225$ PSF OK

MAXIMUM MOMENT IN PIER $M_{MAX} = C_{M_{MAX}} \times Q_{hg} \times T$

$= 0.25(57000) \times 55$

$= 783,750$ (in·lbs)

$= 65$ FK

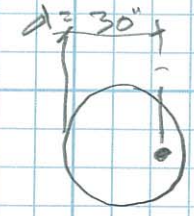
$M_u = 1.5(65)$

$= 98$ FK

PILE REINF

IF 1% STEEL → $A_s = 0.01\left(\frac{36^2\pi}{4}\right) = 10.2$ in^2

12 - #8 $A_s = 9.48$ OK



BENDING

$A_{s_{req'd}} = \frac{98}{4.2(30)} = 0.78$ in^2 ∴ ENGKING (1) #8 BAR SUFFICIENT

77. Laterally Loaded Piles. Where a pile-supported structure is subjected to lateral loads, the vertical piles may provide more lateral resistance than is commonly realized. Prevailing rules of thumb commonly permit an arbitrary lateral load per pile—often 1,000 lb—without any consideration as to the type of pile or the soil in which it is driven. Since a pile-supported structure does not transmit load directly to the soil beneath the pile cap, frictional resistance should not be assumed between the base of the structure and the underlying soil. Therefore, the piles must be adequate to resist all lateral loads.

The ultimate lateral bearing pressure per unit length of pile at a given depth in clay is

$$Q_d = 9cB = 4.5q_uB \tag{44}$$

and in sands

$$Q_d = 3B\gamma' z\frac{1+\sin\phi}{1-\sin\phi} \tag{45}$$

where Q_d = ultimate load per unit length of pile, lb per ft
c = cohesion, psf
q_u = unconfined compressive strength, psf
B = width of pile, ft
γ' = effective unit weight of soil, pcf
z = depth, ft
ϕ = angle of shearing resistance

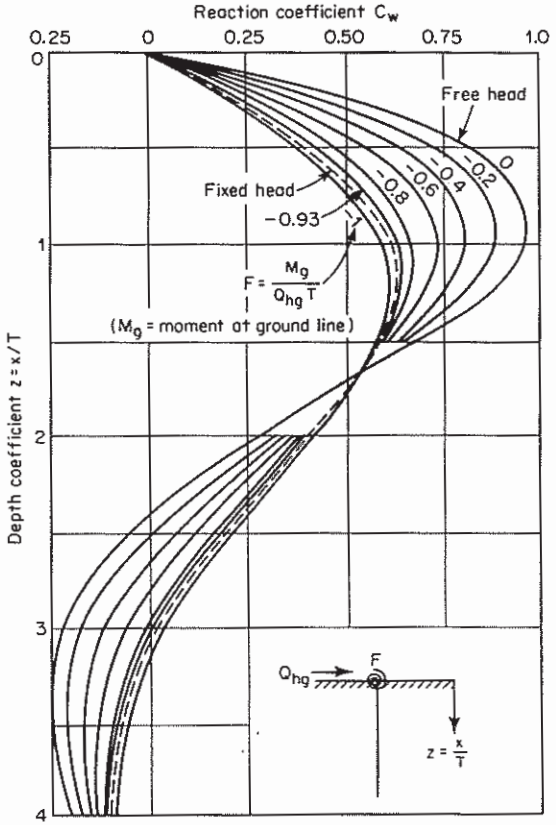


FIG. 49. Coefficients for soil reaction, laterally loaded piles. (*From Prakash, 1961.*)

The working load should not exceed $Q_d/2$ beyond a depth of $4B$ under any circ stance.

For lateral loads smaller than $Q_d/2$, the soil reaction at any depth is given by

$$w = \frac{C_w Q_{hg}}{T}$$

where w = soil reaction, lb per ft
C_w = soil reaction coefficient from Fig. 49
Q_{hg} = shear at ground surface, lb
T = relative stiffness of pile = $\sqrt[5]{EI/n_h}$, in.
EI = flexural stiffness of pile, lb-in.^{2}
n_h = constant of horizontal subgrade reaction, lb per in.^{3}

The modulus of subgrade reaction $k = w/y$ is the ratio of the total reaction per length of pile to the corresponding deflection. For granular soils k is directly portional to the depth x, and it has been shown that k is also proportional to depth normally consolidated clays and silts. However, for overconsolidated clays usually assumed to be a constant and the corresponding relative stiffness is $\sqrt[4]{E}$. Since k is proportional to depth for most soils of interest, the case of constant k is considered here.

The constant of horizontal subgrade reaction is $n_h = k/x$. Typical values of n_h presented in Table 19. Actual values can be determined experimentally by dri

Table 19. Typical Values of n_h*

Soil type	N	n_h, lb/in.^{3}	
		Dry	Submerged
Sand:			
Loose	<10	9.4	5.3
Medium	10–30	28	19
Dense	>30	75	45
Very loose under repeated loading	<5	....	1.5
Silt, very soft, organic	<3	....	0.4–1.0
Clay:			
Very soft	<3		
Static loads	.....	....	2
Repeated loads	.....	....	1

* M. T. Davisson, 1963.

two instrumented piles relatively close together and jacking them apart. By meas ing the loads and deflections at various depths (with a tiltmeter), k can be determin

The lateral deflection y, in inches, given by

$$y = C_y\frac{Q_{hg}T^3}{EI}$$

where C_y = deflection coefficient from Fig. 50, may also be used to evaluate k fro jacking test as well as to determine anticipated deflections.

The moment in a laterally loaded pile (in.-lb) is

$$M = C_m Q_{hg} T \tag{48}$$

where C_m = moment coefficient from Fig. 51. It is noted in Figs. 49, 50, and 51 that a fixed-head pile is generally more favorable than one with a free head. The fixity depends on the structural characteristics of the pile cap and the connection between the pile and the pile cap. The latter is attained by embedding the pile at least 24 in. into the pile cap.

The preceding analyses are for single piles, which corresponds to a minimum spacing of eight pile diameters in the direction of the lateral load and three pile diameters normal to the direction of load. Closer spacings cause a reduction in the modulus of

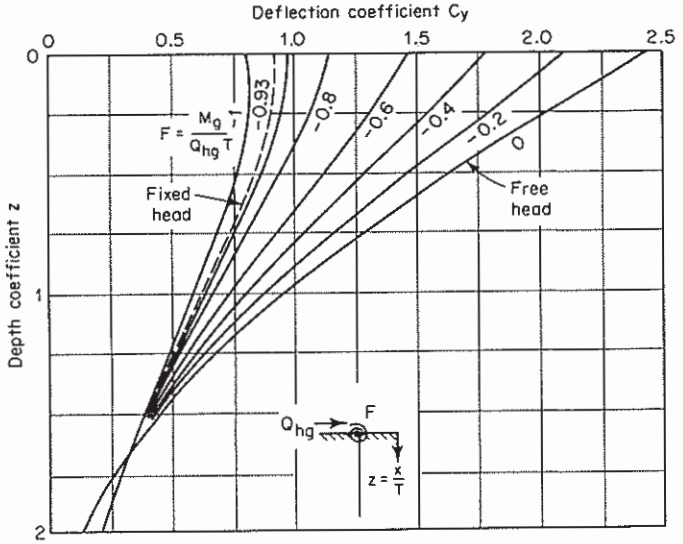


FIG. 50. Deflection coefficients for laterally loaded piles. (*From Matlock and Reese, 1961.*)

subgrade reaction and an increase in the relative stiffness. From the limited information available, it is recommended that a minimum spacing of $3B$ be maintained normal to the load and that T be increased linearly to a limiting value of $1.3T$ as the pile spacing in the direction of the load decreases from $8B$ to $2.5B$.

78. Batter Piles. Batter piles are often used where the lateral loads exceed the lateral resistance of vertical piles. It is commonly assumed that a batter pile has the same axial load capacity as a vertical pile of the same size driven to the same stratum. In the design of a batter-pile foundation, the sum of the horizontal components of the allowable axial loads must equal or exceed the required lateral resistance.

The vertical component Q of load in a batter pile is given by

$$Q = \frac{\Sigma V}{n} \pm \frac{\Sigma M d}{\Sigma d^2} \tag{49}$$

where ΣV = sum of vertical loads acting on foundation
n = number of piles in group
ΣM = sum of moments about center of gravity of pile group
d = distance from center of gravity of group to pile

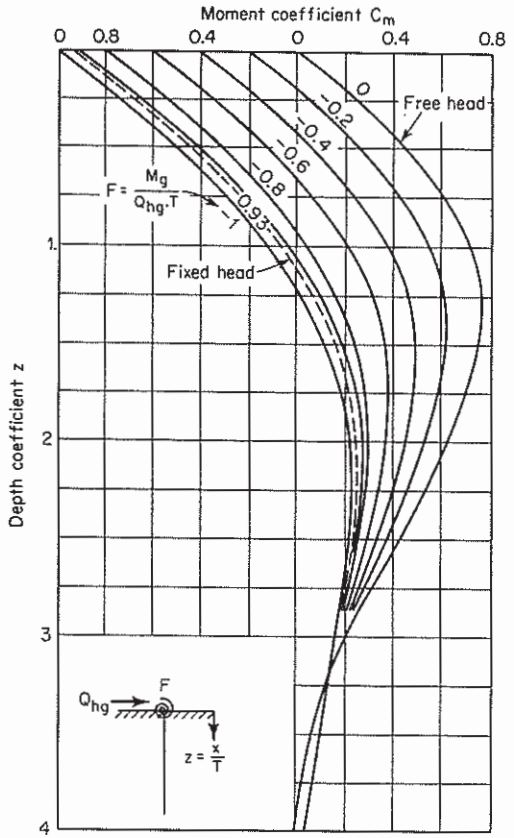


FIG. 51. Moment coefficients for laterally loaded piles. (*From Prakash, 1961.*)

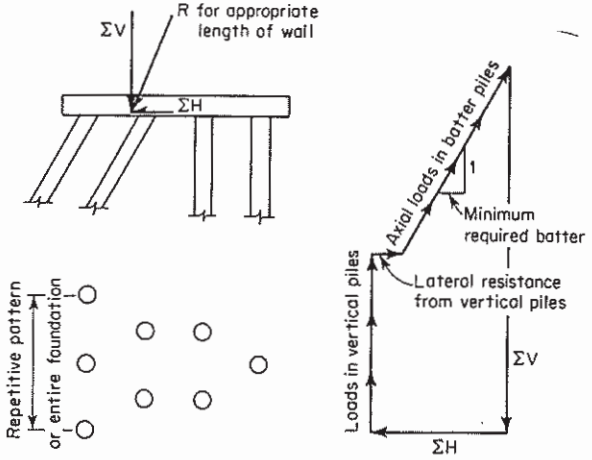


FIG. 52. Batter-pile analysis.

RETAINING WALL ANALYSIS & DESIGN (ACI318/MSJC)

RETAINING WALL ANALYSIS

In accordance with IBC 2009

Tedds calculation version 2.6.04

Retaining wall details

Stem type	Propped cantilever
Stem height	h_{stem} = **16.6** ft
Prop height	h_{prop} = **16.6** ft
Stem thickness	t_{stem} = **12** in
Angle to rear face of stem	α = **90** deg
Stem density	γ_{stem} = **150** pcf
Toe length	l_{toe} = **0.5** ft
Heel length	l_{heel} = **0.5** ft
Base thickness	t_{base} = **16** in
Base density	γ_{base} = **150** pcf
Height of retained soil	h_{ret} = **15.6** ft
Angle of soil surface	β = **0** deg
Depth of cover	d_{cover} = **1** ft
Depth of excavation	d_{exc} = **1** ft

Retained soil properties

Soil type	Medium dense well graded sand
Moist density	γ_{mr} = **135** pcf
Saturated density	γ_{sr} = **145** pcf
Effective angle of internal resistance	ϕ_r = **30** deg
Effective wall friction angle	δ_r = **15** deg

Base soil properties

Soil type	Medium dense well graded sand
Moist density	γ_{mb} = **115** pcf
Cohesion	c_b = **0** psf
Effective angle of internal resistance	ϕ_b = **30** deg
Effective wall friction angle	δ_b = **15** deg
Effective base friction angle	δ_{bb} = **30** deg
Allowable bearing pressure	$P_{bearing}$ = **4000** psf

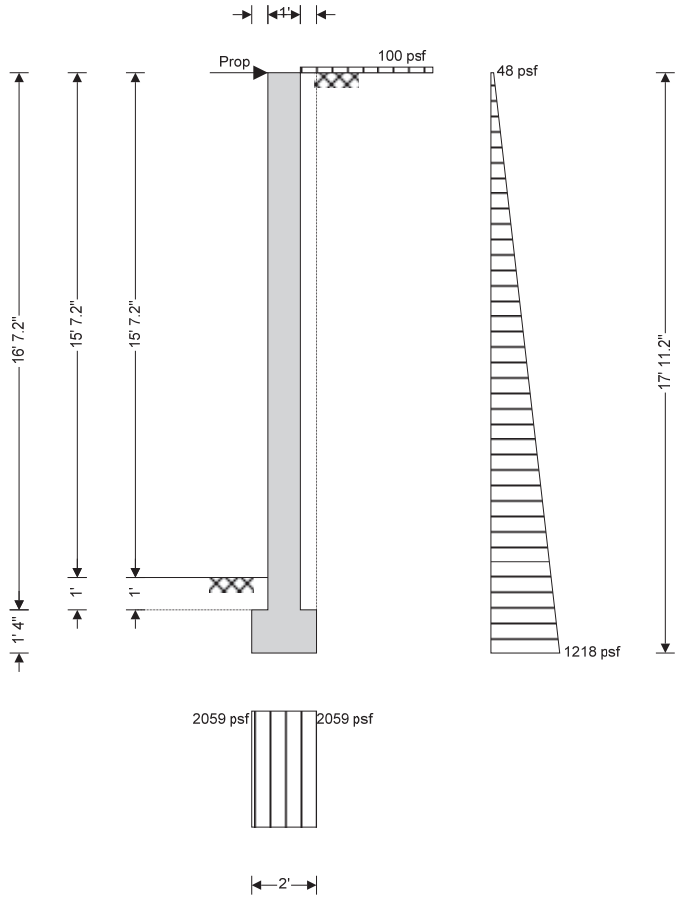
Loading details

Live surcharge load	$Surcharge_L$ = **100** psf

AECOM

CALCULATION SHEET

Calculation No.	YT-13-05-201-001
Project No.	31609
Project Title:	A-USC ComTest at Youngstown Thermal
Subject/Feature:	Basement Wall
Sheet No.	C2 of C9
Rev:	A



Calculate retaining wall geometry

Base length	$l_{base} = l_{toe} + t_{stem} + l_{heel}$ = **2** ft
Moist soil height	$h_{moist} = h_{soil}$ = **16.6** ft
Length of surcharge load	$l_{sur} = l_{heel}$ = **0.5** ft
- Distance to vertical component	$x_{sur_v} = l_{base} - l_{heel} / 2$ = **1.75** ft
Effective height of wall	$h_{eff} = h_{base} + d_{cover} + h_{ret}$ = **17.933** ft
- Distance to horizontal component	$x_{sur_h} = h_{eff} / 2$ = **8.967** ft
Area of wall stem	$A_{stem} = h_{stem} \times t_{stem}$ = **16.6** ft^2
- Distance to vertical component	$x_{stem} = l_{toe} + t_{stem} / 2$ = **1** ft
Area of wall base	$A_{base} = l_{base} \times t_{base}$ = **2.667** ft^2
- Distance to vertical component	$x_{base} = l_{base} / 2$ = **1** ft
Area of moist soil	$A_{moist} = h_{moist} \times l_{heel}$ = **8.3** ft^2
- Distance to vertical component	$x_{moist_v} = l_{base} - (h_{moist} \times l_{heel}^2 / 2) / A_{moist}$ = **1.75** ft
- Distance to horizontal component	$x_{moist_h} = h_{eff} / 3$ = **5.978** ft

AECOM

CALCULATION SHEET

Calculation No. YT-13-05-201-001

Project No. 31609

Project Title: A-USC ComTest at Youngstown Thermal

Subject/Feature: Basement Wall

Sheet No. C3 of C9

Rev: A

Area of base soil	$A_{pass} = d_{cover} \times l_{toe}$ = **0.5** ft^2
- Distance to vertical component	$x_{pass_v} = l_{base} - (d_{cover} \times l_{toe} \times (l_{base} - l_{toe} / 2)) / A_{pass}$ = **0.25** ft
- Distance to horizontal component	$x_{pass_h} = (d_{cover} + h_{base}) / 3$ = **0.778** ft
Using Coulomb theory	
At rest pressure coefficient	$K_0 = 1 - \sin(\phi_r)$ = **0.500**
Passive pressure coefficient	$K_P = \sin(90 - \phi_b)^2 / (\sin(90 + \delta_b) \times [1 - \sqrt{[\sin(\phi_b + \delta_b) \times \sin(\phi_b) / (\sin(90 + \delta_b))]}]^2)$ = **4.977**
From IBC 2009 cl.1807.2.3 Safety factor	
Load combination 1	1.0 × Dead + 1.0 × Live + 1.0 × Lateral earth
Bearing pressure check	
Vertical forces on wall	
Wall stem	$F_{stem} = A_{stem} \times \gamma_{stem}$ = **2490** plf
Wall base	$F_{base} = A_{base} \times \gamma_{base}$ = **400** plf
Surcharge load	$F_{sur_v} = Surcharge_L \times l_{heel}$ = **50** plf
Moist retained soil	$F_{moist_v} = A_{moist} \times \gamma_{mr}$ = **1121** plf
Base soil	$F_{pass_v} = A_{pass} \times \gamma_{mb}$ = **58** plf
Total	$F_{total_v} = F_{stem} + F_{base} + F_{moist_v} + F_{pass_v} + F_{sur_v}$ = **4118** plf
Horizontal forces on wall	
Surcharge load	$F_{sur_h} = K_0 \times \cos(\delta_r) \times Surcharge_L \times h_{eff}$ = **866** plf
Moist retained soil	$F_{moist_h} = K_0 \times \cos(\delta_r) \times \gamma_{mr} \times h_{eff}^2 / 2$ = **10484** plf
Base soil	$F_{pass_h} = -K_P \times \cos(\delta_b) \times \gamma_{mb} \times (d_{cover} + h_{base})^2 / 2$ = **-1505** plf
Total	$F_{total_h} = F_{moist_h} + F_{pass_h} + F_{sur_h}$ = **9846** plf
Moments on wall	
Wall stem	$M_{stem} = F_{stem} \times x_{stem}$ = **2490** lb_ft/ft
Wall base	$M_{base} = F_{base} \times x_{base}$ = **400** lb_ft/ft
Surcharge load	$M_{sur} = F_{sur_v} \times x_{sur_v} - F_{sur_h} \times x_{sur_h}$ = **-7679** lb_ft/ft
Moist retained soil	$M_{moist} = F_{moist_v} \times x_{moist_v} - F_{moist_h} \times x_{moist_h}$ = **-60712** lb_ft/ft
Base soil	$M_{pass} = F_{pass_v} \times x_{pass_v}$ = **14** lb_ft/ft
Total	$M_{total} = M_{stem} + M_{base} + M_{moist} + M_{pass} + M_{sur}$ = **-65486** lb_ft/ft
Check bearing pressure	
Propping force	$F_{prop_stem} = \min((F_{total_v} \times l_{base} / 2 - M_{total}) / (h_{prop} + t_{base}), F_{total_h})$ = **3881** plf
Friction force	$F_{friction} = F_{total_h} - F_{prop_stem}$ = **5964** plf
Moment from propping force	$M_{prop} = F_{prop_stem} \times (h_{prop} + t_{base})$ = **69604** lb_ft/ft
Distance to reaction	$\bar{x} = (M_{total} + M_{prop}) / F_{total_v}$ = **1** ft
Eccentricity of reaction	$e = \bar{x} - l_{base} / 2$ = **0** ft
Loaded length of base	$l_{load} = l_{base}$ = **2** ft

Bearing pressure at toe	$q_{toe} = F_{total_v} / l_{base}$ = **2059** psf
Bearing pressure at heel	$q_{heel} = F_{total_v} / l_{base}$ = **2059** psf
Factor of safety	$FoS_{bp} = P_{bearing} / \max(q_{toe}, q_{heel})$ = **1.943**

PASS - Allowable bearing pressure exceeds maximum applied bearing pressure

RETAINING WALL DESIGN

In accordance with ACI 318-08

Tedds calculation version 2.6.04

Concrete details

Compressive strength of concrete	f'_c = **4000** psi
Concrete type	Normal weight

Reinforcement details

Yield strength of reinforcement	f_y = **60000** psi
Modulus of elasticity or reinforcement	E_s = **29000000** psi

Cover to reinforcement

Front face of stem	c_{sf} = **1.5** in
Rear face of stem	c_{sr} = **2** in
Top face of base	c_{bt} = **2** in
Bottom face of base	c_{bb} = **3** in

From IBC 2009 cl.1605.2.1 Basic load combinations

Load combination no.1	1.4 × Dead
Load combination no.2	1.2 × Dead + 1.6 × Live + 1.6 × Lateral earth
Load combination no.3	1.2 × Dead + 1.0 × Earthquake + 1.0 × Live
Load combination no.4	0.9 × Dead + 1.0 × Earthquake + 1.6 × Lateral earth

Check stem design at 8.619 ft

Depth of section	h = **12** in

Rectangular section in flexure - Chapter 10

Design bending moment combination 2	M = **15674** lb_ft/ft
Depth of tension reinforcement	$d = h - c_{sf} - \phi_{sx} - \phi_{sfM} / 2$ = **9.625** in
Compression reinforcement provided	No.6 bars @ 12" c/c
Area of compression reinforcement provided	$A_{srM.prov} = \pi \times \phi_{srM}^2 / (4 \times s_{srM})$ = **0.442** in²/ft
Tension reinforcement provided	No.6 bars @ 12" c/c
Area of tension reinforcement provided	$A_{sfM.prov} = \pi \times \phi_{sfM}^2 / (4 \times s_{sfM})$ = **0.442** in²/ft
Maximum reinforcement spacing - cl.14.3.5	$s_{max} = \min(18 \text{ in}, 3 \times h)$ = **18** in

PASS - Reinforcement is adequately spaced

Depth of compression block	$a = A_{sfM.prov} \times f_y / (0.85 \times f'_c)$ = **0.65** in
Neutral axis factor - cl.10.2.7.3	$\beta_1 = \min(\max(0.85 - 0.05 \times (f'_c - 4 \text{ ksi}) / 1 \text{ ksi}, 0.65), 0.85)$ = **0.85**

Depth to neutral axis	$c = a / \beta_1 =$ **0.764** in
Strain in reinforcement	$\varepsilon_t = 0.003 \times (d - c) / c =$ **0.034778**
	Section is in the tension controlled zone
Strength reduction factor	$\phi_f = \min(\max(0.65 + (\varepsilon_t - 0.002) \times (250 / 3), 0.65), 0.9) =$ **0.9**
Nominal flexural strength	$M_n = A_{sfM.prov} \times f_y \times (d - a / 2) =$ **20543** lb_ft/ft
Design flexural strength	$\phi M_n = \phi_f \times M_n =$ **18489** lb_ft/ft
	$M / \phi M_n =$ **0.848**
	PASS - Design flexural strength exceeds factored bending moment
By iteration, reinforcement required by analysis	$A_{sfM.des} =$ **0.372** in^2/ft
Minimum area of reinforcement - exp.10-3	$A_{sfM.min} = \max(3 \times \sqrt{f'_c \times 1\ psi}, 200\ psi) \times d / f_y =$ **0.385** in^2/ft
	PASS - Area of reinforcement provided is greater than minimum area of reinforcement required

Check stem design at base of stem

Depth of section	$h =$ **12** in

Rectangular section in flexure - Chapter 10

Design bending moment combination 2	$M =$ **34474** lb_ft/ft
Depth of tension reinforcement	$d = h - c_{sr} - \phi_{sr} / 2 =$ **9.625** in
Compression reinforcement provided	No.6 bars @ 12" c/c
Area of compression reinforcement provided	$A_{sf.prov} = \pi \times \phi_{sf}^2 / (4 \times s_{sf}) =$ **0.442** in^2/ft
Tension reinforcement provided	No.6 bars @ 6" c/c
Area of tension reinforcement provided	$A_{sr.prov} = \pi \times \phi_{sr}^2 / (4 \times s_{sr}) =$ **0.884** in^2/ft
Maximum reinforcement spacing - cl.14.3.5	$s_{max} = \min(18\ in, 3 \times h) =$ **18** in
	PASS - Reinforcement is adequately spaced
Depth of compression block	$a = A_{sr.prov} \times f_y / (0.85 \times f'_c) =$ **1.299** in
Neutral axis factor - cl.10.2.7.3	$\beta_1 = \min(\max(0.85 - 0.05 \times (f'_c - 4\ ksi) / 1\ ksi, 0.65), 0.85) =$ **0.85**
Depth to neutral axis	$c = a / \beta_1 =$ **1.529** in
Strain in reinforcement	$\varepsilon_t = 0.003 \times (d - c) / c =$ **0.015889**
	Section is in the tension controlled zone
Strength reduction factor	$\phi_f = \min(\max(0.65 + (\varepsilon_t - 0.002) \times (250 / 3), 0.65), 0.9) =$ **0.9**
Nominal flexural strength	$M_n = A_{sr.prov} \times f_y \times (d - a / 2) =$ **39652** lb_ft/ft
Design flexural strength	$\phi M_n = \phi_f \times M_n =$ **35687** lb_ft/ft
	$M / \phi M_n =$ **0.966**
	PASS - Design flexural strength exceeds factored bending moment
By iteration, reinforcement required by analysis	$A_{sr.des} =$ **0.851** in^2/ft
Minimum area of reinforcement - exp.10-3	$A_{sr.min} = \max(3 \times \sqrt{f'_c \times 1\ psi}, 200\ psi) \times d / f_y =$ **0.385** in^2/ft
	PASS - Area of reinforcement provided is greater than minimum area of reinforcement required

Rectangular section in shear - Chapter 11

Design shear force	$V =$ **12300** lb/ft

Concrete modification factor - cl.8.6.1	λ = **1**
Nominal concrete shear strength - exp.11-3	$V_c = 2 \times \lambda \times \sqrt{(f'_c \times 1\ psi)} \times d$ = **14610** lb/ft
Strength reduction factor	ϕ_s = **0.75**
Design concrete shear strength - cl.11.4.6.1	$\phi V_c = \phi_s \times V_c$ = **10957** lb/ft
	$V / \phi V_c$ = **1.123**
	FAIL - Shear reinforcement is required, cross-section should be revised

Check stem design at prop

Depth of section	h = **12** in

Rectangular section in shear - Chapter 11

Design shear force	V = **3356** lb/ft
Concrete modification factor - cl.8.6.1	λ = **1**
Nominal concrete shear strength - exp.11-3	$V_c = 2 \times \lambda \times \sqrt{(f'_c \times 1\ psi)} \times d$ = **14610** lb/ft
Strength reduction factor	ϕ_s = **0.75**
Design concrete shear strength - cl.11.4.6.1	$\phi V_c = \phi_s \times V_c$ = **10957** lb/ft
	$V / \phi V_c$ = **0.306**
	PASS - No shear reinforcement is required

Horizontal reinforcement parallel to face of stem

Minimum area of reinforcement - cl.14.3.3	$A_{sx.req} = 0.002 \times t_{stem}$ = **0.288** in^2/ft
Transverse reinforcement provided	No.4 bars @ 8" c/c each face
Area of transverse reinforcement provided	$A_{sx.prov} = 2 \times \pi \times \phi_{sx}^2 / (4 \times s_{sx})$ = **0.589** in^2/ft
	PASS - Area of reinforcement provided is greater than area of reinforcement required

Check base design at toe

Depth of section	h = **16** in

Rectangular section in flexure - Chapter 10

Design bending moment combination 1	M = **301** lb_ft/ft
Depth of tension reinforcement	$d = h - c_{bb} - \phi_{bb} / 2$ = **12.688** in
Compression reinforcement provided	No.5 bars @ 12" c/c
Area of compression reinforcement provided	$A_{bt.prov} = \pi \times \phi_{bt}^2 / (4 \times s_{bt})$ = **0.307** in^2/ft
Tension reinforcement provided	No.5 bars @ 12" c/c
Area of tension reinforcement provided	$A_{bb.prov} = \pi \times \phi_{bb}^2 / (4 \times s_{bb})$ = **0.307** in^2/ft
Maximum reinforcement spacing - cl.10.5.4	$s_{max} = \min(18\ in, 3 \times h)$ = **18** in
	PASS - Reinforcement is adequately spaced
Depth of compression block	$a = A_{bb.prov} \times f_y / (0.85 \times f'_c)$ = **0.451** in
Neutral axis factor - cl.10.2.7.3	$\beta_1 = \min(\max(0.85 - 0.05 \times (f'_c - 4\ ksi) / 1\ ksi, 0.65), 0.85)$ = **0.85**
Depth to neutral axis	$c = a / \beta_1$ = **0.531** in
Strain in reinforcement	$\varepsilon_t = 0.003 \times (d - c) / c$ = **0.068709**
	Section is in the tension controlled zone

Strength reduction factor	$\phi_f = \min(\max(0.65 + (\varepsilon_t - 0.002) \times (250 / 3), 0.65), 0.9) =$ **0.9**
Nominal flexural strength	$M_n = A_{bb.prov} \times f_y \times (d - a / 2) =$ **19116** lb_ft/ft
Design flexural strength	$\phi M_n = \phi_f \times M_n =$ **17205** lb_ft/ft
	$M / \phi M_n =$ **0.017**
	PASS - Design flexural strength exceeds factored bending moment
By iteration, reinforcement required by analysis	$A_{bb.des} =$ **0.005** in^2/ft
Minimum area of reinforcement - cl.7.12.2.1	$A_{bb.min} = 0.0018 \times h =$ **0.346** in^2/ft
	PASS - Area of reinforcement provided is greater than minimum area of reinforcement required

Rectangular section in shear - Chapter 11

Design shear force	V = **1203** lb/ft
Concrete modification factor - cl.8.6.1	$\lambda =$ **1**
Nominal concrete shear strength - exp.11-3	$V_c = 2 \times \lambda \times \sqrt{(f'_c \times 1\ psi)} \times d =$ **19258** lb/ft
Strength reduction factor	$\phi_s =$ **0.75**
Design concrete shear strength - cl.11.4.6.1	$\phi V_c = \phi_s \times V_c =$ **14444** lb/ft
	$V / \phi V_c =$ **0.083**
	PASS - No shear reinforcement is required

Rectangular section in flexure - Chapter 10

Design bending moment combination 2	M = **76** lb_ft/ft
Depth of tension reinforcement	$d = h - c_{bt} - \phi_{bt} / 2 =$ **13.688** in
Compression reinforcement provided	No.5 bars @ 12" c/c
Area of compression reinforcement provided	$A_{bb.prov} = \pi \times \phi_{bb}^2 / (4 \times s_{bb}) =$ **0.307** in^2/ft
Tension reinforcement provided	No.5 bars @ 12" c/c
Area of tension reinforcement provided	$A_{bt.prov} = \pi \times \phi_{bt}^2 / (4 \times s_{bt}) =$ **0.307** in^2/ft
Maximum reinforcement spacing - cl.10.5.4	$s_{max} = \min(18\ in, 3 \times h) =$ **18** in
	PASS - Reinforcement is adequately spaced
Depth of compression block	$a = A_{bt.prov} \times f_y / (0.85 \times f'_c) =$ **0.451** in
Neutral axis factor - cl.10.2.7.3	$\beta_1 = \min(\max(0.85 - 0.05 \times (f'_c - 4\ ksi) / 1\ ksi, 0.65), 0.85) =$ **0.85**
Depth to neutral axis	$c = a / \beta_1 =$ **0.531** in
Strain in reinforcement	$\varepsilon_t = 0.003 \times (d - c) / c =$ **0.074361**
	Section is in the tension controlled zone
Strength reduction factor	$\phi_f = \min(\max(0.65 + (\varepsilon_t - 0.002) \times (250 / 3), 0.65), 0.9) =$ **0.9**
Nominal flexural strength	$M_n = A_{bt.prov} \times f_y \times (d - a / 2) =$ **20650** lb_ft/ft
Design flexural strength	$\phi M_n = \phi_f \times M_n =$ **18585** lb_ft/ft
	$M / \phi M_n =$ **0.004**
	PASS - Design flexural strength exceeds factored bending moment
By iteration, reinforcement required by analysis	$A_{bt.des} =$ **0.001** in^2/ft
Minimum area of reinforcement - cl.7.12.2.1	$A_{bt.min} = 0.0018 \times h =$ **0.346** in^2/ft

PASS - Area of reinforcement provided is greater than minimum area of reinforcement required

Rectangular section in shear - Chapter 11

Design shear force	V = **304** lb/ft
Concrete modification factor - cl.8.6.1	λ = **1**
Nominal concrete shear strength - exp.11-3	$V_c = 2 \times \lambda \times \sqrt{(f'_c \times 1\ psi)} \times d$ = **20776** lb/ft
Strength reduction factor	ϕ_s = **0.75**
Design concrete shear strength - cl.11.4.6.1	$\phi V_c = \phi_s \times V_c$ = **15582** lb/ft
	$V / \phi V_c$ = **0.020**

PASS - No shear reinforcement is required

Transverse reinforcement parallel to base

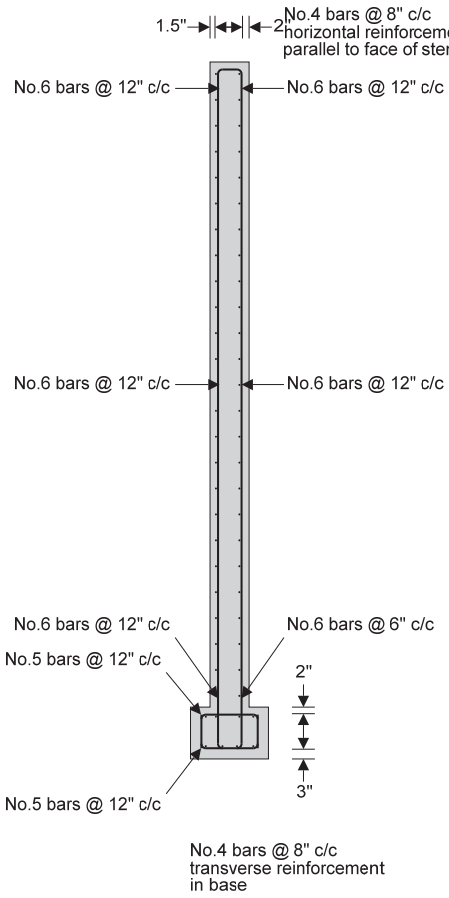
Minimum area of reinforcement - cl.7.12.2.1	$A_{bx.req} = 0.0018 \times t_{base}$ = **0.346** in^2/ft
Transverse reinforcement provided	No.4 bars @ 8" c/c each face
Area of transverse reinforcement provided	$A_{bx.prov} = 2 \times \pi \times \phi_{bx}^2 / (4 \times s_{bx})$ = **0.589** in^2/ft

PASS - Area of reinforcement provided is greater than area of reinforcement required

AECOM

CALCULATION SHEET

Calculation No.	YT-13-05-201-001
Project No.	31609
Project Title:	A-USC ComTest at Youngstown Thermal
Subject/Feature:	Basement Wall
Sheet No.	C9 of C9
Rev:	A



AECOM	Calculation No. YT-13-05-201-001
CALCULATION SHEET	Project No. 31609
Project Title: A-USC ComTest at Youngstown Thermal Subject/Feature: Wind Loads	Sheet No. B1 of B7 Rev: A

WIND LOADS

General

Building Length	L = 270 ft
Building Width	B = 210 ft
Roof height (turbine building)	h_w = 35 ft
Roof height (other area)	h_o = 20 ft
Basic Wind Speed	V = 90 mph
Exposure Category	B
Importance Factor	I = 1.15
Wind Directionality Factor	K_d = 0.85
Topographic Factor	K_{zt} = 1.0
Velocity Pressure Exposure Coefficient	$K_{zw} = 2.01*(h_w / 1200)^{2/7}$ = **0.73**
Velocity Pressure Exposure Coefficient	$K_{zo} = 2.01*(h_o / 1200)^{2/7}$ = **0.62**
Velocity Pressure	$q_{zw} = 0.00256* K_{zw} * K_{zt} * K_d * V^2 * I * 1psf$ = **14.8** psf
Velocity Pressure	$q_{zo} = 0.00256* K_{zo} * K_{zt} * K_d * V^2 * I * 1psf$ = **12.6** psf

MWFRS Wind Loads (ASCE 7-05 Section 6.5.12.2)

Walls

Gust Effect Factor	G = 0.85
External Pressure Coefficient Walls	C_{pww} = 0.8
	C_{plw} = -0.5
	C_{sw} = -0.7
Internal Pressure Coefficient (+-)	GC_{pi} = 0.18

Roof Up to 35ft

Windward Maximum Pressure	$P_{w1} = q_{zw} * (G * C_{pww} + GC_{pi})$ = **12.8** psf
Leeward Maximum Suction	$P_{w2} = q_{zw} * (G * C_{plw} - GC_{pi})$ = **-9.0** psf
Windward + Leeward Total	$P_{w3} = q_{zw} * (G * C_{pww} + GC_{pi}) - q_{zw} * (G * C_{plw} + GC_{pi})$ = **16.4** psf
Windward + Leeward Total	$P_{w4} = q_{zw} * (G * C_{pww} - GC_{pi}) - q_{zw} * (G * C_{plw} - GC_{pi})$ = **16.4** psf
Sidewall Suction	$P_{w5} = q_{zw} * (G * C_{sw} - GC_{pi})$ = **-11.5** psf

Roof Up to 20ft

Windward Maximum Pressure	$P_1 = q_{zo} * (G * C_{pww} + GC_{pi})$ = **10.9** psf
Leeward Maximum Pressure	$P_2 = q_{zo} * (G * C_{plw} - GC_{pi})$ = **-7.7** psf
Windward + Leeward Pressure	$P_3 = q_{zo} * (G * C_{pww} + GC_{pi}) - q_{zo} * (G * C_{plw} + GC_{pi})$ = **14.0** psf
Windward + Leeward Pressure	$P_4 = q_{zo} * (G * C_{pww} - GC_{pi}) - q_{zo} * (G * C_{plw} - GC_{pi})$ = **14.0** psf
Sidewall Suction	$P_5 = q_{zo} * (G * C_{sw} - GC_{pi})$ = **-9.8** psf

AECOM

CALCULATION SHEET

Calculation No. YT-13-05-201-001

Project No. 31609

Project Title: A-USC ComTest at Youngstown Thermal

Subject/Feature: Wind Loads

Sheet No. B2 of B7

Rev: A

Roof

Gust Effect Factor	G = 0.85
External Pressure Coefficient Walls	C_{pr1} = -0.9
	C_{pr2} = -0.5
	C_{pr3} = -0.3
Internal Pressure Coefficient (+-)	GC_{pi} = 0.18

Roof Up to 35ft

Suction Edge to h distance	$P_{w1} = q_{zw} * (G * C_{pr1} - GC_{pi})$ = **-14.0** psf
Suction h distance to 2h distance	$P_{w2} = q_{zw} * (G * C_{pr2} - GC_{pi})$ = **-9.0** psf
Suction >2h distance	$P_{w3} = q_{zw} * (G * C_{pr3} - GC_{pi})$ = **-6.5** psf

Roof Up to 20ft

Suction Edge to h distance	$P_{w1} = q_{zo} * (G * C_{pr1} - GC_{pi})$ = **-12.0** psf
Suction h distance to 2h distance	$P_{w2} = q_{zo} * (G * C_{pr2} - GC_{pi})$ = **-7.7** psf
Suction >2h distance	$P_{w3} = q_{zo} * (G * C_{pr3} - GC_{pi})$ = **-5.5** psf

WIND LOADING (ASCE7-05) C+C WALL 35FT

WIND LOAD (ASCE 7 – 05)

TEDDS calculation version 1.2.04

Classification summary
Structure is a building
Structure is Rigid

Mean roof height	h = **35.0** ft
Horizontal dimension parallel to wind	L = **270.0** ft
Horizontal dimension normal to wind	B = **210.0** ft
Roof angle	θ = **0.0** deg

Wind force resisting element is component or cladding
Structure is enclosed
Structure is low rise

Procedure

Occupancy category (table 1-1)	Category = **3**
Basic wind speed (sect. 6.5.4)	V = **90.0** mph
Region	**Non-Hurricane Prone**
Importance factor (table 6-1)	I = **1.15**
Exposure category (sect. 6.5.6)	**B**
Wind directionality factor	K_d = **0.85**
Topographic factor	K_{zt} = **1.00**

Design procedure - analytical procedure (Method2)

Velocity pressure at mean roof height 'h'(ASCE 7-05, cl. 6.5.10)

Case of loading system (table 6-3)	Case = **1**
Velocity pressure exposure coefficient	K_h = **0.73**
Velocity pressure at mean roof height 'h'	$q_h = 0.00256 \times K_h \times K_{zt} \times K_d \times V^2 \times I \times 1$ psf / mph^2 = **14.80** psf

External pressure coefficient, GC_p for wall components and cladding of enclosed and partially enclosed structures with h <= 60 ft and low rise structure(fig. 6-11A)

Effective area for zone 4	A_{eff_4} = **200.0** ft^2
Effective area for zone 5	A_{eff_5} = **200.0** ft^2

Wall zone 4

Positive external pressure coefficient	$GC_{p_pos_4}$ = **0.693**
Negative external pressure coefficient	$GC_{p_neg_4}$ = **-0.783**

Wall zone 5

Positive external pressure coefficient	$GC_{p_pos_5}$ = **0.693**
Negative external pressure coefficient	$GC_{p_neg_5}$ = **-0.846**

AECOM

CALCULATION SHEET

Calculation No.	YT-13-05-201-001
Project No.	31609
Project Title:	A-USC ComTest at Youngstown Thermal
Subject/Feature:	Wind Loads
Sheet No.	B4 of B7
Rev:	A

Design wind pressure for wall components and cladding in enclosed or partially enclosed low-rise buildings and buildings with h <= 60 ft and low rise structure

Velocity pressure at mean roof height 'h' q_h = **14.80** psf

Internal pressure coefficients

Positive internal pressure coefficient (fig. 6-5) GC_{pi_pos} = **0.18**

Negative internal pressure coefficient (fig. 6-5) GC_{pi_neg} = **-0.18**

Design wind pressure (eq. 6-22)

Wall zone 4

With positive GC_{pi} $p_{neg_4} = q_h \times (GC_{p_neg_4} - GC_{pi_pos})$ = **-14.25** psf

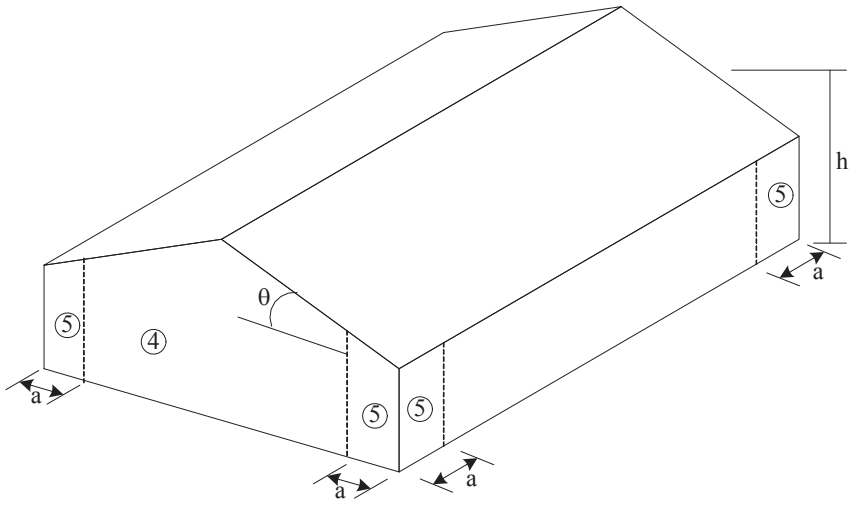
With negative GC_{pi} $p_{pos_4} = q_h \times (GC_{p_pos_4} - GC_{pi_neg})$ = **12.92** psf

Wall zone 5

With positive GC_{pi} $p_{neg_5} = q_h \times (GC_{p_neg_5} - GC_{pi_pos})$ = **-15.19** psf

With negative GC_{pi} $p_{pos_5} = q_h \times (GC_{p_pos_5} - GC_{pi_neg})$ = **12.92** psf

Note: - As per section 6.1.4.2, design wind pressure for components and cladding of buildings shall not be less than a net pressure of 10 psf acting in either direction normal to the surface.



WIND LOADING (ASCE7-05) C+C ROOF 35FT

WIND LOAD (ASCE 7 – 05)

TEDDS calculation version 1.2.04

Classification summary
Structure is a building
Structure is Rigid

Mean roof height	h = **35.0** ft
Horizontal dimension parallel to wind	L = **27.0** ft
Horizontal dimension normal to wind	B = **210.0** ft
Roof angle	θ = **0.0** deg

Wind force resisting element is component or cladding
Structure is enclosed
Structure is not low rise

Procedure

Occupancy category (table 1-1)	Category = **3**
Basic wind speed (sect. 6.5.4)	V = **90.0** mph
Region	**Non-Hurricane Prone**
Importance factor (table 6-1)	I = **1.15**
Exposure category (sect. 6.5.6)	**B**
Wind directionality factor	K_d = **0.85**
Topographic factor	K_{zt} = **1.00**

Design procedure - analytical procedure (Method2)

Velocity pressure at mean roof height 'h'(ASCE 7-05, cl. 6.5.10)

Case of loading system (table 6-3)	Case = **1**
Velocity pressure exposure coefficient	K_h = **0.73**
Velocity pressure at mean roof height 'h'	$q_h = 0.00256 \times K_h \times K_{zt} \times K_d \times V^2 \times I \times 1$ psf / mph^2 = **14.80** psf

External pressure coefficient, GC_p for gable roof components and cladding in enclosed and partially enclosed structures with $\theta <= 7^0$ and h <= 60 ft and low rise structure (fig. 6-11B)

Effective area for zone 1	A_{eff_1} = **500.0** ft^2
Effective area for zone 2	A_{eff_2} = **50.0** ft^2
Effective area for zone 3	A_{eff_3} = **50.0** ft^2

Non-overhang roof zones

Roof zone 1

Positive external pressure coefficient	$GC_{p_pos_1}$ = **0.200**
Negative external pressure coefficient	$GC_{p_neg_1}$ = **-0.900**

Roof zone 2

Positive external pressure coefficient	$GC_{p_pos_2}$ = **0.230**

Negative external pressure coefficient $GC_{p_neg_2}$ = **-1.311**

Roof zone 3

Positive external pressure coefficient $GC_{p_pos_3}$ = **0.230**

Negative external pressure coefficient $GC_{p_neg_3}$ = **-1.612**

Overhang roof zones (fig. 6-11B)

Roof zone 1

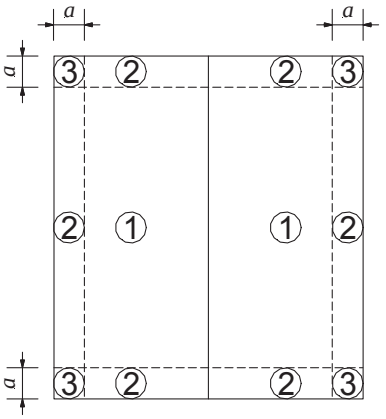
Negative external pressure coefficient $GC_{p_ohang_1}$ = **-1.100**

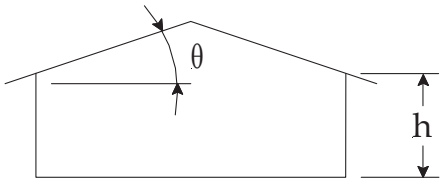
Roof zone 2

Negative external pressure coefficient $GC_{p_ohang_2}$ = **-1.630**

Roof zone 3

Negative external pressure coefficient $GC_{p_ohang_3}$ = **-1.402**





Design wind pressure for roof components and cladding in enclosed or partially enclosed low-rise buildings and buildings with h <= 60 ft and low rise structure

Velocity pressure at mean roof height 'h' q_h = **14.80** psf

Internal pressure coefficients (fig. 6-5)

Positive internal pressure coefficient GC_{pi_pos} = **0.18**

Negative internal pressure coefficient GC_{pi_neg} = **-0.18**

Design wind pressure non-overhang roof zones (eq. 6-22)

Roof zone 1

With positive GC_{pi} $p_{neg_1} = q_h \times (GC_{p_neg_1} - GC_{pi_pos})$ = **-15.98** psf

With negative GC_{pi} $p_{pos_1} = q_h \times (GC_{p_pos_1} - GC_{pi_neg})$ = **5.62** psf

Roof zone 2

With positive GC_{pi} $p_{neg_2} = q_h \times (GC_{p_neg_2} - GC_{pi_pos})$ = **-22.06** psf

With negative GC_{pi} $p_{pos_2} = q_h \times (GC_{p_pos_2} - GC_{pi_neg}) =$ **6.07** psf

Roof zone 3

With positive GC_{pi} $p_{neg_3} = q_h \times (GC_{p_neg_3} - GC_{pi_pos}) =$ **-26.51** psf

With negative GC_{pi} $p_{pos_3} = q_h \times (GC_{p_pos_3} - GC_{pi_neg}) =$ **6.07** psf

Note: - As per section 6.1.4.2, design wind pressure for components and cladding of buildings shall not be less than a net pressure of 10 psf acting in either direction normal to the surface.

Design wind pressure overhang roof zones

Roof zone 1

Resultant pressure $p_{ohang_1} = q_h \times GC_{p_ohang_1} =$ **-16.28** psf

Roof zone 2

Resultant pressure $p_{ohang_2} = q_h \times GC_{p_ohang_2} =$ **-24.12** psf

Roof zone 3

Resultant pressure $p_{ohang_3} = q_h \times GC_{p_ohang_3} =$ **-20.75** psf

Note: - As per section 6.1.4.2, design wind pressure for components and cladding of buildings shall not be less than a net pressure of 10 psf acting in either direction normal to the surface.

AECOM	Calculation No. YT-13-05-201-001
CALCULATION SHEET	Project No. 31609
Project Title: A-USC ComTest at Youngstown Thermal Subject/Feature: Snow Loads	Sheet No. A1 of A1 Rev: A

TYPICAL ROOF SNOW LOAD

SNOW LOADING (ASCE7-05)

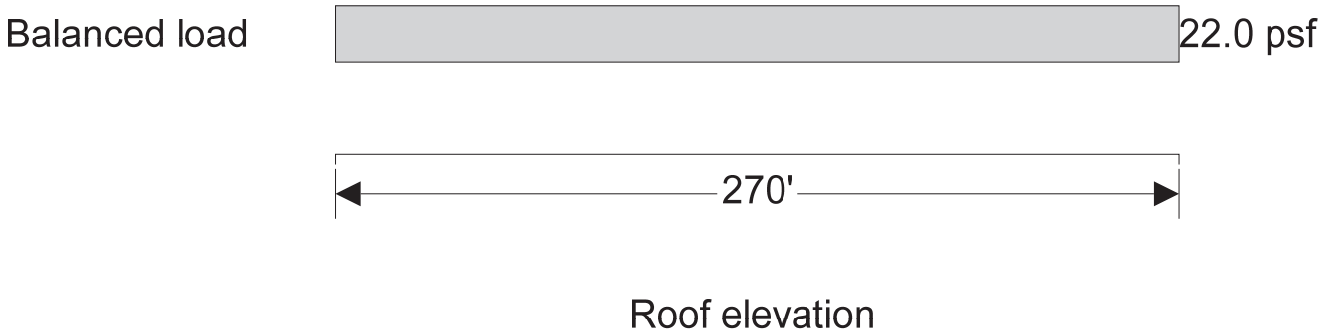
TEDDS calculation version 1.0.04

Building details

Roof type	Flat
Width of roof	b = **270.00** ft

Ground snow load

Ground snow load	p_g = **20.00** lb/ft^2
Density of snow	γ = min(0.13 × p_g / 1ft + 14lb/ft^3, 30lb/ft^3) = **16.60** lb/ft^3
Terrain type	B
Exposure condition (Table 7-2)	Fully exposed
Exposure factor (Table 7-2)	C_e = **0.90**
Thermal condition (Table 7-3)	All
Thermal factor (Table 7-3)	C_t = **1.00**
Importance category (Table 1-1)	III
Importance factor (Table 7-4)	I_s = **1.10**
Min snow load for low slope roofs (Sect 7.3.4)	p_{f_min} = I_s × p_g = **22.00** lb/ft^2
Flat roof snow load (Sect 7.3)	p_f = max(0.7 × C_e × C_t × I_s × p_g, p_{f_min}) = **22.00** lb/ft^2



AECOM

CALCULATION COVER SHEET

Calculation No.			
YT-13-05-201-001			
Prel	**Final**	**Void**	**Revision**
X			A

CLIENT	Energy Industries of Ohio (EIO)	**Discipline** Structural
PROJECT TITLE	A-USC Com Test	**Project No.** 31609
SUBJECT/FEATURE	FEED Design	**No. of Sheets** 22

FOR CALCULATIONS GENERATED BY COMPUTER PROGRAMS

Verified on Master Software List

Computer Program Name **STAAD** **Rev. 20.07.09.31**

REV. NO.	REVISION REASON	PREP. BY	DATE	CHECK BY	DATE	APPROV. BY	DATE
A	Issued for FEED	Jeff Morris	3/18/2016				

AECOM	Calculation No. YT-13-05-201-001
CALCULATION SHEET	Project No. 31609
Project Title: A-USC Com Test at Youngstown Thermal	Sheet No. 1 of 22
Subject/Feature: FEED Design	Rev: A

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Total Attachment Pages..... 25

Total Pages of this Calculation (Inc. Cover Pages)**.....49**

1.0. CALCULATION OBJECTIVE

See cover sheet.

2.0. ASSUMPTIONS / OPEN ITEMS

This is a FEED calculation. Also inputs and assumptions will be verified during detailed engineering.

3.0. DESIGN CRITERIA / DESIGN BASIS

See cover sheet

4.0. REFERENCES / SOURCE DOCUMENTS

See cover sheet

5.0. APPROACH / METHODOLOGY

6.0. COMPUTATIONS

6.1. TURBINE BUILDING

6.1.1. Design Loads

Turbine building is a pre-engineered steel framed building. Hence design loads are by the supplier of the building. The loads below are only used for FEED design to determine preliminary building reactions.

6.1.1.1 Roof Dead Load

20 psf

Includes frames, purlins, roofing metal panel

6.1.1.2 Floor Dead Load

7" concrete slab: 88 psf

Steel framing: Included as self-weight in STAAD model

6.1.1.3 Collateral Dead Load

10 psf at roof

50 psf at turbine floor

6.1.1.4 Roof Live Load

20 psf minimum per ASCE7-05

USE: 20 psf (no live load reduction)

6.1.1.5 Live Load

Turbine building (Lines B to D): 350 psf

Turbine building (Lines A to B): 125 psf

Stairs: 100 psf

No live load reduction

6.1.1.6 Snow Load

Ground snow load: 20 psf per design criteria

Roof snow = 22 psf per Attachment A

USE: 22 psf + 5psf rain surcharge

γ= (0.13 * 20 + 14)* 1 pcf =**16.6** pcf

Drift at Existing Boiler Building N-S: Case 1

L_{u1} = 140 ft

L_{l1} = 75 ft

h_1= 15 ft

h_{d1u} = (0.43* $(L_{u1})^{1/3}$ * $(20+10)^{1/4}$ -1.5) *1ft =**3.7** ft

h_{d1l} = 0.75*(0.43* $(L_{l1})^{1/3}$ * $(20+10)^{1/4}$ -1.5) *1ft =**2.1** ft

h_{d1}= max (h_{d1u} , h_{d1l}) =**3.7** ft

w_1 = 4*h_{d1} =**14.9** ft (Include limit if hd>h)

$Snow_{d1}$= γ * h_{d1} =**61.8** psf In addition to base snow

6.1.1.7 Crane Load

Crane lift capacity:	CC = 60 kips
Crane Class:	Class C
<u>Vertical Loads</u>	
Maximum wheel load:	MWL = 32.1 kips (per quote)
End truck wheel base:	WB = 8.83ft (per quote)
Crane Weight (excluding trolley):	CW = 14.8 kips
Trolley Weight:	TW = 5.2 kips
Maximum reaction to column:	P_{max} = MWL + (22ft-WB)/22ft * MWL =**51.3** kips
Minimum wheel load:	mWL = CW/4 =**3.7** kips
Minimum reaction to column:	P_{min} = mWL + (22ft-WB)/22ft * mWL =**5.9** kips
<u>Lateral Loads (Z – direction)</u>	
Lateral load:	H = 0.20 * (CC + TW) =**13.0** kips
Load per wheel:	LLW = H/4 =**3.3** kips
Column load:	H_L = LLW + (22ft-WB)/22ft * LLW =**5.2** kips
<u>Longitudinal Loads (X- direction)</u>	
Longitudinal load:	LF = 0.10 * (MWL) =**3.2** kips
LF per runway beam:	TLF = 2*LF =**6.4** kips

6.1.1.8 Wind Load

Per design criteria:

Wind Speed: 90 mph

Exposure: B

Use Directional Procedure for MWFRS (Chapter 6 of ASCE7-05)

See attachment B for wind load pressure calculations.

35' Maximum Roof Height

Summary of Wall Design Wind Pressures (MWFRS)

Wall	Pressure (psf)
Windward (Max)	12.8
Leeward (Max)	-9.0
WW+LW	16.4
Sidewall Suction (Max)	-11.5

Summary of Roof Design Wind Pressures (MWFRS)

Roof	Pressure (psf)
Edge to 35ft	-14.0
35ft to 70ft	-9.0
70ft +	-6.5

Summary of Wall Design Wind Pressures (C+C)

Area (sf)	Interior (psf)	Corner (psf)
<10	17.3	21.3
50	15.7	18.1
200	14.3	15.2
>500	13.3	13.3

Corner Zone (a) = 14ft

Summary of Roof Design Wind Pressures (C+C)

Area (sf)	Interior (psf)	Edge (psf)	Corner (psf)
<10	-16.0	-29.3	-44.1
50	-16.0	-22.1	-26.5
>100	-16.0	-19.0	-19.0

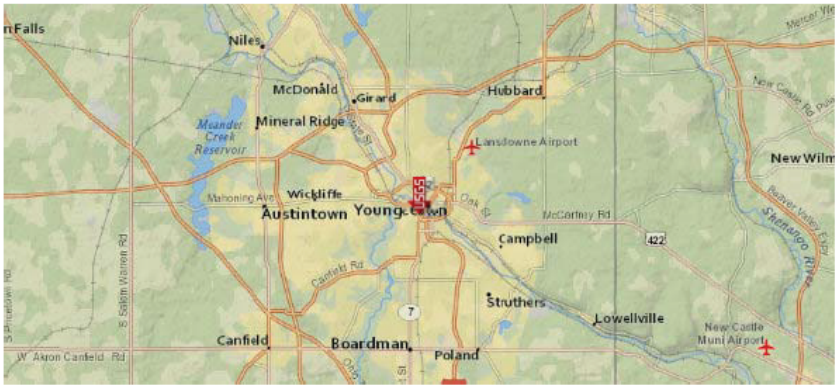
Corner/Edge Zone (a) = 14ft

6.1.1.9 Seismic Load

USGS Design Maps Summary Report

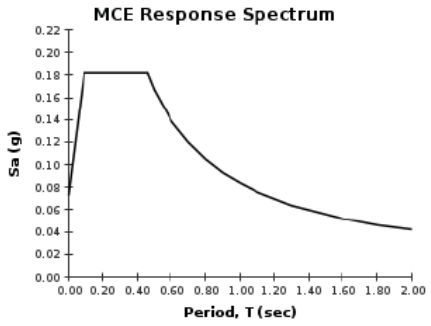
User–Specified Input

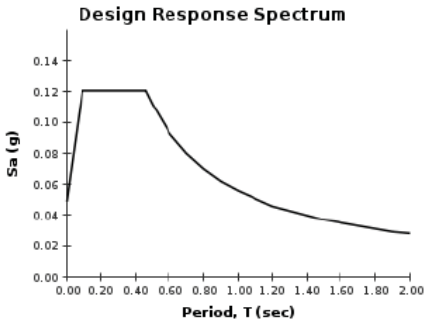
Building Code Reference Document	2006/2009 International Building Code (which utilizes USGS hazard data available in 2002)
Site Coordinates	41.106°N, 80.656°W
Site Soil Classification	Site Class C – "Very Dense Soil and Soft Rock"
Occupancy Category	I/II/III



USGS–Provided Output

S_S =	0.152 g	S_{MS} =	0.182 g	S_{DS} =	0.121 g
S_1 =	0.049 g	S_{M1} =	0.084 g	S_{D1} =	0.056 g





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Per design criteria:

S_s=0.152

S_1=0.049

Per Attachment C:

SDC= A

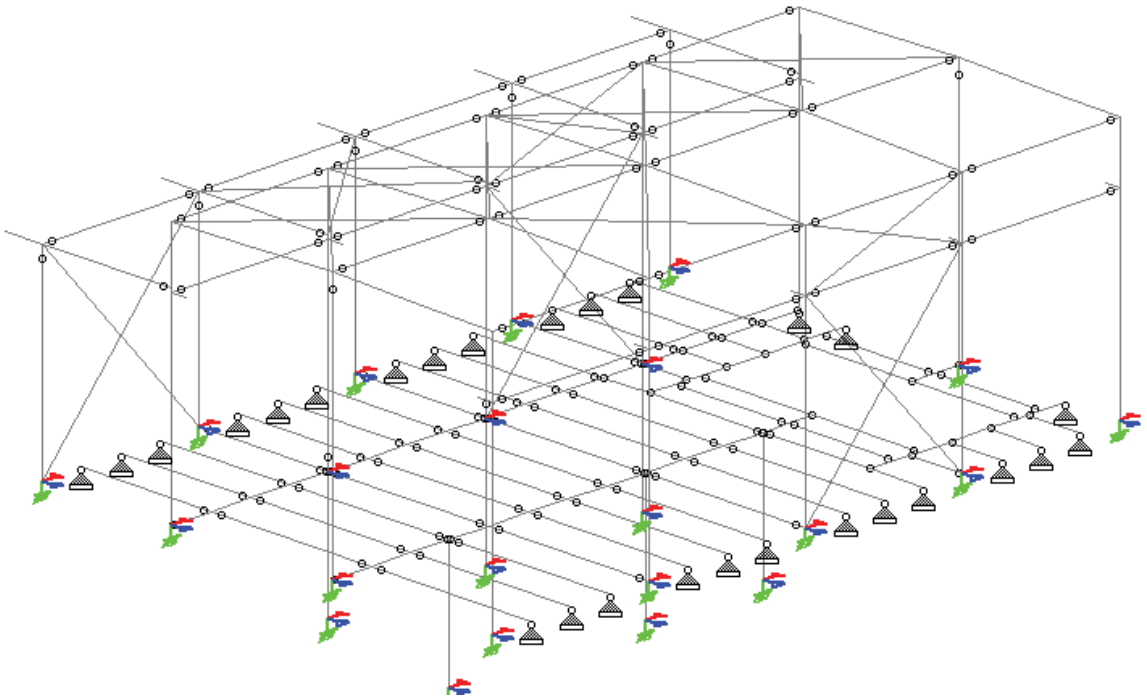
Per ASCE7-05 Section 11.7:

C_s = 0.01

6.1.2. Design Loads

6.1.3. STAAD Model

See Attachment E for STAAD Input file and Attachment F for Output.



6.1.4. Deflections

Design in Detailed Phase

6.1.5. Member Design

Design in Detailed Phase

6.1.6. Support Reactions

Design in Detailed Phase

6.1.7. Baseplate Design

Design in Detailed Phase

6.1.8. Connection Design

Design in Detailed Phase

6.1.9. Stair Stringer

18’ maximum length stringer with 3’-6 width stair

Span:	L = 18.0ft
Width:	sp = 3.5ft
D+L:	Load = 25psf + 100psf =**125**psf
Uniform load:	w= Load*sp/2 = **219** plf
Reaction:	R = w * L/2 =**2.0** kips

Try C10x15.3, full braced by stair treads

Z= 15.9 in^3

I = 67.3 in^4

E = 29000 ksi

Fy = 36ksi

Moment:	M= $w*L^2$ / 8 = **8.9** kip_ft
Allowable Moment:	M_a = Fy * Z / 1.67 = **28.6** kip_ft
Deflection::	Δ= $5*w*L^4$ / (384*E*I) = **0.3** in
Allowable Deflection:	Δ_a = L / 360 = **0.6** in

USE C10x15.3

6.2. PIPE RACKS

6.2.1. Design Loads

6.2.1.1 Structure Dead Load:

Self-weight included in STAAD model

6.2.1.2 Piping Loads:

Operating: 40 psf (envelopes piping thru 8" diameter)

Empty: 60% of Operating

Contents: 40% of Operating

Pipe Friction: 10% of Operating

6.2.1.3 Cable Tray:

Operating: 40 psf (single level tray)

Empty: 25% of Operating

Contents: 75% of Operating

6.2.1.4 Snow Loads:

Include snow loads on steel and cable tray

No snow load on piping

6.2.1.5 Wind Loads

Per ASCE Guidelines for Wind Loads and Anchor Bolt Design for Petrochemical Facilities

$F=q_z * G * C_f * A$ (Equation 5.1)

q_z and G are per ASEC 7-05

Gust Effect Factor (ASCE Section 6.5.8)

G = 0.85

Velocity Pressure Calculation (ASCE Section 6.5.10)

Rack Height	h_r = 22 ft
Basic Wind Speed	V = 90 mph
Exposure Category	B
Importance Factor	I = 1.15
Wind Directionality Factor	K_d = 0.85
Topographic Factor	K_{zt} = 1.0
Velocity Pressure Exposure Coefficient	$K_z = 2.01*(h_r / 1200)^{2/7}$ =**0.64**
Velocity Pressure	$q_z = 0.00256* K_z * K_{zt} * K_d * V^2 * I * 1psf$ =**13.0** psf

Steel Framing

C_f = 1.8 (Section 5.1.4)

W8 F_{w8}= ceiling (q_z * G *C_f * 8in, 1plf) =**14** plf

W10 Column F_{w10}= ceiling (q_z * G *C_f * 10in, 1plf) =**17** plf

W12 F_{w12}= ceiling (q_z * G *C_f * 12in, 1plf) =**20** plf

W24 F_{w24}= ceiling (q_z * G *C_f * 24in, 1plf) =**40** plf

LD4x4 F_{ld4}= ceiling (q_z * G *C_f * 8in, 1plf) =**14** plf

Piping

C_{fp} = 0.7 (Section 5.1.3)

A = L (D + 10% W) (Equation 5.2)

Maximum rack width W = 12ft

24" diameter

A_{24} = (2ft + 10% * W) =**3.2** ft

F_{24}= ceiling (q_z * G *C_{fp} * A_{24}, 1plf) =**25** plf

16" diameter

A_{16} = (1.33ft + 10% * W) =**2.5** ft

F_{24}= ceiling (q_z * G *C_{fp} * A_{16}, 1plf) = **20** plf

Cable Tray

C_{ft} = 2.0 (Section 5.1.5)

A = L (D + 10% W) (Equation 5.2)

Maximum rack width W = 12ft

Assume 6" height

A_{ct} = (6in + 10% * W) =**1.7** ft

F_{ct}= ceiling (q_z * G *C_{fp} * A_{ct} ,1plf) = **14** plf

6.2.1.6 Seismic Loads

Per design criteria:

S_s=0.152

S_1=0.049

Per Attachment C:

SDC= A

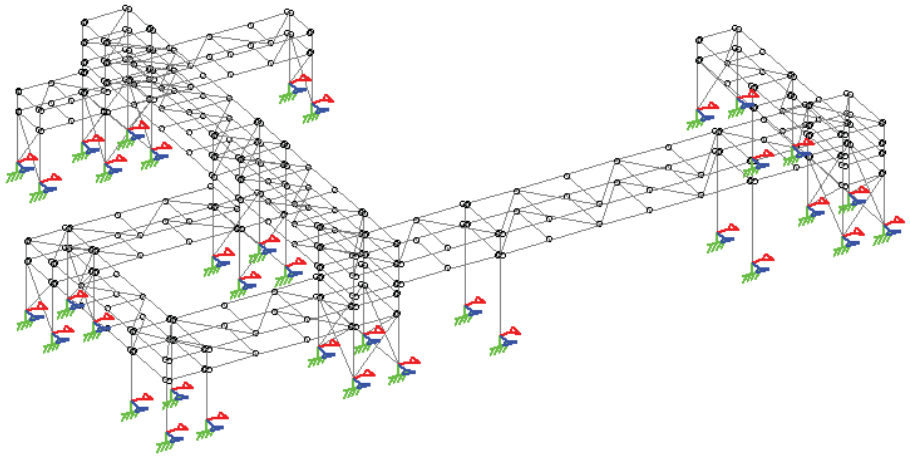
Per ASCE7-05 Section 11.7:

C_s = 0.01

6.3. STAAD Model

Basic Load Cases		
Case	**Symbol**	**Description**
1	D	Dead Load
2	D_O	Operating Dead Load of Pipe / Tray Contents
3	D_T	Test Dead Load of Pipe / Tray Contents
4	A_f	Pipe Anchor Load
5	F_{Fx}	Pipe Friction Load (+X direction)
6	F_{Fz}	Pipe Friction Load (+Z direction)
7	L	Live Load
8	S	Snow Load
9	T	Thermal Loads due to Self-restraining force
10	C	Contingency
20	W_X	Wind Load (+X direction)
21	W_Z	Wind Load (+Z direction)
30	E_X	Seismic Load (+X direction)
31	E_Z	Seismic Load (+Z direction)
40	N_{X1}	Stability Load (+X direction, LC1+2)
41	N_{Z1}	Stability Load (+Z direction, LC1+2)
50	N_{X2}	Stability Load (+X direction, LC1+3)
51	N_{Z2}	Stability Load (+Z direction, LC1+3)

See Attachment E for STAAD Input file and Attachment F for Output.



6.3.1. Deflections

Design in Detailed Phase

6.3.2. Member Design

Design in Detailed Phase

6.3.3. Support Reactions

Design in Detailed Phase

6.3.4. Baseplate Design

Design in Detailed Phase

6.3.5. Connection Design

Design in Detailed Phase

6.4. COOLING TOWER

6.4.1. Design Loads

Loads per Marley drawing SB588633G

Operating Load

P_{OL} = 52719 lb Per Cell

$w_{OL} = P_{OL} / 14.18ft / 2 =$ **1.9** klf

Wind Load

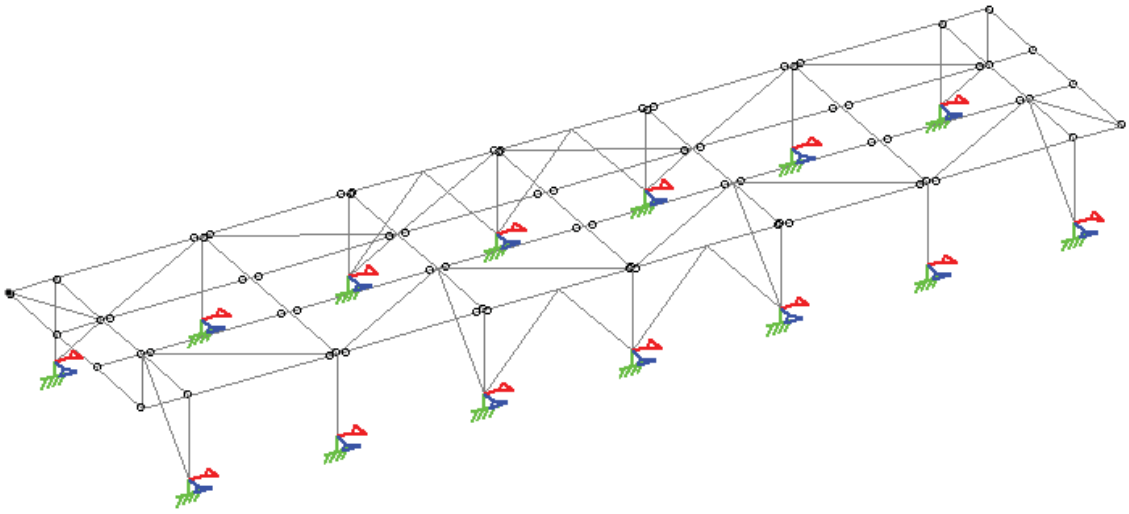
Wind Pressure	W_P = 20 psf		
Vertical wind force	$P_{WV} = 226 * W_P * 1ft^2 =$ **4.5** kips		At each corner A
Horizontal wind force	$P_{WH} = 132 * W_P * 1ft^2 =$ **2.6** kips		At each corner A

Seismic Load

Seismic Coefficient	G= 0.05	
Vertical seismic force	$P_{EV} = 20414 * G * 1lbf =$ **1.0** kips	At each corner A
Horizontal seismic force	$P_{EH} = 12251 * G * 1lbf =$ **0.6** kips	At each corner A

6.4.2. STAAD Model

See Attachment E for STAAD Input file and Attachment F for Output.



6.4.3. Deflections

Design will occur during detailed engineer phase.

6.4.4. Member Design

Design will occur during detailed engineer phase.

6.4.5. Support Reactions

Design will occur during detailed engineer phase.

6.4.6. Baseplate Design

Design will occur during detailed engineer phase.

6.4.7. Connection Design

Design will occur during detailed engineer phase.

7.0. CONCRETE DESIGN

7.1. Turbine Building

7.1.1. Turbine Foundation

Preliminary Weight of Turbine $W_{turbine}$= 115 kips

Preliminary Weight of Water Break W_{wb}= 20 kips

Preliminary Weight of Skid W_s= 15 kips

Total Weight $W_{total} = W_{turbine} + W_{wb} + W_s$ =**150.0** kips

Per design criteria, minimum ratio of centrifugal equipment to foundation weight is 3 to 1.

Minimum foundation weight $W_{fmin} = W_{total} * 3$ =**450.0** kips

Foundation dimension

Length L_f = 36ft

Width W_f =17ft

Minimum thickness $t_{min} = W_{fmin} / (L_f * W_f * 150pcf)$ =**4.9** ft

7.1.2. Building Foundations

Allowable bearing capacity B_{cap} = 3500 psf

Column contingency load per design criteria section 2.1.1.G

Axial load less than 200 kips: 10% of column reaction

Axial load greater than 200 kips: 5% of column reaction but not less than 20 kips

Typical Interior:

P_i = 312 kips + 20 kips =**332.0** kips

$A_{ri} = P_i / B_{cap}$ =**94.9** ft^2

$LW_i = \sqrt{(A_{ri})}$ =**9.7** ft Square

Typical Exterior on Basement Wall/Pier:

P_e = 218 kips + 20 kips =**238.0** kips

$A_{re} = P_e / B_{cap}$ =**68.0** ft^2

$LW_e = \sqrt{(A_{re})}$ =**8.2** ft Square

Line A:

P_e = 51 kips * 1.1 =**56.1** kips

$diA_{re} = P_e / B_{cap}$ =**16.0** ft^2

$LW_e = \sqrt{(A_{re})}$ =**4.0** ft Square

7.1.3. Piers

Piers are 2'-8" x 2'-8" square. Reinforcing design will occur during detailed engineer phase.

7.1.4. Basement Walls

See Attachment C.

7.1.5. 1st Floor Slab Design

Slab is 7" concrete flat slab (formed)

t_{slab} = 7in

Concrete: 4000 psi normal weight concrete

Design concrete slab per ACI 318-08

Dead load DL= 150 pcf* t_{slab} =**87.5** psf

Live load LL = 350 psf

Span (max) L= 5.5 ft

Consider 3 span condition

Fork Truck Parameters:

3 ton Capacity

Pneumatic Tires

Wheel Spacing W_{sp} =3.5ft

Front axle load F_{al} = 16 kips

Rear axle load R_{al} = 2 kips

Effective Width

AASHTO: $W_{effAASHTO}$ = 4*1ft+0.06*L + W_{sp}=**7.8** ft

Gaylord: $W_{effGaylord}$ = 0.5ft + 0.6*L + W_{sp} =**7.3** ft

USE: W_{eff} = 7.0ft

Per STAAD model:

Mp_u = 43.0 kip_in

Mn_u = 28.0 kip_in

V_u = 2.6 kip

Positive Moment

#5 bar @ 12" oc

A_{sp}= 0.31in^2

D_{bp} = 0.625in

$d_p = t_{slab}$ - 0.75in – 1.5* D_{bp} =**5.3** in

$a_p = A_{sp}$ * 60ksi / (0.85*4ksi*12in) = **0.5** in

$\phi M_{np} = 0.9*(A_{sp} * 60ksi*(d_p - a_p /2))$ = **85.1** kip_in

$\phi V_{np} = 0.75* \sqrt{(4000)}* 1psi * 12in* d_p$ = **3.0** kips

Negative Moment

#5bar @ 12" oc

A_{sn}= 0.31in^2

D_{bn} = 0.625in

$d_n = t_{slab}$ -0.75in – 1.5* D_{bn} =**5.3** in

$a_n = A_{sn}$ * 60ksi / (0.85*4ksi*12in) = **0.5** in

$\phi M_{nn} = 0.9*(A_{sn} * 60ksi*(d_n - a_n /2))$ = **85.1** kip_in

$\phi V_{nn} = 0.75* \sqrt{(4000)}* 1psi * 12in* d_n$ = **3.0** kips

USE #5 @ 12" oc each way top and bottom

7.1.6. Basement Slab Design

Design will occur during detailed engineer phase.

USE: 6" slab with #4 bars at 18" oc each way (2" down from top of slab)

7.2. Super heater

7.2.1. Drilled Piers

See Attachment D.

7.2.2. Grade Beams

See Attachment D.

7.2.3. Slab

See Attachment D.

7.3. Dump Exchanger Feed Pumps (PU-7002)

7.3.1. Mat Foundation

Pump skids are 500 HP each (pump and motor)

Preliminary Weight of Pump Skid

W_{PU7002}= 10 kips

Per design criteria, minimum ratio of centrifugal equipment to foundation weight is 3 to 1.

Minimum foundation weight $W_{fmin} = W_{PU7002} * 3 =$ **30.0** kips

Foundation dimension

Length L_f = 10ft

Width W_f =10ft

Minimum thickness $t_{min} = W_{fmin} / (L_f * W_f * 150pcf) =$ **2.0** ft

7.4. Utility Rack

7.4.1. Rack Footings

Allowable bearing capacity B_{cap} = 3500 psf

Column contingency load per design criteria section 2.1.1.G

Axial load less than 200 kips: 10% of column reaction

Axial load greater than 200 kips: 5% of column reaction but not less than 20 kips

Typical Column:

P_{maxt} = 37 kips

P_{mint} = 3.4 kips

$P_t = P_{maxt} * 1.1 =$ **40.7** kips

$A_{rt} = P_t / B_{cap} =$ **11.6** ft^2

$LW_t = \sqrt{(A_{rt})} =$ **3.4** ft Square

Check uplift

$U_{capb} = LW_t^2 * 1.33ft * 150pcf + LW_t^2 * 2.15ft * 120pcf =$ **5.3** kips

USE 4' x 4' x 1'-4" thick footing

Column with Bracing:

P_{maxb} = 60 kips

P_{minb} = -11.2 kips

$P_b = P_{maxb} * 1.1 =$ **66.0** kips

$A_{rb} = P_b / B_{cap} =$ **18.9** ft^2

$LW_b = \sqrt{(A_{rb})} =$ **4.3** ft Square

Check uplift

USE LW =5ft

$U_{capb} = LW^2 * 2ft * 150pcf + LW^2 * 1.5ft * 120pcf =$ **12.0** kips

USE 5' x 5' x 2'-0" thick footing

7.4.2. Rack Piers

Design will occur during detailed engineer phase.

8.0. RESULTS / CONCLUSIONS

Design is acceptable for intended use, as demonstrated in the preceding calculations. Reference the AECOM (URS Energy and Construction) structural drawings for the FEED design.

9.0. ATTACHMENTS