GA-A14999

GAS-COOLED FAST BREEDER REACTOR

CONCEPTUAL DESIGN FOR A HELIUM CIRCULATOR TEST FACILITY

by
PROJECT STAFFS
of
General Atomic Company
San Diego, California

and
The Ralph M. Parsons Company
Pasadena, California
(Under General Atomic Subcontract 5C637841)

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ABSTRACT

The Gas-Cooled Fast Breeder Reactor (GCFR) Development Plant uses three helium loops to transfer heat from the reactor core to the steam generators. Helium flow in each loop is provided by a circulator driven by a 24,000 horsepower electric motor.

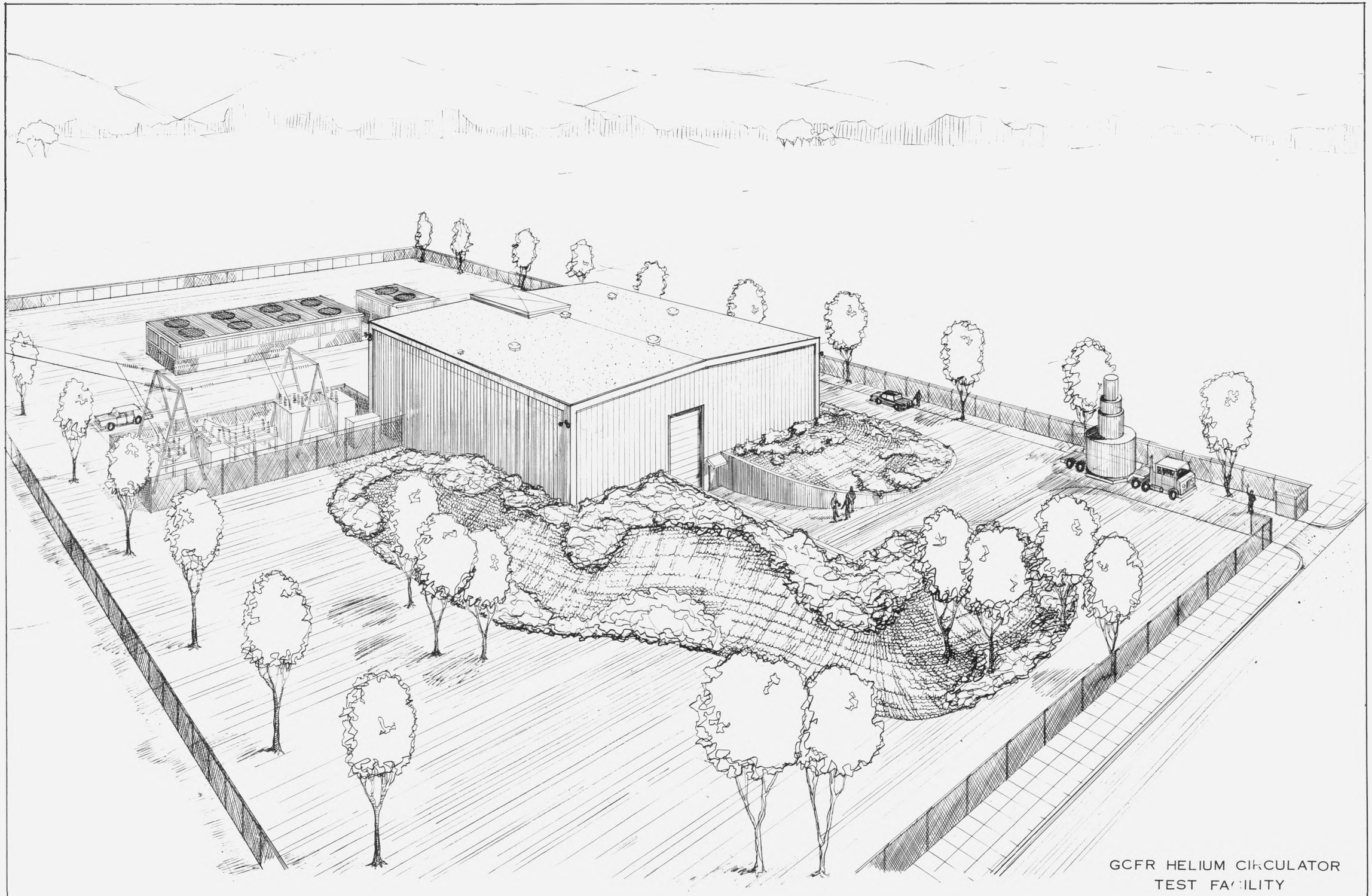
Experimental verification of the circulator design is needed to demonstrate that operational and safety requirements are met. In addition, each circulator must be qualification tested prior to installation in the plant.

A GCFR helium circulator test facility sized for full design conditions is proposed for meeting the above requirements. The circulator is mounted in a large vessel containing high pressure helium which permits testing at the same power, speed, pressure, temperature and flow conditions present in the development plant. The electric drive motor for the circulator obtains its power from an electrical supply and distribution system in which electrical power is taken from a local utility grid via a transformer.

The conceptual design described in this report is the result of close interaction between the General Atomic Company (GAC), designer of the GCFR, and The Ralph M. Parsons Company, architect/engineer for the test facility. A realistic estimate of total project costs is presented, together with a schedule which includes design, procurement, construction and inspection.

The total project cost escalated to the period of spending, including title I, II and III engineering, land, site work, building, special facilitities, utilities, standard equipment, and contingency is $35,212,000. This estimate includes $13,940,000 in special facilities which will be designed by GAC as the operating contractor, designated as Government Furnished Equipment.

This report is provided as support for a DOE Schedule 44 Construction Project Data Sheet request for fiscal year 1980 line item funding of the GCFR Circulator Test Facility. The 1980 need date is based on full power operation of the GCFR Development Plant in 1989.


GCFR HELIUM CIRCULATOR
TEST FACILITY
AEP

CONCEPTUAL DESIGN REPORT

GCFR HELIUM CIRCULATOR TEST FACILITY

TABLE OF CONTENTS

SECTION 1

OVERVIEW

1.1 INTRODUCTION

Implementation of the national objective for the development of energy sources makes it imperative that the Gas-Cooled Fast Breeder Reactor (GCFR) be developed as an alternative source of power. Design studies have been underway since 1963 under contract to the Department of Energy (DOE) and a utility group. The current program calls for the completion of design and construction of a 300 MW(e), three steam loop, development plant by 1989.

One of the highest priorities in the GCFR program is the testing of the circulators, diffusers and isolation valves at the same power, speed pressure, temperature and flow on conditions present in the development plant. This high priority is based on the dual function operation of the circulators in the GCFR. The helium circulators not only provide the necessary flow requirements for the reactor when it is at 100 percent power, but they also provide residual heat removal following normal, off-normal and accident conditions resulting in reactor shutdown.

A progressive development program has been planned for the components of the circulator and its associated service system. The culmination of this program is the integrated full-scale development and acceptance testing of the helium circulators, diffusers and isolation valves in the GCFR Helium Circulator Test Facility described in this report. This facility must be available in FY-83 in order to support full power demonstration of the GCFR by 1989.

1.2 PURPOSE

The Helium Circulator Test Facility will experimentally verify the design and predictive analytical models of the helium circulators, diffusers and isolation valves, thereby reducing the operational and safety uncertainties of the GCFR development plant.

1.3 SCOPE OF WORK

The scope of work for the conceptual design of this facility encompasses that design activity necessary to establish technically viable concepts, to evaluate economic alternatives and to provide the basis for a realistic and current estimate of costs for the total project. It also includes the effort necessary to establish a meaningful and realistic project schedule including design, procurement, construction and inspection.

The design work includes systems and equipment design of adequate depth to assure functional satisfaction of project objectives, and facility design of sufficient detail to permit material takeoffs and equipment outline specifications for a well supported cost estimate. This includes site preparation, building design, test and support systems and equipment design and the design of auxiliary support systems such as utilities and personnel accommodations. The cost estimate is supported by design calculations,[1] drawings and outline specifications.

The project schedule, while necessarily brief in the conceptual design phase, includes sufficient detail, such as milestones, to identify significant activities during both the design and the construction phases.

The resulting conceptual design represents the consolidation of information prepared by the General Atomic Company and by The Ralph M. Parsons Company for those portions of this facility for which each was responsible.

1.3.1 SPECIFIC RESPONSIBILITIES

The conceptual design effort for this facility was divided into two parts: that performed by the General Atomic Company, and that performed by The Ralph M. Parsons Company, under contract to the General Atomic Company. That portion of the conceptual design designated the responsibility of the General Atomic Company includes:

1. The helium circulator, diffuser, main motor, pony motor and motor controllers.

2. The helium isolation valve.

3. The helium circulator service system.

4. Instrumentation and control located within the circulator test vessel or associated with the measurement, transmission, processing and recording of test data.

5. Interface information for all equipment to be tested.

6. Special handling tools or equipment.

7. Environmental effects, except those necessary to comply with OSHA.

8. Consideration of acoustic energy effects on the circulator vessel and its internals.

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[1] "Gas Cooled Fast Freeder Reactor - Helium Circulator Test Facility Conceptual Design Calculations", prepared by The Ralph M. Parsons Company and General Atomic Company, Unpublished Data, June 1978.

9. Land costs.

10. Design, Liaison, management or other project costs expected to be incurred by GAC and included in the "Total Estimated Cost" of the project.

Responsibility for the balance of the facility conceptual design is that of The Ralph M. Parsons Company. This includes the estimation of installation costs of General Atomic Company equipment and systems.

1.4 DESCRIPTION OF TEST HARDWARE

The helium circulator, diffuser and isolation valve comprise the test articles for which the GCFR Helium Circulator Test Facility is being designed.

1.4.1 HELIUM CIRCULATOR

The electric motor powered helium circulator consists of a bearing assembly and radial compressor impeller as shown on Drawing 210100047 in Section 9. The impeller is suspended on a vertical shaft which is supported by water lubricated bearings. Two radial bearings and one thrust bearing of shrouded step design are used. This type of bearing was selected because it provides a large hydro-dynamic lift and is suitable for operating hydrostatically without undue complication.

Bearing water flow causes rotation of the impeller shaft, consequently a pneumatically operated drum brake is used to keep the rotor from turning when the drive motor is not powered. This drum brake is located on the shaft between the main drive motor and the compressor bearing housing, as shown on Drawing 024173 in Section 9. The brake can be applied at up to 1000 rpm to stop the circulator.

1.4.2 DIFFUSER

The kinetic energy of the gas leaving the impeller is partly converted to pressure in a vaneless diffuser consisting of two parallel circular plates as shown on Drawing 024173. Separation between these plates is maintained by a ring of struts around the inlet and another ring of struts around the exit. These struts also maintain the alignment of the front casing of the compressor which is supported by the diffuser structure.

1.4.3 ISOLATION VALVE AND ACTUATOR

The GCFR isolation valve is shown on Drawing 024173 in Section 9. It is of the butterfly disk type design and is pressure/gravity actuated by offsetting the pivot centerline from the geometric center of the disk. The valve disk is supported by two rolling element bearings to minimize friction.

The valve actuator consists of an electric motor, gear reducer, overriding mechanism and frame, located at the side of the pressure vessel, inside a pressure dome. Actuator torque is transmitted to the valve disk through a straight cylindrical shaft. An electro-mechanical override capability is provided to assure complete closing of the valve if the circulator is shut down and no pressure differential exists across the valve.

1.5 DESCRIPTION OF THE FACILITY

The GCFR Helium Circulator Test Facility is comprised of a helium loop, an electric motor drive and an electrical supply and distribution system suitably housed in a building. The electric motor drive consists of a main motor, pony motor, main motor controller and pony motor controller as shown on Drawing EE-2626 in Section 9. Supporting facilities are also provided for circulator bearing lubrication, helium, nitrogen, purified water, cooling water and compressed air. The drawings in Section 9 depict the facility layout.

The helium loop is entirely contained within a circulator test vessel, which is internally partitioned to form the loop circuit as shown on Drawings 024173 and EE-2626. The helium circulator is mounted on the innermost top flange of the test vessel. The main electric motor with its pony motor is mounted on the outer vessel flange. A diffuser assembly within the upper head of the vessel expands the helium flow stream from the radial compressor, into the vessel flow circuit. The helium passes through six restrictor valves into the annular heat exchanger arranged around the inner wall of the vessel. Exiting from the heat exchanger, the helium turns at the bottom of the vessel to flow upwards through a bell mouthed central flow column to return to the inlet of the radial compressor. The flow circuit isolation valve is positioned immediately upstream of the compressor inlet.

The main motor will be a 24,000 HP (17,700 KW), brushless exciter, synchronous machine rated for full power operation at 3600 rpm. The motor will be totally enclosed with a missile proof housing containing the rotor, stator, brushless exciter, bearings, bearing lubrication system and heat exchanger for cooling. The voltage rating will be 13,200 volts at full load with starting being accomplished at zero frequency by a non-safety class, variable frequency controller.

The pony motor will be a 3 phase induction motor rated at approximately 300 HP, suitable for variable speed operation over a speed range of 150 to 1800 rpm. This motor will be safety-related and will be coupled to the top end of the main motor drive shaft. An overrunning clutch is built into the pony motor to prevent rotation when the main motor is operating.

The main motor controller will be a solid-state adjustable frequency power supply with output rating compatible with motor operating and stability requirements over the entire speed range. The power supply consists of two three-phase thyristor bridges linked together through a smoothing reactor (DC link). One three-phase bridge will be connected to the facility power system and will operate as a phase-controlled rectifier to supply power to the DC link. The second bridge will be connected to the synchronous motor and will invert the power from the DC link back to variable frequency current to power and control the circulator main motor.

The electrical power for the pony motor will be from a separate controller. It will be compatible with the operating and stability requirements of the pony motor over its entire speed range.

Electrical power from a local utility is supplied to an outdoor high voltage switchyard which adjoins the building adjacent to the side bay containing the motor controllers. A 138 kV transmission line delivers electrical power to the site where it is stepped down through a power transformer to the required voltages for the helium circulator electric motor drive and for facility auxiliary power needs. Another power transformer, identical to that which would be employed for the development plant, is positioned between the facility main power transformer and the helium circulator main motor controller. This motor controller is a large solid state thyristor device which converts the 60 hertz alternating current to direct current, and then reconverts it to variable frequency alternating current to power and control the circulator motor.

Facility auxiliary power is supplied at 4.16 kV. Four outdoor power transformers, located adjacent to the electrical equipment room on the other side of the building, provide power to two double ended 480 volt load centers for smaller auxiliary electrical loads. The electrical equipment room houses the 480 volt load centers, motor control centers, panelboards, dry transformers for stepping the voltage down for 120/240 volt service, and the battery room with its chargers and batteries.

The 17,950 square foot (gross) building is a steel framed braced structure with insulated metal siding and roofing. It has a high central main bay, flanked on one side by a slightly lower two-story bay and on the other side by a similar but only partial two-story bay. A test pit is located at one end of the central main bay to house the circulator test vessel and essential support service modules. A motor dissassembly pit is located adjacent to the test pit. At the other end of this main bay is a receiving area with a high roll-up door to accommodate delivery of the main helium circulator radial compressor and its drive motor. Storage space for a motor and a radial compressor assembly is located at the end of and to the side of the truck delivery area. A 100 ton overhead crane runs the full length of the central main bay.

Approximately half of the auxiliary bay on the other side of the central bay is made up of a two-story section containing electrical equipment on the second floor (480 volt switchgear, motor control centers, panelboards and a battery room) and mechanical equipment on the first floor (air compressor, HVAC equipment, water treatment equipment, and a helium dryer module). The other half of this auxiliary bay is a controlled environment high ceiling room with a 20-ton crane for disassembly and maintenance work on such equipment as the main helium circulator radial compressor assembly and its drive motor rotor and bearing assembly. A transfer dolly running on a short section of railroad tracks will move the equipment from the central bay into the controlled atmosphere room for pickup by the crane in that room.

The two-story auxiliary bay flanking the central bay will house the main and pony motor controllers on the second floor. A forklift truck room, small machine shop, storage room, locker and toilet facilities, control room and an office will be located on the ground floor.

Outside of the building, at the end of the central bay, is located a covered gas bottle storage area. In this area, the helium and nitrogen gas supply and storage bottles are piped to the headers of their respective systems.

A vehicular parking lot is located at the end of the building, beyond the high voltage switchyard and the gas storage bottles. A driveway along the electrical and mechanical equipment room side of the building connects the parking lot and the central bay receiving area to the street.

Beyond the parking lot are located the Dowtherm G storage tank, its air cooled heat exchanger, expansion tank and pump. Adjacent to the Dowtherm equipment are the facility cooling water heat exchanger, cooling water expansion tank, and pumps.

The total facility occupies a site approximately 280 feet by 480 feet, enclosed by a 6 foot high chain link fence topped with barbed wire. The site layout and building arrangement assume a level site.

The facility is tentatively located in Sorrento Valley adjoining GAC's existing facilities in San Diego, California. This selection permitted the specifying of site related data which would most likely be typical of the site ultimately chosen.

1.6 PROJECT CRITERIA

The Ralph M. Parsons Company conceptual design effort for the facility is based upon General Atomic Company supplied criteria and information, applicable regulator agency published requirements, and the application of state-of-the-art engineering. General Atomic Company supplied documents which constitute criteria, requirements and relevant information are those

listed below; amended, corrected or augmented by correspondence or by information conveyed at meetings or in telephone conversations documented in Parsons Minutes of Meeting and Record of Telephone Calls.

Doc. No. 902712, Issue #2, dated 12/8/76, NSS Electrical System Requirements
PLC, Equip. No. N-2101, 2 shts, dated 11/27/78, Circulator Motor Controller
PLC, Equip. No. N-2102, 2 shts, dated 4/27/78, Pony Motor Controller
PLC, Equip. No. S-2200, 1 sht, dated 2/24/78, Circulator Service System Module Elevations
PLC, Equip. No. S-2201, 2 shts, dated 2/24/78, Helium Dryer Module
PLC, Equip. No. S-2203, 3 shts, dated 2/24/78, Bearing Water Module
PLC, Equip. No. S-2205, 3 shts, dated 2/24/78, Shutdown Bearing Water Module
PLC, Equip. No. M-2101, 2 shts, dated 4/27/78, Electric Motor Drive for Main Circulator
PLC, Equip. No. (none), 6 shts, dated 2/1/78, Main Helium Circulator Assembly
PLC, Equip. No. (none), 2 shts, dated 2/1/78, Diffuser for Main Circulator
PLC, Equip. No. (none), 2 shts, dated 2/1/78, Main Loop Isolation Valve Assembly
Statement of Work, Rev. 1, 35 pages, dated 2/22/78
Doc. No. 903566, Issue A, 35 pages, dated 3/10/78, Spec. for GCFR Main Helium Circulator Tests (Draft)
Schedule 44, Construction Project Data Sheet, 9 pages (Draft)
Dwg. 023859, Issue A, Block Diagram GCFR Main Circulator T/F
Dwg. 023963, Issue A, 3 shts, P&I Diagram Main Circulator Service System T/F
Dwg. 023942, Issue A, 2 shts, GCFR Circulator Test Facility Electric Cable Diagram
Dwg. EE-2604, Issue A, 1 sht, Proposed GCFR Circulator Test Facility
Dwg. 023937, Issue A, 1 sht, Marked up 2/26/78 by L. Weaver, Test Vessel Main Circulator Electric Motor Driven
Dwg. 023837, dated 2/3/78, 1 sht, GCFR Side Penetration Valve Actuator
Dwg. 023835, Issue 1, dated 1/12/78, GCFR Demonstration Plant 300 MWe, Circulator, Electric Drive, External (Marked up by GAC)
Soil Investigation Report - Proposed Doublet III Site, dated 1/30/78, prepared by Southern California Testing Laboratory, Inc.
Ltr. L. M. Weaver to D. R. Nelson, dated 3/27/78, "Comments on Preliminary Vessel and Facility Schedules"
Dwg. EE-2608, Issue A, 1 sht, dated 3/1/78, Schedule-GCFR Circulator Test Facility
Ltr. L. M. Weaver to D. R. Nelson, dated 3/23/78, "GAC Review of Basis of Design entitled, 'Conceptual Design of a GCFR Main Helium Circulator Test Facility', March 10, 1978"
Ltr. L. M. Weaver to D. R. Nelson, dated April 17, 1978, "GAC Review of Task III Electrical Supply and Distribution System Design"
Ltr. L. M. Weaver to D. R. Nelson, dated April 27, 1978, (no subject - Concerns Westinghouse information about the main motor, the pony motor and their controllers)
Memo 7803909152-GCFR, dated 3/9/78, "Design Basis Depressurization Rate for GCFR Circulator Test Facility," H.S. Chung to L.M. Weaver
Memo GDC:045:78, dated 3/9/78, "GCFR Telecon Record dated 3/7/78 between Don Nelson and L. Weaver Regarding Electrical Questions," G. D. Cowles to L. Weaver

Doc. dated 8/3/77, San Diego Coast Regional Commission, "Information on San Diego Coast Regional Commission Proceedings to Permit Matters"
Memo 780314152 - GC 3228, dated 3/14/78, "GCFR Circulator Test Facility - Sound Pressure Levels Outside Vessel and Motor," L. J. Halvers to L. M. Weaver
City of San Diego Proposition "D", "Initiative on Coastal Zone Building Height," voted in by the majority of the Qualified Voters of the City of San Diego at the Special Municipal Election to be held on Tuesday, November 7, 1972
City of San Diego Environmental Quality Department, "Appendix D, Environmental Assessment Form"
San Diego Coast Regional Commission, "Interpretive Guidelines" dated 7/12/77
San Diego Municipal Code, Article 9.5, "Noise Abatement and Control - Division 1, General", dated 3/22/77

1.7 DESIGN UNCERTAINTIES

The GAC criteria specified personnel occupancy duration in the test pit and on the main operating floor above the pit to be eight hours per shift. Calculated noise levels from the helium circulator and its motor drive are such that the 90 db OSHA eight hour exposure limit can be met when a unique acoustic lining of the circulator vessel pit is employed. This lining is in the form of ceramic blocks, shaped as Helmholtz resonators to alleviate wall reflections. With this wall lining the noise level attenuation is sufficient to satisfy the OSHA limit. If the noise levels generated by the circulator radial compressor impeller and the main motor turn out to be higher than the calculated value, an eight hour personnel occupancy of the central bay may not be permissible.

1.8 ALTERNATIVES CONSIDERED

During the course of execution of the conceptual design, several trade-off studies were made. The more significant were:

- A full diameter flanged circulator vessel versus a smaller opening top flanged vessel.
- A drip proof circulator compressor motor housing versus a totally enclosed housing.
- Motor controller location on the ground floor versus location on the second floor.
- Dry cooling towers versus wet cooling towers.

- Liquid versus air cooling for the main motor controller.

A discussion of each of these alternatives is given in Section 7 of this report.

1.9 MANAGEMENT PLAN

A management plan will be developed based on a work breakdown structure that subdivides the work into manageable elements and assigns organizational responsibility for achieving technical objectives for each element within cost and schedule constraints. Control of established technical, budget and schedule baselines will be exercised through a set of operating procedures tailored for the program. Progress on the program will be monitored by GAC and the DOE offices in San Francisco and Washington, D.C. Reviews of design, cost and schedule performance will be conducted on a regular basis.

The preparation of the management plan will coincide with the architect engineer selection preparation. After the initial issue, the General Atomic Company will continually review the need for implementing additional management controls.

SECTION 2

BASIS OF DESIGN

2.1 GENERAL

The GCFR Helium Circulator Test Facility will consist of an unattached free standing structure housing all of the equipment and facilities necessary to support personnel and to permit experimental testing and verification of the helium circulators, the diffusers, and the isolation valves. The test facility will be complete unto itself with all necessary services and utility connections.

Codes, standards and regulatory agency rules and regulations will be referenced in each of the document sections which follow. A few are sufficiently general that they are broadly applicable across most or all of the design effort. These are listed here. Others of a more specific nature are included in the individual sections, as appropriate.

ERDA Manual Appendix 6301, "General Design Criteria"

The Uniform Building Code (UBC)

Occupational Safety and Health Administration (OSHA) Standards, 1976 Edition.

2.2 SITE AND UTILITIES

The exact site for this facility has not been fixed; therefore, assumptions have been made to permit the design to proceed. The assumptions made are:

(1) The site will be in the Sorrento Valley.

(2) The topography of the site will be flat, with adequate drainage.

(3) A street or road will abut the site on at least one side.

(4) Utility services of potable water, fire water and sewer will be available from under the center of the street or road.

(5) Electrical power will be available from a 138 kV transmission system, extended to the facility substation.

(6) All current building and environmental codes, limitations, etc., appropriate to the Sorrento Valley geographical area are presumed to apply.

2.3 CIVIL

The basis for the civil engineering effort is as described below:

2.3.1 CODES AND STANDARDS

The following codes and standards will be applied:

State of California Department of Transportation, "Construction Manual"

American Society of Civil Engineers (ASCE) "Manual of Practice No. 37, Design and Construction of Sanitary and Storm Sewers"

American Iron and Steel Institute (AISI) "Handbook of Steel Drainage and Highway Construction Products"

2.3.2 SOILS CONDITION

The soils investigation work performed in 1974 by Southern California Testing Laboratory, Inc., for the proposed Doublett III site is assumed applicable for this facility.

2.3.3 GROUND PREPARATION

2.3.3.1 Earth Work

The earth work will consist of:

(1) Excavating earth at the building site.

(2) Segregating, handling, stockpiling and disposal of excavated material.

(3) Working grades to provide adequate drainage.

(4) Backfilling and compacting of backfill.

2.3.3.2 Roads, Paths and Parking

Driveways, roadways and parking areas will be asphaltic surfaced. Walkways will be concrete.

2.3.3.3 Electrical Area Surface Finishing

Ground areas under and around equipment in the electrical substation and outdoor metal-clad switchgear and transformers will be surfaced with crushed rock.

2.3.4 FENCING

A chain link fence 6 feet in height will be provided surrounding the site, with a 20 foot double swing vehicle gate and a single personnel gate at the entrance.

2.4 STRUCTURAL

The design basis for structural work will be as follows:

2.4.1 CODES AND STANDARDS

Applicable codes and standards are:

American Concrete Institute (ACI), ACT 318-71, "Building Code Requirements for Reinforced Concrete"

American Institute of Steel Construction, "Manual of Steel Construction", Seventh Edition (as amended to date)

American National Standards Institute, ANSI A58.1-1972, "Building Code Requirements for Minimum Design Loads on Buildings and Other Structures"

American Society of Testing Materials - Applicable Specifications

American Welding Society, AWS D1.1, "Standard Code for Welding in Building Construction"

American Iron and Steel Institute, "Specifications for the Design of Light Gage Cold Formed Steel Structural Members".

2.4.2 DESIGN LOADS

Design loads and forces for all structures will include these loads: live, wind, earthquake, impact, special, and miscellaneous loads as defined below. Equipment loading will be used, as applicable, if equipment loads including impact are greater than the minimum design loads over the area occupied by the equipment. All supports will be designed for the maximum live load that it is possible to put in or on the equipment.

2.4.3 DEFINITIONS AND LOADING CRITERIA

The following definitions and loading criteria will be used:

2.4.3.1 Dead Loads (DL)

Dead load is the vertical load due to the weight of all permanent structural and nonstructural components of a structure, such as walls, floors, roofs, piping, equipment, heating, ventilating, and air conditioning systems. The vertical and lateral pressures of liquids will also be treated as dead loads, as provided in Section 9.3.5 of ACI 318-71.

2.4.3.2 Live Loads (LL)

Live load is the load superimposed by the use and occupancy of the structure not including seismic load, or dead load.

The following live loads will be used:

Roof	20 psf
Floor	100 psf
Stairs & Walkways	100 psf
Office Area	50 psf

2.4.3.3 Construction Loads

Surcharge outside and adjacent to the structure will be 300 psf or 20,000 lbs wheel load, whichever is governing.

2.4.3.4 Crane Loads

The structural system will be designed for impact and horizontal loads in accordance with AISC Manual of Steel Construction.

2.4.3.5 Groundwater Table

The groundwater table will be taken as 8 feet below grade level.

2.4.3.6 Wind and Tornado Load

The design wind load will be twenty (20) pounds per square foot. Tornado loads will not be considered.

2.4.3.7 Seismic Loads

The facility will be designed for Zone 3, in accordance with Section 2312 of the Uniform Building Code.

2.4.3.8 Foundations

Bearing pressure will be limited to 2500 psf on 3 feet of compacted backfill for foundations not supported on piles.

2.4.4 BUILDING

The building will be a steel framed braced structure, with the lateral forces carried from the roof to the foundations by diagonal bracing. The building will be capable of supporting two bridge cranes, one in the test and receiving area and one in the controlled environment disassembly and maintenance area.

The building will contain an open pit in the test vessel area with floor decking covering most of the pit area, and with a separate motor disassembly pit to one side. The rest of the floor area will be concrete on grade.

2.4.5 FOUNDATIONS

The footings, pile caps, and pit shall be of 3000 psi concrete, reinforced with A615 Grade 40 reinforced steel. The building columns not supported by the pit wall will be supported on 12-3/4 inch diameter concrete-filled pipe piles. The pit base slab will be supported on 3 feet of compacted non-expansive fill. The bottom of footings will be a minimum of 5 feet below existing ground surface.

2.5 ARCHITECTURAL

The basis for design for architectural work will be as follows:

2.5.1 CODES AND STANDARDS

Additional codes and standards applicable to this work will be:

City of San Diego Zoning Department and Building Inspector Department, "Regulations and Requirements"

City of San Diego Planning Commission, Section 101.0438 "Science-Research (SR) Zone"

State of California Energy Resources Conservation and Development Commission, "Energy Conservation Standards for New Nonresidential Buildings"

National Fire Protection Association (NFPA), "National Fire Codes and Standards"

San Diego Municipal Code
Article 9.5
Noise Abatement and Control

2.5.2 GENERAL FEATURES

The building will be an earth bermed rectangular steel framed structure with insulated metal siding and a shallow sloped insulated acoustical roof deck. Doors for equipment and personnel access will be provided as required. Gross floor area includes 12,285 square feet on the ground floor and 5,665 square feet on the second floor.

2.5.3 FUNCTIONAL ARRANGEMENT

The building will contain a single storied central high bay, flanked on one side with a two-story bay and on the other side by a partial two story bay. The arrangement of room areas and equipment within these bays is predicated on their functional relationships to one another and to the circulator test vessel and auxiliary systems.

The widest and highest bay of the building will be the single story receiving and test bay area. Provision will be made for truck delivery of large test equipment, such as the circulator radial compressor and the compressor drive motor. A test pit will be located at the opposite end of this bay to house the circulator test vessel and service modules. A large overhead crane will run the full length of this bay to install or remove the ciculator radial compressor assembly, its motor or any of the service modules. The reach of the crane will be such as to readily service all required equipment and an area three feet on all sides of the circulator test vessel. The cable length will be sufficient to permit the crane hooks to reach the bottom of the pit. Provision will be made for placement or removal of the circulator vessel through a removable wall panel in the end of the building.

The bays on each side of the main bay will be a two-story bay on one side and a partial two storied bay on the other side, arranged to accommodate motor control equipment, mechanical support equipment, electrical supply and distribution equipment, an office, a control room, a locker/toilet complex, a shop, a storage room, and a battery operated lift truck storage and charging room.

Locker/toilet room facilities for both male and female personnel will be provided, but with no special consideration for handicapped workers. Operating and maintenance personnel are estimated at a maximum of six people per shift, with a maximum of twelve for all shifts.

Some support systems equipment, including heat exchanger, gas cylinder storage and electrical switchgear, will be located outside but adjacent to the building. The gas cylinder storage area will be shaded by a free standing canopy structure.

2.5.4 CONSTRUCTION

Materials and construction methods will be selected to best satisfy the following considerations:

Structural Integrity

Safety and Health

Noise Control

Energy Conservation

Resistance to Elements

Fire Resistance

Maintenance

Aesthetics

Life Cycle Costs

2.6 MECHANICAL

The basis of design for the mechanical work will be as follows:

2.6.1 CODES AND STANDARDS

The latest edition of the following codes and standards will be used, as applicable, for the design of mechanical equipment and systems:

American Society of Mechanical Engineers (ASME), "Boiler and Pressure Vessel Code", Division VIII

National Fire Protection Association (NFPA), National Fire Codes and Standards

National Plumbing Code

Applicable Codes by the American Society for Testing Materials (ASTM)

National Electric Manufacturers' Association (NEMA) Standards

Underwriters Laboratories (UL), Inc. Standards

2.6.2 SYSTEM DESCRIPTION

2.6.2.1 General

The GCFR Helium Circulator Test Facility is designed to provide systems and equipment to conduct a series of tests of the circulator radial compressor, its motor drive and associated equipment. The test facility will be designed for full circulator design conditions which will permit testing at the power, speed, pressure, temperature and flow conditions present in the 300 MW(e) demonstration plant.

2.6.2.2 System Description

The test facility will include the following:

(1) Helium Loop and Auxiliary Systems

a. Helium Loop
b. Helium Cooling System
c. Helium Storage & Supply System
d. Test Vessel Vacuum Pump
e. Rapid Depressurization Valve

(2) Circulator Service System (By GAC)

a. Helium Dryer Module
b. Bearing Water Module
c. Shutdown Bearing Water Module

(3) Utility Systems

a. Air System
b. Nitrogen Gas System
c. Deionized Water System
d. Cooling Water System
e. Potable Water System

2.6.2.2.1 Helium Loop and Auxiliary System

(1) The Helium Loop is a helium flow circuit, contained within a test vessel, which will permit simulation of expected reactor operating condition for testing the radial compressor. This flow circuit will contain a diffuser, an isolation valve, appropriate helium ducting, a Dowtherm/helium heat exchanger, restrictor valves and appropriate controls and instrumentation.

(2) Helium Cooling System

The helium cooling system will function to automatically maintain the helium temperature in the Helium Loop at the desired operating conditions and remove the energy added to the loop by the radial compressor. The system will consist of a Dowtherm/air heat exchanger, the helium/Dowtherm heat exchanger of the Helium Loop, appropriate pumps, piping, valves and controls.

(3) Helium Supply and Storage System

This system will provide charging and makeup helium to the Helium Loop and provide for helium storage when the Loop is to be opened for changes or maintenance. This system will contain gas storage bottles, compressors, a helium dryer, piping, valves and appropriate controls and instrumentation

(4) Test Vessel Pump

The vacuum pump will permit evacuation of the test vessel prior to helium filling and will permit drying the vessel out in the event of malfunctioning of radial compressor service system.

(5) Rapid Depressurization Valve

This will be a rapid depressurization system, the purpose of which is to permit the Helium Loop test components to be subjected to a rapid depressurization environment, simulating a pipe break. The system will consist of a valve and appropriate piping, to discharge the blowdown gas out through the building roof. Different sizes of pipe breaks may be simulated by adjusting the valve controller.

2.6.2.2.2 Helium Circulator Service System

The helium circulator service system consists of helium dryer, bearing water and shutdown bearing water modules. These modules provide water for circulator bearing lubrication and dry helium for shaft sealing. This will be a safety class I system.

The location of the bearing water and shutdown bearing water modules is critical for proper operation of the circulator bearing system. A datum elevation for locating the modules is specified as 10 feet below the top face of the vessel main motor mounting flange. Also, the bearing water storage tank must be located 35 feet below the motor mounting flange top face.

Cooling water and electrical connections will be provided to the modules.

2.6.2.2.3 Utility Systems

(1) Compressed Air System - Compressed air is required to meet the need for instrument control and plant air requirement.

(2) Nitrogen System - Gaseous nitrogen is required to blanket the test vessel, pressurize the accumulators of the shutdown bearing water module and pressurize the Dowtherm expansion tank. The system will provide nitrogen to this equipment and provide for recovery and storage of the nitrogen.

(3) Deionized Water System - Deionized water is required for the bearing water module and for the shutdown bearing water module. A water treatment system, storage, pumping, piping, controls and instrumentation will be provided.

(4) Cooling Water System - Cooling water is required for the bearing water module, helium dryer module, and the main motor cooling. Appropriate pumping, storage heat dissipation, instrumentation and control will be provided.

2.7 BUILDING SERVICES

The basis of design for building services, which includes heating and ventilation systems, fire protection, and plumbing, will be as follows:

2.7.1 CODES AND STANDARDS

The following Codes and Standards will be used as applicable in the design:

American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)

Sheet Metal and Air Conditioning Contractors National Association (SMACNA)

Uniform Plumbing Code, 1976 Edition

National Fire Protection Association (NFPA)

Plumbing and Drainage Institute (PDI)

American Society of Mechanical Engineers (ASME)

American Society of Testing and Materials (ASTM)

American National Standards Institute (ANSI)

American Water Works Association (AWWA)

Cast Iron Soil Pipe Institute (CISP)

2.7.2 HEATING AND VENTILATION SYSTEMS

HVAC systems will be provided for five general areas. These include a system for the office, control room, and toilet/locker room area; one for the test vessel, the bearing water module and the shutdown bearing water module; the facility shop, storage, the helium dryer module, the compressed air system and the water treatment equipment and other mechanical and electrical equipment; the motor controller area; and a controlled atmosphere room suitable for disassembly and inspection of the motor and compressor assembly. The control room and disassembly room will be maintained at a slightly higher air pressure with respect to the other areas to limit intrusion of dust.

HVAC Requirements Areas	Temperature	% RH	Air Flow Rate
Office Control Room, Toilet/Locker Room	70°F Min. 78°F Max.	N/A	As required to maintain temperature and a slight positive pressure in the control room.
Test Vessel, Bearing Water Module and Shutdown Bearing Water Module Areas	55°F Min. 104°F Max.	N/A	As required to maintain temp.
Facility Shop, Storage, Helium Dryer, Air Compressor and Water Treatment Area	55°F Min. 104°F Max.	N/A	As required to maintain temp.
Circulator Motor and Pony Motor Controller Area	55°F Min. 104°F Max.	N/A	As required to maintain temp.
Controlled Environment Area	75°F $\pm$ 2°	30% Min 50% Max	As required maintain temp. and positive pressure
Janitor Closet and Restrooms	N/A	N/A	2 CFM/FT^2

The controlled environment area will be maintained at a normal positive pressure of +0.10 inches WG relative to atmosphere.

2.7.3 FIRE PROTECTION SYSTEMS

2.7.3.1 Function

The fire protection system within the Helium Circulator Test Facility will be designed to:

(1) Detect, extinguish, limit, and control fires and their resultant hazards and damaging effects.

(2) Provide sufficient capacity and capability for detecting and suppressing fires and transmitting alarms both locally and to the central control area.

(3) Provide equipment including portable fire extinguishers to aid personnel in the control of incipient fires and in manual fire extinguishing.

(4) Provide a wet pipe primary sprinkler system throughout the facility, including the transformer area, except for the control room and the motor control modules where a Halon 1301 fire suppression system will be used.

2.7.3.2 Criteria

(1)	Outside Temperature	Summer 98°F Winter 38°F
(2)	Inside Temperature	Summer 81°F Winter 68°F
(3)	Earthquake Zone	(Later)
(4)	Ordinary Hazard Area	NFPA No. 13

2.7.3.3 System Description

The wet pipe sprinkler system will be designed in accordance with the requirements of NFPA-13 for Ordinary Hazard Occupancies, Group 1.

Fire hose cabinets will be provided in accordance with the requirements of NFPA-10, Class as required for the area.

A Halon 1301 fire suppression system will be provided in the control room area. A Halon supply system will be provided for the motor controller modules. The system will be designed in accordance with the requirements of NFPA-12. The system will combine highly effective detection

devices with specifically designed components for high speed agent discharge. The system will be electrically operated and have a normal design discharge time of less than 10 seconds. Agent storage containers will be strategically located throughout the area and at each cabinet or module to be protected, eliminating the need for expensive piping. The resultant high speed suppression of a fire reduces property damage and the thermal products of decomposition to the lowest possible level. The system proposed will be designed for total flooding of the protected areas, both above and below the floor.

2.7.4 PLUMBING SYSTEM

2.7.4.1 Function

The function of the domestic water system is to supply potable water throughout the building. The domestic water system will be designed to provide cold and/or hot water to the points of domestic water usage such as shower, lavatories, sinks, water closets, electric (drinking) water coolers, etc., located in the Helium Circulator Test Facility. The hot and cold domestic water system pressure will be maintained at 40 psi. The hot water temperature will be maintained at 140°F. The sanitary system will drain off sanitary waste from the building. Domestic water and sanitary drainage piping will be extended to the middle of the street abutting the site.

2.7.4.2 System Description

(1) The plumbing system will include:

- o All plumbing fixtures
- o Electric water cooler and electric water heaters
- o Sewer line from building to center of street
- o All interior piping, hot water, cold water, floor drains, roof drains, sanitary sewer, and vent piping.

(2) Floor drains with automatic fill traps will be provided in rooms with the following equipment:

- o Pumps, hot water heater and air conditioning equipment, etc. Also in the women's and men's change rooms and the janitor's room.

2.8 HELIUM CIRCULATOR VESSEL

The basis for design for the Helium Circulator Test Vessel will be as follows:

2.8.1 CODES AND STANDARDS

The latest edition of the following codes and standards will be applied, as appropriate:

American Society of Mechanical Engineers (ASME), "Boiler and Pressure Vessel Code - Section VIII, Division 1"

Applicable standards of the American Society for Testing Materials (ASTM)

Applicable standards of the American National Standards Institute (ANSI)

2.8.2 VESSEL DESCRIPTION AND CONDITIONS

The vessel will be cylindrical in shape with elliptical heads at the top and bottom. The top head will provide for mounting of the main motor on the head and for mounting of the helium circulator within the head. Suitable nozzles, valve operator penetrations, and manholes will be provided in the vessel and vessel bottom head. The vessel will be supported by a skirt welded to the bottom head and bolted to the test pit floor.

Vessel Inside Diameter	Approx. 12 ft. - 10 in.
Vessel Length	As required - approx. 27 ft.
Design Pressure	1450 psia
Design Temperature	650°F
Material	As required
Circulator Flange Bolt Circle Diam.	70.5 in.
Circulator Motor Flange Bolt Circle Diam.	
Max. Pressure Drop Across Helium Circulator Restrictor Valve	96 in. 60 psi
Material of Vessel Internals SA-285 C Plates, A-106 B Pipe	Carbon steel
Dowtherm Heat Exchanger Material	SA-210 GRA-1
Weight of Radial Compressor Assembly	17.5 tons
Vessel Interior Coating	High temperature zinc, similar to Wisconsin 1100 series coatings
Weight of Main Motor and Pony Motor	79 tons

2.9 ELECTRICAL

The basis of design for the electrical work is described in the following paragraphs.

2.9.1 CODES AND STANDARDS

The following codes and standards will be used as applicable in the design:

National Electrical Code

National Electric Manufacturers Association (NEMA) Standards

American National Standards Institute (ANSI) Standards

Underwriters Laboratories, Inc. (UL) for Master Labeled Lightning Protection Systems

State of California Division of Industrial Safety, High Voltage Electrical Safety Orders

State of California, Division of Industrial Safety, Electrical Safety Orders

State of California General Order No. 95

IPECA Specification for 15 & 5 kV Cross-Linked Polyethylene Insulated, Shielded Power Cables with a Polyvinyl Chloride Jacket

IPECA Specification for 600 Volt, Cross-Linked Polyethylene Insulated, Power Cables

IPECA Specification for Control and Instrumentation Cables, for Non-Flammable, Shielded and Non-Shielded, Single and Multi-Conductor Cables.

2.9.2 POWER SYSTEM

The power system supplying the facility will consist of the following classes of power.

2.9.2.1 Outdoor 138 KV Switchyard

The purpose of this is to transform and control the power from the electric utility's incoming 138 kV, 3 phase power line to the test facility's distribution systems.

The 138 kV switchyards will include:

(1) Incoming 138 kV, 3 pole, group operated disconnect.

(2) Incoming 138 kV, 3 pole, 3 tank oil circuit breaker.

(3) 138/24/4.16, 3 phase, 3 winding main power transformer.

(4) 138 kV outdoor metering unit with:

Potential and current transformers
Outdoor metering cabinet and instruments

(5) 24/13.8/13.8 kV, 3 phase, 3 winding main input power transformer (by GAC).

(6) 15 kV switchgear unit with 2- 1200 ampere, 13.8 kV air circuit breakers (by GAC).

(7) 15 kV, 1200 ampere metal enclosed bus to circulator's main motor.

(8) 5 kV switchgear unit with:

1 - 1200 ampere incoming air circuit breaker
3 - 1200 ampere outgoing air circuit breakers for pony motor fdr, for two feeders to 4.16/.48 kV transformer stations.
1 - Spare space for a future air circuit breaker.

(9) Remote control, protective relaying systems, indicating circuits, electrical instrument circuits and alarms to the test facility's main control room.

(10) Switchyard to be arranged with 138 kV strain bus for incoming line and pedestal mounted disconnect; cable bus between disconnect and oil circuit breaker with a strain bus to main transformer and a 24 kV copper bar bus to the input transformer.

(11) Fence enclosure and gravel.

2.9.2.2 4.16 KV Power Distribution System

The 4.16 kV distribution system will consist of underground 4.16 kV feeder from switchyard to 4.16/.48 kV transformer station, which will include:

(1) 5 kV fused interrupter switchgear with four outgoing compartments.

(2) Four (4) 4.16/0.48 kV 1000/1150 kVA outdoor 3 phase transformers.

(3) Fence enclosure and gravel.

2.9.2.3 480 Volt Power Distribution System

The 480 volt power system will consist of two indoor double ended, three phase switchgear assemblies and the required 480 volt motor control centers. The 480 volt switchgear assemblies will be connected to the 4.16/.48 kV power transformers using 1600 ampere, 600 volt metal enclosed bus.

Motor loads greater than 100 H.P. will be controlled from the 480 volt switchgear by electrically operated air circuit breakers. Lighting transformers, welding outlets, battery chargers, immersion heaters, instrument power transformers and motor loads from 1/4 to 100 H.P. will be supplied power from the motor control centers by means of molded case circuit breakers or combination motor starters.

2.9.2.4 Lighting System

A three phase, 4 wire, 120-208 volt lighting system will be provided as required for an adequate lighting system with convenience outlets. The energy source will be 75 kVA 3 phase 480/120-208 dry type transformers connected to the motor control centers.

2.9.2.5 Instrumentation and Control Power

120 volt, single phase power for the instrumentation and control circuits will be supplied from special circuit breaker panels. These panels will be furnished power from the 480 volt motor control centers through 480/120 volt transformers, each with a Faraday shield.

2.9.2.6 125/250 Volt D.C. Power System

The D.C. power system will consist of:

(1) A 125 volt D.C. system for control circuits and control power supply to all electrically operated breakers. It will consist of a station battery, battery fuse panel; 125 volt D.C. distribution panels and one 3 phase 480 volts A.C. to 125 volts D.C. battery charger.

(2) A second 125 volt D.C. system for the power supply to D.C. valve operators and other small devices. It will consist of a station battery, battery fuse panel, 125 volt D.C. distribution panel and one three phase 480 volt A.C. to 125 volt D.C. battery charger.

(3) The two main 125 volt D.C. distribution panels will be connected by a normally open bus tie switch.

The battery room will be ventilated.

2.9.2.7 Grounding System

The grounding system will consist of a heavy copper cable grid, electrically connected to three copper electrode type ground wells. It will be a common ground mat utilized for both power and electronic circuits.

2.9.2.8 Raceways, Power & Control Cables

(1) Lighting and 480 volt power cables will be stranded copper conductors with 600 volt insulation. All tray and conduit runs will have 30% spare capacity. The smallest 480 volt power conductor will be No. 12 AWG.

(2) 15 kV & 5 kV Power Cables - All 15 & 5 kV power cables will meet the IPECA specifications for cross-linked polyethylene insulated shield power cables with a polyvinylchloride jacket. They will be installed underground in individual transite conduits and above ground in individual galvanized steel conduits.

(3) 15 kV Bus - The 15 kV bus for the 13.8 kV power feeder to the circulator's main motor will be totally enclosed, self-cooled, rated at 1200 amperes.

(4) The control and instrumentation cables will be insulated with a non-flammable insulation. The minimum size will vary from No. 14 AWG for switchboards to No. 12 AWG in the field. Only control and instrumentation cables will be installed in cable trays.

2.9.3 ELECTRIC MOTOR DRIVE

The electric motor drive system powers the circulator by means of a direct shaft coupling. A main motor, pony motor and associated controllers comprise the drive.

2.9.3.1 Main Motor

The main motor will be capable of variable speed operation and have an integral lubrication system. Cooling water will remove heat generated by electrical and mechanical losses. Electrical connections to the main motor will include leads for main power, rotor field, space heaters and instrumentation.

2.9.3.2 Pony Motor

The pony motor will be an induction machine connected to the main motor through an overrunning clutch. Its purpose is to drive the circulator compressor during certain conditions related to reactor operation. Cooling will be provided by the same heat exchanger as for the main motor. The pony motor is IEEE Safety Class IE.

2.9.3.3 Main Motor Controller

This controller furnishes variable frequency electrical power to the main motor. A transformer, switchgear and a solid-state rectifier/inverter unit comprise the controller. Cooling for the solid-state portion will be by water. This controller is non-safety class.

2.9.3.4 Pony Motor Controller

The pony motor controller will be a solid-state, forced commutated power supply designed to IEEE Safety Class IE requirements. Cooling will be by forced air drawn from and exhausted to the motor controller room.

2.10 INSTRUMENTATION AND CONTROL

A multiplex control and instrumentation system will be provided in the facility in order to evaluate its sensitivity to the electromagnetic interference (EMI) generated by the variable frequencies, voltages and currents present in the motor controllers. This multiplex system will be similar in concept to the GCFR demonstration plant system.

Parallel hard wiring will be provided for all critical control, alarm and instrumentation functions so that if problems occur in the multiplex system, no equipment damage will result. Following a successful period of operation with the multiplex system, the hard wiring will be disconnected and operation will be entirely by multiplex signals.

The majority of instrumentation measurements taken in the facility will be used to evaluate the performance of the radial compressor assembly, diffuser and isolation valve. A data acquisition system will be provided to record this data via the following readout and data gathering components:

- Low speed strip chart recorders
- Oscillographic strip chart recorder
- Tape recorder
- Data printer
- Spectral analyzer

The bulk of the instrumentation will be housed in the control room and connected by appropriate transmission devices to their sensors. The electrical cables and pneumatic lines will be run in appropriate cable ways or trays. Provision will be made for isolation of low level signals, intermediate signals and 120 volt control cables.

A computer type floor will be employed in the control room for easy routing of instrument connections. Provision will be made for both top and bottom entry to the control room to facilitate routing. The control room will be sized to adequately accommodate all intended instrumentation and control devices.

2.11 TEST SYSTEMS

The helium circulator, diffuser and isolation valve comprise the GAC designed ASME Safety Class I test systems.

2.11.1 HELIUM CIRCULATOR

When installed in the GCFR demonstration plant, the primary function of the circulator will be to force cool helium through the reactor core. This function is simulated in the test facility by the flow resistance produced in the flow restrictor valves of the helium loop. The circulator design requirements form the basis for the following facility helium loop requirements:

2.11.1.1 Design Requirements

Fluid	Helium
Weight flow, lb/sec	542
Inlet Temperature, °F	577
Inlet Pressure, PSIA	1240
Outlet Temperature, °F	600
Pressure Rise, PSI	60
Rotating Speed, RPM	3600
Shaft Power-in, HP	23700

2.11.1.2 Limiting Parameters

Maximum design helium temperature	650°F
Maximum design helium pressure	1450 PSIA

2.11.1.3 Transient Parameters:

(1) The helium loop component operation shall remain functional after a circulator trip from a full power, full speed condition.

(2) The circulator bearing auxiliary systems shall remain fully operational following a circulator trip.

(3) The maximum heatup rate for the helium loop is 600°F/hr.

2.11.2 DIFFUSER

The diffuser decelerates the helium flow from the circulator radial compressor thereby converting part of the flow kinetic energy into pressure. The operating requirements for the diffuser are the same as those of the circulator.

2.11.3 ISOLATION VALVE

The primary function of this valve is to prevent reverse flow through a primary coolant main loop when the associated circulator is not operating. This check valve function cannot be exactly duplicated in the facility because there is only one simulated primary coolant loop rather than three in parallel as there would be in the GCFR development plant. However, the mechanical characteristics of the valve and actuator can be evaluated without difficulty over the same operating range as the circulator.

2.12 QUALITY ASSURANCE PROGRAM

A quality assurance program will be established for this facility to provide control over activities affecting the quality of structures, systems and components to an extent consistent with their importance to safety. The preparation of the quality assurance plan will coincide with the development of the management plan.

SECTION 3

SITE DESCRIPTION

3.1 LOCATION

The site for this facility is assumed to be the Sorrento Valley in the City of San Diego, California. The terrain is assumed to be flat with adequate drainage. A street or road is presumed to abut at least one side of the property. Right-of-way for the local electric utility to extend a 138 kV subtransmission line to the property is presumed available.

3.2 GENERAL ARRANGEMENT

The facility, as shown on drawing GA-01 in Section 9, is situated on a plot of land approximately 280 feet wide by 480 feet deep. The building is 105 feet wide by 117 feet deep and is partially surrounded by a 10 foot high earth berm. The truck receiving entrance, located at the front of the building, is shielded from the street by the earth berm and by landscaping greenery. The building is set back approximately 130 feet from the street. A driveway on one side of the building provides vehicular access to the receiving entrance at the front of the building and to the service and parking area at the rear of the building.

Four power transformers are located near the rear of the building between the side and the driveway. A covered nitrogen and helium gas bottle area is located immediately to the rear of the building, and a high voltage switchyard on the other side of the building. A facility cooling equipment area is at the rear of the parking lot.

The entire property is surrounded by a 6 foot high chain link fence topped with barbed wire with a personnel and vehicular access gate at the street. Property dimensions to the rear and sides of the building are established by a combination of equipment space and acoustic dispersion requirements.

3.3 GRADING AND DRAINAGE

The site is graded to blend with the existing contours sloping away from the building and down towards the main roadway. The drainage of the site is maintained by means of two ditches, one at the side of the access road, and the other down the inside of the fence on the switchyard side of the site. The two ditches drain into the ditch which runs beside the main road with a culvert supplied under the access road at the entrance to the site.

3.4 ROADS AND PARKING

A 20 foot access road is provided from the main road down the Electrical Transformer Station side of the building, providing access to the Electrical transformer station and the side entrance to the mechanical equipment room. It then continues around the back of the building ending at the switchyard. After entering the site the road branches off in front of the building giving truck access to the receiving entrance.

Parking is provided at the back of the building along side the road, and the paving has been extended to the personnel entrance. The road and parking area is constructed on 2 feet 6 inches of compacted backfill and has 6 inches of base course material.

3.5 UTILITIES

The piped utilities on the site include the potable water, fire water, and sanitary sewer.

3.5.1 POTABLE WATER

The potable water line enters the building in front of the switchyard at the storage room and turns down the side of the berms to connect to the water main at the main road. A gate valve is provided at the connection to the water main.

3.5.2 FIRE WATER

The fire water line loops around the site with hydrants located at the helium storage area and at the front of the building. The fire water main ties into the water main at the main road in two locations with gate valves located at each connection point.

3.5.3 SANITARY SEWER

The sanitary sewer line leaves the building in front of the switchyard at the storage room and continues out from the building until it reaches the drainage ditch. It follows the ditch until it reaches the main road and is then connected to the sewer main at the main road.

A clean out is provided at the 90^{o} turn and a gate valve is provided at the connection to the sewer main.

3.6 LANDSCAPING

The front, sides and rear of the building will be completely landscaped in order to enhance the structure and the site. A majority of the trees, shrubs and ground cover will be planted on the earth berm and between the

berm and the street. This landscape material will provide a natural screen to obscure the receiving (loading) area, the electrical switchyard and the electrical transformer station from the street view.

Landscaping materials will be selected from species commonly used for landscape purposes in the Sorrento Valley area. A complete irrigation system shall be provided for landscape maintenance.

3.7 FENCING AND SECURITY

A 6 foot high security fence topped with barbed wire will surround the designated site perimeter with a personnel gate and a vehicular access gate located at the driveway street entry.

Gate access to the site will be controlled electrically from the public address station. A telephone station will be provided at the gate for communication between arriving personnel and security control.

Generally normal industrial facility security requirements have been followed in the design of the security for this site. A 24 hour security surveillance is recommended.

3.8 ENVIRONMENTAL IMPACT ASSESSMENT

The site information used in preparing the facility conceptual design and the following environmental impact assessment is thought to be representative of the area in which the facility will ultimately be built. This area is located in Sorrento Valley, California near the existing General Atomic Company High Temperature Gas Cooled Reactor (HTGR) Circulator Test Facility.

3.8.1 DESCRIPTION OF THE PROPOSED ACTION

The proposed action is to construct a test facility for developing and qualifying the GCFR helium circulators, diffusers and isolation valves. This facility layout includes the following items:

1. Building with 17,950 square feet (gross).
2. Electrical switchyard.
3. Electrical Transformer station.
4. Air cooled heat exchangers.
5. Helium and nitrogen storage.
6. Driveways and parking spaces for twenty cars based on an anticipated occupancy of 12 persons.

The building contains a 38 x 117 foot centrally located one story, high bay, test area with slightly lower 32 x 117 foot partial two story bays on each side of the high bay. One end of the central bay contains

a 100 ton overhead traveling bridge crane and a below grade pit for the circulator test vessel and service system modules. A smaller pit is also provided for disassembly of the main motor. The other end of the central bay is a receiving area with a roll-up door to accommodate delivery of test items and equipment.

Half of the auxiliary bay on one side of the test area is made up of a two story section containing the electrical equipment room on the second floor and the mechanical equipment room on the first floor. The other half of this bay is a controlled environment assembly room equipped with a 20 ton overhead traveling bridge crane.

The remaining auxiliary bay contains the motor controller room on the second floor which runs the full length of the building. The ground floor provides space for a forklift truck room, a small facility machine shop, storage room, locker and toilet facilities, control room and an office.

Normal building communications, electrical, mechanical and fire protection systems will be provided. Site utilities will be extended to the facility from the access road.

Improvements to the 3.3 acres of land required for the facility include lighting, grading, drainage, paving and landscaping to comply with the scientific research character of the area. Access is provided by a publicly owned street which abuts the front of the property.

3.8.2 DESCRIPTION OF THE EXISTING ENVIRONMENT

The Sorrento Valley area is basically inhabited by a large number of small businesses performing industrial type work and is currently zone Science-Research (SR) or Manufacturing (M1-A). The terrain is basically flat with scattered areas of coastal sage shrubs. The majority of the area surrounding Sorrento Valley is undeveloped with small hills and canyons. The area to the Northwest is the Torrey Pines State Park. The area to the Southwest is partly populated with businesses performing research and development. Access to Sorrento Valley is provided by Interstate 5 with offramps both at the North and South ends of the valley. All the city streets located in the area are improved and capable of handling heavy loads.

3.8.3 POTENTIAL ENVIRONMENTAL IMPACT

3.8.3.1 Construction

The only adverse impact during construction will be that typical of excavation and construction. Provisions will be made to minimize air pollution through compliance with applicable Federal, State and local laws, codes and regulations. Requirements for environmental pollution control will be stated in the project specifications.

Water will be used to restrict dust to tolerable levels on access roads during construction.

A facility of this size will not require an extremely large labor force or impose any traffic problems on the area.

3.8.3.2 Operation

Air polution discharge from the facility will be insignificant since it is electrically powered. Very minor amounts of helium and nitrogen will leak into the air as a result of testing.

Heat will be dissipated by dry type forced air heat exchangers located at the rear of the property. The anticipated sound level at the site boundaries for these heat exchangers will not exceed 75 dba.

Vehicular traffic to and from the site will be minimal. After construction, it is estimated that approximately 50 trips a week would be generated involving 12 cars.

3.8.3.3 Coordination with Federal, State, Regional or Local Plans

Construction and use of this facility does not conflict with any known plan or program sponsored by agencies of the Federal Government, State of California or the City of San Diego.

3.8.4 DESCRIPTION OF ALTERNATIVES

The testing of the GCFR helium circulators, diffusers and isolation valves is an indispensable part of the development plant program such that the "no project" alternative is not acceptable. To GAC's knowledge, there are no existing facilities which could be modified for use in this testing program. Consequently, the facility must be built at GAC or some other location, such as a goverment owned site. However, a location remote from GAC will result in extensive personnel travel, with associated polution generation.

SECTION 4

BUILDING DESCRIPTION

4.1 ARCHITECTURAL

The architectural design of the GCFR Helium Circulator Test Facility includes the considerations and features as listed in the following paragraphs. The layout and arrangement of the building is shown on Drawings AR-01 thru AR-04 in Section 9.

4.1.1 GENERAL DESCRIPTION

4.1.1.1 Building Configuration

The facility is for the most part a rectangular building consisting of a 38 x 117 foot centrally located one story, high bay, test bay area with slightly lower, 32 x 117 foot, partial two story bays, flanking each side of the high bay.

Some support systems equipment including the electrical switchyard, the electrical transformer station, and a roofed gaseous storage area are located outside but adjacent to the building. Heat exchangers and air coolers are also located outside but farther from the building.

The building is of an industrial type with fluted flush metal siding panels framed with a bold metal trim at exterior corners, at the eaves and the rake. The roof is sloped at a minimum pitch and no parapet is provided.

4.1.1.2 Code Classification

According to the Uniform Building Code, 1976 Edition, this building is classified as a Group B-2 Occupancy throughout. The construction is Construction Type II-N, constructed of non-combustible materials with a fire retardent roof system. The maximum height of the building is two stories but the permissible maximum floor area is unlimited due to the provision of an approved automatic fire extinguishing system throughout and the fact that the building is entirely surrounded by yards not less than 60 feet in width.

4.1.1.3 Orientation

The heart of the facility is the circulator test vessel which of necessity is located in a below grade test pit near one end of the test bay area. A tractor trailer receiving (loading) area is provided at the other end of the test bay area to facilitate delivery of the main drive motor and compressor assemblies.

The office and control room are functionally linked to the circulator test vessel and are therefore located adjacent to it. The main personnel entry must be in a location where personnel ingress and egress can be monitored from the office. The City of San Diego Planning Commissions "Science-Research" regulations require one parking space per 500 sq. feet of gross area and parking is not allowed within 25 feet of any abutting street. Only 20 parking spaces are being provided because actual occupancy is for 12 persons total. Additional paved area is available for parking use. For this reason the office end of the building was oriented to the rear of the site with the receiving area to the front.

The earth berm around the building was provided in order to comply with the City of San Diego's Proposition "D" Initiative on Coastal Zone Building Heights. This limits the height of the building to 30 feet maximum, measured from the finish grade to the highest point of a flat roof. The earth berm and landscaping will effectively provide screening of the receiving (loading) area as required by the "Science-Research" regulations.

The electrical equipment and motor controller rooms are located on the second floor level adjacent to and flanking the test bay area. The electrical switchyard, which primarily serves the motor controller modules, has been located adjacent to the side of the motor controller room. The electrical transformer station, which serves the switchgear, is located adjacent to the side of the electrical equipment room.

A roofed gaseous storage area is located adjacent to the building at the test pit end because of functional dependency. A paved access area is provided for motor controller module maintenance. Because of the associated noise the Dowtherm 'G' and facility heat exchangers and air coolers are installed behind the parking area some 100 feet distance from the building.

4.1.2 INTERIOR ARRANGEMENT

The interior arrangement of rooms and areas are predicated on their functional relationships to one another. Certain functions are located adjacent to, or near other functions either due to their dependence or for convenience.

Space within these areas is commensurate with the function of the area, the equipment or furniture to be housed and the passage or equipment movement space required. Table 4-1 delineates the space* for the rooms and the building as a whole.

4.1.2.1 Test Bay Area

The test bay area is the center of the facility operation. Included near one end of this area is the test pit which contains the circulator test vessel and associated equipment. Experimental testing and verification of the helium circulator is accomplished within the circulator test vessel. The main drive motor is located at the ground floor level supported directly on the top of the circulator test vessel.

At the opposite end of the test bay area is the receiving area with a sufficiently sized door and floor space to accommodate entry of a tractor trailer for delivery and/or pickup of components including the helium circulators, main drive motors, pony motors, sub-assemblies and support stands.

A motor pit is provided mid-way in the test bay area and is used to set the main drive motor below the ground floor level in order to have sufficient height for the removal of the motor rotor for maintenance purposes.

The test bay area also provides laydown space for one main drive motor/pony motor assembly.

4.1.2.2 Control Room, Office and Cable Terminal Room

The control room is most functionally related to the operation, monitoring and control of the helium circulator testing being done inside the test vessel. Therefore, the control room is located as near and adjacent as possible to the circulator test vessel. A window is provided for observation of the test bay area.

An access floor system is provided in the control room and extends into the adjoining cable terminal room. The office is located adjacent to the control room and immediately inside the main personnel entry. An observation window looks into the control room. This arrangement facilitates both surveillance and personnel control. Most administrative related functions will be performed in the office.

4.1.2.3 Toilet and Locker Room Area

A janitor's closet, a women's toilet/locker room with adjoining shower and drying stall, a men's toilet room and a men's locker room with adjoining shower and drying stall are provided in a centrally

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*Interior space is net usable space. Gross space is calculated to the outside of the foundation.

located easily accessible area for personnel convenience. No special features have been provided for handicapped personnel since none are expected to be assigned to this facility.

4.1.2.4 Controlled Environment Assembly Room

The controlled environment assembly room is classified as a semi-clean room suitable for disassembly inspection and maintenance of the motors and compressor assemblies. The room humidity, temperature and particulate concentration is controlled and the air pressurized to prevent dust intrusion. Lay-down and storage space is provided for four compressor support stands, a motor rotor support stand, a pony motor and a motor bearing as well. This room is adjacent to the test bay area receiving area and has a large door between for moving large items back and forth between the rooms.

4.1.2.5 Shop and Storage

The shop and storage provides the in-house maintenance and repair function. The shop will be provided with machine shop equipment including lathe, milling machine, floor drill press, cutoff saw, welder, and miscellaneous equipment. Wall shelving and storage bins are provided in the storage area.

4.1.2.6 Motor Lift Maintenance Room

This room provides space for maintenance, recharging of batteries, and parking space for an electric fork lift truck. The room is adjacent to the shop and has a large rolling door providing fork lift truck access to the test bay area.

4.1.2.7 Mechanical Equipment Room

The mechanical equipment room provides space for the air handling units, water treatment, air compressor, helium dryer module and helium and nitrogen aftercoolers. The room is located at the ground floor level.

4.1.2.8 Electrical Equipment Room and Battery Room

The electrical equipment room is located at the second floor level directly above the mechanical equipment room. This room houses the electrical switchgear, the motor control centers, the instrument and electric distribution control panels, the battery chargers and battery control panels. At one end of this room is located the battery room which houses two multiple cell batteries.

4.1.2.9 Motor Controller Room

Located at the second floor level above the office, control room, cable terminal room, toilet and locker room area, storage, shop and motor lift maintenance room is the motor controller room. This room houses the main motor controller and the pony motor controller.

4.1.3 PERSONNEL FLOW

The estimated number of personnel required to normally operate and maintain this facility is 6 persons per shift with a total of 12 per day maximum, including both male and female. Not more than one female is anticipated.

Generally, personnel are expected to arrive by private automobile and park in stalls at the rear of the building. They will enter the facility through the main double door entrance leading to the main aisleway. This aisleway leads to the office, control room, locker/toilet rooms, cable terminal room and the test bay area. From the test bay area personnel have access to the controlled environment assembly room, storage, shop, the mechanical equipment room and a stairway leading to the test pit lower floor levels.

Personnel access to the second floor level motor controller room is by stairway through either the control room or the shop. The shop also provides personnel access to both the fork lift maintenance room and the storage room. Personnel access to the second floor level electrical equipment room is either by stairway from the controlled environment assembly room or by a ramped catwalk from the motor controller room located high across one end of the test bay area.

Personnel access to the top and sides of the test vessel is by a stairway connected to steel grating floors. Access ladders are provided from the test bay area to the test pit floor, to the motor pit floor, to the overhead bridge crane and to the roof. Stairs, ladders, exitways and emergency exits are provided in accordance with all applicable codes and regulations.

4.1.4 EQUIPMENT FLOW

The large size of some of the permanent equipment to be installed in the building requires special consideration in regards to access and conveyance. A removable exterior wall and roof section is provided to allow both initial installation and possible future replacement of the circulator test vessel. The vessel must be hoisted into place by means of a mobile crane stationed outside the building. The main drive motor/pony motor assembly will be delivered into the receiving area of the test bay by tractor trailer and hoisted into position with the 100-ton overhead traveling bridge crane. The same crane will be used for motor maintenance as well as installation and removal of the compressor assemblies. Motor components and compressor assemblies will be transported from the test bay area to the controlled environment assembly room by a specially designed railroad track mounted dolly of 20-ton capacity. Within the controlled environment assembly room all components will be handled with a 20-ton capacity overhead traveling bridge crane.

Main motor controller modules will be brought into or removed from the motor controller room by a permanent overhead monorail having two 10-ton electric hoists. The monorail extends through a removable wall panel to outside the building for raising and lowering modules onto a tractor trailer. An overhead monorail with a 2-ton electric hoist is provided in the electrical equipment room for handling switchgear, etc. The monorail extends outside the building through a removable wall section for access to a truck at ground level.

A 3000 pound capacity electric fork lift has been provided for transport of lighter components throughout the building. Full 8 x 10 foot or larger door openings and 7 foot minimum wide aisleways provide fork lift accessability to all ground floor rooms requiring such service. All major operational material equipment and supplies will be delivered into the receiving area of the test bay area by motor transport and then transported within the building by the fork lift.

4.1.5 ACOUSTIC CONSIDERATIONS

Since this is a test facility, it is important to have all areas of the facility accessible on an eight hour shift basis. In compliance with the 1976 OSHA standards, an eight hour occupancy requires that sound levels be limited to 90 DBA.

4.1.5.1 Test Pit Area

The helium circulator radial compressor and its 24,000 horsepower drive motor will generate significant noise levels, with substantial content in the lower frequency range. Calculations of the total sound levels with in the test pit and on the operating floor of the central bay for various conditions results in the following information:

	Sound Level		OSHA Permissible Exposure (hrs)
	Overall db	DBA	
Uninsulated Vessel			
Test Pit	126	105	1
Test Bay	126	105	1
Insulated Vessel			
Test Pit	123	100	2
Test Bay	123	100	2
Sound Blox Treatment of Test Pit with Insulated Vessel			
Test Pit	113	90	8
Test Bay	112	90	8

The cost estimate includes acoustic treatment of the test pit with sound blox or its equivalent. This arrangement permits personnel occupancy for the desired eight hours.

4.1.5.2 Motor Controllers

Sound levels generated by the motor controllers makes it important to prevent their contribution to that already in the central bay from the radial compressor and its drive motor. To accomplish this the wall and doors between the motor controller room and the central bay will have a minimum sound transmission coefficient of STC-45. The motor controllers will be mounted on vibration dampers to reduce the sound transmission through the floor into the control room below.

4.1.5.3 Personnel Comfort

The interior walls and associated doors surrounding the controlled atmosphere equipment room, the walls between the office, control room, locker room, shop, and storage room area, and the central bay will also be constructed to achieve an STC-45 rating. The purpose of this treatment is to provide personnel comfort. The control room will have additional floor, wall and ceiling treatment and double panel glass in the observation window.

All rotating equipment in the mechanical equipment room and all electrical transformers in the electrical equipment room will be mounted on vibration dampening pads to reduce noise level transmission through structural materials to other areas.

4.1.5.4 Exterior Noise

The distance from the outdoor heat exchangers and ventilating air coolers to the edge of the facility property will be a minimum of 75 feet, and the distance to the rear property line will be 100 feet to ensure a sound level no greater than 75 dba at the property line, as required by San Diego Municipal Code, Article 9.5 Noise Abatement and Control.

4.1.6 ENERGY CONSERVATION

Building services, electrical and architectural design are all impacted by the State of California Energy Resources Conservation and Redevelopment Commission's "Regulations Establishing Energy Conservation Standards for New Nonresidential Buildings". The exterior building envelope including walls, roof, windows and doors is designed to provide the specific "U" values (overall coefficient of thermal transmittance) required to meet the mandatory maximum energy budget allowance.

4.1.7 SAFETY, HEALTH, AND SECURITY

The facility is designed to comply with the Occupational Safety and Health Administrations, Department of Labor's Part 1910-Occupational Safety and Health Standards.

4.1.7.1 Safety

Specifically, all means of egress within the building including aisleways, corridors, doors, stairs, fixed industrial stairs, fixed ladders, catwalks and railings are in compliance. OSHA safety color code for marking physical hazards will be complied with throughout the facility.

4.1.7.2 Health

Sanitary facilities including toilet room fixtures and interior finishes as well as drinking fountains are in accordance with the Standards.

4.1.7.3 Security

Building security consists chiefly of a security fence around the site and master keyed cylinder locks on all exterior doors except motor operated overhead, doors. Windows are fixed type having no operable sash.

4.1.8 MATERIALS OF CONSTRUCTION

All building materials have been selected as necessary to fulfill specific functional requirements while at the same time staying within reasonable budgetary restrictions. The reinforced concrete pit, foundation and exterior retaining walls as well as the structural steel framed structure are described in Paragraph 4.2.

4.1.8.1 Exterior

The building envelope which includes exterior walls, roof, windows, louvers and doors is comprised of components selected to meet energy conservation restrictions, acoustic considerations and weathering requirements. Exterior walls above the concrete curbs and retaining walls are factory laminated baked enamel finished galvanized insulated metal siding panels consisting of inner and outer formed metal panels laminated to a foam polyurethane or isocyanurate insulation core. Side joints are tongue and groove or shiplap design permitting concealed fastening to steel girts and factory caulking. No end joints are permitted. All metal trim

and flashing match the wall panels. The interior face of all exterior metal panel walls are gypsum wallboard fastened to light gage metal stud furring which is attached to the structural girts. This inner face provides both noise attenuation and a smooth inner surface.

The roof construction consists of an accoustical long span wood fiber substrate deck planks topped with a factory manufactured integrally bonded urethane foam insulation. The deck planks are anchored to structural steel purlins with welded steel clips. The roof deck is covered with a 20 year bondable built-up roofing with gravel surfacing. The roof assembly meets Factory Mutual Class I requirements.

Exterior doors are all insulated hollow metal, whether hinged or overhead type, and have special weatherstripping gaskets around their perimeter for both weather protection and sound attenuation. Exterior wall louvers are baked enamel extruded aluminum acoustical type.

4.1.8.2 Interior

Interior walls are gypsum wallboard, screw attached to light gage metal studs supported by the structural steel frame. Certain walls have acoustical blankets within for specific sound attenuation requirements. Toilet rooms, locker rooms, showers, drying stalls and janitor closets have a water resistant type gypsum board on both walls and ceiling with a ceramic tile wainscot on all walls. The office and control room only have a suspended acoustical ceiling consisting of a metal grid and lay-in acoustic panels with an acoustical blanket providing specific sound attenuation requirements.

Interior personnel doors are flush hollow metal hinged type. Special acoustical doors are provided in walls requiring sound attenuation. Equipment access doors are insulated hollow metal overhead doors in sound attenuated walls and steel rolling (roll-up) service doors elsewhere. Glazing for all windows are insulated double glass set in neoprene gaskets providing both insulative and acoustical qualities.

Vinyl asbestos floor tile is installed in the office and control room. Ceramic-mosaic floor tile is installed in the toilet rooms, locker rooms, showers, drying stalls and janitor closet. All exposed concrete floors receive a clear silicone sealer coat. The battery room floor is painted two coats of synthetic floor enamel.

All doors and frames, interior wall surfaces, gypsum board ceilings, exposed structural and miscellaneous steel, and all electrical and mechanical equipment (without manufacturer's finish) are finish painted with two coats of specific types of alkyd enamel.

4.2 STRUCTURAL

4.2.1 FOUNDATIONS

The foundations of the building columns not supported on the test pit are supported on concrete filled pipe piles. The piles will be 12 3/4 inch diameter and will be driven approximately 35 feet. The side columns are supported on pile caps using two piles which are connected by grade beams, and the inside columns are supported on pile caps using three piles. The front and back column foundations are connected by grade beams. The foundations outside the building are spread footings, and with the exception of some of the small foundations in the switchyard, will be at a depth of at least 5 feet. The helium and nitrogen storage building foundation is a slab on grade with the nitrogen storage area slab thickened to support a crane during the removal or placement of the test vessel.

4.2.2 FLOOR SYSTEM

The slabs on grade inside the building are supported on 3 feet of compacted soil with a waterproof membrane provided between the soil and the slab. Rails are recessed into the slab and will run from the truck unloading area of the test bay into the controlled assembly room. Two pits are provided in the floor, the test pit which houses the test vessel, and the motor pit which is used to hold the motor when pulling the rotor. The test pit is 49 feet 6 inches long and 36 feet 0 inches wide with a depth of 46 feet 3 inches at the test vessel, and will rest on 3 feet 0 inches of compacted fill. A series of grating floors surround the vessel with a stairway between floors. A ladder is also provided as a second means of access. The motor pit which is 21 feet 0 inches square and has a depth of 22 feet 0 inches is attached to the test pit. This will also rest on 3 feet 0 inches of compacted fill.

4.2.3 BUILDING STRUCTURE

The building structure is constructed of structural steel and is approximately 117 feet long, 105 feet wide and has an eave height of less than 30 feet above the outside berm and 38 feet 6 inches above the first floor level. The columns are spaced on 19 feet 0 inch centers in the longitudinal direction. The structure has a test bay 38 feet 0 inches high in the middle and two side bays of 32 feet 0 inches.

The structure supports a 100 ton bridge crane. This crane spans the test bay and runs the length of the building. A 20 ton bridge crane spans the side bay in the controlled assembly room. The structure is a braced frame, transferring the horizontal crane, wind or seismic loads, through the roof bracing to the vertical bracing and columns, which transfer

the loads to the foundations. The vertical loads are transferred by beams to the columns and then to the foundations. The roof paneling is supported on the roof framing with the side panels supported by girts to the columns.

4.2.4 CRANES AND HOISTS

A 100 ton bridge crane is provided to service the test bay. One of the major functions is to handle the 79 ton electric motor and pony motor, which includes lifting the motor into position for attachment to the vessel, removing the motor for maintenance, placing the motor in the motor pit, removing the rotor, and loading the rotor onto the dolly to take into the controlled environment assembly room.

A 20 ton bridge crane is provided in the controlled environment assembly room to service that area. One of its functions is to handle the motor rotor while it is being maintained. Two 10 ton electric monorail hoists are provided above the motor control units in the motor control room. The hoists are used to remove and replace the motor control units as it becomes necessary. A 2 ton electric hoist is provided over the electrical equipment room to service that area.

4.3 BUILDING SERVICES

4.3.1 HEATING, VENTILATING AND AIR CONDITIONING

The heating ventilating, and air conditioning systems (HVAC) installed in the facility are provided to create comfort conditions in occupied areas, provide environment control for equipment protection, and remove heat from the test bay area and motor controller room. These systems are shown on Flow Diagram ME-05 in Section 9.

4.3.1.1 Office, Control Room and Toilets

A factory fabricated, water cooled air conditioning unit provides filtered and conditioned air to the office and control room area via sheet metal supply and return ducts so as to maintain 70° minimum and 78° maximum temperatures. No humidification is needed. Fresh air makeup is introduced to the system for the occupants and to maintain space positive pressure within the control room at approximately 0.10" WG. Heating is provided by an electric duct heating coil. The men's and women's toilet and locker room area, including the janitor's closet, are mechanically ventilated through sheet metal ductwork louvers and exhausted to atmosphere by a power roof exhauster.

4.3.1.2 Equipment Rooms

The mechanical equipment room, electrical equipment room, and battery room are heated and ventilated to maintain space temper-

atures of 55°F minimum and 104°F maximum. Outdoor air is drawn into spaces through intake louvers and discharged to the atmosphere via power roof exhausters. Electric unit heaters provide space heat.

4.3.1.3 Controlled Environment Assembly Room

The controlled environment assembly room is air conditioned to meet the requirements of a Class 100,000 Clean Room, as defined in Federal Standard 209B. A factory fabricated, water cooled air conditioning unit, provides filtered and cooled air to the space by sheet-metal supply and return ducts. Fresh air make up is provided to the system to maintain a positive pressure of 0.10 inch WG. The controlled environment assembly room will be maintained at 75°F ± 2% and 30% RH minimum to 50% RH maximum. System components include an electric duct heating coil, a duct himidifier and HEPA filters.

4.3.1.4 Test Pit and Test Bay

A 24,000 cfm air handling unit provides filtered air to the test pit area by sheet metal ducts, and is exhausted by power roof exhausters interlocked with the air handling unit. The air handling unit and roof exhausters only operate when testing of components is required. Another 21,500 cfm air handling unit provides general ventilation to the test bay area, storage room shop and the motor lift maintenance room by sheet metal supply and return ducts. The unit is arranged so as to re-circulate 75% of the air when air temperature drops below 55°F. Fresh air makeup is introduced to the system to provide positive filtered air. The test bay roof exhausters are interlocked with the air handling unit for complete shut down during non-working hours. Electric duct heaters provide heating in these areas.

4.3.1.5 Motor Controller Room

The motor controller room is maintained at 104°F maximum and 55°F minimum. Fresh air is introduced to the system to maintain space positive pressure. No humidification is required. A factory fabricated, water cooled air conditioning unit provides filtered and cooled air to the space via a supply duct.

4.3.2 FIRE PROTECTION

The purpose of the fire protection systems for the facility is protection of the general public, protection of plant personnel and the protection against loss of equipment. Although the combustible loading in the facility is minimal, the potential for a fire exists. Choosing adequate fire protection for the facility was determined by the following:

1. Classification of occupancies

2. Fire Hazard Analysis, type of equipment and materials

3. Cost

4. Codes and standards i.e., National Fire Protection Association (NFPA), Factory Mutual Company, and the Underwriter Laboratories.

The Classification of Occupancies (NFPA #13) indicates that the facility ranges from Light Hazard to Ordinary Hazard (Group 1). Therefore, except for the control room, the facility and transformer areas will be protected by a wet pipe sprinkler system, which conforms to NFPA codes and standards. The control room, motor controller module and pony motor controller will be protected by a Halon 1301 system, since a water system not being three dimensional cannot penetrate all areas, such as cabinets, to ensure full extinguishment as a gaseous agent (Halon 1301) can.

4.3.2.1 Wet Pipe Automatic Sprinkler System

The wet pipe sprinkler system is the most effective and efficient type of sprinkler system available because of its relatively simple design. It consists of an area distributed network of water-filled pipes with pendent sprinkler heads installed on pipes. The distribution system of pipes with the sprinkler heads on the branch lines is connected to the fire water line which enters the building adjacent to the switchyard and rises in the storage area.

The system is actuated by the softening or melting of a low melting point (212^{o}F) fusible link in the sprinkler head. The relaxation or melting of this link allows a tensional lever arm to unblock the flow passage, allowing water to be discharged into the fire area. In turn, the flow water in the piping system activates an alarm check in the main supply riser, located in the storage area, causing an alarm device (water gong) to be triggered. Technically, this system will extinguish or control a greater percentage of fire occurance with fewer sprinkler heads operating, (only the sprinklers in the vicinity of the fire operates) than other systems such as dry pipe, preaction or deluge systems. Each sprinkler head in the facility covers 130 square feet at a rate of 0.1 gpm per square foot at 15 psi, and a discharge rate of 0.25 gpm per square foot at the transformers.

4.3.2.2 Halon 1301 System

The protection of the control room is accomplished by a total flooding Halon 1301 system. Halon 1301, and odorless, colorless, non-toxic, non-corrosive, clean agent was chosen because of the following advantages over the other types:

Safety to personnel

Equipment cost

Decreased sub-cooling of components

Less space/weight for agent storage

Less pressure buildup

Better control of agent loss through uncloseable openings

Halon 1301 extinguishes fires by a chemical chain reaction and not through oxygen starvation. Following the extinguishment there is no residue to clean up. The system combines highly effective detection devices with specially designed components for high speed agent discharge. It is electrically operated and has a normal design discharge time of less than ten seconds. Agent storage containers will be strategically located throughout the zone to be protected, eliminating the need for expensive piping. The high-speed suppression of a fire reduces property damage and thermal products of decomposition to the lowest possible level.

The motor controller module, consisting of 7 cabinets joined together to form one modular unit, is protected in case of fire by a total flooding Halon 1301 system, with a design concentration of 5 percent. Each cabinet is protected by its own system, thereby reducing the cost of installation. Each cabinet system consists of a Halon 1301 cylinder, solenoid release, manual release, pressure switch, flexible connection and 12 feet of 1/2 inch copper tubing. The Halon 1301 cylinder is mounted on the back of the cabinet and piped to top of the cabinet. The module consists of the following cabinets and a Halon required for each cabinet.

Cooling Water Cabinet	10.5 LB Halon, 10 LB Cylinder
Control Panel	4.1 LB Halon, 5 LB Cylinder
Input Controller	25.5 LB Halon, 25 LB Cylinder
D.C. Link Reactor	17.5 LB Halon, 20 LB Cylinder
Control Panel	4.1 LB Halon, 5 LB Cylinder
Output Control	24.5 LB Halon, 25 LB Cylinder
Output Disconnect Rears	10.5 LB Halon, 10 LB Cylinder

The pony motor controller is protected in case of fire by a total flooding Halon 1301 system with a design concentration of 5 percent. The system consists of a 5 pound Halon 1301 cylinder, solenoid release, manual release, pressure switch, flexible connection and 10 feet of 1/2 inch copper tubing. The Halon 1301 cylinder is mounted on the cabinet and piped to the top of cabinet. The Halon 1301 Fire Suppression System proposed is designed for total flooding of the protected areas both above and below the floor in accordance with NFPA Standard 12A.

4.3.2.3 Portable Fire Extinguishers

Portable fire extinguishers will be provided throughout the facility and will be 10 pound dry chemical (potassium bicarbonate) type. Portable extinguishers are first aid devices provided

close at hand for immediate use on incipient fires. Extinguishers are effective only when they are immediately accessible and promptly used. They are the first line of defense and never a substitute for sprinklers. The extinguishers will be conspicuously located so they are not likely to be blocked, hidden or damaged.

4.3.3 PLUMBING

Water supply to the facility is provided through a 6 inch diameter combined fire and domestic water system, valved so that the domestic system can be shut down without impairing the supply to the fire protection sprinkler system within the facility. The water supply for the combined system is from the municipal water mains at the site. On entering the facility in the storage area, the 6 inch diameter combined fire and domestic water line is tee'd upstream of the fire protection O.S & Y control valve, alarm check valve, and siamese connection for the domestic (potable) water supply system. Adjacent to the tee'd connection a back flow preventor and a pressure reducing valve are installed to ensure no contamination of the system via the fire system or siamese connection. Also to reduce the water pressure to 40 psi for the plumbing fixtures a 1 inch diameter pipe line is taken off the main domestic water line to the 40 gallon electric hot water heater located in the janitor's closet. The hot water heater then supplies 140^{o}F water to all lavatories, showers and the service sink. The men's toilet room will contain a water closet, a urinal, two lavatories, a shower and an eyewash. The women's toilet room contains a water closet, a lavatory complete with countertop, a shower and an eyewash. An additional eyewash is located in the shop area. A wall hung type lavatory and a hose bibb is also installed in the mechanical equipment room. Hose bibbs are also installed in the test bay area and in the shop area. A water cooler for drinking is located in the aisleway outside the toilet rooms, with the service sink installed in the janitor's closet. A sump pump located in the pit is provided to periodically transfer any accumulated water to the sanitary system. Normal operation of the sump pump is automatically controlled by a float switch; however a manual override is also provided.

4.3.4 COMPRESSED AIR SYSTEM

Compressed air is provided for instruments and controls, pneumatic tools, cleaning equipment, and miscellaneous shop purposes. The system will be purchased as a package with all the components mounted on a skid. This consists of two 30 Hp compressors with associated coolers, each capable of delivering 100 SCFM of dry clean air at 125 psig. Normally, only one compressor is working. If necessary, both compressors can be brought up on stream at the same time to meet a sudden surge of demand.

A dessicant type dryer is provided to dry the air to dew point of 0^{o}F. This unit is electrically regenerated and fully automatic controlled. A receiver is also provided to dampen the fluctuation of pressure which normally is inherited from a reciprocal compressor unit.

4.4 ELECTRICAL

The electrical systems, supporting the outdoor areas, building, test equipment, and other support systems and equipment, is described in the subsequent paragraphs. The Single Line Drawing EE-01 showing the power systems, and the layout Drawings EE-02 and 03 showing the arrangement of the switchyard, transformer station, and electrical equipment room are included in Section 9.

4.4.1 POWER SYSTEMS

The electrical power system is structured as shown on the Single Line Diagram EE-01 in Section 9.

4.4.1.1 Incoming 138 KV Power Supply

Power is furnished to the test facility at 138 kV from the local electrical utility's 138 kV subtransmission system. This power is controlled by the facility's 138 kV switchyard, which is arranged as shown on Drawing EE-02. The incoming 138 kV line terminates at an "A" frame type dead end structure, from which it is connected to a horizontally mounted 138 kV group operated, 3 pole, vertical break disconnect switch, mounted directly under the "A" frame structure.

The incoming 138 kV disconnect switch; 138 kV outdoor, pad-mounted, oil circuit breaker; three outdoor, surface mounted, 138 kV current transformers; and the 138 kV bushings of the main transformer are all connected in series by means of the overhead ACSR bare conductor and the 138 kV strain bus. The overhead 138 kV strain bus terminates at one end of the incoming "A" frame dead end structure and at the other end on the main transformer's "A" frame dead end structure.

The 138 kV metering current transformer's outgoing conductor is also connected to a horizontally mounted vertical break 138 kV disconnect switch ahead of the 3 - metering potential transformers rated 80/.12 kV and connected in wye. These potential transformers and the current transformers supply the revenue metering equipment, consisting of a kilowatt hour meter, and a recording kilowatt demand meter. Both meters are mounted in an outdoor weather-proof metering cabinet.

4.4.1.2 The Main Power Transformer

The facility's electrical loads are furnished power from a 3 winding 138/24/4.16 kV power transformer rated and connected as follows:

138 kV winding 24/32 MVA OA/FA - Delta connected

24 kV winding 18/24 MVA OA/FA - Delta connected

4.16 kV winding 6/7.5 MVA OA/FA - Wye connected

The transformer's 138 kV and 24 kV bushings are outdoor, cover type. The 138 kV bushings are connected to the strain bus as outlined above. The 24 kV bushings are connected by means of an 800 ampere, outdoor, copper bus to the 24 kV outdoor cover bushings of the helium circulator 24/13.8/13.8 kV main motor input transformer. Also connected to the outdoor 24 kV bus, through a 3 pole, side break 24 kV disconnect switch, are two 24/.12 kV potential transformers arranged to supply the required potential to the indicating and recording instruments and voltage relays associated with the helium circulator's main motor drive. All the instruments are located in the main control room.

The main power transformer's 4.16 kV bushings are housed in an outdoor enclosure and are cable connected to the incoming 1200 ampere air circuit breaker of the 5 kV outdoor metal clad switchgear assembly by means of two single conductor 750 MCM, 5 kV underground power cables, per phase. The neutral bushing for the transformers 4.16 kV windings is an outdoor cover type and is connected by an overhead conductor to the pedestal mounted, outdoor neutral grounding reactor.

4.4.1.3 Outdoor Open Strain and Rigid Busses

All open buses, both of the strained and rigid bar type, within the switchyard are sized and spaced to carry the power load and to withstand the forces developed during the various possible fault conditions. A summary of these fault conditions, for two different power system short circuit capacities is shown on Table 4-2.

4.4.1.4 Lightning Protection

The switchyard equipment and the main transformer is protected by lightning arrestors. Lightning arrestors are connected so as to ground high frequency surges and must have no sharp bends in their connection.

4.4.1.5 Power Supply to the Main Motor Drive

The main motor drive of the helium circulator is supplied power from the main transformer's 18/24 MVA, OA/FA delta connected, 24 kV windings. These windings are connected by a 3 phase, outdoor, 800 ampere 24 kV feeder to the circulator's main motor input power transformer rated as follows:

Voltage:	24 kV Delta
	13.8 kV Delta
	13.8 kV Wye
MVA:	18/24 MVA OA/FA

This transformer is identical to those to be used in the development plant. It steps the voltage down to 13.8 kV and

divides the load between two separate phase shifted windings. Each winding furnishes power to the main motor's 15 kV thyristor controller through its own 15 kV outdoor metal enclosed air circuit breaker. The main motor's controller is connected to the motor by means of a 1200 ampere, metal enclosed, 15 kV, non-segregated bus and 15 kV cable.

The neutral point of the Wye connected synchronous main motor is grounded through a 12/.24 kV transformer, loaded on the secondary side by a 240 volt resistor. The resistor is sized to dissipate the capacitive KVA developed during a phase to ground fault condition within the main motor grounding system including the 15 kV bus and the main synchronous motor. The KVA rating of the grounding transformer, with a primary voltage rating of at least 1-1/2 times the line to neutral voltage, is determined from the secondary current to the resistor.

4.4.1.6 Facility Auxiliary Power

The 4.16 kV windings of the main transformer are connected to the 4.16 kV outdoor switchgear by means of two single conductor 750 MCM, 5 kV underground power cables per phase. The neutral point of the main transformer's 4.16 kV Wye connected winding is grounded through a 0.30 OHM, 5 kV, single phase grounding reactor rated at 3.6 kA for 4 seconds. This reactor, as is indicated on Table 4-2, limits the maximum fault current during a phase to ground fault condition to approximately 26 percent of the fault-current which would occur during a 3 phase fault condition, without causing an overvoltage condition on the unfaulted phases or on the transformer's neutral. The XO/X1 ratio of the 4.16 kV power system to this point is less than ten. The 4.16 kV outdoor switchgear assembly consists of one incoming, four outgoing and one space for future 1200 ampere, 5 kV air circuit breakers. This supplies 4.16 kV power to the following auxiliary loads by means of 5 kV underground power cables.

4.16 kV 300 H.P. pony motor variable speed controller

4.16 kV fused interrupter switch assembly "A" in the 4.16/.48 kV transformer station

4.16 kV fused interrupter switch assembly "B" in the 4.16/.48 kV transformer station

One space for a future 5 kV circuit breaker

4.4.1.7 480 Volt Power

The 480 volt power system is supplied through two double ended 480 volt, metal enclosed, load center units, located in the electrical equipment room, as shown on Drawing EE-03. The required 4.16 kV Delta/480 volt Wye connected transformers are located outside and connected to each load center unit by metal enclosed bus duct.

Each transformer is supplied power through a 4160 volt fused interrupter switch, located in the transformer station and cable connected to the 4160 volt switchgear as outlined above. The neutral of each 480 volt transformer connection is grounded through a 0.04 OHM, 600 volt, single phase grounding reactor, rated at 25,000 amperes for 5 seconds. This reactor limits the ground fault current to approximately 27 percent of the three phase fault current without causing an overvoltage condition on the unfaulted phase or on the transformer's neutral.

Each incoming 480 volt circuit breaker of a double ended 480 volt load center is rated at 1600 amperes and is electrically operated and interlocked with its 480 volt bus tie circuit breaker. Motors 125 H.P. to 200 H.P. are powered and switched from the 480 volt load centers through electrically operated 480 volt air circuit breakers. They have 125 volt D.C. control circuits and undervoltage protection by means of a bus undervoltage relay.

The two 480 volt load centers, with the four bus sections, supply power to the six motor control centers. Motors 100 H.P. and smaller, together with nonrotating loads and equipment with integral controls, are controlled from these centers. The motors are controlled by a combination of manually operated magnetic tripped circuit breakers and an electrically operated starter. The nonrotating loads and equipment with integral controls are furnished power by a manually operated, ambient compensated circuit breaker.

4.4.1.8 125 Volt D.C. Systems

The test facility is furnished with two complete 125 volt D.C. systems, each system consists of a 125 volt, 60 cell, 600 ampere hour, 8 hour rated battery bank. A distribution panel and a battery charger are supplied for each system and the systems are interconnected through a normally open, non-automatic bus tie switch. The 125 volt D.C. distribution panels, with manually operated, magnetic tripped circuit breakers, provide power to the facility's control, instrumentation, emergency lighting and all other 125 volt D.C. loads required for normal operation, and for an orderly and safe shutdown of the facility. The total 125 volt D.C. load requirements are divided equally between these two distribution panels. Each battery is sized to handle the following loads:

	Operation Duration (Hrs)
50% emergency light load	4
All breaker's control, closing, tripping and indicating circuits	8
Annunciators	8

Each battery charger furnished will supply the normal 125 volt D.C. load plus the recharge of its associated battery within 2 hours. Each D.C. system is ungrounded, and is equipped with a ground detector for continuous monitoring of ground fault current.

4.4.1.9 Battery Charger for Fork Lift Trucks

A separate 3 phase, 480 volt to 48 volt D.C. battery charger, supplied power from the 480 volt motor control center and installed on the first floor of the facility, is furnished for the purpose of recharging the battery of a D.C. motor operated fork lift truck.

4.4.1.10 Instrument A.C. System

The 120 volt instrument A.C. is furnished from two 480/120 volt single phase dry type transformers; each with an electrostatic Faraday shield between the primary and secondary winding. The 120 volt instrument A.C. is distributed from two instrumentation panel boards, each with 15 ampere circuit breakers with magnetic trip units only.

4.4.2 LIGHTING SYSTEM

Indoor lighting is provided by fluorescent and mercury devices. Non-highbay areas utilize fluorescent and incandescent lighting with appropriate overlap for incandescent emergency coverage. Each lighting transformer is supplied from a different 480 volt motor control center. Stairwells, doorways, closed areas are covered by emergency lighting. Normally, this lighting is powered from 120 volt A.C. but is automatically transferred to 125 volts D.C. upon A.C. power interruption.

Highbay areas utilize mercury lighting with a small amount of emergency incandescent cover. General illumination levels correspond to the minimum recommendations of the Illumination Engineering Society (IES).

Intended Principal Interior Type of Lighting and Design Lighting Levels

Area	Illumination	Type of Fixture
Control Room	100 ft. candles	Fluorescent
Shop	100 ft. candles	Fluorescent
Office	100 ft. candles	Fluorescent
Receiving & Prep. Room	75 ft. candles	Fluorescent
Test Pit	60 ft. candles (at grade)	Mercury Vapor or Lucalox
Equipment Room	40 ft. candles	Fluorescent
Toilet	30 ft. candles	Fluorescent
Exterior Equipment Area	2-5 ft. candles	Mercury Vapor or Lucalox
High Bay Areas	60 ft. candles	Mercury Vapor or Lucalox

Electric convenience outlets are provided throughout the building near floor level so that any floor area can be reached with a 25 foot extension cord. Outdoor lighting is provided in all outdoor equipment areas, on all road ways and parking areas, and at all building entrances. Roadway and parking area lighting is photo electric controlled. All other outdoor lighting is manually controlled from the lighting panels within the building.

Intended Principal Type of Exterior Lighting and Design Lighting Levels

Area	Illumination	Type
Equipment Areas	2-5 ft. candles	Mercury Vapor or Lucalox
Exterior Doorways	2-5 ft. candles	Mercury Vapor or Lucalox
Roadways & Parking Areas	2-5 ft. candles	Mercury Vapor or Lucalox

Emergency lighting is provided in the 138 kV switchyard, adjacent to the 15 kV and 5 kV switchgear, and in the transformer station.

4.4.3 POWER SYSTEM CONTROL AND ANNUNCIATION

The control design for the electric power system is based on centralized controls, monitoring and protection for each motor. Also provided is a local start and stop control station with a lockout stop button. All disconnect switches, and all power supply circuit breakers are provided with position indicating lights in the control room. All electrically operated circuit breakers, and essential auxiliary motors are controlled from the control room. This also includes position indication. Non-critical auxiliary loads are controlled locally at the load or from the motor control center. Position indication is provided at the motor control center with start-stop button at each motor, the stop button being a lockout type.

The 125 volt D.C. system is used for the operation of control circuits wherever practicable, for reliability. Motor control center circuits and some control and instrumentation circuits operate from A.C. control power supplies. Whenever practicable, the control circuits are designed to allow continued unit operation without change of circuit status. This minimizes the action required by the operator after a brief loss of control power.

Control equipment is grouped in a functional manner and provided with control power disconnect devices to facilitate maintenance of one circuit without loss of unrelated circuits. Non-essential fractional-hp motors, lighting, and space heaters are not connected to vital A.C. control power sources in order to improve reliability and reduce the load demand on these buses. Control circuit interlocks and control room supervision of maintenance devices is not provided unless major hazards are involved. For example, pump block valves are not interlocked with the pump controls because the suitability of the equipment for operation must be determined by the maintenance crew before it is turned over for remote or automatic control.

Whenever practicable, the unit trip initiating and auxiliary relays are located in cabinets in the control room area to facilitate testing and to minimize inadvertent tripping while maintaining control circuits. Unit tripping circuits are physically and electrically separated from control and alarm devices whenever practicable, and will be clearly identified. Each major unit tripping function has two sets of tripping devices to provide redundancy for increased reliability. Trip contact cutout switches are provided to allow isolation of individual tripping devices. The tripping logic circuit power supplies will be monitored.

An annunciator system is provided to indicate off-limit, abnormal, or trouble conditions while the station is in normal operation. The alarm circuits are designed to avoid nuisance alarms that indicate only status and not trouble when the unit is in normal operation. Several alarms are connected to one alarm point to reduce the panel space required, providing the necessary alarm information is not hampered by such combining. The annunciator will operate when standby equipment is automatically put into service to allow investigation of the reason for starting. Disconnecting means and a ground detector will allow convenient identification of a grounded alarm wire. The annunciator will operate in a fail-safe mode; i.e., operating through N.C. trouble contacts.

All essential control and alarm functions are hard wired into terminal cabinets or signal conditioning cabinets located in the control room area. Local control stations are provided in parallel with control room control stations for all digital control functions.

An analog multiplexer is provided for analog signals used for data acquisition, performance calculations or efficiency test. Analog controls are of the split architecture type construction. Control operating panels and signal conditioning cabinets are separate. Cabinets are supplier's standard or 19 inches wide relay cabinets by 90 inches high. A digital multiplexer is provided for all digital signals not associated with alarm, shutdown or safety functions. It includes pre-alarm, equipment starters and process starter functions for operator interfacing.

4.4.4 POWER SYSTEM PROTECTIVE RELAYING

The protective relays for the protection of all major transformers are centralized and mounted in the control room. All other protective relays, associated with either the 13.8 kV and/or 4.16 kV switchgear units are mounted on hinged panels within the associated switchgear unit.

Protection of electrical equipment is accomplished by means of coordinated relay systems, fuse and circuit breaker operations and a selective tripping arrangement. This protection system is designed to offer maximum service dependability and minimum shutdown time due to electrical disturbances.

4.4.4.1 Main Transformer Protection

The main transformer is provided with the following protection:

1. Transformer differential, with hand reset lockout auxiliary tripping relay.

2. Transformer, differential back up on the 138 kV side; consisting of phase overcurrent relays with very inverse characteristics.

3. Sudden fault pressure.

4. Overtemperature alarm.

5. 24 kV bus under and over voltage alarm.

6. Neutral overcurrent on 4.16 kV winding.

4.4.4.2 Main Motor Input Transformers

The protective relaying for the main motor is provided by GAC and is as follows:

1. Transformer differential with hand reset lockout auxiliary tripping relay.

2. Sudden fault pressure.

3. Overtemperature alarm.

4.4.4.3 13.8 KV Feeders to the Main Motor's Controller

The protection for 13.8 kV feeders to the main motor's controller includes:

1. Phase overcurrent with an instantaneous attachment.

2. Ground alarm in the 13.8 kV Delta feeder to the circulator's main motor's controller.

The protection for the circulator's main 13.8 kV motor will be furnished with the motor's controller.

4.4.4.4 4.16 KV Power System

The protection for the 4.16 kV power system includes:

1. Incoming 4.16 kV breaker and 4.16 kV bus

   Phase overcurrent

2. Outgoing 4.16 kV feeders to motors

   Phase overcurrent with an instantaneous attachment

   Instantaneous ground sensor

   4.16 kV bus under voltage

3. Outgoing feeders to transformer stations

   Phase overcurrent

   Inverse time ground sensor

4. 4.16 kV feeders to 4.16/.48 kV auxiliary transformer

   Fused interrupter switches

4.4.4.5 4000 Volt Motors

The protection for the 4000 volt motor includes:

1. Differential for 2000 H.P. and above
2. Overcurrent (overload and short circuit)
3. Starter winding protection (RTD for motors 1250 H.P. and above)
4. Bearing overtemperature

4.4.5 GROUNDING SYSTEM

The grounding system is a ground grid consisting of buried bare copper cable meshes and copper anode ground wells, with the anodes installed below the water table's low level. The grid extends throughout all areas, including the cooling water air coolers area, pumping station areas, switchyard, 4.16 kV transformer station, and all floors of the test facility.

The details of the grounding system are described in the outline specification, Section 10, which includes the sizing of the anodes, connecting cables, grounding cables and type of connections. All major electrical equipment connected to the grounding grid is indicated on Drawings EE-02 and EE-03.

All electrical motors, all steel support structures in the switchyard and transformer station area, all steel building columns, transformer neutral grounding reactors and resistors and all switchgear ground busses are connected to the grounding grid as outlined above.

4.4.6 COMMUNICATION SYSTEM

Telephone sets and public address speakers, all wiring raceways, and telephone jacks are provided for intraplant communications. All locations including the switchyard and outlying areas, as dictated by the overall facility's operation requirements, are covered.

The public address system will include the power amplifier, pre-amplifier, speakers and horns. Two types of horns, indoor and outdoor, are provided. The speakers are used in the offices and corriodor areas.

TABLE 4-1

SPACE ALLOCATION

FUNCTION	NET AREA (Sq. ft.)	GROSS AREA (Sq. Ft.)
Main Floor		
Central Bay (includes pits)	4210	
Office	195	
Control Room	500	
Cable Terminal Room	140	
Janitor Closet	40	
Locker/Rest Rooms	350	
Storage Room	560	
Shop	700	
Motor Lift Maintenance Room	280	
Controlled Environment Room	1800	
Mechanical Environment Room	1680	
Halls and Aisleways	830	
Stairwells	420	
First Floor Total	11,705	12,285
Second Floor		
Motor Controller Room	3430	
Electrical Equipment Room	1570	
Battery Room	160	
Halls and Aisleways	230	
Stairwells	265	
Second Floor Total	5,655	5,665
Building Total	17,360	17,950

Table 4-2

SUMMARY OF FAULT CONDITIONS CALCULATIONS
EQUIPMENT CAPACITY-NEUTRAL GROUNDING REACTORS EFFECTS

ITEM	SHORT CIRCUIT		EQUIPMENT SHORT CIRCUIT RATING		RATIO PH. TO GROUND	XO/X1
	MVA	RMS AMPERES	MVA	RMS AMPERES	3 PH.	
3 PHASE FAULT 138 KV BUS	3295	13,800				
138 kV Disc. Switch		Furnished by		61 kA	--	--
138 kV Power Circ. Bkr.		Local Utility	8590	36 kA: 58 kA		
138 kV P.T. Disc. Switch				40 kA		
3 PHASE FAULT 24 KV BUS						
Infinite Utility System	308.6	7,433	BY	GAC/W	--	--
Limited Utility System	300.4	7,235				
3 PHASE FAULT 4.16 KV BUS						
Infinite Utility System	182.1	25,303	250[1]	34,738		
Limited Utility System	173.4	24,094				
PHASE TO GRD. FAULT-4.16 KV BUS			270[2]	37,517		
Infinite Utility System	47.6	6,615			26%	9.48
Limited Utility System	47.2	6,557			27%	9.02
3 PHASE FAULT 0.48 KV BUS						
Infinite Utility System	15.81	19,044	34.9[3]	42 kA: 30 kA		
Limited Utility System	15.74	18,950	24.9[4]			
PHASE TO GRD. FAULT 0.48 KV BUS			18.3[5]			
Infinite Utility System	4.26	5,124		22 kA	26.9%	9.13
Limited Utility System	4.25	5,121			27.0%	9.10

1. 4.16 kV Switchgear
2. 4.16 kV Fused Interrupter Switches
3. 0.48 kV 1600 AMP ACB's
4. 0.48 kV Switchgear Bus
5. 0.48 kV MCC's Bus & Outgoing 0.48 kV ACB's

SECTION 5

SYSTEM DESCRIPTION

5.1 TEST SYSTEMS

This section describes those portions of the test facility and its systems that are required to support the testing of the helium circulators and the diffusers and the isolation valves.

5.1.1 HELIUM TEST LOOP

The helium test loop is entirely contained within the circulator test vessel, which is internally partitioned to form the loop circuit. The helium circulator radial compressor is mounted within the top of the vessel, supported by its flange assembly from one of the two large circulator vessel flanges on top of the upper head of the vessel. The other larger flange supports the radial compressor motor. A diffuser assembly within the upper head of the vessel expands the helium flow stream from the radial compressor, into the vessel flow circuit. The helium passes through six restrictor valves into the annular heat exchanger arranged around the inner wall of the vessel. Exiting from the heat exchanger, the helium turns at the bottom of the vessel to flow upwards through a bell mouthed central flow column to return to the inlet of the radial compressor. A helium isolation valve is positioned immediately upstream of the compressor inlet. When the circulator is operating this valve is fully open.

5.1.1.1 Vessel

The circulator vessel, as shown on Drawing ME-01, in Section 9, has an overall outside length of 37 feet 9 inches, including the top head flange structure and the bottom support skirt. Its outside diameter, exclusive of nozzles and insulation, is almost 14 feet. Internally, the vessel has a diameter of 12 feet 10 inches, and a length of 27 feet 4 inches. It is designed in accordance with the American Society of Mechanical Engineers "Boiler and Pressure Vessel Code - Section VIII, Division 1," and is constructed of carbon steel with a minimum wall thickness of 6.65 inches. Three inches of mineral wool insulation will be applied to the outside of the vessel for thermal and acoustic purposes. Twenty one nozzles or access ports penetrate the vessel for such things as restrictor valve actuators, helium supply, heat exchanger coolant, instrumentation, personnel access, etcetera. The vessel is designed for 1450 psia and 650^{o}F, with safety relief valves set for 1435 psig. Normal operating pressure and temperature will be 1300 psia and 600^{o}F.

All nozzles are flanged, with the Dowtherm heat exchanger nozzles sized to accommodate a thermal sleeve. Flanges have a 900 pound rating. The two personnel access ports have bolted hinged covers. One is located at the bottom of the vessel, access to which is obtained through two openings in the vessel support skirt. This port opening provides access to the interior of the central flow tube and to the bottom of the Dowtherm heat exchanger. The other personnel access port is located on the side of the vessel immediately above the Dowtherm heat exchanger. This provides access to the upper end of the heat exchanger and to the restrictor valve housings and actuator shafts.

The vessel support skirt will be a 3/4 inch thick, 13 foot 5-1/2 inch outside diameter, carbon steel cylinder welded to the bottom head of the circulator vessel. This skirt supports the circulator vessel and is bolted to the circulator vessel test pit floor by means of a base ring and anchor bolt lugs attached to the bottom of the skirt. Both the inside and the outside of the skirt are fireproofed with 2 inches of gunite.

5.1.1.2 Restrictor Valves

The function of the restrictor valves is to control the helium loop pressure drop so that expected reactor operating conditions can be simulated thereby obtaining the main helium circulator radial compressor operating characteristics.

There are six restrictor valves within the circulator test vessel, circumferentially positioned every 60 degrees. Each valve is made up of a valve body, a vessel feed-through actuator shaft, and an external actuator. The valve is a 12 inch butterfly type, constructed of stainless steel. Inlet and outlet passages are bell mouthed to improve the gas flow profile.

The splined operating shaft is connected to the vessel actuator feed-through shaft by a linkage mechanism which frees the device from feed-through shaft thermal expansion problems. This feed-through shaft penetrates a 4 inch vessel flange, upon which the actuator device is mounted.

The valve actuator employs a pneumatic diaphragm with a characterizable positioner, which drives the shaft, using a conventional butterfly valve type linkage. A shaft position transmitter provides valve position information for control purposes.

5.1.1.3 Dowtherm Heat Exchanger

The Dowtherm heat exchanger is made up of carbon steel cooling coils arranged in single pass annular banks running nearly the full internal circumference of the circulator vessel. One main inlet header and one main outlet header, with short radial sub-headers, terminate these circumferential coils. As presently conceived, there would be at least 32 vertical banks of coils, each with their own sub-header to which are attached

7 1-1/2 inch (OD) cooling coil tubes. Vertical baffles within the heat exchangers support the coil tubes. The tubes would terminate at, penetrate and be welded to the sub-headers and the sub-headers would in turn penetrate and be welded to the headers. Both the inlet and the outlet headers would connect to the external Dowtherm system by means of nozzles in the bottom head of the vessel. Because this heat exchanger forms a pressure boundary similar to the circulator vessel, its tubes and headers must similarly be designed for 1450 psia and 650°F.

5.1.1.4 Flow Ducting

A cylindrical flow baffle separates the helium passages in the Dowtherm heat exchanger from the interior of the vessel. At its upper end, this baffle is attached to a flow inlet structure in which is mounted the restrictor valves. Near the bottom of the vessel, it turns inward to form a bell mouthed entrance to the central flow tube. A 1/2-inch square opening screen covers the mouth of the flow tube, as a safety measure, to prevent possible injection of foreign material into the compressor inlet by helium stream pickup. This cylindrical flow baffle is additionally stiffened by axial stiffeners or supports, as required.

A bolted, hinged cover in the cylindrical flow baffle, opposite the personnel access port in the vessel wall, provides access to the interior of the vessel. Ladder rungs attached to the interior of the baffle wall permit personnel to climb down into the interior region to reach instrumentation devices or to perform maintenance and inspection.

The central flow tube is 29 inches in diameter and returns the helium to the compressor inlet. It extends upwards from the bell mouthed entrance near the bottom of the vessel to the inlet of the radial compressor near the top of the vessel. An isolation valve is positioned at the upper end of this flow path near the compressor inlet, and is connected to the central flow tube by a bellows expansion device to accommodate differential thermal expansion.

5.1.2 RAPID DEPRESSURIZATION SYSTEM

To simulate a design basis accident, a rapid depressurization valve, connected to the circulator vessel, has been provided. This valve has a controllable opening rate to provide a depressurization curve similar to that which would occur in the reactor vessel in the event of a line break or a major leak. Different depressurization rates simulating different leak sizes may be obtained by adjusting the valve controller. The valve discharge is ducted to the roof through a silencer to atmosphere.

5.1.3 HELIUM CIRCULATOR SERVICE SYSTEM

The helium circulator service system consists of a water supply for the compressor bearing lubrication and a dry helium supply for the buffer shaft seal. These systems will be skid mounted modules, identified as the Bearing Water Module, the Shutdown Bearing Water Module and the Helium Dryer

Module, as shown schematically on Drawing 23859, in Section 9. They are ASME Safety Class I systems prototypical of the service systems to be used in the development plant.

5.1.3.1 Helium Dryer Module

The circulator buffer helium supply system provides flow to the circulator labyrinth shaft seal. The helium flow in the labyrinth seal is split so that half flows into the circulator test vessel and half is mixed with bearing water. The helium mixed with the bearing water is reclaimed via a high pressure helium/water separator. Helium flows from the test vessel and the helium/water separator are sent through the Helium Dryer Module where the gas is dried, filtered, and compressed to be recycled back to the circulator labyrinth seals. The moisture removal capacity of the driers is adequate to attain 10 ppm of moisture from a saturated condition at 1300 psia and 110°F. The helium flow from the dryer to the circulator is as follows:

Volume Flow (constant)	10 acfm
Pressure (above test vessel pressure)	5 psi
Temperature	110°F (max.)

5.1.3.2 Bearing Water Module

The main function of this system is to provide a continuous flow of pressurized water to the circulator bearings. The water shall be continuously filtered to 10 u nominal and cooled to remove heat input from circulator bearing friction and the bearing water supply pumps. In addition, water flows are required for the helium/water drain jet pumps which are used to maintain the integrity of the buffer helium seal and to prevent leakage of bearing water into the test vessel. Bearing water flow to the circulator is as follows:

Flow	500 gpm
Pressure (inlet to bearing housing)	1000 psi above test vessel pressure
Temperature	110°F (nominal)
Test Pump Flow (total)	drain cavity pressure

5.1.3.3 Shutdown Bearing Water

If the normal bearing water supply fails (as indicated by low bearing differential pressure), the shutdown bearing water supply system will be automatically actuated and will provide sufficient bearing water for the circulator to trip and come to a complete stop. Then the static shaft seals will be set to prevent out-leakage of test vessel helium. Shutdown bearing water is supplied by high pressure, nitrogen-powered, water accumulators. Following actuation of this system, the accumulators will be refilled and nitrogen will be vented to a reclamation system where it will be dried, compressed and recycled to the nitrogen gas pressurizer.

This system must be in "ready" status before the circulator can be restarted.

The shutdown bearing water system characteristics are as follows:

Flow	450 gpm (for max. of 3 min.)
Pressure	800 psi above test vessel pressure
Temperature	110°F (max.)
Nitrogen pressure	2800 psia
Nitrogen inventory	4600 lbs or 6500 scf

5.1.4 ELECTRIC MOTOR DRIVE

The circulator motor drive will consist of a main motor, a pony motor and associated controllers.

5.1.4.1 Main Motor

The main motor will be a 17,900 KW synchronous motor with brushless exciter rated for full power operation at 3600 RPM. The motor will be designed for variable speed operation (360 - 3600 RPM) and will have its first critical speed above 3600 RPM. The motor will be of totally enclosed construction. The housing will enclose the rotor, stator, brushless exciter, bearings, bearing lubrication system, heat exchanger equipment for cooling the windings and bearings, and the pony motor and associated equipment. The voltage rating will be 13,200 volts at full load with starting being accomplished at zero frequency by a variable frequency power supply. The main motor will not be IEEE Safety Class IE. However, it is safety-related to the extent that it must be structurally and seismically qualified to remain capable of being driven by a safety-related pony motor under certain off-normal conditions. The motor overall dimensions, including the pony motor, are approximately 179 inches in diameter by 260 inches high.

5.1.4.2 Pony Motor

The pony motor will be a 3-phase induction motor rated for full power operation at 1800 RPM. This motor will be designed for variable speed operation over the speed range from 150 - 1800 RPM. It will be designed to IEEE Safety Class IE requirements and will receive its power from a separate safety-related controller (see Section 5.1.4.4). The pony motor will be mounted on top of the main motor and coupled to the shaft through an overrunning clutch to prevent rotation when the main motor is operating.

5.1.4.3 Main Motor Controller

The main motor controller is a solid-state adjustable frequency power supply with output rating compatible with motor operating and stability requirements over the entire speed range. The power supply consists of two three-phase thyristor bridges linked together through a smoothing reactor (DC link). One three-phase bridge is connected to the facility power system and operates as a phase-controlled rectifier to supply power to the DC link. The second bridge is connected to the synchronous motor and inverts the power from the DC link into the motor stator.

During normal motoring (above 10 percent speed), the speed of the motor is approximately proportional to the voltage of the DC link and the torque is approximately proportional to the current in the DC link. These values are adjusted by the electronic circuits contained in the logic section of the controller; the circuits will be arranged to provide a braking mode. For operation below approximately 10 percent: the rectifier is phased on and off to provide low frequency pulses which are directed to the proper motor windings by the inverter thyristors. This results in a three-phase system of low frequency pulses being applied to the motor and permits starting and accelerating from zero frequency.

The controller for the main motor is not safety-related and connection to the motor will be by a combination of bus duct and cable run. Connection to the input side of the controller will be through an input transformer located in the switchyard. The dimensions of the main motor controller will be approximately 90 feet long by 10 feet wide by 10 feet high.

5.1.4.4 Pony Motor Controller

The pony motor controller will be a safety-related solid-state forced-commutated power supply with output rating compatible with pony motor operating and stability requirements over the entire speed range. The controller will be connected to the motor by a cable run. The controller dimensions will be approximately 7 feet long by 3 feet wide by 7.5 feet high. This controller will be designed to IEEE Safety Class IE requirements.

5.1.5 INSTRUMENTATION

Special test instrumentation is required for monitoring test variables and equipment performance. This instrumentation is discussed below.

5.1.5.1 Test Instrumentation Sensors

5.1.5.1.1 Helium Circulator and Diffuser

The test helium circulator and diffuser will have the same sensors as will be used in the development power plant plus several needed for determining aerodynamic performance and machine efficiency. The sensors will detect flow, pressure drops, temperatures and shaft vibration and displacement.

5.1.5.1.2 Test Vessel

The test vessel will have sensors for detecting helium temperature, pressure, sound level, sound frequencies, moisture, coolant inlet and outlet temperatures, vessel skin temperatures, crack and flaw propagation, and restrictor valve and isolation valve positions.

5.1.5.1.3 Helium Circulator Service System

The circulator service system will have sensors for measuring pressures, temperatures, flows, pressure differentials and levels for the bearing water and buffer helium systems.

5.1.5.1.4 Main Motor

The main motor will have sensors for measuring winding temperatures; lube oil pressure, temperature and flow; and shaft vibration, displacement and speed.

5.1.5.1.5 Main Motor Controller

The main motor controller will have sensors for measuring motor voltage and current for each phase, ground faults, cooling water inlet and outlet temperatures and cabinet temperature.

5.1.5.1.6 Pony Motor

The pony motor will have sensors for measuring bearing oil temperature, oil level, winding temperature and shaft speed.

5.1.5.1.7 Pony Motor Controller

The pony motor controller will have sensors for detecting motor voltage, current and ground faults for each phase plus cabinet and cooling air outlet temperatures.

5.1.5.2 Signal Transmission

Nearly all sensor outputs require local conditioning before they may be transmitted to the control and data acquisition system. The system to be used here will have local coupling stations where the signals will be conditioned, converted and transmitted by multiplexing over a single coaxial cable to the control room. Signals which perform essential control or alarm functions will be parallel hard wired to the control room.

5.1.5.3 Data Acquisition System

The majority of instrumentation measurements taken in the facility will be used to evaluate the performance of the helium compressor and its drive system. A data acquisition system is provided for recording this data by appropriate means. This data acquisition system has the following read-out and data gathering components:

Low speed strip chart recorders.
Oscillographic strip chart recorder
Tape recorder
Data printer
Spectral analyzer
CRT display
Panel display and alarms for essential measurements

5.2 SERVICE SYSTEMS

The previously discussed systems or equipment will be subject to testing. The systems discussed herein, while essential to the operation of the facility, do not include experimental systems or equipment, or equipment on which tests will be run in satisfaction of the purpose of this facility.

5.2.1 VACUUM SYSTEM

Before charging the circulator vessel with helium, it must be evacuated of whatever atmosphere or water vapor it contains. A vacuum system discharging to atmosphere will remove the gaseous contents and dry the vessel out. The system will be capable of drawing the vessel down to an absolute pressure no greater than 1 mm of Hg. This system is shown on Drawing ME-02, in Section 9.

5.2.2 HELIUM STORAGE AND SUPPLY SYSTEM

A helium supply and storage system, as shown on Drawing ME-02 in Section 9, is provided to charge the test loop and to provide storage space for reclaiming helium from the loop. The system consists of gaseous helium storage bottles, a helium compressor system, an aftercooler, a dryer and associated piping, valves and controls. The helium storage bottles are rated 3000 psig (working pressure 2400 psig). Each bottle has approximately 9 cu. ft. of volume.

Initially, the helium is fed from storage directly to the test vessel. When the pressure difference between the storage bottles and the test vessel has equalized, part of the helium compressor system will be started to pump the rest of the vessel charge from the storage bottles to the test vessel.

When makeup helium is required, this same procedure will be utilized to add helium to the vessel.

After the pressure of the helium inside the test vessel reaches 604 psig, the filling will be stopped, and the helium circulator will be started to heat the helium in the vessel by compression and frictional dissipation losses until the pressure and temperature reach 1300 psia and 600 F, respectively, at the circulator outlet. At this point, the Dowtherm G cooling system will be brought on stream to remove excess heat generated by the helium circulator and to maintain the pressure and temperature inside the vessel at the above mentioned level.

After a particular test is performed, or during a shutdown period, helium will be transferred back to the storage bottles via the helium dryer module, to remove possible moisture contained in the helium. The dried helium then will be compressed into the storage bottles. The heat generated by the compression process will be removed by water-cooled heat exchangers.

5.2.3 DOWTHERM G COOLING SYSTEM

The function of the Dowtherm G cooling system, as shown on Drawing ME-02, in Section 9, is to remove the excess heat from the gaseous helium inside the test vessel, to automatically maintain a desired pressure and temperature level during the test operation, and to lower the helium temperature before transfer of helium back to storage.

The major equipment of the system is the Dowtherm G/helium heat exchanger, Dowtherm G circulating pump, Dowtherm G to air dry cooling tower, expansion tank, Dowtherm G storage tank, and associated piping, valves and controls. The system is capable of removing 61 million Btu's/hr at full load operation.

The system is actuated by starting the Dowtherm G circulating pump first. When Dowtherm G fluid starts circulating inside the system, it begins to transfer heat from inside the test vessel to the outside air cooler, which in turn will dissipate heat carried by the Dowtherm G fluid to the atmosphere. During operation, the Dowtherm G fluid will have expanded due to its temperature increase. An expansion tank is provided to compensate the volumetric change of the fluid.

A Dowtherm G storage tank, and a drain pump have been provided for storage of the Dowtherm G during maintenance and repair.

5.2.4 COOLING WATER SYSTEM

The cooling water system, as shown on Drawing ME-03, in Section 9, provides cool water to facility equipment, such as the circulator motor cooler, the circulator motor controller cooler, the bearing water cooler, the bearing oil cooler, etc., for heat removal purposes. It is designed to provide cooling water at 90^{o}F to using equipment and return the water at a temperature no greater than 120^{o}F. The warm water will circulate

through a dry water-to-air heat exchanger located at the back of the facility property. A circulating pump, with 100 percent redundancy, will circulate the water through the system. An expansion tank will accommodate volumetric changes in temperature and serve as a reservoir for makeup water. Appropriate piping, valves, and controls complete the system.

5.2.5 NITROGEN SYSTEM

Nitrogen is provided to pressurize the circulator radial compressor shutdown bearing water module accumulators and to blanket the circulator vessel after the helium has been reclaimed and returned to storage. This system is shown on Drawing ME-04, in Section 9.

The nitrogen is stored in gaseous form at 2400 psig in storage bottles outside in the gas storage area, in back of the building. Compressors are capable of raising this pressure to 2800 psig for bearing water accumulator use. During maintenance of the accumulators, the nitrogen will be reclaimed and stored in the bottles. Vessel blanketing nitrogen will be discharged to atmosphere after use.

5.2.6 WATER TREATMENT SYSTEM

The water treatment system produces water to the following specification:

pH: 10.0 - 10.2

O_2: Below 1 ppm

Conductivity: 1 micromho

The system as shown on Drawing ME-03, in Section 9, consists of the following components:

1- Cation Unit
1- Anion Unit
1- Mixed Bed Polisher
1- $NaSO_3$ Feed System for Oxygen Scavenging
1- Ammonium Hydroxide System for pH Control
1- Caustic and Acid System for Regeneration
1- Automatic Control System
1- Piping System

All the components listed above are mounted on a skid. All the water production, regeneration and rinse operations are automatically controlled.

5.3 CONTROL AND INSTRUMENTATION

Controls and instrumentation required for the facility, other than test instrumentation described in Paragraph 5.1.5, are described in the subsequent paragraphs.

5.3.1 CONTROL ROOM

The information and control functions managed or monitored from the control room are displayed, acted upon or controlled from control panels. The control panels consist of approximately sixteen feet of 84 inch high vertical panels and a six foot bench type control console. Functions which must be frequently monitored or controlled during operation will be displayed or controlled from the console. Support or less frequently referenced devices will occupy the vertical panels. Approximately six feet of vertical panel space is devoted to the electrical power systems, approximately six feet to test parameters and special equipment, and four feet to auxiliary and support service systems.

A two-foot wide signal conditioning cabinet is located in the terminal room. It houses the signal conditioning devices and equipment. The terminal room is a conductor termination and cable spreading room, located at one side of the control room. All of the wiring going to or from the control room, except power, terminates in this room.

Essential control and information circuits are hard wired. Signal conditioned circuits are connected with control room devices with prefabricated cables having quick disconnect terminals. Normal control room wiring is run under the floor, which is designed like a computer room floor, and enters the console and cabinets from below. Overhead entry to the vertical panels is also available by conduit or wiring ducts extended into the false ceiling of the room.

5.3.2 LOCAL CONTROL

Those devices or system modules which do not require direct control room control or monitoring, such as the water treatment system, have local control stations as appropriate to their function and actuation requirements. In all cases motor controlled devices have full local control capability. When both control room and local control stations exist, the local control will always have emergency stop and lockout capability. These local stations will have start capability only with control room control switch permission. Local control condition will be indicated in the control room.

SECTION 6

SAFETY EVALUATION

6.1 FIRE PROTECTION AND RISK EVALUATION

The facility building is structural steel framed with reinforced concrete partial side walls and insulated steel for the remaining walls and the roof.

The building construction conforms with the requirements of NFPA 101. The site and building location will not create a fire hazard to other facilities nor will it be endangered by potentially adjacent structures.

6.1.1 FIRE PROTECTION

The facility is equipped with portable fire extinguishers and an automatic wet pipe sprinkler system throughout, except in the control room and in the motor controllers where automatic Halon 1301 systems are employed. The outdoor power transformer is protected by automatic water spray deluge systems and surrounded by small curbs to contain and prevent the spread of any oil leakage. A fire wall separates the 4.16 kV/480 volt transformers from each other. All of the automatic fire protection systems are alarmed in the control room and at the security gate or the fire station.

6.1.2 MOST PROBABLE FIRE INCIDENT

The most probable cause of fire in this facility would be from insulation failure in electrical equipment. The main motor controller is valued at $2,674,000 but with the automatic fire protection systems, it is highly improbable that any fire loss would be as great as $100,000.

It is believed that this facility meets the criteria of the "Improved Risk" rating and the requirements of ERDA Manual Chapters 0552 and 6301.

6.2 EXPLOSION AND HIGH PRESSURE PROTECTION

High pressure gases are used in this facility at pressures up to 1436 psig in the circulator vessel, up to 2500 psig in the helium supply and storage system, and up to 2850 psig in the nitrogen system. The vessels in all high pressure systems are designed and will be fabricated in

conformance with the ASME Boiler and Pressure Vessel Code - Section VIII, and the piping with ANSI B 31.1. Gas storage cylinders will conform to the U.S. Department of Transportation Title 49, Code of Federal Regulations, Transportation Parts 100-199.

6.3 INDUSTRIAL SAFETY

The principle industrial safety hazards and risks that may be encountered during operation of this facility are:

- o Standard hazards associated with office space, shops and multi-storied large equipment test facilities.
- o Standard hazards associated with movement of heavy equipment.
- o Implosion and explosion hazards from high vacuum and intermediate pressure gas systems.
- o Electric shock from contact with high and intermediate voltage electrical systems.
- o Burns from high temperature vessels and piping.

Single or dual fatalities are the maximum probable consequences of injuries that would result from these hazards. Property damage could occur from several of them. Measures taken to prevent accidents and reduce damage and risks from these hazards are discussed below.

6.3.1 RISKS ASSOCIATED WITH OFFICE SPACE, SHOPS AND MULTI-STORIED LARGE EQUIPMENT TEST FACILITIES

These risks will be controlled by designing and constructing the facility in accordance with the requirements of ERDA Manual Appendix 6301, and applicable national, federal and state standards, codes and regulations.

Emergency electrical power is provided from batteries for lighting of all stairways, hallways, ladders, exits and essential equipment areas, both indoors and outdoors.

Railings are used for all open pit areas, catwalks and stairways. Cages surround all escape and access ladders.

6.3.2 RISKS ASSOCIATED WITH MOVEMENT OF HEAVY EQUIPMENT

All heavy equipment will be moved by overhead cranes or by a transfer dolly. The cranes will be constructed, tested, certificated, operated, and maintained in compliance with the State of California Division of Industrial Safety, General Industry Safety Orders.

6.3.3 RISKS FROM FAILURE OF VACUUM SYSTEMS OR INTERMEDIATE PRESSURE GAS SYSTEMS

A vacuum system has been provided for circulator vessel dryout. Intermediate pressure air systems have been provided for instrument and service air. Operations involving the use of these systems will be planned and personnel trained to ensure knowledgeable usage in compliance with engineering and operational safeguards and all governing regulations.

6.3.4 RISKS OF ELECTRIC SHOCK FROM ELECTRICAL SYSTEMS

The electrical equipment and facilities conform to the latest edition of the National Electrical Code, to the requirements of the City of San Diego and to the State of California Division of Industrial Safety, High Voltage Electrical Safety Orders and Electrical Safety Orders, and to the State of California General Order No. 95. High voltage equipment will be operated only by a qualified operator, as defined in the State of California Division of Industrial Safety, High Voltage Electrical Safety Orders.

6.3.5 RISK OF BURNS FROM HIGH TEMPERATURE VESSELS OR PIPING

All high temperature piping vessels or other equipment will either be thermally insulated so that exposed surfaces will not exceed 150^{o}F or will be protected by barriers so that personnel cannot be inadvertently exposed to the risk of burns.

6.4 SEISMIC PROTECTION

6.4.1 BUILDING STRUCTURES

The facility structures are designed in accordance with the Uniform Building Code and ERDA Manual, Appendix 6301.

6.4.2 MECHANICAL AND ELECTRICAL EQUIPMENT

All large fixed equipment will be secured to its foundation so that overturning cannot occur. The building is designed to survive an earthquake intact, so that damage to the facility from an earthquake is **not** expected.

6.5 RADIATION AND HEAVY METAL SAFETY

There will be no radioactive materials or heavy metals handled in this facility.

6.6 INDUSTRIAL HYGIENE

It is not anticipated that any toxic materials will be handled in this facility. High voltages of sufficient magnitude to potentially cause

ozone production or air ionization occurs only in the outdoor high voltage switchyard where natural dispersion and air currents will prevent potentially dangerous concentrations.

6.7 FLOOD HAZARDS

This facility will be located out of the flood plain and has a site drainage system adquate to handle anticipated surface runoff. All below grade structures will have a waterproof membrane to prevent water seepage. There is a negligible chance of flooding or causing water damage to any parts of this facility.

SECTION 7

ALTERNATIVES CONSIDERED

7.1 TRADE-OFF STUDIES

In the course of the development of this conceptual design many trade-off studies were made in the areas of space arrangement, equipment design, noise abatement, materials, heat dissipation, etcetera. Some of the trade-off studies were quantitatively evaluated, others qualitatively, and still others were of a minor nature not significant enough to describe in this report. The following paragraphs describe the most significant trade-off studies.

7.2 MOTOR ENCLOSURE

Two types of motor enclosures were initially considered; one a drip proof enclosure, which is acoustically open to the atmosphere, and another of a totally enclosed construction. Initial estimates of the sound levels generated by a vertical motor of this size, considered acoustically open to the atmosphere, made it extremely difficult if not impossible to muffle the noise to intensity levels acceptable under OSHA. This problem is particularly onerous because of the substantial low frequency contribution from the type of bearing necessary for vertical orientation.

Partially for this reason a motor of totally enclosed construction was selected. The noise attenuation provided by this sealed acoustic environment was adequate to permit full shift of personnel occupancy on the operating floor under OSHA guidelines.

7.3 CIRCULATOR VESSEL

The circulator vessel houses the main helium loop. Initially it was designed to provide a full diameter flanged vessel to provide ready access to all vessel internals for maintenance or replacement. Because of the pressure, temperature, nozzle location, and the necessity of being able to insert and remove flange bolts, a long massive circulator vessel design was required.

An alternative vessel was considered wherein the opening into the vessel was of the diameter necessary to accommodate the insertion of the radial compressor and its supporting flange. This type of vessel design requires a different approach to the design of the vessel internals so that they may be inserted through this smaller diameter vessel opening.

One of the considerations favoring the full diameter flanged vessel was the flexibility to accommodate design changes. If future design work necessitated changing the mounting flange diameter for the radial compressor support, a full diameter flanged vessel would only require replacement of the upper head of the vessel. A vessel with an opening only as large as the radial compressor support flange would require replacement of the entire vessel.

Both vessels were cost estimated, including vessel internals and an extra head for the full diameter flanged vessel. The conclusion was that it was more economical to replace the entire smaller vessel rather than go to the higher initial cost of the full diameter flanged vessel, plus the cost of a later replacement of the upper head. The estimated costs, without escalation or contingency, were:

Full Diameter Flanged Vessel and Internals	$3,100,000
Replacement Head	1,380,000
Smaller Vessel	2,000,000

7.4 MOTOR CONTROLLER LOCATION

It was initially considered that the motor controllers would be located adjacent to and on the same floor level as the control room. This resulted in a wider building with a large floor slab and roof covering. It also caused additional length of heavy conductor runs to the main motor from its controller.

The recommended alternative was to double deck the side bay and locate the motor controller above the control room. This arrangement saved real estate, concrete slab, and roofing and shortened the conductor runs. Conversely, it causes a slight increase in the cost of building structural steel, due to the added length of the outside columns, and necessitated inserting vibration dampers under the motor controller to limit the conducted sound intensities in the control room. As a result of the cost savings, the two story concept was adopted.

7.5 HEAT DISSIPATION SYSTEM

The atmospheric heat dissipation system for cooling water and the Dowtherm system was chosen as dry type, fluid-to-air heat exchangers. This choice was made in spite of the more favorable costs of wet cooling towers because of the location of the facility within the Southern California coastal fog belt. A potentially hazardous water vapor addition to atmosphere, under a coastal fog inversion layer, could jeopardize vehicular traffic. Consequently, the cooling towers selected and costed were dry cooling towers.

7.6 MAIN MOTOR CONTROLLER COOLING

Cooling of the main motor controller is required because of rectifier and inverter losses. The controller manufacturer was not far enough along in his design to have the cooling system firmed up. Two possibilities

were assumed. The first was that the controller modules required an externally supplied source of cooling water and the second, that the controller modules required a source of cooling air.

The cooling water approach was included in the cost estimate for this project and required that sufficient water capacity and cooling tower capacity be provided. With this approach it is assumed that the controller manufacturer takes the cooling water at the controller wall and utilizes it within the controller in whatever manner desired. If air cooling is employed then the air is assumed taken from and returned to the controller room at ambient temperature.

The cooling air approach requires a separate refrigerated air supply at 70^{o}F inlet and sufficient volume to keep discharge temperature within 104^{o}F. In this arrangement a separate outdoor pad mounted air conditioning unit would be located on the ground adjacent to the side wall of the motor controller room. The air would then be ducted into the controller and ducted out through the roof. Because of the volume of air required, this becomes rather expensive. The cost for this air system has been estimated at $73,000(1).

(1) Includes all adders, installation, time of installation prices and contingency.

SECTION 8

COST ESTIMATE AND SCHEDULE

8.1 COST ESTIMATE

The level-of-effort of this cost estimate is comparable to the conceptual design contained in this report. The estimated costs of equipment and systems for which GAC was responsible are included herein as provided to Parsons by GAC.

8.1.1 BASIS OF COST ESTIMATE

The conceptual design cost estimate as presented in this report is based on the following:

1. Conceptual design drawings included in Section 9.

2. Preliminary engineering and construction schedule included in this section.

3. Outline specifications included in Section 10.

4. Engineering costs reflect Parsons best estimate of the effort required to completely design this facility as a "first of a kind".

5. It is assumed that this facility will be constructed by a general contractor operating under a "lump sum" contract, and the estimate has been so structured.

6. Where possible, vendor quotations were obtained for the cost of equipment. Where quotations were not available, the cost was developed on the basis of historical data pertaining to similar type equipment.

7. The pricing of bulk material is based on current experience in the San Diego area.

8. Manual labor rates are work operation composites based on labor agreements in effect in the San Diego area as of April 1978, and include travel, fringe benefits, payroll taxes and insurance where applicable. Labor costs are based on a straight time, standard single shift work week of 40 hours.

9. Labor productivity included in the estimate reflects Parsons standards for construction of this type in the San Diego area.

10. Indirect field costs reflect past experience on other similar projects.

11. The escalation rates used were taken from escalation tables developed by the Cost Engineering Department of Parsons. This data was collected by the Procurement Department from direct contact with Industry and from experience. The escalation tables are not the result of direct economic and/or market studies conducted by The Ralph M. Parsons Company. They are the subjective forecast of Parsons management based on reliable sources.

12. The contingency used in the estimate represents Parsons evaluation of job scope adequacy, reliability of quotations and historical data.

13. The CSI coding system, developed by the Construction Specification Institute, was used to identify the estimate components.

14. Electricity, water and sanitary sewer services are assumed available at the site boundary.

15. The cost base of the estimate is May 1978 (present day).

8.1.2 INCLUDED IN COST ESTIMATE

The costs for the following items have been included in this conceptual design cost estimate:

1. Titles I, II, and III Architect-Engineering services, including preliminary engineering, final design, and inspection services.

2. Titles I, II and III General Atomic Company services, including engineering, procurement, liaison and project management.

3. Site clearing, grading, excavation, dewatering, and piling.

4. Bulk materials and the labor of installation.

5. Mechanical and electrical equipment, vessels, tanks, conduit, wire, busways, cable, heating, ventilating

and air conditioning, fire protection, plumbing, roofing, painting and related items and the labor of installation.

6. An allowance for contractors' insurances, overhead and profit.

7. Escalation on materials and labor to the mid-point of construction as determined from the preliminary engineering and construction schedule.

8. A contingency which reflects Parsons experience in developing cost estimates for this type of project and with this degree of engineering and design.

9. Installation of GAC supplied equipment and materials.

GAC has developed and furnished costs for inclusion in this estimate for the following items:

1. Special equipment for which GAC has design responsibility.

   Helium circulator service system
   Main motor
   Pony motor
   Main motor controller
   Pony motor controller

2. Instrumentation and control equipment for the following:

   Helium circulator
   Main motor
   Pony motor
   Main motor controller
   Pony motor controller
   Helium circulator service system
   Diffuser
   Isolation valve
   Test vessel

3. Land and land rights

4. Environmental impact reports or other special reports required to obtain permits or licenses.

5. Operating and maintenance manuals.

6. Operating contractors' services.

8.1.3 EXCLUDED FROM COST ESTIMATE

The costs for the following items have been excluded from the total estimated cost of the test facility shown in Table 8-1.

1. Quality assurance requirements on materials, equipment, and construction are limited to those normally obtained on an industrial project. Excluded are quality assurance requirements beyond the construction scope as defined within the Conceptual Design Report.

2. Roads for the moving in of heavy equipment from manufacturer to facility access are assumed available and are directly dependent upon site location.

3. Security and guard services are assumed provided by the General Atomic Site Security.

4. Tests other than those normally provided by a construction contractor are excluded. Performance testing of major equipment is included within the Title III effort.

5. Insurance coverage over and above that which is normally required is not included.

8.1.4 COST ESTIMATE SUMMARY

The construction and engineering costs for the project are presented in Table 8-1. The format is in conformance with ERDA Appendix 1301, Part II, Section C2, entitled, "Schedule 44 Construction Project Data Sheet." Government furnished equipment is used in this table to refer to items that the General Atomic Company, as the operating contractor, would procure and provide to the constructor for installation.

Cost breakdowns are provided in supplemental tables to permit cost tracing of an account from the Schedule 44 format to the Construction Specification Institute (CSI) Divisions, Tables 8-2, 8-3, 8-4 and 8-5. Further breakdowns are possible by referring to the collected estimate sheets.[2]

8.1.5 FINANCIAL SCHEDULE

Fiscal year obligational needs for each year for which appropriations are to be requested are shown on Table 8-6.

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[2] "Gas Cooled Fast Breeder Reactor - Helium Circulator Test Facility Conceptual Design Cost Estimate," prepared by the General Atomic Company Unpublished Data, June 1978.

8.2 RELATED OPERATING EXPENSE FUNDED COSTS

8.2.1 RESEARCH AND DEVELOPMENT NECESSARY TO COMPLETE CONSTRUCTION

Research and development necessary to complete construction include the following:

- Conceptual and preliminary design of the radial compressor, loop isolation valve, and circulator service system.
- Development and testing of the compressor inlet diffuser, bearings and seals and the loop isolation valve.
- Conceptual design of the circulator test facility.
- Detailed design of the circulator drive main and pony motors and the controllers for these motors.

The estimated cost for this effort is $4,514,000 (July 78 dollars).

8.2.2 PROGRAMMATIC OPERATING EXPENSES

First-of-a -kind engineering and manufacturing for the radial compressor and loop isolation valve is estimated at $5,917,000 (July 78 dollars).

8.2.3 INSTALLATION AND OPERATOR TRAINING

Installation of circulators 1, 2 and 3 plus operator training is estimated at $366,000 (July 78 dollars).

8.2.4 FACILITY OPERATION

Electricity, salaries, spare parts, consumables and start-up services for the 4-1/2 year operation of the facility is estimated at $7,100,000 (July 78 dollars).

8.2.5 SCHEDULE

Schedule 8-1 shows dates and time spans for the operating expense funded items described above.

8.3 PROJECT SCHEDULE

The conceptual design engineering and construction schedule is based on the feneral Atomic Company's desire to have the facility constructed and available for their checkout on August 1, 1982.

Schedule 8-2 identifies the time periods in which the engineering and construction may occur for the conceptual design developed. The schedule also identifies major milestones and interfaces for engineering and design, procurement, installation and construction, and for start-up testing.

The overall objective of the schedule is to produce an engineering and construction plan that will provide the following:

- o Basis for estimating engineering and construction costs.
- o Determination of the total time required for facility construction.
- o Definition of the major project schedule parameters.
- o Identification of the pacing or long lead time items.

The conceptual schedule for the Helium Circulator Test Facility is included in this section.

8.3.1 ENGINEERING SCHEDULE

Based on the start of Architect-Engineer Title I engineering and design on October 1, 1979, it will be necessary to perform engineering and construction on a "fast track" approach. Two basic construction packages would be required. One for site work, grading, excavation, and piling; and the other for the overall building, its internals, and finish site work.

The Architect-Engineer Title I work, based on this conceptual design, can be completed in a period of five months permitting a review period by the client of two weeks. The Architect-Engineer Title II final design can be completed in a period of nine months. The first construction package, referred to as site package, would be issued for bid five months after start of Architect-Engineer Title II work, or on July 1, 1980.

Architect-Engineer Title III services would begin two months after issue of the Site Package, and one month prior to the award of contract on the Site Package. Title III would continue for 24 months or for one month beyond facility completion, to allow time to prepare as-built drawings, etcetera.

8.3.2 PROCUREMENT AND CONSTRUCTION SCHEDULE

The most critical pacing or long lead time item is the 24,000 horsepower motor and controller. Unless procurement of these items is initiated by October 1979, the end date of the construction schedule cannot be met. The only other long lead procurement specification that must be issued prior to the completion of the Title II work is for the circulator test vessel.

8.4 COST AND SCHEDULE UNCERTAINTIES

The principle cost uncertainties are those associated with escalation. Considering the unpredictability of inflation, the ability to correctly anticipate price changes many months in the future is only approximate.

Schedule uncertainties are primarily associated with the ability to start the project on schedule and the correct anticipation of procurement lead times. To start the project on schedule requires the project money to be available as planned. Delays in congressional authorization or for any other cause will not only impact the schedule, but also the escalation costs for equipment, materials and labor.

If equipment fabricator shops fill up with large industrial and utility orders, the lead times for equipment procurement could lengthen considerably. This would impact both schedule and escalation costs.

8.5 METHOD OF PERFORMANCE

The design will be accomplished by a negotiated Architect-Engineer contract. Construction and procurement will be accomplished by fixed-price contracts and subcontracts awarded on the basis of competitive bids to the extent feasible.

TABLE 8-1

FACILITY TOTAL ESTIMATED COST SUMMARY

(Thousands of Dollars)

	Architect/ Engineer	Government-Furnished Equipment	Total
A. Engineering			
Title I	$ 494	$ 185	$ 679
Title II	1,575	1,135	2,710
Title III	570	656	1,226
B. Land & Land Rights	-	78	78
C. Construction Costs			
1. Improvement to Land	763	47	810
2. Building - 17,950 Sq. Ft. Gross ($152.20 Sq. Ft.)	2,732	-	2,732
3. Other Structures	608	-	608
4. Special Facilities:			
a. Test Vessel & Internals	3,715	-	3,715
b. Helium Circulator Service System	-	2,504	2,504
c. Main Motor & Pony Motor	84	2,339	2,423
d. Main Motor Controller	184	3,169	3,353
e. Pony Motor Controller	43	839	882
f. Special I & C	-	639	639
g. Cranes & Hoists	713	-	713
h. Misc. Special Equipment	3,616	26	3,642
5. Utilities	1,365	-	1,365
D. Standard Equipment	81	-	81
Subtotal A	$16,543	$11,617	$28,160
Contingency - 20%	3,309	2,323	5,632
Subtotal B	$19,852	$13,940	$33,792
FY 78 Construction Planning and Design (CP&D)			420
FY 79 Plant Engineering and Design (PE&D)			1,000
Total Estimated Cost of Facility			$35,212

TABLE 8-2

ENGINEERING COST BREAKDOWN

(Thousands of Dollars)

Architect/Engineer

Title I - Preliminary Design			
a)	Basis = 4% x (Constr Cost + Contractor's Overhead & Profit) .04 x $11,123	445	
b)	Escalation = 11% x $445	49	494
Title II - Final Design			
a)	Basis = 12% x (Constr Cost + Contractor's Overhead & Profit) .12 x $11,123	1,335	
b)	Escalation = 18% x $1,335	240	1,575
Title III - Construction Management & Surveillance			
a)	Basis = 4% x (Constr Cost + Contractor's Overhead & Profit) .04 x $11,123	445	
b)	Escalation = 28% x $445	125	570

Government-Furnished Equipment

Title I			
a)	GAC Liaison & Project Management	121	
b)	Instrumentation & Control Design	45	
c)	Escalation ($12 + 16% of $45)	19	185
Title II			
a)	GAC Liaison & Project Management	218	
b)	Helium Circulator Service System Design	695	
c)	Instrumentation & Control Design	68	
d)	Escalation ($32 + 16% of $763)	154	1,135
Title III			
a)	GAC Liaison & Project Management	533	
b)	Escalation (23% x $533)	123	656

TABLE 8-4

CONSTRUCTION COST BREAKDOWN

(Thousands of Dollars)

Architect/Engineer

C-1. Improvements to Land

Div.	Item		
1.	Gen. Requirements ($1,353 x 8%)	108	
2.	Site Work	422	
	O/H & P & Escalation[1]	233	763

C-2. Buildings

Div.	Item		
1.	Gen. Requirements ($1,353 x 27%)	365	
3.	Concrete	420	
4.	Masonry	32	
5.	Metals	412	
7.	Thermal & Moisture Protection	120	
8.	Doors and Windows	24	
9.	Finishers	96	
10.	Specialties	4	
13.	Special Construction	27	
15.	Mechanical		
	Sect. 1 - Plumbing	8	
	Sect. 2 - Piping	85	
	Sect. 3 - HVAC	55	
	Sect. 4 - Fire Protection	27	
16.	Electrical, Raceways & Steel Structures:		
	Sh. 4	62	
	Sh. 10	171	
	Sh. 11	6	
	O/H & P & Escalation	818	2,732

C-3. Other Structures

Div.	Item		
1.	Gen. Requirements ($1,353 x 2%)	27	
11.	Equipment Sect. 1 (Heat Exchanger)	397	
	O/H, P & Escalation	184	608

[1] O/H & P - Overhead and Profit

TABLE 8-4 (CONT.)

CONSTRUCTION COST BREAKDOWN (Cont.)

C-4. Special Facilities

a. Test Vessel & Internals

Div.	Item		
1.	Gen. Requirements ($1,353 x 15%)	203	
11.	Equipment		
	Sect. 6 Circulator Test Vessel	2,338	
	Sect. 7 Restrictor Valves	43	
	O/H & P & Escalation	1,131	3,715

g. Cranes & Hoists

Div.	Item		
1.	Gen. Requirements ($1,353 x 2%)	27	
14.	Conveying Systems	469	
	O/H & P and Escalation	217	713

h. Misc. Special Equipment

Div.	Item		
1.	Gen. Requirements ($1,353 x 25%)	338	
11.	Equipment		
	Sect. 2 - Pumps	59	
	Sect. 3 - Vessels & Tanks	457	
	Sect. 4 - Compressors	78	
	Sect. 5 - Pkg Units & Spec Equip	189	
15.	Mechanical		
	Sect. 2 - Piping	408	
	Sect. 4 - Fire Protection	9	
16.	Electrical		
	Installation Labor	287	
	1200 amp Switch - 1 ea (Sh 2)	16	
	1600 amp Breaker - 1 ea (Sh 2)	78	
	3 Winding Transformer - 1 ea (Sh 3)	229	
	Nonsegregated Bus - 50 ft (Sh 3)	47	
	Switchgear Assembly - 1 ea (Sh 3)	100	
	138 KV Bus - 1 Lot (Sh 4)	34	
	5 KV Interrupter - 2 ea (Sh 5)	24	
	2 Winding Transformer - 4 ea (Sh 5)	53	
	Switchgear Assembly - 2 ea (Sh 6)	95	
	Power Gear & Disk - 1 Lot (Sh 12)	14	
	O/H & P and Escalation	1101	3,616

TABLE 8-4 (CONT.)

CONSTRUCTION COST BREAKDOWN (Cont.)

C-5.	Utilities		
	Div.		
	1. Gen. Requirements ($1,353 x 4%)	54	
	16. Electrical		
	Instrumentation	171	
	Switchgear and Transformers		
	Sh 2	64	
	Sh 4	36	
	Sh 5	49	
	Sh 6	75	
	Sh 7	65	
	Sh 8	117	
	Sh 9	185	
	Sh 10	96	
	Sh 11	23	
	O/H & P and Escalation	430	1,365

Government Furnished Equipment

C-1.	Improvements to Land		
	a. Environmental Impact Reports	45	
	b. Escalation (4% of $45)	2	47
C-2.	Buildings	None	
C-3.	Other Structures	None	
C-4.	Special Facilities		
	a. Test Vessel & Internals	None	
	b. Helium Circulator Service System	2122	
	O/H & P and Escalation	382	2,504
	c. Main Motor & Pony Motor	1981	
	O/H & P and Escalation	358	2,339
	d. Main Motor Controller	2674	
	O/H & P and Escalation	495	3,169
	e. Pony Motor Controller	705	
	O/H & P and Escalation	134	839
	f. Special I & C	541	
	O/H & P and Escalation	98	639
	g. Cranes and Hoists	None	
	h. Misc. Special Equipment	20	
	Escalation	6	26

TABLE 8-5

STANDARD EQUIPMENT COST BREAKDOWN

(Thousands of Dollars)

Architect/Engineer

Div.			
1.	Gen. Requirements ($1,353 x 10%)	14	
12.	Furnishings	42	
	O/H & P and Escalation	25	81

TABLE 8-6

FACILITY FINANCIAL SCHEDULE

(Thousands of Dollars)

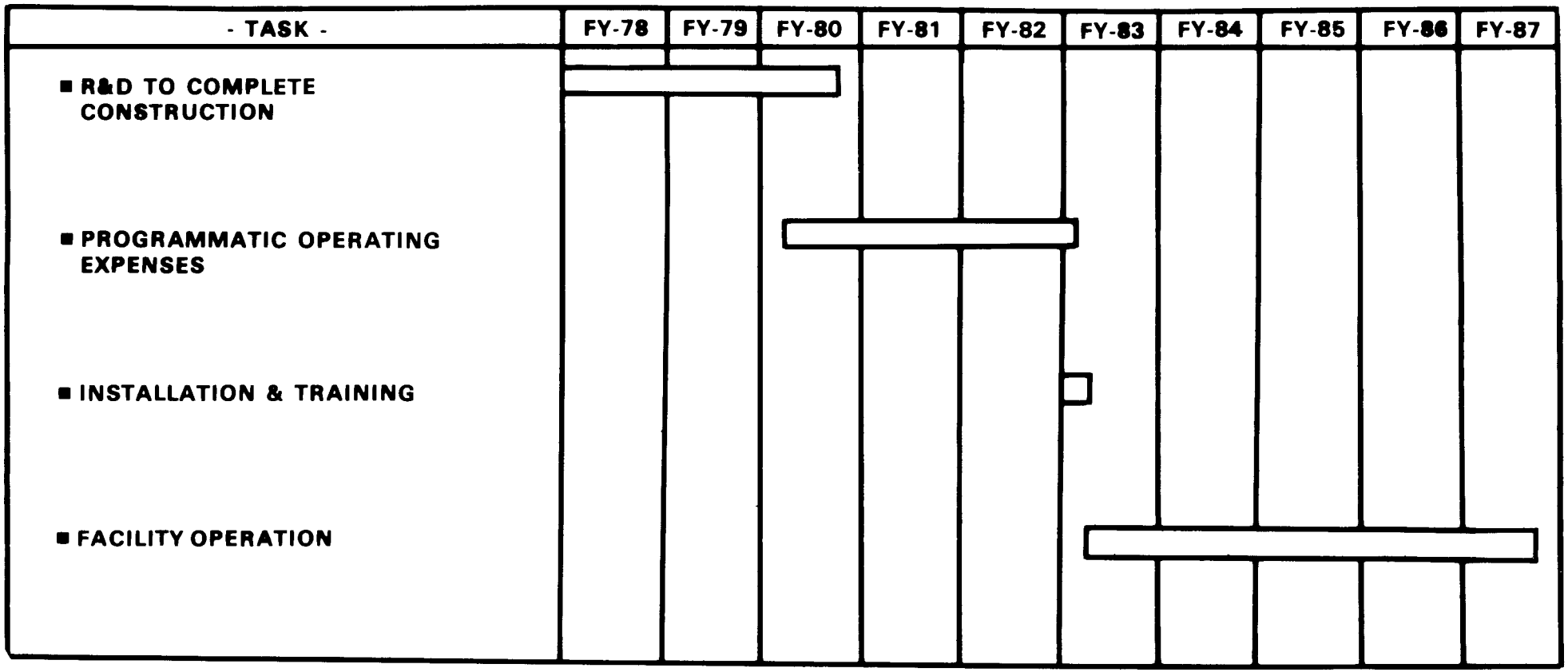
	Facility Construction Cost	Government Furnished Equipment	Total
FY 78		420[1]	420
FY 79		1,000[2]	1,000
FY 80	1,714	1,545	3,259
FY 81	11,496	10,367	21,863
FY 82	6,642	2,028	8,670
Total	19,852	15,360	35,212

[1]Construction Planning and Design (CP&D)

[2]Plant Engineering and Design (PE&D)

SCHEDULE 8-1

OPERATING EXPENSE FUNDED ITEMS



FISCAL YEAR	FY1980												FY1981												FY1982								
CALENDER YEAR	1979			1980										1981												1982								
MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP

TITLE I - PRELIMINARY DESIGN

TITLE II - FINAL DESIGN

TITLE III - SERVICES

CONSTRUCTION

TITLE I REVIEW

TITLE I COST ESTIMATE

PREPARE PROCESS FLOW SHEETS

PREPARE PIPING & INSTRUMENT DIAGRAMS

EQUIPMENT ARRANGEMENTS

BUILDING ARRANGEMENTS

ELECTRICAL & H&V SINGLE LINES

UPDATE PIPING & INSTRUMENT DIAGRAMS

FINAL EQUIPMENT DESIGN & ARRANGEMENTS

PREPARE PIPING DRAWINGS AND SPECIFICATIONS

PREPARE ARCHITECTURAL AND STRUCTURAL DRAWINGS AND SPECIFICATIONS

PREPARE CIVIL SPECIFICATIONS

PREPARE ELECTRICAL, H&V AND INSTRUMENTATION DRAWINGS AND SPECIFICATIONS

PREPARE LONG LEAD PROCUREMENT SPECIFICATIONS FOR TEST VESSEL

TITLE II REVIEW

TITLE II COST ESTIMATE

BID AND AWARD SITE PACKAGE

MOBILIZE SITE PREPARATION CONTRACTOR

SITE PREPARATION AND BUILDING EXCAVATION

DRIVE PILES

BID AND AWARD BUILDING PACKAGE

MOBILIZE GENERAL CONTRACTOR

FORM AND PLACE CONCRETE- TEST PIT

BACKFILL TO -22 FT

FORM AND PLACE CONCRETE- MOTOR PIT

BACKFILL TO GRADE

FORM AND PLACE SLABS ON GRADE

FORM AND PLACE ABOVE GRADE WALLS

ERECT STRUCTURAL STEEL-WALLS & ROOF

INSTALL METAL SIDING

INSTALL BUILT UP ROOFING

FORM & PLACE SECOND FLOOR SLABS

INSTALL HVAC EQUIPMENT & DUCTWORK

INSTALL BUILDING FINISH ITEMS

CONTRACTOR CLEAN UP & DEMOBILIZE

CONSTRUCT BERM

IRRIGATION SYSTEM & LANDSCAPING

FINAL SITE DEVELOPMENT

ERECT GAS STORAGE AREA

BID AND AWARD BRIDGE CRANE PROCUREMENT PACKAGE

FABRICATE AND DELIVER 100 TON BRIDGE CRANE (6 MONTHS)

INSTALL CRANES & TEST

BID AND AWARD TEST VESSEL PROCUREMENT PACKAGE

FABRICATE AND DELIVER TEST VESSEL (9 MONTHS)

SET EQUIPMENT

INSTALL PIPE, CONDUIT, AND INSTRUMENTATION

BID AND AWARD TRANSFORMER PROCUREMENT PACKAGE

FABRICATE AND DELIVER POWER TRANSFORMERS (12 MONTHS)

INSTALL ELECTRICAL EQUIPMENT

ESTABLISH FACILITY POWER AND LIGHTING

SYSTEMS OPERATIONS TESTS

FACILITY ACCEPTANCE AND TURNOVER

BID AND AWARD MOTOR AND CONTROLLER PROCUREMENT PACKAGE

MOTOR AND CONTROLLER MANUFACTURE, TEST AND DELIVER

BID AND AWARD HELIUM CIRCULATOR SERVICE SYSTEM PROCUREMENT PACKAGE

FABRICATE, TEST AND DELIVER SERVICE SYSTEM (15 MONTHS)

MILESTONES

1. SUBMIT TITLE I DESIGN PACKAGE FOR CLIENT APPROVAL 2-7-80
2. ISSUE SITE PACKAGE 7-1-80
3. MOBILIZE SITE PREP CONTRACTOR 10-1-80
4. BEGIN SITEWORK AND BUILDING EXCAVATION 11-1-80
5. SUBMIT TITLE II DESIGN PACKAGE FOR CLIENT APPROVAL 11-7-80
6. MOBILIZE GENERAL CONTRACTOR 3-1-81
7. BUILDING COMPLETE TO GRADE 8-15-81
8. BEGIN SETTING EQUIPMENT 10-1-81
9. INSTALL PIPE, CONDUIT AND INSTRUMENTATION 12-1-81
10. INSTALL ELECTRICAL EQUIPMENT 3-1-82
11. BEGIN SYSTEMS OPERATIONS TESTS 5-15-82
12. FACILITY ACCEPTANCE AND TURNOVER 8-1-82
- A. BEGIN BID PERIOD FOR TEST VESSEL 10-1-80
- B. BEGIN BID PERIOD FOR TRANSFORMERS 12-1-80
- C. BEGIN BID PERIOD FOR CRANES 2-15-81

LEGEND

- ACTIVITY
- BID AND AWARD ACTIVITY
- LOGIC RESTRAINT

CONCEPTUAL SCHEDULE FOR GCFR HELIUM CIRCULATOR TEST FACILITY

SCHEDULE S-2

5830 | JUNE 9, 1978 | AJP

SECTION 9

DRAWINGS

9.1 DESCRIPTION OF DRAWINGS

The drawings prepared during this conceptual design phase and referred to in the text are included in this section. The drawings are found in the numerical sequence listed below:

9.1.1 GENERAL ATOMIC COMPANY PREPARED DRAWINGS

210100047	Compressor Bearing Housing Assembly
024173	Circulator Test Vessel
EE-2626	GCFR Helium Circulator Test Facility Schematic
023859	Block Diagram GCFR Main Circulator T/F

9.1.2 THE RALPH M. PARSONS COMPANY PREPARED DRAWINGS

Site

GA-01	Site Plan Location Map and General Notes

Architectural

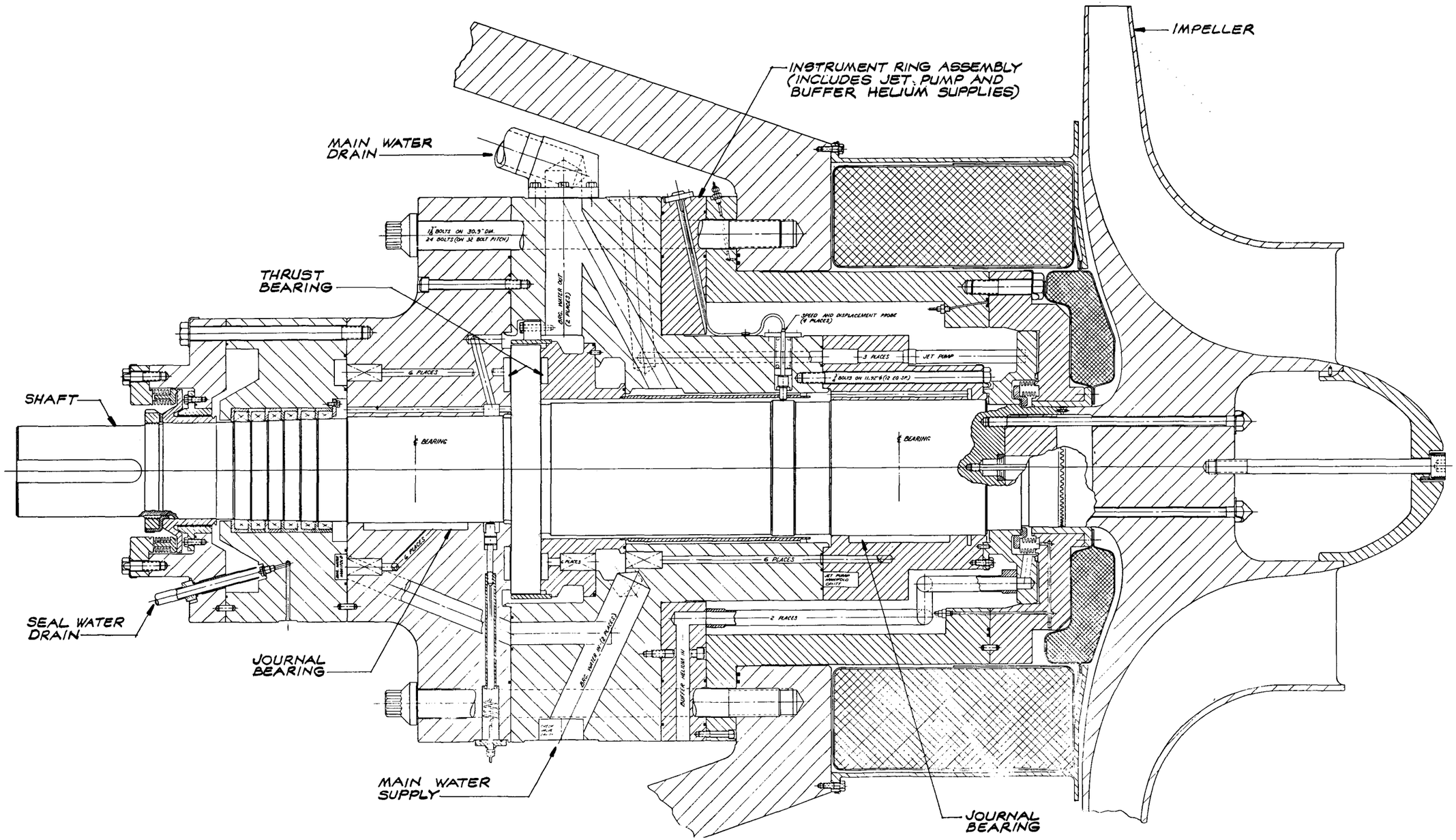
AR-01	Ground Floor and Lower Level Floor Plans
AR-02	Second Floor and Roof Plans
AR-03	Building Sections "A" and "B"
AR-04	Building Section "C" and Street Side Elevation

Mechanical

ME-01	Circulator Test Vessel
ME-02	Piping and Instrumentation Diagram - Helium Loop and Auxiliary Systems
ME-03	Piping and Instrument Diagram - Cooling Water and Water Treatment System
ME-04	Piping and Instrument Diagram - Nitrogen and Compressed Air Systems
ME-05	Heating, Ventilating, and Air Conditioning Flow Diagram

Electrical

EE-01	Electrical Single Line Diagram
EE-02	Electrical Switchyard Layout
EE-03	Electrical Transformer Station and Equipment Room Layout



DRAWN BY: D TANNER 11-7-77
APPD. BY:

GENERAL ATOMIC COMPANY
SAN DIEGO, CALIFORNIA

TITLE: COMPRESSOR BEARING HOUSING ASSEMBLY

SIZE	CODE IDENT NO.	DWG. NO.	ISSUE
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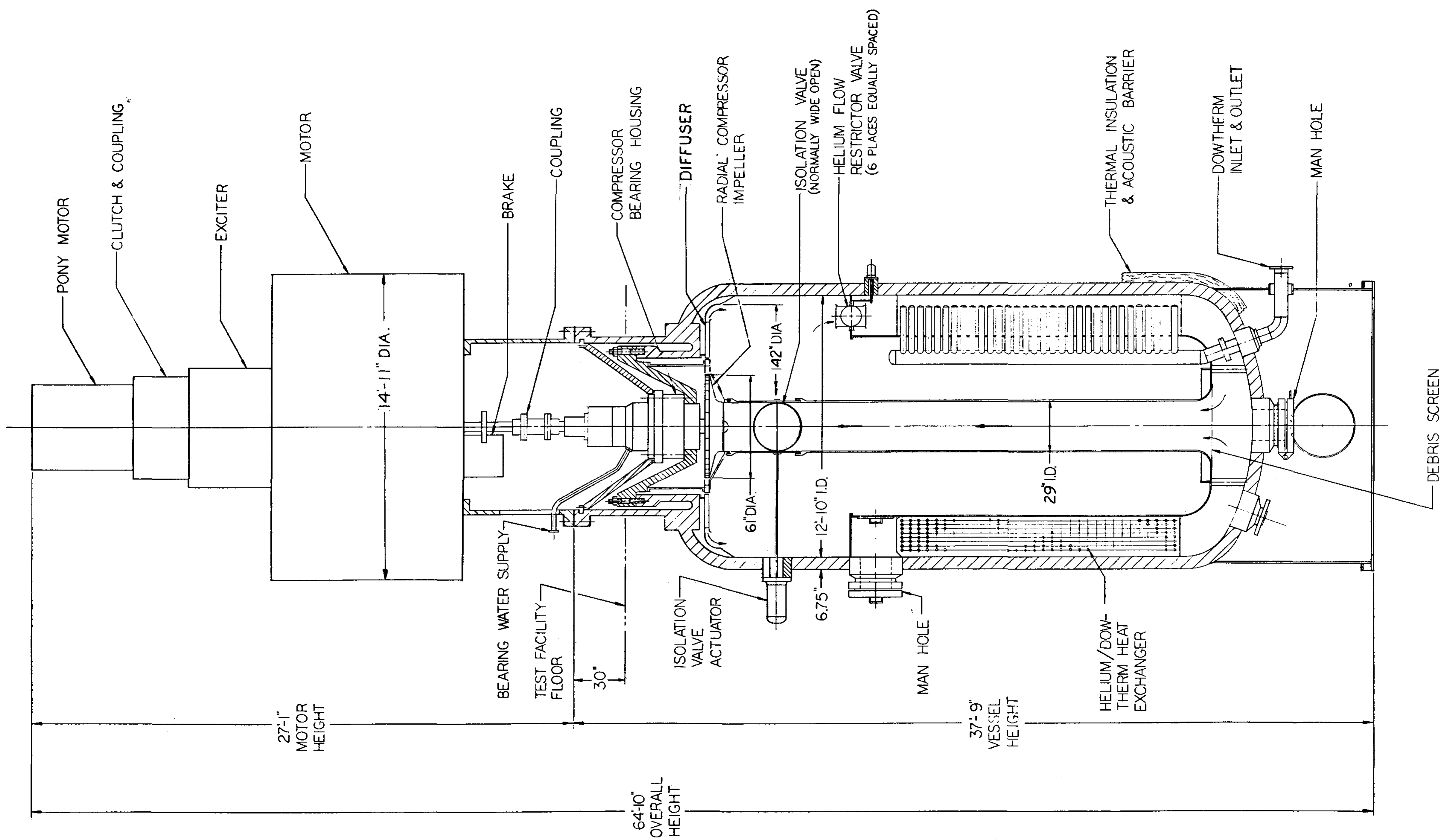
SCALE ½ SIZE	QAL	SHEET 1 OF 1	



LTR	DATE	ISSUE DESCRIPTION	DR.	CHK.	DES.	APPD	APPD
		PRELIMINARY					

GCFR

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
NO BURRS OR SHARP EDGES
DIMENSIONS PER ANSI-Y-14.5
TOLERANCE:
DECIMAL FRACTION ANGLE
.XXX = ± ± ±
.XX = ±
ALL MACHINED SURFACES ✓
DO NOT SCALE PRINT

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GENERAL ATOMIC COMPANY
SAN DIEGO, CALIFORNIA

TITLE
CIRCULATOR
TEST VESSEL

SIZE	CODE IDENT. NO.	DWG. NO.	ISSUE
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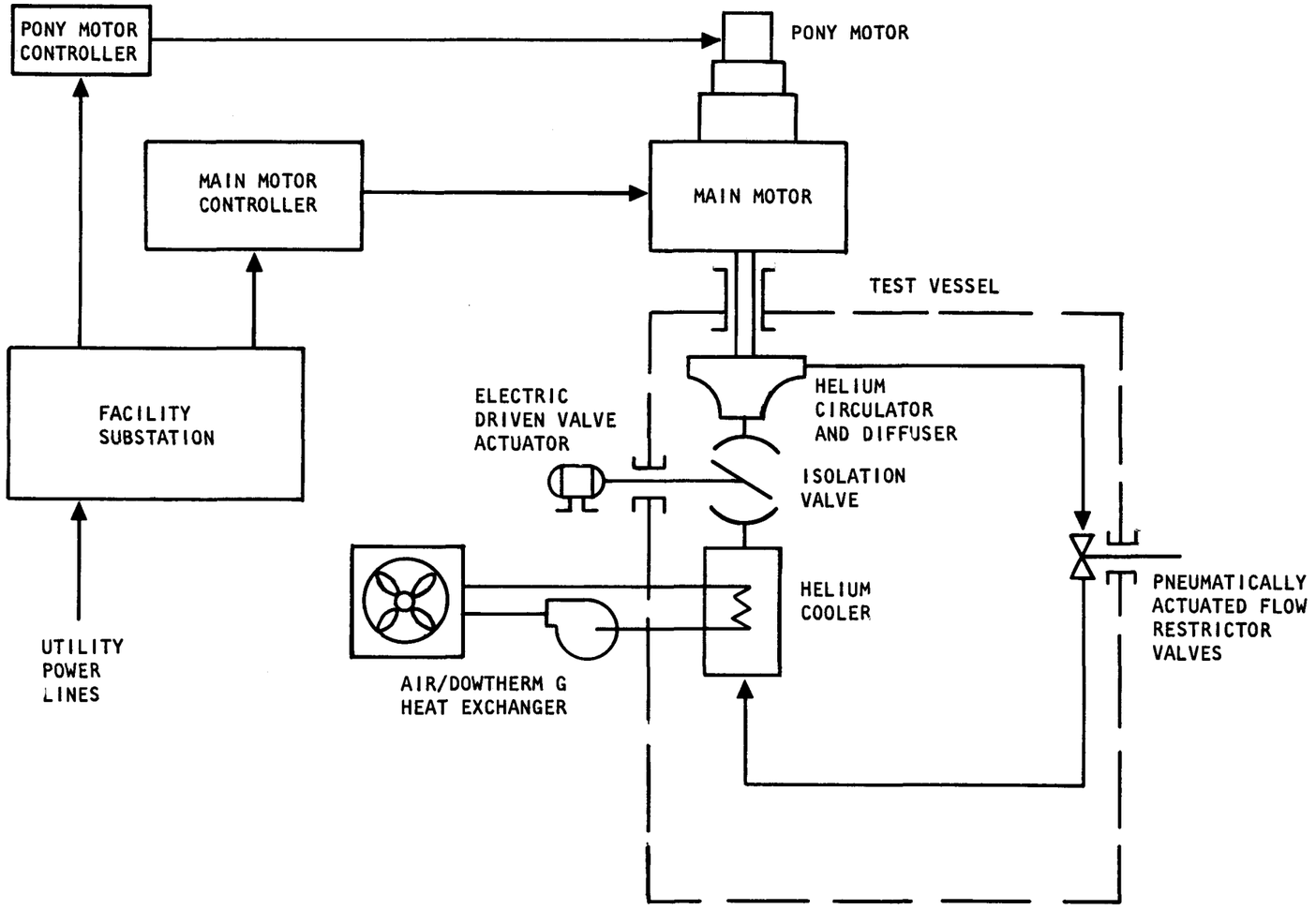
SCALE 1" = 1'-0" QAL 1 CAT I SHEET 1 OF 1



GENERAL ATOMIC COMPANY
SAN DIEGO, CALIFORNIA

TITLE

GCFR HELIUM CIRCULATOR TEST FACILITY SCHEMATIC

SIZE	CODE IDENT. NO.	DWG. NO.	ISSUE
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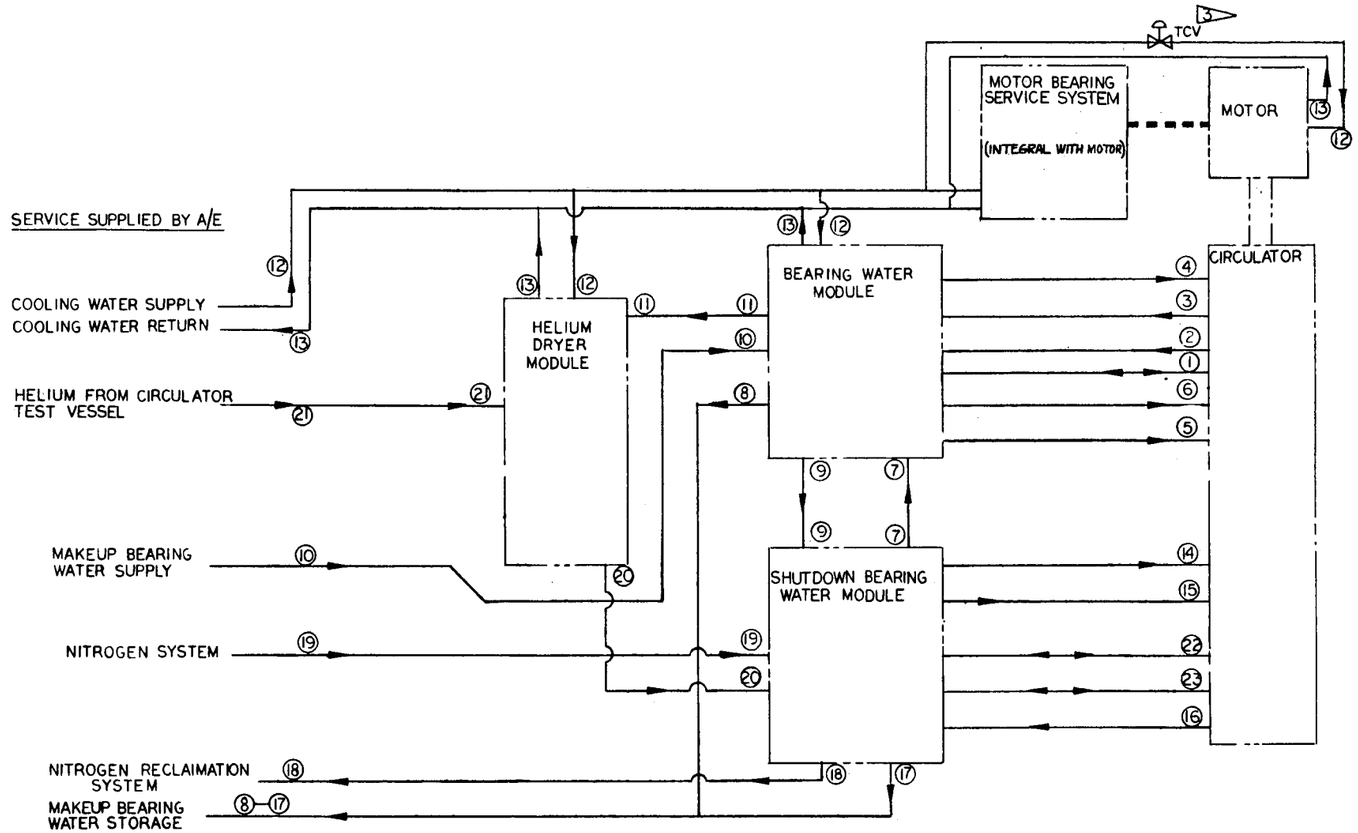
SCALE	QAL	SHEET OF	

GA 1279 B



GENERAL NOTES:

1. THE SERVICE SYSTEM FOR THE GCFR MAIN CIRCULATOR TEST FACILITY IS DESCRIBED IN SPEC. [illegible].
2. MODULE CONNECTIONS ARE LOCATED WITH FLOW REQUIREMENTS AS SPECIFIED IN T/F LAYOUT CRITERIA
3. THE COOLING WATER FLOW TO THE MOTOR WILL BE TEMPERATURE CONTROLLED

LEGEND

1. PRESSURE EQUALIZATION LINE
2. He WATER DRAIN
3. BEARING WATER DRAIN
4. BEARING WATER SUPPLY
5. H.P JET PUMP SUPPLY
6. L.P JET PUMP SUPPLY
7. H.P JET PUMP SUPPLY X CONN
8. BEARING WATER RETURN TO BEARING WATER STORAGE
9. ACCUMULATOR FILL
10. MAKEUP BEARING WATER SUPPLY
11. HELIUM TO DRYER
12. COOLING WATER SUPPLY
13. COOLING WATER RETURN
14. SHUTDOWN BEARING WATER SUPPLY
15. BUFFER HELIUM SUPPLY TO LOWER LABRINTH
16. END SEAL DRAIN
17. SEAL DRAIN RETURN TO BEARING WATER STORAGE
18. NITROGEN RETURN
19. NITROGEN SUPPLY
20. BUFFER HELIUM SUPPLY
21. HELIUM FROM CIRCULATOR TEST VESSEL
22. UPPER SEAL HELIUM SUPPLY AND VENT
23. LOWER SEAL HELIUM SUPPLY AND VENT

LTR	DATE	ISSUE DESCRIPTION	DR.	CHK.	DES.	APPD.	APPD.
		REVISED MOTOR SERVICES	8/19/77	ELT	ELT 8-19-77	PHK 8/22/78	
ISSUED 2	11 1/26/78	PRELIMINARY	[illegible]	[illegible]	ELT 1-26-78	PHK 1/26/78	

DIST.

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
NO BURRS OR SHARP EDGES
DIMENSIONS PER ANSI-Y-14.5
TOLERANCE:
DECIMAL FRACTION ANGLE
.XXX = ± ± ±
.XX = ± ✓
ALL MACHINED SURFACES
DO NOT SCALE PRINT

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GENERAL ATOMIC COMPANY
SAN DIEGO, CALIFORNIA

TITLE
BLOCK DIAGRAM
GCFR MAIN CIRCULATOR T/F

SIZE	CODE IDENT NO.	DWG. NO.	ISSUE
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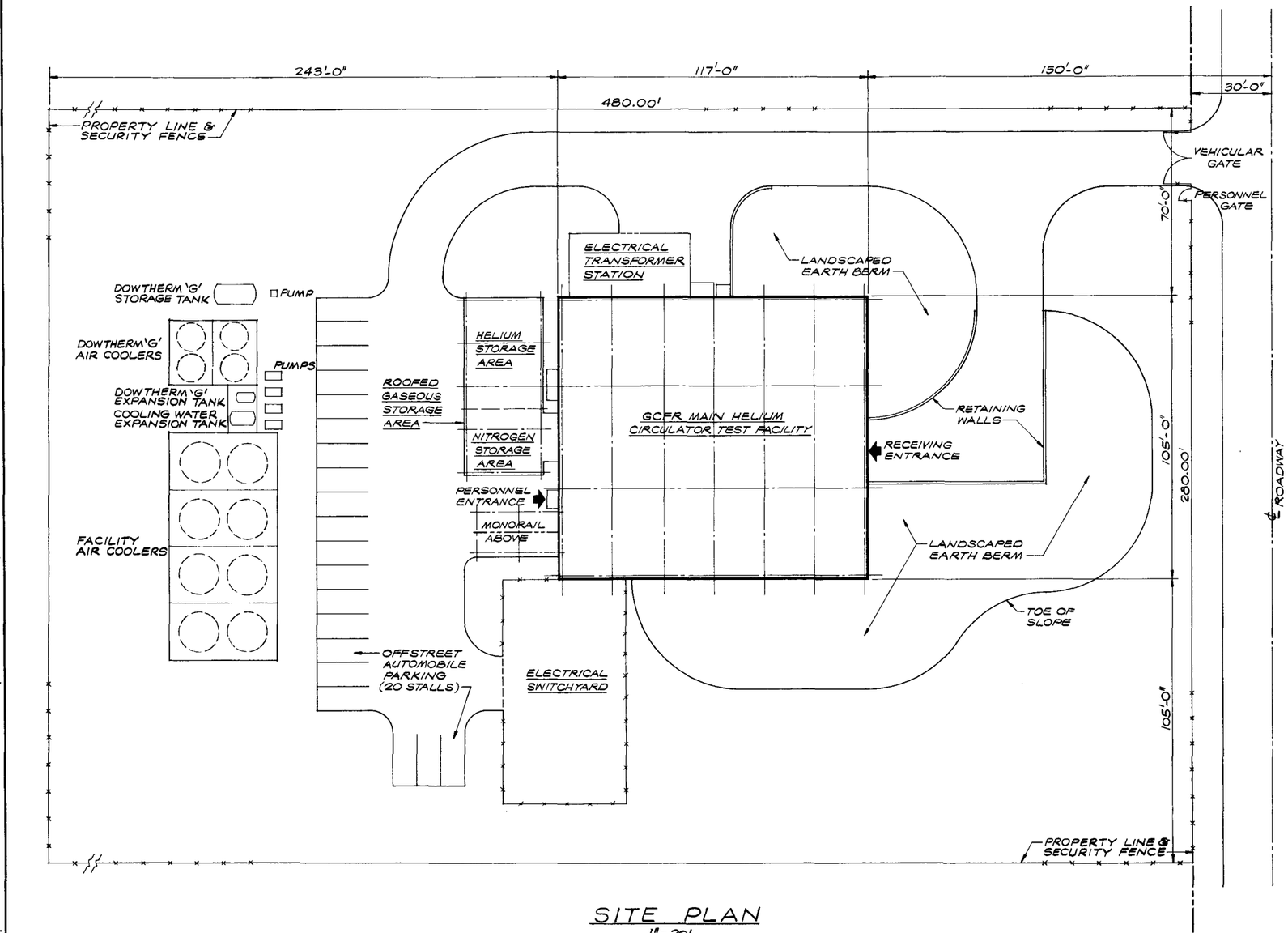
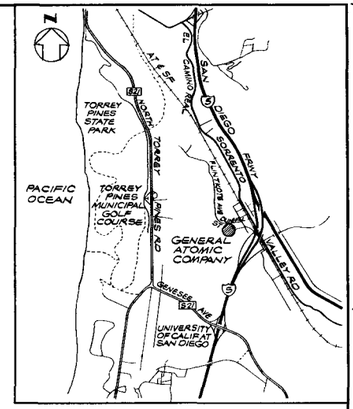
SCALE — | QAL II | CAT. NON I | SC- N N | AP LVL 2
SHEET 1 OF 1

023859



SITE PLAN
1"= 20'



LOCATION MAP
SCALE 0 ½ 1 MILE

PRELIMINARY
(NOT FOR CONSTRUCTION)

GENERAL ATOMIC COMPANY
SAN DIEGO, CALIFORNIA
GCFR MAIN HELIUM CIRCULATOR TEST FACILITY

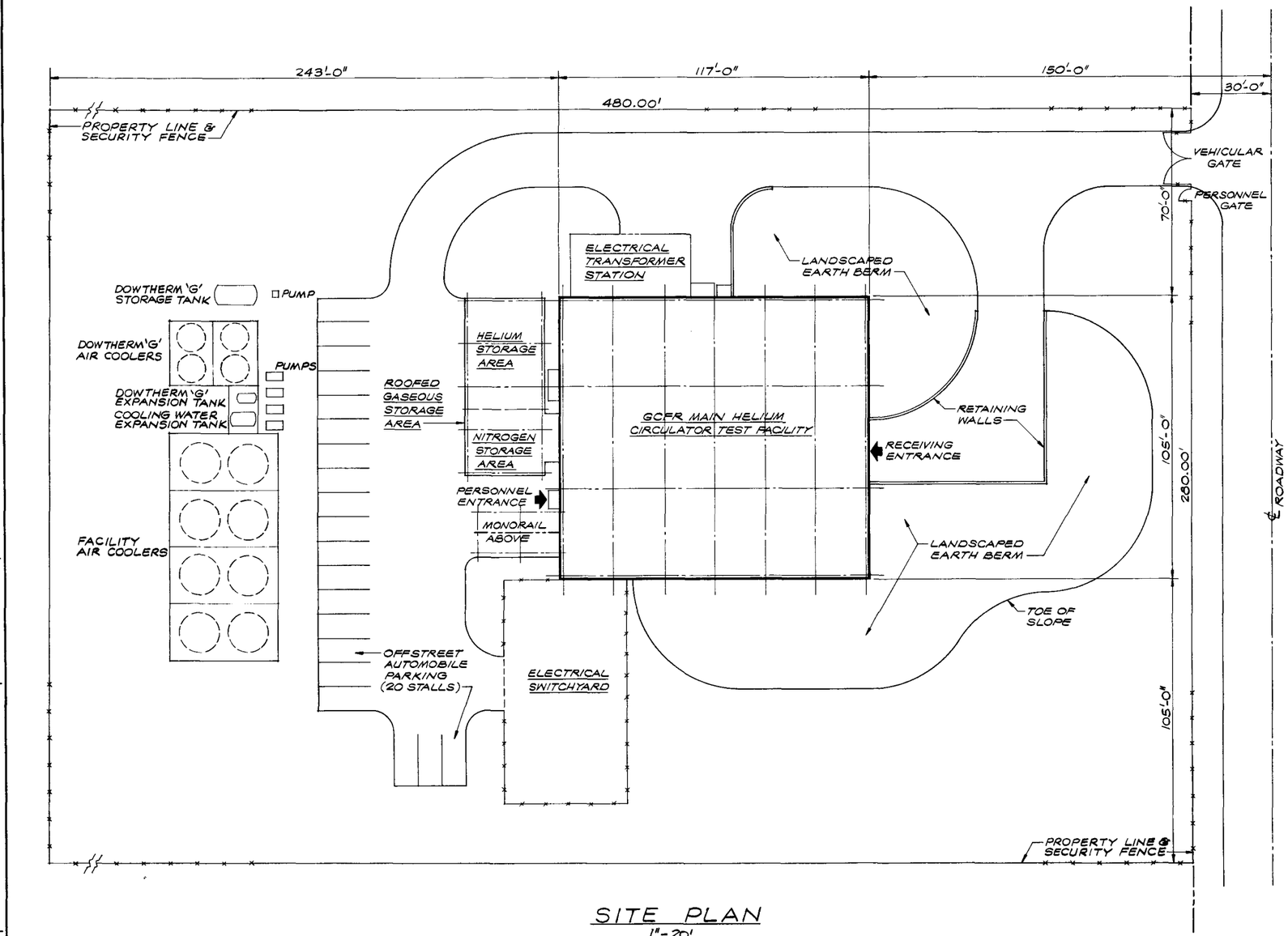
THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

TITLE: SITE PLAN LOCATION MAP & GENERAL NOTES
SCALE: 1"=2'-0"
ACCOUNT NUMBER:
JOB NUMBER: 5830-1
DRAWING NUMBER: GA-01
REV.: B

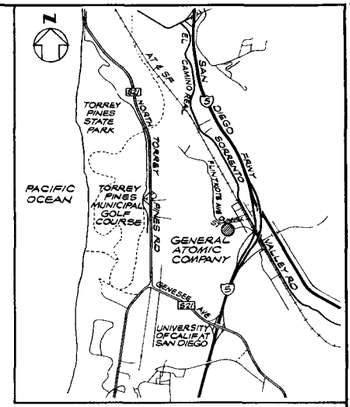
REFERENCES			REFERENCES			REVISIONS									REVISIONS									
DRAWING NO.	DESCRIPTION		DRAWING NO.	DESCRIPTION		NO.	DATE	BY	CK.	SEC.	PROJ.	CLIENT	DESCRIPTION		NO.	DATE	BY	CK.	SEC.	PROJ.	CLIENT	DESCRIPTION		

BY		DATE 4/19/78
CHECKED	S. BRYAN	4/20/78
SECTION	R. Jones	4/21/78
PROJECT		5/31/78
CLIENT		5/31/78

ENG-6623



SITE PLAN
1"= 20'



LOCATION MAP
SCALE 0 ½ 1 MILE

PRELIMINARY
(NOT FOR CONSTRUCTION)

GENERAL ATOMIC COMPANY
SAN DIEGO, CALIFORNIA
GCFR MAIN HELIUM CIRCULATOR TEST FACILITY

REFERENCES	DRAWING NO.	DESCRIPTION

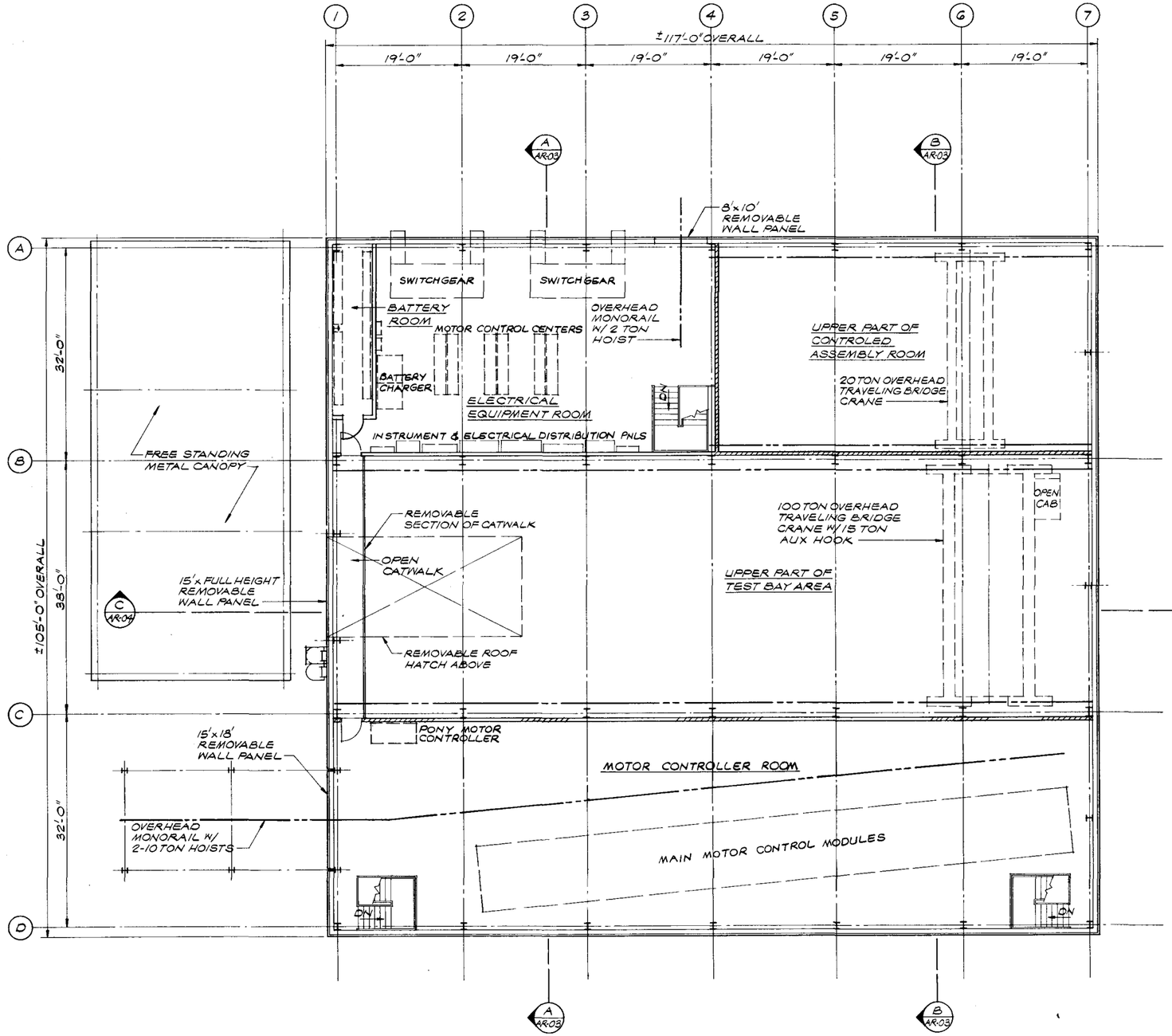
REVISIONS	NO.	DATE	BY	CK.	SEC.	PROJ.	CLIENT	DESCRIPTION

BY		DATE 4/19/78
CHECKED	S. BRYAN	4/20/78
SECTION	R. Jones	4/21/78
PROJECT	D. Nelson	5/31/78
CLIENT	L. M. Wenn	5/31/78

THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

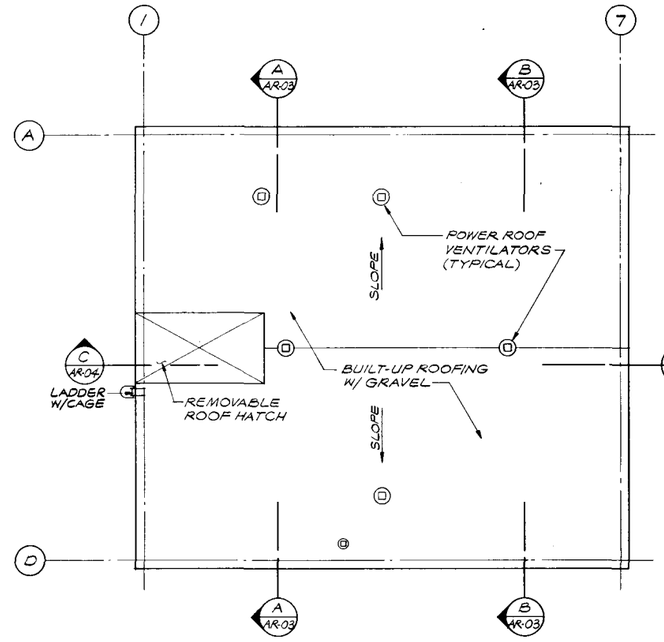
TITLE	SCALE
SITE PLAN LOCATION MAP & GENERAL NOTES	1"=2'-0"
	ACCOUNT NUMBER
JOB NUMBER 5830-1	DRAWING NUMBER GA-01
	REV. B

ENG-GE-23



SECOND FLOOR PLAN

1/8" = 1'-0"



ROOF PLAN

1/16" = 1'-0"

PRELIMINARY
(NOT FOR CONSTRUCTION)

GENERAL ATOMIC COMPANY
SAN DIEGO, CALIFORNIA
GCFR MAIN HELIUM CIRCULATOR TEST FACILITY

TITLE	SECOND FLOOR & ROOF PLANS
SCALE	AS NOTED
ACCOUNT NUMBER	
JOB NUMBER	5830-1
DRAWING NUMBER	AR-02
REV.	8

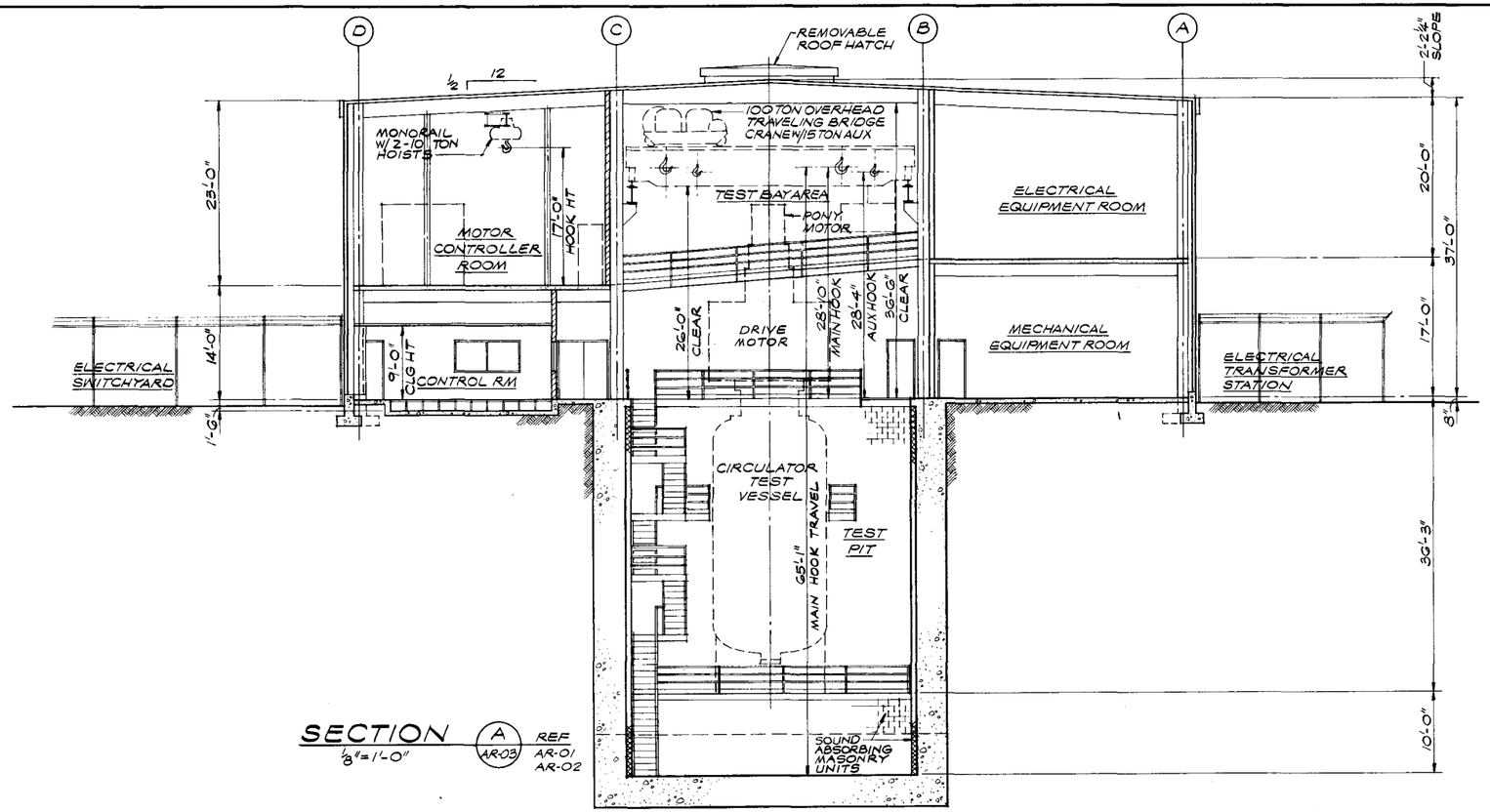
THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

BY		DATE 4/19/78
CHECKED	S. BRYAN	4/20/78
SECTION	R. Weirs	4/21/78
PROJECT		5/31/78
CLIENT	K. McKeon	5/31/78

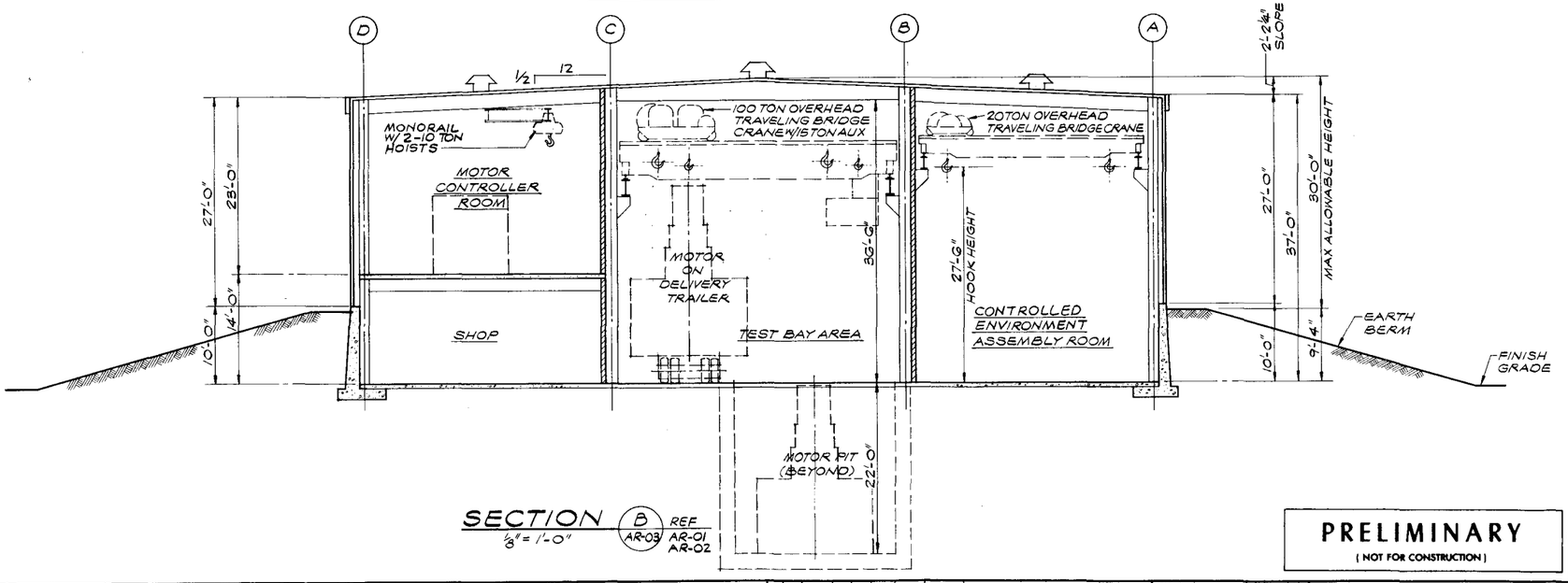
REFERENCES — DRAWING NO. | DESCRIPTION

REVISIONS — NO. | DATE | BY | CK. | SEC. | PROJ. | CLIENT | DESCRIPTION

ENG-GE-23



SECTION A (AR-03) 1/8"=1'-0" REF AR-01 AR-02



SECTION B (AR-03) 1/8"=1'-0" REF AR-01 AR-02

PRELIMINARY
(NOT FOR CONSTRUCTION)

GENERAL ATOMIC COMPANY
SAN DIEGO, CALIFORNIA
GCFR MAIN HELIUM CIRCULATOR TEST FACILITY

TITLE: BUILDING SECTIONS "A" & "B"
SCALE: 1/8"=1'-0"
ACCOUNT NUMBER:
JOB NUMBER: 5830-1
DRAWING NUMBER: AR-03
REV. B

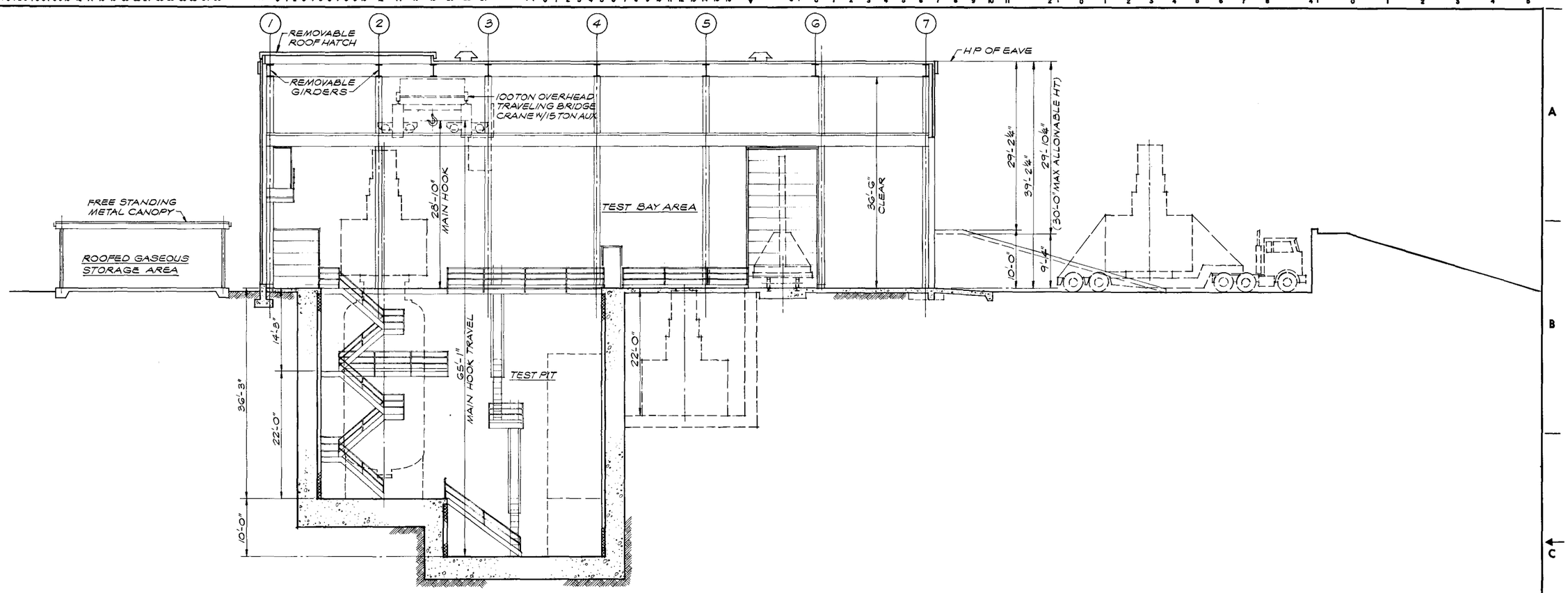
THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

	BY	DATE
CHECKED	S. BRYAN	4/29/78
SECTION		4/21/78
PROJECT		5/31/78
CLIENT		5/31/78

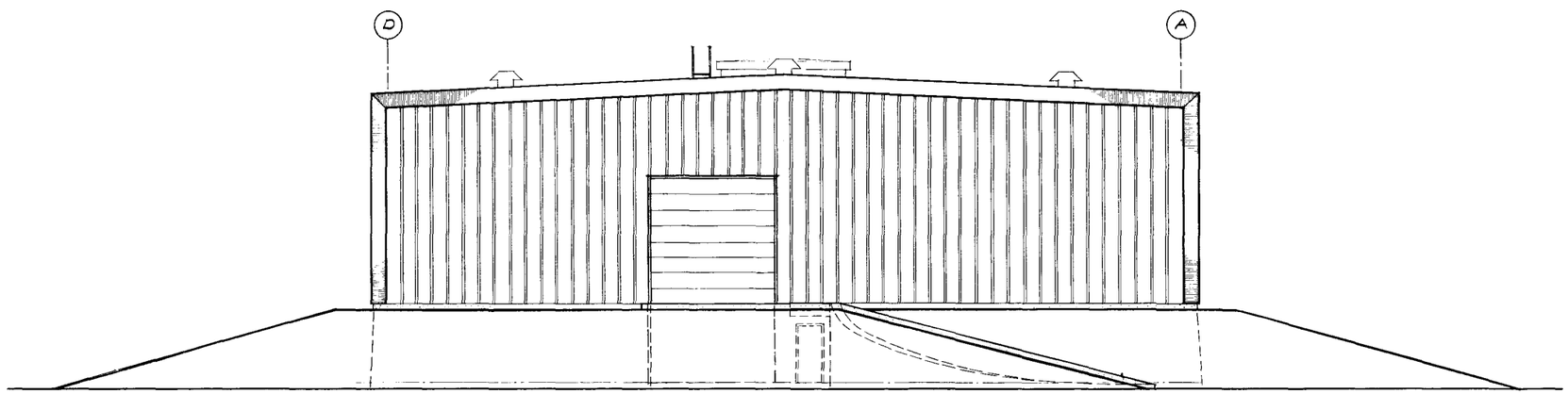
ENG-GE-23

REFERENCES: DRAWING NO. | DESCRIPTION

REVISIONS: NO. | DATE | BY | CK. | SEC. | PROJ. | CLIENT | DESCRIPTION



SECTION C (AR-04) REF AR-01 AR-02
1/8" = 1'-0"



STREET SIDE ELEVATION
1/8" = 1'-0"

PRELIMINARY
(NOT FOR CONSTRUCTION)

GENERAL ATOMIC COMPANY
SAN DIEGO, CALIFORNIA
GCFR MAIN HELIUM CIRCULATOR TEST FACILITY

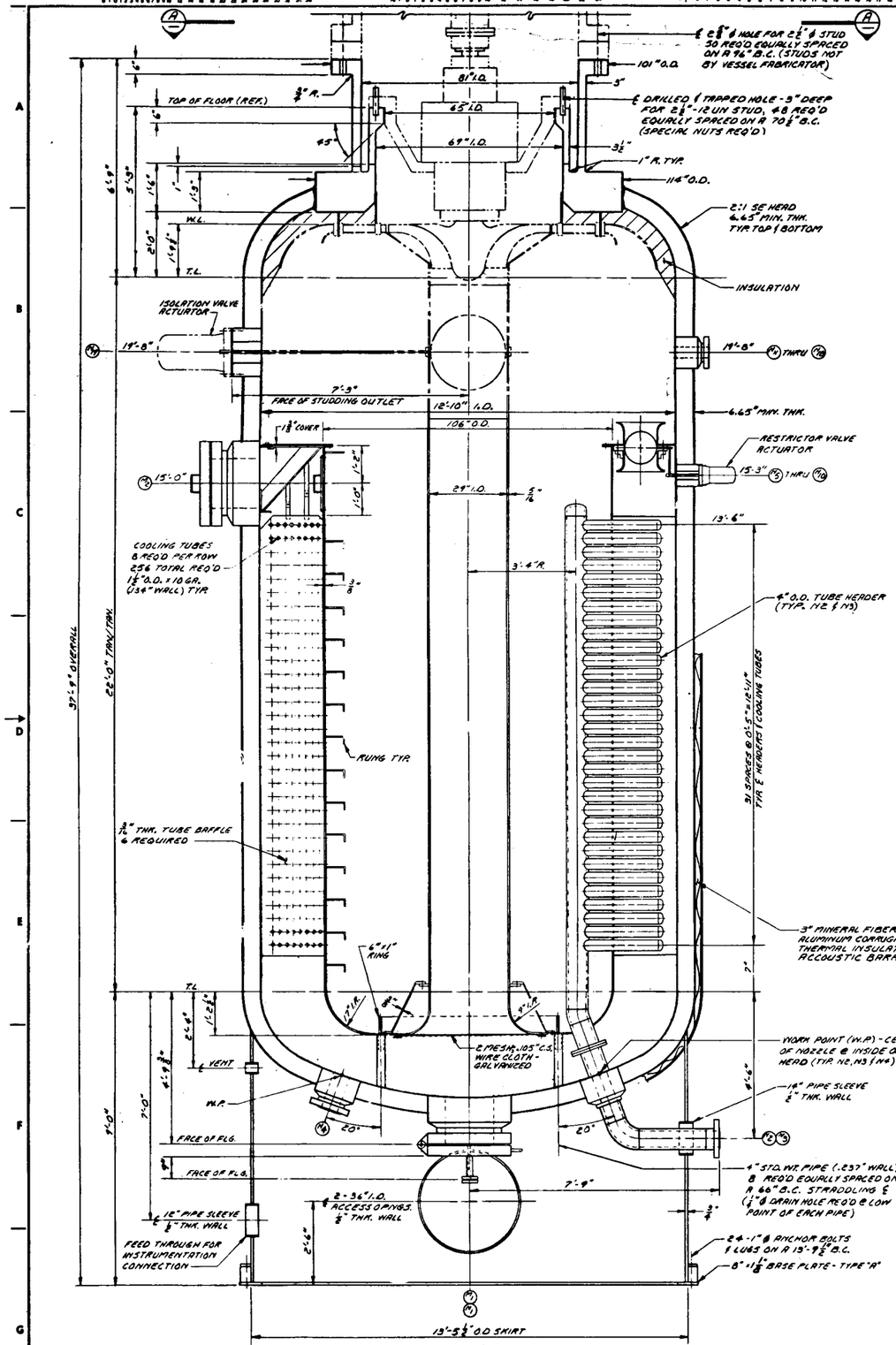
TITLE	BUILDING SECTION "C" & STREET SIDE ELEVATION
SCALE	1/8" = 1'-0"
ACCOUNT NUMBER	
JOB NUMBER	5830-1
DRAWING NUMBER	AR-04
REV.	B

	BY	DATE
CHECKED	S. BRYAN	4/24/78
SECTION	[illegible]	4/24/78
PROJECT	D. [illegible]	5/24/78
CLIENT	[illegible]	5/31/78

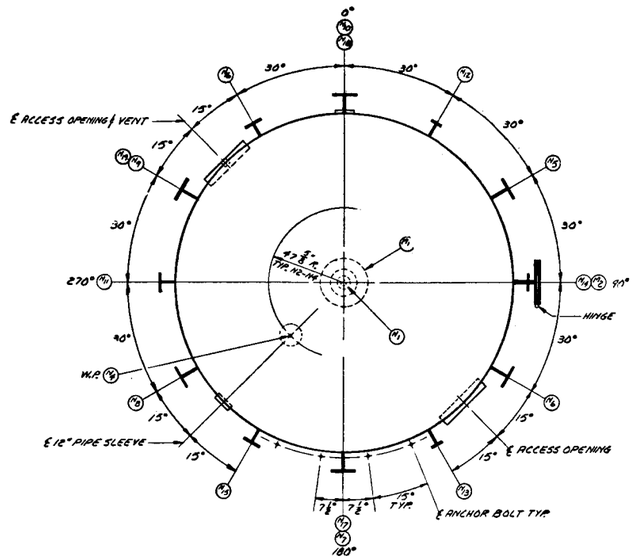
RMP
THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

ENG-GE-23

REFERENCES		REFERENCES		REVISIONS								REVISIONS							
DRAWING NO.	DESCRIPTION	DRAWING NO.	DESCRIPTION	NO.	DATE	BY	CK.	SEC.	PROJ.	CLIENT	DESCRIPTION	NO.	DATE	BY	CK.	SEC.	PROJ.	CLIENT	DESCRIPTION



ONE REQ'D
SEE PLAN "A" FOR TRUE ORIENTATION



PLAN A

NOTES

1. OPERATING PRESSURE AND TEMPERATURE:
   SHELL SIDE 1336 PSIG (INT.) AT ___°F
   TUBE SIDE ___ PSIG ( ) AT ___°F
   Δ P INTERNALS: ___ PSIG AT ___°F
2. DESIGN PRESSURE AND TEMPERATURE:
   SHELL SIDE 1436 PSIG (INT.) & 15 PSIG (EXT.) AT 650°F
   TUBE SIDE: 1436 PSIG (INT.) & 1436 PSIG (EXT.) AT 650°F
   Δ P INTERNALS: 60 PSIG AT 650°F
3. VESSEL PRESSURE NEW LIMITED BY SHELL AT AMBIENT TEMPERATURE, 1436 PSIG.
   COIL PRESSURE NEW LIMITED BY ___ AT ___°F, ___ PSIG.
4. HYDROTEST SHELL AND COIL AT AMBIENT TEMPERATURE, 2154 PSIG (INDEPENDENTLY).
5. NOZZLE AND MANHOLE RING JOINT GASKETS: OVAL SOFT STEEL
   GASKET FOR 65" I.D. HEAD OPENING: LATER
   GASKET FOR 81" I.D. HEAD OPENING: LATER
6. VESSEL INTERNAL SHELL SURFACE TO BE COATED WITH A ZINC MATERIAL PER WISCONSIN PROTECTIVE COATING CORP. TECHNICAL BULLETIN M-1100.
   SURFACE PREPARATION: WHITE METAL BLAST 1 TO 2 MIL ANCHOR PATTERN, REFERENCE SSPC-SP5.
   COATING: 3 MILS OF #1100 PRIMER WITH 3 MILS OF #1120 TOP COAT.
   VESSEL EXTERNAL SHELL SURFACE SAME AS INTERNAL SHELL SURFACE EXCEPT ELIMINATE THE #1120 TOP COAT AND SURFACE PREPARATION SHALL BE SSPC-SP6.
7. ALL ITEMS SHOWN IN PHANTOM ARE NOT FURNISHED OR INSTALLED BY VESSEL FABRICATOR.

ITEM	NO. REQ'D	SIZE	RATING	FACING	SERVICE
M1	1	24"	900#	R.J.	VALVE RESTRICTOR CONN.
M2	1	24"	900#	R.J.	HELIUM OUTLET
M3	1	10"	900#	R.J.	RAPID DEPRESSURIZATION
M4, M4a	3	4"	900#	R.J.	INSTRUMENTATION CONN.
M5, M5a	6	24"	900#	R.J.	RECIRC VALVE CONN.
M6	1	24"	900#	R.J.	HELIUM INLET
M7, M7a	6	4"	900#	R.J.	RESTRICTOR VALVE INSTRUMENTATION CONN.
M8	1	6"	150#	R.J.	COOLANT OUTLET
M9	1	6"	900#	R.J.	COOLANT INLET
M10	1	6"	150#	R.J.	DRAIN
M11	2	18"I.D.	900#	R.J.	MANHOLE W/ HINGE & MANHOLE

NOZZLES AND COUPLINGS

RADIAL NOZZLE AND MANHOLE PROJECTIONS FROM O.D. OF VESSEL TO EXTREME FACE OF FLANGE.

SIZE	PROJECTION	SIZE	PROJECTION
THRU 4"	11"	6", 8" AND 10"	13"
12", 14", 16", 18", AND 20"	16"		

EXCEPT AS NOTED

DESIGN DATA

1. OPERATING PRESSURE AT SEE NOTE 1 °F SEE NOTE 1 PSIG
2. DESIGN PRESSURE AT SEE NOTE 2 °F SEE NOTE 2 PSIG
3. PRESSURE NEW LTD. BY ___ AT ___ °F SEE NOTE 3 PSIG
4. CORROSION ALLOWANCE, SHELL NONE HEADS NONE INT. NONE
5. CODE ASME SEC. VIII DIV.1 LATEST EDITION
6. CODE CERTIFICATES REQ'D YES CODE STAMP YES
7. PW HT YES X-RAYED YES AT 1
8. ALL STRESS AT DESIGN TEMP. 17,700 JT. EFF. SHELL 100 %
9. HYDROTEST AT 2154 PSIG (HORIZONTAL) HEADS 100 %
10. MATERIALS:
    SHELL SA-516-70
    HEAD SA-516-70
    SUPPORT SA-283-C EXCEPT LUGS & BASE @ SA-36
    INTERNALS SA-285-C PIPING SA-106-B TUBING SA-210-A1
    BOLTS (EXTERNAL) SA-193 B7 NUTS SA-194-2H
    FORGED HEAD SA-508 GR.3
    NOZZLE SA-350 LF2
    GASKETS SEE NOTE 5
11. CAPACITY 3400 CU.FT.
12. FABRICATION WEIGHT (INCLUDING INT,) 486800#
13. INTERNALS 53000#
14. EMPTY WEIGHT 700000#
15. OPERATING WEIGHT 700000#
16. TEST WEIGHT 920500#
17. PAINT SEE NOTE 6
18. INSULATION 3" OUTSIDE SHELL
19. FIREPROOFING 2" REF. DET. OUTSIDE SKIRT
20. ACCESSORIES SUPPLIED & INSTALLED BY FABRICATOR:
    VESSEL DAVIT NO MARK NO. —
    LADDER AND PLATFORM CLIPS NO
    PIPE SUPPORT AND PIPE GUIDE CLIPS NO
    INSULATION SUPPORTS YES
    FIREPROOFING SUPPORTS YES
21. [illegible]
22. ALL DIMENSIONS ARE FROM BOTTOM HEAD TANGENT LINE EXCEPT AS SHOWN.
23. BOLT HOLES SHALL STRADDLE CENTER LINES EXCEPT AS NOTED
24. NOZZLES, MANHOLES AND TRAYS SHALL HAVE THE SAME DESIGNATION AS SHOWN ON THIS DRAWING.
25. VESSEL SHALL BE THOROUGHLY CLEANED INSIDE AND OUTSIDE, AND FREE FROM RUST, SLAG, SCALE, WELD SPATTER AND FOREIGN MATTER.

REFERENCES	DRAWING NO.	DESCRIPTION

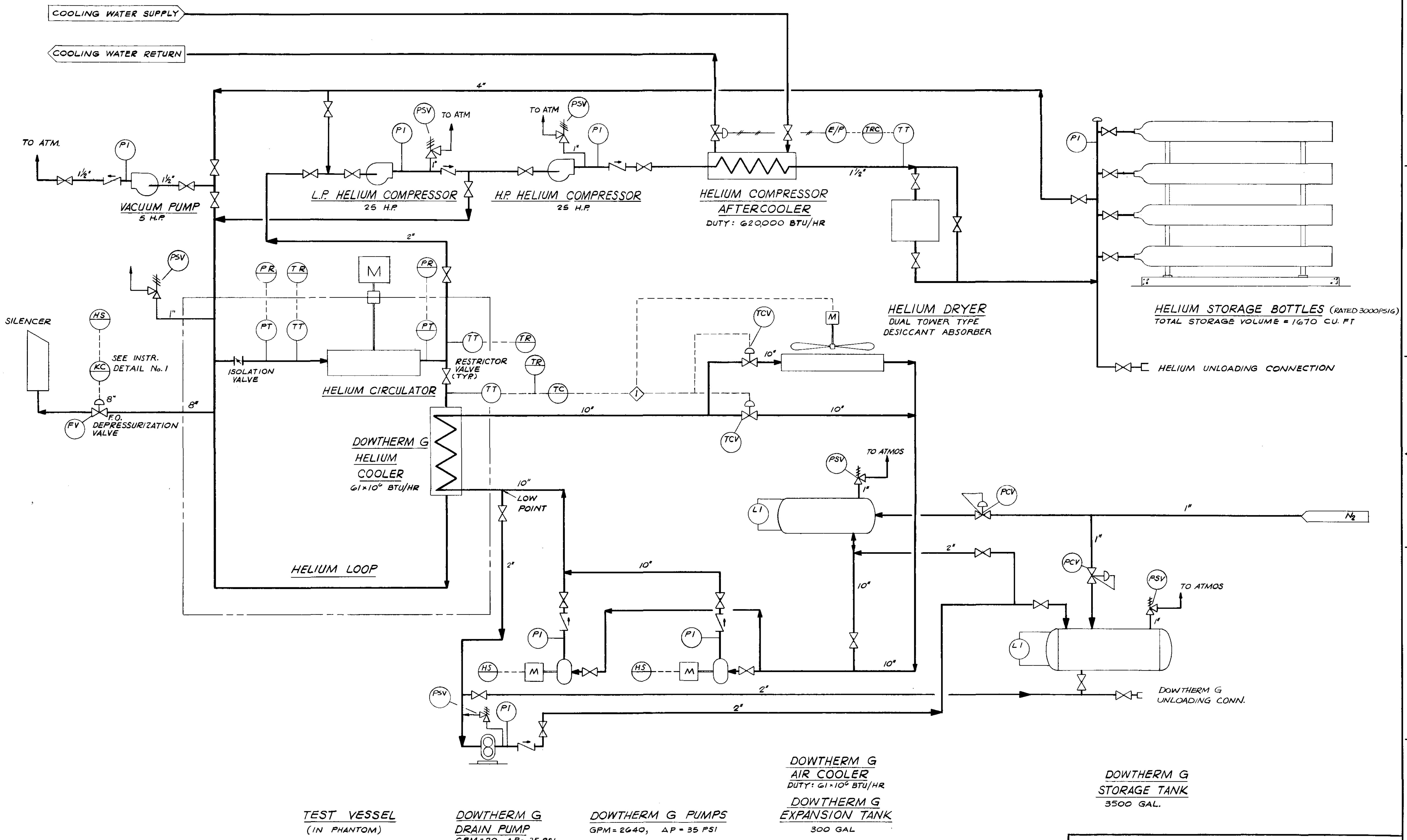
REVISIONS	NO.	DATE	BY	CK.	SEC.	PROJ.	CLIENT	DESCRIPTION

	BY	DATE
CHECKED	SHP	3-30-71
SECTION	[illegible]	3-31-71
PROJECT	[illegible]	4-21-71
CLIENT	[illegible]	4-21-71

RMP
THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

GENERAL ATOMIC COMPANY
SAN DIEGO, CALIFORNIA
GCFR MAIN HELIUM CIRCULATOR TEST FACILITY

TITLE: CIRCULATOR TEST VESSEL
SCALE: NONE
ACCOUNT NUMBER
JOB NUMBER 5830-1
DRAWING NUMBER ME-01
REV. B



GENERAL ATOMIC COMPANY
SAN DIEGO, CALIFORNIA
GCFR MAIN HELIUM CIRCULATOR TEST FACILITY

TITLE: PIPING & INSTRUMENT DIAGRAM
HELIUM LOOP & AUXILARY SYSTEMS

BY	E.H.
CHECKED	C. L. — 3-30-78
SECTION	3-31-78
PROJECT	5-31-78
CLIENT	5-31-78

RMP THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

JOB NUMBER 5830-1 | DRAWING NUMBER ME-02 | REV. B

SCALE | ACCOUNT NUMBER

REFERENCES: DRAWING NO. | DESCRIPTION

REVISIONS: NO. | DATE | BY | CK. | SEC. | PROJ. | CLIENT | DESCRIPTION

EXPANSION TANK
750 GAL.

COOLING WATER COOLER
DUTY: 18×10^6 BTU/HR

MAKE UP WATER

CIRCULATOR MOTOR COOLER
HELIUM DRYER PRECOOLER
BEARING WATER COOLERS
BEARING OIL COOLERS
HELIUM COMPRESSOR COOLERS
MOTOR CONTROLLER COOLERS
NITROGEN COMPRESSOR COOLERS
HVAC COOLERS
AIR COMPRESSOR

COOLING WATER CIRCULATING PUMPS
GPM = 1200 ΔP = 50 PSI

COOLING WATER SYSTEM

CONTROL PANEL

CATION
ANION
MIXED BED

TO MIXED BED
TO MIXED BED

CAUSTIC
ACID
AIR

WASTE TO NEUTRALIZATION

AMMONIUM HYDROXIDE INJECTION PACKAGE
½ H.P.

FM N_2 HEADER
¾" CORROSION INHIBITOR

TO BEARING WATER MODULE

BEARING WATER STORAGE TK.
3500 GAL

BEARING WATER MAKE-UP PUMP
GPM = 20 OP = 1500 PSI

CITY WATER

N_2SO_4 INJECTION PACKAGE
½ H.P.

ACID INJECTION PACKAGE
½ H.P.

CAUSTIC INJECTION PACKAGE
½ H.P.

DEMINERALIZER CATION EXCHANGER
18"Ø x 5'-0" T-T

DEMINERALIZER ANION EXCHANGER
18"Ø x 5'-0" T-T

DEMINERALIZER MIXED BED ION EXCHANGER
18"x 6'-0" T-T

WATER TREATMENT SYSTEM

REFERENCES	DRAWING NO.	DESCRIPTION

REFERENCES	DRAWING NO.	DESCRIPTION

REVISIONS	NO.	DATE	BY	CK.	SEC.	PROJ.	CLIENT	DESCRIPTION

REVISIONS	NO.	DATE	BY	CK.	SEC.	PROJ.	CLIENT	DESCRIPTION

BY	P.L.	DATE 9/15/78
CHECKED	C.L.	4-19-78
SECTION	J.M.	4-19-78
PROJECT	Nelson	5-31-78
CLIENT	M Wilson	5-31-78

RMP
THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

GENERAL ATOMIC COMPANY
SAN DIEGO, CALIFORNIA
GCFR MAIN HELIUM CIRCULATOR TEST FACILITY

TITLE: PIPING & INSTRUMENT DIAGRAM COOLING WATER AND WATER TREATMENT SYSTEM

SCALE:

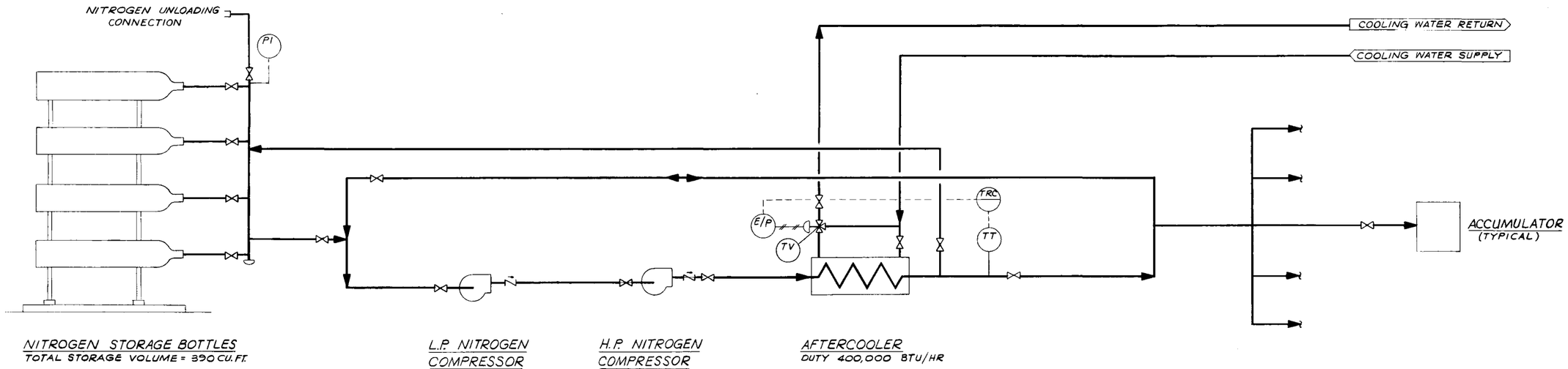
ACCOUNT NUMBER:

JOB NUMBER 5830-1

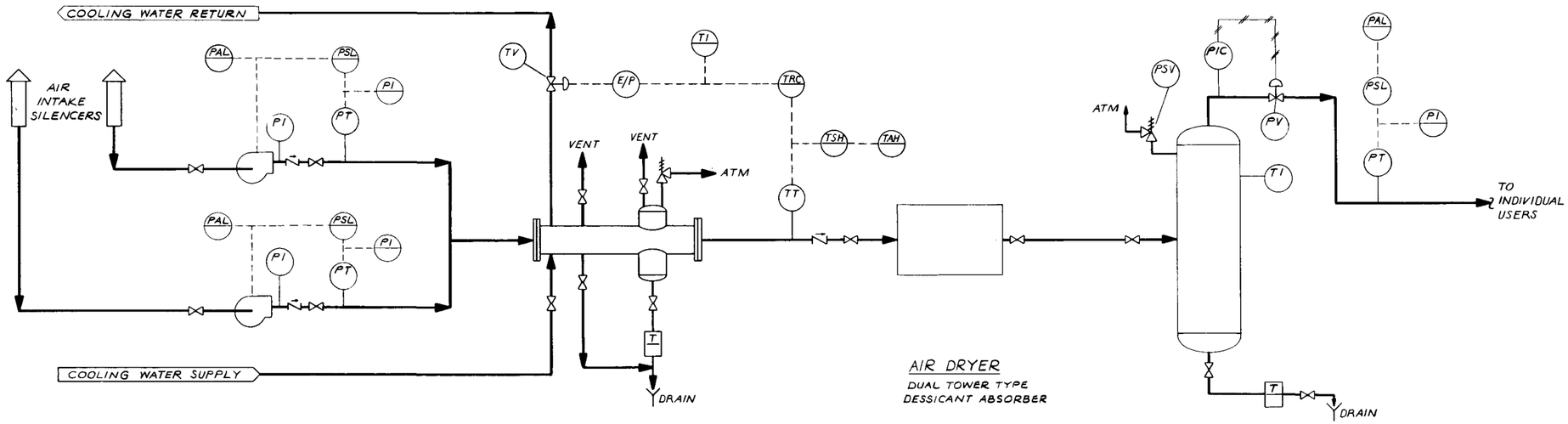
DRAWING NUMBER ME-03

REV. B

ENG-GE-23



NITROGEN SYSTEM



COMPRESSED AIR SYSTEM
(SKID MOUNT PACKAGE UNIT)

REFERENCES	DRAWING NO.	DESCRIPTION

REVISIONS	NO.	DATE	BY	CK.	SEC.	PROJ.	CLIENT	DESCRIPTION

BY E.H. DATE
CHECKED 4-19-78
SECTION 4-19-78
PROJECT 5-31-78
CLIENT 5-31-78

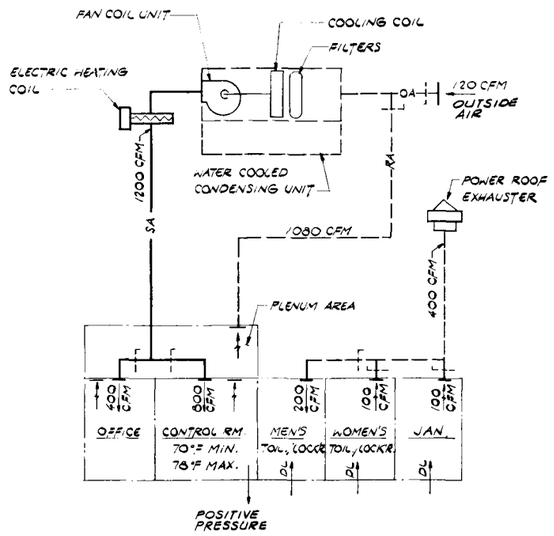
THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

GENERAL ATOMIC COMPANY
SAN DIEGO, CALIFORNIA
GCFR MAIN HELIUM CIRCULATOR TEST FACILITY

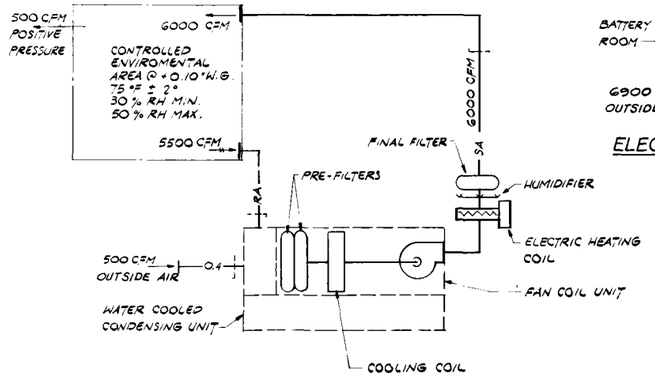
TITLE: PIPING & INSTRUMENT DIAGRAM
NITROGEN & COMPRESSED AIR SYSTEM

SCALE
ACCOUNT NUMBER
JOB NUMBER 5830-1
DRAWING NUMBER ME-04
REV. B

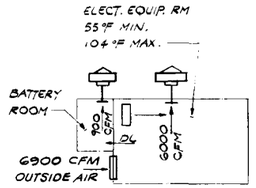
13



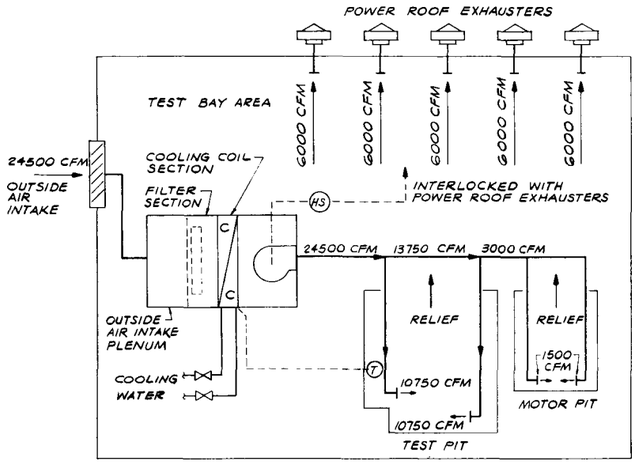
OFFICE AREA FLOW DIAGRAM



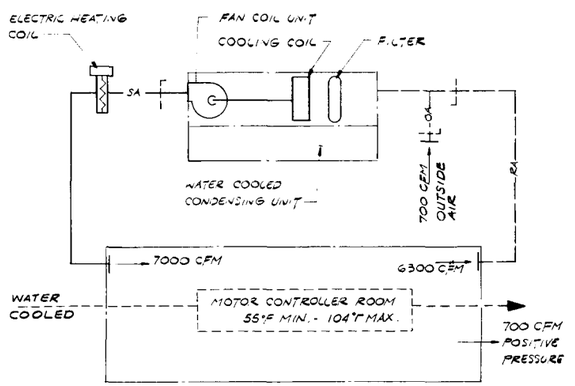
CONTROLLED ENVIRONMENT ASSEMBLY ROOM FLOW DIAGRAM
(CLASS 100,000 AREA)



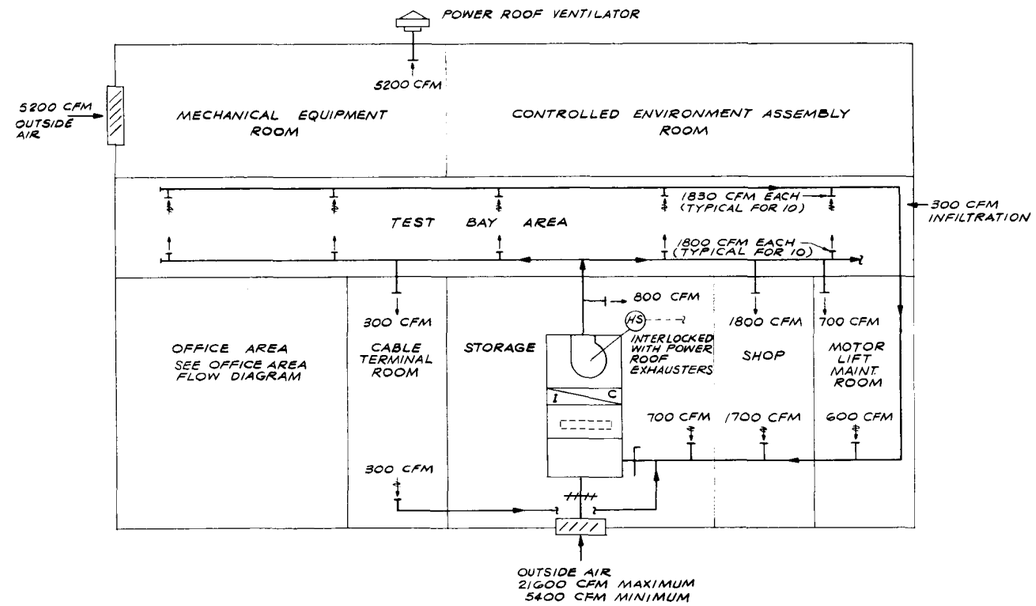
ELECT. EQUIP. & BATT. ROOM



TEST PIT & MOTOR PIT FLOW DIAGRAM



MOTOR CONTROLLER RM. FLOW DIAGRAM



TEST AREA FLOW DIAGRAM

ENG-GE-23

REFERENCES	DRAWING NO.	DESCRIPTION
REFERENCES	DRAWING NO.	DESCRIPTION

REVISIONS	NO.	DATE	BY	CK.	SEC.	PROJ.	CLIENT	DESCRIPTION
REVISIONS	NO.	DATE	BY	CK.	SEC.	PROJ.	CLIENT	DESCRIPTION

BY	E. TRUJILLO	DATE 4-20-78
CHECKED		4-20-78
SECTION		4-21-78
PROJECT		5-31-78
CLIENT		5-31-78

THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

GENERAL ATOMIC COMPANY
SAN DIEGO, CALIFORNIA
GCFR MAIN HELIUM CIRCULATOR TEST FACILITY

TITLE: HEATING, VENTILATING, & AIR COND. FLOW DIAGRAM

SCALE: NONE

ACCOUNT NUMBER

JOB NUMBER: 5830-1

DRAWING NUMBER: ME-05

REV. B

14

138 KV INCOMING POWER LINE
(3) L.A.
1200 A, 138 KV, 3 POLE DISC SW.
5 CT
138 KV, 1600 A OIL CIRC BKR RATED 8590 MVA
* SEE NOTE 2 (TYP.)
600 A, 138 KV, 3 POLE
REVENUE METERING
3 PT METERING 80/1.2 KV
MAIN TRANSFORMER
3-WINDING, 3 Ø
138 - 24, 14.16 KV
24/32 MVA, 18/24 MVA, 6/8 MVA, OA/FA
Z H-M = 7.5%, Z H-L = 5.5%, Z M-L = 13.8%
FARADAY SHIELD from VOLTAGE WINDING
0.30 Ω, 3.6 KV, 3 SEC.
TRANSFORMER
3-WINDING, 3Ø
24-13.8 GD, 13.8 Y KV
18/24 MVA, OA/FA
6-1C-750 MCM, 5 KV CABLE, 2/Ø
4.16 KV SWGR, 1200 A, 3Ø, 182 MVA DUTY
1600 A, ACB 5 KV, 250 MVA (TYP.)
2 PT 4.16 - 12 KV
3-1C-250 MCM, 5 KV PWR CABLE
3 PT 80/1 KV
3-1C-750 MCM, 15 KV PWR CABLE IN CONDUIT
BY G.A.C.
50/51 RELAYS TO BE PROVIDED ON 8 A.C.B.S 15 KV & C.B.S
5 VH. MOTOR CONTR.
1200 A, 15 KV BUS
BY G.A.C.
5 VH. MOTOR 2400
VARIABLE FREQ. CONV. BY G.A.C.
1000
3-1C-250 MCM, 5 KV PWR CABLE
POINT MOTOR
SPACE
4.16 KV SWGR 'A', 1200 A, 3Ø, 182 MVA DUTY
SWITCH 600 A INTERRUPTING, 400 E CONT.
FUSE 50000 A INTERRUPTING, 61000 A, MOMENTARY
3-1C # 2/0, 5 KV, PWR CABLE (TYPICAL)
TRANSFORMER N°1 1000/1150 KVA OA/FA, 3Ø 4.16 - 0.48 KV Z = 5.75% (TYPICAL)
(TYPICAL)
1600 A BUS (TYPICAL)
1600 AF
480 V. LOAD CENTER N° 1, 1600 A, 3Ø, 30000 A RMS DUTY
1600 AF N.O.
480 V. LOAD CENTER N° 2, 1600 A, 3Ø, 20,000 A RMS DUTY
800 AF 30 000 A RMS (TYPICAL)
800 AF
6-1C-350 MCM (TYP.)
TRANSFORMER N°3
TRANSFORMER N°4
4.16 KV SWGR 'B', 1200 A, 3Ø, 182 MVA DUTY
480 V. LOAD CENTER N°3, 1600 A, 3Ø, 20000 A RMS DUTY
480 V. LOAD CENTER N°4, 1600 A, 3Ø, 20 000 A RMS DUTY
SPARE
200
BEARING WTR PP N°1
BEARING WTR PP N°2
BEARING WTR PP N°3
BEARING WTR PP N°4
480 V, MCC N° 1, 600 A, 3Ø, 3W, 20000 A RMS DUTY
480 V, MCC N° 2, 600 A, 3Ø, 3W, 20000 A RMS DUTY
480 V, MCC N° 3, 600 A, 3Ø, 3W, 20000 A RMS DUTY
480 V, MCC N° 4, 600 A, 3Ø, 3W, 20000 A RMS DUTY
480 V, MCC N° 5, 3Ø, 600 A, 3W, 20000 A RMS DUTY
480 V, MCC N° 6, 3Ø, 600 A, 3W, 20000 A RMS DUTY
MOTOR CONTROLLER ROOM HOIST
WELDING OUTLETS
LTG. TRANSF. N°1 75 KVA 3Ø 480 - 120/208 V.
LTG. TRANSF. N°2 30 KVA 3Ø 480 - 120/208 V.
LIGHTING PANEL N°1 75 KVA, 3Ø 480 - 120/208 V.
ROOF VENTILATING FAN N°1
DONTHERMA COOL WTR. FAN N°3
AIR BLAST COOLING N°1
AIR HANDLING UNIT N°1
ROLL UP DOOR N°3
ROOF VENTILATING FAN N°2
CIRC WTR PUMP N°1A
CIRC WTR PUMP N°1
SPARE
BEARING WTR MAKE UP PP
COOLING WTR FAN N°2
ROLL UP DOOR N°2
LTR. TRANSF. N°2 75 KVA 480 - 120/208 V.
H.P. AIR COMPRESSOR
COOLING WTR FAN N°3
AIR HANDLING UNIT N°2
H.P. AIR COMPRESSOR
SPARE
DONTHERMA COOL WTR FAN N°2
SUMP PUMP N°2
PURIFICATION COMPR.
BATTERY CHARGER FOR BATT. OPERATED LIFT TRUCKS
HELIUM DRYER 10 KW
CRANE FOR
BATTERY CHARGER N°1
AIR COMPRESSOR N°1
SPARE
CIRC WTR PP N°1A
CIRC WTR PP N°2
ROOF VENTILATING FAN N°3
ROOF VENTILATING FAN N°4
AIR BLAST COOL N°2
DONTHERMA COOL WTR FAN N°4
DONTHERMA DRAIN PUMP
WELDING OUTLETS
SPARE
TO NORMAL INSTR. SINGLE PHASE PWR TRANSF. N°2 75 KVA (WHEN ALT. SUPPLY) 480 V - 240/480 V
TO NORMAL INSTR. SINGLE PHASE PWR TRANSF. N°1 75 KVA (WHEN ALT. SUPPLY) 480 V - 240/480 V
COOLING WTR FAN N°5
COOLING WTR FAN N°6
L.P. AIR COMPRESSOR
DONTHERMA G.P. PP N°1
ROOF VENT. FAN N°5
ROOF VENT. FAN N°6
CIRC WTR PMP N°3
CIRC WTR PMP N°3A
WTR TREAT. PP N°2
WATER BEARING PR. PP N°2
AIR COMP. N°2
WATER BEARING BYS. PP N°2
CIRC WTR PP N°4A
CIRC WTR PP N°4
ROOF VENT. FAN N°7
ELECTRIC AIR HEATER (SPARE)
COOLING WTR CIRC PP N°2
COOLING WTR FAN N°7
COOLING WTR FAN N°8
DONTHERMA G. PP N°2
COOLING WTR FAN N°9
BATTERY CHARGER N°2
WELDING OUTLETS
SPARE
LTR. TRANSFORMER 25 KVA 3Ø 480 - 208/120
125 V. DC SYSTEM
125 V. DC MAIN DISTR. PNL N°1, 600A
125 V. DC MAIN DISTR. PNL N°2, 600A
600A N.A. 2P
400A 2P
BATTERY N°1 60 CELLS 600 A H
BATT. FUSE PNL
BATTERY CHARGER N°1, 400A
125 V. D.C. DISTR. PNL
BATTERY CHARGER N°2, 400A
BATTERY N°2 60 CELLS 600 A H
TO 480 V MCC # 4
TO 480 V MCC # 6

NOTES:
1. ALL DEVICES ARE LOCATED IN THE RESPECTIVE SWGR CUBICLE UNLESS OTHERWISE SHOWN.
2. * DENOTES DEVICE LOCATED IN CONTROL ROOM OR EQUIPMENT CONTROLLED FROM CONTROL ROOM.

ONE LINE DIAGRAM SYMBOLS
N.A. HIGH AUTOMATIC
N.O. NORMALLY OPEN
3-POLE OUTDOOR OIL CIRCUIT BRKR
3 POLE, 13.8 OR 4.16 KV, DRAW OUT AIR CKT BRKR
3 POLE, 480 V, DRAW OUT AIR CKT. BRKR
3 POLE 480 V STATION AIR CKT BRKR
480 V MAGNETIC CONTROLLED MOTOR STARTER
FUSED DISCONNECT SWITCH
FUSE
BUS DUCT
BUS OR POWER CONDUCTORS
GROUND CONNECTION
SEPARABLE CONNECTOR OR DISCONNECTING DEVICE (DRAW-OUT TYPE)
RESISTOR REACTOR
GROUND CURRENT SENSOR
LIGHTNING ARRESTER
CURRENT TRANSF.

BASIC SYMBOL
(V) THE LETTER INSIDE INDICATES TYPE OF DEVICE AS SHOWN BELOW.

METERS, INSTRUMENT
A - INDICATING AMMETER
V - INDICATING VOLTMETER
RV - RECORDING VOLTMETER
KWH - KILOWATT HOUR METER
RA - RECORDING AMMETER
R DEM - RECORDING KILOWATT DEMAND METER

RELAYS
87T - TRANSF. DIFFERENTIAL (VOL 1 & 2)
50 - INSTANTANEOUS OVERCURRENT
51 - INVERSE TIME OVERCURRENT
50/GS - INSTANTANEOUS GROUND SENSOR
86 - AUXILIARY LOCK OUT RELAY (VOL 1 & 2)
64 - GROUND ALARM RELAY
27 - UNDER & OVER VOLTAGE RELAY
49/OIL OIL TEMPERATURE
49/W - WINDING TEMPERATURE
63/L OIL LEVEL
63/P SUDDEN PRESSURE RELAY
63/PRL PRESSURE RELEASE DEVICE

INSTR. AND CONTROL SWITCHES
VS - VOLTMETER SWITCH
TS - TEST SWITCH
CS - CONTROL SWITCH
AS - AMMETER SWITCH

REFERENCES DRAWING NO.	DESCRIPTION	REFERENCES DRAWING NO.	DESCRIPTION	REFERENCES DRAWING NO.	DESCRIPTION

REVISIONS NO.	DATE	BY	CK.	SEC.	PROJ.	CLIENT	DESCRIPTION

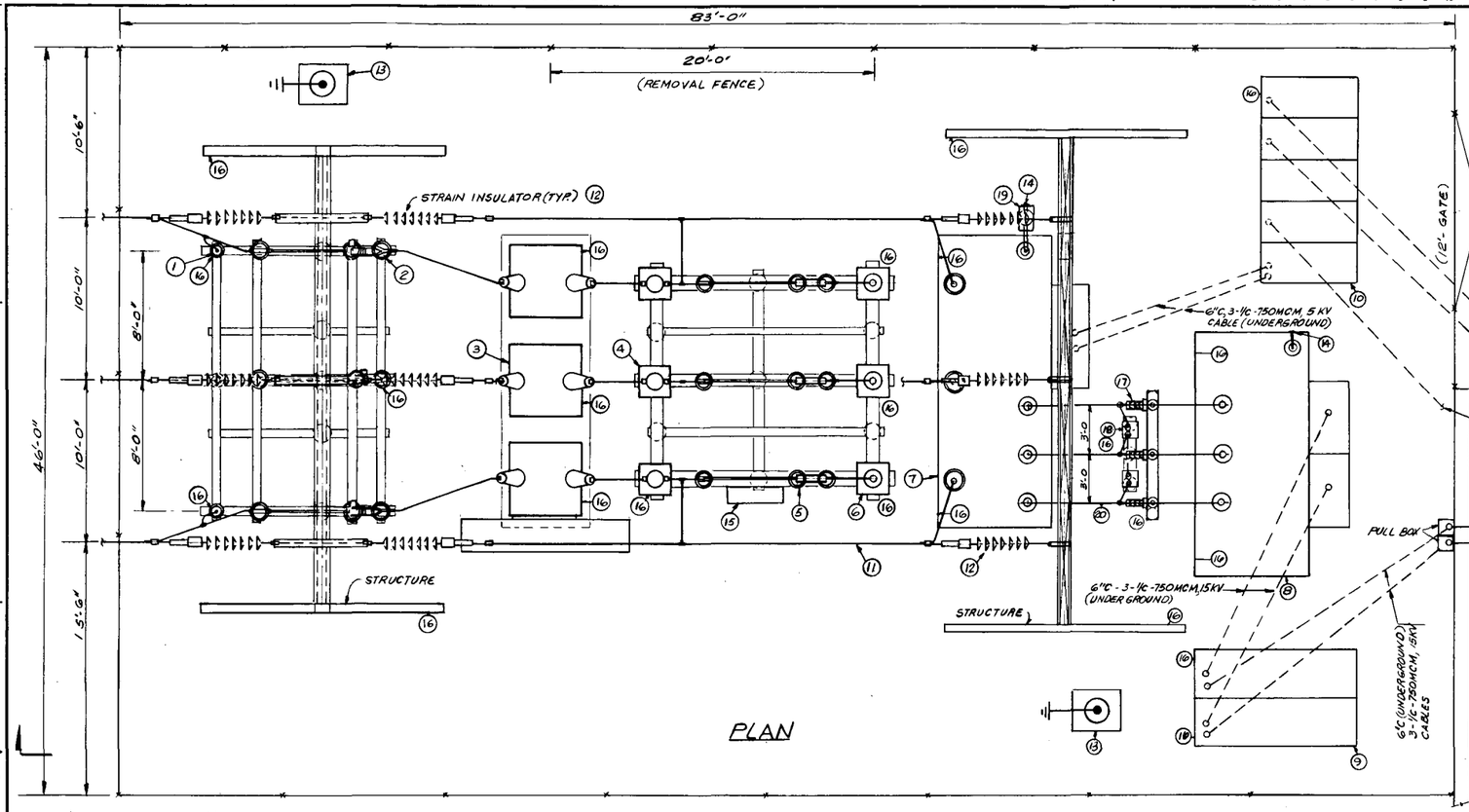
REVISIONS NO.	DATE	BY	CK.	SEC.	PROJ.	CLIENT	DESCRIPTION

	BY	DATE
ENGINEER	T.C.	4/4/78
CHECKED	JJM	5/16/78
SECTION	PWJ	5/8/78
PROJECT	D. Yates	5-31-78
CLIENT	D. Miller	5-31-78

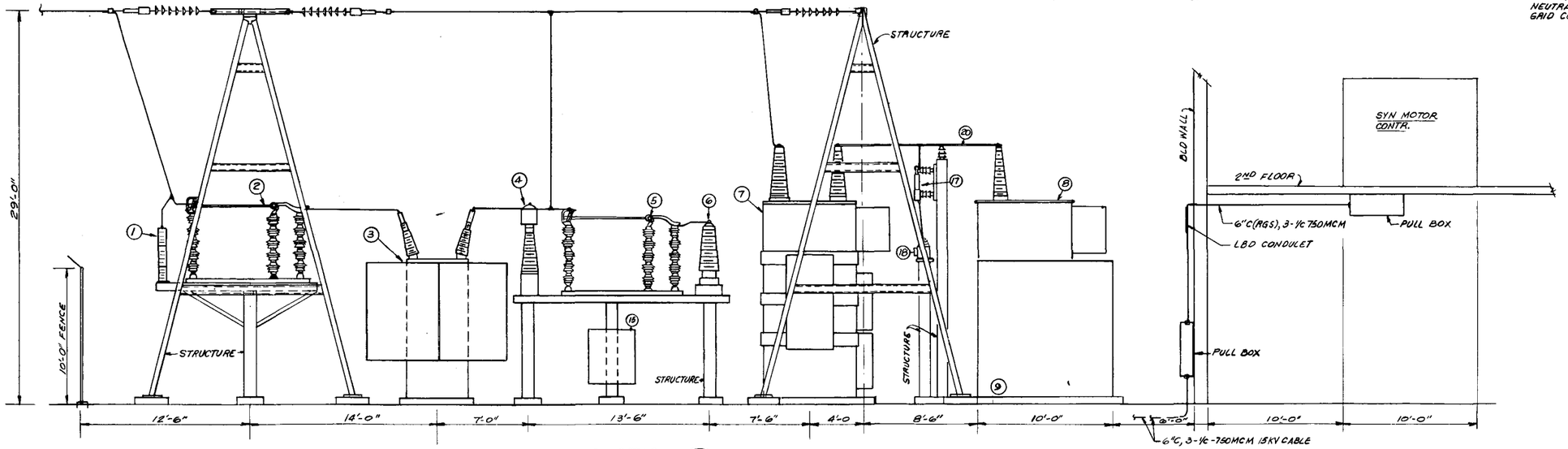
THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

GENERAL ATOMIC COMPANY
SAN DIEGO, CALIFORNIA
GCFR MAIN HELIUM CIRCULATOR TEST FACILITY

TITLE: ELECTRICAL SINGLE LINE DIAGRAM
SCALE: NONE
ACCOUNT NUMBER:
JOB NUMBER: 5830-1
DRAWING NUMBER: EE-01
REV. B



PLAN



SECTION (A)

LIST OF ELECTRICAL EQUIPMENT

1. LIGHTNING ARRESTERS - 120 KV L-G
2. 138 KV, VERTICAL BREAK, 3 POLE, GROUP OPERATED, DISCONNECT SWITCH, 1200A, 61 KA
3. 138 KV, 1600A, 3 POLE, BASE MOUNTED, 3 TANKS OIL CIRCUIT BREAKER - 38 KA INTERRUPTING CAPACITY
4. 160 A., 138 KV OUTDOOR CURRENT TRANSFORMERS
5. 138 KV, VERTICAL BREAK, 3 POLE, GROUP OPERATED DISCONNECT SWITCH, 600A, 40 KA
6. 3 PHASE, OUTDOOR POTENTIAL TRANSFORMERS 80 KV - 120/67 VOLTS
7. OUTDOOR, 138 KV - 24/4.16 KV, 3 WINDING POWER TRANSFORMER. RATED 24/32 MVA, 18/24 MVA, 6/7.5 MVA OA/FA
8. OUTDOOR, 24 - 13.8Δ/13.8Y KV, 3 WINDING PWR TRANSF. RATED 18/24 MVA OA/FA (BY GAC/W)
9. OUTDOOR, METAL ENCLOSED, 15 KV SWGR UNIT, 2 - 1200A 13.8 KV AIR CIRCUIT BREAKERS RATED AT 500 MVA INTERRUPTING CAPACITY (BY GAC)
10. OUTDOOR, METAL ENCLOSED, 5 KV SWITCHGEAR LINE UP- ONE (1) 1200A INCOMING AIR CIRCUIT BRKR, THREE (3) 1200A. OUTGOING AIR CIRCUIT BRKRS 1 - SPARE SPACE
11. 300 MCM ACSR STRA. CONDUCTOR
12. STRAIN INSULATORS - FOG TYPE.
13. GROUND WELL
14. NEUTRAL GROUNDING STRAP - SET OF STAND-OFF INSULATORS
15. OUTDOOR REVENUE METERING CABINET
16. GROUNDING GRID CONNECTIONS.
17. 3 POLE, SINGLE THROW, MANUALLY GROUP OPERATED SIDE BREAK 600A. 24 KV DISCONNECT SWITCH
18. 24/0.12 KV OUTDOOR POTENTIAL TRANSFORMERS WITH TWO PRIMARY BUSHINGS - CONNECTORS OPEN DELTA
19. NEUTRAL GROUNDING REACTOR WITH PEDESTAL SUPPORT.
20. 1200A BARE COPPER BUS

NOTES:

1. ALL ELECT. EQUIPMENT, ALL SWGR GROUND BUSES, ALL ELECT. MOTORS, STEEL STRUCTS AND ALL TRANSFORMER NEUTRALS WILL BE CONNECTED TO A COMMON GROUNDING GRID CONNECTING ALL THREE GROUND WELLS TOGETHER.

REFERENCES	DRAWING NO.	DESCRIPTION
ENG-GE-23		

REFERENCES	DRAWING NO.	DESCRIPTION

REVISIONS	NO.	DATE	BY	CK.	SEC.	PROJ.	CLIENT	DESCRIPTION

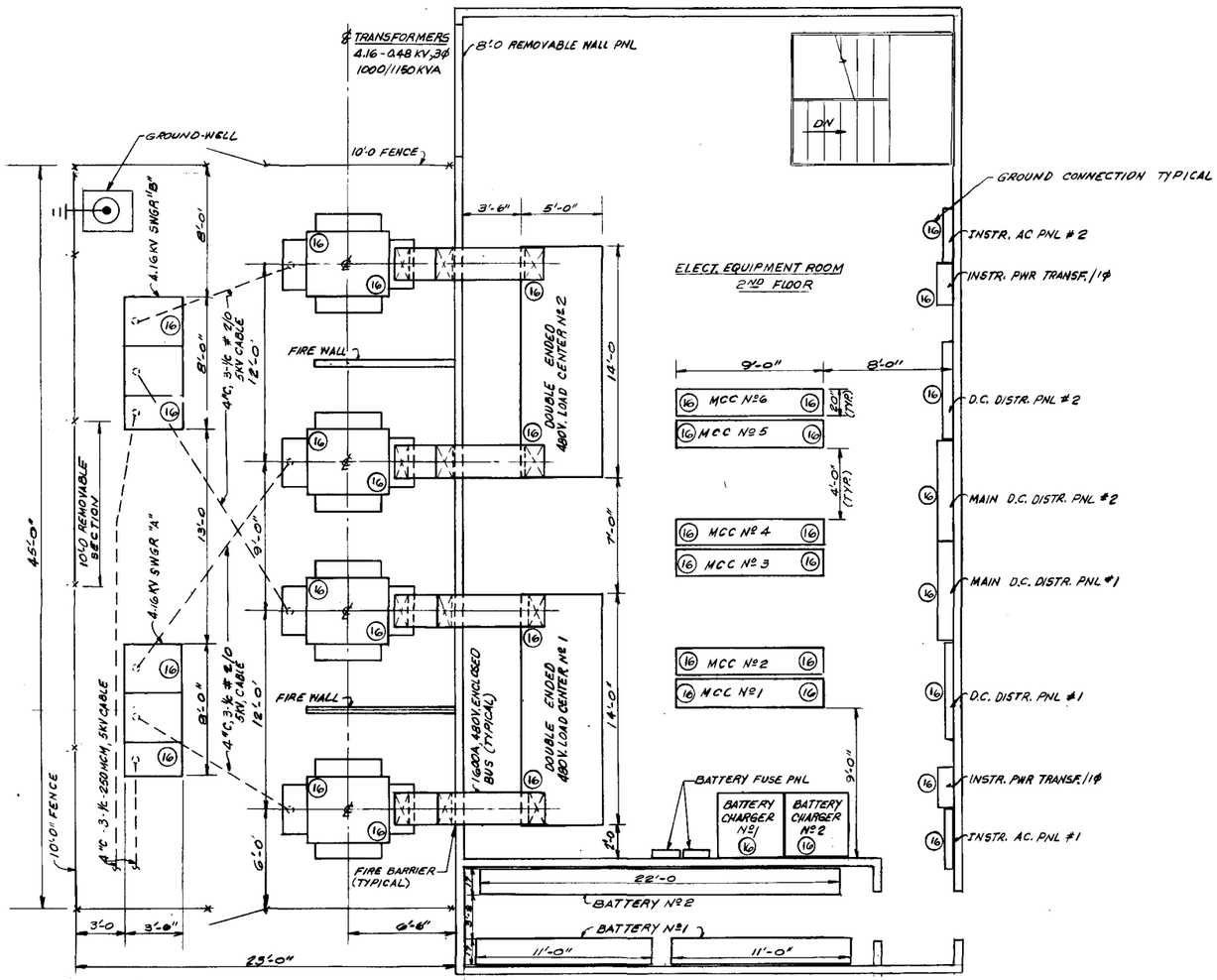
REVISIONS	NO.	DATE	BY	CK.	SEC.	PROJ.	CLIENT	DESCRIPTION

	BY	DATE
CHECKED	T.O.	3/21/78
SECTION	[illegible]	5/10/78
PROJECT	D. Nelson	5-31-78
CLIENT	M. Wilkerson	5-31-78

THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

GENERAL ATOMIC COMPANY
SAN DIEGO, CALIFORNIA
GCFR MAIN HELIUM CIRCULATOR TEST FACILITY

TITLE	SCALE
ELECTRICAL SWITCH YARD LAYOUT	1/4: 1'-0"
	ACCOUNT NUMBER
JOB NUMBER 5830-1	DRAWING NUMBER EE-02
	REV. 5



PLAN

NOTES

1. EQUIPMENT DIMENSIONS SHOWN ARE PRELIMINARY.
2. SEE OUTLINE SPECIFICATIONS AND SINGLE-LINE DIAGRAM EE-01 FOR RATING OF THE EQUIPMENT AND NUMBER OF BREAKERS, COMBINATION MOTOR STARTERS, FUSED SWITCHES ETC.
3. ALL ELECT. EQUIPMENT, ALL SWGR GROUND BUSES, ALL ELECT. MOTORS, STEEL STRUCTURES AND ALL TRANSFORMER NEUTRALS WILL BE CONNECTED TO A COMMON GROUNDING GRID CONNECTING ALL THREE GROUND WELLS TOGETHER.

ENG-GE 23

REFERENCES			REFERENCES			REVISIONS								REVISIONS							
DRAWING NO.	DESCRIPTION		DRAWING NO.	DESCRIPTION		NO.	DATE	BY	CK.	SEC.	PROJ.	CLIENT	DESCRIPTION	NO.	DATE	BY	CK.	SEC.	PROJ.	CLIENT	DESCRIPTION

BY	T.O.	DATE 3/27/78
CHECKED	AM	5/10/78
SECTION	PMW	7/3/173
PROJECT	DMcL	5-31-78
CLIENT	KMcK	5-31-78

RMP
THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

GENERAL ATOMIC COMPANY
SAN DIEGO, CALIFORNIA
GCFR MAIN HELIUM CIRCULATOR TEST FACILITY

TITLE: ELECTRICAL TRANSFORMER STA. AND EQUIPMENT ROOM - LAYOUT
SCALE: 1/4= 1'0"
ACCOUNT NUMBER:
JOB NUMBER: 5830-1
DRAWING NUMBER: EE-03
REV. B

1 2 3 4 5 6 DC- 7 DT-

SECTION 10

OUTLINE SPECIFICATIONS

10.1 SPECIFICATIONS IN THE CSI FORMAT

Final project specifications will be prepared using the Construction Specifications Institute (CSI) format as follows:

PART I - GENERAL

- o Description
- o Quality Assurance
- o Submittals
- o Product Delivery, Storage, and Handling
- o Job Conditions
- o Alternatives and Allowances
- o Guarantee

PART 2 - PRODUCTS

- o Materials
- o Mixes
- o Fabrication and Manufacture

PART 3 - EXECUTION

- o Inspection
- o Preparation
- o Installation/Application/Performance/Erection
- o Field Quality Control
- o Adjustment and Cleaning
- o Schedules

10.2 OUTLINE SPECIFICATIONS

Outline specifications for Division 1 through 16 of the CSI format are presented below.

DIVISION 1 - GENERAL REQUIREMENTS

This division of the specification will include general and technical provisions. Some of the subjects that may be included are as follows:

- o Summary of Work
- o Alternatives
- o Measurement and Payment
- o Project Meetings
- o Submittals
- o Schedule and Cost Control Requirements
- o Quality Control
- o Temporary Facilities and Controls
- o Material and Equipment
- o Project Closeout

The division shall also note that where items are called out specifically, "or equal" is applicable.

DIVISION 2 - SITE WORK

Section 1 - Clearing

The clearing shall consist of the removal and disposal of all trees, brush, roots and other organic matter, fences, debris, trash and all other obstructions.

Section 2 - Earthwork

The earthwork shall consist of excavation and backfilling in the building area and in the area of the pit, grading the site, and providing subgrades for roads and walks. Excavated material shall be segregated, stockpiled, and if approved, used as backfill. Backfill shall be placed symmetrically, and shall be compacted to 95 percent of maximum density in accordance with ASTM Specification D-1557.

All subgrades for roads and walks shall be finished to a true compacted surface.

Site shall be graded to give adequate drainage, and to blend into the existing contours.

Section 3 - Culverts

Corrugated steel pipe for culverts shall conform to the applicable requirements of AASHTO M-36 and be galvanized.

Section 4 - Paving and Surfacing

Bituminous paving shall consist of material specified and shall be placed in accordance with the State of California, Department of Transportation Construction Manual.

Section 5 - Fencing

A 6-foot chain link galvanized steel security fence, topped with barbed wire, shall be supplied.

All tubular members shall conform to ASTM-A120 for weight and coating. All structural shapes shall conform to ASTM-A123 for galvanized coating.

Gate posts shall be 3 in. dia. pipe for personnel gate and 4 in. dia. for truck gate. End and line post shall be 3 in. dia. pipe, with two strands of barbed wire at top of fence. Chain link fabric shall be 2 in. mesh with 9 gauge wire.

Section 6 - Irrigation System

The irrigation system shall include both materials and installation of all control valves, piping, lawn and shrub sprinkler heads, and accessories necessary for proper layout and functioning of the system as indicated.

Piping shall be PVC 2110 Schedule 40 and fittings shall be PVC 11, IPS Schedule 40. Sprinkler heads shall be brass.

Section 7 - Landscaping

All landscaping plan materials shall meet the specifications of Federal, State and County laws requiring inspection for plant diseases and insect infestations. Soil additives shall be provided and planting methods followed as specified.

Trees, shrubs, and ground cover materials furnished and planted shall be of the specified size, species, quantity and location as indicated.

Shrubs and ground covers shall be maintained and guaranteed for 60 days after acceptance. Trees shall be guaranteed for one year.

Section 8 - Dewatering System

A dewatering system shall be provided that is adequate to keep the pit excavation in a dry condition during excavation of the pit and up until the concrete pit walls have been placed and have reached their required strength.

Section 9 - Pile Foundations

Pile foundations using concrete-filled pipe piles 12-3/4" dia. shall be provided to support the building columns. The steel shells shall conform to ASTM A252 and shall be driven approximately 35 feet.

DIVISION 3 - CONCRETE

Section 1 - Concrete Reinforcement

All reinforcing bars shall be new deformed billet-steel conforming to ASTM A615, Grade 40. All welded wire fabric shall conform to ASTM A185.

Section 2 - Cast-in-Place Concrete

All cast-in-place concrete shall meet the requirements of quality specified in Chapter 4 of the ACI 318, reaching a strength of 3000 psi at 28 days.

DIVISION 4 - MASONRY

Section 1 - Sound Absorbing Structural Masonry Units

All interior wall faces of the Test Pit shall be lined with 8x8x16 inch (nominal) sound absorbing structural masonry units. The units shall be specially slotted structural grade concrete blocks with incombustible acoustical filler material. The units shall be Soundblox Type "R" as manufactured by Proudfoot, Inc., or equal.

The units shall be laid in full mortar beds, with the open end of cavities turned down, and anchored to the concrete pit walls with suitable ties.

DIVISION 5 - METALS

Section 1 - Structural Steel

Structural steel shall conform to ASTM Specification A-36, and shall be detailed, fabricated and erected in accordance with AISC Specifications and Code of Standard Practice. All welding shall conform to the American Welding Society Specification D.1.1.

Bolts used to connect structural steel shall conform to ASTM Specification A-325. Anchor bolts shall conform to Specification ASTM A 307.

All fabricated carbon steel shall be painted with one shop coat of primer.

Section 2 - Lightgage Metal Framing

Metal studs shall be non-bearing screwable type 1-5/8 and 3-5/8 inch, 20 gage, punched for utility lines, complete with top and bottom runners.

Suspended gypsum wallboard ceiling system shall be constructed of special metal furring channels clipped to 1-1/2 inch runner channels which are supported by #8-ga. galvanized hanger wire attached to the structure above.

All lightgage metal framing shall be similar and equal to those manufactured by U.S. Gypsum Company.

Section 3 - Miscellaneous Metals

Miscellaneous metal includes steel access ladders, stairs, catwalks, railings, angle guards, wall opening frames, floor plate and miscellaneous support and anchor items.

Design and fabrication shall be in accordance with AISC Specifications. Materials shall be new and conform to ASTM A-36.

DIVISION 6 - WOOD AND PLASTICS

Section 1 - Rough Carpentry

All rough carpentry work including wood railers, blocking and shelving shall be Douglas Fir No. 2 in accordance with rules of the Lumber Manufacturer's Association.

Lumber shall be pressure treated against rot, decay and fire as recommended by the American Wood Preserver Bureau.

All necessary anchors and fasteners shall be furnished and properly installed.

DIVISION 7 - THERMAL AND MOISTURE PROTECTION

Section 1 - Waterproofing

A moisture barrier shall be placed between the compacted backfill and the pit sidewalls, and between the mud mat and the pit basemat. The moisture barrier shall be a polyethylene sheet material meeting the requirements of Federal Specification WP-147.

Section 2 - Dampproofing

A moisture barrier shall be placed between the compacted backfill and all concrete floor slabs on grade, and between the earth banks and the

retaining walls. The moisture barrier shall be a polyethylene sheet material meeting the requirements of Federal Specification WP-147.

Section 3 - Roof Deck, Insulation and Roofing

Roof deck and insulation shall be 5 inch thick Long Span Tectum II/25, comprised of a 3-inch thick tongue and groove Long Span Tectum structural wood fiber substrate deck topped with a 2-inch thick integrally bonded urethane foam insulation providing a "U" factor of .05. Tectum II/25 shall be as manufactured by Gold Bond Building Products, Division of National Sypsum Company, or equal. The substrate deck shall provide a sound absorption NRC Range of .65-.75 and comply with Federal Specification SS-S-118a, as Type IX, Class 25. The deck shall be secured by use of steel clips at each support fastened by puddle welding.

Roofing shall be as manufactured and installed as recommended by Johns-Manville, or equal, for a 20 year bondable built-up roofing with gravel surfacing.

The roof must meet the requirements of Factory Mutual for Class I, including inspections by a Factory Mutual field engineer.

Section 4 - Insulated Metal Siding

Insulated metal siding panels shall be 24 to 36 inches wide and of sufficient thickness to achieve a "U" value of .068 or less. Panels shall be inner and outer galvanized steel sheet laminated to an inner core of isocyanurate or urethane foam insulation.

All materials shall be as manufactured by INRYCO, Inc., or equal, and shall be installed in accordance with the manufacturer's instructions. Certified test report verifications including the following:

1. Structural - Wind load of 30 psf per ASTM E72
2. Thermal - "U" value of .068 or less per ASTM C236
3. Fatigue - No evidence of delamination at wind loads.
4. Air Infiltration - NAAMM Test Procedure TM-1
5. Water Penetration - NAAMM Test Procedure TM-1
6. Fire Testing - Tested by Underwriters Laboratories per ASTM Test E84, with a flame spread rating of 25 or less. Factory Mutual Test Std. No. 4411 resulting in a Class I rating.

Panels shall be full height with no horizontal joints. Side joints shall be tongue and groove or shiplap design permitting concealed fasteners and factory caulked. Exterior finish shall be baked enamel and interior shall be polyester coated. Trim and flashing shall match panels. Color shall be as selected.

Section 5 - Flashing and Sheet Metal

All necessary sheet metal work including gravel stop/fascias, gutters, down-spouts, cap flashings, etc., shall be .032 thick aluminum alloy 3003-H14. Finish shall be baked enamel of a color matching the adjoining metal siding.

Section 6 - Caulking and Sealants

All joints shall be properly caulked with elastomeric sealants as manufactured by Dap, Inc., or equal. Type shall be as recommended by the manufacturer for each intended use.

DIVISION 8 - DOORS AND WINDOWS

Section 1 - Hollow Metal Doors and Frames

All hinged personnel doors and frames shall be formed of No. 16 gage cold-rolled stretcher-leveled sheet steel as fabricated by Ceco Steel Co. or an approved equal. Doors shall be flush panel with insulation core.

Fire resistive doors and frames shall bear the proper Underwriters' Laboratory label.

Section 2 - Rooling (Roll-up) Steel Doors

All rolling steel doors shall be standard items as manufactured by the Apton Metal Products Corp., or equal. Curtains shall have flat interlocking galvanized steel slats with polyurethane filler inserts. Doors shall be furnished with neoprene jamb seals, weather stripped guides, hood baffles and astragals.

Doors less than 100 sq. ft. in area shall be manually chain operated. Doors exceeding 100 sq. ft. in area shall be motor operated with a safety edge bottom bar.

Section 3 - Upward Acting Sectional (Overhead) Doors

All upward acting sectional doors shall be Series 416 as manufactured by the Overhead Door Corp., or equal, constructed of 2-inch thick flush insulation filled hollow metal panel sections with weathertight joints.

Panel sections shall be formed of No. 16 gage cold rolled zinc coated steel. Doors shall be engineered to a 30 lb./sq. ft. wind load. Entire perimeter of door shall have neoprene weather stripping.

Doors shall have full vertical or high lift tracks. Doors exceeding 100 sq. ft. in area shall be motor operated with a safety bottom mechanism.

Section 4 - Acoustical Doors

All sound attenuating door openings shall have door, frame and seal units as manufactured by the Overly Manufacturing Co., or equal. Doors shall be 1-3/4 inch thick with flush appearance, designed for use with standard builders hardware. STC ratings shall be as required for each specific opening. Certification of tested performance in accordance with ASTM E90-61T shall be provided.

Section 5 - Metal Windows

Both interior and exterior windows shall consist of fixed insulated glass set with neoprene gaskets into extruded aluminum store front type frames as manufactured by Kawneer, Inc., or equal.

Frames shall have a hard anodoic finish as selected.

Section 6 - Finish Hardware

Finish hardware including latchsets, locksets, panic devices, hinges, closers, thresholds, flush bolts, push/pull/kick plates, door holders, and all necessary items shall be heavy duty as manufactured by Sargent and Company, or equal. Exposed surfaces of hardware shall have a finish as selected.

Installation of finish hardware shall include lock cylinders which are to be furnished by General Atomic Company.

Weather stripping shall be as manufactured by Zero Weatherstripping Co., Inc., or equal.

Section 7 - Glazing

Glazing for all windows shall be + 1 inch thick insulated (double glazed) panes consisting of two sheets of 1/4 inch clear tempered float glass with air space between and a metal perimeter edge closure. Neoprene gaskets shall be used for setting of glass.

Glazing for door vision panels shall be 1/4 inch clear wire glass set in metal stops.

All glass shall be as manufactured by a nationally recognized major glass manufacturer.

DIVISION 9 - FINISHES

Section 1 - Gypsum Wallboard (Dry-Wall)

The complete installation of gypsum wallboard shall include attaching 5/8 inch tapered-edge type S.W. (water resistant type in Toilet Rooms and Janitor's Closet) to metal studs with self tapping screw fasteners, metal corner beads, metal edge trim, and finishing of joints with joint compound and reinforcing tape. Materials and installation methods shall be similar and equal to those of U. S. Gypsum.

Section 2 - Ceramic Tile

Ceramic-mosaic floor tile shall be unglazed porcelain type, with cushion edges, of 1 x 1, 1 x 2 or 2 x 2 inch size. Installation shall be the setting bed method. Shower stalls shall have waterproof receptors. Ceramic wall tile shall be bright or matte glazed, of 4 x 4, 4 x 6 or 6 x 6 inch size. Installation shall be by the dry-set method over water-resistant type gypsum wallboard.

Tile shall conform to ASHI Standard A 137.1, and be standard grade. Colors shall be as selected.

Section 3 - Acoustical Ceilings

Suspended acoustical ceilings shall be of the noncombustible type, consisting of suspended exposed metal grid supports and lay-in type acoustical panels. Suspension system shall include a 2 x 2 ft. grid of either cold rolled steel or extruded aluminum main runner and cross tees with a white factory enameled finish. Hanger wires shall be 12 gauge galvanized steel.

Lay-in acoustical panels shall be mineral fiber type. Pattern shall be fissured with a white factory finish surface. An acoustical rating of STC 45 will be obtained with 2 in. acoustical blankets above panels.

Section 4 - Resilient Tile Flooring and Base

Vinyl asbestos tile shall be standard 12 x 12 x 1/8 inch installed with water resistive adhesive. Top set vinyl cove base shall be 6 in. high and vinyl stair treads with safety nosing on stairs shall be installed with water resistive adhesive. Materials and installation methods shall be similar and equal to those of the Armstrong Cork Co. Color of materials will be as selected.

Section 5 - Painting

Except as excluded herein, all surfaces of the building shall be properly prepared, primed, and finished including floors, walls, doors, ceilings, equipment, piping, hangers, conduits, grilles and miscellaneous exposed materials which normally require painting.

The following items shall be factory finished:

1. Exterior metal siding and flashing.
2. Acoustical ceiling grid and panels.
3. Factory fabricated mechanical and electrical equipment.

The following items shall be factory primed:

1. Hollow metal doors, frames and windows.
2. Rolling (roll-up) steel doors.
3. Upward acting sectional doors.
4. Structural steel.
5. Steel stairs, platforms, catwalks, railings and ladders.
6. Metal roof deck

The following surfaces shall not be painted but shall receive one coat of clear silicone sealer:

All concrete floors (except Battery Room), curbs and walls.

Paints, primers and finishes shall be ready-mixed and equal to first line products manufactured by:

Devoe and Reynolds, Inc.
Pratt and Lambert, Inc.
E. I. DuPont de Nemours and Co.
Rust-Oleum Corporation
Glidden Company
Benjamin Moore and Co.

Surfaces shall be prepared and paints shall be applied in strict accordance with the manufacturer's recommendations. Colors shall be as selected by the General Atomic Company.

Painting Schedule

Insulated metal siding, flashing and roof deck:	Baked enamel shop finish (Touched up after installation)
All metal doors, frames and windows:	Factory primer Two coats high gloss Alkyd Enamel
Exposed structural steel and miscellaneous metal	Factory primer Two coats high gloss Alkyd Enamel
Gypsum wallboard:	1 coat Alkyd Primer Sealer 2 coats semi-gloss Alkyd Enamel
Electrical & mechanical equipment (without manufacturer's finish):	2 coats Red Lead Primer 1 coat quick dry Alkyd Enamel
Battery room floor	2 coats Synthetic Floor Enamel

Paint colors shall be as selected. Contents and flow of all piping shall be indicated by adhesive identification and flow markers.

DIVISION 10 - SPECIALTIES

Section 1 - Lockers and Benches

Metal lockers shall be 12 inches wide x 18 inches deep x 72 inches high, single tier type, with sloping top, as manufactured by the Lyon Co., or equal. Color of baked enamel finish shall be as selected.

Wooden benches shall be natural finished oak supported on fixed metal pedestals.

Section 2 - Toilet Partitions and Screens

Metal toilet partitions shall be ceiling hung and metal urinal screens shall be wall hung. Materials shall be standard items as manufactured by Sanymetal Products, or equal.

Color of the baked enamel finish shall be as selected.

Section 3 - Toilet Accessories

Toilet room accessories including combination mirror and shelf units, soap dispensers, towel dispensers, sanitary napkin dispensers, toilet tissue dispensers and waste receptacles shall be standard items as manufactured by Bobrick Washroom Equipment Co., or equal.

DIVISION 11 - EQUIPMENT

Section 1 - Heat Exchangers and Air Coolers

The following heat exchangers and air coolers shall be provided:

Dowtherm G Air Cooler

Duty: 61 x 10^6 BTU/hr
Function: To cool 2640 GPM of Dowtherm G from 400°F to 300°F
Design pressure: 100 PSIG
Design temperature: 650°F

Cooling Water Air Cooler

Duty: 18 x 10^6 BTU/hr
Function: To cool 1200 GPM of cooling water from 120°F to 90°F.
Design pressure: 60 PSIG
Design temperature: 150°F

Helium Compressor After Cooler (Water Cooled)

Duty: 620,000 BTU/hr
Function: To cool compressed gaseous helium to an acceptable temperature for storage.
Type: Double tube heat exchanger
Design pressure: 3000 PSIG
Design temperature: 500°F
Size: 6 inch dia. x 20 ft. long

Nitrogen Compressor After Cooler (Water Cooled)

Duty: 400,000 BTU/hr
Function: To cool compressed gaseous nitrogen to an acceptable temperature for storage.
Type: Double tube heat exchanger
Design pressure: 3000 PSIG
Design Temperature: 500°F
Size: 6 inch dia. x 15 ft. long

Section 2 - Pumps

The following pumps shall be provided:

Dowtherm G Pumps (2)

Type: Centrifugal electrical motor driven, base plate mounted
Capacity: 2640 GPM
Total head: 35 PSI
Maximum temperature: 650°F
Maximum pressure: 150 PSIG
Motor HP: 100
Material of construction:
Housing - Carbon steel
Impeller - Carbon steel
Shaft/Sleeve - Stainless steel

Dowtherm G Drain Pump

Type: Positive displacement, electrical motor driven, base plate mounted.
Capacity: 20 GPM
Total head: 25 PSI
Maximum temperature: 200°F
Maximum pressure: 150 PSIG
Motor HP: 1/2
Material of construction: Carbon steel

Cooling Water Circulating Pumps (2)

Type: Centrifugal, electrical motor driven, base plate mounted
Capacity: 1200 GPM
Total head: 50 PSI
Motor HP: 50
Material of construction:
Housing - Carbon steel
Impeller - Carbon steel
Shaft/Sleeve - Stainless steel

Bearing Water Makeup Pump

Type: Positive displacement, electrical motor driven, base plate mounted
Capacity: 20 GPM
Total head: 1500 PSI
Motor HP: 25
Material of construction: Stainless steel

Section 3 - Vessels and Tanks

The following vessels and tanks shall be provided:

Dowtherm G Expansion Tank

Type: Horizontal, cylindrical
Size: 3 ft-0 in.dia. x 6 ft-0 in.long
Capacity: 300 gal.
Design pressure: 50 PSIG
Design temperature: 650°F
Material of construction: Carbon steel

Gaseous Helium and Nitrogen Storage Bottles

Type: Horizontal, cylindrical
Size: 9 in.dia. x 24 ft-0 in.long
Capacity: 9 cu. ft.
Pressure rating: 3000 PSIG
Material of construction: Carbon steel

Cooling Water Expansion Tank

Type: Horizontal, cylindrical
Size: 4 ft-0 in.dia. x 8 ft-0 in.long
Capacity: 750 gal.
Design pressure: 75 PSIG
Design temperature: 150°F
Material of construction: Carbon steel

Bearing Water Storage Tank

Type: Horizontal cylindrical
Size: 7 ft-0 in.dia. x 14 ft-0 in.long
Capacity: 3500 gal.
Design pressure: ATM
Design temperature: AMB
Material of construction: Stainless steel

Section 4 - Compressors

The following compressors shall be provided:

Helium Compressor System

Type: Diaphragm
Capacity: Av. 200 SCFM
Discharge pressure: 2500 PSIG

This compressor system consists of two AMINCO single stage compressors. Each is driven by a 25 HP electrical motor.

Nitrogen Compressor System

Type: Diaphragm
Capacity: Av. 200 SCFM
Discharge pressure: 2850 PSIG

This compressor system consists of two AMINCO single stage compressors. Each is driven by a 25 HP electrical motor.

Section 5 - Packaged Unit and Special Equipment

Water Treatment Package

Capacity: 10 GPM
Product water quality: 30 ppm
Water source: City water

Package shall consist of one anion tank, one cation tank, caustic and acid regeneration equipment, chemical feedpump system for PH control, and automatic control for production, regeneration and rinse sequences.

Compressed Air Unit

Capacity: 100 ACFM
Discharge pressure: 125 PSIG

Package shall include two compressors, 30 HP each, dual tower type desiccant absorber, and a receiver. Intercoolers and after-coolers shall be water cooled units. Package shall be fully automatic controlled.

Vacuum Pump

Average capacity: 12 SCFM
Vacuum pump shall be capable of evacuating air and water vapor from test vessel at atmospheric pressure to abs. vacuum of 1 mm Hg, and exhaust to atmosphere
Driver: 5.0 HP electric motor

Helium Dryer

Type: Dual tower, desiccant absorber.
Electric regeneration.
Capacity: 200 SCFM (average)
Design pressure: 2500 PSIG

Unit shall be capable of drying gaseous helium at 2500 PSIG to dew point of 0°F. Regeneration shall be manually controlled.

Section 6 - Circulator Test Vessel and Internals

Design Presure: 1436 PSIG (Int.)
Design Temperature: 650°F
Size: 12 ft-10 in.ID x 22 ft-0 in.T-T with 2:1 SE heads
Wall thickness: 6.65 in min.
Nozzles required:
1 - Valve actuator conn.
1 - Helium outlet
1 - Rapid depressurization conn.
4 - Instrument conn.
2 - Relief valve conn.
1 - Helium inlet
6 - Restrictor valve
1 - Coolant outlet
1 - Coolant inlet
1 - Drain
1 - Side manhole
1 - Bottom manhole
Insulation: Mineral wool, approximately 3 inches thick with a 20 guage aluminum outer jacket.
Internals:

The test vessel is a cylindrical, vertical vessel with a special flanged connection (65 in. ID) on the top to accommodate the helium circulator radial impeller. The electrical motor of the circulator will be mounted on a second flange on the top of the vessel and the impeller of the circulator will be extended inside the vessel.

Inside the vessel, a specially shaped partition will separate the vessel into a central flow column (29 in. ID) and an annular outer flow ring (24 in. wide).

The central flow column extends upward in the center of the vessel, through an isolation valve located at the circulator suction inlet, to the suction of the radial compressor.

At the discharge side of the radial impeller is a diffuser which distributes the flow evenly to the outer flow ring.

Downstream of the diffuser are located six restrictor valves, 60° apart, which control the helium flowing through the annular Dowtherm G heat exchanger. This heat exchanger is 12 ft-11 in. in height, and is constructed of 224 1-1/2 in. diam. 10 GA tubes. Thirty-two sub-headers at each end of the coil bank are required to carry the Dowtherm G fluid to the inlet and outlet pipe.

Downstream of the Dowtherm G coil bank, at the bottom of the vessel, the outer flow passage folds back to redirect the helium upward through a bell shaped entrance into the central flow column.

Inside the specially shaped flow partition, ladder rungs are provided so maintenance personnel can reach inside and do service work.

Material of Construction:

Shell: SA-516-70
Head: SA-516-70
Internals: SA-285-C
Piping: SA-106-B
Tubing: SA-210-A1

Code Certificates and Stamp Required

ASME Boiler and Pressure Vessel Code, Sec. VIII, Div. 1.

Testing:

Witnessed hydrostatic test
Helium leak test

Section 7 - Restrictor Valve

This helium control valve, located inside the circulator vessel in the main helium flow loop, shall be of the butterfly type ANSI Class 150, Size 12 inch. The following restrictor valve features shall be provided:

1. Bolt Circle: 17.0 inches
2. Approximate weight $\pm$ 20 pounds: 120 pounds
3. Inboard valve shaft: Splined
4. Shaft diameter: 0.750 in. minimum
5. Valve center line to outboard bearing: 9.4 inches (+2.0 - 0.0 inches)
6. Valve center line to end of inboard shaft: 12.0 inches (+ 2.0 - 0.0)
7. Number of flange bolts: 12
8. Body thickness: 2 inches ($\pm$ 0.5 - 0.0 inches)
9. Body and disc material: 316 stainless steel
10. Pressure drop: 60 PSI max.
11. Temperature: 700°F max.
12. Shaft material: 316 stainless steel
13. Bearings: Inboard and outboard packing, Crane 177A1
14. Disc rotation: 0 to 90 degrees rangeability, 100 to 1 or greater
15. Inboard driven lever: 12 inches (adjustable)
    12 inches by 1-1/4 inches by 3/8 inches thick.
    Provide a series of 9 each 1/2 inch diameter holes on 1 inch centers beginning 3 inches from the center of rotation.
    (Connecting link and clevises shall be provided by others.)

Restrictor Valve Drive

The butterfly valve drive shall be of the rotary-type mounted through the vessel wall using the 900 pound ANSI 4 inch nozzle penetrations provided. These nozzles shall be fitted with 900 pound ANSI ring-type joint flanges to enable removal, assembly and maintenance of the valve drive unit.

The following features shall be provided:

1. Inboard and outboard shaft ends: splined
2. Shaft diameter: 0.750 inches minimum
3. Shaft material: 316 stainless steel
4. Housing material: 316 stainless steel
5. Pressure differential: 1500 PSI
6. Temperature: 700°F
7. Bearings: Inboard and outboard packing, Crane 177A1
8. Rotation: 0 to 90 degrees
9. Inboard and outboard drive levers: Two each required, 12 inches by 1-1/4 inches by 3/8 inches thick. Provide a series of 9 each 1/2 inch diameter holes on 1 inch centers beginning 3 inches from center of rotation. (Connecting link and clevises shall be provided by others.)
10. Inboard housing: The dimension between face of mounting flange to centerline of inboard drive lever shall be 4 feet $\pm$ 0.1 inch.

Actuator

A pneumatic actuator control element shall be provided with the following provisions:

1. Mounting bracket: Surface type
2. Control signal: 3-15 PSI
3. Positioner: With characterizable cam
4. Linkage: To match restrictor valve drive

System Calibration

The in-vessel restrictor valve driven lever and the drive lever shall be connected with clevis pin linkage to form a parallelogram at 45° disc opening. The linkage system shall be installed such that an expansion coefficient due to temperature between the vessel and its internals shall cause the restrictor valve disc to open. Hence at ambient temperature, the restrictor valve disc shall be set in its closed position.

A transmitter sensing vessel internal gas temperature shall input to a computing relay installed in the output of the restrictor valve's controller for automatic temperature compensation due to differential thermal expansion of the vessel and its internals.

Section 8 - Helium Dryer Module

This module is 8 feet wide by 10 feet long by 8 feet high, and contains piping, valves, instrumentation and the following major equipment:

Purification Compressor

Type: rotary, fluid-piston type
Capacity: 1200 SCFM (max.)
Discharge pressure: 1300 PSIG
Pressure rise: 20 PSI
Driven: 3 HP electric motor

Compressor Precooler

Duty: 100,000 BTU/HR
Function: To cool 1200 SCFM (max.) saturated helium from 120°F to 60°F and drain condensed moisture.
Design pressure: 1500 PSIG
Design temperature: 200°F

Helium Dryers

Type: Dual tower, desiccant absorber, hot helium regeneration
Capacity: 1200 SCFM (max.)
Design pressure: 1500 PSIG
Unit shall be capable of drying helium at 1250 PSIG to dew point of 0°F. Regeneration shall be automatically controlled.

Regeneration Heater

Type: Electric resistance on helium piping
Function: To heat dryer regeneration helium (40 SCFM) from 60°F to 600°F
Duty: 17,000 BTU/HR

Section 9 - Bearing Water Module

This module is 10 feet wide by 13 feet long by 25 feet high, and contains piping, valves, instrumentation and the following major equipment:

Bearing Water Pumps

Type: Multistage centrifugal, electrical motor driven, vertical
Number required: 3 operating, 1 spare
Capacity: 500 GPM each
Total head: 375 PSI each
Discharge pressure: 2500 PSIG
Motor HP: 200 each
Material: Carbon steel

Bearing Water Filters

Type: Flanged, cleanable, element, sintered metal
Number required: 2
Flow: 500 GPM each

Design pressure: 2500 PSIG
Design temperature: 200°F
Particle retention: 20 μ nominal
Maximum ΔP clean: 10 PSI

Bearing Water Cooler

Duty: 3×10^6 BTU/HR
Function: To cool 500 GPM of bearing water from 132°F to 120°F
Design pressure: 1500 PSIG
Design temperature: 200°F

Surge Tank

Type: Vertical cylindrical
Size: 3 feet 0 inches OD by 20 feet 0 inches long
Capacity: 1000 gal.
Design pressure: 1500 PSIG
Design temperature: 200°F

Section 10 - Shutdown Bearing Water Module

This module is 10 feet wide by 13 feet long by 25 feet high, and contains piping, valves, instrumentation, and the following major equipment:

Gas Presurizer Tanks

Number required: 9
Type: Vertical cylindrical, USS seamless pressure vessels, or equivalent
Size: 2 feet 0 inches OD by 16 feet 2 inches long
Capacity: 270 gal. each
Design pressure: 3000 PSIG
Design temperature: 200°F

Shutdown Bearing Water Accumulator Tanks

Number required: 7
Design requirements: Same as for gas pressurizer tanks

Shutdown Bearing Water Filter

Type: Flanged, cleanable element, sintered metal
Flow: 50 GPM
Design pressure: 2800 PSIG
Design temperature: 200°F
Particle retention: 20 μ nominal
Maximum ΔP clean: 10 PSI

Seal Separator Tank

Type: Vertical cylindrical
Size: 2 feet 0 inches OD by 5 feet 0 inches long
Capacity: 50 gal.
Design pressure: ATM
Design temperature: AMB

DIVISION 12 - FURNISHINGS

Section 1 - Furniture

Office furniture shall include the following items:

1 Desk - 60 x 30 inch double pedestal (metal)
1 Chair - 28 x 28 inch upholstered swivel (metal)
1 File Cabinet - 3 drawer legal vertical (metal)
1 Bookcase - 30 x 11 x 30 inch two shelf (metal)

Section 2 - Storage Shelving

Storage Room shelving shall include the following:

7 Wall Shelving Units - 42 x 18 x 99 inch heavy duty (metal)
9 Storage Bins - 24 x 24 x 75 inch heavy duty (metal)

Section 3 - Shop Equipment

Shop equipment shall include the following:

1 Metal Working Lathe
1 Milling Machine
1 Floor Drill Press
1 Cutoff Saw
1 Welder
1 Torch and Tank Set
1 Pipe Threader and Cutoff

DIVISION 13 - SPECIAL CONSTRUCTION

Section 1 - Access Flooring

Access flooring shall consist of removable 2 x 2 foot modular panels supported and positioned by stringerless pedestals, all items as manufactured by Construction Specialties Limited, or equal.

Removable floor panels shall be vinyl covered particleboard laminated to a formed metal panel. Pedestals shall be free standing adjustable metal type.

Floor loading requirements include a uniform load of 250 psf and concentrated load of 1000 lbs, with a maximum deflection of 0.085 inches.

Section 2 - Sound Attenuation Blankets

Sound attenuation blankets for installation in sound rated metal stud and gypsum board walls and suspended ceilings shall be 2 inch thick "Thermafiber" Sound Attenuation Blankets as manufactured by United States Gypsum, or equal.

Section 3 - Free Standing Metal Canopy

The free standing metal canopy shall be constructed of galvanized high-tensile steel columns and framing members with cold formed high-tensile galvanized steel structural panels having a baked enamel finish. All structural members and panels shall be designed in accordance with "Light Gauge Cold-Formed Design Manual" as published by American Iron and Steel Institute. Entire structure shall be designed to provide the required roof and/or wind load in accordance with U.B.C.

The complete free standing metal canopy shall be as manufactured by Childers Manufacturing Company, or equal.

DIVISION 14 - CONVEYING SYSTEMS

Section 1 - Hoists and Cranes

The Test Bay Area shall have a Class C, Moderate Service, medium speed, pendant operated, double bridge truck 100-ton capacity, electric overhead traveling bridge crane with a 15-ton auxiliary hoist.

The Controlled Atmosphere Assembly Room shall have a Class B Light Service, slow speed, pendant operated, single bridge truck, single hoist, 20-ton capacity electric overhead traveling bridge crane.

Overhead traveling bridge cranes shall be as manufactured by Whiting Corporation, or equal.

The Motor Controller Room shall have an overhead monorail with two 10-ton capacity low headroom, motor driven trolley, single speed electric hoists.

The Electrical Equipment Room shall have an overhead monorail with a 2-ton capacity low headroom, hand geared trolley, single speed electric hoist.

All monorail electric hoists shall be as manufactured by Shaw-Box, or equal.

Section 2 - Dolly

A railroad track mounted, specially designed 20-ton capacity dolly shall be manufactured for transporting equipment between the Test Bay Area and the Controlled Assembly Room.

Section 3 - Fork Lift

A 36 volt electric fork lift truck, with a 3000 lb. capacity and standard equipment, shall be provided (Glyster Model E30B or equal).

DIVISION 15 - MECHANICAL

Section 1 - Plumbing

This section covers all plumbing fixtures, including water closets, urinals, lavatories, service sink, drinking water coolers, floor drains, piping accessories, installation, cleaning, and testing.

Water Closets - American Standard AFWALL 2477.016 vitreous china siphon jet, elongated bowl, wall mounted. Sloan Royal No. 110 flush valve, and Moltex No. 5320.114 heavy duty solid plastic, open front.

Urinals - American Standard "Lynbrook" No. 6530.018 vitreous china, blowout. Sloan Royal, 180 HYVC P flush valve with 1-1/4 inch top spud, wall and spud flanges and vacuum breaker.

Lavatory (Men's Toilet and Mechanical Equipment Room) - American Standard "Ragalyn," 20 in. x 18 in. No. 4867.024 wall hanger, with No. 2248.219 Heritage combination valves and pop-up drain, and with "p" trap with cleanout plug.

Lavatory (Women's Toilet) - American Standard "Merrilyn," 20 in. x 18 in. No. 0140.012 countertop, with No. 2248 Heritage faucet and pop-up drain and with "p" trap with cleanout plug.

Service Sink - American Standard "Akron" 7695.018, 24 in. x 20 in. and resisting enamel wall hung service sink with rim guard, 7798.176 "p" trap standard, 8340.234 faucet with vacuum breaker, stops in shanks and bucket hook.

Water Cooler - Haines Model HWS-8 or approved equal, cooling capacity 8 gallons per hour stainless steel top with gray hammertone side panels.

The unit shall have a 1-1/4 inch "p" trap waste connection to wall, a water supply with cutoff valve and strainer, and a three-wire electric power cord with standard grounding plug. Ground wire shall be connected so that all noncurrent-carrying metal parts of the unit will be effectively grounded. All waste, water, and electrical connections shall be concealed by the cabinet.

The unit shall be provided with a regulator, adjusted to suit the water pressure available at the individual location.

Compressor motors shall be wound for 115 volt, single-phase, 60 Hertz alternating current and shall be of the capacitor type.

Electric Hot Water Heater - Water heater shall be of the electric, self-contained type. Water heater shall have a recovery rate of not less than 37 gallons per hour, based on a temperature rise of 100 degrees F, and a storage capacity of not less than 40 gallons.

The heaters shall be of the fully automatic, storage type, each unit combining a tank, heating elements, automatic controls, and electrical connections. The name of manufacturer and the model number shall be attached to the front of the heater. Heating elements shall be of the immersion type and shall be individually removable for replacement. Elements shall consist of nickel-chromium wire, centered and embedded in a magnesium oxide refractory, and sealed against moisture in a seamless copper sheath. Watt density shall not exceed 50 watts per square inch of sheath surface. Heater shall be complete with automatic temperature control to maintain a constant average water temperature of 140 degrees F, and shall be adjustable from 120 degrees F to 160 degrees F. An overtemperature protector shall automatically shut off power if desired temperature is exceeded. Heater shall be factory prewired for 208 volts, 1 phase, 60 Hertz alternating current.

Shower Assembly - American Standard "Colony" No. 1261.015, angle valves with renewable seats. Colony shower head with adjustable spray, threaded shower arm with escutcheon, union inlets for threaded 1/2-inch pipe.

Emergency Shower and Eyewash - Bradley combination drench shower (eyewash unit Model No. S1931).

Drench shower - 10 inch yellow Cycolac plastic Model S24-070.

Valve - Chrome plated brass one inch IPS stay-open ball valve operated by stainless steel pull rod with triangle handle. Pull open-push closed.

Eyewash - 10 inch diameter yellow Cycolac bowl. Chrome-plated brass yoke assembly with twin aerated eyewash heads. Chrome plated 1/2-inch IPS stay-open ball valve, hand-operated by stainless steel push flag handle. The 3 gpm flow control assures safe steady flow under varying water supply conditions.

Standard - 1-1/4-inch galvanized steel pipe with 9 inch diameter floor flange. Provisions for vertical or horizontal supply.

Eyewash - Bradley eyewash fountain/pedestal-mounted Model No. S1921.

Bowl - 10 inch diameter yellow Cycolac plastic.

Heads - Chrome plates brass yoke assembly with twin aerated eyewash heads.

Valve - Chrome plated 1/2-inch IPS stay-open ball valve manually operated by stainless steel push flag handle.

Stream control - Integral flow control assures safe steady flow under varying water supply conditions.

Supply - 1/2 IPS.

Waste - Dome type strainer and 1-1/4-inch drain fitting furnished.

Support - 1-1/4-inch galvanized steel pipe with 9 inch diameter floor flange. 1-1/4-inch waste tee.

Hose Bibbs - Zurn 1340, nickel bronze, anti-siphon wall hydrant, or approved equal. Combination hose connection and back-flow preventer shall be integral with the hydrant.

Roof Drains - Zurn 100 round Duco cast iron body with aluminum dome. Openings in each strainer shall have a combined area not less than twice the area of the drain outlet.

Floor and Equipment Drains - Zurn No. 415ZN cast iron body with nickel bronze top, Type B strainer - four inch pipe size.

Water Hammer Arrestor - Jay R. Smith Manufacturing Co. "Hydrotrol" water hammer eliminators or approved equal shall be provided at the end of all water line fixtures.

Sump Pump

Type - Vertical with cover plate

Flow G.P.M. - 40

Total Dynamic Head, Ft. - 35

Design Temperature, °F - 90

Design Specific Gravity - 1.0

Pump Efficiency - 37

Shutoff Head, Ft. - 40

Minimum Submergence, Ft. - 0.50

Brake Horsepower, HP - 2

Section 2 - Piping

The piping materials for Dowtherm G system shall be as follows:

Piping: Carbon steel, ASTM A53 GRB
1/2 in. to 1-1/2 in. XS
2 in. only, std wt.
3 in. to 10 in., ERW stl API-5L Gr. B std wt.

Fittings: 1/2 in. to 1-1/2 in. 3000 lb. SW CS ASTM A105
2 in. to 10 in. Stl buttwelding fittings
ASTM A234 gr WPB, std wt.

Flanges: 150 lb. stl RF ASTM A105
1/2 in. to 1-1/2 in. socketweld (SX bore)
2 in. to 10 in. weld neck (std wt. bore)

Gaskets: 1/2 in. to 10 in. comp. asb. JM60
150 lb., 1/8 in. thk

Bolting: 1/2 in. to 10 in. ASTM A193 gr. B7M
studs 2/2 hexnuts ASTM
A194 Gr 2H

Valves: Gate -
1/2 in. to 1-1/2 in. 800 lb. stl SW
2 in. to 10 in. 150 lb. stl RF flgd

Globe -
1/2 in. to 1-1/2 in. 800 lb. stl SW
2 in. to 4 in. 150 lb. stl RF flgd

Check -
1/2 in. - 1-1/2 in. 800 lb. stl SW, horiz lift
2 in. to 10 in. 150 lb. stl RF, swing

The piping materials for the Helium System, the Nitrogen System, interconnecting piping between bearing water module, shutdown bearing water module, helium dryer module, and the circulator and motor shall be as follows:

Piping: Seamless stainless steel ASTM A376
Grade TP304L

Fitting: 1/2 in. to 1-1/2 in. 6000 lb. SW forged SS ASTM
A403 Grade WP304L
2 in. to 6 in. forged SS buttwelding ASTM
A403 Grade WP304L Wall thickness to match pipe

Flanges: 1500 lb. forged SS RF ASTM A182
Grade F304L

Gaskets: Flexitallic gasket, Style CG, Type 304 SS

Bolting: ASTM A193 Gr B7M stud w/2 hvy hexnuts

Valves: Gate -

1/2 in. to 1-1/2 in.	ANSI 1500 lb. 304 SS SW, full port
2 in. to 3 in.	ANSI 1500 lb. 304 SS BW 160 bore
4 in. to 6 in.	ANSI 1500 lb. 304 SS BW PSB flex. G.O. Sch. 120 bore

Globe

1/2 in. to 1-1/2 in.	ANSI 1500 lb. 304 SS SW
2 in. to 3 in.	ANSI 1500 lb. 304 SS weld-end Sch 160 bore

Check

1/2 in. to 1-1/2 in.	ANSI 1500 lb. 304 SS SW
2 in.	ANSI 1500 lb. 304 SS weld-end, swing Sch 160 bore
3 in. to 6 in.	ANSI 1500 lb. 304 SS weld-end, PS cover Sch 120 bore

The piping materials for Cooling Water System shall be as follows:

Piping: Stainless stl ASTM A53 Gr B, galvanized

1/2 in. to 1-1/2 in.	XS (T & C)
2 in. only	std wt
3 in. to 10 in.	ERW stl ASTM A53 Gr. B, galvanized std. wt.

Fittings:

1/2 in. to 1-1/2 in.	300 lb. MI scrd ASTM A197, galvanized
2 in. to 10 in.	Stl butt welding ASTM A234 Gr WPB, galvanized, std wt.

Flanges: 150 lb. stl FF ASTM A105
1/2 in. to 1-1/2 in. SCRD
2 in. to 10 in. weld neck (std wt. bore)

Gaskets: Comp Asb JM60
All sizes 150 lb. 1/8 in. thk full face

Bolting: All sizes, hex head galv. machine bolts
ASTM A307 Gr. B
for 150 lb. flanges

Valves:	Gate - 1/2 in. to 1-1/2 in. 200 lb. scrd bronze 2 in. to 10 in. 125 lb. PSF 1BBT Globe 1/2 in. to 1-1/2 in. 200 lb. scrd bronze 2 in. to 4 in. 125 lb. FF 1BBT Check - 1/2 in. to 1-1/2 in. 200 lb. scrd bronze, swing 2 in. to 10 in. 125 lb. FF CI split disc.

The piping materials for the domestic hot water, and domestic cold water systems shall be as follows:

Piping:	All sizes. Type "L" hard drawn, seamless copper tube, ASTM B88. Unions at all steel tanks or piping shall be insulated to stop electrolytic currents.
Fittings: Cold Water	2 in. and smaller. 300 lb. galvanized, malleable iron, banded, screwed, ANSI - B16.3. 2-1/2 in. and larger. 125 lb. cast iron, flanges, ANSI - B16.1.
Hot Water:	3 in. and smaller. Cast bronze, solder joint, ANSI - B16.18
Flanges:	All sizes. 150 lb. forged steel, screwed, FF, ASTM A105, dimensions to ANSI B16.5.
Gaskets:	All sizes. 1/16 in. thick compressed asbestos; ANSI - B16.21, full-face with bolt holes.
Bolting:	All sizes. Carbon steel, square head machine bolts, with one semi-finished, heavy hex nut, ASTM - A307, Grade B.
Valves: Cold Water Application	2 in. and smaller. Gate - 125 lb. bronze, screwed-end, non-rising stem, solid wedge disc, Crane #438. Globe - 125 lb. bronze, screwed-end with bronze disc, Crane #1.

Check - 125 lb. bronze, screwed-end with swing type bronze disc., Crane #36.

Cock - 125 lb. iron body, screwed-end with bronze plug and waste, Crane #324.

Hot Water Application

Gate - 125 lb. bronze, solder-joint end, non-rising stem, solid wedge disc, Crane #1320.

Globe - 125 lb. bronze, solder-joint end, with composition disc, Crane #1310.

Check - 125 lb. bronze, solder-joint end with swing type bronze disc, Crane #1342.

Cock - 125 lb. bronze, screwed-end with square head, Crane #250.

Approved equal may be substituted for above valves.

Valves:

2-1/2 in. and larger. All services.

Gate - 125 lb. iron body, bronze trim, OS&Y, bolted bonnet, flanged-end, F&D, Crane #465-1/2 or approved equal.

Globe - 125 lb. iron body, bronze trim, OS&Y, bolted bonnet, flanged-end, F&D, Crane #351 or approved equal.

Check - 125 lb. iron body, bronze trim, bolted cap, swing type, flanged-end, F&D, Crane #375 or approved equal.

Hose Couplings:

All sizes. Brass, quick-connect/disconnect type, full-flow, hose coupling unit to be Snap-tite, style "B", or approved equal.

The piping materials that shall be specified for the fire water system shall be as follows:

Piping:

All sizes. Underground - centrifugally cast cast-iron pressure pipe for water service with mechanical joints. ANSI - A 21.6; ANSI - A21.8 or Federal Specification WW-P-421 mechanical joints - ANSI-A21-11.

	Aboveground - standard weight black seamless (or welded) steel pipe; Federal Specification WW-P-406, Type I, Class "A", & N.B.F.U. No. 13.
Fittings:	All sizes. Underground - 250 lb. cast iron short body, with mechanical joints. Fittings to be ANSI-A21-10. Mechanical joints to be ANSI-A21-11.
	Aboveground - 250 lb. cast iron, screwed; Federal Specification WW-P-501, Type I, Class "A", & N.B. F.U. No. 13.
	Includes specialties.
	Mechanical joints shall be used for all underground piping except for the tee fitting used for the tie-in to the existing header. This fitting shall be in conformance with AWWA-C100, Class "D", where applicable.
Flanges:	All sizes. 150 lb. forged steel, threaded, F&D, FF: ASTM -A181, Grade "I", ANSI - B16.5.
Gaskets:	All sizes. 1/16 in. thick compressed asbestos; ASA - B16.21. Ring or full-face with bolt holes as required to mate flange facing.
Bolting:	All sizes. carbon steel, square head machine bolts, with one semi-finished heavy hex nut, ASTM -A307, Grade "B".
Valves:	2-1/2 in. and larger, inside building, aboveground.
	Gate - 175 lb. iron body, bronze trim, Underwriters Pattern, OS&Y, bolted bonnet, flanged-end F&D, Crane #467, or approved equal.
	Check - 175 lb. iron body, bronze trim, Underwriters Pattern, bolted bonnet, flanged-end F&D, Crane #375 or approved equal.

The plant air piping materials shall be as follows:

Piping:	4 In. and smaller. Black seamless steel pipe; ASTM -A53, Grade "B", standard weight.

Screwed Fittings:	2 in. and smaller. 300 lb. black malleable iron, banded, ANSI - B16.19.
Welding Fittings	2-1/2 in. and larger. Standard weight seamless steel, ASTM -A234, Grade "WPB".
Flanges:	2 in. and smaller. 150 lb. forged steel, screwed, FF, ASTM -A105, Dimensions to ANSI - B16.5.
	2-1/2 in. and larger. 150 lb. forged steel, slip-on, FF, ASTM, A105, dimensions to ANSI - B16.5.
	Weld-neck flanges may be used against fittings when it is impractical to use slip-on flanges.
Gaskets:	All sizes. 1/16 in. thick compressed asbestos ANSI - B16.21, full-face with bolt holes.
Bolting:	All sizes. Carbon steel square head machine bolt, with one semi-finished heavy hex nut, ASTM -A307, Grade "B".
Valves:	2 in. and smaller
	Globe - 400 lb. bronze, screwed-end, rising stem, union bonnet with composition disc, Crane #130 or approved equal.
	Check - 400 lb. bronze, screwed-end, horizontal lift, union cap with bronze disc, Crane #72 or approved equal.
	2-1/2 in. and larger.
	Globe - 125 lb. iron body, bronze trim, OS&Y, bolted bonnet, flanged-end, F&D, Crane #351 or approved equal.
	Check - 125 lb. iron body, bronze trim, bolted cap, swing type, flanged-end, F&D, Crane #373 or approved equal.
	4 in. only.
	Globe - 400 lb. bronze, screwed-end, OS&Y bolted bonnet, Powell #1212, or approved equal.

Hose Couplings:	All sizes. Brass, quick-connect/disconnect type, full-flow coupling unit, Snap-tite style "H" or approved equal.

The piping materials for the sanitary soil, waste, and vent piping shall be as follows:

All Soil and Vent Lines 3 in. and larger to a point 5 ft.-0 in. outside the building wall shall be cast iron.

Soil Piping:	3 in. and larger. Extra heavy cast iron bell and spigot; ASA-A-0.1.
Soil Fittings:	3 in. and larger. Extra heavy cast iron bell & spigot; ASA-440.1.
Cleanouts:	3 in. and larger. Extra heavy cast iron cleanout tee with slotted flush-type closure, round access cover, and flush-head screw; for finished wall, Zurn #Z-1320, or approved equal.

All waste and vent lines 2-1/2 in. and smaller above ground shall be galvanized steel.

Piping:	2-1/2 in. and smaller. Schedule 40 galvanized welded steel pipe; ASTM-A120.
Waste Fittings:	2-1/2 in. and smaller. Black cast iron recess screwed drainage type; ASA-B16.12.
Vent Fittings:	2-1/2 in. and smaller. 150 lb. galvanized malleable iron banded screwed ASA-B16.3.

Section 3 - Heating, Ventilating and Air Conditioning

This section covers all heating and ventilating equipment, ductwork, installation, cleaning and testing.

Single-Package Cooling Units

1. For Office Area and Control Room - The unit shall be of a single-package, vertical type and shall include a self-contained, water-cooled condenser or have provisions for connection of a remote, air-cooled condenser (similar to Carrier Model 50 BA004 or equal). Total cooling capacity shall be 37,000 Btu/hr - 1,200 CFM.

The compressor shall be of the hermetic type equipped with suitable vibration isolators, crankcase heater and filter-drier and shall be located in a sound attenuating compartment located in the unit cabinet.

The evaporator shall consist of aluminum plate fins mechanically bonded to seamless copper tubes and shall be fed by a thermostatic expansion valve.

The indoor air fan shall be of the forward-curved centrifugal type, belt driven by 1/2 HP @ 858 RPM motor and shall have an adjustable motor pulley. The unit shall contain a water-cooled, tube-in-tube condenser with continuous copper tubing. Tubes shall be seamless with no interior joints. Construction shall be in accordance with ASME safety code. A refrigerant connection or field-supplied water regulating valve shall be provided.

2. For Motor Controller Room and Controlled Atmosphere Assembly Room - The units shall be single-package vertical type and shall include self-contained water-cooled condenser (similar to Carrier Model 50 BA016 or equal). total cooling capacity shall be 196,000 Btu/hr - 6,000 CFM.

The compressors shall be serviceable hermetic type equipped with suitable vibration isolators, crankcase heaters, filter-drier, suction and discharge shutoff valves, and shall be located in a sound attenuating compartment within the cabinet.

The condenser units shall be constructed in accordance with ASME safety codes. Tubes shall be seamless with no interior joints. Each unit shall contain a full operating refrigerant charge.

Evaporator air fans shall be centrifugal forward curved and belt driven by a 5 HP motor @ 960 RPM.

Evaporator coil shall be of non-ferrous construction with aluminum plate fins mechanically bonded to seamless copper tubing and shall be fed by thermostatic expansion valves.

Air Handling Units

1. Test Bay Area

   Horizontal unit, similar to Aladdin Series 6000, Type "HV," heating size 1-33L, with No. 18 flat filter box 24393 CFM @ 1 in. SP 10 HP @ 767 RPM. Fan outlet area 13.6 sq. ft.

2. Test Pit Area

Single fan horizontal unit similar to Aladdin Series 6000 Type "MV," Heating size 1-33L with No. 18 flat filter box 24393 CFM @ 1 in. SP 10 HP @ 767 RPM. Fan outlet area 13.6 sq. ft.

Power Roof Exhaust Ventilators

Power roof exhaust ventilators shall be all aluminum factory fabricated type arranged for curb mounting on the roof (similar to ExitAire Type S Size 24, 5,260 CFM @ 3/8 in. SP, Motor 1 HP and fan RPM 720).

Motor and fan suspension shall be vibration isolation type. Each unit shall be complete with shielded centrifugal fan wheel, direct drive, felt edged weighted matching back draft dampers and removable bird screen. Each unit shall be provided with a factory mounted disconnect switch located inside motor and drive cover.

Air Filters

1. Low efficiency filters shall be of the sectional, 2-inches thickness, fiberglass media throwaway type.

2. Filters rated at 30% efficiency in accordance with ASHRAE 52-68 Test Standard on atmospheric air shall be the rigid, deep pleated, disposable cotton mat media type.

3. Filters rated at 80% efficiency in accordance with ASHRAE 52-68 Test Standard on atmospheric air shall consist of a replaceable cartridge supported in a permanent retainer assembly. The cartridge filtering media shall be a reinforced mat of fine glass fibers.

Electric Unit Heater

Electric unit heater shall be of the suspended horizontal discharge type with direct-driven propeller fan (similar to ILG Model 360). The unit shall be complete, including heating element, vibration-isolated motor mounts, factory-finished casing, adjustable air deflectors, fan guards, and streamlined air-inlet rings. Heater rating 5 KW-480V, 3 phase, with wall mounted theremostat.

Electric Air Duct Heaters

Electric air duct heaters, similar to Chromalox Type D.H. Fintube Air Duct heaters, complete with overcurrent protective fuses, safety contractors and

manual reset rated at 15 amp 240 V-AL, 3 phase. Duct heaters to be 5 KW capacity.

Sheet Metal Ductwork and Accessories

1. Sheet metal ductwork shall be constructed of galvanized steel sheets. Square elbows shall be provided with double wall turning vanes. Ducts and supports shall be fabricated in conformance with SMACNA Low Velocity Duct Construction Standards.

2. Flexible Duct Connections - Where sheet metal connections are made to equipment, a noncombustible flexible connection of durolon or other approved noncombustible material approximately 6 inches in width shall be provided.

3. Diffusers, Registers, Grilles

   Diffusers, registers, and grilles shall be factory-fabricated steel or aluminum and shall distribute the quantity of air specified evenly over space intended without causing noticeable drafts over 50 fpm in occupied zone. The inlets and outlets shall be sound rated and certified in accordance with Equipment Test Code Standard 1062R2.

   Fresh air intake louvers for the single-package cooling units shall be fixed bladed extruded aluminum sound attenuating acoustical type as manufactured by Construction Specialties, Inc., or equal. Finish shall be baked enamel to match the metal insulated siding panels.

Equipment Installation

All floor-mounted equipment shall be set on not less than 4-inch raised concrete pads. Air handling units shall be mounted on spring isolators. Return and exhaust air fan will be suspended from combination spring and double deflection rubber isolators.

Section 4 - Fire Protection

This section covers the fire sprinkler system, Halon 1301 system, fire hose cabinet, portable hand extinguishers, installation, cleaning, and testing.

1. Halon 1301 System

   The system is designed to provide a specific volume concentration of extinguishing agent with discharge time not to exceed 10 seconds. The system shall be capable of meeting the performance parameters in the National Fire Protection Association Standard 12A.

Hazard Title	Total Flood Volume	Method of Application	Design Concentration	Pounds of Halon
Motor Controller Module	4626.2 cu ft	Total Flooding	5%	95.3
Pony Motor Controller	231.7 cu ft	Total Flooding	5%	4.7

The extinguishing system for the control room shall include the following components:

Agent Storage Container shall be a spherical refillable container constructed of high strength alloy steel. It shall include: burst disc type valve assembly, safety plug mounting bracket, a 0.600 psig pressure gauge and a lifting ring. The container shall contain 150 pounds of HALON 1301.

Two Discharge Nozzles shall be used to distribute the agent in the protected volume. Nozzles shall be chrome plated brass.

The Initiator shall be an electro-explosive device which operates the burst disc type valve.

Mounting bracket shall be designed for installation on a well or other rigid vertical surface and serve as the support for the spherical agent storage container.

Two Dual Chamber Ionization detectors

Manual Pull Station

Electrical Control Panel
The unit is capable of providing supervision of the following functions:

Input Power
Manual Pull Station
Initiator
Alarm Bell
Time Delay
Trouble and Alarm Silence Switch

Alarm bell and red rotating beacon.

The extinguishing system for the main motor controller module and the pony motor controller shall include the following components:

Agent Storage Cylinder - Steel cylinders to be manufactured to the requirements of Department of Transport Spec. 48A, for compressed gas, and have internal neck threads for cylinder valve connection. The following cylinders are required:

For the Main Motor Controller Module 2-5 lb, 2-10 lb, 1-20 lb and 2-25 lb each filled with Halon 130L and super pressurized with dry nitrogen to a

pressure of 360 psig (± 5%) at 70°F.

For the Pony Motor Controller, the cylinder shall contain 5 lbs of halon 1301 and super pressurized with dry nitrogen to a pressure of 360 psig (± 5%) at 70°F.

Flexible Connector - 8-1/2 in. by 12 in. lg flexible connections, connectors to be stainless steel wire braid cover and a teflon liner, each end with 1/2 in. NPT male threads.

Solenoid Release - 8- 2 way normally closed explosion proof valves with the following characteristics:

24 VDC
Orifice 5/6 in. dia.

Maximum operating pressure: 630 psig
Power consumption: 10 watts
Solenoid: Continuous duty
Material: Stainless steel body, neoprene plunger insert

Pressure Switch - 8 required, NEMA 1 enclosure switch rating 30 amp @ 250 VAC

Manual Releases - 8- Pilot operated discharge heads with handwheels.

2. Fire Sprinkler System

The system will include all piping, sprinklers, controls and alarms in accordance with NFPA 13 - ordinary hazard occupancies. A 4 in. shutoff valve and a sprinkler alarm check valve shall be provided in the sprinkler main. A 2-1/2 in. fire department siamese connection shall be provided.

Sprinkler heads shall be pendant type, fusible link set at 212°F.

Fire hose cabinet shall contain a brass angle hose valve, 75 feet of hose, and a 1-1/2 inch hose nozzle.

A shutoff valve and a check valve shall be provided on the fire hose main.

A branch line tester shall be provided to permit testing and flushing of lines without shutdown of system or loss of fire protection capability.

3. Valves

Gate, globe, check, double check, and OS&Y gate valves (all sizes) as indicated in drawing shall be UL or FM listed and approved type.

Underground Piping

Elbows, tees, reducing tees, wyes, couplings, increasers, crosses, transitions and end caps shall be of the same type and class of material as the piping, or of material having equal or superior physical and chemical properties.

Water pipe shall be steel pipe and conform to AWWA C200, and NFPA 13 & 24.

Aboveground piping shall be in accordance with NFPA 13.

Portable Fire Extinguisher

Portable fire extinguisher shall be in accordance with NFPA 10.

DIVISION 16 - ELECTRICAL

Section 1 - 138 KV Incoming Disconnect Switch

The incoming 138 kV disconnecting switch shall be a 3 pole, outdoor, manually group operated, pedestal mounted, vertical break type. It will be used as an isolating switch for the main incoming 138 kV oil circuit breaker and will be furnished in accordance with the latest NEMA, IEEE, and ASA requirements for outdoor group operated disconnect switches. The disconnect switch shall have:

1. A continuous current rating of 1200 amps.
2. A momentary current rating of 61 kA.
3. A basic impulse level of 650 kV.
4. A positive closed position lock.
5. A 3 pole manual group operated grounding switch.
6. A temperature rise of not more than 30°C, over a 40°C ambient.
7. Interlocked group operating mechanism for the disconnecting and grounding switches.
8. 138 kV station post type supporting insulators, each with a 5 inch bolt circle.
9. Phase spacing of 8 feet.
10. Cable connectors for 300 MCM bare ACSR conductor.

The grounding switch shall have:

1. A continuous current rating of 600 amps.

2. Cable connectors for a 250 MCM bare stranded copper ground cable.

Installation shall be in accordance with Drawing EE-02.

Section 2 - Outdoor, Station Type, 120 KV Lightning Arresters

The outdoor, station type, pedestal mounted 120 kV lightning arresters shall be designed, manufactured and tested in accordance with the latest applicable ANSI, IEEE and NEMA Standards for outdoor station type lightning arresters.

Each outdoor station type lightning arrester shall be rated as follows:

Nominal Circuit Voltage	138 kV RMS
Arrester Voltage Rating	120 kV
Max. ANSI Front of Wave Sparkover	338 kV Crest
Max. 1.2 x 50 Microsecond Sparkover	282 kV Crest
Max. Switching Surge Protective Characteristic	272 kV Crest
Min. 60 Hz Sparkover	168 kV RMS
Max. Discharge Voltage with 1.5 kA Impulse Current of 8 x 20 Microseconds	226 kV Crest

Each arrester will be pedestal mounted, will be furnished with a connector for 300 MCM ACSR, bare stranded conductor and will also be furnished with a ground connector sized for a 250 MCM bare stranded copper conductor.

Section 3 - 138 KV Outdoor, Transmission Oil Power Circuit Breaker

The 138 kV outdoor oil power circuit breaker shall be designed, tested and manufactured in accordance with applicable ANSI and NEMA standards, and with ANSI Standards C37.06 and C37.6. It shall be a 3 pole, 3 tank, floor mounted, electrically operated, stored energy type, 1600 ampere, transmission oil power circuit breaker; to be furnished with the following:

1. A welded structural steel base with the complete breaker, all three tanks, mounted thereon.

2. A complete operating mechanism control for all three phases with a common weatherproof mechanism housing including:

   Pneumatic closing mechanism, or Purchaser's approved equal, operating from a 125 volt D.C. power source.

   Shunt trip coil operating from a 125 volt D.C. power source.

   Complete control circuit for the pneumatic closing mechanism, or Purchaser's approved equal, including any pumps, air compresors,

governor, alarm switches, etc., all of which shall operate from a 125 volt D.C. power source.

The required auxiliary switches - Short circuiting terminal blocks for the breaker's current transformers - space heater, with the required thermostat - an operation counter - required control relays - required two-pole fused knife switches, for the incoming 125 volt D.C. power and others as required by the operating mechanism's power requirements - maintenance closing device.

3. Six 138 kV condenser type bushings, two per tank, with connectors arranged to receive 300 MCM ACSR bare stranded conductor.

4. Nine 1600/5 ampere multi-ratio bushing type current transformers, with relaying accuracy and with their secondaries furnished wired to the shorting terminal blocks in the breaker's operating mechanism's housing.

5. Six interrupters - Two per phase.

6. Mechanical "open" and "close" position indicator.

7. Drain valve each tank.

8. Oil level sight gauge each tank.

The 138 kV outdoor oil power circuit breaker shall be rated and shall meet the following requirements:

1. Maximum rated voltage 145 kV.

2. Rated continuous current - 1600 amperes.

		145 kV	138 kV
3.	Rated short circuit Interrupting current RMS - symmetrical	40 kA	36 kA
4.	Short circuit MVA rating	10,000 MVA	8,590 MVA
5.	Closing & latching amperes:	64 kA	58 kA
6.	3 second ampere rating	40 kA	36 kA

7. Interrupting Time - 3 cycles

8. Impulse withstand - 650 kV

This 138 kV oil power circuit breaker will be remotely controlled from the main control room, where the breaker status position will be continuously indicated.

The power circuit breaker will be installed on a concrete foundation in the Sorrento Valley, California.

The power circuit breaker shall be furnished with all surfaces finished as follows:

1. All surfaces first grit blasted to white metal.

2. Apply a rust inhibiting primer coat to all cleaned surfaces.

3. Apply two coats of top coating to all surfaces, using a coating material which will give long outdoor service in varying climatic exposures and still maintain an attractive appearance.

Section 4 - Outdoor, Oil Immersed, 138/24/4.16 KV 3 Phase Power Transformer

The 138/24/4.16 kV outdoor, 3 phase power transformer shall be designed, manufactured and tested in accordance with the latest applicable ANSI and NEMA standards. It shall be an outdoor, oil immersed, 3 phase, 3 winding, 60 Hz, 138/24/4.16 kV power transformer rated as follows:

1. H - Winding - 138 kV - Delta Connected - 24/32 MVA OA/FA

2. X - Winding - 24 kV - Delta Connected - 18/24 MVA OA/FA

3. Y - Winding - 4.16 kV - Wye Connected - 6/7.5 MVA OA/FA

4. The rating of each winding based on a 55°/65°C temperature rise.

5. Basic impulse level - 650 kV

6. Approx. impedances - Z_{xh} = 7.5%; Z_{xy} = 5%; Z_{yh} = 13.8% - all on a 24 MVA "OA" base.

It shall be furnished with or have the following features:

1. Painted steel, all welded transformer tank, welded to a welded structural steel base, formed using structural steel I beams.

2. Three 138 kV, condenser type, outdoor, cover bushings; each with connectors to receive a 300 MCM, ACSR bare stranded conductor.

3. Three 24 kV condenser type outdoor cover bushings; each arranged for connection to 1/4 inch by 4 inch copper bus bar.

4. Each 24 kV bushing will be furnished with 3- 1000/5 ampere multi-ratio bushing type current transformers (total of nine).

5. The 138 kV transformer windings shall be furnished with a shielded disk winding construction (Faraday Shield).

6. Three 5 kV bushings to be furnished housed in an air-insulated, steel terminal chamber, arranged for two six inch incoming steel conduits, each with 3-1/C - 750 MCM 5 kV power cables, entering the bottom side of the terminal chamber, which is to be sized so that the 6-1/C 750 MCM, shielded 5 kV power cables can be terminated and connected to the 5 kV bushings, 2-1/C - 750 MCM cable per phase.

7. The required removable type cooling units; each with 240 volt A.C. single phase motor driven cooling fan. Shutoff valves will also be furnished.

8. The required fan motor control equipment will be furnished to completely control the cooling fans by the transformer's winding temperature.

9. Four 2-1/2% voltage taps in the transformer's 138 kV winding with a manually, externally operated, de-energized tap changer.

10. Mechanical relief device, arranged to relieve abnormally high internal pressure and mounted in the cover of the transformer.

11. A 5 kV neutral bushing for the wye connected 4.16 kV windings neutral connection. The bushing to be mounted in the transformer's cover.

12. The transformer is also to be furnished with the following instruments, gauges and relays:

    a. Sudden pressure relay with alarm and tripping contacts.

    b. Magnetic liquid level gauge with alarm contacts.

    c. Dial type thermometer with red peak temperature pointer and alarm contacts to measure the temperature of top liquid.

13. Complete oil preservation system with all required valves, pressure and vacuum gauges.

14. Transformer tank grounding pads - one back and one on the front side of the transformer tank.

15. Provisions for jacking.

16. Lifting lugs and eyes.

17. Instruction nameplate, stainless steel; mounted on transformer tank.

This transformer will be installed outdoors, on a concrete foundation.

The transformer tank shall be furnished with all surfaces finished as follows:

1. All surfaces first grit blasted to white metal.

2. Apply a rust inhibiting primer coat to all cleaned surfaces.

3. Apply two coats of top coating to all surfaces, using a coating material which will give long outdoor service in varying climatic exposures and still maintain an attractive appearance.

Section 5 - 138 KV Disconnecting Switch for 138 KV Bus Potential Transformers

The 138 kV disconnecting switch for the 138 kV bus potential transformers shall be a 3 pole, outdoor, manually group operated, pedestal mounted, vertical break type. It will be used to disconnect and to isolate the three bus potential transformers, as shown by Drawings Nos. EE-01 and EE-02. It will be furnished in accordance with the latest NEMA, IEEE and ASA requirements for outdoor group operated disconnect switches. The disconnect switch shall have:

1. A continuous current rating - 600 amperes

2. A momentary current rating - 40 kA

3. A basic impulse level - 650 kV

4. A positive closed position lock

5. 138 kV station post type supporting insulators, each with 5 inch bolt circle.

6. Group operating mechanism, manually operated.

7. A supporting base, formed from galvanized steel.

8. A temperature rise of not more than 30°C over a 40°C ambient.

The 138 kV potential transformer disconnecting switch will be installed and connected, using a 300 MCM bare ACSR conductor, in accordance with Drawing No. EE-02. It will be furnished with the required cable connector for the above conductor.

Section 6 - 138 KV Outdoor, Base Mounted Potential Transformers

The 138 kV outdoor, oil filled, potential transformers shall be designed, manufactured and tested in accordance with the applicable ANSI and NEMA standards for ANSI metering accuracy class, 60 Hz, potential transformers. They shall be rated and shall meet the following requirements:

1. Accuracy - ANSI 0.3 class accuracy at standard burdens - W, X, M, Y, Z, ZZ

2. Rating

   Operating voltage from 138 kV line to neutral - 80 kV.

   Voltage ratio - 80/0.12 kV - 3- Potential transformers to be connected in wye to a 138 kV wye connected power system.

   Secondary voltage 120 volts - Wye.

   Overvoltage withstand 173% of normal for one minute operation under emergency conditions as required by ANSI Standard C57.13.

3. Temperature Rise - 55°C at 30°C ambient.

4. Basic impulse level 650 kV.

5. No. of potential transformers required - three (3)

6. General Requirements -

   Each potential transformer to be oil filled, outdoor type, base mounted, self-supporting and to be furnished with a primary cable connection for 300 MCM ACSR, bare, stranded conductor and with a secondary terminating box, arranged for a 1-1/2 inch conduit entrance.

The oil filled potential transformers will be installed outdoors on a steel pedestal and will be used in the metering of a 138 kV feeder circuit.

Section 7 - 138 KV, Outdoor Base Mounted Current Transformers

The 138 kV, outdoor, oil filled current transformers shall be designed, manufactured and tested in accordance with applicable ANSI and NEMA standards for ANSI metering accuracy class, 60 Hz current transformers. They shall be rated and shall meet the following requirements:

1. Accuracy - ANSI Metering Accuracy Class (60 Hertz)

   0.3 class for B-0.1, B-0.2, B-0.3, B-1.0 & B-2.0 burden.

2. Rating

   Operating voltage 138 kV 60 Hz

   Primary ampere rating 160 amperes

   Secondary ampere rating 5 amperes

   Rating factor 1.5

3. Thermal Rating

   65 times normal for one second.

   29 times normal for five seconds.

4. Mechanical Rating - (RMS Symmetrical)

   85 times normal

5. Temperature rise: 55°C at 30°C ambient

6. Basic impulse level: 650 kV

7. Number of current transformers required: Three (3)

8. General Requirements:

   Each current transformer to be oil filled, outdoor type, base mounted, self supporting and to be furnished with primary cable connector for 300 MCM ACSR, bare, stranded conductor and a secondary terminating box, arranged for 1-1/2 inch conduit entrance.

The 138 kV oil filled current transformers will be installed outdoors on a steel pedestal and will be used in the metering of a 138 kV feeder circuit.

Section 8 - Outdoor Metering Equipment

The outdoor metering equipment shall be furnished, mounted and wired to outgoing terminal blocks, on a steel instrument panel; housed in an outdoor, weatherproof steel cabinet, with a gasketed hinged door.

The metering equipment shall consist of the following:

1. One three phase watt hour meter arranged for semi flush mounting on the above steel instrument panel, to measure the watt hours of a 138 kV, three phase feeder line and operating with the following instrument transformers.

   3 - 160/5 ampere, outdoor 138 kV pedestal mounted current transformers connected in wye.

   3 - 80 kV/120 volt outdoor, pedestal mounted potential transformers connected in wye in the 138 kV three phase feeder line.

   The watt hour meter shall also be furnished a three-wire contact device to operate with the following A.C. strip-chart demand meter.

2. One A.C. recording, contact operated, strip-chart demand meter to totalize the impulses received from the above watt hour meter's 3 wire contact device for a coincident KW demand. This device to be furnished with a case suitable for semi flush mounting on the above steel instrument panel.

3. A panel mounted current and potential test block; consisting of three current elements and four potential elements; each back connected and mounted on the above instrument panel.

4. The required pressure type terminal blocks.

All the instrument and devices, as listed above shall be mounted on the instrument panel and completely wired to the outgoing terminal blocks.

The surfaces of the instrument panel and of the outdoor weatherproof housing cabinet shall be finished with a rust inhibiting primer coat and two coats of top coating, using a coating material which will give a long outdoor service in varying climatic exposures and still maintain an attractive appearance.

Section 9 - 24 KV, Outdoor, Base Mounted, Potential Transformers

The 24 kV, outdoor, PTOM type, base mounted potential transformers shall be designed, manufactured and tested in accordance with ANSI standard requirements for instrument transformers no. C57.13 and applicable IEEE and NEMA standards.

Each 24 kV potential transformer shall meet the following requirements:

1. Accuracy - ANSI metering accuracy class: 0.3 for W, X, Y burdens.

2. Thermal Rating - 1500 VA at 30°C ambient

3. Operating Voltage; 24 kV line to line, 60 Hz

4. Voltage Ratio; 200/1, 2- potential transformers to be connected in open delta to a 24 kV delta connected power system.

5. Secondary Voltage; 120 volts, open delta

6. Number of primary Bushings - 2

7. Basic Impulse Level - 150 kV

8. Ratio - 200/1

9. Number of Potential Transformers Required - 2

10. General Requirements:

    Each potential transformer to be an outdoor type, base mounted, self-supporting, PTOM-IEO type, and to be furnished with a primary cable connection for 300 MCM ACSR, bare stranded conductor and with a secondary terminating box, arranged for 1-1/2 inch conduit entrance.

The 24 kV potential transformers will be installed outdoors, on a steel structure and will be used for metering and relaying of a 24 kV 3 phase, 3 wire feeder circuit.

Section 10 - 24 KV Disconnecting Switch for 24 KV Bus Potential Transformers

The 24 kV disconnecting switch for the 24 kV bus potential transformers shall be a 3 pole, outdoor, manually group operated, vertical mounted, side break type. It will be used to disconnect and to isolate the 24 kV bus potential transformers, as shown by Drawings Nos. EE-01 and EE-02. It will be furnished in accordance with the latest NEMA, IEEE and ASA requirements for outdoor group operated disconnect switches.

The disconnect switch shall be furnished with:

1. A positive closed position lock.

2. 24 kV station post type supporting insulators, each with 3 inch bolt circle.

3. Group operating mechanism, manually operated.

4. A supporting base, formed from galvanized steel.

5. A temperature rise of not more than 30°C over a 40°C ambient.

The disconnect switch shall be rated as follows:

1. Nominal voltage rating - 24,000 amperes.

2. Continuous current rating - 600 amperes

3. Momentary current rating - 40 KA

4. Basic impulse level - 150 kV

The 24 kV potential transformer disconnecting switch will be installed and connected, using a no.4/0 stranded copper conductor, in accordance with Drawing No. EE-02. It will be furnished with the required cable connector for the above conductor.

Section 11 - 15 KV Indoor Metal Enclosed Bus

The 15 kV indoor totally metal enclosed, 3 phase, 3 wire, non-segregated self-cooled bus shall be designed, manufactured and tested in accordance with the applicable ANSI standard for switch-gear assemblies, including metal enclosed bus C37.23. It shall be used as follows:

1. The Indoor Metal Enclosed Bus:

   To connect the main motor controller to the main motor. See Drawings Nos. EE-01 and EE-02.

Description of Non-Segrated Bus

1. Conductors

   High conductivity aluminum, 6101.T64 extruded in square tube or channel.

2. Enclosure

   A totally enclosed, self supporting enclosure for an indoor location in accordance with Drawing No. EE-02.

3. Insulators

   Porcelain insulators, rated 15 kV and bolted to the support members of the enclosure.

4. Silver Plating

   The conductor surfaces shall be silvered for bolted connections.

5. Grounding

   The bus enclosure shall be furnished with copper grounding connection pads at each end of the bus and all gasketed connections shall be shunted by a copper conductor.

6. Conductor Insulation

   A heat shrinkable tube, ANSI class 130 shall be used to insulate all straight sections of bus; insulating tape will be used at corners, tees, and terminations.

7. Finish

   All enclosing surfaces shall be shot blasted to assure a uniform, clean painting surface; followed by a zinc chromate primer and then two coats of an air dry lacquer.

The bus shall be rated as follows:

Item	Value
Design Voltage Rating	15,000 Volts
Nominal Voltage Rating	13,800 Volts
Nominal Current Rating	1,200 Ampere
Number of Conductors	3
Number of Phases	3
Basic Impulse Lever	95 kV
Momentary Short Circuit Withstand	80 kA
Temperature Rise	65°C above 40°C Ambient

The number of elbows, terminating boxes and length of the indoor bus sections shall be in accordance with Drawing No. EE-02.

Section 12 - Outdoor, Pedestal Mounted 5 KV Transformer Neutral Grounding Reactor

The outdoor, pedestal mounted 5 kV transformer neutral grounding reactor shall be designed, manufactured and tested in accordance with the latest applicable ANSI and NEMA standards.

The reactor shall be rated as follows:

1.	Insulation Class	5 kV
2.	Number of Phases	1
3.	Terminals	Silver Plated
4.	Continuous Ampere Rating	90° Apart
5.	Short Time Ampere Rating	4.0 kA for 4.0 Seconds
6.	Momentary Withstand Rating	10 kA
7.	Basic Impulse Level	60 kV
8.	Reactance - OHMS	0.3 OHMS
9.	Supporting Insulator - Post Type	7.5 kV
10.	Type of Mounting	Pedestal

11.	Type of Construction	Outdoor
12.	Number Reactors Required	1

The above reactor will be used for grounding the neutral of a 4.16 kV 3 phase wye connected transformer. It will be installed outdoors mounted on a pedestal.

Section 13 - 5 KV Outdoor, Metal Enclosed Switchgear Assembly

The 5 kV outdoor, metal enclosed, weather proof draw-out type, switchgear assembly shall be designed, manufactured and tested in accordance with applicable ANSI and NEMA standards and with the American National Standard Test Procedure for AC High-Voltage Circuit Breakers, C37.09 and C37.09a. The switchgear assembly shall be furnished with the following:

1. An outdoor, welded, base mounted, self-supporting, weather-proof steel enclosure; arranged to be installed outdoors on a flat concrete pad and to house five (5) 1200 ampere air circuit breaker units with a common 5000 volt bus and associated equipment as follows:

2. A 5 kV, 3 phase, 3 conductor, 1200 ampere insulated bus, braced for the short circuit currents as outlined in paragraph no. 2 of this specification and arranged to be connected to the following:

   Five (5) - 3 conductor insulated bus taps, each for a drawout type 5 kV, 1200 ampere air circuit breakers as indicated by Drawing No. EE-01.

   One (1) - 3 conductor insulated bus tap for two (2) drawout type 4.32/.12 kV potential transformers.

3. One 5 kV, drawout type 1200 ampere, electrically operated, stored energy type incoming air circuit breaker; complete with 5 kV primary bus disconnecting means: 125 volt D.C. closing, shunt tripping and controlling circuits; all of which are connected and disconnected when the breaker is inserted and withdrawn from the switchgear enclosure.

   The incoming air circuit breaker compartment shall also be furnished with a 5 kV insulated bus section arranged for connection to the breaker's disconnecting means and to the incoming 5 kV power cables, entering from the bottom side; 6 - 1200/5 ampere multi-ratio current transformers, connected as indicated on Drawing No. EE-01.

4. Three 5 kV, drawout type 1200 ampere, electrically operated, stored energy type outgoing air circuit breakers; each complete as outlined above for the incoming breaker; except each outgoing breaker's 5 kV bus section will be arranged to connect to 3 - 250 MCM 5 kV power calbes and 3 - 1200/5 ampere current transformers and one ground senor all connected as indicated on Drawing No. EE-01.

5. Each 1200 ampere drawout type, 5 kV air circuit breaker shall be rated as outlined in paragraph no. 2 of this specification. Each 5 kV breaker's drawout mechanism shall be designed so that the breaker can be put in an operating position and a test position. In each position, its operation will be as outlined in paragraph no. 3 of this specification.

6. Two drawout type, fused 4.32/.12 kV potential transformers, connected open delta and fused on the primary and secondary sides: for remotely located indicating and recording instruments and relays.

7. Space only for one future 5 kV, drawout type 1200 ampere, electrically operated, air circuit breaker compartment.

The 5 kV outdoor, metal enclosed, drawout type switchgear assembly shall be rated as follows:

1. 5 kV insulated bus, bus taps and bus sections in each compartment.

Rated Voltage	5000 Volts
Rated Continuous Current	1200 Amperes
Momentary Withstand	37,500 Amps
Insulation Lever	
Low Frequency Withstand	19 kV
Impulse Withstand	60 kV
Temperature Rise	
Joints	65°C
Insulation "Class B"	80°C
Terminals	45°C

2. Each 5 kV drawout type 1200 ampere air circuit breaker.

Rated Voltage	5000 Volts
Rated Continuous Current	1200 Amperes
Rated 3 Phase Symmetrical MVA	250 MVA
Rated Asymmetrical Rating Factor	1.2
Momentary Withstand Current	
Amperes	37,500 Amps
Duration	3 Seconds

Interrupting Rating - RMS	
Symmetrical Amperes at 4.16 kV	35,000 Amps
Close and Latch Rating	60,000 Amps
Interrupting Time	5 Seconds
Insulation Lever	
Low Frequency Withstand	19 kV
Impulse Withstand	60 kV
Temperature Rise	
Contacts and Joints	65°C
Insulation "Class B"	80°C
Terminals	45°C
Operating Mechanism	Stored Energy
Operating Mechanism Voltage	
Closing Circuit	125 Volts D.C.
Shunt Trip Circuit	125 Volts D.C.
Control Circuit	125 Volts D.C.

The 5 kV drawout type air circuit breakers will each be controlled and its status indicated as follows:

	5 kV Switchgear		Main Control Room	
4.16 kV Breakers in:	Indicating Lights	Control	Indicating Lights	Control
Operating Position	Yes	No	Yes	Yes
Test Position	Yes	Yes	No	No

Each of the 5 kV compartments of the 5 kV switchgear shall be furnished with a control panel, within the weather-proof enclosure on which shall be mounted:

1. The Incoming Breaker Compartment

   Three extremely inverse time over current protective relays, without an instantaneous trip attachment.

2. The Two Outgoing Feeder Compartments for Motor Control

   Three very inverse time over current protective relays with an instantaneous trip attachment.

   One instantaneous over current relay.

3. The Two Outgoing Feeder Compartments for the 4.16 kV Distribution Feeders

Three extremely inverse time over current protective relays, each without an instantaneous trip attachment.

One inverse time over current ground relay.

The 5 kV switchgear shall be a self-cooled unit with all openings provided with screens and air filters.

The 5 kV switchgear unit shall be furnished with all surfaces finished as follows:

1. All surfaces first grit blasted to white metal.

2. Apply a rust inhibiting primer coat to all cleaned surfaces.

3. Apply two coats of top coating to all surfaces using a coating material which will give long outdoor service in varying climatic exposures and still maintain an attractive appearance.

Section 14 - 4.16 KV Outdoor, Metal Enclosed, Fused Interrupter Switch Assemblies

4.16 kV outdoor, metal enclosed, fused interrupter switch assemblies shall be designed, manufactured and tested in accordance with the applicable ANSI and NEMA standards. Each assembly shall consist of the following:

1. An outdoor, weather-proof pad mounted, supporting enclosure with three individual compartments, each with a hinged, locked door.

2. Each individual compartment shall house the following:

One bus entrance compartment with space to terminate 3-1/c - 250 MCM 5 kV power cables entering from the bottom side; a 600 ampere 5 kV bus section, connected to a common bus through out the assembly and with a bus tap to connect to the incoming 5 kV power cables.

Two fused interrupter switch feeder compartments: each with a connection to the common 5 kV bus, a 600 ampere, 3 pole, single throw, manually group operated interrupting switch and 3 - single pole power fuses.

Each fused interrupter switch assembly shall be rated as follows:

1. Fused Interrupting Switch

Switch	
Continuous Ampere Capacity	300E Amperes
Interrupting Capacity	600 Amperes
Number of Poles	3
Operating Mechanism	Manual - Group Operated

2.	Fuse	60,000 Amperes
3.	Bus - Continuous Ampere Capacity	600 Amperes
4.	Nominal Voltage Rating	4160 Volts
5.	Maximum Design Voltage Rating	4760 Volts
6.	Basic Impulse Level	60 kV
7.	Short Circuit Rating Asymmetrical at 4.16 kV	60,000 Amperes
8.	Three Phase Symmetrical at 4.16 kV	270 MVA

The number and arrangement of fused interrupter switch assemblies shall be in accordance with Drawings Nos. EE-01 and EE-03.

Each fused interrupter switch assemblies shall be furnished with all surfaces finished as follows:

1. All surfaces first grit blasted to white metal.

2. Apply a rust inhibiting primer coat to all cleaned surfaces.

3. Apply two coats of top coating to all surfaces, using a coating material which will give long outdoor service in varying climate exposures and still maintain an attractive appearance.

Section 15 - 4.16/.48 KV Outdoor Auxiliary Transformers

The 4.16/.48 kV, outdoor, oil immersed, 3 phase auxiliary power transformers shall each be designed, manufactured and tested in accordance with the latest applicable ANSI and NEMA standards. Each auxiliary transformer shall be an outdoor, oil immersed, 3 phase, 2 winding, 60 Hz, 4.16/.48 kV power transformer rated as follows:

1. 4.16 kV delta connected winding 1000/1150 KVA "OAFA"

2. 480 volt wye connected winding 1000/1150 KVA "OAFA"

3. The rating of each winding based on a 55°/55° temperature rise.

4. Basic impulse lever 60 kV

5. Approximate impedance 5.75% on 1000 KVA base.

Each 4.16/.48 kV transformer to be furnished with the following:

1. Painted steel, all welded transformer tank, welded to a welded structural steel based, formed using structural steel I beams.

2. Three 5 kV bushings to be furnished housed in an air-insulated, steel terminal chamber, arranged for one 4 inch incoming steel conduit, with 3-1/c - 250 MCM 5 kV power cables, entering the bottom side of the terminal chamber. Each bushing rated 400 amperes.

3. The requied cooling units; each with 240 volt, A.C. single phase motor driven cooling fans.

4. The required fan motor control equipment, which will completely control the cooling fans operation by the transformer's winding temperature.

5. Three, 1500 ampere 600 volt bushings, to be furnished, housed in an air-insulated, steel terminal chamber, arranged to be connected to a 1600 ampere, 3 phase, metal enclosed bus duct. This bus duct to be installed overhead and to enter the top side of the terminal chamber.

6. Four 2-1/2% voltage taps in the transformer's 4.16 kV winding with a manually, externally operated de-energized tap changer.

7. Mechanical relief device, arranged to relieve abnormally high internal pressure and mounted in the cover of the transformer.

8. A 600 volt neutral bushing for the wye connected 0.48 kV windings neutral connection. The bushing to be mounted in the transformer's cover.

9. The transformer is also to be furnished with the following instruments, gauges and relays:

   Magnetic liquid level gauge with alarm contacts.

   Dial type thermometer with red peak temperature pointer and alarm contacts to measure the temperature of top liquid.

10. Complete oil preservation system with all required valves, pressure and vacuum gauges.

11. Transformer tank grounding pads; one back and one on the front side of the transformer tank.

12. Provisions for jacking.

13. Lifting lugs and eyes.

14. Instruction nameplate - stainless steel - mounted on transformer tank.

These transformers will be installed outdoors on a concrete foundation in the Sorrento Valley in California.

Section 16 - 600 Volt Outdoor Metal Enclosed Bus

The 600 volt outdoor, totally metal enclosed, 3 phase, 3 wire non-segregated self-cooled bus shall be designed, manufactured and tested in accordance with the applicable ANSI standard for switchgear assemblies, incluidng metal enclosed bus C37.23. It shall be used as follows:

To connect each 4.16/.48 kV auxiliary power transformer to its associated 480 volt double ended switchgear, located in the electrical equipment room: See Drawings Nos. EE-01 and EE-03.

Description of the non-segregated bus

1. Conductor

   High conductivity aluminum, 6101-T64 extruded in square tube or channel.

2. Enclosure

   Total enclosed, self-supporting, weatherproof enclosure for an outdoor location. See Drawing No. EE-03.

3. Insulators

Porcelain insulators, rates 600 volts and bolted to the support members of the enclosure.

4. Silver Plating

The conductor surfaces shall be silvered for bolted connections.

5. Grounding

The bus enclosure shall be furnished with copper grounding connection pads at each end of the bus and all gasketed connections shall be shunted by a copper conductor.

6. Conductor Insulation

The conductors will be bare aluminum.

7. Finish

All enclosing surfaces shall be shot blasted to assure an uniform, clean painting surface; followed by a zinc chromate primer and then two coats of an air dry lacquer.

The bus shall be rated as follows:

Item	Value
Nominal Voltage Rating	600 Volts
Nominal Current Rating	1600 Amperes
Number of Conductors	3
Number of Phases	3
Momentary Short Circuit Withstand	30 kA
Temperature Rise	65°C above 40°C Ambient
Number of Bus Runs	4

The number of elbows, terminating boxes and length of the bus sections shall be in accordance with Drawing No. EE-03.

The 600 volt bus will be installed outdoors.

Section 17 - 480 Volt Switchgear (Double Ended Load Centers)

The 480 volt switchgear assemblies shall be drawout circuit breaker equipment conforming to NEMA Standards SG-3 and SG-5, and ANSI C-36,.13 and C37.20.

The switchgear shall be rated 480 volts, three phase, three wire, 60 Hertz, 1600 amperes. Bussing shall be copper and shall be braced to the short circuit rating of the largest breaker. The arrangement shall be double ended as shown on Drawings Nos. EE-01 and EE-03.

Power circuit breakers shall be stored energy type, electrically operated, air circuit breakers, complete with static trip unit with long-time, short-time, instantaneous and integral ground fault protection. The 480 volt feeder breakers will be furnished without an instantaneous TMP unit. Breakers shall have the following ratings at 480 volts:

Continuous Rating - Amps	Short Circuit Rating - Amps. Sym.
800	30,000
1,600	42,000

The bus tie breakers shall have automatic throw-over control. The main and tie breakers of any one switchgear assembly shall be electrically interlocked to permit no more than two of the three breakers to be closed at one time. All controls shall be local.

The incoming section shall accommodate 1600 ampere non-segregated bus duct.

An indicating ammeter and voltmeter with associated current transformers, potential transformers and selector switches shall be provided in each incoming section.

A full length copper ground bus shall be provided.

The number and ampere rating of each incoming, outgoing and bus tie breaker for each 480 volt switchgear assembly shall be in accordance with Drawing No. EE-01.

Section 18 - 480 Volt Motor Control Centers

Motor control centers shall be NEMA Class II, Type B wiring. The enclosure shall be NEMA Type I. The rating shall be 480 volts, three phase, three wire, 60 Hertz with 600 ampere main copper bus, braced for 22,000 amperes symmetrical minimum, short circuit duty.

Vertical sections shall be free standing self-supporting, dead front, dead rear structures approximately 20 inches wide, 11 inches deep, and 90 inches high, conforming to NEMA Standard ICS-1. Each vertical section shall be complete with vertical and horizontal buses, and wiring troughs which match and line up with adjacent sections. Each section shall contain not more than six (6) size 2 starters or equivalent.

Unit compartments for motor and other feeder circuits through size 4 starters and 400 ampere circuit breakers shall be of the plug-in type readily removed from the front.

Each motor starter cubicle shall consist of a combination magnetic contactor with overloads, a molded case, magnetic trip only, circuit breaker; a 480-120 volt control power transformer; a red indicating light; and start-stop pushbuttons.

Each motor starter shall also be wired for a remotely located control section.

Each manually operated circuit breaker's short circuit rating at 480 volts shall be at least 22,000 amperes symmetrical.

The number, arrangement, ampere rating and starter size shall be in accordance with Drawings Nos. EE-01 and EE-03.

Section 19 - 600 Volt Outdoor, Base Mounted Neutral Grounding Reactors

The outdoor, base mounted, 600 volt transformer neutral grounding reactors shall each be designed, manufactured and tested in accordance with the latest applicable ANSI and NEMA standards.

Each reactor shall be rated as follows:

Insulation class	600 volts
Number of phases	1
Terminals	Silver plated
Continuous current rating	600 amperes
Short time ampere rating	2.2 kA - 5.0 seconds
Momentary withstand rating	5.5 kA
Basic impulse level	45 kV
Reactance	0.04 ohms
Supporting insulator rating	1,000 volts
Type of mounting	Steel pedestal
Type of construction	Outdoor
Number of reactors required	4

Section 20 - Dry Type Transformers

Lighting transformers shall be two winding 60 Hz, three phase, general purpose, dry type in ventilated enclosures for indoor use; with class H-80 or better insulation. Transformers shall conform to ANSI C89.1, NEMA STI-4, and UL-506, and shall be rated as shown on Drawing #EE-01.

Instrumentation transformers shall be as above except the transformers shall have an electrostatic shield between the primary and secondary winding. The transformers shall be rated 25 KVA, 480-120/240 volts, single phase, three wire, 60 Hz.

The required number of the various dry type transformers is as follows:

Type	Required Number
Lighting Transformers	4
Instrumentation Transformers	2

Section 21 - Panelboards

All panelboards shall be UL listed, dead-front copper bus type, and shall conform to Federal Specification W-P-155a, Type I, Class 1 for fusible panelboards. Circuit breakers shall be bolt-on type, 10,000 amperes interrupting rating minimum, and shall conform to Federal Specification W-C-375. Fusible switches shall be 2 pole, quick make, quick break type. Neutral buses where specified shall be insulated from the enclosure. An equipment ground bus shall be provided in all panelboards.

1. Lighting panelboards shall be combination panels with lockable door, consisting of three sections as follows:

   120/208 volt, 3 phase, 4 wire, 225 ampere bus, solid neutral with 23 single pole 15 ampere circuit breakers, 1 single pole, 50 ampere circuit breaker and one 225 ampere 3 pole main breaker.

   Lighting contactor, 60 amperes, 4 pole (2 NO and 2 NC) rated 240 VAC and 250 VDC in a separate wiring compartment with access cover. Contactor shall be automatically energized from the 120 volt ac source. Supply to the contactor shall be from the 50 ampere single pole breaker and panel neutral, and from a separate 2 wire 125 VDC source.

   125 VDC, 2 wire, 70 ampere bus with 4- two pole 15 ampere circuit breakers.

2. Instrumentation panelboards shall be 120 volt, single phase, three wire, with neutral bar. Each panelboard shall be equipped with 12-15 ampere single pole circuit breakers and one 150 ampere main breaker. Main buses shall be rated 225 amperes. The 15 ampere air circuit breakers are to have magnetic trip units only.

3. 125 volt DC Main Distributing panelboards shall be circuit breaker type with 600 ampere main buses. Main and branch circuit requirements shall be shown on Drawing #EE-01.

4. 125 volt DC distribution panelboards shall be circuit breaker type with 400 ampere mains and the following branches:

   10 - 30 A, 2P

   6 - 60A, 2P

5. The required number of the various panelboards is as follows:

Type	Required Number
Main D.C. Distr. Panelboards	2
Lighting Panelboards	4
Instrumentation Panelboards	2
D.C. Distr. Panelboards	2

Section 22 - Neutral Grounding Transformer and Resistor for the Main Drive Motor

The main drive motor shall be grounded through a transformer, connected between the motor's neutral point and the ground and loaded by a secondary resistor.

The neutral grounding transformer shall be rated as follows:

Primary voltage rating	12,000 volts
Number of phases	One
KVA rating	10 KVA for 30 minutes
Voltage ratio	50/1
Secondary voltage rating	240 - 120 volts
Type of transformer	Non-flammable - Askarel indoor
Number of primary bushings	Two
Voltage rating of primary bushings with connectors sized to receive No. 2 AWG 5 kV power cable	12,000 volts
Voltage rating of secondary bushings	600 volts
Connectors with secondary bushings, sized to receive No. 1/0-600 volt power cable	
Grounding pad for the transformer's tank	

The secondary resistor shall be rated as follows:

Voltage rating	240 volts A.C.
F.L. ampere rating	25 amperes for 30 minutes
Resistance rating	2.6 ohms
Enclosure	Indoor protective screen
Material of resistor's plates	Stainless steel
Connectors sized to receive No. 1/0 - AWG 600 volt power cable	
Grounding pad for the enclosure	

The neutral grounding transformer and the resistor will be installed indoors in the Helium Circulator's Main Test Facility's Building.

All transformer surfaces shall be cleaned, coated with a rust inhibiting primer coat to all cleaned surfaces and followed by two coats of top coating.

Section 23 - Raceway Systems and Enclosures

Conduits installed underground will be encased in concrete. Underground conduits will be transite 2-in. minimum size, except for short runs to equipment, which will be PVC Schedule 80, 1-in. minimum. At equipment terminations, Schedule 80 PVC or rigid-steel conduits will be used. For all underground conduit runs, elbows shall be transite on Schedule 40 PVC.

Cable in the test facility building for control and instrumentation will be run in cable trays with connections from the tray to equipment and devices made with exposed or concealed rigid-steel conduits or if underground, in Schedule 80 PVC conduits. Only control and instrumentation cables will be installed in cable trays.

Cable trays will be ladder-type with 9-in. rung spacing, fabricated from galvanized steel or aluminum.

All conduit runs exposed will be galvanized rigid steel, 3/4-inch minimum, except that for lighting raceways installed indoors, electrical metallic tubing will be used. All conduits embedded in structural concrete will be galvanized rigid steel, transite or Schedule 80 PVC, 1 inch minimum.

Enclosures for equipment and devices installed indoors will be NEMA 1A, gasketed. Enclosures for outdoor installations will be NEMA 3.

Section 24 - Battery Panels

The battery panels shall consist of one 2 pole non-automatic circuit breaker with separate fuse blocks mounted in a common NEMA 1 steel enclosure with hinged door. The circuit breaker shall be operable by an external

lockable handle with open and closed position identified on the door. The circuit breaker shall conform to Federal Specification W-C-375. All components shall be UL listed.

125 Volt Station Battery

1. Storage Battery

Each battery shall consist of sixty (60) cells with a nominal rating of 620 ampere-hours and a nominal output of 125 volts, mounted in a two-tier steel rack. The battery cells shall be the sealed lead-acid calcium type assembled in a heat resistant shock absorbing clear plastic container. The cell design shall provide for adequate sediment for the normal life of the cell, and electrolyte level lines shall be clearly marked on each container.

2. Intercell Connectors

Intercell connectors shall be lead-plated copper.

3. Battery Rack

Each battery charger shall be furnished with a two tier, Uniform Building Code Zone 3 type steel rack finished with two coats of epoxy base acid-resistant paint.

Battery Chargers

1. Station Battery Chargers

Each battery charger shall be of the solid state constant potential type with a regulated output voltage stability of $\pm$ 1% from zero to full nominal current rating over an input voltage variation of $\pm$ 10%. The input shall be 480 volts, 60 Hertz, 3 phase A.C. The output shall be 400 amperes, 130 volts D.C. nominal. Separate FLAT and EQUALIZE voltage adjustments shall be provided. Features shall include the following:

1 - FLOAT/EQUALIZE selector switch
1 - Output ammeter and voltmeter, 2%
1 - "AC ON" lamp
1 - AC power loss alarm relay
1 - Low DC voltage alarm relay
1 - High DC voltage alarm relay
1 - Low DC current alarm relay
1 - Ground detection switch using output voltmeter
1 - "EQUALIZE ON" lamp
Surge protection across the SCR's and diodes

All components shall be in a single floor standing heavy-gage steel cabinet with front access.

2. Lift Truck Battery Charger

The lift truck battery charger shall be a solid state mag-amp type charger with electronically programmed charge characteristics, charge termination circuit, polarity and current limit protection and overload protection. The charger shall be capable of fully recharging a 36 volt 24 cell lead acid industrial truck battery of 660 ampere hour (30.5 KWH at 6 hour rate) capacity within 8 hours. The charger shall provide a full safe charge with an input voltage of 480 volts ± 10% three phase, 60 Hertz. A D.C. ammeter and hand set timer shall be mounted in the door. The timer shall provide a daily and weekend setting. Ten feet of cable and a suitable connector shall be furnished with the charger for connection to the lift truck.

Section 25 Public Address System

Power Amplifier

Type	:	Solid State, temperature stabilized
Output	:	200 watts rms
Frequency response	:	20 to 20,000 Hz ± 1 db
Load voltage	:	25 and 70 volts
Control	:	input level control
Input power source	:	105-125 volts, 60 Hz
Auxiliary output	:	28 volts D.C. at 50 ma maximum
Mounting type	:	19-inch wide rack mounting
Enclosure	:	Ventilated wall hung
Input	:	Provide input transformer to match preamplifier

Preamplifier

Remote preamplifier, designed for outlet box mounting near microphone station, to include microphone receptacle and volume control mounted in face.

Gain	:	60 db
Input impedance	:	150/200 ohms
Load impedance	:	600 ohms
Output level	:	+8 dbm
Frequency response	:	20 to 20,000 Hz ± 2 db
Input power source	:	5 mA @ 24 VDC

Microphone

Furnish with 15' of cable and desk stand.

Type	:	Dynamic
Pattern	:	Cardiod
Frequency range	:	40 to 15,000 Hz

Output level : -55 db
Impedance : Low (150 ohms)

Speakers & Horns

1. Indoor horns shall be directional with built-in tapped, matching transformer for 70 volt line as follows:

Power rating : 30 watts full range
Frequency response : 250 - 13,000 Hz
Sound pressure level: 123 db at 4' on axis with 30 watts
Distribution : 100°
Mounting : Three-way adjustable
Transformer taps : 1.8, 3.7, 7.5, 15, 30 watts

2. Outdoor horns shall be similar to indoor horns, except they shall be weatherproof and have approximately 120° x 60° distribution.

3. Speakers for use in offices and corridor areas shall be permanent magnet type mounted in a sloped front, wall mounting, vinyl finish baffle, complete with 70 volt matching transformer. Speaker rating shall be as follows:

Power rating : 15 watts
Size and type : 8-inch PM type
Frequency response : 30-20,000 Hz
Transformer taps : 1/2, 1, 2, 4 watts

Section 26 - 15 kV, 5 KV and 600 Volt Power Cables

The 15 and 5 kV power cables shall be designed, manufactured and tested in accordance with the latest applicable IPCEA standards for "EPA" or "XLP" insulated, shielded, single or three conductor power cables, with a "PVC" or neoprene outer jacket.

The 15 and 5 kV power cables shall be rated as follows:

Conductor material	Stranded copper
Insulation material	"EPR" or "XLP"
Outer jacket material	"PVC" or Neoprene
Nominal circuit voltage	For15 kV cables: 13.8 kV - For 5 kV cables: 4.16 kV
Shielding material	Copper tap, lapped
Conductor temperature	90°C
Insulation level	100% - 15 & 5 kV grounded system 133% - 15 kV ungrounded system

The 600 volt power cables shall be designed, manufactured and tested in accordance with the latest applicable IPCEA standards for 600 volt power cables with copper conductors and "EPR" or "XLP" insulation.

The 600 volt power cables shall be rated as follows:

Conductor material	Stranded copper
Insulation material	"EPR" or "XLP"
Nominal circuit voltage	480 volts
Conductor temperature	98°C
Insulation level	100%

Each power cable circuit, including 15 kV, 5 kV and 600 volt power circuit, will be installed in its individual conduit, which shall be complete with its individual pull boxes and terminating cabinets. These cables will not be installed in any common, more than one power circuit, pull box or in any cable tray.

The above power cables will be installed underground in transite, PVC and galv. steel conduits. They will also be installed above ground, both outdoors and indoors, in exposed galv. steel conduits.

The 15 kV cables will be installed in a 13.8 kV power system with a grounded neutral and in a 13.8 kV delta connected ungrounded power system.

The 5 kV and 600 volt power cables will be installed in power systems with their neutrals grounded.

Section 27 - Control and Instrumentation Cables

The control and instrumentation cables shall be designed, manufactured and tested in accordance with the latest applicable IPECA standards for non-flammable insulated, shielded and non-shielded, single and multi-conductor control and instrumentation cables.

The control and instrumentation cables shall be rated as follows:

Control Cables - Single & Multi-Conductor

Design voltage	600 volts
Nominal circuit voltage	125 volts D.C. or 120 volts A.C.
Insulation material	Non-flammable - Tefcel or approved equal.
Conductor temperature	90°C
Conductor size minimum, except for P.T. & C.T. leads	No. 14 AWG
Conductor size, minimum for P.T. & C.T. leads	No. 10 AWG

Instrument cabling shall be classified in accordance with current capacity and isolation provided between classifications. Example: Thermocouple and resistance measurements, 4 to 20 M.A. transmitions, digital multiplexed and analog multiplexed signals.

All instrument cabling shall contain an overall shield grounded at one point.

Digital multiplexing wiring shall be a co-axial cable with an overall shield.

Analog multiplexing wiring shall be multi-conductor (10 pair) 18 ga twisted and shielded with overall grounded shield. Balance of wiring shall be of multi-conductor 18 ga overall shield and grounded.

The control and instrumentation cables shall meet the requirements for "TC," cable tray cables and shall be approved for installation in ladder type galv. steel cable trays. These cables will be installed underground in transite, "PVC" and galv. steel conduits. They will be installed above ground, both outdoors and indoors, in exposed galv. steel conduits; also indoors in galv. steel ladder type cable trays.

Section 28 - Grounding System

The grounding system shall be a ground grid, consisting of buried bare copper cable meshes and copper anode ground wells, with the anodes installed below the water table's low level. The grid shall extend throughout all areas, including the cooling water air coolers areas, the pumping station areas, the switchyard, the 4.16/.48 kV transformer station and all floors of the test facility.

The grounding system shall consist of the following:

Three ground wells, two within the switchyard and one within the 4.16/.48 kV transformer station. Each ground well will include:

A 30 foot, 3 inch copper tube anode, with four (4) 250 MCM stranded copper cables, cad welded to one end of the anode and with sufficient length to reach the surface grade after the anode has been installed in the well.

The anode will then be lowered into a well, drilled to a depth below the water table's low level. With the anode in place, the well will then be back filled, with one end of each of the four 250 MCM copper cables remaining on the surface.

The surface end of each 250 MCM copper cables will then be connected to a 1/4 in. x 4 in. copper terminating bar, installed a foot below the surface grade and protected by a concrete enclosure with a removable steel plate.

The grounding grid will then be formed by connecting all three ground wells with at least four 250 MCM buried bare copper cables and connecting these buried copper cables to each other with buried 250 MCM bare copper copper cables to form the grid. All connections will be cadwelded.

Grounding plates will be installed flush with the floor and connected to the grounding grid at the required locations throughout the facility's building.

All electrical equipment with the switchyard, transformer station and electrical equipment room shall be connected, as indicated by Drawings

Nos. EE-02 and EE-03 to this grounding grid, using copper tee bolts at the equipment, a No. 4/0 stranded bare copper cable and a cadwelded connection at the grounding grid.

All electrical motors, all steel support structures in the switchyard and transformer station area, all steel building columns, transformer neutral grounding reactors and resistors and all switchgear ground busses shall be connected to the grounding grid as outlined above.

All copper ground cables shall be insulated and installed in sealed PVC conduit, when located underground within 25 feet of any uninsulated steel (iron) tanks, vessels, piping or structural steel not encased in concrete. Any underground bonding of copper to steel must be fully insulated.

Section 29 - Protective Relays, Indicating and Recording Instruments, Indicating Lights, Control and Instrument Switches

The following protective relays, indicating and recording instruments, indicating lights, control and instrument switches shall be furnished installed on the steel relay and control panels to be installed in the main control room.

Protective Relays

The following protective relays shall be furnished with semi-flush, draw-out or flexitest cases, with C.T. shorting and P.T. opening devices, arranged for mounting on the control panels in the main control room.

3- Transformer differential relays, each with a tap plug for slope percentages of 15, 25 or 40 and a harmonic-current restraint, for main transformer's differential relaying system.

3- Inverse time overcurrent relays; to provide backup protection for the main transformer's differential relaying system.

1- Hand reset lockout auxiliary, tripping relay.

1- Inverse time overcurrent, main transformer's neutral grounding backup tripping relay.

3- Over and under voltage alarm relays, connected to 24 kV bus potential transformers.

1- Ground alarm relay to alarm a phase-to-ground condition in the circulator's main drive synchronous motor.

3- Over and under voltage alarm relays, connected to 4.16 kV bus potential transformers.

Indicating and Recording Instruments, Indicating Lights, Control and Instrument Switches

10- Switchboard type ammeters, indicating:

Each phase of the incoming 138 kV power.

Each phase of the 24 kV feeder to the circulator's main drive motor.

1 phase incoming 4.16 kV power to 4.16 kV switchgear, with an ammeter selector switch.

1 phase of the two 4.16 kV feeders to the 4.16/.48 kV transformer station, with an ammeter selector switch.

1 phase of the 4.16 kV feeder to the 4.16 kV pony motor, with an ammeter selection switch.

8- Single phase switchboard type voltmeters, indicating:

Each phase of the incoming 138 kV power.

Each phase of the 24 kV power to the circulator's main drive motor.

The secondary voltage of the neutral grounding transformer for the circulator's main drive motor, with two ranges.

The voltage of the 4.16 kV bus, supplying power to the auxiliaries, with a voltmeter switch.

1- Single phase switchboard type recording voltmeter, indicating:

One phase of the incoming 138 kV power, with a voltmeter phase selection switch.

The Following Additional Instruments for the Circulator's Main Motor

1- Three phase switchboard type watthour meter.

1- Three phase, switchboard type power factor meter.

1- Single phase, switchboard type wattmeter.

1- Single phase, switchboard type recording voltmeter, two speed.

1--Single phase, switchboard type recording ammeter, two speed.

1- Three phase, flush mounted, switchboard type voltmeter switches.

1- Two range, flush mounted, switchboard type voltmeter switch.

1- One phase, flush mounted, switchboard type ammeter switch.

Additional Switchboard Control Devices

12- Flush mounted switchboard type circuit breaker control switches; each with two switchboard type indicating lights (one green, one red). Each indicating light assembly to be furnished complete with a resistor and a lamp assembly for operation in series across a 125 volt D.C. circuit.

35- Flush mounted, switchboard type, motor starter pushbutton stations, each with two indicating lights (one green and one red); each indicating light assembly to be furnished with a resistor and a lamp assembly for operation in series across a 120 volt A.C. circuit.

Section 30 - Instrumentation and Control

All control and alarm functions shall be hard wired into terminal cabinets or signal conditioning cabinets located in the control room area.

Local control stations shall be provided in parallel with control room control stations for all digital control functions.

An analog multiplexer shall be provided for analog signals used for data acquisition, performance calculations or efficiency tests.

A digital multiplexer shall be provided for all digital signals not associated with alarm, shutdown or safety functions.

Analog controls shall be of the split-architecture type construction. Control operating panels and signal conditioning cabinets shall be separate. Cabinets shall be supplier's standard or 19 inches wide relay cabinets by 90 inches high.

Panel instruments shall be of the miniture type and in general meet the following size requirements:

Indicators:	2 x 6 inches
Recorders:	6 x 6 inches
Controllers:	2 x 6 inches

Section 31 - Indoor and Outdoor Lighting

The lighting circuits will be furnished power from the lighting transformers and the lighting panels with the 208-120 volt A.C. and 125 volt D.C.

sections as specified in the dry type transformer and the panelboards outline specifications.

The interior lighting system will provide lighting within all areas of the building and its entrances; using lighting fixtures with fluorescent, incandescent and mercury lamps where feasible, as follows:

	Illumination	Type of Fixture
Control Room	100 ft. candles	Fluorescent
Shop	100 ft. candles	Fluorescent
Office	100 ft. candles	Fluorescent
Receiving and Prep. Room	75 ft. candles	Fluorescent
Test Pit	60 ft. candles (at grade)	Mercury Vapor or Lucalox
Equipment Room	40 ft. candles	Fluorescent
Toilet	30 ft. candles	Fluorescent
Exterior Equipment Area	2-5 ft. candles	Mercury Vapor or Lucalox
Exterior over doorways		Mercury Vapor or Lucalox
High Bay Areas	60 ft. candles	Mercury Vapor or Lucalox

The emergency lighting will be incandescent so that it may be supplied by alternating current during normal operations and from direct current during emergencies.

Lighting fixture mounting height and spacing will not exceed the manufacturer's recommendations, except where physical requirements force some deviation.

The outdoor lighting system will provide lighting in the cooling water air coolers area, in the pumping stations, in the switchyard and in the 4.16/.48 kV transformer area and on all roadways. The general methods for lighting these areas will be as follows:

1. Cooling Water Air Coolers and Pumping Station

   Outdoor mercury or Lucalox floodlighting, adjustable fixtures supported by galvanized, tapered, pedestal type poles with single and double arms.

   Outdoor, incandescent, vapor-tight floodlighting fixtures supported by galvanized, tapered pedestal type poles. These fixtures to be connected to the emergency lighting circuits.

2. Switchyard and 4.16/.48 kV Transformer Area

   Outdoor, incandescent substation type luminairs, supported by galvanized, tapered pedestal type poles; with mercury type floodlighting units mounted lower on the supporting poles than the substation type luminairs. The substation luminairs are for lighting the tops of the electrical

power equipment, while the mercury flood lighting units are for general lighting requirements at the grade level. A portion of the substation luminairs will be connected to the emergency lighting circuits.

3. Roadways and Parking Areas

   Outdoor mercury vapor or Lucalox roadway lighting fixtures, controlled by photo-electric controllers and supported by galvanized, tapered steel poles with single and double arms.

The outdoor lighting fixtures mounting heights, spacings and areas covered will not exceed the manufacturer's recommendations and the light intensities will be at least equal to the minimum recommended by the Illuminating Engineering Society.

Section 32 - Main Motor

The main motor shall be designed, manufactured and tested in accordance with the latest applicable ANSI, IEEE and NEMA standards. It shall have the following characteristics:

1. Type - Motor shall be vertically mounted. It is non IEEE safety class IE; however, it must be structurally and mechanically safety related such that it is capable of being driven by a safety class IE pony motor.

2. Full Power Output - 24,000 HP (17.9 MW) at 3600 RPM.

3. Load - The load will be a helium compressor, the impeller of which will have a polar moment of inertia of 100 lb-ft-sec^2.
   The impeller weight will be 1500 lbs.

4. Speed Range - Motor shall be designed to be stable and controllable over the speed range of 10% to 100% of full power speed. All shaft critical speeds shall be at least 15% above maximum operating speed.

5. Enclosure - Motor shall be totally enclosed and designed to contain maximum momentum missiles generated by rotor burst at maximum credible speed. Enclosure shall have an external flange for mounting, which is compatible with the test vessel.

6. Cooling - Motor shall be a Totally-Enclosed, Water-Air Cooled (TEWAC) motor.

7. Operating Environment Relative to Demonstration Plant Installation

	Normal	Abnormal
Ambient Temperature, °F	100-130 (air)	1 Atm - 29 psig *
Ambient Pressure, psig	AMB (air)	100°F - 757°F **

* Pressure in the containment building can range from atmospheric to 29 psig (helium and air) during certain accident conditions.

** Temperature in the containment building is expected to be normally 100-130°F with brief transients to 757°F.

In addition, in the event of a steam line rupture, the containment relative humidity will rise to 100% with elevated temperature and pressure.

These transients are described in General Atomic's "Criteria for Environmental Qualification of NSS Equipment," Document 5040500000.

8. Seismic - The seismic design environment at the motor support location will be specified by design response spectra.

9. Service Life - Motor shall be designed for 30 years of continuous operation at full power. In addition, operation assumes 1000 starts from zero to full load over the 30-year life.

10. Bearing Design - All thrust loads shall be taken by a thrust bearing located in the circulator. Connection of the motor to the circulator shall be with a rigid shaft coupling. The motor bearing lubrication system shall be included as part of the motor package.

11. Codes and Standards - Safety-related components shall be designed, built and qualified in conformance with the latest issue of all applicable standards relating to nuclear service requirements in the United States. These standards include the following as a minimum.

IEEE Std 308 - "IEEE Standard Criteria for Class IE Electric Systems for Nuclear Power Generating Stations"

IEEE Std 323 - "General Guide for Qualifying Class I Electric Equipment for Nuclear Power Generating Stations"

IEEE Std 334 - "Trial-Use Guide for Type Tests of Continuous-Duty Class I Motors Installed Inside the Containment of Nuclear Power Generating Stations"

IEEE Std 344 - "Seismic Qualification of Class I Electric Equipment for Nuclear Power Generating Stations"

NEC - National Electric Code, ANSI C1

Section 33 - Pony Motor

The pony motor shall be designed, manufactured and tested in accordance with the latest applicable ANSI, IEEE and NEMA standards. It shall have the following characteristics:

1. Purpose - The pony motor shall provide an alternate means of driving the compressor during certain off-normal conditions.

2. Type - The pony motor shall be an IEEE Safety Class IE induction machine connected to the main shaft thorugh an overrunning clutch.

3. Power Output - The pony motor shall operate with the following characteristics for the stated off-normal condition:

Parameter	Pressurized Cooldown	(Subatmospheric) Refueling	Depressurization Accident (DBDA)
Max. speed (RPM)	360	1800	None - Assume transfer to core auxiliary cooling system in 60 sec.
Power at max. speed (HP)	100 (approx.)	300 (approx.)	

4. Speed Range - The pony motor shall be designed to be stable and controllable over the entire speed range of 0 to 1800 RPM.

5. Other provisions shall be the same as stated in Section 32 for the main motor.

Section 34 - Main Motor Controller

The main motor controller shall be designed, manufactured and tested in accordance with the latest applicable ANSI, IEEE and NEMA standards. It shall have the following characteristics:

1. Type - A solid state rectifier/converter to provide variable frequency power to the motor. It shall be Non-Safety Class.

2. Output - Controller shall be compatible with motor operating and stability requirements over the motor's speed range, as outlined in Section 32.

3. Input Power Quality - The controller receives its power from the input transformer specified in Section 36. If additional features are required to assure that the controller can maintain the output specified in paragraph 2 with the power deviations described in Section 36, then such features shall be included.

4. Operating Environment Relative to Demonstration Plant Installation - The controller will be located outside of the reactor containment where the conditions will be:

		Normal	Abnormal
Relative Humidity (%)	Max.	80	90
	Min.	20	10
Pressure (atm)		1	1+
Temperature (°F)	Max.	105	120 for 4 hours
	Min.	50	40
Radiation (mRem per hour)		less than 1	(later)

5. Fire Protection - The controller shall be equipped with a HALON 1301 fire protection system.

6. Seismic - The seismic design environment at the controller support location will be specified by design response spectra.

Section 35 - Pony Motor Controller

The pony motor controller shall be designed, manufactured and tested in accordance with the latest applicable ANSI, IEEE and NEMA standards. It shall have the following characteristics:

1. Type - A solid state rectifier/inverter to provide variable frequency power to the motor. It shall be IEEE Safety Class IE.

2. Output - Controller shall be compatible with pony motor operating and stability requirements over the pony motor's speed range as outlined in Section 33.

3. Availability - Controller shall be immediately available to control motor should the main motor trip.

4. Input Power Quality - The quality of power derived from the available power system shall be:

	Normal	Abnormal
Voltage	± 10%	-25% for 60 seconds
Frequency	± 5%	+3 Hz, -5 Hz for 5 minutes

During normal operation, the combined voltage and frequency variation shall be no greater than ± 10%, provided frequency remains within ± 5%.

If additional features are required to assure that the controller can maintain the output specified in paragraph 2 with the power deviations described, then such features shall be included.

5. Operating Environment Relative to Demonstration Plant Installation - The controller will be located outside of the reactor containment where the conditions will be:

		Normal	Abnormal
Relative Humidity (%)	Max.	80	90
	Min.	20	10
Pressure (atm)		1	1+
Temperature (°F)	Max.	105	120 for 4 hours
	Min.	50	40
Radiation (mRem per hour)		less than 1	(later)

6. Seismic - The seismic design environment at the controller support location will be specified by design response spectra.

7. Fire Protection - The controller shall be equipped with a HALON 1301 fire protection system.

8. Codes and Standards - Safety-related components shall be designed, built and qualified in conformance with the latest issue of all applicable standards relating to nuclear service requirements in the United States. These standards include the following as a minimum:

IEEE Std 308 - "IEEE Standard Criteria for Class IE Electric Systems for Nuclear Power Generating Stations"

IEEE Std 323 - "General Guide for Qualifying Class I Electric Equipment for Nuclear Power Generating Stations"

IEEE Std 344 - "Seismic Qualification of Class I Electric Equipment for Nuclear Power Generating Stations"

NEC - National Electric Code, ANSI C1

Section 36 - Main Motor Controller Input Transformer

The main motor controller input transformer shall be designed, manufactured and tested in accordance with the latest applicable ANSI, IEEE and

NEMA standards. It shall have the following characteristics:

1. Type - Transformer shall be Non-Safety Class.

2. Output - Transformer shall be compatible with the controller output requirements as specified in Section 34. Transformer shall be rated on a FOA basis.

3. Input Power Quality - The quality of power derived from the available power system will be:

	Normal	Abnormal
Voltage	± 10%	-25% for 60 seconds
Frequency	± 5%	+3 Hz, =5 Hz for 5 minutes

During normal operation, the combined voltage and frequency variation shall be no greater than ± 10%, provided frequency remains within ± 5%.

If additional features are required to assure that the transformer can maintain the output specified in paragraph 2 with the power deviations described, then such features shall be included.

4. Operating Environment Relative to Demonstration Plant Installation -

The transformer will be located outside of the reactor containment where the conditions will be:

		Normal	Abnormal
Relative Humidity (%)	Max.	80	90
	Min.	20	10
Pressure (atm)		1	1+
Temperature (°F)	Max.	105	120 for 4 hours
	Min.	50	40
Radiation (mRem per hour)		less than 1	(later)

5. Seismic - The seismic design environment at the transformer support location will be specified by design response spectra.

6. Compatibility - Transformer shall be designed, manufactured and tested together with the main motor controller specified in Section 34 in order to assure compatibility.