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**MULTIPLE POLLUTANT REMOVAL USING  
THE CONDENSING HEAT EXCHANGER**

**Final Test Plan**

**For**

**Task 2 Pilot Scale IFGT Testing**

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## 1.0 INTRODUCTION

The purpose of Task 2 (IFGT Pilot-Scale Tests at the B&W Alliance Research Center) is to evaluate the emission reduction performance of the Integrated Flue Gas Treatment (IFGT) process for coal-fired applications. The IFGT system is a two-stage condensing heat exchanger that captures multiple pollutants - while recovering waste heat. The IFGT technology offers the potential of addressing the emission of SO<sub>2</sub> and particulate from electric utilities currently regulated under the Phase I and Phase II requirements defined in Title IV, and many of the air pollutants that will soon be regulated under Title III of the Clean Air Act. The performance data will be obtained at pilot-scale conditions similar to full-scale operating systems.

All Task 2 activities will be conducted at B&W's Alliance Research Center 0.8 MW pilot-scale IFGT facility. This facility has a flue gas capacity corresponding to a 6 million Btu/hr combustor. Up to four coals will be tested in this Task. These are a high-sulfur Ohio coal, a medium-sulfur coal, a lignite coal, and the coal that is used at EPRI's Environmental Control Technology Center (ECTC). Tests using the ECTC coal will provide data that will be directly applicable to the long-term IFGT testing in Task 3, and the 5.0 MW IFGT tests in Phase II.

The Task 2 IFGT tests have been designed to investigate several aspects of IFGT process conditions at a broader range of variables than would be feasible at a larger scale facility. The data from these tests greatly expands the IFGT performance database for coals and is needed for the technology to progress from the component engineering phase to system integration and commercialization. The performance parameters that will be investigated are as follows:

- SO<sub>2</sub> removal
- Particulate removal
- Removal of mercury and other heavy metals
- NO<sub>x</sub> removal
- HF and HCl removal
- NH<sub>3</sub> removal
- Ammonia-sulfur compounds generation
- Steam injection for particle removal

For all of the pollutant removal tests, removal efficiency will be based on measurements at the inlet and outlet of the IFGT facility. Heat recovery measurements will also be made during these tests to demonstrate the heat recovery provided by the IFGT technology.

This report provides the Final Test Plan for the first coal tested in the Task 2 pilot-scale IFGT tests. It will be available to test personnel for review so that activities such as facility preparations and materials procurement can be completed in an efficient and timely manner.

This test plan includes a detailed test schedule and test matrix, which describes the number of tests, the test variables, and measurements to be made. This plan contains a summary of the measurement techniques, detailed information on the estimated uncertainty in the measurements with respect to mercury and trace elements.

## **2.0 IFGT TASK 2 TEST PROGRAM OBJECTIVES**

The goal of Task 2 is to develop pollutant removal performance data for the IFGT process that will be applicable to full-scale units. The Phase II tests at the ECTC will provide scale-up verification of the pilot-scale data. The tests conducted in this Task will investigate a broader range of variables than would be feasible at a larger scale facility. The overall objectives of these tests are to:

- Demonstrate the pollutant removal performance (SO<sub>2</sub>, particulate, and air toxics) and heat recovery of the integrated flue gas treatment (IFGT) condensing heat exchanger for a range of operating conditions and a variety of coals under controlled conditions.
- Evaluate the potential of operating an IFGT in conjunction with an SCR or SNCR to achieve higher NO<sub>x</sub> removal rates by addressing the problem of ammonia slip.

Specific test program objectives are to:

- Determine the effect of flue gas flow rate, reagent flow rate, flue gas outlet temperature and reagent pH on SO<sub>2</sub> removal.
- Determine the effect of flue gas flow rate and reagent flow rate on particulate removal efficiency as a function of particle size.
- Determine the effect of interstage steam injection on particulate removal efficiency as a function of particle size.
- Measure the effect of reagent flow and outlet flue gas temperature on mercury and heavy metals removal.
- Determine mercury speciation at both the inlet and outlet of the IFGT to quantify total, elemental, and oxidized mercury removal.
- Establish the repeatability of mercury and heavy metals removal measurements.
- Determine the fate of HCl and HF entering the IFGT system if they are present in the parent coal.

- Measure ammonia removal through the IFGT system.
- Estimate the amount of ammonia that reacts with SO<sub>3</sub> before the IFGT system.
- Evaluate the thermal performance of the IFGT in terms of the recovered energy in each cooling stage, and the flow rate of condensed water.
- Obtain waste water samples for later treatment testing.

### 3.0 FACILITY AND PROCESS DESCRIPTION

#### 3.1 INTEGRATED FLUE GAS TREATMENT SYSTEM

As shown in Figure 1, the IFGT is essentially a two-pass counter flow shell and tube heat exchanger. The hot flue gas enters at the top and flows downward through the first cooling stage, across a horizontal transition, and then upward through the second cooling stage. The first cooling stage consists of 56 rows of Teflon™ covered tubes with 6 tubes in each row. The water flow path through the tubes is counter flow to the gas path. The second cooling stage consists of 64 rows of Teflon™ covered tubes.

Each tube in the IFGT system is covered with Teflon™, which is extruded over the outside of the tube. Since Teflon™ is hydrophobic, condensation on the surface of the tube occurs in drops rather than as a film. This allows continuous exposure of most of the surface and improves heat transfer. Teflon™ is also durable and resistant to abrasion by solid particles in the gas. The inside surfaces of the heat exchanger shell are covered with Teflon™ sheets. During fabrication, the Teflon™ covered tubes are pushed through the Teflon™ tube sheet lining to form a Teflon™/Teflon™ seal, ensuring that all heat exchanger surfaces exposed to the flue gas are protected against acid corrosion. Interconnections between the heat exchanger tubes are made outside the tube sheet and are not exposed to the corrosive flue gas stream.

There are four major sections of the IFGT; the first heat exchanger stage, the interstage transition region, the second heat exchanger stage, and the mist eliminator. Most of the sensible heat is removed from the flue gas in the first heat exchanger stage of the IFGT. Condensation can occur within the first heat exchanger stage if the gas temperature at the tube surface is below the dew point. Some flue gas pollutant removal can occur within the first heat exchanger as the particulate impact the tubes and acid gas condensation occurs.

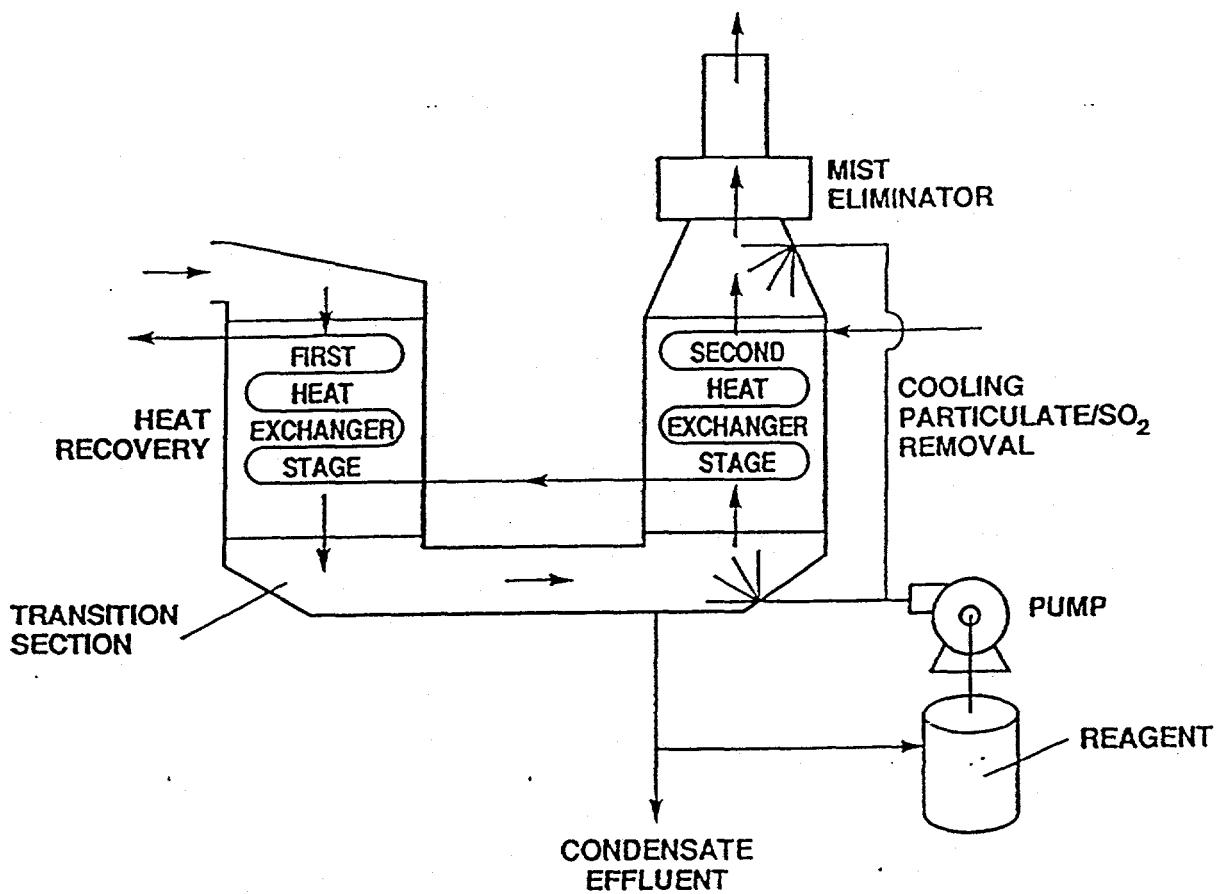


Figure 1 Process Flow Schematic Of The Pilot IFGT Condensing Heat Exchanger

The inter-stage transition provides a gas flow path between the two heat exchanger stages and also acts as a collection sump for reagent/condensate. The transition is equipped with water spray nozzles that can be used to assist in removing pollutants from the flue gas. The transition piece is made of corrosion resistant fiberglass-reinforced plastic.

The second heat exchanger stage is operated in the condensing mode, removing both latent and sensible heat from the gas along with pollutants. The flue gas in this stage is flowing upward while the liquid droplets in the gas fall downward. This provides a scrubbing mechanism that enhances particulate and pollutant capture. The dimensions and spacing of the heat exchanger tubes ensure that the larger particulate impact the wet tubes where droplet condensation is taking place. Sub-micron size particles act as condensation sites in the gas and are collected in the condensate stream. The top of the second heat exchanger stage is equipped with an alkali reagent spray system to enhance SO<sub>2</sub> removal. The condensed gases, particulate, and reacted alkali reagent are collected in the transition section. The condensate/alkali reagent solution is recirculated to the spray system to improve the efficiency of the process. The flue gas outlet of the IFGT system is equipped with a mist eliminator to reduce moisture carryover.

Three plastic sections are installed above the second heat exchanger stage. Each section is about 18 inches in height. The plastic sections contain the second-stage reagent spray nozzles and chevron style mist eliminators. They also provide a disengagement zone for liquid drops entrained in the flue gas as it exits the second heat exchanger stage.

An alkali reagent tank is used to provide the alkali spray for the SO<sub>2</sub> removal tests. Sodium carbonate is added to the water in the tank either manually or with a feeder controlled by the pH controller. A mixer stirs the solution in the tank to dissolve the sodium carbonate. The spent reagent and condensate collected at the bottom of the transition piece during operation is gravity fed to the reagent tank. The reagent tank is equipped with an overflow drain to accommodate the increase in water/reagent inventory from condensation and the addition of makeup water. Approximately 300 lb/hr of makeup water is added to the system to maintain the reagent feed liquor below 15% dissolved solids.

The reagent spray can be directed to the top of the second stage heat exchanger or to the transition section. The fiberglass transition piece located between the two heat exchanger stages is equipped with six spray nozzles. The six nozzles are aimed to direct the sprays horizontally into the transition region:

- Four spray nozzles are located on the sidewalls. One pair is located on opposite sidewalls directly under the first heat exchanger stage and the other pair is located about midway between the two heat exchanger stages.

- The other two spray nozzles are located in opposite ends of the transition piece. One nozzle is located directly under the first heat exchanger stage and directs the spray in the direction of the gas flow. The second nozzle is located directly below the second heat exchanger stage, with the spray directed against the gas flow stream.

Duct work is installed to bring the exhaust gas from the SBS to the pilot IFGT. The 12-inch insulated duct is tied into the exhaust of the SBS downstream of the baghouse and I.D. fan. The flue gas enters at the top of the first heat exchanger stage and exits out the top of the second heat exchanger stage. A 12-inch non-insulated PVC duct is installed at the exit of the pilot IFGT to an exhaust stack located outside the building.

Gas sampling lines and 4-inch ports for in-situ sampling are located at the inlet and outlet of the IFGT facility. The gas sample lines are used to continuously withdraw flue gas for the on-line gas sample analyzers. One gas sample line is located in the inlet duct just upstream of the first heat exchanger stage. The other gas sample line is located in the PVC outlet duct. Heat-traced lines are used to transport the flue gas samples from the ducts to the gas analyzers. Two four-inch ports are installed both in the inlet and in the outlet flue gas ducts for particulate sampling and other gas sampling as required by the test.

### 3.2 SMALL BOILER SIMULATOR (SBS) FURNACE

Flue gas for Task 2 will be provided by the Small Boiler Simulator (SBS) furnace. This 6 million Btu/hr combustion research facility includes fuel preparation and handling equipment, a furnace and convection pass that provide a prototypical flue gas time-temperature history, a heat exchanger, dry scrubber module and a baghouse. Figure 2 shows an isometric view of the major components of the SBS facility and how they are connected to the pilot IFGT condensing heat exchanger. The IFGT facility is located in a bypass loop downstream of the SBS induced draft fan. For IFGT testing, the dry scrubber module is not in service, and a portion of the flue gas can be bypassed around the baghouse.

The SBS baghouse typically removes 99.9+% of the particulate from the flue gas leaving the furnace. For these tests a measurable particle loading at the IFGT unit will be needed to characterize the particle removal efficiency of the condensing heat exchanger. To provide a measurable particle loading at the CHX facility, approximately 10% of the flue gas from the SBS furnace will be bypassed around the baghouse. The dry scrubber module will not be in operation, but provides the gas path from the convection pass to the baghouse. The temperature of the flue gas at the baghouse will be maintained at about 300°F, to provide the maximum temperature possible to the condensing heat exchanger, while maintaining the integrity of the bags. Heat loss and air infiltration between the baghouse and condensing heat exchanger limits the flue gas temperature to about 250°F at the inlet of the IFGT system.

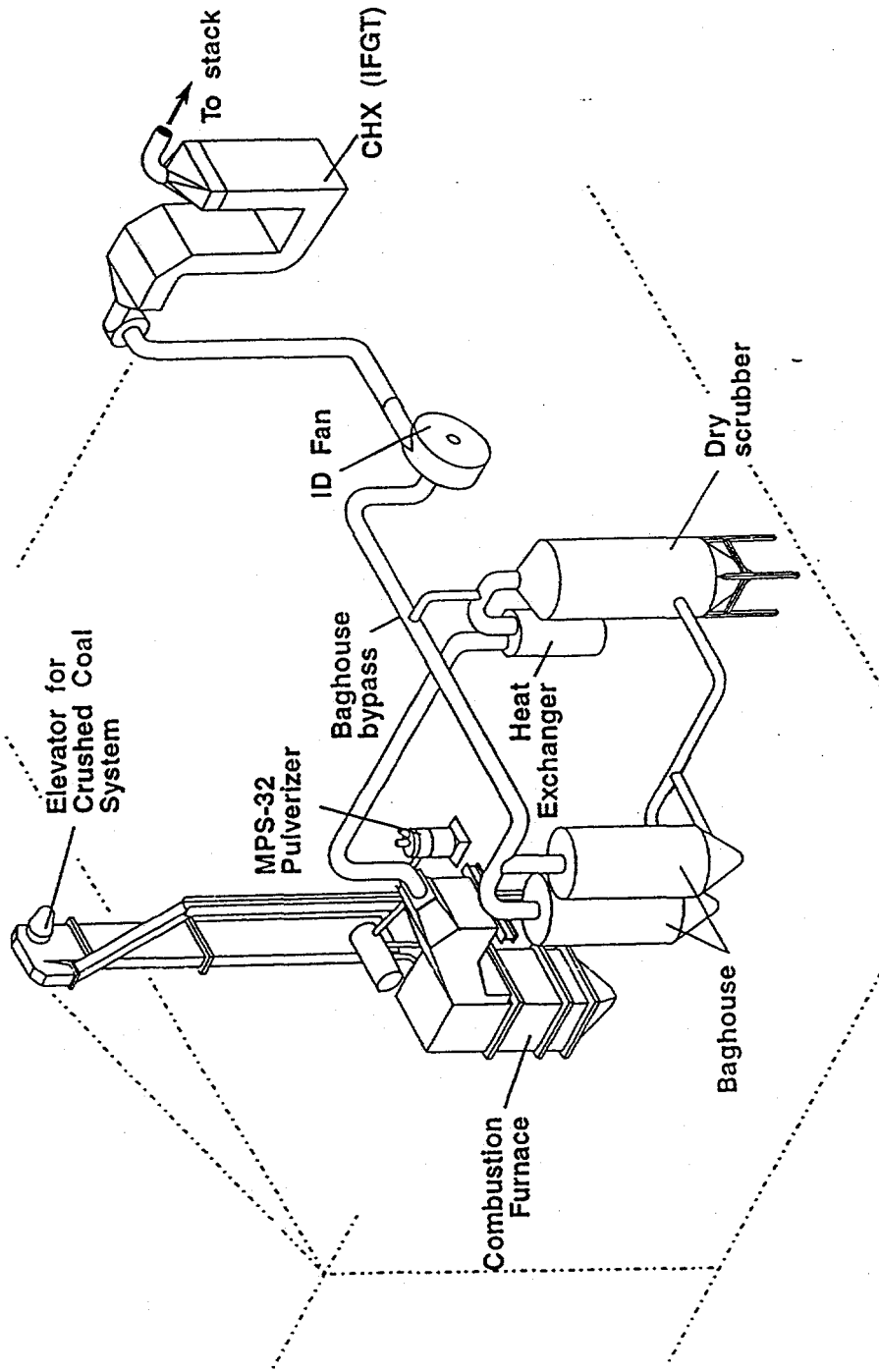


Figure 2 Small Boiler Simulator And Condensing Heat Exchanger Test Facilities

#### 4.0 GENERAL EXPERIMENTAL APPROACH

#### 4.1 FACILITIES OPERATION AND CONTROL

To complete the test program, B&W will operate the SBS/IFGT facilities for up to 10 days for each coal. B&W will provide the necessary personnel to operate the IFGT facility, conduct particulate and air toxics measurements, and collect and analyze samples. The planned schedule includes 2 weeks for testing and 4 weeks for data reduction for each coal. To gather the required information on four coals, approximately 6 months of periodic testing and data reduction will be required.

The SBS facility is operated and controlled independently from the IFGT facility. For these tests the SBS facility will be used to generate representative flue gas that will be routed to, and treated by the IFGT facility. Before testing begins, both facilities will be prepared, raw materials will be procured, and test equipment will be installed and calibrated. The raw materials include up to four different coals and the sodium carbonate (soda ash) reagent.

##### *Small Boiler Simulator Facility*

A prototypical low NO<sub>x</sub> burner will be installed in the SBS and used to combust the coals. The burner will not be specifically optimized to minimize NO<sub>x</sub>. Rather, the facility will be operated to attain good combustion with carbon burnout and CO levels typical of utility power plants. Typical combustion conditions will consist of a heat release of 5 million Btu/hr, excess oxygen at the furnace outlet of 3% and a NO<sub>x</sub> level of approximately 300 ppm. Unless specifically identified in the test matrix for a coal, the furnace operation will be maintained at a single combustion operating condition for all tests.

For these tests pollutant removal across the condensing heat exchanger will be based on inlet/outlet measurements, so that specific SBS operating conditions will not be required. However, during the course of testing a single coal, it will be desirable to maintain steady furnace operation during the test day, and to maintain repeatable conditions from day to day.

Typically, the air flow and coal-feed rate required to achieve a specific heat release and excess oxygen is calculated based on an ultimate analysis of the coal. At start-up, the air flow to the furnace is set to the desired value, and the coal-feed rate is adjusted to provide the desired excess oxygen. Minor drift in excess air is compensated with changes to coal-feed rate. Thus, load is allowed to drift slightly to maintain constant excess oxygen and, therefore, furnace combustion conditions.

For those tests in which coal fly ash is required in the flue gas stream leaving the SBS facility, a portion of the flue gas that normally passes through the SBS baghouse will be diverted

around the baghouse. The bypass flow rate (% of total) will be set based on the fly ash in the coal and the desired fly ash concentration in the flue gas entering the IFGT facility. The percentage bypass flow will be set by reducing the baghouse differential pressure a corresponding percentage. This is based on established pressure-flow relationship for a baghouse which is nearly linear over a limited range.

When operating the SBS facility using coal it is necessary to periodically soot-blow the superheater tubes in the convection pass. The soot-blowing operation provides a short term increase in the flue gas particle loading to the baghouse, and possibly to the IFGT facility. Testing at the IFGT facility will be suspended during the soot-blowing operation to prevent bias in the data due to heavy than normal particle loadings in the flue gas.

A heat exchanger located upstream of the SBS dry scrubber and baghouse is used to set the flue gas temperature. The dry scrubber will not be in service for these tests. The flue gas temperature will be automatically controlled to maintain the flue gas temperature at the baghouse below the maximum temperature of 300°F. This temperature will be maintained during the course of the testing.

The SBS facility contains a dedicated data acquisition system that provides for detailed characterization of the burner/furnace operating conditions along with manually recorded data. The data acquisition system (DAS) will be used for this test. However, only data that is needed to define the furnace/boiler operation will be reported. These parameters include:

- coal feed rate
- primary air flow rate and temperature
- secondary air flow rate and temperature
- excess oxygen concentration at the furnace outlet
- CO concentration
- furnace exit gas temperature
- flue gas temperature at the SBS baghouse
- furnace energy balance

Additionally, the burner used for the test will be documented along with the burner settings (e.g., vane angles).

Although the SBS data is monitored by the DAS continually during boiler operation, the data will be saved only periodically during a test day. The periodic data storage will be concurrent with the manual recording of data at intervals of approximately 2 hours. The data will be averaged to determine daily average conditions and test average conditions.

### *Integrated Flue Gas Treatment Facility*

The IFGT facility is located in a by-pass loop downstream of the SBS combustor (Figure 2), and can accommodate up to the full flue gas flow rate corresponding to a heat release of 5 million Btu/hr. The gas flow to the IFGT can be reduced using the IFGT by-pass, without changing the combustion conditions in the SBS combustor.

Typically, the IFGT facility is brought on-line while the SBS furnace is heating up on natural gas fuel. This provides time to set and adjust the cooling water flow rate and for the duct work and IFGT structure to come into thermal equilibrium. The cooling water inlet flow rate and temperature can be controlled independently. The cooling water source is the Alliance city water supply. The temperature of this water defines the lower limit inlet temperature available. The temperature of the inlet water can be raised by mixing in some of the heated cooling water before it is discharged to the drain. The water flow rate is measured with a Micro-Motion mass flow meter.

Reagent flow is provided by a pump connected to the reagent tank. The reagent flow rate is controlled manually with valves, and the location of the reagent spray is likewise controlled with manual valves. A dry hopper and screw feeder on top of the reagent tank provide the feed system for the dry reagent. A pH meter in the reagent supply line along with a set point controller provide a control signal that drives the screw feeder and maintains reagent pH at the set point. The reagent flow rate and specific gravity is measured with a Micro-motion mass flow meter. The specific gravity is also periodically checked with a hydrometer.

Normally, the flue gas flow rate and temperature are not controlled at the IFGT facility since these are set by the operation of the SBS. However, they are continually monitored and recorded. For partial load tests, a by-pass valve is manually adjusted to obtain the desired flow rate through the IFGT facility. The excess O<sub>2</sub> leaving the SBS combustor is nominally set to 3%. However, because of air infiltration at the dry scrubber, baghouse and induced draft fan, the excess O<sub>2</sub> at the IFGT facility is typically 1-1/2% to 2% greater.

The IFGT facility is equipped with a DAS for monitoring and recording IFGT data during a test. All instrumentation providing an electrical signal output are connected to the DAS. The data are updated at 6 to 10 second intervals and during a test the data are recorded at this interval for later data analysis. These data are averaged over the duration of the test to determine the test average conditions.

## 4.2 COAL SELECTION

The coals that have been identified for testing in this Task are a high-sulfur Ohio coal, an unspecified medium-sulfur coal, a lignite coal, and the coal that is used at the Kintigh power

station that is the site of the EPRI ECTC. With the exception of the ECTC coal, the generic descriptions of the coals allows for latitude in selecting the exact coal to be used (i.e., the mine or coal seam).

Two of the coals have been selected for testing in this Task. The high sulfur Ohio coal will consist of Ohio #5 and Ohio #6 coal with a sulfur content of approximately 4%. The coal representing the ECTC coal will be a Blacksville Pittsburgh #8. To the degree possible, the other coals that are tested in Task 2 will be selected to best meet the needs of the test program. These include the need to characterize the IFGT system using a range of coal types, and to the degree possible, the need to select coals with measurable concentrations of trace element constituents.

### 4.3 TEST CONDITIONS

The experimental test program proposed for the SBS/IFGT facilities has been designed to investigate the major system operating parameters and are discussed in the following sections. The SBS/IFGT facilities will be operated for up to 10 days on each type of coal to characterize the performance of the IFGT system. Up to four coals will be tested that include a high-sulfur Ohio coal, a medium-sulfur coal, a lignite coal, and the coal that is used at the ECTC. Tests using the ECTC coal will provide data that will be directly applicable to the 5.0 MW IFGT tests at the ECTC scheduled for Phase II.

Table 1 summarizes the planned test matrix for Task 2 testing. The matrix is grouped according to the different types of pollutant removal under study in this program. This test matrix will be used on the first coal (high sulfur Ohio coal), and will be revised, as appropriate, for subsequent coals as test results become available. The test matrix will be completed on a best effort basis, subject to funding constraints. The order of the testing will be dictated by the most efficient operation of the facility and manpower utilization, along with limitations in the amount of simultaneous sampling that can be conducted. Tests for mercury and heavy metals removal will be given the highest priority, followed by HCL and HF removal tests, ammonia removal tests, particulate removal, SO<sub>2</sub> removal and heat transfer tests. Approximately 5 replication tests for SO<sub>2</sub> removal efficiency, and thermal efficiency will be included in the test series for each coal. Replication tests are an essential element of a test program and are used to estimate the precision, or repeatability, of the data that has been obtained.

During Task 2, approximately 100 gallons of condensate waste water will be collected in drums for each coal. This condensate waste will be used to evaluate disposal methods in Phase II of the program. Additionally, smaller samples of the condensate will be collected to determine the chemistry of the waste water and to test for mercury, particulate and other heavy metals.

**Table 1 - Pollutant Removal Test Matrix**

	Flue Gas Outlet pH	Flue Gas Inlet Temperature (F)	Flue Gas Inlet Velocity (ft/s)	Stage 2 L/G (GPM/1000ACFM)	Particulate Loading (lb/MBtu)	IFGT Inlet NH3 (ppm)	Stage 2 Steam Injection (lb/hr)
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**SO2 and NOx Removal, and Heat Recovery**

8	Dewpoint	40	0.5, 1, 2, 5, 8	<0.01 to 0.3
8	Dewpoint	20	0.5, 1, 2, 5, 8	<0.01 to 0.3
8	Dewpoint - 20F	40	0.5, 1, 2, 5, 8	<0.01 to 0.3
7	Dewpoint	40	0.5, 2, 8	<0.01 to 0.3
6	Dewpoint	20	0.5, 2, 8	<0.01 to 0.3
7	Dewpoint - 20F	20	0.5, 1, 2, 5, 8	<0.01 to 0.3

**HCl and HF Removal**

8	Dewpoint	40	5	0.3
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**Hg and Heavy Metals Removal**

8	Dewpoint	40	5	0.3
8	Dewpoint	40	5	<0.01
8	Dewpoint - 20F	20	5	0.3

**Ammonia Removal**

8	Dewpoint	40	5	0.3	50
8	Dewpoint	40	5	0.3	10
8	Dewpoint - 20F	40	5	0.3	50

**Particulate Mass Removal**

8	Dewpoint	40	5	0.3	----	0
8	Dewpoint - 20F	40	5	0.3	----	0
8	Dewpoint	40	5	0.3	----	100
8	Dewpoint	40	5	<0.01	----	0

**Particulate Cascade Removal**

8	Dewpoint	40	5	0.3	----	0
8	Dewpoint - 20F	40	5	0.3	----	0
8	Dewpoint	40	5	0.3	----	100

**Fixed Operating Conditions**

Parameter	Value
Inlet O2 (% Dry)	5.0±1.0
Flue Gas Inlet Temp (F)	250±10
Reagent	Sodium Carbonate
Nozzle Type	1 HH 4.2
Nozzle Quantity	2
Cooling H2O Flow Rate	10 GPM ± 0.5

#### 4.3.1 Acid Gas Pollutant Removal

In these tests, SO<sub>2</sub> and NO<sub>x</sub> removal, and HCl and HF removal will be evaluated. A test matrix for 27 conditions is shown in Table 1. SO<sub>2</sub> and NO<sub>x</sub> removal measurements will be conducted over a wide range of operating parameters. A greater or lesser number of tests may be conducted on any given coal so that sufficient data will be collected to determine the SO<sub>2</sub> and NO<sub>x</sub> removal characteristics of the IFGT.

At high liquid pH with Na<sub>2</sub>CO<sub>3</sub> reagent, the significant resistances to absorption of SO<sub>2</sub> are those affecting mass transfer from the gas phase to the alkaline liquid surface. Above a liquid pH greater than about 7.7, the vapor pressure of SO<sub>2</sub> in the liquid is essentially zero. Under these conditions, the major factors for SO<sub>2</sub> removal performance are the amount of gas-liquid surface area in the 2nd stage of the IFGT and flue gas velocity. When the absorbing reagent liquids pH falls below about 7.7, then the liquid phase SO<sub>2</sub> vapor pressure increases which can contribute to a measurable reduction in the absorption of SO<sub>2</sub>. To investigate these effects, the test matrix includes conditions at a variety of liquid pH, flue gas inlet velocity, and liquid-to gas ratio (L/G) values.

The absorption of NO<sub>x</sub> occurs by mechanisms similar to SO<sub>2</sub>. However, approximately 95% of NO<sub>x</sub> is in the form of NO, and the solubility of NO is less by a factor of about 1300. While some NO is absorbed in the IFGT system, it is estimated that the mass transfer of NO<sub>x</sub> will be approximately 1/20th less than what is obtained for SO<sub>2</sub>. These levels of NO<sub>x</sub> absorption may be detectable, and NO<sub>x</sub> measurements at the IFGT inlet and exit will be conducted simultaneously with SO<sub>2</sub>. Should the initial measurements of NO<sub>x</sub> at the inlet and outlet of the IFGT indicate NO<sub>x</sub> removals are too small to accurately quantify, then NO<sub>x</sub> measurements will be suspended for the balance of the tests.

The test matrix includes one test to investigate HCl and HF removal. These acid gases are absorbed by mechanisms similar to SO<sub>2</sub>. However, at the planned IFGT test conditions, the solubility of HCl and HF is significantly higher than SO<sub>2</sub> and their removal rates are expected to be greater than 98%. The HCl and HF removal efficiency will be quantified across the IFGT. The liquid condensate and the sodium carbonate reagent will be analyzed for chloride and fluoride content to better understand the fate of chlorides and fluorides across the IFGT.

#### 4.3.2 Mercury and Heavy Metals Removal

The ability of the IFGT to remove mercury and heavy metals from the flue gas and the fate of the mercury will also be determined. Three tests are planned for the range of conditions shown in Table 1. Mercury speciation measurements will be conducted at both the inlet and outlet of the IFGT to quantify total, elemental, and oxidized mercury removal for each of the coals evaluated. Quantifying the individual species is important since each species has different

chemical and physical properties. The main forms of mercury emitted in flue gas are elemental (Hg) or the oxidized state (mercuric chloride [HgCl<sub>2</sub>]). Previous SBS measurements indicate that the total mercury emissions were within the expected range of 1 -10 ug/m<sup>3</sup> coal-fired boilers.

Mercury species are removed from the flue gas by either condensation of elemental Hg or absorption of HgCl<sub>2</sub> into the reagent liquid. Condensation of elemental Hg is usually not complete as the trace metal concentration is relatively low. However, the lower outlet flue gas temperature of the IFGT (90°F) over a commercial wet scrubber (120°F - 130°F) may provide for higher levels of elemental mercury removal.

Based on the similar gas-liquid mechanics of commercial wet scrubbers, the IFGT will likely provide for high level of removal for the water-soluble mercury. These forms have aqueous solubilities that are approximately 1000X higher than that for the elemental form (Hg). The IFGT operating conditions that are expected to affect the mercury species removal efficiency are the outlet flue gas temperature, operating load, reagent spray flux and pH. Mercury removal is anticipated to be enhanced by reduced flue gas temperature, high reagent pH and increased reagent liquid-to-gas ratio.

To address the final form of the mercury and to evaluate mercury material balances across the IFGT system, the IFGT liquid condensate, collected particulate and the sodium carbonate reagent will be analyzed for mercury concentration. Other streams outside of the IFGT system that will be evaluated for mercury content include the coal feed and upstream baghouse ash.

To summarize, mercury concentration measurements will be conducted on the following process streams:

- coal feed
- IFGT inlet and outlet gas flows and particulate
- IFGT condensate/blowdown
- baghouse ash

Under steady-state operating condition, measurements will be conducted in triplicate to determine the repeatability of the data. Blanks will be run in order to assess the uncertainty in the measurements and to detect unknown sources of contamination.

At the IFGT system inlet, most other trace metals have condensed on the particulate or exist as a submicron fume. The exception is selenium, which can exist in the vapor state at typical IFGT inlet conditions. Provided that selenium is present in the parent coal, the vapor phase and particle concentration will also be measured.

### 4.3.3 Ammonia Removal

To determine ammonia removal using the IFGT, ammonia will be injected upstream of the IFGT system at a constant measured flow rate. Below 450°F ammonia reacts with sulfur trioxide (SO<sub>3</sub>) in the flue gas, so that some of the ammonia may be removed from the flue gas upstream of the IFGT. A matrix of 3 tests is shown in Table 1. For all of these tests, removal will be based on measurements at the inlet and outlet of the IFGT. A continuous ammonia analyzer will be used to sequentially measure the ammonia concentration upstream and downstream of the IFGT to determine ammonia removal. Differences between the measured and calculated concentration based on the injection rate of ammonia at the IFGT inlet will be a measure of the ammonia-sulfur reactions. For the ammonia removal tests the concentration of NO<sub>x</sub> at the inlet and outlet of the IFGT will also be measured.

### 4.3.4 Particulate Removal

These tests will determine the overall particulate removal efficiency of the IFGT facility and the removal efficiency as a function of particle size. The particulate loading to the IFGT facility will consist of the fugitive emissions from the SBS baghouse, and a portion of the flue gas from the SBS that is diverted around the baghouse and fed directly to the IFGT.

A matrix of 3 tests is shown in Table 1. Additional total particulate removal will also be obtained as part of the sampling for mercury and acid gases. For those measurements the sampling technique requires collection of particulate as well as the gas sample. In addition to those tests, specific tests will be conducted in which the particle size distribution as well as the particle loading at the inlet and outlet of the IFGT will be measured.

The effect of steam injection on particulate removal will also be investigated in this test program. It has been proposed that the addition of steam to water saturated flue gas can enhance the removal of fine particulate. Supersaturating the flue gas causes condensation to occur on particulate, resulting in particle growth. As the smaller submicron size particles increase in diameter they may become easier to remove from the flue gas stream. Steam will be injected between the first and second stage of the IFGT and particulate loading measurements will be conducted at the inlet and outlet to the IFGT. The change in particulate removal efficiency and particulate size distribution at the outlet of the IFGT due to steam injection will be determined.

As with wet scrubbers, a fraction of the particulate leaving the IFGT is likely caused by carry out of liquid drops, and possibly the formation of fume in the IFGT. To characterize the effect of carry out on the measured particle loading at the outlet of the IFGT, one test will be conducted using a "clean" flue gas from the SBS baghouse.

#### 4.3.5 Heat Recovery

The heat recovery provided by the IFGT is an integral part of the standard data acquisition. It will be recorded continuously for all of the tests. In addition to this standard data, The following tests will be conducted on the first coal to investigate specific heat transfer mechanisms.

**Onset of 1st Stage Condensation** - For this test, cooling water will flow only through the 1st stage heat exchanger. The cooling water flow rate will be increased until condensate initially forms on the tubes. The data will be compared to heat transfer models to better understand the conditions that initiate condensation.

**Onset of 1st Stage Measurable Condensate Flow** - This is an extension of the previous test, where the cooling water flow rate is sufficient to produce a continuous flow of condensate that can be collected and weighed. The data will be compared to heat transfer models to better understand the conditions that initiate condensation.

**Effect of Recirculated Reagent Flow on Heat Transfer in the 2nd Heat Exchanger Stage** - This test will measure the liquid side and flue gas side temperature distribution with and without reagent flow. The data will be compared to heat transfer models to better understand the effect of operating the 2nd stage with higher flue gas temperature on the heat recovery distribution between the 1st and 2nd stages.

#### 4.4 SAMPLING METHODOLOGY

This section summarizes the sampling methodology for the process chemistry variables that will be periodically monitored, and presents the sampling and analytical methods to be used during the air toxics test series. All of the analysis procedures will be completed at ARC by B&W personnel. Sampling ports are in place at the inlet and outlet flues of the IFGT pilot facility for simultaneous flue gas measurements such as cascade impactor or total particulate measurements and gas sampling for mercury, heavy metals and other air toxics. The sampling and analysis matrix for the solid streams and liquid process streams is given in Table 2.

There are six different types of test blocks in Task 2, each requiring a different combination of sampling and sample analyses. During the test program liquid and solid samples will be obtained, stored and analyzed at sufficient intervals to supplement the test data acquired by the DAS. The most complex sampling and analytical schedule is for the mercury, mercury speciation, and heavy metals test block. Routine sampling and analytical procedures will be used to ensure that:

Table 2 - IFGT Sampling and Analysis Matrix

Stream Analyses	IFGT Inlet Flue Gas	IFGT Outlet Flue Gas	Coal	Baghouse Ash	Particulate	Na2CO3 Reagent	Reagent Supply	makeup Water
Particulate Loading	PM, M, H, A	PM, M, H, A						
Particulate Size Distribution	PC	PC						
Ultimate, Ash, Hv			Each Coal					
Total dissolved solids							Steady State	
Total Suspended solids							Steady State	
Specific Gravity							Steady State	
Sulfate							Steady State	
Sulfur			Each Coal				Steady State	
Chloride	H	H	Each Coal			H		H
Flouride	H	H	Each Coal			H		H
Sodium								
Magnesium								
Major Elements						1 x batch		
Trace Heavy Metals								
Total Mercury	M	M	Each Coal	M	M	M	M	M
Mercury Speciation	M	M	Each Coal	M	M	M	M	M
NH3-S Compounds					A			

1) SO2 and NOx gas concentration measurements will be made continuously during all tests

**Test Block**

- H - HCl and HF Testing.
- M - Mercury & Heavy Metals Testing.
- PC - Particulate Cascade Impactor Testing
- PM - Particulate Mass Load Testing.
- A - Ammonia Removal Testing.

- process sampling can be safely accomplished,
- samples are representative of the process stream,
- sample contamination is minimized,
- samples are preserved, stored and handled correctly, and
- that sample analyses are traceable to nationally recognized standards.

For mercury and heavy metals analysis, the sampling time must be consistent with the detection limits of the analytical measurement procedures. For the thirteen trace elements that will be measured, the B&W lab detection limits for liquids and solids delivered to the lab are tabulated in Table 3 in columns A and B respectively. Using typical criteria for EPA method sampling time and sampling rates, the corresponding flue gas gas-phase and solid-phase minimum detection limits were estimated and are listed in columns C and D. The minimum detection concentration for the gas-phase species is for barium at 2.8 ppm. The minimum detection limit for particulate species is for barium at 0.2 ug/m<sup>3</sup>. The estimates are based on a 2-hour sampling time and are sufficiently low to use this sampling time for test planning purposes. The sampling time will be reevaluated once the coal is delivered and analyzed for the thirteen heavy metals. The coal will be sampled initially at delivery to confirm heavy metals composition and general coal quality. Daily coal and sodium carbonate samples will be obtained throughout the test period and a representative sample analyzed for average values for data reduction.

The air toxics trace substance sampling and analytical techniques selected are those either approved or recommended by the EPA. Table 4 lists the sampling methods to be employed for all air toxics sampling. Table 5 provides the appropriate method of sample preparation and the method reference. Tables 6, 7, and 8 outline the analytical methods to be employed for solid streams (coal, ash, and Na<sub>2</sub>CO<sub>3</sub>), flue gas impingers and liquid process streams. Table 9 summarizes the standard analytical methods used to characterize the coal stream. It should be noted that EPA Method 29 is the only draft method in the test program. B&W has been informed by the DOE/EPA that after reviewing previous draft Method 29 air toxics results, that there may be an update to the draft method that could be incorporated into this test program. B&W will include these updated procedures into this project as appropriate.

Flue gas from the IFGT inlet and exit will be continuously sampled and analyzed for SO<sub>2</sub>, NO<sub>x</sub> and O<sub>2</sub> by an extractive gas analyzer system. The system will consist of six analyzers and associated heated hose and flue gas conditioning equipment that is consistent with EPA Method 6C.

**Table 3 - Mercury and Heavy Metals Sampling Detection Limits**

ANALYTE	B&W Lab Detection Limit in Liquids (1) (ppm or ug/g) A	B&W Lab Detection Limit in Solids (2) (ppm or ug/g) B	Flue Gas Gas-Phase Detection Limit (3) (ppm or ug/g) C	Detection Limit of Solids in the Flue Gas (3) (ug/m <sup>3</sup> ) D
	Sb	0.0010	1.00	0.2800
As	0.0005	0.50	0.1400	0.020
Ba	0.0100	5.00	2.8000	0.200
Be	0.0005	0.30	0.1400	0.012
Cd	0.0001	0.05	0.0280	0.002
Cr	0.0010	0.50	0.2800	0.020
Co	0.0020	1.00	0.5600	0.040
Pb	0.0001	0.05	0.0280	0.002
Mn	0.0003	0.20	0.0840	0.008
Hg	0.0001	0.10	0.0280	0.004
Ni	0.0020	1.00	0.5600	0.040
Se	0.0005	0.50	0.1400	0.020
V	0.0100	5.00	2.8000	0.200

Assumptions

- 1) 700 ml of liquid analyte.
- 2) 0.1 gram of particulate catch.
- 3) 2.5 m<sup>3</sup> gas sample.

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**DISCLAIMER**

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Table 4 - IFGT Sampling Methods

Sampling Methods	
Target Substance	Method
<b>Gas Streams</b>	
Metals	Draft EPA Method 29
Chloride, Fluoride	EPA Method 26A
<b>Liquid Streams</b>	EPRI Method A1
<b>Solid Streams</b>	
Coal	ASTM D - 197
Particulate	EPA Method 5 & Anderson Mark III
Na <sub>2</sub> CO <sub>3</sub>	Grab/Composite

Table 5 IFGT Sample Preparation Techniques

Analytes	Matrix	Preparation Technique	Method Reference
Metals	Coal	Microwave Digestion	ASTM E926-88
Mercury	Coal	Oxygen Bomb	ASTM D3684-78
Chloride, Fluoride	Coal	Oxygen Bomb	ASTM D2361
Metals	Particulate	Microwave Digestion	ASTM E926-88
Mercury	Particulate	Acid Digestion	EPA 7471A
Chloride, Fluoride	Particulate	Acid Digestion	EPA SW3051
Metals	Na <sub>2</sub> CO <sub>3</sub>	Microwave Digestion	ASTM C-25
Mercury	Na <sub>2</sub> CO <sub>3</sub>	Acid Digestion	EPA 7471A
Chloride, Fluoride	Na <sub>2</sub> CO <sub>3</sub>	Acid Digestion	EPA SW3051, mod
Metals	Solids	Microwave Digestion	ASTM E926-88
Mercury	Solids	Acid Digestion	EPA 7471A
Chloride, Fluoride	Solids	Acid Digestion	EPA SW3051, mod
Metals (As, Se)	Liquid Streams	Acid Digestion	EPA SW3020
Metals (Other)	Liquid Streams	Microwave Digestion	EPA SW3010
Mercury	Liquid Streams	Acid Digestion	EPA 3015
Chloride, Fluoride	Liquid Streams	None	ASTM D2361

**Table 6 Analytical Methods for Solid Streams**

Analytes	Analytical Method	Method Title
Ba, Be, Cd, Cr, Co, Mn, Ni, Pb	GFAAS	Graphite Furnace Atomic Absorption Spectroscopy
As, Se	HGAAS	Hydride Generation Atomic Absorption Spectroscopy
Hg (Coal)	CVAAS ASTM D364-78	Standard Method for Total Mercury in Coal by Oxygen Bomb/Cold Vapor Atomic Absorption Spectroscopy
Hg (Others)	CVAAS SW7471/SW846	Mercury in Solids or Semi Solids Waste/Cold Vapor Atomic Absorption Spectroscopy
Chloride (Coal)	Oxygen Bomb,	ASTM D4208-88
Fluoride (Coal)	Oxygen Bomb,	ASTM D3761-91
Chloride (Others)	IC	ASTM D4327, modified
Fluoride (Others)	IC	ASTM D4327, modified
Carbon (Coal)	Gravimetric	ASTM D3178-89

Others - Ash, Reagent, Solids

**Table 7 Analytical Methods for Flue Gas Impingers**

<b>Analytes</b>	<b>Analytical Method</b>	<b>Method Reference</b>
Ba, Be, Cd, Cr, Co, Mn, Ni, Pb, As	GFAAS	Graphite Furnace Atomic Absorption Spectroscopy
Se	HGAAS	Hydride Generation Atomic Absorption Spectroscopy
Hg, Elemental	CVAAS	Cold Vapor Atomic Absorption Spectroscopy
Hg, Ionic	CVAAS	Cold Vapor Atomic Absorption Spectroscopy
Chloride, Fluoride	IC	Ion Chromatography

**Table 8 Analytical Methods for Liquid Process Streams**

<b>Analytes</b>	<b>Analytical Method</b>	<b>Method Reference</b>
Ba, Be, Cd, Cr, Co, Mn, Ni, Pb	GFAAS	Graphite Furnace Atomic Absorption Spectroscopy
As, Se	HGAAS	Hydride Generation Atomic Absorption Spectroscopy
Hg, Total	CVAAS	Cold Vapor Atomic Absorption Spectroscopy
Chloride, Fluoride	IC	Ion Chromatography

Table 9 Coal Analytical Methods

Analyte	Analytical Method	Method Reference
Moisture	Gravimetric	ASTM D3173-87
Heating Value	Calorimetry	ASTM D2015-19
Ultimate Analysis		
C, H	Gravimetric	ASTM 3178-89
S	Instrumental	ASTM D4239-85, Method C
N	Titrimetric	ASTM 3179-89
Ash	Gravimetric	ASTM 3179-89

## 5.0 DATA ACQUISITION AND REDUCTION

### 5.1 TEST DATA

Most of the IFGT facility operating data will be obtained by a computerized data acquisition system. B&W utilizes a PC-based computerized Data Acquisition System (DAS) to monitor and record all instrumentation with an electronic signal output. The process measurements that will be obtained for data reduction will consist of temperatures, pressures, flow rates of gases and liquids, and flue gas species such as SO<sub>2</sub>, O<sub>2</sub>, and NO<sub>x</sub>. Table 10 contains a list of continuous monitoring instrumentation planned for Task 2. Most of the data will be collected approximately every 10 seconds by the DAS and stored for later data reduction. Some of the data, such as ammonia flow rate, and gas side pressure drop will be manually recorded. A Chessell multichannel chart recorder will be used to continuously record the outputs of the gas analyzers and other selected instrumentation.

Temperature data will be continuously collected to measure the heat exchanger tubeside water temperature profiles. Figure 3 shows the location of 26 thermocouples that are connected to the 1st stage heat exchanger water tubes. Figure 4 shows the location of 19 thermocouples placed on the 2nd stage heat exchanger water tubes. The specific thermocouple locations were chosen after reviewing previous temperature profile measurements in an effort to better measure the vertical temperature profile and the side-to-side water temperature distribution.

Data will be analyzed during the test program to determine if adjustments are necessary to the remaining test blocks. The data collected during the tests of the four coals will be analyzed to determine removal efficiency of the IFGT for the various air pollutants including:

SO <sub>2</sub>	Ammonia
Mercury by species	HCl & HF
Total particulate	Ammonia-sulfur compounds
Particulate by particle size	Selenium and other heavy metals, if present
NO <sub>x</sub>	

The removal efficiencies of the IFGT for these pollutants will be determined as a function of the test variables. In addition to this data, the thermal performance of the IFGT measured during the tests will be analyzed. Energy and condensate mass balances on the IFGT will be made for steady-state operating conditions.

### 5.2 QUALITY ASSURANCE

The Research & Development Division (R&DD) has two levels of quality assurance under which the R&D work is performed. They are Standard Practice, and Specified Quality

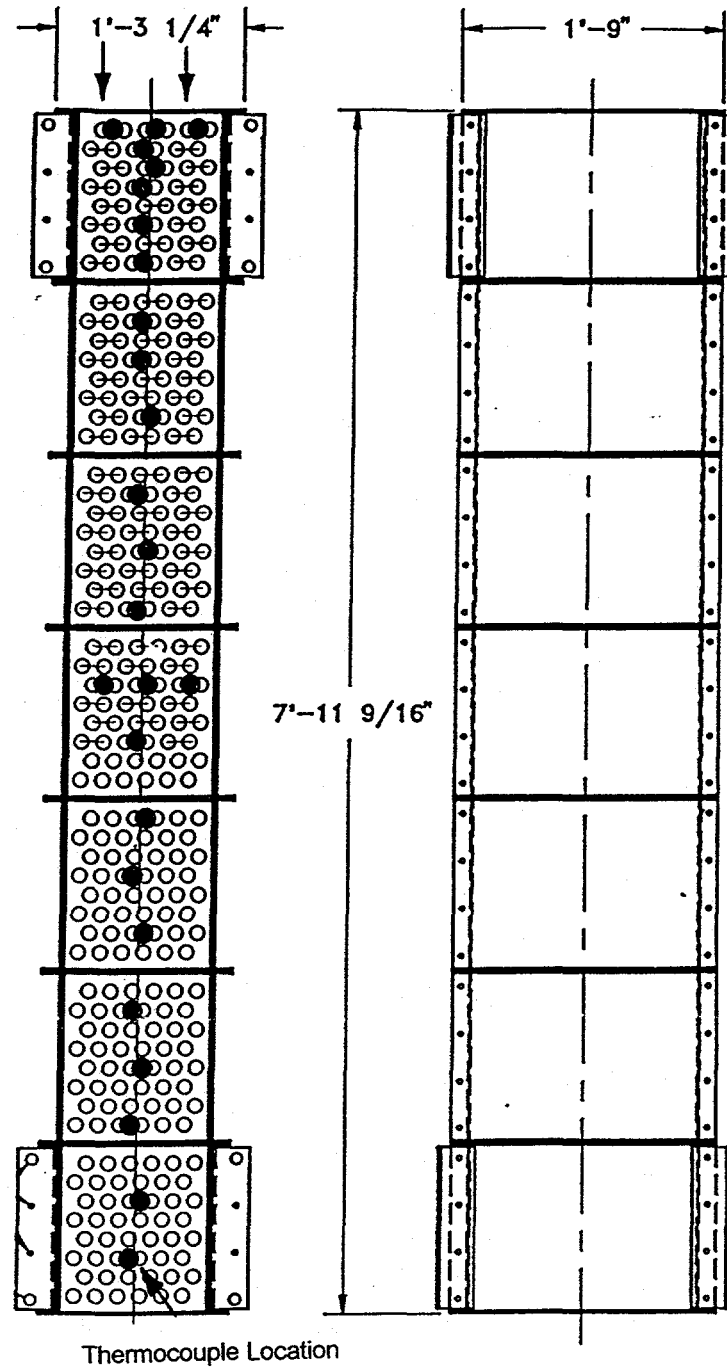
Table 10 - IFGT Continuous Monitoring Instrumentation

MEASUREMENT	UNITS	METHOD
1st Stage Differential Pressure	in H2O	Manual
1st Stage Inlet Static Pressure	In. H2O	Manual
2nd Stage Differential Pressure	In. H2O	Manual
Ammonia Flow Pressure	PSIG	Manual
Ammonia Flow Rate	Lb/Hr	Manual
Ammonia Flow Temperature	Deg F	Manual
Barometric Pressure (Outside)	PSIA	DAS
Cooling Water Flow Rate	Lb/hr	DAS
Cooling Water Inlet Temperature	Deg F	DAS
Cooling Water Interstage Temperature	Deg F	DAS
Cooling Water Outlet Temperature	Deg F	DAS
Differential Pressure	In. H2O	Manual
Flue Gas NH3 Conc. at Inlet/Outlet	PPM, Wet	DAS
Flue Gas NOx Conc. At Inlet	PPM, Dry	DAS
Flue Gas NOx Conc. At Outlet	PPM, Dry	DAS
Flue Gas O2 Conc. At Inlet	%, Dry	DAS
Flue Gas O2 Conc. At Outlet	%, Dry	DAS
Flue Gas SO2 Conc. At Inlet	PPM, Dry	DAS
Flue Gas SO2 Conc. At Outlet	PPM, Dry	DAS
Gas Flow Orifice Differential Pressure	In. H2O	Manual
Gas Flow Orifice Differential Pressure	In. H2O	DAS
Gas Flow Orifice Gage Pressure	In. H2O	Manual
Gas Flow Orifice Gage Pressure	In. H2O	DAS
Gas Flow Orifice Temperature	Deg F	DAS
Gas Temperature @ Inlet To Analyzers	Deg F	DAS
Gas Temperature @ Module 1 Inlet	Deg F	DAS
Gas Temperature @ Module 1 Outlet	Deg F	DAS
Gas Temperature @ Module 2 Inlet	Deg F	DAS
Gas Temperature @ Module 2 Outlet	Deg F	DAS
Gas Temperature @ Outlet Flue	Deg F	DAS
Makeup Water Flow Rate	Lb/Hr	DAS
Reagent Blowdown Flow Rate	Lb/Hr	DAS
Reagent Flow Rate	Lb/hr	DAS
Reagent Nozzle Pressure - Top Spray	PSIG	Manual
Reagent pH - Return	-LOG[H+ ACT]	DAS
Reagent pH - Supply	-LOG[H+ ACT]	DAS
Reagent Return Density (Micromotion)	Spec. Grav.	DAS
Reagent Return Temperature	Deg F	DAS
Reagent Return Temperature (Micromotion)	Deg F	DAS
SBS Coal Flow	Lb/hr	DAS

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Table 10 (Cont'd)

MEASUREMENT	UNITS	METHOD
SBS Flue Gas Out Flow Rate	Lb/hr	DAS
SBS O2 Out Conc.	%, Dry	DAS
Steam Injection Flow Rate	Lb/hr	Manual
Steam Plenum Pressure	PSIG	Manual
Steam Temperature	Deg F	Manual
TC @ Tube Row 01A -Stage 2	Deg F	DAS
TC @ Tube Row 01B -Stage 2	Deg F	DAS
TC @ Tube Row 01C -Stage 2	Deg F	DAS
TC @ Tube Row 01D -Stage 2	Deg F	DAS
TC @ Tube Row 01E -Stage 2	Deg F	DAS
TC @ Tube Row 03 -Stage 1	Deg F	DAS
TC @ Tube Row 06 -Stage 1	Deg F	DAS
TC @ Tube Row 07 -Stage 2	Deg F	DAS
TC @ Tube Row 09 -Stage 1	Deg F	DAS
TC @ Tube Row 12 -Stage 1	Deg F	DAS
TC @ Tube Row 15 -Stage 1	Deg F	DAS
TC @ Tube Row 15 -Stage 2	Deg F	DAS
TC @ Tube Row 18 -Stage 1	Deg F	DAS
TC @ Tube Row 21 -Stage 1	Deg F	DAS
TC @ Tube Row 23 -Stage 2	Deg F	DAS
TC @ Tube Row 24 -Stage 1	Deg F	DAS
TC @ Tube Row 27 -Stage 1	Deg F	DAS
TC @ Tube Row 30C -Stage 1	Deg F	DAS
TC @ Tube Row 30E -Stage 1	Deg F	DAS
TC @ Tube Row 30W -Stage 1	Deg F	DAS
TC @ Tube Row 31A -Stage 2	Deg F	DAS
TC @ Tube Row 31B -Stage 2	Deg F	DAS
TC @ Tube Row 31C -Stage 2	Deg F	DAS
TC @ Tube Row 31D -Stage 2	Deg F	DAS
TC @ Tube Row 31E -Stage 2	Deg F	DAS
TC @ Tube Row 33 -Stage 1	Deg F	DAS
TC @ Tube Row 36 -Stage 1	Deg F	DAS
TC @ Tube Row 39 -Stage 1	Deg F	DAS
TC @ Tube Row 39 -Stage 2	Deg F	DAS
TC @ Tube Row 42 -Stage 1	Deg F	DAS
TC @ Tube Row 45 -Stage 1	Deg F	DAS
TC @ Tube Row 47 -Stage 1	Deg F	DAS
TC @ Tube Row 47 -Stage 2	Deg F	DAS
TC @ Tube Row 49 -Stage 1	Deg F	DAS
TC @ Tube Row 51 -Stage 1	Deg F	DAS
TC @ Tube Row 53 -Stage 1	Deg F	DAS
TC @ Tube Row 54 -Stage 1	Deg F	DAS
TC @ Tube Row 55 -Stage 1	Deg F	DAS
TC @ Tube Row 55 -Stage 2	Deg F	DAS
TC @ Tube Row 56C -Stage 1	Deg F	DAS
TC @ Tube Row 56E -Stage 1	Deg F	DAS
TC @ Tube Row 56W -Stage 1	Deg F	DAS
TC @ Tube Row 63A -Stage 2	Deg F	DAS
TC @ Tube Row 63C -Stage 2	Deg F	DAS
TC @ Tube Row 63E -Stage 2	Deg F	DAS



1st Stage, North Side

Figure 3. Location Of Thermocouples On The Stage 1 Heat Exchanger

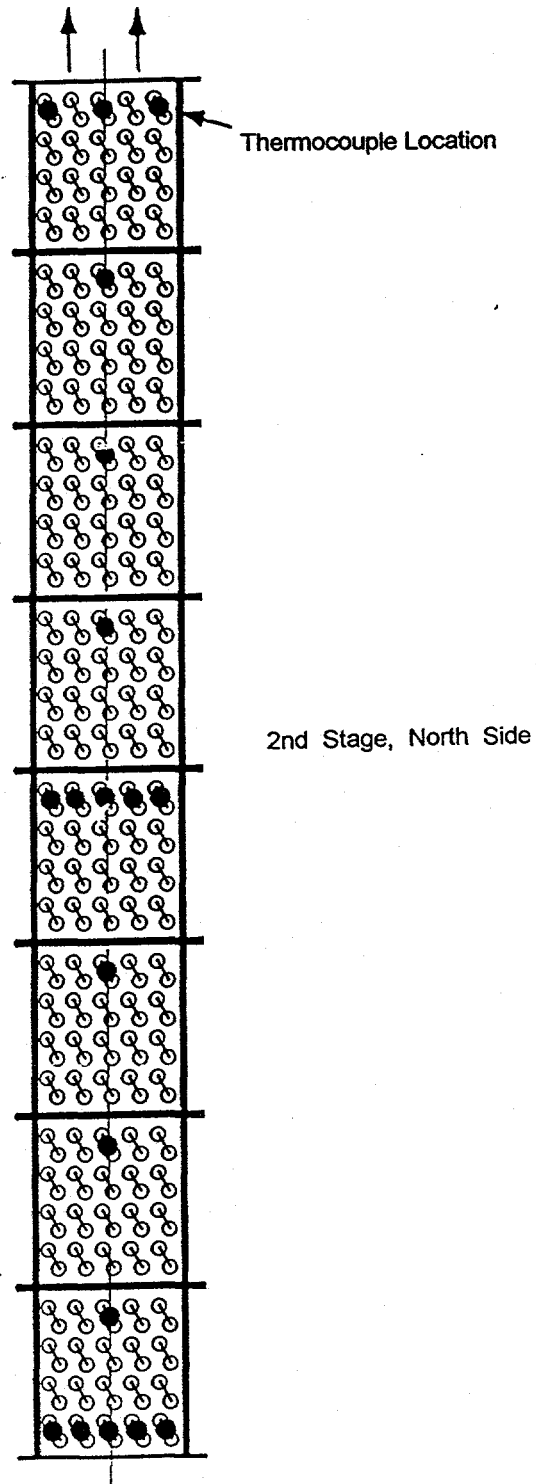


Figure 4. Location Of Thermocouples On The Stage 2 Heat Excahnger.

Assurance (SQA). Standard Practices are those activities normally performed by the Research and Development Division when no specific customer requirements are imposed. These practices are well recognized as an outstanding base quality system for research work by organizations such as the U.S. DOE, U.S. DOD, Electric Power Research Institute, Gas Research Institute, and many others. These practices are described in the STANDARD PRACTICE MANUAL and are further implemented by R&DD Administration Procedures.

This project will utilize the R&DD Standard Practice quality assurance system. The Task Leader and the R&DD management will ensure these requirements are met and appropriate documentation is on file. Specific activities will include:

- The certification or standardization of all measurement standards and measuring and test equipment used on the project to ensure that measurements made are accurate and reproducible in terms of nationally recognized standards. Suppliers of instruments and calibration services are audited periodically to determine that calibration requirements are being satisfied.
- Throughout the test program, several measurements, such as flue gas analyzers and pH transmitters will be standardized before and after use with calibration standards that are traceable to NIST.
- Grab samples of various solids and liquids will have adequate chain of custody control.
- Mercury determinations will include the use of blanks to account for any background concentrations that may be present.

## 6.0 REPORTING

A Topical report will be prepared that is a complete and detailed evaluation of the testing conducted during Task 2 of the Project. The report will include a description of the facilities, instrumentation used for making the measurements, a description of measurement techniques, and test procedures as appropriate.

The report will include test data, calculated results for each coal tested, and applicable observations by personnel performing the tests. The performance of the IFGT as a pollutant removal device will be presented and the test results from the different coals will be compared. The report will include coal analyses, the measured pollutant concentrations at the inlet and outlet of the IFGT facility, pollutant concentration in the blow down liquid stream and pollutant removal efficiencies across the IFGT facility.

## 7.0 SITE RESTORATION/WASTE DISPOSAL

After the completion of the test program, the SBS combustor and IFGT pilot scale facility will be restored to pre-test conditions. The interior of the SBS furnace is insulated with refractory to simulate full-scale furnace temperatures. Over a period of time this insulation gradually erodes and must be periodically replaced or repaired. At the conclusion of testing, the insulation will be repaired or replaced as required.

Waste water condensate and reagent blowdown collected during testing of each of the four test series will also require disposal. The waste water condensate waste water will be analyzed to determine the presence and concentration of toxic or hazardous materials. Based on the analysis, the waste water will be disposed in an environmentally acceptable manner that is in compliance with EPA and local regulations. Selected local waste water discharge limits are shown in Table 11. A suitable quantity of waste water for each coal, about 100 gallons, will be saved for bench scale testing under Phase II.

Table 11 Selected City of Alliance, Ohio Local Discharge Limits

Element	Discharge Limit (ug/L)
Arsenic	500
Cadmium	25
Chromium	1400
Copper	1000
Lead	500
Mercury	1
Molybdenum	0
Nickel	500
Selenium	10
Silver	1400
Zinc	2500