DEP ROUTING AND TRANSMITTAL SLIP

TO: (NAME, OFFICE, LOCATION)

1. Jonathan Holtom

2. DARM - MS 5505

3. ___

4. ___

5. ___

PLEASE PREPARE REPLY FOR:	COMMENTS:
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___ MY SIGNATURE	
___ YOUR SIGNATURE	
___ DUE DATE ___	
ACTION/DISPOSITION	RECEIVED FEB 04 2004 BUREAU OF AIR REGULATION
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___ SHARE WITH STAFF	
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FROM: Rita Smith DATE: 2-2-04 PHONE: ___

DEP 15-026 (12/93)

Rayonier

Performance Fibers
Fernandina Mill

STATE OF FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION
2004 JAN 30 P 1: 12
NORTHEAST DISTRICT JACKSONVILLE, FL

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Certified Mail, Return Receipt Requested

January 28, 2004

Mr. Lee Page
Region IV
Environmental Protection Agency
61 Forsyth Street
Atlanta, GA 30303-8960

RE: Application for Alternate Monitoring Method for the Recovery Boiler subject to 40 CFR Part 63, Subpart MM at the Rayonier Performance Fibers LLC, Ammonia Based Dissolving Sulfite Pulp Mill, at Fernandina Beach, FL

Dear Mr. Page:

Rayonier owns and operates an ammonia based sulfite recovery boiler at Fernandina Beach, Florida. This boiler is subject to 40 CFR Part 63, Subpart MM. This rule limits particulate emissions from combustion sources at sulfite pulp mills, specifically the recovery boilers. It also requires specific monitoring for boilers using scrubbers to control particulate emissions. The recovery boiler at the Rayonier Performance Fibers LLC Fernandina Beach Sulfite Mill uses a Brinks filter to control particulate emissions. This device is different than a scrubber. This letter is an application for an Alternate Monitoring Method for devices other than those anticipated by the rule as allowed by 40 CFR 63.864(a)(5).

For alternate Monitoring Method Applications Section 864(f) requires the owner provide to the Administrator a monitoring plan that includes a description of the control device, test results verifying the performance of the control device, the appropriate operating parameter that will be monitored, and the frequency of the measuring and recording to establish continuous compliance with the standards. This letter provides the information required by the regulation and requests approval of this Alternate Monitoring Method as allowed.

1. Description of the Control Device

An ammonia based sulfite recovery boiler does not remove smelt, as does a kraft recovery boiler because the red liquor fired as fuel has little if any ash. Ammonia based sulfite recovery boilers have accumulated bottom ash removed once or twice a week. With no components in the fuel to cause bottom or flyash little particulate occurs in the boiler, except any due to improper combustion. Improper combustion causes the recovered ammonium sulfite to become black and this is intolerable in the cooking process. Thus good combustion practices are mandatory for process as well as regulatory reasons, and little particulate is formed by the boiler.

The recovery boiler burns the spent sulfite liquor, releasing sulfur dioxide, which is collected to form ammonium bisulfite in the subsequent scrubber. In this process some ammonium sulfite is converted to ammonium sulfate. Ammonium sulfate forms a fine, highly reflective particle, and in this case is in a moisture saturated stream. It is the predominate particulate emission from this boiler.

Collecting this particulate is difficult because it is a wet stream. Measuring for it is also difficult because opacity monitors do not function on saturated streams since or as the water vapor interferes with the measurements. Also the particle is so highly reflective very small amounts overwhelm the opacity monitor. The parameters referenced in the rule, scrubber pressure drop and liquid media flow, are not useful parameters for estimating particulates from Brinks type filters.

2. Test results verifying the performance of the control device

There are many stack tests of this emission source following the Brinks. The air operating permits have required annual tests. These tests have been submitted to the Florida Department of Environmental Protection for review and approval. There are only a few tests of this source after the Brinks was recently upgraded and the beta gauge installed. All 11 of these tests used to determine compliance and to select surrogate parameter ranges are presented in the attached Table 1.

These tests demonstrate the control device meets the existing permit limit and the proposed limit in 40 CFR Part 63, Subpart MM. The Subpart MM regulation requires that particulate matter emissions from this boiler not exceed 0.092 grams/dscm. The existing permit limits the boiler to 67.5 pounds per hour. Three tests run on July 24 and 25, 2003 to establish an out of compliance limit for intentionally exceed the allowed particulate emission rate and the subject of a modification of a Title V permit to allow temporary, partial opening of the Brinks bypass damper for this purpose. This enabled calibration of the proposed particulate monitor over a range that included compliance. The upgraded Brinks has reduced particulate emissions to very low levels and bypassing the Brinks filters was the only practical way to increase particulates to determine monitor performance at higher particulate emissions. Below is a detailed discussion of the proposed surrogate monitor and its ability to predict particulate emissions.

3. Operating Parameter that will be monitored

Many efforts have been made to find boiler, scrubber or Brinks operating parameters that indicated particulate emissions. All efforts failed. Since no operating parameters were found that relate to particulate emissions, and opacity monitoring was impossible, the mill searched for other methods to measure particulates in the emission. The mill found a company marketing a device professing to be able to monitor particulate emissions on almost a continuous basis using glass fiber filter tape sampling technology. After a trial the mill purchased a monitor and has found good agreement between monitored and tested particulate emissions.

This monitor measures the added mass on a glass fiber filter tape using beta particle attenuation. A clean section of tape is measured for beta attenuation. A sample of stack gas is isokinetically taken from the stack and pulled through the tape. Beta attenuation is re-measured. The difference in beta attenuation is correlated to stack gas particulate concentration.

Table 1 presents the Beta attenuation monitor reading for each EPA Method 5 test. The results are also graphically presented in Figure 1. The initial tests were clustered at readings well below the Subpart MM limit. The three high tests resulted from cracking open the control equipment by-pass valve. A permit was obtained from the Florida Department of Environmental Protection to open this bypass specifically for these tests only. Its is not certain that the intervening points are linear as is drawn in Figure 1. Of course the instrument is new technology and the precision of this method over time is also unknown. The Beta source, Carbon 14, has a known half-life of 5000 years. To date, (it was installed April 8, 2003) the instrument has been relatively maintenance free compared to other such monitors. The Brinks filter media has a history of deteriorating with use. As time passes and more stack tests are accumulated the intervening emission concentrations will be obtained to compare with meter readings.

Daily the instrument runs both span and zero checks on both the beta particle measurement and the sample flow measurement. The attached letter dated January 27, 2004 to Richard Langford, of Rayonier Performance Fibers LLC from Eric Reber of MSI/Mechanical Systems, the manufacturer, describes the routine drift checks and calibration checks. Also attached is the manufacturer's description of this monitor.

4. Frequency of Measuring and Recording that will establish continuous compliance

At least one sample is taken every 15 minutes. A record of each 15-minute sample result will be maintained for 5 years. One sample every 15 minutes complies with the CAM Rule and meets the required monitoring frequency of Subpart MM.

The rule at 40 CFR 63.864(C)(2)(v) provides that, for an affected source equipped with an alternative air pollution control system approved by the Administrator, a violation of the standard occurs with 6 or more 3-hour average values within any 6 month reporting period are outside the range of parameter values established in paragraph (b)(2). The monitor readings proposed in the next section are meant to be those 3 hours averages which when exceeded 6 or more times in any 6 months period will be deemed to be a violation of Subpart MM.

Proposed Alternate Monitoring Method

We are proposing to monitor beta particle attenuation across a sample of particulate collected by a glass fiber tape sampler. This monitor has been described above.
A linear regression analysis determined the correlation equation and the correlation coefficient relating meter readings to EPA Method 5 stack test data. As can be seen from Figure 1, where this analysis is presented, a very good correlation coefficient of 0.98 was obtained.

When this meter is approved as an alternate method, we will submit a modification of the Title V permit for this facility to include a limit which exceeded by 6 or more 3-hour average values within any 6 months reporting period, a violation of this standard has occurred. Based on the regression analysis of the available data that limit should be a meter reading of 0.045. By inspection of Figure 1, even at a meter reading of 0.045, one is quite confident the 0.092 gm/dscm emission limit is not exceeded.

If you have questions regarding these applications, please contact David Tudor at (904)277-1452, E-mail: david.tudor@rayonier.com, or Richard Hopper at (904) 277-1480, E-mail: richard.hopper@rayonier.com.

Sincerely,

W. M. Burch
General Manager

cc: Christopher L Kirts
FL DEP - JAX

TABLE 1 SULFITE RECOVERY BOILER PARTICULATE EMISSIONS

Date	Run No.	PM (gm/dscm) @8% O_2	Beta Monitor PM (g/scm)
4/14/2003	1	0.0236	0.0156
4/14/2003	2	0.0264	0.0175
4/14/2003	3	0.0300	0.0189
4/14/2003	4	0.0370	0.0188
4/15/2003	5	0.0360	0.0191
7/24/2003	4	0.0321	0.0155
7/24/2003	5	0.0356	0.0150
7/24/2003	6	0.0264	0.0150
7/25/2003	7	0.1509	0.0786
7/25/2003	8	0.1812	0.0755
7/25/2003	9	0.1405	0.0733

FIGURE 1

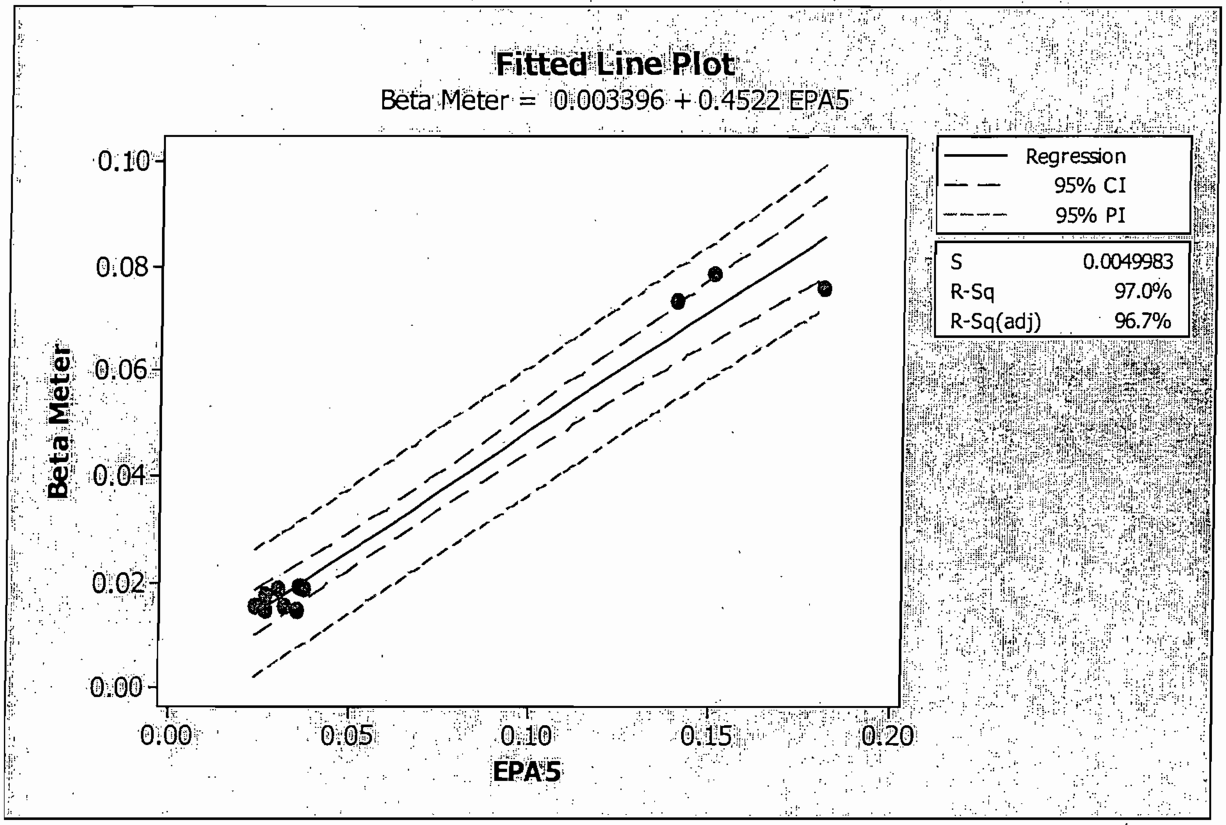
Regression Analysis: Beta Meter versus EPA5

```
The regression equation is
Beta Meter = 0.003396 + 0.4522 EPA5

S = 0.00499832   R-Sq = 97.0%   R-Sq(adj) = 96.7%

Analysis of Variance
```

Source	DF	SS	MS	F	P
Regression	1	0.0073758	0.0073758	295.23	0.000
Error	9	0.0002248	0.0000250		
Total	10	0.0076006			



January 27, 2004

Rayonier Performance Fibers LLC
Fernandina Beach, FL

Dear Mr. Langford:

Following are the descriptions of the MSI BetaGuard PM Daily Automatic Drift Checks.

The BetaGuard PM was placed in service at Rayonier Performance Fibers LLC, Fernandina Beach, Florida, on April 8, 2003

The Daily Automatic Beta Drift Check checks the repeatability of the mass-measuring components of the BetaGuard PM: the radiation sources and detectors, the preamplifier, counters and controller, and the filter tape transport system. The routine is as follows:

Step 1	The stepper motor advances the filter tape to a clean section within the filter holder (about 92mm [3.6"]).
Step 2	No stack gas sample is passed through the filter tape during the Drift Check routine. Both Beta Gauges measure a clean section of the filter tape for 2 minutes. This provides the zero measurement of that spot of the filter tape.
Step 3	The stepper motor reverses the filter tape until the spot measured by the Left Beta Gauge in Step 2 is exactly beneath the conical pipe sample gas outlet (46mm [1.8"]).
Step 4	The stepper motor reverses the filter tape again until the spots measured by the Beta Gauges in Step 2 are returned exactly to the zeroing positions.
Step 5	The Beta Gauges remeasure the previously zeroed spots and calculate the deviation from the original measurement. This checks both the repeatability of the beta measurement at zero and the repeatability of the filter tape transport system.
Step 6	Unique contacts are closed at TB5 indicating that the zero measurement is available at the analog output for the Left Beta Gauge. This output is held for one minute.
Step 7	Unique contacts are closed at TB5 indicating that the zero measurement is available at the analog output for the Right Beta Gauge. This output is held for one minute.
Step 8	Both Beta Gauges continue to measure the repositioned filter tape spots to provide an upscale measurement. After about eight minutes, unique contacts are closed at TB5 indicating that the upscale measurement is available at the analog output for the Left Beta Gauge. This output is held for one minute. This measurement is compared to a previously recorded upscale value.

Step 9 Unique contacts are closed at TB5 indicating that the upscale measurement is available at the analog output for the Right Beta Gauge. This output is held for one minute. This measurement is compared to a previously recorded upscale value.

Step 10 The BetaGuard PM restarts its normal measurement cycle from the beginning.

The Daily Automatic Flow Drift Check checks the repeatability of the flowmeter components of the BetaGuard PM by adjusting its internal valving to shunt the flowmeters in series with each other. Known flow is then routed through all of the flowmeters at two separate flow setpoints to perform a low flow and a high flow drift check. These results are reported out the analog output along with the corresponding contact closures in similar fashion to the Beta Drift Check above.

Sincerely,

Eric Reber
MSI/Mechanical Systems, Inc.

MSI
BetaGuard PM

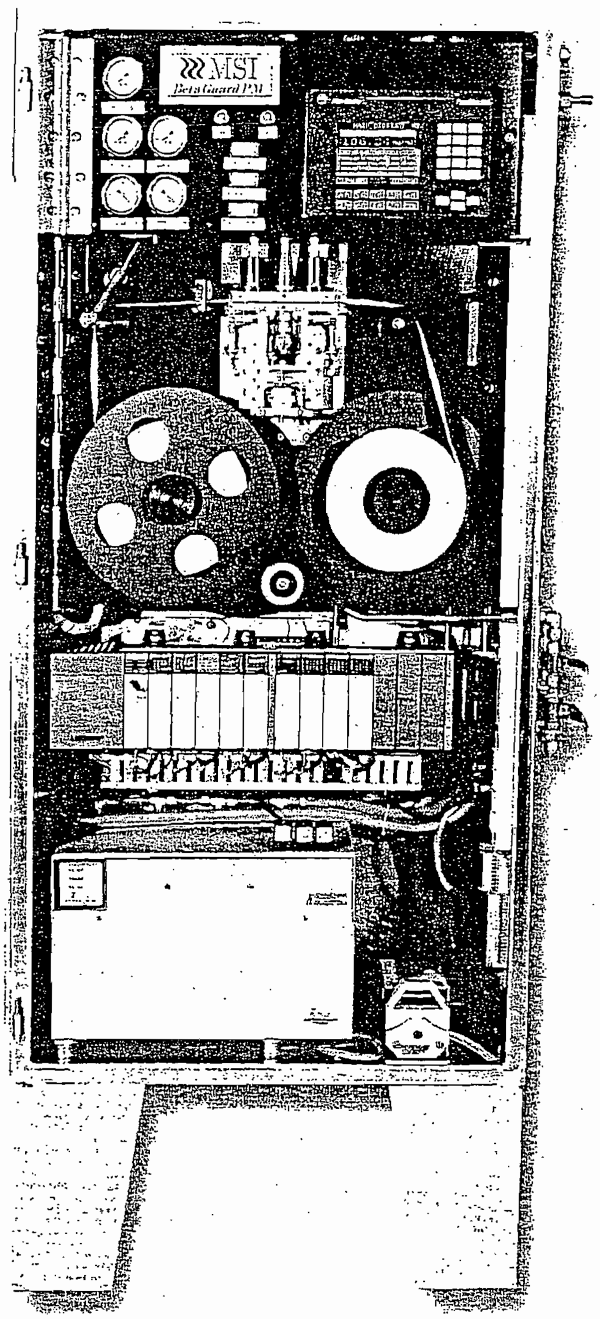
MSI BetaGuard PM Continuous Source Particulate Monitor

MADE IN

Best Available Copy

Description

The MSI BetaGuard PM beta gauge measures particulate emissions from all types of sources under all conditions. Stacks with changing particulate conditions (size, shape, color, density, composition) or varying operating parameters (flow rate, moisture concentration, temperature, pressure) are accurately measured. Wet basis, dry basis and process rate measurements are now available from a single instrument!



MSI BetaGuard PM

Applications

- Coal Fired Power Plants
- Cement Kilns
- Petroleum Refineries
- Hazardous Waste Incinerators
- Boiler Industrial Furnaces
- Municipal Waste Combustors

Capabilities

- Dual Beta Sensor Design
- Built-In Redundancy
- Dry Basis Measurement
- Wet Basis Measurement
- Process Rate Measurement
- Isokinetic Flow Sampling
- Isothermal Sampling

Certifications

- Method 5 Equivalence
- Method 5i Equivalence
- Method 17 Equivalence

Calibrations

- Seven Point Beta Characterization
- Seven Point Flow Characterization
- Automatic Daily Beta Calibration
- Automatic Daily Flow Calibration
- Quarterly Beta Audit
- Quarterly Flow Audit

Features

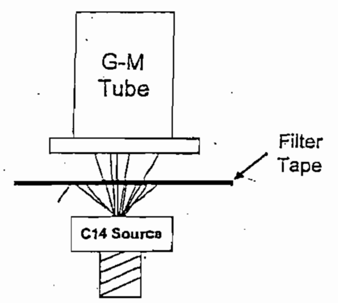
- NEMA 4X Construction
- Allen Bradley SLC 500 Control
- Heated Dilution Air
- Simplified Filter Tape Replacement
- Complete Alarms
- Complete Diagnostics
- Built-In Lightning Surge Protection
- 115 VAC Operation
- Manufactured in the U.S.A.

Options

- Remote Display and I/O to 10,000 Feet
- Outdoor Walk-In Enclosure
- Heavy Metals Monitoring Package
- Continuous Moisture Measurement

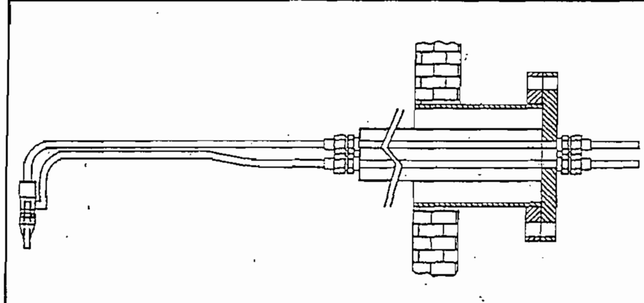
Principle of Operation

A low energy Carbon-14 source furnishes a constant supply of beta electrons which are detected by a Geiger-Mueller tube. A filter tape is interposed between the source and detector and the mass of the initial clean filter spot is recorded by measuring the counts of beta electrons reaching the G-M tube. This clean spot is then moved under a collection apparatus for sample extraction from the stack. A sample of stack gas is drawn through and deposits particulate on the filter tape. All particles above 0.1 microns (μ) are collected.



Beta Transmission Sensor Principle

Once a sufficient amount of sample is collected on the filter tape, the filter tape is moved back under the beta detector and remeasured. The difference in beta emission counts measured from the original clear spot to the collected sample is directly proportional to the mass on the tape.


BetaGuard PM Dilution Probe

The MSI BetaGuard PM extracts the sample isokinetically from the stack using a dilution probe to suppress moisture and increase sample transport velocity. During the time the mass is building up on the tape, the BetaGuard PM is measuring the sample volume extracted from the stack to produce that mass. Combining the collected mass with the drawn sample volume provides a measure of mass concentration.

The MSI BetaGuard PM measures the flow both wet and dry to provide mass concentration readings on both a wet and a dry basis.

BetaGuard PM Measures Accurately Under All Conditions Regardless Of:

Emission Control Technology

- Dry Electrostatic Precipitator
- Wet Electrostatic Precipitator
- Dry Scrubber
- Wet Scrubber
- Fabric Filter/Baghouse
- Quench Tower

Changes in Particle Properties

- Size
- Shape
- Color
- Chemical Composition
- Density

Changes in Stack Gas

- Velocity
- Water Vapor Content (Humidity)
- Pressure
- Temperature

Stack/Duct Construction

- Size
- Shape
- Internal Lining
- Materials of Construction

Equipment Changes Over Time

- Ball Mill/Pulverizer Wear
- ESP Degradation
- Fabric Filter Deterioration
- SO_3 Injection Rate
- Carbon Injection Rate

BetaGuard PM
General Specifications

Particulate Conc. Range (Selectable):	0 - 1000 mg/m^3
	0 - 0.5 $grains/ft^3$
Diluted Sample Flow Range:	0 - 3.5 m^3/hr, 0 - 60 l/min
	0 - 120 ft^3/hr
Minimum Batch Sampling Time:	140 seconds
Minimum Measurement Update Time:	6 minutes
Measurement Sources (2)	
Isotope:	Carbon-14
Activity:	<12 µCi
Half Life:	5700 years
Licensing:	None Required - Exempt
Measurement Detectors (2):	Geiger-Mueller (G-M) Tube
Filter Medium:	Glass Fiber, Low Heavy Metals
Digital I/O:	16 in / 16 out
Analog I/O:	10 in / 2 out
Warm-up Time:	30 minutes
Power Requirements	
Main Instrument:	115 Vac, 15 A max
Heated Sample Line:	115 Vac, 10 A max
Dilution Air Heater:	115 Vac, 6 A
Instrument Air Requirements:	80 psig, 6 scfm min
Dimensions:	72"h x 30"w x 12"d
Weight:	275 pounds
Environmental Rating:	NEMA 4X
	IP66
Operating Temperature:	50° - 120°F / 10° - 50°C
Storage Temperature:	-20° - 135°F / -30° - 60°C

MSI
MECHANICAL SYSTEMS, INC.
480 Progress Way
Sun Prairie, Wisconsin 53590
Telephone 608-825-2055
Facsimile 608-825-[illegible]

The MSI BetaGuard® PM

Principles of Operation of a Beta Gauge Particulate Monitor

The BetaGuard PM is an instrument for measuring the concentration of particulate matter in combustion exhaust. It operates by drawing a sample of exhaust from a probe through a piece of filter tape. The filter tape is made of a glass fiber mesh, similar to fiberglass, and traps any dust particles larger than 0.3 microns. A mass measuring sensor called a Beta Gauge measures the mass of the filter tape first when the filter is clean, and again when the filter is loaded with particles. The instrument subtracts the filter mass before and after loading to calculate the mass of the particles in milligrams (mg). The instrument also measures the flow of the stack sample gas in cubic meters (m^3) used to extract the sample, and calculates the particulate concentration by dividing the mass by the volume in units of mg per m^3. This process emulates USEPA Methods 5, 5i and 17.

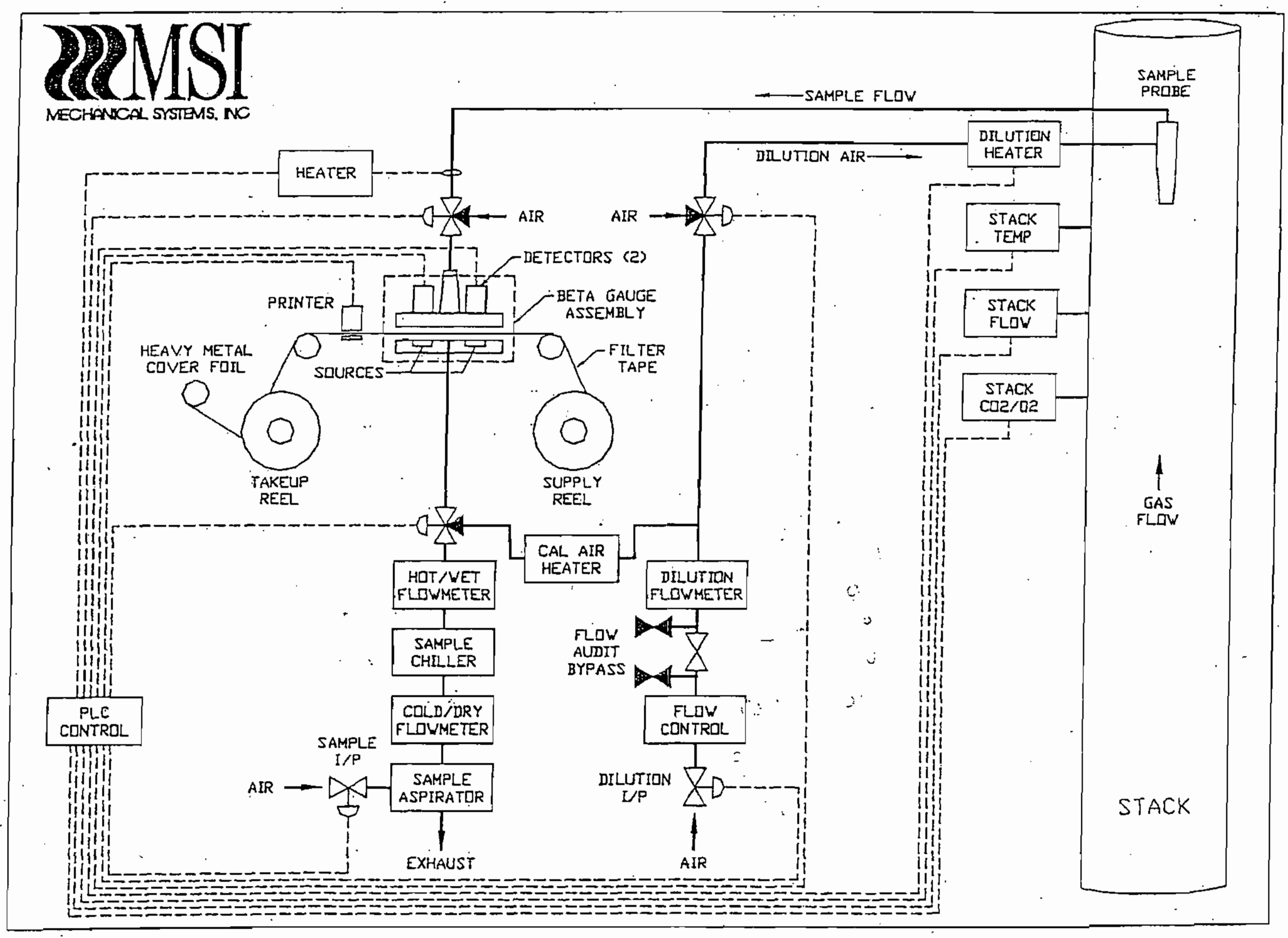


Figure 1.5: MSI BetaGuard PM Schematic Diagram

Beta Gauge

The Beta Gauge is a transmission-style sensor that transmits Beta particles through the filter tape and measures the Beta particles that get through the filter on the other side (see Figure 1.6).

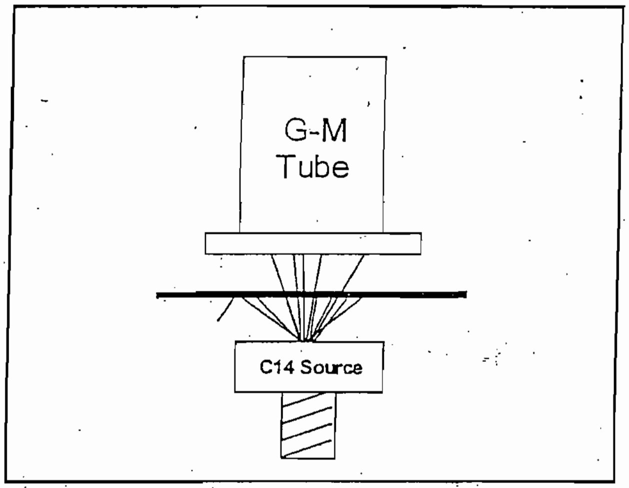


Figure 1.6: Beta Gauge Source and Detector

Beta particles are high energy electrons emitted from a radioactive isotope as it decays. They are not themselves radioactive, nor do they make anything they contact radioactive. The radioactive material, in this case Carbon-14 (C-14), is sealed in the source capsule and is not allowed to escape. The Beta particles are continuously being emitted through the source capsule window. Some are absorbed by the window itself, many are absorbed by the filter tape and the particulate particles, some are absorbed in the G-M Tube detector window and the rest are detected by the G-M Tube detector.

The Beta particles being emitted from the C-14 Source have an energy of 156 kev (kilo-electron volts), which is somewhat higher than the electrons striking the phosphor coating on the inside of a home television tube. The C-14 Beta particles can only travel about 10 inches in air before they are absorbed, and they are easily blocked by clothing and skin. The amount of radioactivity in the BetaGuard PM is similar to that in a household smoke detector, so no special labeling or licensing is required. It is recommended, however, that whenever any work is performed on the sources, filter tape holder or detectors, safety glasses must be worn.

The G-M Tube detector is a device that counts ionizing radiation (Alpha, Beta, Gamma) and is therefore called an ionization detector. A G-M, or Geiger-Mueller, Tube is a metal canister of gas with a thin window on one end and an electrode in the inside center (see Figure 1.7). A Beta particle that passes through the filter tape and the thin G-M Tube window will collide with the atoms of gas in the G-M Tube. Since a Beta particle is really a high energy electron, it has mass and an electrical charge and it is moving quickly. As the Beta particle collides with a gas atom, it gives some of its energy to an outer shell electron of that gas atom. If the outer shell electron now has enough energy to overcome the binding energy of the nucleus, it can escape from its atom. This results in an extra free electron in the G-M tube and an atom that has one fewer electron than it needs to be electrically neutral. This electron-deficient atom has an overall positive charge and is called an ion. This is the process of ionization and one Beta particle can ionize many hundreds of gas atoms. The gas in the G-M Tube is selected for its density and the ease with which its outer shell electrons can be stripped by the incoming Beta particle (ionization potential).

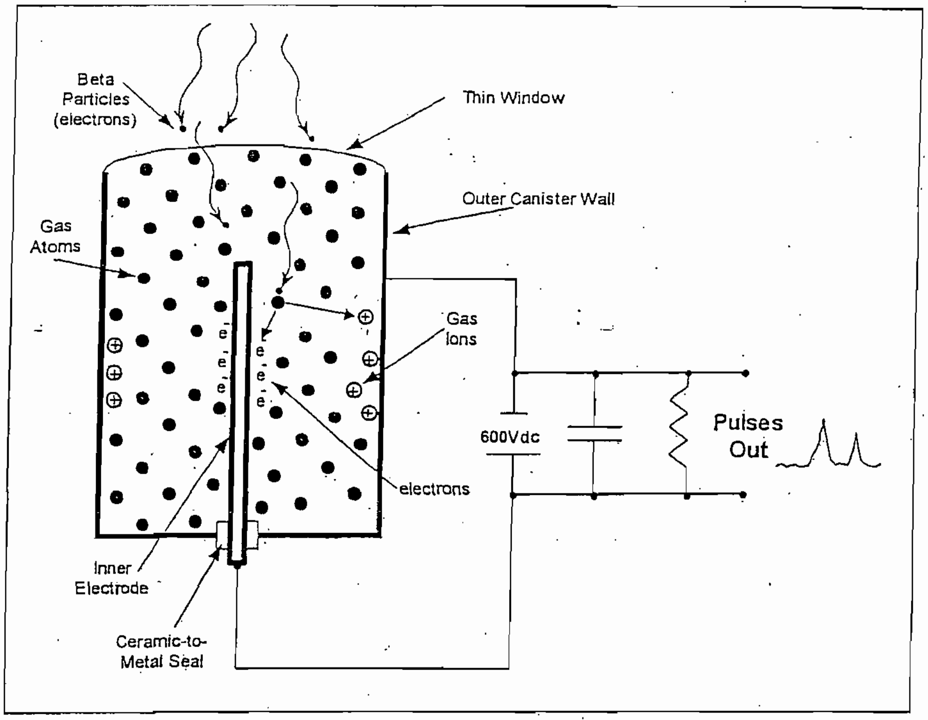


Figure 1.7: Geiger-Mueller Tube Schematic

An electrode is sealed into the G-M tube through the bottom but is electrically isolated from the outer canister by a ceramic-to-metal seal. A high voltage is applied across the inner electrode and the outer canister that creates a large radial electric field inside the G-M Tube. Since the free electrons caused by the Beta ionization have a negative charge, they are attracted to the high potential inner electrode and the positively charged ions are attracted to the low potential canister wall. Since the electric field is so high, these charged particles are accelerated fast enough to cause ionization in more gas atoms. This process known as secondary ionization results in a rush of flowing charge to the inner electrode and the outer canister wall. This rapid charged particle flow is seen as a burst of current on the conductors attached to the electrode and canister. A resistor placed across these conductors converts the current burst to a voltage pulse for each Beta particle entering the G-M tube. Counting these pulses determines how many Beta particles are passing through either the clean filter tape or the filter tape with particulate. The ratio between the two pulse counts determines the net mass on the filter tape.

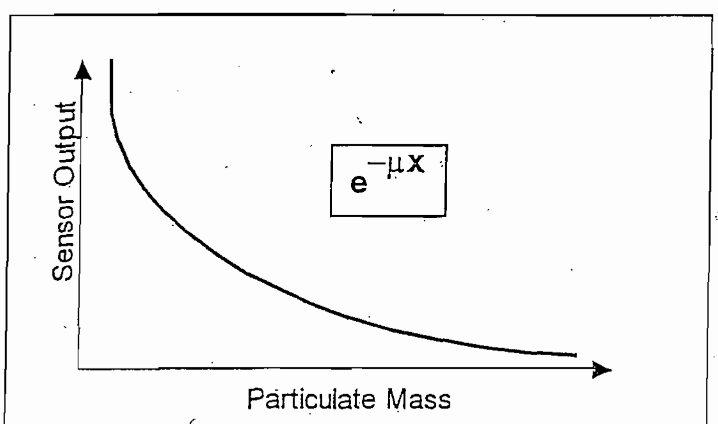


Figure 1.8: Inverse Exponential Beta Transmission Sensor Response

The response of the Beta transmission sensor to particulate mass is similar to that of an optical opacity sensor that shines light through the stack and measures its intensity after it has traveled through the stack gas where it has been partially scattered and absorbed. The sensor output is inversely proportional to the amount of mass between the source and detector and exhibits an exponential dependence as shown in Figure 1.8

Sample Flow

The stack gas is isokinetically drawn through a nozzle attached to a stainless steel ½" (12mm) diameter tube. The nozzle points against the direction of stack gas flow and has a well defined circular opening, typically 5 or 6mm diameter. A dilution tube, also ½" diameter stainless steel, connects to a mixing chamber just behind the rear of the nozzle and adds dry filtered ambient air in the dilution ratio set by the BetaGuard PM (typically between 1:1 and 10:1). The dilution flow is measured by a mass flowmeter in the instrument.

The total diluted sample is drawn through a heated ½" stainless steel sample line and passed through the filter tape where any particulates (dust) in the sample larger than 0.3 microns (0.01 thousandths of an inch diameter) are accumulated.

The filtered diluted sample gas then passes through a flowmeter that measures the diluted sample gas flow in the hot, wet state. If a dry basis particulate concentration measurement is needed, the diluted sample gas flows through a chiller where the water is removed, and then through another mass flowmeter to calculate the dry total flow. The sample gas is finally vented back into the stack or into open air.

Sample Heater

The sample line is actively heated by an electrical resistance heater that is controlled by the BetaGuard PM. The dilution line is optionally heated at the Probe flange by an electrical resistance in-line air heater. Additional closed loop controlled heaters are mounted in the filter holder and optionally in the cabinet sample gas circuit to insure that the sample remains hot. The BetaGuard PM can also be set to continuously vary the sample temperature to track the stack gas temperature if Isothermal Sampling mode is selected.

Particulate Measurement Cycle

The diluted stack gas sample is brought to the filter tape through a conical pipe that is mounted to the top half of the filter holder. The top and bottom half of the filter holder fit together tongue-in-groove style to trap the filter tape and seal around the conical pipe. A stainless steel tube is attached to the bottom half of the filter holder below the filter tape opposite the conical pipe. This assembly insures that the filter tape remains stationary while the sample gas is passed through it without allowing any of the sample gas to escape.

The sample gas is passed through the filter tape long enough to deposit a sufficient amount of mass for the BetaGuard PM measurement, typically 4 – 28 mg. The sample flow cycle is usually 7-15 minutes depending on stack particulate concentration. The filter tape is moved back and forth from under the sample gas flow to between the Beta gauge source and detector by a stepper motor and a friction wheel drive. Each time the filter tape is moved, a solenoid separates the two halves of the filter holder. When the filter tape stops moving, the filter holder halves are pressed tightly together by compression springs.

A typical measurement cycle is as follows:

Step 1	The stepper motor advances the filter tape to a clean section within the filter holder (about 92mm [3.6"])
Step 2	No sample is passed through the filter tape while the left-hand Beta Gauge measures a clean section of the filter tape for 2 minutes. This provides the zero measurement of that spot of the filter tape.
Step 3	The stepper motor reverses the filter tape until the spot measured in Step 2 is exactly beneath the conical pipe sample gas outlet (46mm [1.8"]).
Step 4	The valve opens to allow the sample gas to flow through the filter tape for the predetermined cycle time. At the same time, the right-hand Beta Gauge measures the clean section of filter tape between its source and detector for 2 minutes to obtain the zero measurement of that spot.
Step 5	The stepper motor advances the filter tape until the spot that just filtered the sample gas is again directly between the source and detector of the left-hand Beta Gauge (46mm [1.8"]).
Step 6	The left-hand Beta Gauge measures for 2 minutes the same spot of the filter tape where it measured the zero previously, only now it is loaded with particulates. Simultaneously, the valve opens to allow the sample gas to flow through the spot of filter tape that was measured for a zero reference with the right-hand Beta Gauge in Step 4 for the predetermined cycle time.
Step 7	After the left-hand Beta Gauge has measured the particulate-loaded spot for two minutes, the particulate concentration is displayed and the 4-20mA output is updated.
Step 8	When the sample gas flow cycle time of Step 6 is complete, the stepper motor reverses the filter tape until the spot measured in Step 4 by the right-hand Beta Gauge is returned, now loaded with particulates (46mm [1.8"]).
Step 9	The right hand Beta Gauge measures the particulate loaded filter spot for 2 minutes, the particulate concentration is displayed and the 4-20mA output is updated.
Step 10	Upon completion of the Step 9, the measurement process begins again at Step 1.

An important consequence of the BetaGuard PM measurement principle is that it always re-zeros the filter prior to depositing the particulate sample. This allows the instrument to reuse the filter spot a number of times before it begins to clog and the filter must be advanced. If this resampling option is selected, the life of a reel of filter tape can be extended from one month to two or three months.

Blowback

When compressed air is provided to the BetaGuard PM and the measurement cycle begins, the compressed air actuates a pneumatically actuated valve that allows the stack gas to be drawn into the instrument and the BetaGuard PM to operate. The position of the pneumatic actuator is sensed to always insure that compressed air is present so that the probe can be blown back on a regular basis to eliminate the possibility of dirt build-up and clogging. The interval between blowbacks is user selectable from the BetaGuard PM display and is usually eight (8) hours. When blowback is initiated, either automatically or manually, a valve is closed to stop sample gas from flowing through the filter tape and high pressure (≈70psig) air is forced through the sample and dilution lines, through the nozzle into the stack. The compressed air is pulsed in 2 second on, 2 second off cycles for about 20 seconds.

Automatic Beta Calibration

This routine is usually run daily and initiated by the data logger and lasts about 30 minutes. Automatic Beta Calibration checks the repeatability of the Beta Gauge measurement component of the BetaGuard PM by performing a zero check, a span check and a filter tape positioning check. During an Automatic Beta Calibration, the normal measurement mode of the BetaGuard PM is suspended. The Automatic Beta Calibration routine can also be initiated immediately through the BetaGuard PM display.

Automatic Flow Calibration

This routine is usually run daily and initiated by the data logger and lasts about 30 minutes. Flow Calibration can be run concurrent to the Automatic Beta Calibration. Automatic Flow Calibration checks the repeatability of the flowmeter components of the BetaGuard PM by routing the same flow through all of the flowmeters at two separate flow setpoints to perform a low span and a high span check. During an Automatic Flow Calibration, the normal measurement mode of the BetaGuard PM is suspended. The Automatic Flow Calibration routine can also be initiated immediately through the BetaGuard PM display.

THEORY OF NUCLEAR GAUGING

There are typically three types of radioactive emission used for industrial mass gauging, Alpha (α), Gamma (γ) and Beta (β).

Alpha Emission

An Alpha particle is a ^{4}He nucleus and as such, is very large and heavy compared to the other forms of radioactive emission. They have very limited penetrating ability in solids and since Alpha gauging applications are used primarily for the measurement of gases, they will not be discussed further here.

Gamma Emission

Unlike Alpha (or Beta) radiation, Gamma radiation is not in the form of charged particles, but instead is electromagnetic radiation in and above the X-Ray spectrum. By analogy, a Beta source of, say, 500mCi activity emits as many Beta particles per second as the Gamma photons per second emitted by a 500mCi Gamma source.. Unlike Beta particles, Gamma photons are emitted at a single energy determined by the particular isotope and interact with matter through fundamentally different mechanisms. Gamma photons have no charge and no mass, and are consequently much more penetrating than Beta particles in matter (like X-Rays) and are used primarily for quite thick targets and for fluorescence measurements.

Beta Emission

Beta particles are in fact high energy electrons ejected from the nuclei of certain radioactive materials. They are negatively charged, have energies ranging from zero to a maximum energy (units of electron Volts [eV]) determined by the specific radioactive isotope and are emitted in an average number per second defined by the Activity (units of Curies [Ci]) of the particular radioactive source.

Beta particles interact with matter through three primary mechanisms:

1) Inelastic collisions with electrons in the target (*Absorption*)

$$f_1\{k_1\rho(Z/A)\} \qquad \textbf{eq. 11.1}$$

2) Elastic collisions with nuclei in the target (*Scatter*)

$$f_2\{k_2\rho(Z^2/A)\} \qquad \textbf{eq. 11.2}$$

3) Inelastic collisions with nuclei in the target (*Bremsstrahlung*)

$$f_3\{k_3\rho(Z^2/A)\} \qquad \textbf{eq. 11.3}$$

where k_n are constants proportional to the Beta energy,
ρ is target density,
Z is the target Atomic Number and
A is Atomic Mass.

Beta particles are particularly ideal for use in industrial gauging because of their relatively short range in matter and therefore high sensitivity to small changes in mass, and since the source / detector components are very long-term stable and industrially rugged. The Carbon-14 isotope used in most Beta Gauge Particulate Monitors has a half-life of over 5000 years, and therefore exhibits no measurable change in radiation output and thus no measurement drift throughout the life of the instrument. The G-M Tube detectors are simple gas-filled canisters with no moving parts. They exhibit no drift characteristics unless they are physically damaged, in which case their output goes to zero, an easily identifiable fault condition. In the unlikely event of a G-M Tube failure, the dual detector BetaGuard PM has the ability to sense the zero output condition and automatically switches its operating mode to that of a single detector Beta Gauge. In this way, the instrument will continue to measure properly with no loss of data, and repairs can be made in a non-emergency manner.

A consequence of the manner in which Beta particles interact with matter to determine mass is that there can be some measurement dependence on the chemical composition of the specific particulate. It is therefore worthwhile to investigate the extent to which the chemical composition dependence of the BetaGuard PM has on its ability to accurately measure the products of combustion. When considering the design of a Beta Transmission Sensor, a radioactive source is mounted on one side of the target and a Beta particle detector is mounted on the target's other side. The detector then measures the Beta particles that pass through the target.

Assuming that all the Beta particles that do not pass through the target and are not detected are in fact absorbed via mechanism 1, the response curve of the ß-Sensor would describe an exponential dependence (derived from Equation 1 above) on target mass and be independent of target chemical composition.

$$e^{-\mu x}, \text{ where } \mu = f1\{k_1\rho(Z/A)\}$$

If Equations 2 and 3 above are combined as

$$F\{K\rho(Z^2/A), \qquad \text{eq. 11.4}$$

then the total interactions of Beta particles with matter can be expressed by the following definition of μ, the absorption coefficient:

$$f_1\{k_1\rho(Z/A)\} + F\{K\rho(Z^2/A)\} \qquad \text{eq. 11.5}$$

where k and K include a dependence on the incident Beta energy,
Z is the target atomic number,
A is the target atomic mass, and
ρ is the target density.

Bear in mind that in the case of a Beta Transmission Sensor, any Beta particle that is not detected is assumed to be absorbed.

This implies that if some Beta particles that are not detected interact with the target by some mechanism other than absorption, such as backscatter from the target or deceleration and emission of X-Rays (Bremsstrahlung) that cannot be measured by the Beta detector, then a measurement error may occur. The practical threshold of the target atomic number below which K of equation 5 approaches zero, is a function of the Beta energy. In the case of the C14 Beta-emitting isotope used for particulate monitors, the beta energy (max) is 156kev and for target atomic numbers below 20, **K** of Equation 5 can be considered to be zero and the sensor is virtually insensitive to compositional changes.

If the target contains components of atomic number greater than 20, such as Iron, Chromium or lead, then **K** of Equation 5 is not zero, and any variation in the relative concentration of these elements may cause a measurement error proportional to the $\mathbf{Z^2/A}$ additive function (F) which becomes more pronounced with increasing concentration and increasing Z.

Compound	Class F	Class C
SiO_2	48	33
Al_2O_3	20	18
Fe_2O_3	20	8
CaO	3	25
MgO	1	8
K_2O	2	1
Na_2O_3	1	3
SO_3	1	3
LOI	3	0.5

Figure 11.1: Coal Fly Ash Composition by Class

It is important at this time to qualify the magnitude of any error due to changing chemical composition in stack gas effluent. One principle application of the BetaGuard PM is the measurement of airborne particulates from the stacks of coal-fired electric generating utilities. The typical fly ash chemistry will vary as a function of the fuel and can range from high Fe_2O_3, low CaO to high CaO, low Fe_2O_3 in the cases of various Lignite and Anthracite coals (see Figure 11.1).

Equation 5 can be rewritten in terms of the detected Beta particles passing through the target as:

$$I = I_0 \Sigma e^{-w_i \mu_i \rho x} \qquad \text{eq. 11.6}$$

where I is the Beta particle intensity after passing through the target,
I_0 is the original intensity of Beta particles emitted from the source,
μ_i is the Beta attenuation coefficient of each element in the target (the i^{th} element; physically, μ can be viewed as the probability of interaction per unit distance),
w_i is the concentration by weight of the i^{th} element,
ρ is the homogeneous material density and
x is the homogeneous material thickness.

μ_i is a function of the Beta particle energy, E, and the electron density of the absorber and is of the form,

$$\mu_i = Ci_1E(Z/A) + Ci_2E(Z^2/A)$$

where **Ci_1** is an empirically derived constant for mechanism 1 above and **Ci_2** is an empirically derived constant for the combined mechanisms 2 and 3 above.

It is interesting to compare the energy lost by each of the two terms above. Dividing these terms,

$$[(dE/dx)_{2,3} / (dE/dx)_1] = [Ci_2E(Z^2/A) / Ci_1E(Z/A)] = C \cdot E \cdot Z,$$

where **C** is a new constant, empirically derived as approximately 1/500 when **E** is in units of Mev.

At a maximum Beta energy for C14 of 0.156Mev, the amount of error created by a change in fly ash chemical composition of 15% Fe (Z = 26) is 0.8%. Substituting this effect into the exponential argument of equation 6, the effect of even this large a change in the higher atomic number composition of the fly ash chemistry will lead to at most a 1% measurement change not attributable to the consequent change in real particulate density.

For this reason, the BetaGuard PM is calibrated in the factory to a known, traceable set of mass standards. Upon installation on a stack, there is virtually no subsequent recalibration of the instrument required for the various application specific fly ash chemistry. The BetaGuard PM is virtually insensitive to chemical changes in the products of combustion. It will measure the particulate mass correctly and repeatably. In the cases of installation of the BetaGuard PM on other combustion or incineration processes that emit high atomic number pollutants, a correction factor may be required to bring the BetaGuard PM into calibration. This is facilitated by user-enterable scaling or offset factors stored in a comprehensive recipe in the Gauge electronics.

References:

1 Gardner, Robin P., and Ely, Ralph L., *Radioisotope Measurement Applications in Engineering*, Reinhold Publishing Corp, NY , 1967.

2 Knoll, Glenn F., *Radiation Detection and Measurement*, John Wiley & Sons, Inc., NY, 1989.

3 *Handbook of Nuclear Technology*, reprinted from Nucleonics, McGraw-Hill Publishing Co., NY, various dates.

4 *The Fly Ash Resource Center*, World Wide Web Site: http://www.geocities.com/CapeCanaveral/Launchpad/2095/flyash.html

5 *Various Publications*, The World Coal Institute, Oxford House, 182 Upper Richmond Road, Putney, London SW15 2SH United Kingdom.

DEP ROUTING AND TRANSMITTAL SLIP

TO: (NAME, OFFICE, LOCATION)

1. Bruce Mitchell
2. DARM MS5505
3.
4.
5.

PLEASE PREPARE REPLY FOR:

____ SECRETARY'S SIGNATURE

____ DIV/DIST DIR SIGNATURE

____ MY SIGNATURE

____ YOUR SIGNATURE

____ DUE DATE ________

ACTION/DISPOSITION

X DISCUSS WITH ME

____ COMMENTS/ADVISE

____ REVIEW AND RETURN

____ SET UP MEETING

____ FOR YOUR INFORMATION

____ HANDLE APPROPRIATELY

____ INITIAL AND FORWARD

____ SHARE WITH STAFF

____ FOR YOUR FILES

COMMENTS:

Recovery Boiler — increased red liquor solids — same heat input — lower PM due to MACT II.

AC for increased throughput?

RECEIVED
FEB 10 2004
BUREAU OF AIR REGULATION

SC 807-

FROM: Rita Smith DATE: 2-5-04 PHONE: 3239

DEP 15-026 (12/93)

Rayonier

Performance Fibers

Fernandina Mill

STATE OF FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION
2004 FEB -5 A 12: 16
NORTHEAST DISTRICT JACKSONVILLE, FL

February 3, 2004

Certified Mail, Return Receipt Requested

Mr. Christopher Kirts
Florida Dept. of Environmental Protection
7825 Baymeadows Way, Suite B200
Jacksonville, FL 32256

Re: Request for Additional Information on Title V Permit Renewal Application Dated November 5, 2003 for Final Title V Permit No. 08900004-5-AV

Dear Mr. Kirts:

In response to your request for additional information, please find the questions and Rayonier's answers below.

1. **It appears from the submitted data that PM emissions start to go back up if the pressure becomes too high. It appears that a maximum pressure drop across the scrubber for each boiler is warranted in addition to the minimum. Please provide this information.**

   It is true that the A scrubber graph on page 8 of the Capstone report does indicate a trend of higher emissions with higher differential pressure. This is merely an indication of the effect of other variables during the A scrubber (Nos. 1&2 boilers flue gas) testing. This effect was not apparent for the B (only No. 3 boiler flue gas) scrubber graph on page 4 of the Capstone report. The graphs were designed to illustrate the lower limit of pressure drop for which compliance could be assured. Attachment 1 (Control of Particulate Emissions Manual from the USEPA) and Attachment 2 (Operating and Maintenance Instructions for the Airpol Venturi scrubber) provide evidence of the relationship between pressure drop and particulate removal. It is scientifically accepted and apparent from the design data that higher pressure differential will improve the particulate emissions within the control range provided by these AirPol venturi scrubbers. In all cases the particulate tests were below the permit limit. Therefore, a maximum pressure drop limit is not needed.

ok min pressure only

2. **Please explain the submitted tests data. It is not clear why the PM lb/hr limit is equivalent to the permitted PM lb/hr limits for the three boilers. As an example, for the No. 2 Power Boiler firing oil only, the PM lb/hr limit is stated to be 31.2 lb/hr instead of 15.2. Please explain why the PM lb/hr limit is different for each test run despite being under the same fuel source.**

This is briefly explained on page 13 of the Capstone report. The EPA Method 5 particulate test can only be run on the scrubber stack. A-scrubber receives the flue gas from No. 1 and No. 2 power boilers. No. 1 boiler only burns oil. When No. 2 boiler, which is an oil and bark boiler, is only burning oil, A scrubber is on oil only. The particulate limit is based on the 16.0 lb/hr for No. 1 boiler plus the 15.2 lb/hr for No. 2 boiler resulting in a total of 31.2 lb/hr for the A scrubber emissions. For No. 3 boiler, which is normally the only boiler feeding the B-scrubber, the limit will always be 16.7 lb/hr when the boiler is burning oil only.

3. **On page 19, under subsection D, Monitoring Approach, and Data Representativeness, it is stated that, "The sample size on the tape can be controlled by the pressure drop across the tape or by timer." Please explain what is mean by this statement. Can the sample size be easily altered? If this is the case, then it appears that an indicator will need to be established that can demonstrate that the sample size is being maintained equivalent to the size measured during the test.**

   Attached to the initial Title V permit Application of November 5, 2002 was a Continuing Compliance Methodology dated August 16, 2002 which included MSI BetaGuard PM monitor operating and calibration procedures. The entire sample procedure is automatic and cannot be easily altered. The sample size [volume of sample gas] timer is set during the initial installation to assure there is enough particulate collected on the fiberglass filter tape. Any variability in the sample volume is from the automatic isokinetic sampling provided by the metering system. For each measurement, the actual volume of gas, which passes through the filter, is measured. Even if it sample time could be adjusted, it would have no effect on the mg/scm result.

   ? No CAM for No. 6 R.B. Due to MACT and AC. J.H. 6/29/04

4. **Page 22 of the CAM Plan states that a beta guard monitor concentration reading of less than 66 mg/scm indicates the particulate emissions are in compliance at less than 67.5 lb/hr. The permitted PM emissions limit for the Recovery Boiler are not to exceed 2.6 lb. PM/air dry ton of unbleached pulp. Equivalent emissions are 67.5 pounds per hour and 295.6 tons per year. It is requested that the proposed indicator range be changed as it is currently set right at the permit exceedance level. The selection of indicator ranges should be such that the allowable emissions limitations are protected by operations at those indicator ranges.**

   Please find attached an Application for Alternative Monitoring Method for the Recovery Boiler subject to 40 CFR Part 63, Subpart MM submitted to Mr. Lee Page of EPA Region IV. This is for the Beta Guard PM monitor method described in the CAM Plan. Since the rule provides a lower limit for particulate at 0.092 grams/dscm, the Beta Guard PM monitor concentration must also be lowered. In that application, statistics were used to determine the variability of the emissions around the calibration line. Based on this analysis and the requirements of the new rule a limit of 45 mg/scm three-hour average Beta Guard reading is now provided in the revised CAM plan attached. The requirement for a CAM Plan for the recovery boiler will end when the MACT requirements noted above go into effect on March 13, 2004. NOT SO!

As noted in the answer to question 4 above, section B of the recovery boiler CAM Plan states that after the MACT provisions go into effect for this boiler on March 13, 2004, the CAM Plan will not be required for the recovery boiler.

5. **Please explain how a "fuel transition" is performed. What actually happens during a fuel transition? Are there excess emissions generated during a fuel transition? If so, please state the typical duration of such excess emissions.**

   The operator training material provided with the October 3 RAI response covered this question in some detail. To specifically answer the question, there are three fuel options – oil only, bark and oil mixture, and bark only. No. 1 boiler can only burn oil. For boilers 2 and 3, bark is the most economical and therefore the preferred fuel. As the manual explains, the boiler combustion control surrogate, oxygen concentration, must be within CAM limits after 45 minutes from the transition or the boiler automatically shuts down [removes all fuel].

   When transitioning from bark to bark & oil burning, the operator opens the air to oil damper prior to lighting an oil gun. He sets the air to provide more excess air than will be required after the transition to assure thorough combustion. Oxygen control is the key to assuring there are no excess emissions. It is possible that an oxygen supply imbalance occurs during the transition with an excess emission, but this is usually returned to control within 2 minutes.

   When transferring from bark & oil to oil only, bark flow to the boiler is stopped. The bark in the boiler will then burn down until it is all combusted. The operator controls the air to bark ratio as long as there is bark in the boiler. This transition normally has no potential for excess emissions, as the bark requires more excess oxygen than oil.

   When bark is re-introduced to the boiler, it is done gradually. There are bark feeder controls for each boiler bark-burning cell. Again, excess oxygen concentration is increased before the bark is started into the boiler. This transition does not normally result in excess emissions due to the gradual addition of bark to the boiler and the higher excess air provided. Once a full bark fire is established throughout the boiler and there is a stable steam production header pressure, oil flow may be discontinued. At this transition the air to oil damper is initially open resulting in higher excess air for the bark. On this basis, there is normally no excess emission with this transition.

   In summary, fuel transitions are under good control and excess emissions are normally under 2 minutes.

As requested, the updated CAM Plan is enclosed in both paper and electronic formats. Also enclosed are:

1. A copy of our "Application for Alternate Monitoring Method for the Recovery Boiler" subject to 40 CFR Part 63, Subpart MM at the Rayonier Performance Fibers LLC, Ammonia Based Dissolving Sulfite Pulp Mill, at Fernandina Beach, FL" as submitted to Mr. Lee Page of EPA Region IV on January 29, 2004 is enclosed. This document includes the lower emissions requirement under the MACT II regulations which go into effect on March 13, 2004.

2. A Title V General Emissions Unit Information form for the Recovery Boiler at a higher input burning rate of 74,300 lb. spent sulfite liquor solids per hour is provided. This allows for additional recovery boiler catch-up capacity at a lower MACT II emissions limit. The overall liquor burning for the year continues to be limited by the pulp production limit of 153,205 ADMT per year. This form was completed with the present Title V emissions limits and the MACT II limits as suggested by Ms. Rita Felton-Smith of your office.

The requested Responsible Official (R.O.) Certification Statement and the Professional Engineer (P.E. Certification Statement) are enclosed for this submittal.

Yours very truly,

W. M. Burch
General manager

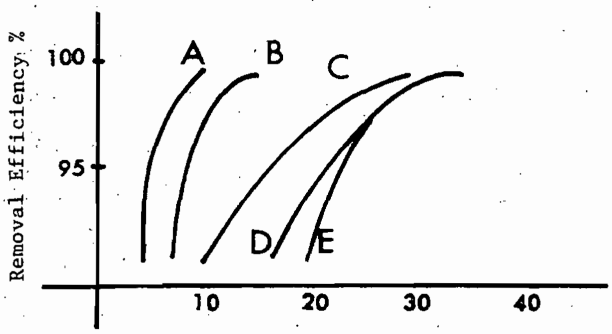
Attachement 1

Control of Particulate Emissions

Conducted by
CONTROL PROGRAMS DEVELOPMENT DIVISION
Air Pollution Training Institute
Research Triangle Park, North Carolina 27711

June, 1973

The Control of Particulate Emissions manual has been prepared specifically for the trainees attending the course and should not be included in reading lists or periodicals as generally available.



Venturi Pressure Drop (in. w. g.)

Curve A: Rotary iron powder kiln

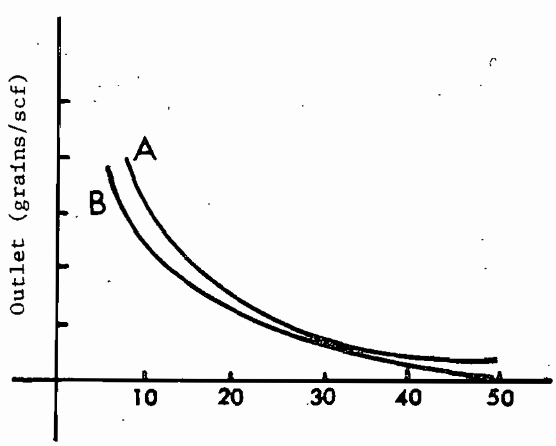
B: Lime kiln, asphalt plant

C: Iron cupola

D: Phosphoric acid plant (acid mist)

E: Incinerator (sodium oxide fumes)

Figure 2[5]

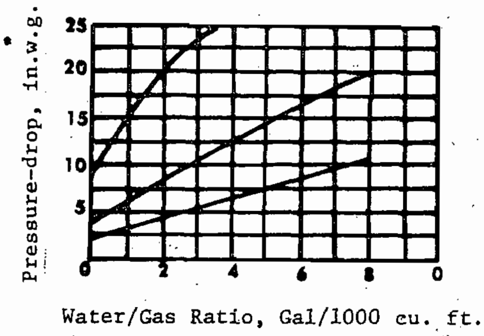


Venturi Pressure Drop (in.w. g.)

Curve A: Cupola gases

B: Blast furnace gases

Figure 3[5]



Relation Between Pressure-loss and Water Usage in Venturi Scrubber

Figure 4

4 When gas cleaning requirements change, the only adjustment necessary to the Venturi scrubber, in most cases, is in the flow of scrubbing liquid to increase the pressure drop. Thus higher cleaning efficiency is accomplished without modification or addition.

B Effect of Particle Concentration on Efficiency

1 If the number of water droplets is held constant and the number of particles (concentration) is increased, the number of collisions would be expected to increase. In other words, collection efficiency should increase as loading increases.

2 This increase, however, is due not only to the increased chances of particle collision with droplets, but also due to collisions between the particles themselves.

C Size-Efficiency

1 The Venturi scrubber approaches 100% for all particles larger than 1.5 to 2 microns.

2 Figure 5 shows a size-efficiency curve for a Venturi scrubber[1]. Sizes above 2-microns were obtained on special

APPLICATION INFORMATION

Application Responsible Official Certification

Complete if applying for an initial/revised/renewal Title V permit or concurrent processing of an air construction permit and a revised/renewal Title V permit. If there are multiple responsible officials, the "application responsible official" need not be the "primary responsible official."

1. Application Responsible Official Name:

2. Application Responsible Official Qualification (Check one or more of the following options, as applicable):
   - ☐ For a corporation, the president, secretary, treasurer, or vice-president of the corporation in charge of a principal business function, or any other person who performs similar policy or decision-making functions for the corporation, or a duly authorized representative of such person if the representative is responsible for the overall operation of one or more manufacturing, production, or operating facilities applying for or subject to a permit under Chapter 62-213, F.A.C.
   - ☐ For a partnership or sole proprietorship, a general partner or the proprietor, respectively.
   - ☐ For a municipality, county, state, federal, or other public agency, either a principal executive officer or ranking elected official.
   - ☐ The designated representative at an Acid Rain source.

3. Application Responsible Official Mailing Address...
   Organization/Firm:
   Street Address:
   City: State: Zip Code:

4. Application Responsible Official Telephone Numbers...
   Telephone: ( ) - ext. Fax: ( ) -

5. Application Responsible Official Email Address:

6. Application Responsible Official Certification:

   I, the undersigned, am a responsible official of the Title V source addressed in this air permit application. I hereby certify, based on information and belief formed after reasonable inquiry, that the statements made in this application are true, accurate and complete and that, to the best of my knowledge, any estimates of emissions reported in this application are based upon reasonable techniques for calculating emissions. The air pollutant emissions units and air pollution control equipment described in this application will be operated and maintained so as to comply with all applicable standards for control of air pollutant emissions found in the statutes of the State of Florida and rules of the Department of Environmental Protection and revisions thereof and all other applicable requirements identified in this application to which the Title V source is subject. I understand that a permit, if granted by the department, cannot be transferred without authorization from the department, and I will promptly notify the department upon sale or legal transfer of the facility or any permitted emissions unit. Finally, I certify that the facility and each emissions unit are in compliance with all applicable requirements to which they are subject, except as identified in compliance plan(s) submitted with this application.

   [signature] 2/4/04
   Signature Date

APPLICATION INFORMATION

Professional Engineer Certification

1. Professional Engineer Name: **David A. Buff**
   Registration Number: **19011**
2. Professional Engineer Mailing Address...
   Organization/Firm: **Golder Associates Inc.****
   Street Address: **6241 NW 23rd Street, Suite 500**
   City: **Gainesville** State: **FL** Zip Code: **32653-1500**
3. Professional Engineer Telephone Numbers...
   Telephone: **(352) 336 - 5600** ext. Fax: **(352) 336 - 6603**
4. Professional Engineer Email Address: **dbuff@golder.com**
5. Professional Engineer Statement:

I, the undersigned, hereby certify, except as particularly noted herein, that:*

(1) To the best of my knowledge, there is reasonable assurance that the air pollutant emissions unit(s) and the air pollution control equipment described in this application for air permit, when properly operated and maintained, will comply with all applicable standards for control of air pollutant emissions found in the Florida Statutes and rules of the Department of Environmental Protection; and

(2) To the best of my knowledge, any emission estimates reported or relied on in this application are true, accurate, and complete and are either based upon reasonable techniques available for calculating emissions or, for emission estimates of hazardous air pollutants not regulated for an emissions unit addressed in this application, based solely upon the materials, information and calculations submitted with this application.

(3) If the purpose of this application is to obtain a Title V air operation permit (check here ☒, if so), I further certify that each emissions unit described in this application for air permit, when properly operated and maintained, will comply with the applicable requirements identified in this application to which the unit is subject, except those emissions units for which a compliance plan and schedule is submitted with this application.

(4) If the purpose of this application is to obtain an air construction permit (check here ☐, if so) or concurrently process and obtain an air construction permit and a Title V air operation permit revision or renewal for one or more proposed new or modified emissions units (check here ☐, if so), I further certify that the engineering features of each such emissions unit described in this application have been designed or examined by me or individuals under my direct supervision and found to be in conformity with sound engineering principles applicable to the control of emissions of the air pollutants characterized in this application.

(5) If the purpose of this application is to obtain an initial air operation permit or operation permit revision or renewal for one or more newly constructed or modified emissions units (check here ☐, if so), I further certify that, with the exception of any changes detailed as part of this application, each such emissions unit has been constructed or modified in substantial accordance with the information given in the corresponding application for air construction permit and with all provisions contained in such permit.

David A. Buff
Signature

2/03/04
Date

(seal)

* Attach any exception to certification statement.
** Board of Professional Engineers Certificate of Authorization #00001670

ITT RAYONIER	SED PROJECT S-73/9
P. O. 00123 TAG	FILE 17
VENDOR Air Pollution Ind.	
CONTENT	

Attachment 2

OPERATING & MAINTENANCE INSTRUCTIONS

AirPol Job #1644

PAR 3F-72-81

December 11, 1974

Client:	ITT Rayonier
Client Order #	FPA 00123
Job Site:	ITT Rayonier Inc. Fernandina Division Fernandina Beach, Fla.

INDEX

Application: Venturi Scrubbers to Clean Gases From Two (2) Power Boilers

I OPERATING CONDITIONS

Fuel Fired		Bark and Oil
Scrubber Inlet Gas Volume		162,000 ACFM (System B) 182,000 ACFM (System A)
Inlet Gas Temperature		443°F (System B) 446°F (System A)
Inlet Scrubber Loadings	SO_2	Particulate
System B	1045 lbs/hr.	310 lbs/hr. or .48gr/SCFD
System A	880 lbs/hr.	1240 lbs/hr. or 1.76 gr/SCFD
Pressure Drop Across Venturi		15" w.g.
Pressure Drop Across Separator		2" w.g.
Scrubbing Liquid		Caustic Effluent (pH 6)
Recycle Rate		1500 GPM (System B) 1800 GPM (System A)
Make-Up For Evaporation		77 GPM
Outlet Gas Volumes		122,792 CFM (System B) 135,972 CFM (System A)
Outlet Gas Temperature		154°F
Maximum Outlet Loadings	SO_2	Particulate
System B	385 lbs/hr.	35 lbs/hr. or .039 gr/SCFD
System A	324 lbs/hr.	29 lbs/hr. or .03 gr/SCFD

II DESCRIPTION OR PROCESS

Flue gases discharged from the power boiler power boiler proceed through ducting and enter an AirPol Circular Type Venturi Scrubber. The scrubber is provided with an adjustable throat for compensation of changes in gas volumes. The venturi scrubber operates on a principle of thorough atomization of the scrubbing liquid and prolonged contact to remove essentially all plus micron particulates as well as sub-micron particles depending upon pressure drop across the unit.

The scrubbing liquid enters the scrubber through six nozzles distributed around the inlet and throat creating a complete wet flooded approach to eliminate build-up problems and reduce abrasion effects. The scrubbing liquid may be dirty, containing 1 - 3% solids which can be recycled without major treatment. No plugging difficulties are anticipated with the AirPol Venturi design.

The scrubbed gases and liquid with collected solid particles continue to an AirPol Spin-Vane Separator which further cleans the gas to remove particulate. Finally, the gas spins through the separator spin vanes exiting at the top of the unit, while liquid and solids exit at the bottom of the vessel to a separate recycle tank for recirculation to the scrubber. Make-up caustic is added to the recirculation system and proper bleed rates establish required percentage solids solution.

III PRINCIPLE OF VENTURI OPERATION

The AirPol Venturi Scrubber contains a liquid inlet which sprays a curtain of scrubbing liquid on the walls of the converging section (self-cleaning action) of the venturi. The scrubbing liquid uniformly flows along the converging section creating a completely wetted surface to the dirty gas entering through the inlet. As the liquid enters the throat, it is deflected into the gas stream. In this manner, the gas must penetrate through a solid curtain of scrubbing liquid in the high velocity throat. The gas breaks up the liquid into fine droplets which collide with the suspended dust and fume, and trap the particles in the liquid droplets.

The cleaning efficiency of the venturi depends on the pressure drop across the unit, increasing with increasing pressure drop. Thus the unit should be operated at as high a pressure drop as is practical within available pressure limits. (Figure 1). This is independent of whether the pressure drop is maintained by liquid rate (figure 2) or by flowing gas volume (Figure 3).

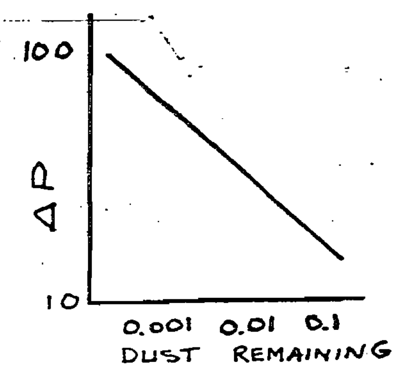


FIG 1

The operation of the venturi scrubber is primarily controlled by the amount of water in contact with the gas at the throat. For a fixed gas flow, the pressure drop across the venturi will increase (as will the efficiency of dust removal) with increased liquid flow to the venturi (Figure 2).

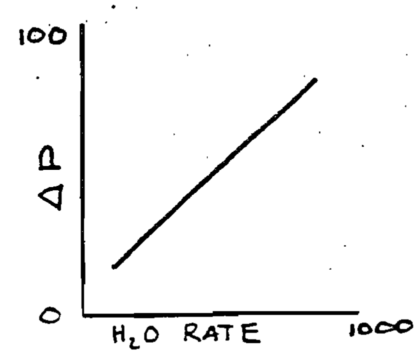


FIG. 2

For a fixed rate of scrubbing liquid, the pressure drop across the venturi increases as the gas flow is increased (Figure 3).

PRINCIPLE OF VENTURI OPERATION (cont'd.)

More liquid is required, therefore, at reduced gas flows to maintain scrubbing efficiency.

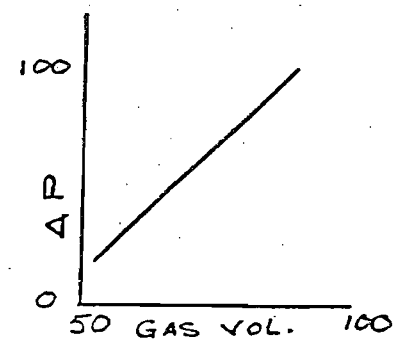


FIG. 3

The unit has been designed specifically to handle a full range of gas volumes. Since the control of pressure drop by varying liquid rates for changes in gas volume is limited to a percentage of the design volume, radical changes in gas flow will require an adjustment of throat area.

AirPol's air-cylinder operated "leaf-type" dampers have been installed in the venturi throat to enable the operator to reduce the cross-sectional throat area to compensate for different gas flows.

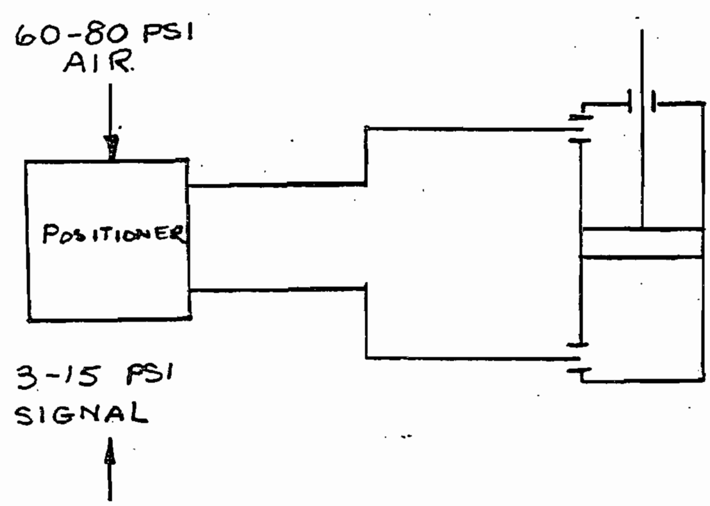
For this particular application, the operator can vary the pressure drop across the venturi by controlling a fixed pressure at venturi inlet or he can keep the venturi pressure drop constant.

IV INSTRUMENTATION

Generally, it is recommended that the Client provide a flow measuring device (indicating or recording type) to measure scrubbing liquid flow to the venturi and a gas pressure drop instrument (indicating or recording type) to measure venturi pressure drop. The liquid supply may be regulated by a remotely operated manual or automatic control valve, if the Client desires.

The "leaf-type" dampers in the venturi throat are controlled by the air cylinder and positioner supplied by AirPol. The throat pressure drop is continuously measured by a differential pressure transmitter (supplied by the Client). It sends a signal, proportional to the throat pressure drop, to the recorder-controller (also supplied by the Client). A deviation from the preset pressure differential will cause the controller to send a signal to the AirPol positioner. The AirPol air cylinder is then moved by the air signal from the positioner.

The positioner receives plant air, in this case 40 to 80 psi instrument quality air, on one side which moves the piston in the cylinder. It also receives a 3 to 15 psi signal on the other side from the controller. At the 3 psi signal, the cylinder closes the dampers and at the 15 psi signal the cylinder opens the dampers or vice versa. If the signal is 9 psi the piston is mid-way.



V INSTALLATION

V.1 Venturi Scrubber

Caution. The venturi scrubber is not designed to support any weight or absorb any momements from external connections such as piping or ductwork.

Be sure to use both a gasket and caulking compound when making up the outlet flange of the venturi scrubber. This flange must be water tight! Adaquate clearance adjacent to the venturi should be provided for removal of the shafts in the adjustible throat assembly. (10 feet minimum).

No special instructions are required for piping to the venturi scrubber, other than as mentioned in the caution above. If plastic piping is used, refer to manufacturer's instructions. Be sure a cleanout plug is installed at each water inlet. Water pressure gauges in the venturi lines (with proper diaphram protection) should be installed as shown on AirPol drawing S-106.

Before starting up the venturi, a check should be made to see that there are no obstructions in the throat. This may be accomplished by visual inspection through the flooded elbow access door and by physically moving the throat damper blades.

Liquid distribution should also be checked using liquid before start-up of the system. All drains and overflow connections from the separator should be checked as to adequate seal legs.

V.2 Separator

No special installation instructions are required. The separator is not designed to support any weight or absorb any moments from external connections such as piping or ductwork.

Equipment should be level and all liquid connections gasketed and tight enough to prevent leaks.

INSTALLATION (cont'd.)

V.3 Recirculation Tank

No special installation instructions are required except it is important that this equipment is level, because of proper operation of the skimming mechanism.

VI START-UP PROCEDURE

Before starting the following procedure, make sure all manholes are covered and all erection debris has been flushed out of ducts, water lines and vessels. System is to be started before power boiler is in operation and kept in operation until boiler is shut down.

1. Set water lines

   a) Venturi inlet water valve open
   b) Venturi throat water valve closed
   c) Pump suction valve open

2. Turn main water valve on. This will start filling system. The recirculation tank bleed valve will maintain tank level for a given rate of make-up water.

3. Start recirculation pump. Observe that flow to the venturi inlet is established by adjusting the venturi inlet flow control valve.

4. Put venturi throat control to "manual" and partially close venturi damper.

5. Start fan and after fan is up to speed, manually adjust throat damper to establish venturi static pressure.

6. Open venturi throat water valve to establish flow.

7. Put throat control on automatic and readjust venturi inlet and throat flow control valves to establish flows. Verify inlet and throat water pressure.

8. System is now in operation, and power boiler may be put into operation. Check the items given on the "operating check list" at intervals stated.

VII MAINTENANCE

The AirPol Venturi Scrubber requires little maintenance, due to its inherent design characteristics. It is specifically designed to handle all types of liquids from clear liquid to heavy slurries. If heavy slurries are being used as the scrubbing liquid, periodic inspections should be made to determine if any build-up of solids has occurred. Such build-up may be easily removed by flushing with fresh water or manually scraping clean.

The only item requiring maintenance is the adjustable throat mechanism which requires some periodic maintenance of some of the parts which are located outside the venturi and are easily accessible. These parts and the maintenance schedule are as follows:

Air Cylinder — The cylinder supplied with the venturi is prelubricated and should require no further lubrication. If lubrication data is required, consult cylinder manufacturer. (See list of replacement parts to determine what parts, if any, you might want to stock.)

Positioner — This instrument is relatively free of mechanical problems and should require no maintenance. (See Bailey instrumentation)

Air Supply Lines — Although the sizes and design layout of these lines is not specified on any AirPol drawings, we wish to make the following suggestions:

1. The pressurized air should be free of dirt and moisture of any kind and should be in accordance with "instrument air quality standards."

2. The pipe lines must be properly sized and sloped toward the drain collecting legs or bottom plugs.

3. After some days of inactivity, the air supply lines must be drained and purged by allowing the air to be discharged

MAINTENANCE (cont'd.)

through the open drains. This must be done before placing the cylinder and positioner in operation.

Bearings — These are located at the ends of each shaft and must be greased periodically. There are four (4) such bearings and they are equipped with grease fittings, as shown on attached drawing S-294 and S-294B.

Pivot Points — These are points where the connected parts turn and these points are between the cylinder end and the arms. (See drawing) There are four (4) such points and the pins are of stainless steel material. A small quantity of commercial grease with graphite spread periodically between the washers is sufficient to keep these parts lubricated.

OPERATING CHECK LIST

	At Start-Up	Hour	Shift	Day
At Equipment Location				
Sump/Drains			X	
Pump Pressure	X		X	
Sump Pump				X
Dump Recycle Tank				X
At Panel				
Water Level	X			
Pressure Drops	X		X	
Amperage		X		X
Throat Operation	X		X	
Make-Up Solenoid Valve	X			
At Venturi Platform				
Venturi Water Pressures	X		X	

MAINTENANCE CHECK LIST

	Daily	Weekly	Monthly	Six Months*
Check Fan Vibration	X			
Clean and Inspect Fan			X	
Clean Level Control		X		
Check High Temperature Alarm		X		
Clean Trap of Pressure Gauges			X	
Check Venturi Throat Damper		X		
Lubrication				
Fan & Motor		X		
Pump Motor		X		
VS Throat Opr.		X		
Check Pump Impeller			X	
Check for Corrosion and Cleanliness				
Separator				X
Fan Inlet Duct				X
Separator/Stack				X
Recycle Tank				X

* After original start-up, these items should be checked monthly for the first six months.

VIII TROUBLE SHOOTING

1) Stack temperature is above 150 °F (except where by-pass is used)

   a) There is not enough scrubber water flow. Check and verify flow rates to both venturi and separator. Check pumps and verify pump amperage is normal.

2) Recirculation pump amperage rises at normal slurry flow

   a) Slurry solids may be rising. Check and restore bleed-off flow if necessary.

   b) Slurry pump has mechanical problem.

3) No correlation between venturi pressure drop and outlet loading efficiencies

   a) Check for plugging of venturi gauges giving incorrect static pressure readings, or if used, pressure control valves are malfunctioning.

IX RECOMMENDED SPARE PARTS LIST

The following is a list of spare parts, short of nuts and bolts for one scrubbing system, that can be kept on hand in the event of emergencies arise. Some of the items that make-up and the adjustable throat mechanism are proprietary items and can be supplied by AirPol. These items are the dampers, shafts, inserts and spray nozzles.

Item	Quantity	Description
1	1	Air Cylinder: Series LR2A, Style MS2 cushioned both ends, 10" bore x 19" stroke. Vendor: Hycholine Company or equivalent.
2	1 (Insurance)	Bailey Pneumatic positioner: Type P88-4 with linear relation cam, and 3/16" pilot valve stem complete with by-pass valve. Stroke length = 3½", 50 - 100 psig, 3 - 15 psig signal. Positioner 5321130A2 per dwg. B3010419-G and linkage 5312449-4.
3	2 (Insurance)	Dodge Bearings: 3" type E flange bearings with 3" shaft size.
4	75 ft.	Packing: 3/8" square asbestos rope for stuffing box (Rayasbestos #380 BY)
5	40 ft.	Gasketing: 1/8" thick asbestos gasket 3" wide drilled to suit for stuffing box flange cover.

Rayonier

Performance Fibers

Fernandina Mill

Certified Mail, Return Receipt Requested

January 28, 2004

Mr. Lee Page
Region IV
Environmental Protection Agency
61 Forsyth Street
Atlanta, GA 30303-8960

RE: Application for Alternate Monitoring Method for the Recovery Boiler subject to 40 CFR Part 63, Subpart MM at the Rayonier Performance Fibers LLC, Ammonia Based Dissolving Sulfite Pulp Mill, at Fernandina Beach, FL

Dear Mr. Page:

Rayonier owns and operates an ammonia based sulfite recovery boiler at Fernandina Beach, Florida. This boiler is subject to 40 CFR Part 63, Subpart MM. This rule limits particulate emissions from combustion sources at sulfite pulp mills, specifically the recovery boilers. It also requires specific monitoring for boilers using scrubbers to control particulate emissions. The recovery boiler at the Rayonier Performance Fibers LLC Fernandina Beach Sulfite Mill uses a Brinks filter to control particulate emissions. This device is different than a scrubber. This letter is an application for an Alternate Monitoring Method for devices other than those anticipated by the rule as allowed by 40 CFR 63.864(a)(5).

For alternate Monitoring Method Applications Section 864(f) requires the owner provide to the Administrator a monitoring plan that includes a description of the control device, test results verifying the performance of the control device, the appropriate operating parameter that will be monitored, and the frequency of the measuring and recording to establish continuous compliance with the standards. This letter provides the information required by the regulation and requests approval of this Alternate Monitoring Method as allowed.

1. Description of the Control Device

An ammonia based sulfite recovery boiler does not remove smelt, as does a kraft recovery boiler because the red liquor fired as fuel has little if any ash. Ammonia based sulfite recovery boilers have accumulated bottom ash removed once or twice a week. With no components in the fuel to cause bottom or flyash little particulate occurs in the boiler, except any due to improper combustion. Improper combustion causes the recovered ammonium sulfite to become black and this is intolerable in the cooking process. Thus good combustion practices are mandatory for process as well as regulatory reasons, and little particulate is formed by the boiler.

The recovery boiler burns the spent sulfite liquor, releasing sulfur dioxide, which is collected to form ammonium bisulfite in the subsequent scrubber. In this process some ammonium sulfite is converted to ammonium sulfate. Ammonium sulfate forms a fine, highly reflective particle, and in this case is in a moisture saturated stream. It is the predominate particulate emission from this boiler.

Collecting this particulate is difficult because it is a wet stream. Measuring for it is also difficult because opacity monitors do not function on saturated streams because the water vapor interferes with the measurements. Also the particle is so highly reflective very small amounts overwhelm the opacity monitor. The parameters referenced in the rule, scrubber pressure drop and liquid media flow, are not useful parameters for estimating particulates from Brinks type filters.

2. Test results verifying the performance of the control device

There are many stack tests of this emission source following the Brinks. The air operating permits have required annual tests. These tests have been submitted to the Florida Department of Environmental Protection for review and approval. There are only a few tests of this source after the Brinks was recently upgraded. All 11 of these tests used to determine compliance and to select surrogate parameter ranges are presented in the attached Table 1.

These tests demonstrate the control device meets the existing permit limit and the proposed limit in 40 CFR Part 63, Subpart MM. The Subpart MM regulation requires that particulate matter emissions from this boiler not exceed 0.092 grams/dscm. The existing permit limits the boiler to 67.5 pounds per hour. Three tests run on July 24 and 25, 2003 to establish an ~~out-of~~ compliance limit for intentionally exceed the allowed particulate emission rate ~~and~~ were the subject of a modification of a Title V permit to allow temporary, partial opening of the Brinks bypass damper for this purpose. This enabled calibration of the proposed particulate monitor over a range that included compliance. The upgraded Brinks has reduced particulate emissions to very low levels and bypassing the Brinks filters was the only practical way to increase particulates to determine monitor performance at higher particulate emissions. Below is a detailed discussion of the proposed surrogate monitor and its ability to predict particulate emissions.

3. Operating Parameter that will be monitored

Many efforts have been made to find boiler, scrubber or Brinks operating parameters that indicated particulate emissions. All efforts failed. Since no operating parameters were found that relate to particulate emissions, and opacity monitoring was impossible, the mill searched for other methods to measure particulates in the emission. The mill found a company glass fiber filter

marketing a device professing to be able to monitor particulate emissions on almost a continuous basis using ~~paper~~ tape sampling technology. After a trial the mill purchased a monitor and has found good agreement between monitored and tested particulate emissions.

This monitor measures the added mass on a glass fiber filter tape using beta particle attenuation. A clean section of tape is measured for beta attenuation. A sample of stack gas is isokinetically taken from the stack and pulled through the tape. Beta attenuation is re-measured. The difference in beta attenuation is correlated to stack gas particulate concentration.

Table 1 presents the Beta attenuation monitor reading for each EPA Method 5 test. The results are also graphically presented in Figure 1. The initial tests were clustered at readings well below the Subpart MM limit. The three high tests resulted from cracking open the control equipment by-pass valve. A permit was obtained from the Florida Department of Environmental Protection to open this bypass specifically for these tests only. Its is not certain that the intervening points are linear as is drawn in Figure 1. Of course the instrument is new technology and the precision of this method over time is also unknown. The Beta source, Carbon 14, has a known half-life of 5000 years. To date, (it was installed ~~last~~ April 8, 2003) the instrument has been relatively maintenance free compared to other such monitors. The Brinks filter media has a history of deteriorating with use. As time passes and more stack tests are accumulated the intervening emission concentrations will be obtained to compare with meter readings.

Daily the instrument runs both span and zero checks on both the beta particle measurement and the sample flow measurement. The attached letter dated January 27, 2004 to Richard Langford, of Rayonier Performance Fibers LLC from Eric Reber of MSI/Mechanical Systems, the manufacturer, describes the routine drift checks and calibration checks. Also attached is the manufacturer's description of this monitor.

4. Frequency of Measuring and Recording that will establish continuous compliance

At least one sample is taken every 15 minutes. A record of each 15-minute sample result will be maintained for 5 years. One sample every 15 minutes complies with the CAM Rule and meets the required monitoring frequency of Subpart MM.

The rule at 40 CFR 63.864(C)(2)(v) provides that, for an affected source equipped with an alternative air pollution control system approved by the Administrator, a violation of the standard occurs with 6 or more 3-hour average values within any 6 month reporting period are outside the range of parameter values established in paragraph (b)(2). The monitor readings proposed in the next section are meant to be those 3 hours averages which when exceeded 6 or more times in any 6 months period will be deem to be a violation of Subpart MM.

ed

Proposed Alternate Monitoring Method

We are proposing to monitor beta particle attenuation across a sample of particulate collected by a glass fiber tape sampler. This monitor has been described above.
A linear regression analysis determined the correlation equation and the correlation coefficient relating meter readings to EPA Method 5 stack test data. As can be seen from Figure 1, where this analysis is presented, a very good correlation coefficient of ~~0.99~~ 0.98 was obtained.

When this meter is approved as an alternate method, we will submit ~~obtain~~ a modification of the Title V permit for this facility to include a limit which exceeded by 6 or more 3-hour average values within any 6 months reporting period, a violation of this standard has occurred. Based on the regression analysis of the available data that limit should be a meter reading of 0.045. By inspection of Figure 1, even at a meter reading of 0.045, one is quite confident the 0.092 gm/dscm emission limit is not exceeded.

If you have questions regarding these applications, please contact David Tudor at (904)277-1452, E-mail: david.tudor@rayonier.com, or Richard Hopper at (904) 277-1480, E-mail: richard.hopper@rayonier.com.

Sincerely,

W. M. Burch
General Manager

cc: Christopher L Kirts
FL DEP - JAX

TABLE 1 SULFITE RECOVERY BOILER PARTICULATE EMISSIONS

Date	Run No.	PM (gm/dscm) @8% O_2	Beta Monitor PM (g/scm)	
4/14/2003	1	0.0236	0.0156	66.1%
4/14/2003	2	0.0264	0.0175	66.3%
4/14/2003	3	0.0300	0.0189	63.%
4/14/2003	4	0.0370	0.0188	50.8%
4/15/2003	5	0.0360	0.0191	53.1%
7/24/2003	4	0.0321	0.0155	48.3%
7/24/2003	5	0.0356	0.0150	42.1%
7/24/2003	6	0.0264	0.0150	56.8%
7/25/2003	7	0.1509	0.0786	52.1%
7/25/2003	8	0.1812	0.0755	41.7%
7/25/2003	9	0.1405	0.0733	52.2%

.092 grams/dscm
& 67.5 lb/hr.

FIGURE 1

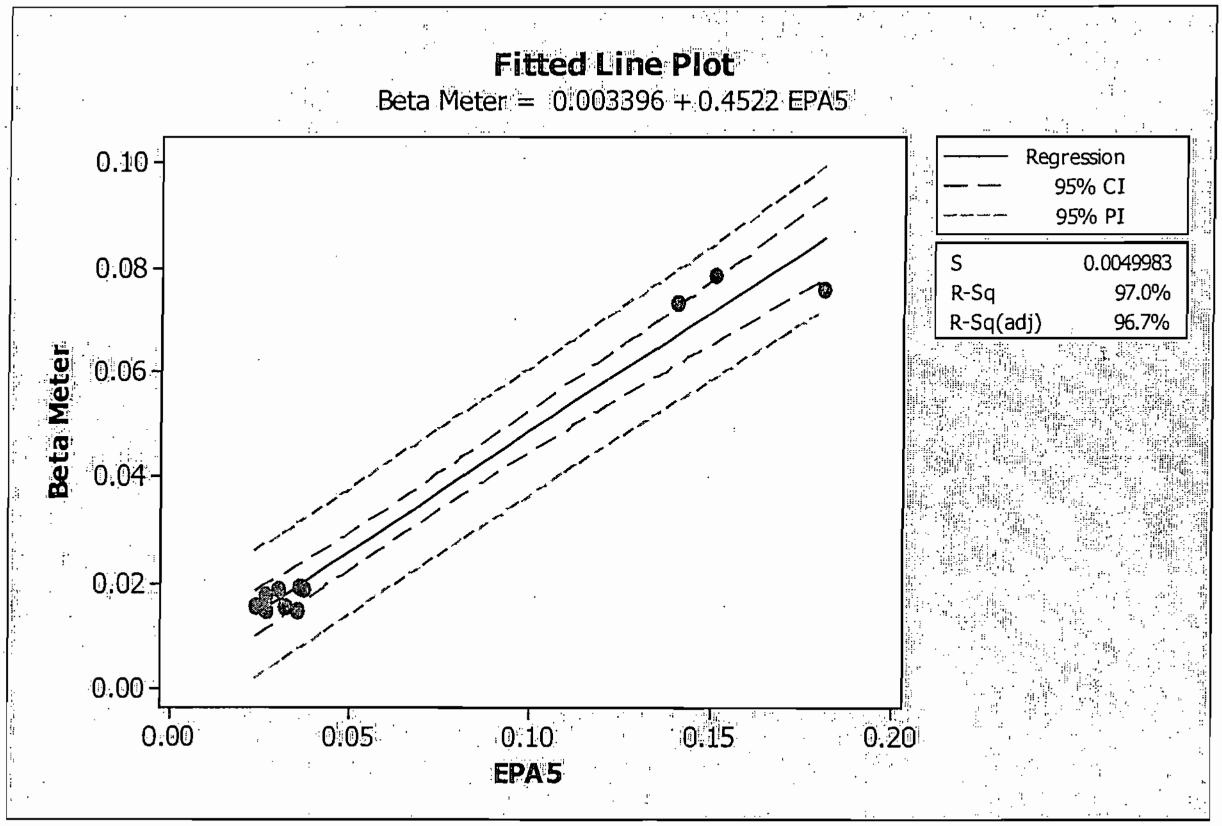
Regression Analysis: Beta Meter versus EPA5

The regression equation is
Beta Meter = 0.003396 + 0.4522 EPA5

S = 0.00499832   R-Sq = 97.0%   R-Sq(adj) = 96.7%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	0.0073758	0.0073758	295.23	0.000
Error	9	0.0002248	0.0000250		
Total	10	0.0076006			



COMPLIANCE ASSURANCE MONITORING PLAN
(CAM PLAN)

FOR

Rayonier, Inc.

Fernandina Beach, Florida

Dissolving Sulfite Pulp Mill

February 3, 2004

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LIST OF ATTACHMENTS

1. **Table A**
2. **Specifications for the AMETEK Thermox Oxygen Monitor**
3. **Specification for Beta Gauge Particulate Monitor**
   - **MSI BetaGuard® PM**
   - **The MSI BetaGuard® PM**
   - **Beta Gauge Particulate Monitoring – Theory and Practice**

I. EMISSION UNITS REQUIRING CAM PLANS

A. Cam Rule Applicability Definition

Title V of the Clean Air Act Amendments of 1990 mandated a new permit program now referred to as Title V Permitting. Title V Permits were not to require additional emission limits. However these permits were to enumerate all applicable requirements and to establish a monitoring program to track compliance with all the applicable requirements. The monitoring must conform to the applicable requirement in form and averaging time and provide the basis for the annual certification of compliance.

EPA adopted rules governing these monitoring programs in 40 CFR Part 64. The monitoring required is referred to as Compliance Assurance Monitoring (CAM) and the Plans required are referred to as CAM Plans.

CAM Plans are required of all Title V permitted emission units using air pollution control equipment to meet emission limits (applicable requirements) if "before-control" emissions are greater than that level defining a major source, unless the source is specifically exempt.

Exempted emissions units include those with stratospheric ozone protection and acid rain requirements and those with other caps are included in the Title V Permit. Also exempted are all emission units subject to NSPS (40 CFR Part 60) and NESHAP (40 CFR Part 63) promulgated after 11/15/1990, as these sources have equivalent monitoring requirements included as part of the standard.

B. Fernandina Mill Emissions Units Requiring Cam Plans

The Fernandina mill has a Title V permit that expires May 5, 2003. Pursuant to 40 CFR Part 64 CAM Plans must be submitted with the permit renewal application. The required CAM provisions must be addressed in the Plan and included with the renewed permit.

Emission units at the Fernandina Mill have been examined and those Units to which the CAM Rule applies have been determined. This analysis has been conducted by emission unit and by pollutant because the CAM rule applies to each pollutant emitted in amounts greater than that amount which defines the unit as a major source. Generally this amount is 100 tons per year for the Fernandina Mill.

The following sources have "before-control" emissions greater than 100 tons per year, have emission limits in the Title V Permit and rely on equipment to achieve the permit limit.

Emissions Unit	Pollutant	Applicable Requirement	Max Potential Emission TPY	Control Equipment
No. 1 Boiler	Particulate	Title V Operating Permit 0890004-005-AV, Condition III(A)(4)	70.0	Standard variable throat venturi scrubber
No. 2 Boiler	Particulate	Title V Operating Permit 0890004-005-AV, Condition III(B)(4)	212.5	Standard variable throat venturi scrubber
No. 3 Boiler	Particulate	Title V Operating Permit 0890004-005-AV, Condition III(C)(4)	212.6	Standard variable throat venturi scrubber
Recovery Boiler	Particulate	Title V Operating Permit 0890004-005-AV, Condition III(E)(4)	198.4	Fiber type mist eliminator.

Other emission limitations apply to the Fernandina Mill, but these are not subject to the CAM rule:

1. The sulfur dioxide emissions from power boilers Nos. 1, 2 and 3 are limited based on 2.5 percent sulfur oil. While the sulfur dioxide emissions from each boiler exceed 100 tons per year, no control equipment is used to meet this limitation.

2. Many sources have opacity limitations. Since opacity is not emitted in terms of tons per year it is not a pollutant that is directly subject to the CAM rule. Opacity monitoring may be used to monitor compliance with a particulate emission standard. However, since the

stacks subject to CAM for particulate matter at the Fernandina Mill have wet scrubbers, opacity is not used as a surrogate for particulate matter.

3. It is very difficult to estimate fugitive particulate emissions from the Molten Sulfur Handling System. But this system does emit particulate and this emission is controlled by work practices required in the regulation. The Cam Rule does not apply to the Molten Sulfur Handling System because there is no control equipment used to meet a specified emission limit. Also the emissions are expected to be much less than 100 tons per year.

C. Use of Surrogate Parameters in this Plan to Monitor Compliance.

A CAM Plan for this facility is required only for particulate emissions. There is no continuous particulate monitor available on the market. Thus the use of various particulate control equipment parameters must be used. Generally, several operating conditions are included when selecting control equipment parameters ranges. Ranges are chosen with a margin of safety for all operating conditions and that margin of safety may be considerably larger for certain of those operating conditions. Therefore, just because the surrogate parameter is out of range does not necessarily mean the permit limit is being exceeded. But since the ranges are generally selected conservatively, i.e. under worst case conditions, operating within the ranges assures compliance with the permit limits.

II. PARTICULATE EMISSIONS FROM NO. 1 BOILER

A. *Emissions Unit Identification*

This Emission Unit is a #6 oil fired water tube boiler with a maximum heat input rate of 185 mmBTU per hour. The emissions from this boiler pass through "A" venturi scrubber along with the emissions from No. 2 boiler. No. 1 Boiler is Emission Unit ID No. 001 and designated B1 in the Title V permit for the Fernandina Mill.

B. *Applicable Regulation, Emissions Limits, and Monitoring Requirements*

In Air Operating Permit AO45-183504 particulate emissions were limited to 16.0 lb./hr. Subsequently Rayonier asked for an increase in operating rate from a heat input of 160 mmBTU per hour to 185 mmBTU/hr. However, it intended that this increase in heat rate not increase calculated emissions, thereby avoiding PSD permitting. Consequently the emission rate decreased from 0.1 lbs./mmBTU to 0.086 lbs./mmBTU, but the mass emission rate remained at 16.0 lbs./hr and 70 tons per year, as is contained in Title V permit [0890004-005-AV] Condition III(A)(4).

C. *Control Technology Description*

The emissions from this #6 oil fired boiler pass up through a standard venturi scrubber using pH controlled wastewater as the scrubbing media. The pH control reduces corrosion of the venturi scrubber body. Particulate emissions control is set by the effectiveness of the venturi scrubber and the combustion efficiency of the boiler. Oxygen meters and other operational instruments monitor the boiler combustion efficiency. The venturi scrubber effectiveness is determined by the pressure drop across the venturi and the volume of liquid recycled through the venturi nozzles.

D. Monitoring Approach

	Indicator No. 1	Indicator No. 2	Indicator No. 3
Indicator	**Venturi Pressure Differential.**	**Venturi Recycle Flow Rate**	**Oxygen Meter**
Measurement Approach	A differential pressure meter [Rosemont Model 3051 dp] is used to measure the pressure drop.	An orifice plate with differential pressure taps provides the flow rate. A differential pressure meter [Rosemont Model 3051 dp] is used to measure the pressure drop across the orifice plate.	An Ametek Thermox Model WDG-HPIIC Oxygen Monitor using an electrochemical cell.
Indicator Range	The indicator range is a minimum inches of water pressure differential for a running one-hour average as defined in Table A based on the ratio of oil and bark burned.	The indicator range is a minimum flow for a running one-hour average when using recycled water and a different flow for a running one-hour average when using fresh water. See Table A	The indicator range is a minimum % excess oxygen for a running one-hour average as defined in Table A.
Data Represen-tativeness	The pressure sensors are installed on either side of the venturi and directly measure the difference in pressure of the gas at those locations.	The pressure sensors are installed on either side of the orifice and directly measure the difference in pressure of the water at those locations.	The gas sample is taken directly out of the boiler utilizing convection. Since it is a gas sample, it should be completely representative of boiler combustion conditions.
Verification of Operational Status	Alarms are set at levels outside the normal operating range to alert the operators and have the meter serviced.	Alarms are set at levels outside the normal operating range to alert the operators and have the meter serviced.	Alarms are set at levels outside the normal operating range to alert the operators and have the meter serviced. The meter is accurate to within 0.05% O_2.

	Indicator No. 1	Indicator No. 2	Indicator No. 3
QA/QC Practices and Criteria	The meter is set-up on the mill's preventative maintenance system for transmitter calibrations.	The meter is set-up on the mill's preventative maintenance system for transmitter calibrations.	The meter is calibrated monthly against a standard O_2 span gas.
Monitoring Frequency	This is a continuous monitor. The operator has instantaneous and running hourly average readouts and alarms.	This is a continuous monitor. The operator has instantaneous and running hourly average readouts and alarms.	This is a continuous monitor. The operator has instantaneous and running hourly average readouts and alarms.
Data Collection Procedures	The meter provides input on a second-by-second basis. About once each month these data are downloaded, consolidated into 15-minute averages and stored in an Environmental Data Management Database.	The meter provides input on a second-by-second basis. About once each month these data are downloaded, consolidated into 15-minute averages and stored in an Environmental Data Management Database.	The meter provides input on a second-by-second basis. About once each month these data are downloaded, consolidated into 15-minute averages and stored in an Environmental Data Management Database.
Averaging Period	15-minute averages are stored for 5 years to comply with the CAM Rule and Title V record-keeping requirements. A running one-hour average is used for compliance.	15-minute averages are stored for 5 years to comply with the CAM Rule and Title V record-keeping requirements. A running one-hour average is used for compliance.	15-minute averages are stored for 5 years to comply with the CAM Rule and Title V record-keeping requirements. A running one-hour average is used for compliance.

E. Justification

1. Background

Particulate emissions are controlled by the venturi scrubber [A scrubber] provided for this boiler and No. 2 power boiler. Established combustion controls are provided for the boiler itself. To monitor the particulate emissions affected by the boiler combustion controls and the venturi scrubber operation, an oxygen meter, venturi recirculation flow meter and venturi differential pressure meter are used. Technical specifications for the oxygen meter are attached.

2. Rationale for Selection of Performance Indicators

Particulate testing indicate that the parameters selected will verify good control of the boilers and the scrubber.

The gases from this boiler pass through a standard variable throat venturi scrubber. The EPA Engineering Manual and standard engineering design practices for such scrubbers use liquid media flow and gas pressure drop across the unit as measures of effectiveness. The Model CAM Plan Guidance from EPA and recent MACT standards where the required monitoring must comply with the CAM rule, for venturi scrubbers use liquid media flow rate and gas pressure drop as the surrogates.

In this CAM Plan Rayonier has recognized that an additional parameter is needed to determine that the source is not overloading the scrubber. Periods of poor combustion could increase particulate loading beyond scrubber capability. Oxygen concentration was chosen as the surrogate parameter for good combustion because it was already being monitored and correlated well to particulate.

3. Rationale for Selection of Indicator Ranges

The indicator ranges were selected through comparing the indicators to actual EPA method 5 tests. Alarms below the upper limit are provided for hourly averages as well as instantaneous test results. Most stack tests on which the ranges are based were conducted while both boilers were operating. This provides the maximum particulate loading and gas flow for the scrubber to handle. Thus it would represent worst-case conditions. See the discussion under Section III.E.3 for boiler No. 2 for the justification of the surrogate parameters for the combined flow operation.

III. PARTICULATE EMISSIONS FROM NO. 2 BOILER

A. *Emissions Unit Identification*

This Emission Unit is a combination #6 oil and wood waste (bark) fired water tube boiler with a maximum heat input rate of 184 mmBTU per hour on oil and 218 mmBTU per hour on wood waste. The emissions from this boiler pass through "A" venturi scrubber along with the emissions from No. 1 boiler. No. 2 Boiler is Emission Unit ID No. 002 and designated B2 in the Title V permit for the Fernandina Mill.

B. *Applicable Regulation, Emissions Limits, and Monitoring Requirements*

In Air Operating Permit AO45-183504 particulate emissions were limited to 50.6 lb. PM/hr. Subsequently Rayonier asked for an increase in operating rate from a heat input of 180 mmBTU per hour to 218 mmBTU per hour. However, it intended that this increase in heat rate not increase calculated emissions, thereby avoiding PSD permitting. Consequently the emission rate decreased from 0.280 lbs./mmBTU to 0.230 lbs./mmBTU for wood waste burning, but the mass emission rate remained at 50.6 lbs./hr and 212.5 tons per year, as is contained in Title V permit [0890004-005-AV] Condition III(B)(4). For oil the particulate matter emission rate limits are 15.2 lb./hr. and 63.9 tons per year.

C. *Control Technology Description*

The emissions from this boiler pass up through a standard venturi scrubber using pH-controlled water as the scrubbing media. The pH control reduces corrosion of the venturi scrubber body. Particulate emissions control is set by the effectiveness of the venturi scrubber and the combustion efficiency of the boiler. Oxygen meters and other operational instruments monitor the boiler combustion efficiency. The pressure drop determines the venturi scrubber effectiveness across the venturi and the volume of liquid recycled through the venturi nozzles.

D. Monitoring Approach

	Indicator No. 1	Indicator No. 2	Indicator No. 3
Indicator	**Venturi Pressure Differential.**	**Venturi Recycle Flow Rate**	**Oxygen Meter**
Measurement Approach	A differential pressure meter [Rosemont Model 3051 dp] is used to measure the pressure drop.	An orifice plate with differential pressure taps provides the flow rate. A differential pressure meter [Rosemont Model 3051 dp] is used to measure the pressure drop across the orifice plate.	An Ametek Thermox Model WDG-HPIIC Oxygen Monitor using an electrochemical cell.
Indicator Range	The indicator range is a minimum inches of water pressure differential for a running one-hour average as defined in Table A based on the ratio of oil and bark burned.	The indicator range is a minimum flow for a running one-hour average when using recycled water and a different flow for a running one-hour average when using fresh water. See Table A	The indicator range is a minimum % excess oxygen for a running one-hour average as defined in Table A.
Data Represen-tativeness	The pressure sensors are installed on either side of the venturi and directly measure the difference in pressure of the gas at those locations.	The pressure sensors are installed on either side of the orifice and directly measure the difference in pressure of the water at those locations.	The gas sample is taken directly out of the boiler utilizing convection. Since it is a gas sample, it should be completely representative of boiler combustion conditions.
Verification of operational Status	Alarms are set at levels outside the normal operating range to alert the operators and have the meter serviced.	Alarms are set at levels outside the normal operating range to alert the operators and have the meter serviced.	Alarms are set at levels outside the normal operating range to alert the operators and have the meter serviced. The meter is accurate to within 0.05% O_2.
QA/QC Practices and Criteria	The meter is set-up on the mill's preventative maintenance system for transmitter calibrations.	The meter is set-up on the mill's preventative maintenance system for transmitter calibrations.	The meter is calibrated monthly against a standard O_2 span gas.

	Indicator No. 1	Indicator No. 2	Indicator No. 3
Monitoring Frequency	This is a continuous monitor. The operator has instantaneous and running hourly average readouts and alarms.	This is a continuous monitor. The operator has instantaneous and running hourly average readouts and alarms.	This is a continuous monitor. The operator has instantaneous and running hourly average readouts and alarms.
Data Collection Procedures	The meter provides input on a second-by-second basis. About once each month these data are downloaded, consolidated into 15-minute averages and stored in an Environmental Data Management Database.	The meter provides input on a second-by-second basis. About once each month these data are downloaded, consolidated into 15-minute averages and stored in an Environmental Data Management Database.	The meter provides input on a second-by-second basis. About once each month these data are downloaded, consolidated into 15-minute averages and stored in an Environmental Data Management Database.
Averaging Period	15-minute averages are stored for 5 years to comply with the CAM Rule and Title V record-keeping requirements. A running one-hour average is used for compliance.	15-minute averages are stored for 5 years to comply with the CAM Rule and Title V record-keeping requirements. A running one-hour average is used for compliance.	15-minute averages are stored for 5 years to comply with the CAM Rule and Title V record-keeping requirements. A running one-hour average is used for compliance.

E. Justification

1. Background

Particulate emissions are controlled by the venturi scrubber [A scrubber] provided for this boiler and No. 1 power boiler. Established combustion controls are provided for the boiler itself. To monitor the particulate emissions affected by the boiler combustion controls and the venturi scrubber operation, an oxygen meter, venturi recirculation flow meter and venturi differential pressure meter are used. Technical specifications for the oxygen meter are attached.

2. Rationale for Selection of Performance Indicators

Particulate testing indicate that the parameters selected will verify good control of the boilers and the scrubber.

The gases from this boiler pass through a standard variable throat venturi scrubber. The EPA Engineering Manual and standard engineering design practices for such scrubbers use liquid media flow and gas pressure drop across the unit as measures of effectiveness. The Model CAM Plan Guidance from EPA and recent MACT standards where the required monitoring must comply with the CAM rule, for venturi scrubbers use liquid media flow rate and gas pressure drop as the surrogates.

In this CAM Plan Rayonier has recognized that an additional parameter is needed to determine that the source is not overloading the scrubber. Periods of poor combustion could increase particulate loading beyond scrubber capability. Oxygen concentration was chosen as the surrogate parameter for good combustion because it was already being monitored and correlated well to particulate.

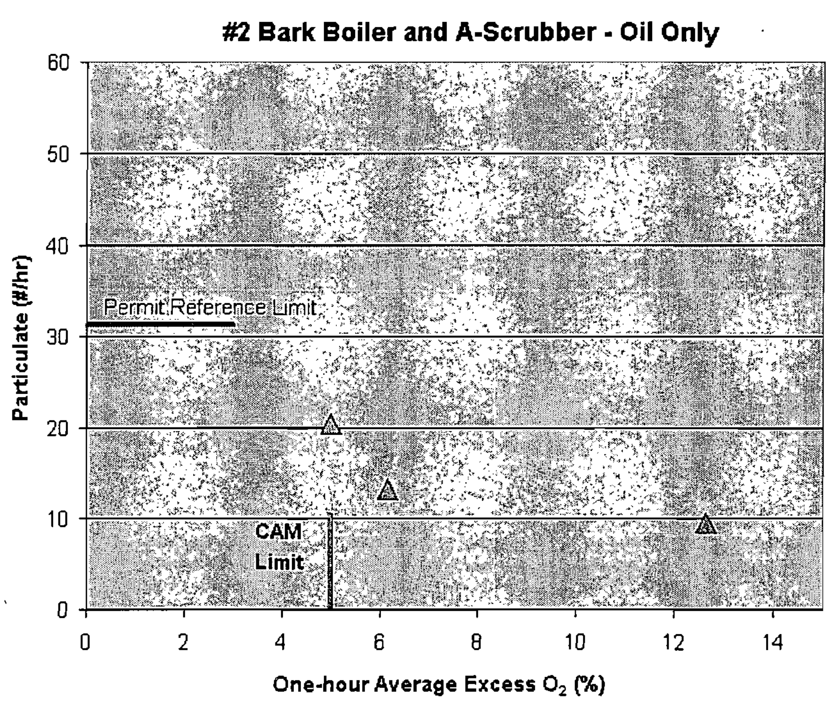
3. Rationale for Selection of Indicator Ranges

The indicator ranges were selected through comparing the indicators to actual EPA method 5 tests. Alarms below the upper limit are provided for hourly averages as well as instantaneous test results.

A series of stack tests using EPA Method 5 were completed under varying liquid media flow rates and gas pressure drops and oxygen levels. Most of these tests were run while both No. 1 and No. 2 boilers were operating. This provides the maximum loading to A scrubber through which they usually vent. The Table below presents the summarized data for the 10 stack test runs used to define the surrogate ranges for A scrubber. These tests and others are provided in the attached test report provided by Capstone Technology Corporation in the memo from Ron B Aldus to Dick Hopper dated June 03, 2003. Note that none of the tests used to determine the ranges exceeded 85% of the standard. Since this scrubber can be fed either water or filtrate both scrubbing media were tested. Through testing it was determined that filtrate provided higher particulate likely due to the dissolved solids that carried over in the scrubber plume. Thus the ranges were based on filtrate stack tests. However, a set of tests were also run to verify that the scrubber can be operated at low flow rates on fire water should that be necessary due to a scrubber circulation pulp failure.

Test #	Flow gpm	DP H_2O	Fuels	% of limit	Liquid Media
C1	1900	14.1	bark/oil	61	filtrate
C2	1892	14.1	bark/oil	62	filtrate
C3	1889	14.1	bark/oil	71	filtrate
A6	2041	14.4	bark/oil	83	filtrate
A7	2068	14.5	bark/oil	70	filtrate
A8	2074	14.5	bark/oil	85	filtrate
A4	1548	13.2	bark	59	filtrate
A5	407	8.7	bark	29	filtrate
A7	1481	12.6	bark/oil	31	filtrate
A9	2020	14.7	oil	71	filtrate

In separate testing the excess oxygen level where each boiler started to exhibit poor combustion was determined. Generally less than 3.0% excess air the boiler generally started to exhibit poor combustion. However, No. 2 boiler on oil needed more excess air to maintain good combustion. See the graph below which is reproduced from the June 03, 2003 memo from Capstone referenced above.



IV. PARTICULATE EMISSIONS FROM NO. 3 BOILER

A. *Emissions Unit Identification*

This Emission Unit is a combination #6 oil and wood waste (bark) fired water tube boiler with a maximum heat input rate of 207 mmBTU per hour on oil and 245 mmBTU per hour on wood waste. The emissions from this boiler pass through "B" venturi scrubber. No. 3 Boiler is Emission Unit ID No. 003 and designated B3 in the Title V permit for the Fernandina Mill.

B. *Applicable Regulation, Emissions Limits, and Monitoring Requirements*

In Air Operating Permit AO45-183504 particulate emissions were limited to 50.6 lb. PM/hr. Subsequently Rayonier asked for an increase in operating rate from a heat input of 180 mmBTU per hour to 245 mmBTU per hour. However, it intended that this increase in heat rate not increase calculated emissions, thereby avoiding PSD permitting. Consequently the emission rate decreased from 0.280 lbs./mmBTU to 0.207 lbs./mmBTU for wood waste burning, but the mass emission rate remained at 50.6 lbs./hr and 212.6 tons per year, as is contained in Title V permit [0890004-005-AV] Condition III(C)(4). For oil the particulate matter emission rate limits are 16.7 lb./hr. and 70.1 tons per year.

C. *Control Technology Description*

The emissions from this boiler pass up through a standard venturi scrubber using pH-controlled water as the scrubbing media. The pH control reduces corrosion of the venturi scrubber body. Particulate emissions control is set by the effectiveness of the venturi scrubber and the combustion efficiency of the boiler. Oxygen meters and other operational instruments monitor the boiler combustion efficiency. The venturi scrubber effectiveness is determined by the pressure drop across the venturi and the volume of liquid recycled through the venturi nozzles.

D. Monitoring Approach

	Indicator No. 1	Indicator No. 2	Indicator No. 3
Indicator	**Venturi Pressure Differential.**	**Venturi Recycle Flow Rate**	**Oxygen Meter**
Measurement Approach	A differential pressure meter [Rosemont Model 3051 dp] is used to measure the pressure drop.	An orifice plate with differential pressure taps provides the flow rate. A differential pressure meter [Rosemont Model 3051 dp] is used to measure the pressure drop across the orifice plate.	An Ametek Thermox Model WDG-HPIIC Oxygen Monitor using an electrochemical cell.
Indicator Range	The indicator range is a minimum inches of water pressure differential for a running one-hour average as defined in Table A based on the ratio of oil and bark burned.	The indicator range is a minimum flow for a running one-hour average when using recycled water and a different flow for a running one-hour average when using fresh water. See Table A	The indicator range is a minimum % excess oxygen for a running one-hour average as defined in Table A.
Data Represen-tativeness	The pressure sensors are installed on either side of the venturi and directly measure the difference in pressure of the gas at those locations.	The pressure sensors are installed on either side of the orifice and directly measure the difference in pressure of the water at those locations.	The gas sample is taken directly out of the boiler utilizing convection. Since it is a gas sample, it should be completely representative of boiler combustion conditions.
Verification of operational Status	Alarms are set at levels outside the normal operating range to alert the operators and have the meter serviced.	Alarms are set at levels outside the normal operating range to alert the operators and have the meter serviced.	Alarms are set at levels outside the normal operating range to alert the operators and have the meter serviced. The meter is accurate to within 0.05% O_2.
QA/QC Practices and Criteria	The meter is set-up on the mill's preventative maintenance system for transmitter calibrations.	The meter is set-up on the mill's preventative maintenance system for transmitter calibrations.	The meter is calibrated monthly against a standard O_2 span gas.

	Indicator No. 1	Indicator No. 2	Indicator No. 4
Monitoring Frequency	This is a continuous monitor. The operator has instantaneous and running hourly average readouts and alarms.	This is a continuous monitor. The operator has instantaneous and running hourly average readouts and alarms.	This is a continuous monitor. The operator has instantaneous and running hourly average readouts and alarms.
Data Collection Procedures	The meter provides input on a second-by-second basis. About once each month these data are downloaded, consolidated into 15-minute averages and stored in an Environmental Data Management Database.	The meter provides input on a second-by-second basis. About once each month these data are downloaded, consolidated into 15-minute averages and stored in an Environmental Data Management Database.	The meter provides input on a second-by-second basis. About once each month these data are downloaded, consolidated into 15-minute averages and stored in an Environmental Data Management Database.
Averaging Period	15-minute averages are stored for 5 years to comply with the CAM Rule and Title V record-keeping requirements. A running one-hour average is used for compliance.	15-minute averages are stored for 5 years to comply with the CAM Rule and Title V record-keeping requirements. A running one-hour average is used for compliance..	15-minute averages are stored for 5 years to comply with the CAM Rule and Title V record-keeping requirements. A running one-hour average is used for compliance.

E. Justification

1. Background

Particulate emissions are controlled by the venturi scrubber [B scrubber] provided for this boiler. Established combustion controls are provided for the boiler itself. To monitor the particulate emissions affected by the boiler combustion controls and the venturi scrubber operation, an oxygen meter, venturi recirculation flow meter and venturi differential pressure meter are used. Technical specifications for the oxygen meter are attached.

2. Rationale for Selection of Performance Indicators

Particulate testing indicate that the parameters selected will verify good control of the boilers and the scrubber.

The gases from this boiler pass through a standard variable throat venturi scrubber. The EPA Engineering Manual and standard engineering design practices for such scrubbers use liquid media flow and gas pressure drop across the unit as measures of effectiveness. The Model CAM Plan Guidance from EPA and recent MACT standards where the required monitoring must comply with the CAM rule, for venturi scrubbers use liquid media flow rate and gas pressure drop as the surrogates.

In this CAM Plan Rayonier has recognized that an additional parameter is needed to determine that the source is not overloading the scrubber. Periods of poor combustion could increase particulate loading beyond scrubber capability. Oxygen concentration was chosen as the surrogate parameter for good combustion because it was already being monitored and correlated well to particulate.

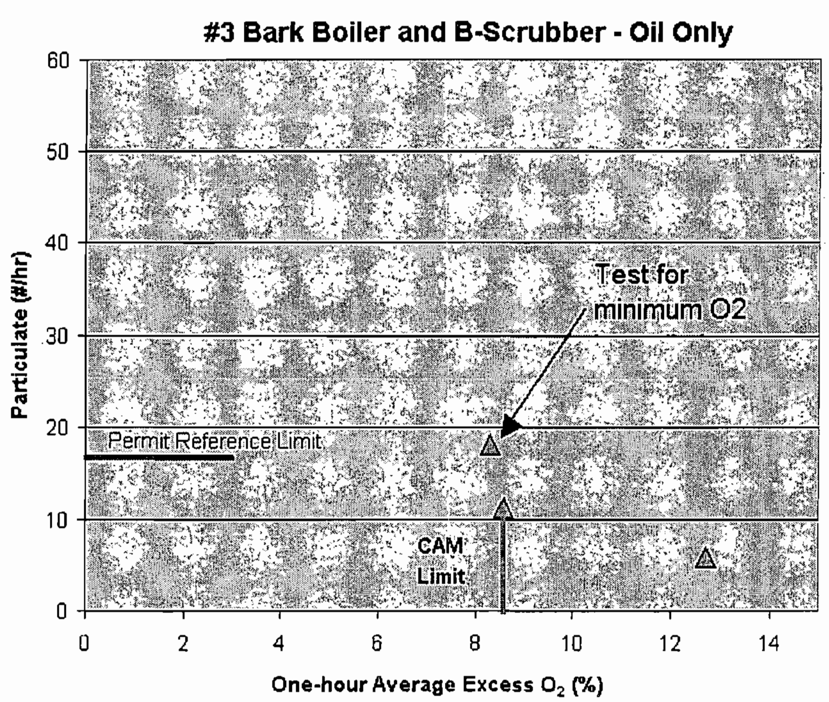
3. Rationale for Selection of Indicator Ranges

The indicator ranges were selected through comparing the indicators to actual EPA method 5 tests. Alarms below the upper limit are provided for hourly averages as well as instantaneous test.

A series of stack tests using EPA Method 5 were completed under varying liquid media flow rates and gas pressure drops and oxygen levels. The Table below presents the summarized data for the 7 tests used to define the surrogate ranges for B scrubber. These tests and others are provided in the attached test report provided by Capstone Technology Corporation in the memo from Ron Baldus to Dick Hopper dated June 03, 2003. Note that none of the tests used to determine the ranges exceeded 51% of the standard. The boiler had at least 3.0 excess oxygen during all tests. As noted elsewhere, this scrubber can be fed either water or filtrate. Through testing it was determined that filtrate provided higher particulate due to the dissolved solids that carried over in the scrubber plume. Thus the ranges were based on stack tests when filtrate was the scrubbing media. However, a set of tests were run to verify that the scrubber can be operated at low flow rates on fire water should that be necessary if a scrubber circulation pump fails.

Test #	Flow gpm	DP H_2O	Fuels	% of limit	Liquid Media
B1	1825	12.3	bark	51	filtrate
B2	1831	12.4	bark	35	filtrate
B4	1676	10.8	bark	36	filtrate
B5	1675	10.8	bark	33	filtrate
B6	250	6.1	bark	51	filtrate
B7	1654	10.8	bark/oil	33	filtrate
B3	1380	9.8	bark	46	filtrate

In separate testing the excess oxygen level where each boiler started to exhibit poor combustion was determined. Generally less than 3.0% excess air the boiler generally started to exhibit poor combustion. However, No. 3 boiler on oil needed more excess air to maintain good combustion. See the graph below which is reproduced from the June 03, 2003 memo from Capstone referenced above.



V. PARTICULATE EMISSIONS FROM RECOVERY BOILER

A. *Emissions Unit Identification*

Emission Unit ID No. 6 in the Title V Permit is a sulfite recovery boiler. This boiler burns evaporated spent cooking liquor. Liquor used to remove unwanted portions of the wood chip contains sugars, tannins and combined lignins. Evaporation concentrates this organic portion of the liquor to the point it will sustain combustion when fired into the recovery boiler. Steam generated by the recovery boiler is used for electricity generation and process purposes. The evaporated liquor contains sulfur compounds, which are converted to sulfur dioxide during combustion. This sulfur dioxide is captured in a scrubber using ammonium hydroxide scrubbing media producing ammonium bisulfite that is recycled as fresh cooking liquor. Sulfur dioxide also reacts with ammonium hydroxide to produce ammonium sulfate and ammonium bisulfite. All of these ammonium compounds are dissolved in the carryover droplets from the scrubber. Reducing the emission of droplets reduces the particulate emissions. There is little ash in the liquor and little unburned carbon that would color the recovered ammonium bisulfite cooking liquor. The ammonium sulfate formed as a co-product in the liquid droplets carried over is the predominate source of particulate. Capturing droplets carried over from the scrubber is accomplished by a Brinks mist eliminator, described below.

B. *Applicable Regulation, Emissions Limits, and Monitoring Requirements*

The Reasonably Available Control Technology (RACT) determination for this source is dated 7/12/76 and is based on State of Washington Sulfite Pulp Mill Rules. The consent order history was through OGC Case No. 90-0332, DOAH Case 90-2153, Air Construction permit 0890004-001-AC, Air Operations permit 0890004-003-AO and Florida Rule 62-212.400(6). The particulate emission requirement is presently part of Operating Permit No. 0890004-005-AV, condition No. .4. This Emission Limitation is that the particulate emission not exceed 2.5 pounds per ton of air dried unbleached pulp or 67.5 pounds per hour.

In addition, MACT II regulations utilize particulate matter as a surrogate for hazard air pollutant metals and has a limit of 0.092 gmPM/dscm for sulfite recovery boiler emissions.

These regulations go into effect on March 13, 2004, and at that time the CAM Plan for the recovery boiler is no longer required.

C. Control Technology Description

The combustion process produces very small amount of soot from incomplete combustion in the boiler. As described above, a scrubber is installed after this boiler to recover sulfur dioxide used as the active ingredient in the cooking liquor. A small portion of the sulfur dioxide and ammonium hydroxide react to form ammonium sulfate instead of the preferred ammonium bisulfite. A portion of the ammonium sulfate formed is emitted by the boiler as a fume. All the exhaust gases pass through a Brinks mist eliminator which mechanically captures the fume.

A Brinks mist eliminator is comprised of a series of tubes wrapped in fiberglass or polyester fiber bats, through which the exhaust gases from the scrubber must pass. The fibers filter out the droplets of scrubber media carried over and drain to a tank leading to evaporator feed so that another attempt can be made to recover the sulfur. This also reduces the ammonia sewered, which aids in reducing ammonia discharged to the Amelia River.

D. Monitoring Approach

	Indicator No. 1
Indicator	Particulate concentration via an extractive beta gauge particulate monitor.
Measurement Approach	The monitoring system isokinetically collects a sample of particulate on to a filter tape and compares the amount of radiation absorbed with the sample and without the sample on the tape. The instrument readout can be converted to particulate concentration. The concentration can then be calibrated against EPA Method 5 particulate tests.
Indicator Range	The indicator range is based on EPA Method 5 testing. The range the present testing indicates is within permit limits is any Beta Gauge reading calibrated to concentration where the indicated concentration is less than 45 mg/scm.

	Indicator No. 1
Data Representativeness	The system is designed to collect a representative sample, which is repeatable as compared to Method 5. This has been verified and the sampling system will not be altered. The sample size on the tape can be controlled by the pressure drop across the tape or by timer.
Verification of operational Status	Each sample step provides a physical zero. The beta absorption using the C-14 source is virtually independent of the chemical composition, size or color of the collected particulate and shows no interference from water droplets or fogging in the stack. As a result there is no need for site-specific reference calibration.
QA/QC Practices and Criteria	As noted above there is a zero for each sample taken. In addition there is a monthly automatic beta calibration. This checks the repeatability of the Beta gauge measurement component of the instrument system by performing a zero check, a span check and a filter tape positioning check. At the same time there is a automatic flow calibration. This checks repeatability of the flow meter components of the instrument system by routing the same flow through all of the flow meters at two separate flow set points to perform a low span and a high span check.
Monitoring Frequency	There will be a particulate value provided at least every 15 minutes except for the monthly 30-minute calibrations.
Data Collection Procedures	The monitor is queried once each minute and the latest value is stored on a server with other process data. About once each month this data will be downloaded, consolidated into 15-minute averages, and stored in an Environmental Data Management Database.
Averaging Period	15-minute averages will be stored for 5 years to comply with the CAM Rule and Title V record-keeping requirements.

E. Justification

1. Background

There are few methods available for continuously, or semi-continuously, determining mass particulate emissions. Historically, opacity or light transmissivity through the plume has been used as a surrogate. But the particulate involved for this emission is ammonium sulfate which has a very high reflectance and is difficult for opacity monitors to measure. For certain types of combustion, the blackness, or shade of gray, of the plume was used as an indication of soot and therefore particulate emissions. But this is a white plume and not caused by incomplete combustion. Sources employing wet scrubbing technologies can sometimes relate liquid media flow and pressure drop to mass particulate emission. Liquid scrubbers emit saturated plumes and the condensing water droplets interfere with the opacity measurements. However, the scrubber on this recovery boiler is to remove heat and sulfur dioxide and has no impact on particulate control.

Efforts to find a surrogate parameter using other equipment operating parameters failed. A method found that has worked is based on measuring the beta particle attenuation from particulate collected on a filter paper. A small radioactive beta source is used. A baseline measurement of beta radiation passing through a clean portion of a fiberglass tape is taken. The tape is moved to a position where a gas stream sample from the stack gases is passed through the filter tape. This sample is taken isokinetically from the stack gases to avoid biasing the size particulate sampled. The tape filters out particles down to about 0.3 micron in size. After filtering out the particulate in the gas stream the beta ray attenuation across the sampled area on the tape is measured again. The difference is used to relate to the quantity of particulate in the gas stream sampled.

2. Rationale for Selection of Performance Indicators

The attenuation of beta radiation is related to the thickness of the material. Beta gauges have been used for a long time to measure thickness of various thin materials with great accuracy. In this application the thickness of a paper filter is measured before and after being used to filter stack gases containing particulate. Testing has verified that the thickness of particulate buildup on paper used to filter stack gases is related to the particulate in the stack.

3. Rationale for Selection of Indicator Ranges

A series of Method 5 stack tests at different operating rates were performed, while simultaneously measuring the beta gauge output. The attenuation of beta particles due to the particulate left on the paper has been calibrated in terms of stack concentration. The following graph presents the correlation of beta attenuation estimate of stack gas concentration. This approach elected to use only the in-stack concentration to relate to the permit limit which is in mass flow units (lbs/hour) (g/dscm for MACT II) because all testing used for the calibration was during periods of the maximum expected flow rate. Thus this concentration selected is the greatest that could be tolerated without a permit exceedance at the highest expected flow rate.

The stack gas flow rate decreases during other operating conditions, such as when less liquor is fired, because less oxygen is needed and less gaseous products of combustion are generated. Using this maximum concentration range during these lower stack gas flow periods only provides greater assurance the particulate limit is not exceeded. The graph below present the test data available to date and demonstrates that the correlation between stack gas particulate concentration and particulate mass flow is excellent. All these tests were run at approximately the same gas flow rate. The higher concentrations on this graph were obtained by bypassing a small slip stream around the control device (the Brinks), while the boiler operated essentially at the same rate and therefore the same stack flow rate.

Using the correlation equation from the graph of the stack test data below, a beta guard monitor concentration reading of less than 45 mg/scm indicates the particulate emissions are in compliance at less than 0.092 g/dscm (45.3 lbPM/hr).

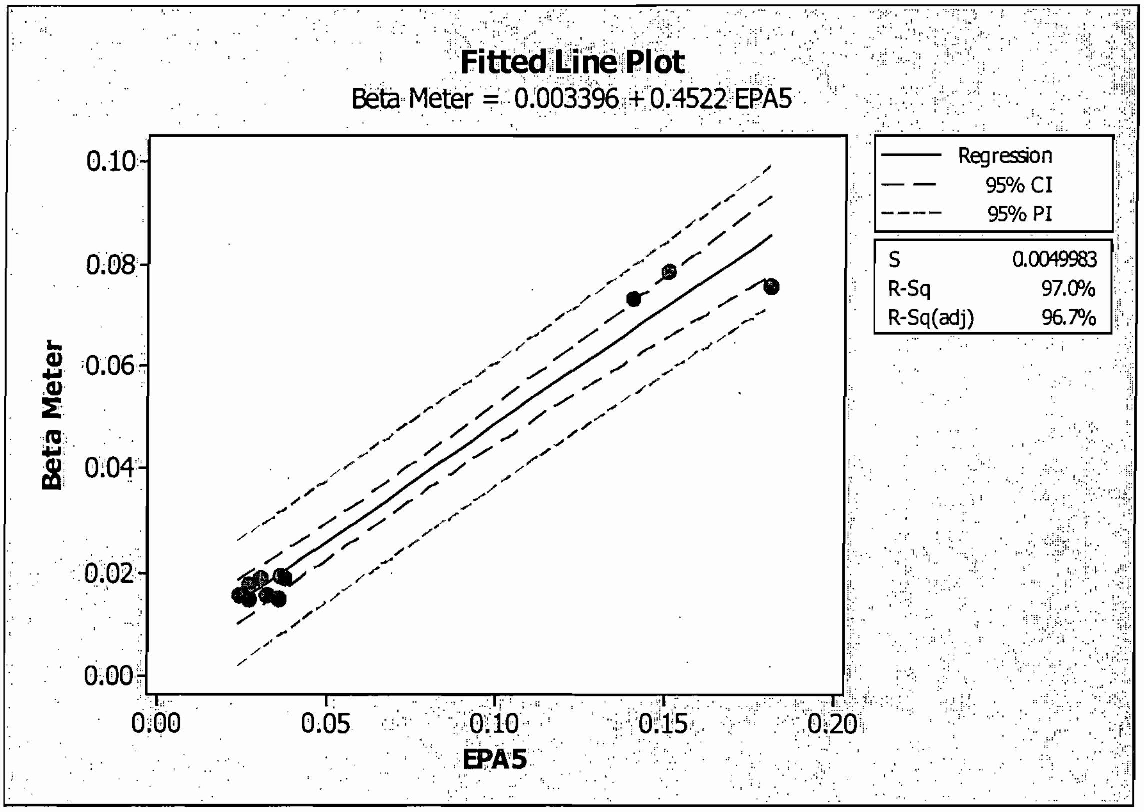


Table A

Compliance Assurance Monitoring

CAM LIMITS

This Table provides the operating limits which assure compliance during <u>normal</u> operating conditions.

With Normal Recycle Water Make-up	Hourly Average Differential Pressure [inches water]	Hourly Average Recirculation Flow Rate [gpm]
A Scrubber	>12.0	>1300
B Scrubber	>9.5	>1300
With Fresh Water Make-up	Except when the boilers are on only oil	
A Scrubber	>9.0	>380
B Scrubber	>6.0	>250

		Hourly Average Excess Oxygen [%]
No. 1 Power Boiler	Oil Only	>3.0
No. 2 Power Boiler	Oil Only	>5.0
No. 2 Power Boiler	Bark & Oil	>3.0
No. 2 Power Boiler	Bark Only	>3.0
No. 3 Power Boiler	Oil Only	>8.6
No. 3 Power Boiler	Bark & Oil	>3.0
No. 3 Power Boiler	Bark Only	>3.0

<u>Abnormal Operations Include:</u>

Fuel Transition — When the fuel source is changed the hourly average will start averaging immediately for control, but will not be comparable to the CAM limit until a full hour has passed.

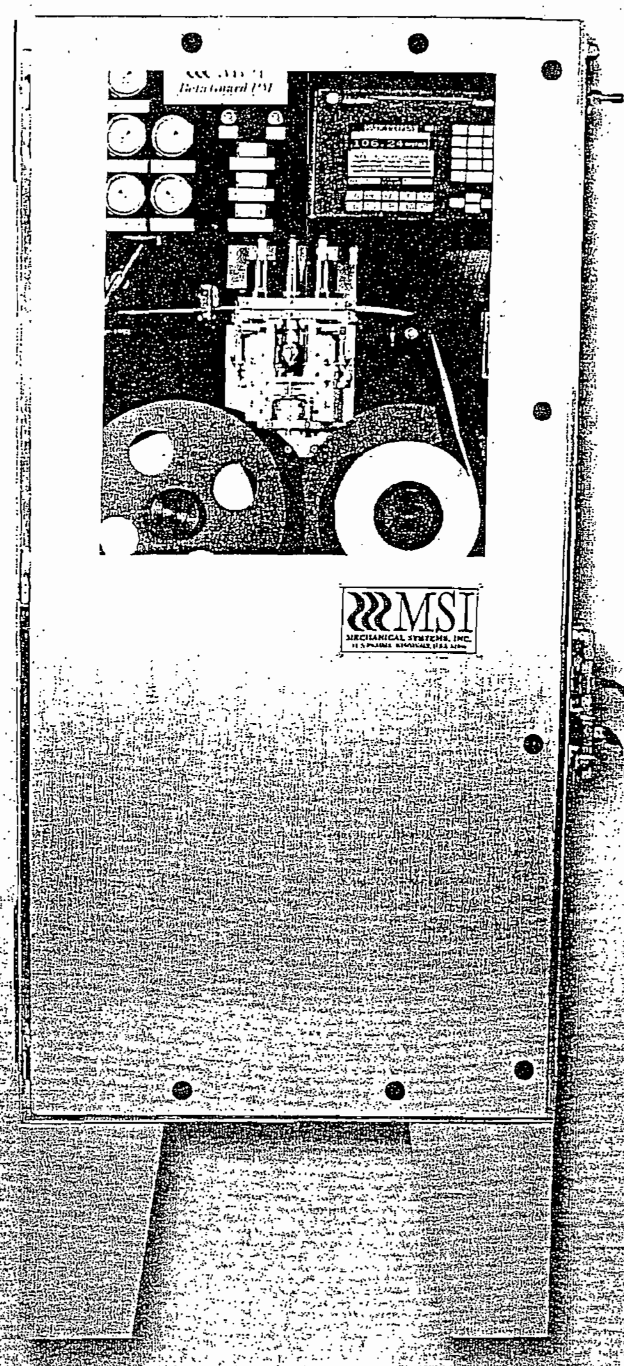
Cold Start-up — When the boiler has been down for an extended period of time there is a warm-up curve for the boiler refractory. During this period [24 hours] the boiler should have low emissions but is subject to major upsets. The hourly averages will begin as soon as fuel is added to the boiler for control, but the CAM limits will not apply until the end of the 24 hours.

Warm Start-up — When the boiler is started up and a warm-up curve is not required there is a 6 hour period when the emissions should be low but the boiler is subject to upsets. The hourly averages will begin as soon as fuel is added to the boiler for control, but the CAM limits will not apply until the end of the 6 hours.

Best Available Copy

MSI

BetaGuard PM

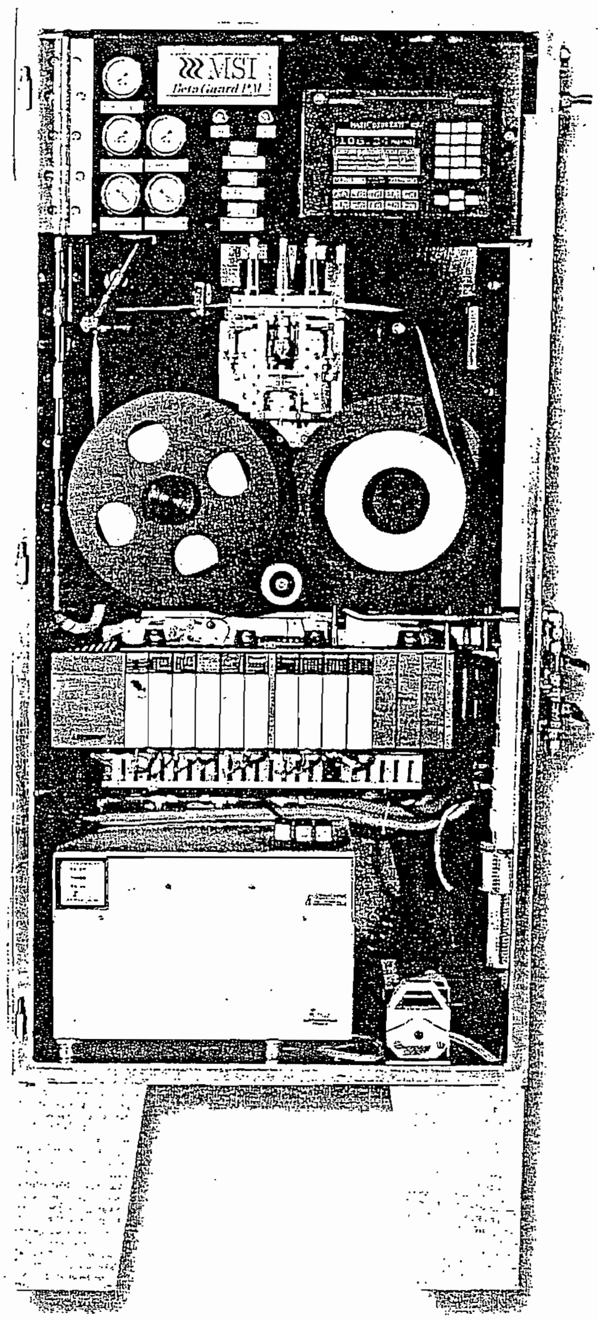


MSI BetaGuard PM Continuous Source Particulate Monitor

MADE IN U.S.A.

Description

The MSI BetaGuard PM beta gauge measures particulate emissions from all types of sources under all conditions. Stacks with changing particulate conditions (size, shape, color, density, composition) or varying operating parameters (flow rate, moisture concentration, temperature, pressure) are accurately measured. Wet basis, dry basis and process rate measurements are now available from a single instrument!



MSI BetaGuard PM

Applications

- Coal Fired Power Plants
- Cement Kilns
- Petroleum Refineries
- Hazardous Waste Incinerators
- Boiler Industrial Furnaces
- Municipal Waste Combustors

Capabilities

- Dual Beta Sensor Design
- Built-In Redundancy
- Dry Basis Measurement
- Wet Basis Measurement
- Process Rate Measurement
- Isokinetic Flow Sampling
- Isothermal Sampling

Certifications

- Method 5 Equivalence
- Method 5i Equivalence
- Method 17 Equivalence

Calibrations

- Seven Point Beta Characterization
- Seven Point Flow Characterization
- Automatic Daily Beta Calibration
- Automatic Daily Flow Calibration
- Quarterly Beta Audit
- Quarterly Flow Audit

Features

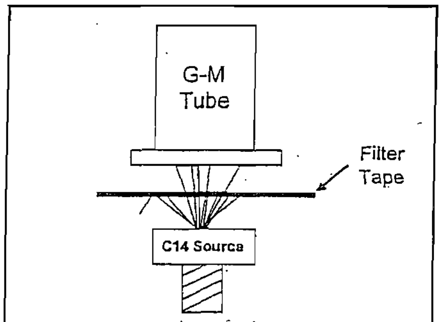
- NEMA 4X Construction
- Allen Bradley SLC 500 Control
- Heated Dilution Air
- Simplified Filter Tape Replacement
- Complete Alarms
- Complete Diagnostics
- Built-In Lightning Surge Protection
- 115 VAC Operation
- Manufactured in the U.S.A.

Options

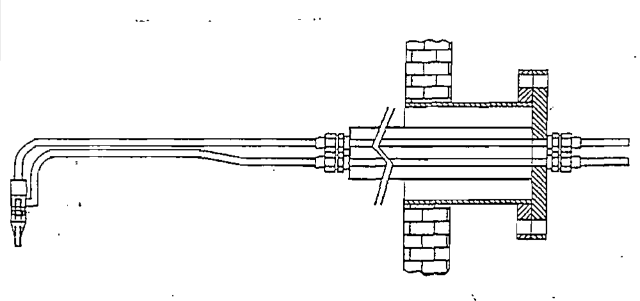
- Remote Display and I/O to 10,000 Feet
- Outdoor Walk-In Enclosure
- Heavy Metals Monitoring Package
- Continuous Moisture Measurement

Principle of Operation

A low energy Carbon-14 source furnishes a constant supply of beta electrons which are detected by a Geiger-Mueller tube. A filter tape is interposed between the source and detector and the mass of the initial clean filter spot is recorded by measuring the counts of beta electrons reaching the G-M tube. This clean spot is then moved under a collection apparatus for sample extraction from the stack. A sample of stack gas is drawn through and deposits particulate on the filter tape. All particles above 0.1 microns (μ) are collected. Once a sufficient amount of sample is collected on the filter tape, the filter tape is moved back under the beta detector and remeasured. The difference in beta emission counts measured from the original clear spot to the collected sample is directly proportional to the mass on the tape.



Beta Transmission Sensor Principle


BetaGuard PM Dilution Probe

The MSI BetaGuard PM extracts the sample isokinetically from the stack using a dilution probe to suppress moisture and increase sample transport velocity. During the time the mass is building up on the tape, the BetaGuard PM is measuring the sample volume extracted from the stack to produce that mass. Combining the collected mass with the drawn sample volume provides a measure of mass concentration.

The MSI BetaGuard PM measures the flow both wet and dry to provide mass concentration readings on both a wet and a dry basis.

BetaGuard PM Measures Accurately Under All Conditions Regardless Of:

Emission Control Technology

- Dry Electrostatic Precipitator
- Wet Electrostatic Precipitator
- Dry Scrubber
- Wet Scrubber
- Fabric Filter/Baghouse
- Quench Tower

Changes in Particle Properties

- Size
- Shape
- Color
- Chemical Composition
- Density

Changes in Stack Gas

- Velocity
- Water Vapor Content (Humidity)
- Pressure
- Temperature

Stack/Duct Construction

- Size
- Shape
- Internal Lining
- Materials of Construction

Equipment Changes Over Time

- Ball Mill/Pulverizer Wear
- ESP Degradation
- Fabric Filter Deterioration
- SO_3 Injection Rate
- Carbon Injection Rate

BetaGuard PM
General Specifications

Particulate Conc. Range (Selectable):	0 - 1000 mg/m^3
	0 - 0.5 grains/ft^3
Diluted Sample Flow Range:	0 - 3.5 m^3/hr, 0 - 60 1/min
	0 - 120 ft^3/hr
Minimum Batch Sampling Time:	140 seconds
Minimum Measurement Update Time:	6 minutes
Measurement Sources (2)	
Isotope:	Carbon-14
Activity:	<12 µCi
Half Life:	5700 years
Licensing:	None Required - Exempt
Measurement Detectors (2):	Geiger-Mueller (G-M) Tube
Filter Medium:	Glass Fiber, Low Heavy Metals
Digital I/O:	16 in / 16 out
Analog I/O:	10 in / 2 out
Warm-up Time:	30 minutes
Power Requirements	
Main Instrument:	115 Vac, 15 A max
Heated Sample Line:	115 Vac, 10 A max
Dilution Air Heater:	115 Vac, 6 A
Instrument Air Requirements:	80 psig, 6 scfm min
Dimensions:	72"h x 30"w x 12"d
Weight:	275 pounds
Environmental Rating:	NEMA 4X
	IP66
Operating Temperature:	50° - 120°F / 10° - 50°C
Storage Temperature:	-20° - 135°F / -30° - 60°C

MSI
MECHANICAL SYSTEMS, INC
480 Progress Way
Sun Prairie, Wisconsin 53590
Telephone 608-825-2055
Facsimile 608-825-2295

The MSI BetaGuard® PM

Principles of Operation of a Beta Gauge Particulate Monitor

The BetaGuard PM is an instrument for measuring the concentration of particulate matter in combustion exhaust. It operates by drawing a sample of exhaust from a probe through a piece of filter tape. The filter tape is made of a glass fiber mesh, similar to fiberglass, and traps any dust particles larger than 0.3 microns. A mass measuring sensor called a Beta Gauge measures the mass of the filter tape first when the filter is clean, and again when the filter is loaded with particles. The instrument subtracts the filter mass before and after loading to calculate the mass of the particles in milligrams (mg). The instrument also measures the flow of the stack sample gas in cubic meters (m^3) used to extract the sample, and calculates the particulate concentration by dividing the mass by the volume in units of mg per m^3. This process emulates USEPA Methods 5, 5i and 17.

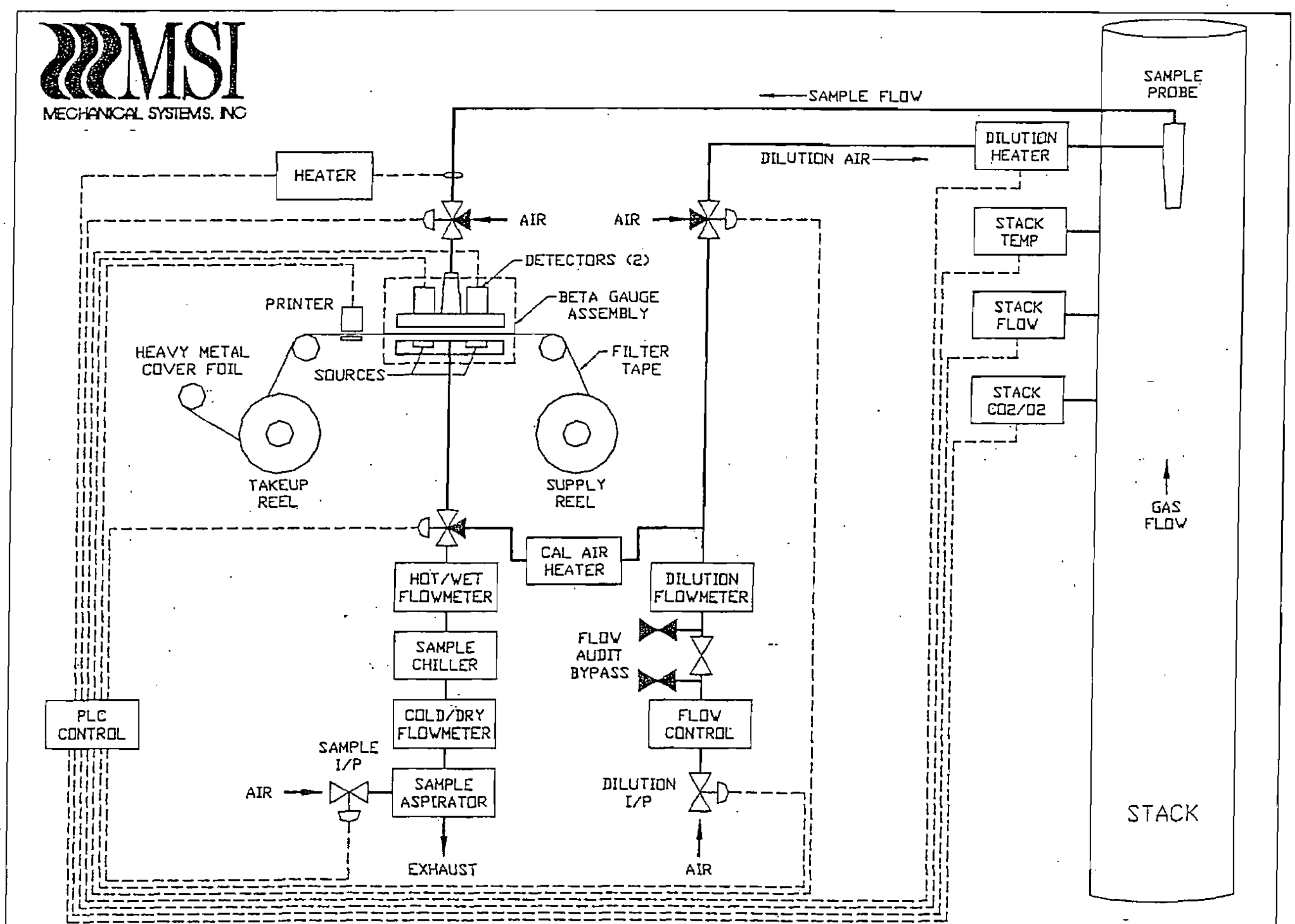


Figure 1.5: MSI BetaGuard PM Schematic Diagram

Beta Gauge

The Beta Gauge is a transmission-style sensor that transmits Beta particles through the filter tape and measures the Beta particles that get through the filter on the other side (see Figure 1.6).

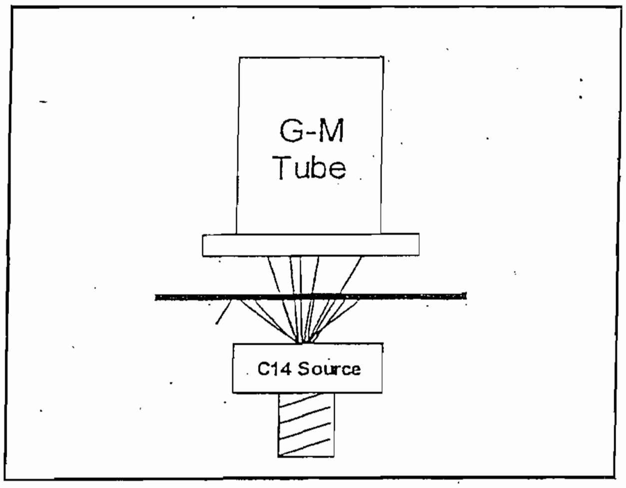


Figure 1.6: Beta Gauge Source and Detector

Beta particles are high energy electrons emitted from a radioactive isotope as it decays. They are not themselves radioactive, nor do they make anything they contact radioactive. The radioactive material, in this case Carbon-14 (C-14), is sealed in the source capsule and is not allowed to escape. The Beta particles are continuously being emitted through the source capsule window. Some are absorbed by the window itself, many are absorbed by the filter tape and the particulate particles, some are absorbed in the G-M Tube detector window and the rest are detected by the G-M Tube detector.

The Beta particles being emitted from the C-14 Source have an energy of 156 kev (kilo-electron volts), which is somewhat higher than the electrons striking the phosphor coating on the inside of a home television tube. The C-14 Beta particles can only travel about 10 inches in air before they are absorbed, and they are easily blocked by clothing and skin. The amount of radioactivity in the BetaGuard PM is similar to that in a household smoke detector, so no special labeling or licensing is required. It is recommended, however, that whenever any work is performed on the sources, filter tape holder or detectors, safety glasses must be worn.

The G-M Tube detector is a device that counts ionizing radiation (Alpha, Beta, Gamma) and is therefore called an ionization detector. A G-M, or Geiger-Mueller, Tube is a metal canister of gas with a thin window on one end and an electrode in the inside center (see Figure 1.7). A Beta particle that passes through the filter tape and the thin G-M Tube window will collide with the atoms of gas in the G-M Tube. Since a Beta particle is really a high energy electron, it has mass and an electrical charge and it is moving quickly. As the Beta particle collides with a gas atom, it gives some of its energy to an outer shell electron of that gas atom. If the outer shell electron now has enough energy to overcome the binding energy of the nucleus, it can escape from its atom. This results in an extra free electron in the G-M tube and an atom that has one fewer electron than it needs to be electrically neutral. This electron-deficient atom has an overall positive charge and is called an ion. This is the process of ionization and one Beta particle can ionize many hundreds of gas atoms. The gas in the G-M Tube is selected for its density and the ease with which its outer shell electrons can be stripped by the incoming Beta particle (ionization potential).

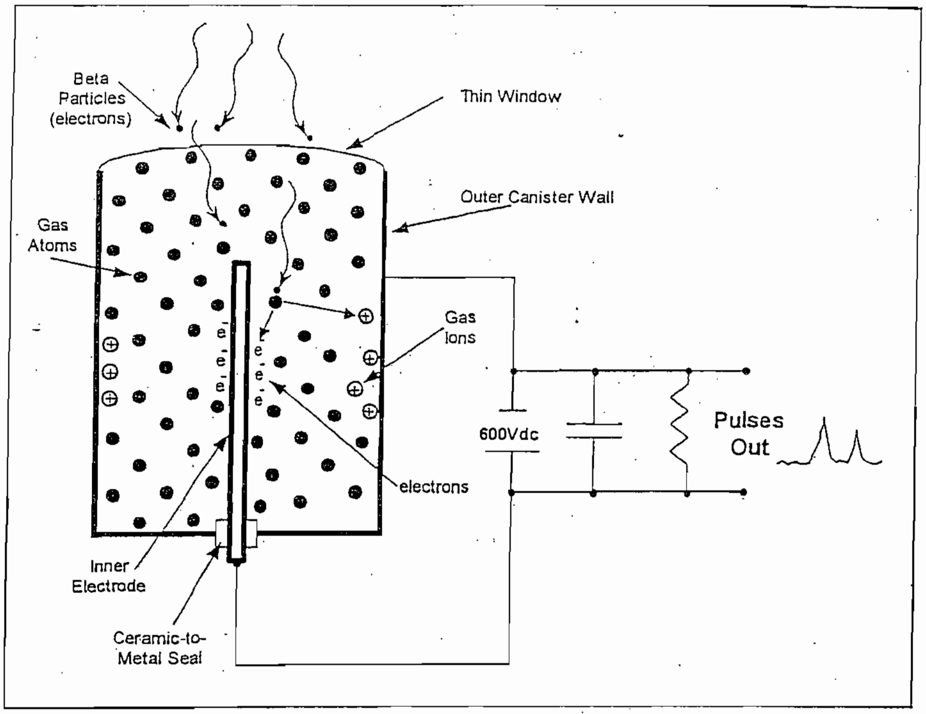


Figure 1.7: Geiger-Mueller Tube Schematic

An electrode is sealed into the G-M tube through the bottom but is electrically isolated from the outer canister by a ceramic-to-metal seal. A high voltage is applied across the inner electrode and the outer canister that creates a large radial electric field inside the G-M Tube. Since the free electrons caused by the Beta ionization have a negative charge, they are attracted to the high potential inner electrode and the positively charged ions are attracted to the low potential canister wall. Since the electric field is so high, these charged particles are accelerated fast enough to cause ionization in more gas atoms. This process known as secondary ionization results in a rush of flowing charge to the inner electrode and the outer canister wall. This rapid charged particle flow is seen as a burst of current on the conductors attached to the electrode and canister. A resistor placed across these conductors converts the current burst to a voltage pulse for each Beta particle entering the G-M tube. Counting these pulses determines how many Beta particles are passing through either the clean filter tape or the filter tape with particulate. The ratio between the two pulse counts determines the net mass on the filter tape.

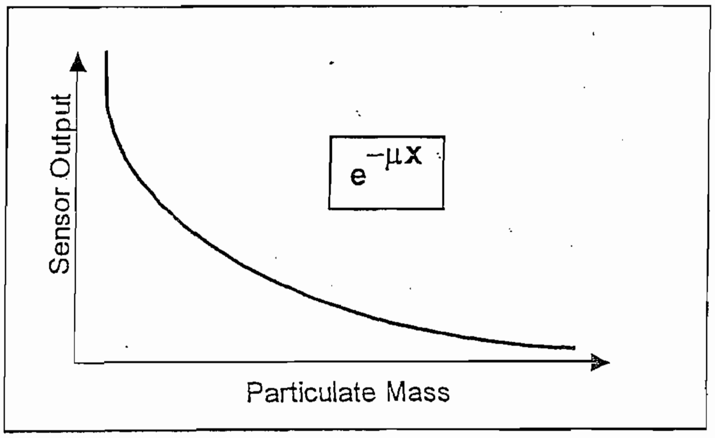


Figure 1.8: Inverse Exponential Beta Transmission Sensor Response

The response of the Beta transmission sensor to particulate mass is similar to that of an optical opacity sensor that shines light through the stack and measures its intensity after it has traveled through the stack gas where it has been partially scattered and absorbed. The sensor output is inversely proportional to the amount of mass between the source and detector and exhibits an exponential dependence as shown in Figure 1.8

Sample Flow

The stack gas is isokinetically drawn through a nozzle attached to a stainless steel ½" (12mm) diameter tube. The nozzle points against the direction of stack gas flow and has a well defined circular opening, typically 5 or 6mm diameter. A dilution tube, also ½" diameter stainless steel, connects to a mixing chamber just behind the rear of the nozzle and adds dry filtered ambient air in the dilution ratio set by the BetaGuard PM (typically between 1:1 and 10:1). The dilution flow is measured by a mass flowmeter in the instrument.

The total diluted sample is drawn through a heated ½" stainless steel sample line and passed through the filter tape where any particulates (dust) in the sample larger than 0.3 microns (0.01 thousandths of an inch diameter) are accumulated.

The filtered diluted sample gas then passes through a flowmeter that measures the diluted sample gas flow in the hot, wet state. If a dry basis particulate concentration measurement is needed, the diluted sample gas flows through a chiller where the water is removed, and then through another mass flowmeter to calculate the dry total flow. The sample gas is finally vented back into the stack or into open air.

Sample Heater

The sample line is actively heated by an electrical resistance heater that is controlled by the BetaGuard PM. The dilution line is optionally heated at the Probe flange by an electrical resistance in-line air heater. Additional closed loop controlled heaters are mounted in the filter holder and optionally in the cabinet sample gas circuit to insure that the sample remains hot. The BetaGuard PM can also be set to continuously vary the sample temperature to track the stack gas temperature if Isothermal Sampling mode is selected.

Particulate Measurement Cycle

The diluted stack gas sample is brought to the filter tape through a conical pipe that is mounted to the top half of the filter holder. The top and bottom half of the filter holder fit together tongue-in-groove style to trap the filter tape and seal around the conical pipe. A stainless steel tube is attached to the bottom half of the filter holder below the filter tape opposite the conical pipe. This assembly insures that the filter tape remains stationary while the sample gas is passed through it without allowing any of the sample gas to escape.

The sample gas is passed through the filter tape long enough to deposit a sufficient amount of mass for the BetaGuard PM measurement, typically 4 – 28 mg. The sample flow cycle is usually 7-15 minutes depending on stack particulate concentration. The filter tape is moved back and forth from under the sample gas flow to between the Beta gauge source and detector by a stepper motor and a friction wheel drive. Each time the filter tape is moved, a solenoid separates the two halves of the filter holder. When the filter tape stops moving, the filter holder halves are pressed tightly together by compression springs.

A typical measurement cycle is as follows:

Step 1	The stepper motor advances the filter tape to a clean section within the filter holder (about 92mm [3.6"])
Step 2	No sample is passed through the filter tape while the left-hand Beta Gauge measures a clean section of the filter tape for 2 minutes. This provides the zero measurement of that spot of the filter tape.
Step 3	The stepper motor reverses the filter tape until the spot measured in Step 2 is exactly beneath the conical pipe sample gas outlet (46mm [1.8"]).
Step 4	The valve opens to allow the sample gas to flow through the filter tape for the predetermined cycle time. At the same time, the right-hand Beta Gauge measures the clean section of filter tape between its source and detector for 2 minutes to obtain the zero measurement of that spot.
Step 5	The stepper motor advances the filter tape until the spot that just filtered the sample gas is again directly between the source and detector of the left-hand Beta Gauge (46mm [1.8"]).
Step 6	The left-hand Beta Gauge measures for 2 minutes the same spot of the filter tape where it measured the zero previously, only now it is loaded with particulates. Simultaneously, the valve opens to allow the sample gas to flow through the spot of filter tape that was measured for a zero reference with the right-hand Beta Gauge in Step 4 for the predetermined cycle time.
Step 7	After the left-hand Beta Gauge has measured the particulate-loaded spot for two minutes, the particulate concentration is displayed and the 4-20mA output is updated.
Step 8	When the sample gas flow cycle time of Step 6 is complete, the stepper motor reverses the filter tape until the spot measured in Step 4 by the right-hand Beta Gauge is returned, now loaded with particulates (46mm [1.8"]).
Step 9	The right hand Beta Gauge measures the particulate loaded filter spot for 2 minutes, the particulate concentration is displayed and the 4-20mA output is updated.
Step 10	Upon completion of the Step 9, the measurement process begins again at Step 1.

An important consequence of the BetaGuard PM measurement principle is that it always re-zeros the filter prior to depositing the particulate sample. This allows the instrument to reuse the filter spot a number of times before it begins to clog and the filter must be advanced. If this resampling option is selected, the life of a reel of filter tape can be extended from one month to two or three months.

Blowback

When compressed air is provided to the BetaGuard PM and the measurement cycle begins, the compressed air actuates a pneumatically actuated valve that allows the stack gas to be drawn into the instrument and the BetaGuard PM to operate. The position of the pneumatic actuator is sensed to always insure that compressed air is present so that the probe can be blown back on a regular basis to eliminate the possibility of dirt build-up and clogging. The interval between blowbacks is user selectable from the BetaGuard PM display and is usually eight (8) hours. When blowback is initiated, either automatically or manually, a valve is closed to stop sample gas from flowing through the filter tape and high pressure (≈70psig) air is forced through the sample and dilution lines, through the nozzle into the stack. The compressed air is pulsed in 2 second on, 2 second off cycles for about 20 seconds.

Automatic Beta Calibration

This routine is usually run daily and initiated by the data logger and lasts about 30 minutes. Automatic Beta Calibration checks the repeatability of the Beta Gauge measurement component of the BetaGuard PM by performing a zero check, a span check and a filter tape positioning check. During an Automatic Beta Calibration, the normal measurement mode of the BetaGuard PM is suspended. The Automatic Beta Calibration routine can also be initiated immediately through the BetaGuard PM display.

Automatic Flow Calibration

This routine is usually run daily and initiated by the data logger and lasts about 30 minutes. Flow Calibration can be run concurrent to the Automatic Beta Calibration. Automatic Flow Calibration checks the repeatability of the flowmeter components of the BetaGuard PM by routing the same flow through all of the flowmeters at two separate flow setpoints to perform a low span and a high span check. During an Automatic Flow Calibration, the normal measurement mode of the BetaGuard PM is suspended. The Automatic Flow Calibration routine can also be initiated immediately through the BetaGuard PM display.

THEORY OF NUCLEAR GAUGING

There are typically three types of radioactive emission used for industrial mass gauging, Alpha (α), Gamma (γ) and Beta (ß).

Alpha Emission

An Alpha particle is a ^{4}He nucleus and as such, is very large and heavy compared to the other forms of radioactive emission. They have very limited penetrating ability in solids and since Alpha gauging applications are used primarily for the measurement of gases, they will not be discussed further here.

Gamma Emission

Unlike Alpha (or Beta) radiation, Gamma radiation is not in the form of charged particles, but instead is electromagnetic radiation in and above the X-Ray spectrum. By analogy, a Beta source of, say, 500mCi activity emits as many Beta particles per second as the Gamma photons per second emitted by a 500mCi Gamma source. Unlike Beta particles, Gamma photons are emitted at a single energy determined by the particular isotope and interact with matter through fundamentally different mechanisms. Gamma photons have no charge and no mass, and are consequently much more penetrating than Beta particles in matter (like X-Rays) and are used primarily for quite thick targets and for fluorescence measurements.

Beta Emission

Beta particles are in fact high energy electrons ejected from the nuclei of certain radioactive materials. They are negatively charged, have energies ranging from zero to a maximum energy (units of electron Volts [eV]) determined by the specific radioactive isotope and are emitted in an average number per second defined by the Activity (units of Curies [Ci]) of the particular radioactive source.

Beta particles interact with matter through three primary mechanisms:

1) Inelastic collisions with electrons in the target (*Absorption*)

$$f_1\{k_1\rho(Z/A)\} \quad \textbf{eq. 11.1}$$

2) Elastic collisions with nuclei in the target (*Scatter*)

$$f_2\{k_2\rho(Z^2/A)\} \quad \textbf{eq. 11.2}$$

3) Inelastic collisions with nuclei in the target (*Bremsstrahlung*)

$$f_3\{k_3\rho(Z^2/A)\} \quad \textbf{eq. 11.3}$$

where k_n are constants proportional to the Beta energy,
ρ is target density,
Z is the target Atomic Number and
A is Atomic Mass.

Beta particles are particularly ideal for use in industrial gauging because of their relatively short range in matter and therefore high sensitivity to small changes in mass, and since the source / detector components are very long-term stable and industrially rugged. The Carbon-14 isotope used in most Beta Gauge Particulate Monitors has a half-life of over 5000 years, and therefore exhibits no measurable change in radiation output and thus no measurement drift throughout the life of the instrument. The G-M Tube detectors are simple gas-filled canisters with no moving parts. They exhibit no drift characteristics unless they are physically damaged, in which case their output goes to zero, an easily identifiable fault condition. In the unlikely event of a G-M Tube failure, the dual detector BetaGuard PM has the ability to sense the zero output condition and automatically switches its operating mode to that of a single detector Beta Gauge. In this way, the instrument will continue to measure properly with no loss of data, and repairs can be made in a non-emergency manner.

A consequence of the manner in which Beta particles interact with matter to determine mass is that there can be some measurement dependence on the chemical composition of the specific particulate. It is therefore worthwhile to investigate the extent to which the chemical composition dependence of the BetaGuard PM has on its ability to accurately measure the products of combustion. When considering the design of a Beta Transmission Sensor, a radioactive source is mounted on one side of the target and a Beta particle detector is mounted on the target's other side. The detector then measures the Beta particles that pass through the target.

Assuming that all the Beta particles that do not pass through the target and are not detected are in fact absorbed via mechanism 1, the response curve of the ß-Sensor would describe an exponential dependence (derived from Equation 1 above) on target mass and be independent of target chemical composition.

$$\mathbf{e^{-\mu x}, \text{ where } \mu = f1\{k_1\rho(Z/A)\}}$$

If Equations 2 and 3 above are combined as

$$F\{K\rho(Z^2/A), \qquad \text{eq. 11.4}$$

then the total interactions of Beta particles with matter can be expressed by the following definition of μ, the absorption coefficient:

$$f_1\{k_1\rho(Z/A)\} + F\{K\rho(Z^2/A)\} \qquad \text{eq. 11.5}$$

where k and K include a dependence on the incident Beta energy,
Z is the target atomic number,
A is the target atomic mass, and
ρ is the target density.

Bear in mind that in the case of a Beta Transmission Sensor, any Beta particle that is not detected is assumed to be absorbed.

This implies that if some Beta particles that are not detected interact with the target by some mechanism other than absorption, such as backscatter from the target or deceleration and emission of X-Rays (Bremsstrahlung) that cannot be measured by the Beta detector, then a measurement error may occur. The practical threshold of the target atomic number below which K of equation 5 approaches zero, is a function of the Beta energy. In the case of the C14 Beta-emitting isotope used for particulate monitors, the beta energy (max) is 156kev and for target atomic numbers below 20, **K** of Equation 5 can be considered to be zero and the sensor is virtually insensitive to compositional changes.

If the target contains components of atomic number greater than 20, such as Iron, Chromium or lead, then **K** of Equation 5 is not zero, and any variation in the relative concentration of these elements may cause a measurement error proportional to the Z^2/A additive function (F) which becomes more pronounced with increasing concentration and increasing Z.

Compound	*Class F*	*Class C*
SiO_2	48	33
Al_2O_3	20	18
Fe_2O_3	20	8
CaO	3	25
MgO	1	8
K_2O	2	1
Na_2O_3	1	3
SO_3	1	3
LOI	3	0.5

Figure 11.1: Coal Fly Ash Composition by Class

It is important at this time to qualify the magnitude of any error due to changing chemical composition in stack gas effluent. One principle application of the BetaGuard PM is the measurement of airborne particulates from the stacks of coal-fired electric generating utilities. The typical fly ash chemistry will vary as a function of the fuel and can range from high Fe_2O_3, low CaO to high CaO, low Fe_2O_3 in the cases of various Lignite and Anthracite coals (see Figure 11.1).

Equation 5 can be rewritten in terms of the detected Beta particles passing through the target as:

$$I = I_0 \Sigma e^{-w_i \mu_i \rho x} \qquad \textbf{eq. 11.6}$$

where I is the Beta particle intensity after passing through the target,
I_0 is the original intensity of Beta particles emitted from the source,
μ_i is the Beta attenuation coefficient of each element in the target (the i^{th} element; physically, μ can be viewed as the probability of interaction per unit distance),
w_i is the concentration by weight of the i^{th} element,
ρ is the homogeneous material density and
x is the homogeneous material thickness.

μ_i is a function of the Beta particle energy, **E**, and the electron density of the absorber and is of the form,

$$\mu_i = C_{i1}E(Z/A) + C_{i2}E(Z^2/A)$$

where $\mathbf{Ci_1}$ is an empirically derived constant for mechanism 1 above and $\mathbf{Ci_2}$ is an empirically derived constant for the combined mechanisms 2 and 3 above.

It is interesting to compare the energy lost by each of the two terms above. Dividing these terms,

$$[(dE/dx)_{2,3} \,/\, (dE/dx)_1\,] = [C_{i2}E(Z^2/A) \,/\, C_{i1}E(Z/A)] = C \cdot E \cdot Z,$$

where **C** is a new constant, empirically derived as approximately 1/500 when **E** is in units of Mev.

At a maximum Beta energy for C14 of 0.156Mev, the amount of error created by a change in fly ash chemical composition of 15% Fe (Z = 26) is 0.8%. Substituting this effect into the exponential argument of equation 6, the effect of even this large a change in the higher atomic number composition of the fly ash chemistry will lead to at most a 1% measurement change not attributable to the consequent change in real particulate density.

For this reason, the BetaGuard PM is calibrated in the factory to a known, traceable set of mass standards. Upon installation on a stack, there is virtually no subsequent recalibration of the instrument required for the various application specific fly ash chemistry. The BetaGuard PM is virtually insensitive to chemical changes in the products of combustion. It will measure the particulate mass correctly and repeatably. In the cases of installation of the BetaGuard PM on other combustion or incineration processes that emit high atomic number pollutants, a correction factor may be required to bring the BetaGuard PM into calibration. This is facilitated by user-enterable scaling or offset factors stored in a comprehensive recipe in the Gauge electronics.

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3 *Handbook of Nuclear Technology*, reprinted from Nucleonics, McGraw-Hill Publishing Co., NY, various dates.

4 *The Fly Ash Resource Center*, World Wide Web Site: http://www.geocities.com/CapeCanaveral/Launchpad/2095/flyash.html

5 *Various Publications*, The World Coal Institute, Oxford House, 182 Upper Richmond Road, Putney, London SW15 2SH United Kingdom.

Beta Gauge Particulate Monitoring - Theory and Practice

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Venue: CEM User Group Meeting 1999
Cincinnati, Ohio
May 12-14, 1999

Sponsors: Electric Power Research Institute, Inc.
Cinergy Corporation

Continuous particulate monitoring is becoming an issue in the electric utility industry. Title V permitting, compliance assurance monitoring, and credible evidence rules are forcing the utility industry to look critically at the question of particulate emissions. The industry has known for some time that changing the operating parameters of electrostatic precipitators can result in changes in particulate emissions. What has become evident recently to both utilities and regulators is that there are other factors that can significantly influence particulate emissions independent of precipitator operation, and these factors are not well documented. Unless these factors can be characterized properly or somehow related to full load stack tests, monitoring may become necessary.

Few electrostatic precipitators operate at full power all of the time. It is standard practice to vary precipitator power on the basis of external parameters such as load, opacity, spark rate, etc. and take for granted that the emissions remain in compliance with permit conditions. Even though particulate tests are normally only done at full load and under one set of operating conditions, it is assumed that precipitator operating parameters can be varied from full load test conditions and not affect emissions. Many utilities are beginning to question this assumption. What is really happening when precipitator operation is optimized using some other parameter than actual emissions? Are the emissions going up or going down?

The introduction of low NOX burners on an industry wide basis has complicated the problem. Poor efficiencies and higher loss on ignition have plagued many plants and resulted in numerous changes in firing procedures and precipitator operating parameters. Every change affected particulate emissions, but little if any data has been collected to document the effect of the changes.

The use of different coals and other opportunity fuels has had even more effect on particulate emissions. The change from a high sulfur eastern bituminous coal to a low sulfur western subbituminous coal has well known effects on the amount of ash generated and the amount of particulate emissions produced. What has been surprising is the growing body of evidence suggesting that changing coal within the same classification can also noticeably affect emissions. Changing from one bituminous coal to another bituminous coal may noticeably change particulate emissions. Those plants that are constantly changing or blending fuels will not be able to use periodic performance testing to determine particulate emissions unless all combinations of coals are tested.

Continuous verification of acceptable particulate emissions will become necessary when either regulators or utility risk managers become uncomfortable with undocumented operation. When this happens plants need options as to how to monitor particulates. While there is a concerted effort to see if modeling will work to address these problems, there will be significant difficulty in the application of this approach for those plants that require flexibility in operation. Continuous particulate emission monitors will likely be the instrument of choice for those facilities that cannot operate within very narrow and well defined ranges.

Historically there have been four types of particulate monitors:

Gravimetric (Reference method)

Triboelectric (Broken bag detectors)

Optical
- Light Transmission (Opacity monitors)
- Scintillation
- Light Scatter
  - Back
  - Side
  - Forward

Beta Gauge

The gravimetric method has been used as the reference method with little or no application for continuous particulate monitoring. Recent refinements in the reference methods to measure lower concentrations have resulted in much more complicated procedures. This has only made it less likely that any continuous gravimetric instrument will ever be developed.

Triboelectric instruments have been used extensively as a cost effective method of monitoring catastrophic failures in fabric filters and baghouses. Although there are notable efforts in both England and Germany at this time to use these devices for compliance monitoring, the application in North American utilities is not expected to be that significant where the vast majority of particulate control is done by electrostatic precipitators.

Precipitators impart a charge to the entrained particles which is similar to the effect the triboelectric devices are measuring. This makes measurements very difficult if not impossible to characterize for most utility applications with this technology.

Light transmission devices or opacity monitors have been used extensively for visible emission compliance in the United States for over twenty years. The technology has worked well in the utility industry when opacity limits were in the 20% to 40% range. As permit limits come down, the correlation between mass concentration and light transmission becomes very difficult to measure with opacity monitors. The technology becomes unreliable and unable to accurately measure particulate concentrations below 50 mg/scm (.02 gr/scf). The EPA has expressed significant doubts that this technology will be acceptable for continuous particulate monitoring. As a result, opacity monitors have not been included in most of the official EPA tests and are not expected to have a significant presence in the particulate monitoring market.

There is another optical technology which uses the ability of particles to scatter light instead of obscure light to produce more accurate measurements. Light scattering instruments as a group have been used in Europe for almost the same amount of time as opacity monitors have been used in the United States. The results have been uniformly good at emission detection limits significantly below those presently seen with opacity monitors.

There are three variations of this technology; forward scatter, side scatter, and back scatter. All of the scatter technologies can work well under the right conditions and generally have the same limitations and restrictions as opacity monitors with one exception. Most scatter instruments do not measure across the stack, but measure a point a set distance in from the stack wall. This point is normally less than one foot from the stack wall which can be a problem for large utility stacks. The boundary layer effects that have been found and documented in recent flow studies by EPRI and the EPA will affect the distribution of particulates near the stack walls. Analyzing the sample at a more representative location farther from the stack wall will help ensure more accurate measurements.

Scatter instruments are very similar to opacity monitors in terms of operation and maintenance and will likely be the instrument of choice where they can be certified. They solve the lower detection limit problem of opacity monitors and only need one stack opening to be installed. With optical based scatter instruments apparently working well in other parts of the world, why is there a need for another method to monitor particulate?

Beta transmission technology was developed to address three very specific applications; wet stacks, changing stack conditions, and changing particle properties. Optical instruments cannot measure in wet stacks. Entrained moisture refracts, reflects, and diffracts light making it impossible for optical technology of any kind to work correctly. For years the opacity readings reported for wet scrubber stacks were taken before the scrubbers to circumvent this problem. While this may continue to be allowed, there is an incentive to move the particulate monitor to the stack to report more accurate data and take advantage of a scrubber's natural ability to remove particulate from the exhaust gas stream.

It is also well documented that changing stack conditions and changing particle properties make optical measurements unreliable. Figure 1 shows the problem associated with changing the particle size distribution in a stack. As the particle size varies, optical instruments will produce different readings even though the actual mass emission is not varying. Particle size variations occur commonly as the operating parameters on an electrostatic precipitator are varied.

Figure 1: Optical Instrument Response

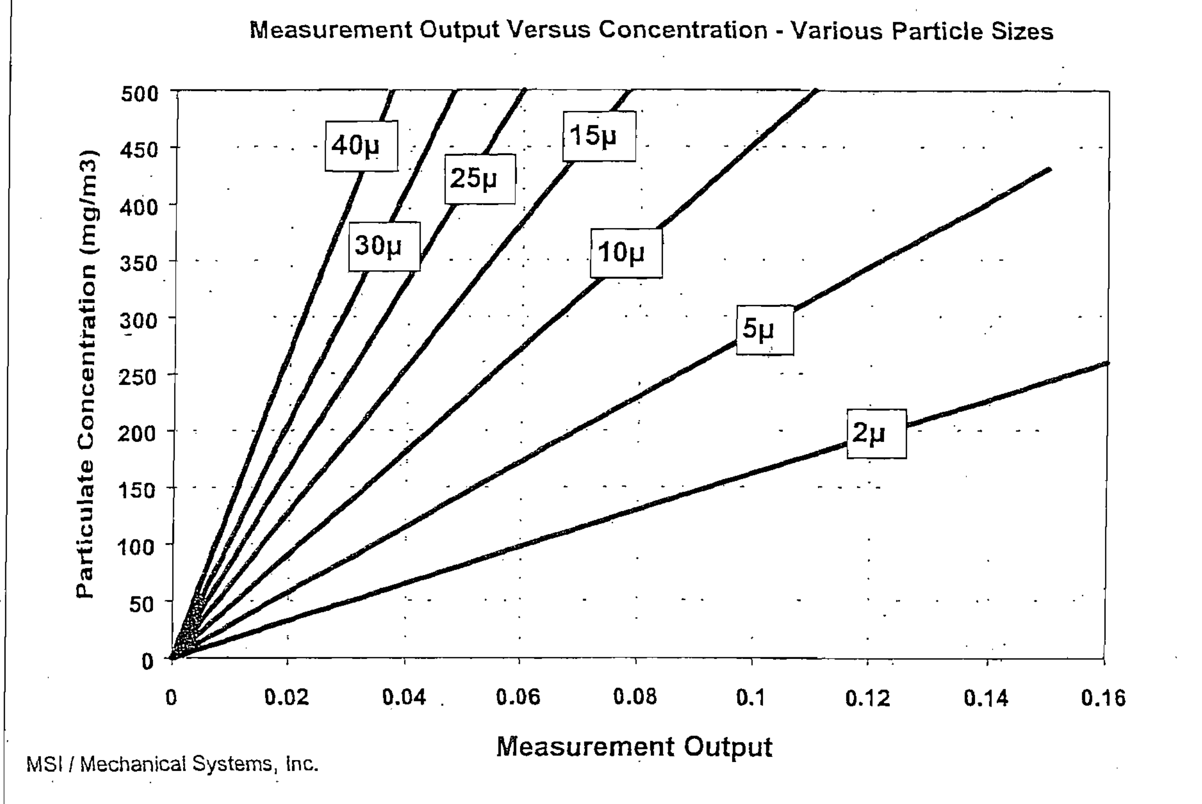
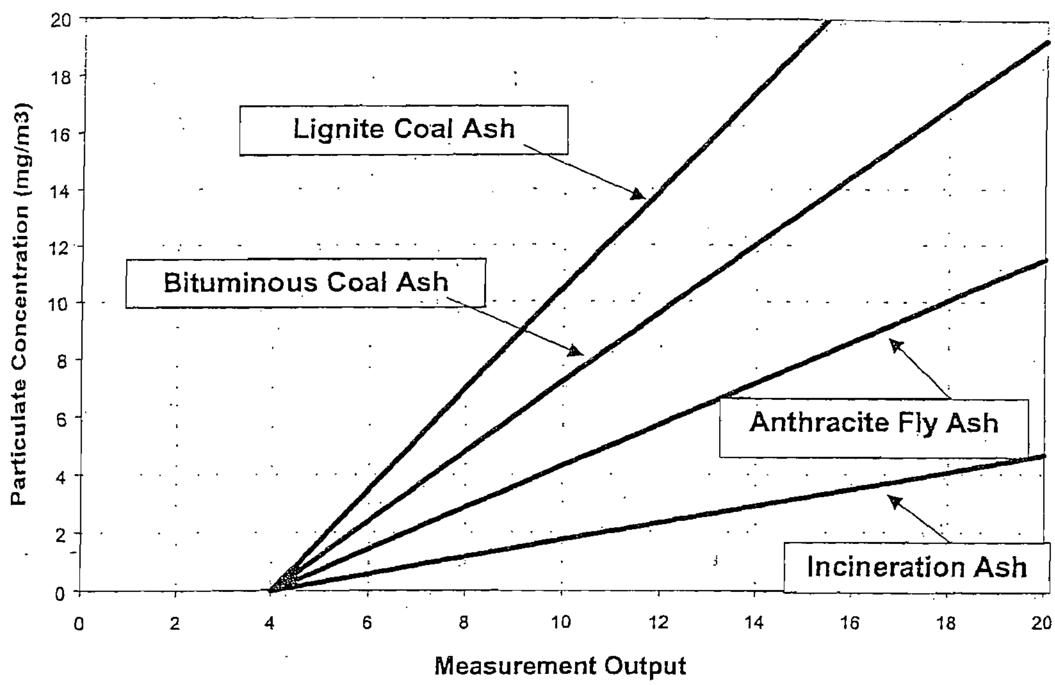


Figure 2 depicts a similar problem when the type of fuel changes. Here again optical instruments produce different outputs depending on the type of coal being burned and not on the amount of mass being emitted.

The difference in readings noted in Figure 2 are for several different types of coal but similar graphs can be produced for coals within the same classification. There are different optical responses between low sulfur and high sulfur eastern bituminous coal and between high sulfur West Virginia coal and high sulfur Illinois coal.

Figure 2: Optical Opacity Instrument

Measurement Output Versus Concentration - Various Ash Types



MSI / Mechanical Systems, Inc.

Different coals produce different outputs for the same mass emission in optical instruments for many different reasons. The average size distribution could be changing. The color or refractive index of the coal could be changing. The moisture in the coal could be changing. The average heat content/velocity in the stack could be changing. Optical instruments work well and are a cost effective solution when things don't change. For utilities with changing conditions or utilities who do not want to be limited to a one set of operating conditions, another technology had to be found.

The beta gauge particulate monitor is uniquely suited for documenting compliance of source particulate emissions and for optimizing precipitator and fabric filter operation. Beta gauge measurements are not affected by stack conditions or by particle characteristics.

Beta gauge measurements show no sensitivity to stack velocity, temperature, and moisture, or to particle size, shape, color, and refractive index. This non-optical technology can be installed in wet or dry stacks and will measure reliably even when the characteristics of the particulate emissions are constantly changing.

Figure 3 shows a typical beta gauge source and detector combination. A low energy Carbon-14 source furnishes a constant supply of beta electrons which are detected by a Geiger Mueller tube or photodiode array. A filter tape is interposed between the source and detector which produces an initial reduction in the number of beta electrons reaching the detector. The particulate measurement cycle begins by measuring a clean area (spot) on the tape for a fixed time period to determine a zero value. This clean spot is then moved under a collection apparatus for sample extraction from the stack. A sample of stack gas is drawn through and deposits particulate on the filter tape. All particles above 0.1 microns are collected. Once a sufficient amount of sample is collected on the filter tape, the tape is moved back under the beta source and remeasured. The difference in beta emissions measured from the original clear spot to the collected sample is directly proportional to the mass on the tape.

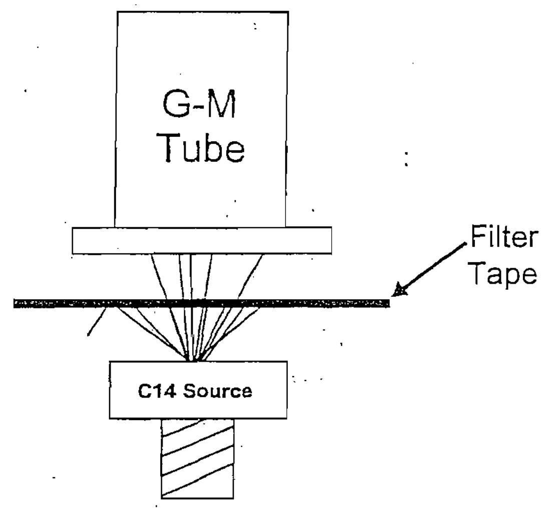
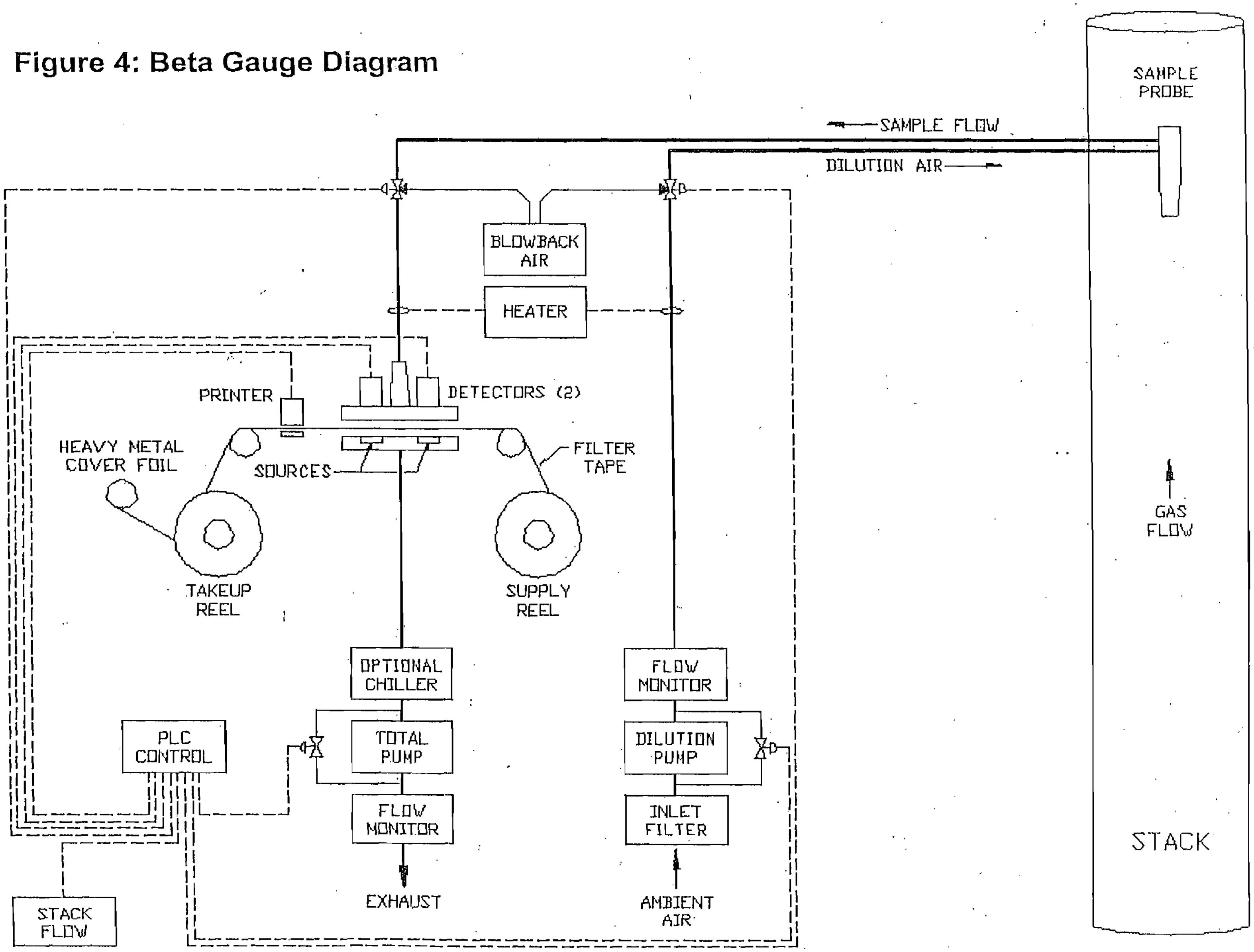


Figure 3: Beta Transmission Sensor

Figure 4 shows a diagram of the complete beta gauge. The beta gauge extracts a sample isokinetically from the stack using a dilution probe to suppress moisture and increase sample flow. The sample is transported through a resistance heated line at high velocity to maintain particulate entrainment and prevent sample loss. The particulate is drawn through and deposited on a filter tape in a heated collection holder (Figure 5). The tape is held in place and sealed from the surrounding atmosphere by the heated holder. Heating the holder prevents condensables from dropping out of the sample during the collection process.

The sample is collected for a set period of time or until a maximum pressure differential through the tape is detected. The tape is then moved back under the beta source and re-analyzed for total mass. During the time mass is building up on the tape, the beta gauge is also measuring the sample volume extracted from the stack to produce that mass. Combining the mass collected with the sample drawn provides an output for mass concentration.

Figure 4: Beta Gauge Diagram



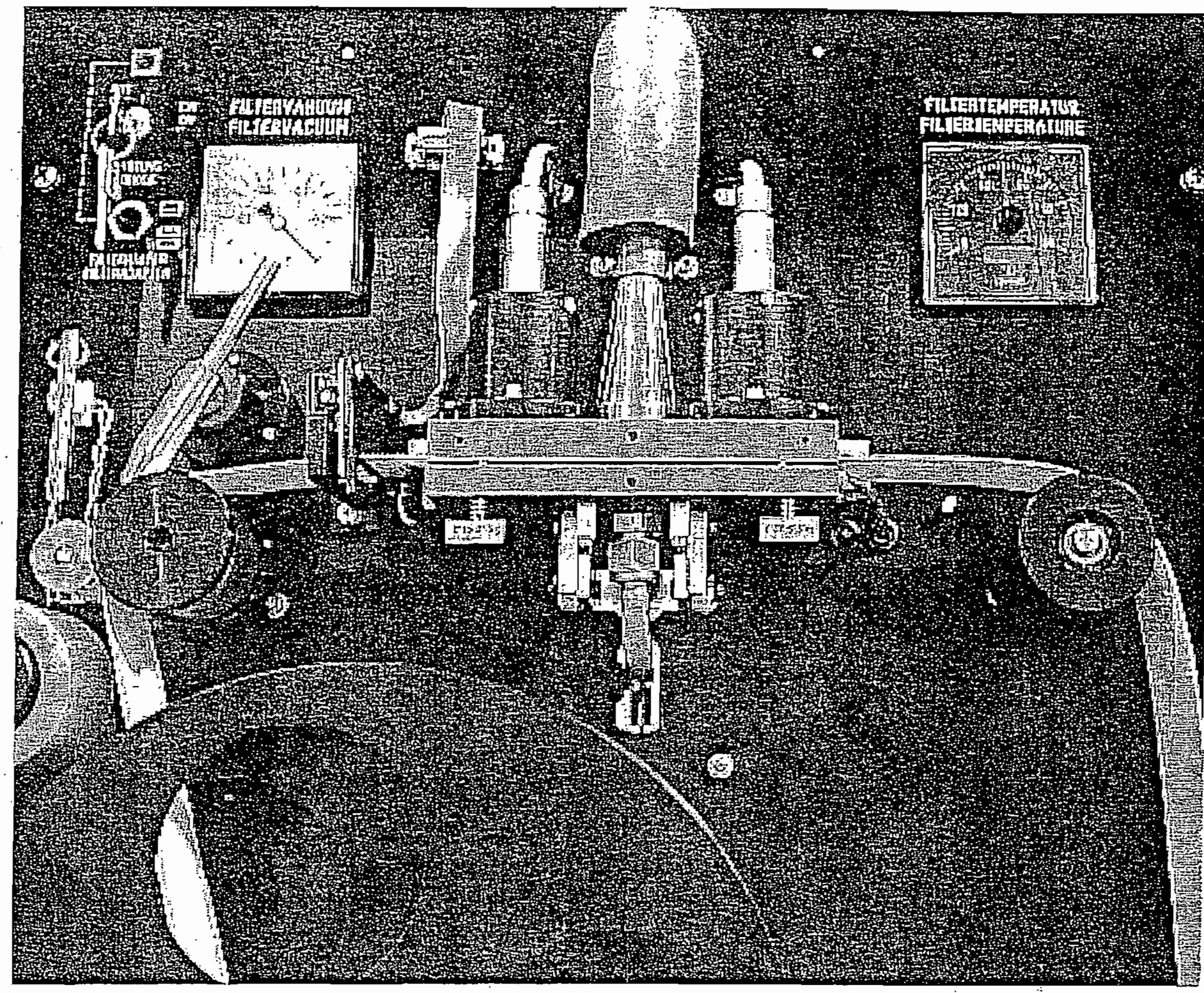


Figure 5: Beta Gauge Measuring Head

While relatively straightforward in concept, the actual sample extraction and measurement have proven much more difficult in practice. A great deal of time has been spent devising reliable methods for sample extraction and transport. Figure 6 shows the dilution probe used to extract the sample from the stack. As dilution technology addressed many of the sample conditioning problems with gas monitoring for the Acid Rain Program, dilution technology also addresses many of the sample conditioning problems with mass emission extraction.

Figure 7 shows the detail of the sample extraction nozzle at the end of the dilution extraction probe. Accurately measured dilution air is introduced into the probe at right angles to the extracted flow. The dilution air surrounds and envelopes the sample to minimize contact with the sampling system components. Rapid mixing of the dilution air and sample follows due to the turbulence produced in the mixing chamber.

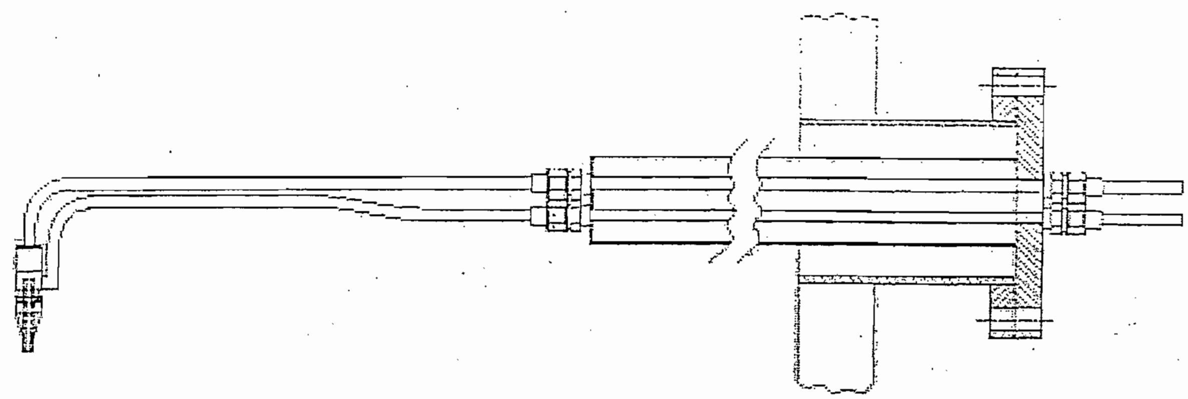


Figure 6: Beta Gauge Dilution Probe

This rapid mixing suppresses the moisture in the sample and eliminates the problem of condensation in the sample line. Moisture condensation trapping particulate in the sample line is one of the more difficult problem associated with particulate sample transport from saturated stacks. Without dilution the transport of the sample becomes progressively more unreliable as the moisture content of the sample increases.

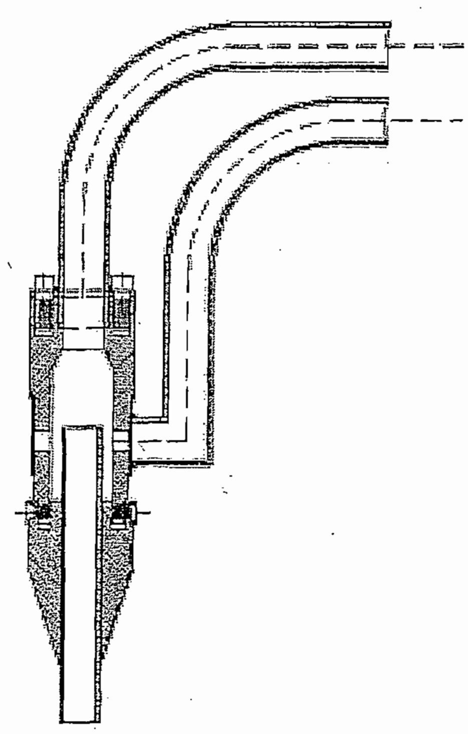


Figure 7: Dilution Probe Detail

Diluting the sample simplifies the transport of particulate samples from all types of stacks and allows wet scrubber stacks to be analyzed as accurately as dry stacks. Using dilution air also provides enough excess air so that there is more than enough flow to maintain a critical sample velocity. This is true even though the sample is extracted isokinetically from the stack and the amount of flow can change drastically from low load to high load operation. The total sample transported to the filter tape is maintained above critical sample velocity at all times by dilution air alone. The total sample flow is not dependent on the extracted sample flow to prevent sample loss during transport.

Maintaining a high sample velocity is absolutely critical to ensure that the sample is deposited on the tape and not in the sample tubing. At present sample tubing lengths up to fifty feet are possible under all stack conditions and could be longer on a case by case basis.

Flow monitors measure both the dilution air supplied to the probe and the total sample (dilution air plus extracted sample) drawn through the filter tape. The difference between the two measurements is the sample extracted from the stack. The sample extraction rate is controlled isokinetically by varying the dilution flow and maintaining constant the total sample drawn through the filter. This variation is based on an external flow measurement taken directly from the existing stack flow monitors or through the 40CFR75 data acquisition and handling system.

The beta gauge has a resistance heated sample line which is maintained at a constant temperature of 120° Celsius for Method 5/5i testing or allowed to vary slightly above stack temperature for Method 17 testing. Keeping the sample temperature slightly above stack temperature for Method 17 testing provides a more accurate measurement of front half particulate by ensuring that condensables are neither formed nor destroyed during sample transport. The resistance heated sample line is driven by low voltage AC transformers that operate at either 6 Vac or 12 Vac depending on the length of sample line. The heating circuit is formed by passing a current through the sample line, probe, and dilution line. The probe and connected sample and dilution lines are electrically insulated from the probe holder to allow the probe inside the stack to be heated.

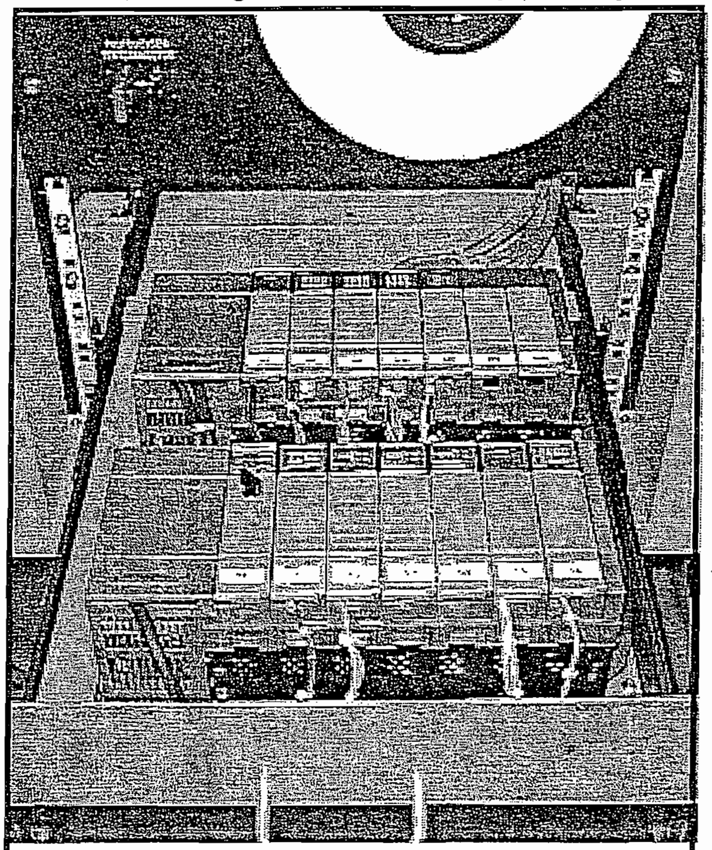


Figure 8: Allen-Bradley SLC500 PLC

The sample line is 0.50" diameter by 0.035" wall Type 316 seamless stainless steel tubing. The interior surface of the tubing is specially cleaned and polished to minimize particle entrapment. The fittings and valves in the sample line likewise are specially prepared to minimize turbulence and eddies that might allow particulate to fall out of the sample stream during transport to the filter tape.

The beta gauge is controlled by an Allen-Bradley SLC 500 programmable logic controller (Figure 8). The PLC controls the filter tape movement, pump operation, measurement cycles, and all aspects of instrument operation.

The PLC also calculates the concentration and mass emissions and outputs this information in analog (4-20 mA) or serial form (RS-232/485). Digital contact closures indicating system operations including calibrations, blowbacks, and alarms are also available. The PLC can accept digital inputs to control calibration or blowback cycles.

Other advantages of the beta gauge worth noting are:

1. The EPA calibration correlation between mass emissions and output is linear with a beta gauge. All optical instruments show decidedly non-linear operation which makes initial calibration and set up of the instruments for particulate monitoring difficult.
2. The collected samples can be protected for latter analysis by other techniques such as x-ray diffraction for heavy metals. A polyester cover foil dispenser used to protect the sample, and a dot matrix printer used to mark the filter tape with date and time and collected mass.
3. Automatic blowback of the sample lines during filter tape transport is standard to ensure the sample probe tip does not become plugged. Additional timed or manual blowbacks can also be initiated as required.
4. Quarterly audits using NIST traceable standards are possible.
5. Dual measurement heads minimize the amount of sample time lost to the batch process. Should a Geiger Mueller tube fail, the instrument automatically goes into single head sampling mode.
6. Multiple spot resampling extends the life of the filter tape. The measured amount of mass of one cycle becomes the zero of the next cycle.
7. An optional high capacity chiller is furnished for dry basis measurements. This chiller is rated at over 50 lpm and comes complete with integral temperature control and water carryover alarm.

Particulate concentration is rather unique in being one of the few Title V permit parameters that is not directly measured by utilities. It is not reasonable to assume that this situation will go on too much longer given the significant contribution utilities make to controllable particulate emissions in ambient air. The reference methods are being revised, and the performance specifications are being finalized at this time for particulate monitors. The process has been anything but easy or well controlled and is being driven by an industry, hazardous waste incinerators, that could not be more different in approach or application than the electric utility industry. Many utilities now face the installation of significant new capital equipment for controlling nitrogen oxides which will only make particulate monitoring more difficult for all instruments except beta gauges.

Beta gauge measurements can be used not only to monitor but also to control electrostatic precipitators and fabric filters. Performance of exhaust gas cleanup equipment in the future will likely be optimized based on actual emissions and not on other easier to measure, but less reliable and less accurate parameters. It is surprising this is not being done now and even more surprising that little attention is being given to this problem by the utility industry. The impact on the utility industry could be significant and deserves to be addressed in a more involved manner.

The technology is there to do the job. Beta gauges and other mass emission monitoring technologies have been in use for years. Beta gauge and scatter technologies in particular need to be applied and tested now by the utility industry to confirm applicability and long term viability. We suggest it is time for this process to begin before some unexpected event forces the issue on an unprepared industry.

III. EMISSIONS UNIT INFORMATION

A separate Emissions Unit Information Section (including subsections A through J as required) must be completed for each emissions unit addressed in this Application for Air Permit. If submitting the application form in hard copy, indicate, in the space provided at the top of each page, the number of this Emissions Unit Information Section and the total number of Emissions Unit Information Sections submitted as part of this application.

A. GENERAL EMISSIONS UNIT INFORMATION
(All Emissions Units)

Emissions Unit Description and Status

1. Type of Emissions Unit Addressed in This Section: (Check one)

[X] This Emissions Unit Information Section addresses, as a single emissions unit, a single process or production unit, or activity, which produces one or more air pollutants and which has at least one definable emission point (stack or vent).

[ ] This Emissions Unit Information Section addresses, as a single emissions unit, a group of process or production units and activities which has at least one definable emission point (stack or vent) but may also produce fugitive emissions.

[ ] This Emissions Unit Information Section addresses, as a single emissions unit, one or more process or production units and activities which produce fugitive emissions only.

2. Regulated or Unregulated Emissions Unit? (Check one)

[X] The emissions unit addressed in this Emissions Unit Information Section is a regulated emissions unit.

[ ] The emissions unit addressed in this Emissions Unit Information Section is an unregulated emissions unit.

3. Description of Emissions Unit Addressed in This Section (limit to 60 characters):
Type 1 Recovery Boiler – RB

4. Emissions Unit Identification Number: **006**
[ ] No ID ID: **RB** [ ] ID Unknown

5. Emissions Unit Status Code:	6. Initial Startup Date:	7. Emissions Unit Major Group SIC Code:	8. Acid Rain Unit?
A	**N/A**	**26**	[**No**]

9. Emissions Unit Comment: (Limit to 500 Characters)

Emissions Unit Control Equipment

1. Control Equipment/Method Description (Limit to 200 characters per device or method):
Tray type liquid scrubber which controls combustion gases from the boiler and noncondensible gases from the evaporators followed by a Brinks fiber type mist eliminator.

Brinks type mist eliminator for particulates – high velocity.

2. Control Device or Method Code(s): **051 and 014**

Emissions Unit Details

1. Package Unit: **N/A**
   Manufacturer:
   Model Number:
2. Generator Nameplate Rating: **N/A** MW
3. Incinerator Information: **N/A**
   Dwell Temperature: °F
   Dwell Time: seconds
   Incinerator Afterburner Temperature: °F

B. EMISSIONS UNIT CAPACITY INFORMATION
(Regulated Emissions Units Only)

Emissions Unit Operating Capacity and Schedule

1. Maximum Heat Input Rate:		**653.1** mmBTU/hr
2. Maximum Incineration Rate: **N/A**		lb/hr
3. Maximum Process or Throughput Rate: **74,300 lb/hr of red liquor solids.**		
4. Maximum Production Rate: **N/A**		
5. Requested Maximum Operating Schedule:	**24** hours/day	**7** days/week
	52 weeks/year	**8760** hours/year
6. Operating Capacity/Schedule Comment (limit to 200 characters):		

C. EMISSIONS UNIT REGULATIONS
(Regulated Emissions Units Only)

List of Applicable Regulations

Federally Enforceable Rules	
Ray. Core list of rules applying to entire facility. See Attachment 2.	
FAC 62-297.310	
FAC 62-297.401(1)	
FAC 62-297.401(2)	
FAC 62-297.401(3)	
FAC 62-297.401(4)	
FAC 62-297.401(5)	
FAC 62-297.401(6)	
FAC 62-297.401(9)	
FAC 62-297.411	
FAC 62-297.412	
FAC 62-297.415	
FAC 62-297.417	
FAC 62-297.420	
FAC 62-297.570	
FAC 62-297.520(1)(b)	
FAC 62-204.800(10)(b)(28)	

D. EMISSION POINT (STACK/VENT) INFORMATION
(Regulated Emissions Units Only)

Emission Point Description and Type

1. Identification of Point on Plot Plan or Flow Diagram? **RB**	2. Emission Point Type Code: **1**	
3. Descriptions of Emission Points Comprising this Emissions Unit for VE Tracking (limit to 100 characters per point): **RB041 – Recovery Boiler Stack**		
4. ID Numbers or Descriptions of Emission Units with this Emission Point in Common: **N/A**		
5. Discharge Type Code: **V**	6. Stack Height: **264** feet	7. Exit Diameter: **7.33** feet
8. Exit Temperature: **126** °F	9. Actual Volumetric Flow Rate: **160,096** acfm	10. Water Vapor: **13.55**%
11. Maximum Dry Standard Flow Rate: **131,400** dscfm	12. Nonstack Emission Point Height: **N/A** feet	
13. Emission Point UTM Coordinates: Zone: **17**	East (km): **454.7**	North (km): **3392.2**
14. Emission Point Comment (limit to 200 characters):		

E. SEGMENT (PROCESS/FUEL) INFORMATION
(All Emissions Units)

Segment Description and Rate: Segment ___1__ of __2___

1. Segment Description (Process/Fuel Type) (limit to 500 characters): **Recovery system NH_3 – combustion of red liquor solids – emissions related to quantity of red liquor solids burned in boiler**		
2. Source Classification Code (SCC): **30700222**	3. SCC Units: **air dried tons unbleached pulp**	
4. Maximum Hourly Rate: **37.69**	5. Maximum Annual Rate: **330,192**	6. Estimated Annual Activity Factor: **N/A**
7. Maximum % Sulfur: **N/A**	8. Maximum % Ash: **N/A**	9. Million Btu per SCC Unit: **20**
10. Segment Comment (limit to 200 characters): **(74,300 lb.SSLS/hr.)(8760 hr./yr.)(34.7 ADUBT/cook)/68,400 lb.SSLS/cook = 330,192 ADUBT/yr.**		

Segment Description and Rate: Segment __2___ of _2____

1. Segment Description (Process/Fuel Type) (limit to 500 characters): **Recovery system NH_3 – combustion of Nr. 6 fuel oil in recovery boiler, emission related to quantity of oil burned.**		
2. Source Classification Code (SCC): **30790022**	3. SCC Units: **1000 gallons burned**	
4. Maximum Hourly Rate: **1.789 gpm**	5. Maximum Annual Rate: **15671.6**	6. Estimated Annual Activity Factor: **N/A**
7. Maximum % Sulfur: **2.5%**	8. Maximum % Ash: **N/A**	9. Million Btu per SCC Unit: **150**
10. Segment Comment (limit to 200 characters):		

F. EMISSIONS UNIT POLLUTANTS
(All Emissions Units)

1. Pollutant Emitted	2. Primary Control Device Code	3. Secondary Control Device Code	4. Pollutant Regulatory Code
PM	**051**	**014**	**EL**
SO_2	**051**	**014**	**EL**
PM10	**051**	**014**	**NS**
CO	**N/A**	**N/A**	**NS**
NO_X	**N/A**	**N/A**	**NS**
VOC	**N/A**	**N/A**	**NS**
H120 MEK	**N/A**	**N/A**	**NS**
H001 AcHO	**N/A**	**N/A**	**NS**
H115 methanol	**N/A**	**N/A**	**NS**
H186 m,p-xylene	**N/A**	**N/A**	**NS**
H187 o-xylene	**N/A**	**N/A**	**NS**
H163 syrene	**N/A**	**N/A**	**NS**
H124 trichlorobenzene	**N/A**	**N/A**	**NS**
H113 manganese	**N/A**	**N/A**	**NS**
H133 nickel	**N/A**	**N/A**	**NS**
H148 phosphorus	**N/A**	**N/A**	**NS**
HAPs	**N/A**	**N/A**	**NS**

G. EMISSIONS UNIT POLLUTANT DETAIL INFORMATION
(Regulated Emissions Units - Emissions-Limited and Preconstruction Review Pollutants Only)

Potential/Fugitive Emissions

1. Pollutant Emitted: **PM**	2. Total Percent Efficiency of Control: **N/A**
3. Potential Emissions: **67.5** lb/hour **295.6** tons/year MACT II **45.3** lb/hour **198.4** tons/year	4. Synthetically Limited? [**No**]
5. Range of Estimated Fugitive Emissions: **N/A** [ ] 1 [ ] 2 [ ] 3 ______ to ______ tons/year	
6. Emission Factor: **2.5 lb PM/ADT UB Pulp** MACT II **0.092 g/dscm** Reference: **Permit A045-171127 Specific Condition 4** **MACT II 40 CFR Part 63, Subpart mm**	7. Emissions Method Code: **0**
8. Calculation of Emissions (limit to 600 characters): **131,000 dscf/m X 60mm/hr X 0.092 gm/dscm X 0.002205 lb/gm X 0.02832 cu.m/cu.ft = 45.3 lb/hr.** **45.3 lb/hr X 8760 hr/yr ÷ 2000 lb/T = 198.4 ton/yr**	
9. Pollutant Potential/Fugitive Emissions Comment (limit to 200 characters):	

Allowable Emissions Allowable Emissions ___1___ of __1____

1. Basis for Allowable Emissions Code: **Other**	2. Future Effective Date of Allowable Emissions: **N/A**
3. Requested Allowable Emissions and Units: **2.5 lb/adtub pulp** **0.092 gm/dscm**	4. Equivalent Allowable Emissions: **67.5** lb/hour **295.6** tons/year **45.3** lb/hour **198.4** tons/year
5. Method of Compliance (limit to 60 characters): **Stack test EPA Method 5**	
6. Allowable Emissions Comment (Desc. of Operating Method) (limit to 200 characters): **Condition 4 of existing permit references RACT analysis dated 7/12/76 using State of Washington Sulfite Pulp Mill Rules.** **The second limit is from the MACT II regulations which go into effect March 13, 2004.**	

Potential/Fugitive Emissions

1. Pollutant Emitted: **SO_2**	2. Total Percent Efficiency of Control: **N/A**
3. Potential Emissions: **321.9** lb/hour **1410** tons/year	4. Synthetically Limited? [**No**]
5. Range of Estimated Fugitive Emissions: **N/A** [ ] 1 [ ] 2 [ ] 3 ______ to ______ tons/year	
6. Emission Factor: **300 ppm** Reference: **Rate used in 6/75 model**	7. Emissions Method Code: **0**
8. Calculation of Emissions (limit to 600 characters): **See comment.**	
9. Pollutant Potential/Fugitive Emissions Comment (limit to 200 characters): **Basis for SO_2 emission limit is 300 ppm concentration in the stack gas. Pounds per hour values have been taken from the existing permit.**	

Allowable Emissions Allowable Emissions ___1___ of __1____

1. Basis for Allowable Emissions Code: **Other**	2. Future Effective Date of Allowable Emissions: **N/A**
3. Requested Allowable Emissions and Units: **300 ppm dry hourly average**	4. Equivalent Allowable Emissions: **321.9** lb/hour **1410** tons/year
5. Method of Compliance (limit to 60 characters): **Continuous emission monitor**	
6. Allowable Emissions Comment (Desc. of Operating Method) (limit to 200 characters):	

H. VISIBLE EMISSIONS INFORMATION
(Only Regulated Emissions Units Subject to a VE Limitation)

Visible Emissions Limitation: Visible Emissions Limitation ___1___ of __1____

1. Visible Emissions Subtype: **30**	2. Basis for Allowable Opacity: [**X**] Rule [ ] Other

3. Requested Allowable Opacity:
Normal Conditions: **30**% Exceptional Conditions: **40**%
Maximum Period of Excess Opacity Allowed: **2** min/hour

4. Method of Compliance:
Operation of the Brinks demisters constitutes compliance

5. Visible Emissions Comment (limit to 200 characters):
OGC case 90-0332, DOAH case 90-2153 determined that the visible emissions were not a surrogate for particulate emissions. Compliance with the visible emission standard is now operating the Brinks mist eliminator.
Comment on item 3: Brinks can be offline when no liquor is being fired. FAC 62-296.410(1)(b)(1).

I. CONTINUOUS MONITOR INFORMATION
(Only Regulated Emissions Units Subject to Continuous Monitoring)

Continuous Monitoring System: Continuous Monitor __1___ of __2___

1. Parameter Code: **EM**	2. Pollutant(s): **SO_2**

3. CMS Requirement: [ ] Rule [**X**] Other

4. Monitor Information:
Manufacturer: **Siemens**
Model Number: **Ultramat SE 7MB1120-1MH20-OBB** Serial Number: **F6-185**

5. Installation Date: **20-Jul-1994**	6. Performance Specification Test Date: **24-Feb-00**

7. Continuous Monitor Comment (limit to 200 characters):

Continuous Monitoring System: Continuous Monitor __2___ of __2___

1. Parameter Code: **VE**	2. Pollutant(s): **PM**
3. CMS Requirement: Other	[ ] Rule [**X**]
4. Monitor Information: **Foxboro Analog Manual Station** Manufacturer: **Foxboro** Model Number: Serial Number:	
5. Installation Date: **15-Jan-1984**	6. Performance Specification Test Date: **N/A**
7. Continuous Monitor Comment (limit to 200 characters):	

1. Parameter Code: **PM**	2. Pollutant(s): **PM**
3. CMS Requirement:	[**X**] Rule [ ] Other
4. Monitor Information: **MSI Beta Guard PM Continuous Source Particulate Monitor** Manufacturer: **Mechanical Systems Incorporated (MSI)** Model Number: **Beta Guard PM** Serial Number:	
5. Installation Date: **April 8, 2003**	6. Performance Specification Test Date: **April - July 2003**
7. Continuous Monitor Comment (limit to 200 characters):	

J. EMISSIONS UNIT SUPPLEMENTAL INFORMATION
(Regulated Emissions Units Only)

Supplemental Requirements

1. Process Flow Diagram [**X**] Attached, Document ID:_**21** __ [ ] Not Applicable [ ] Waiver Requested
2. Fuel Analysis or Specification [**X**] Attached, Document ID:__**15**____ [ ] Not Applicable [ ] Waiver Requested
3. Detailed Description of Control Equipment [**X**] Attached, Document ID:__**22**__ [ ] Not Applicable [ ] Waiver Requested
4. Description of Stack Sampling Facilities [**X**] Attached, Document ID:__**23**__ [ ] Not Applicable [ ] Waiver Requested
5. Compliance Test Report [ ] Attached, Document ID:________ [ ] Previously submitted, Date:_________ [**X**] Not Applicable
6. Procedures for Startup and Shutdown [ ] Attached, Document ID:________ [**X**] Not Applicable [ ] Waiver Requested
7. Operation and Maintenance Plan [ ] Attached, Document ID:________ [**X**] Not Applicable [ ] Waiver Requested
8. Supplemental Information for Construction Permit Application [ ] Attached, Document ID:________ [**X**] Not Applicable
9. Other Information Required by Rule or Statute [ ] Attached, Document ID:________ [**X**] Not Applicable
10. Supplemental Requirements Comment:

Additional Supplemental Requirements for Title V Air Operation Permit Applications

11. Alternative Methods of Operation [ ] Attached, Document ID:________ [X] Not Applicable
12. Alternative Modes of Operation (Emissions Trading) [ ] Attached, Document ID:________ [X] Not Applicable
13. Identification of Additional Applicable Requirements [X] Attached, Document ID:__24__ [ ] Not Applicable
14. Compliance Assurance Monitoring Plan [ ] Attached, Document ID:________ [X] Not Applicable
15. Acid Rain Part Application (Hard-copy Required) [ ] Acid Rain Part - Phase II (Form No. 62-210.900(1)(a)) Attached, Document ID:________ [ ] Repowering Extension Plan (Form No. 62-210.900(1)(a)1.) Attached, Document ID:________ [ ] New Unit Exemption (Form No. 62-210.900(1)(a)2.) Attached, Document ID:________ [ ] Retired Unit Exemption (Form No. 62-210.900(1)(a)3.) Attached, Document ID:________ [ ] Phase II NOx Compliance Plan (Form No. 62-210.900(1)(a)4.) Attached, Document ID:________ [ ] Phase NOx Averaging Plan (Form No. 62-210.900(1)(a)5.) Attached, Document ID:________ [X] Not Applicable

--ATTENTION MAIL ROOM--

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Jonathan Holtom - DARM

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JUL 11 2003

BUREAU OF AIR REGULATION

Department of Environmental Protection

Northeast District
7825 Baymeadows Way, Suite B200
Jacksonville, Florida 32256-7590

Jeb Bush
Governor

David B. Struhs
Secretary

July 9, 2003

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

Mr. W. M. Burch, General Manager
Rayonier, Inc.
Post Office Box 2002
Fernandina Beach, Florida 32035

Nassau County –Air Permitting
Rayonier, Inc.
Final Title V Permit No. 0890004-005-AV
Request for Additional Information Regarding Title V Permit Renewal Application (Project 011)
Request for Additional Information Regarding Air Construction Permit Application (Project 015)

Dear Mr. Burch:

On June 9, 2003, the Department received your response to the Department's request for additional information dated January 3, 2003, for the referenced facility, as well as an application for an air construction permit for the three power boilers.

However, in order to continue processing your Title V and construction permit applications, the Department will need the below additional information pursuant to Rule 62-213.420(1)(b)4., F.A.C., and Rule 62-4.070(1), F.A.C. Should your response to any of the following items require new calculations, please submit the new calculations, assumptions, reference material and appropriate revised pages of the application form.

1. Someone other than the designated Responsible Official, Mr. Burch, signed the construction permit application for the three power boilers.

   In accordance with Rule 62-213.420(4), F.A.C., a submitted application for a Title V Source must contain a certification signed by a responsible official. More than one responsible official may be designated provided the requirements of Rule 62-213.202, F.A.C. are met. The copy of the email stating that Kathy Wolfla and Kellin Anderson have Mr. Burch's signing authority during the week of 6/2/03 is not acceptable for the purposes of this air construction permit application. Therefore, please submit the application with Mr. Burch' signature as the Responsible Official or submit a Responsible Official Notification Form (DEP Form No. 62-213.900(8)) pursuant to the requirements of Rule 62-213.202, F.A.C. that designates Kathy Wolfla or Kellin Anderson as Responsible Officials.

   CAM Plan Questions:

Boiler Number 1 and Boiler Number 2 (EU 001 & 002)

2. The choice of venturi pressure differential and liquid flow rate through the scrubber are acceptable indicators to monitor. However, indicator ranges must be clearly stated in the monitoring approach table. The selection of the indicator ranges must also be clearly justified and demonstrate that operation at those levels is protective of the allowable emissions limitations. Please provide a table of test data that correlates the maximum and minimum pressure differentials and flow rates to the tested PM emissions levels.

3. Because boilers number 1 and 2 both utilize venturi scrubber A for control of PM emissions, in the event of an excursion, please describe how it will be determined which of the boilers is in danger of exceeding it's emissions limit.

4. Please identify the selected indicator ranges that are justified by the submitted data. Indicator ranges should be sufficiently protective of the emissions standards in order to prevent exceedences. Provide ample justification to show that the selected indicator ranges are sufficient for assuring that emissions from both boilers number 1 and 2 will remain below their respective emissions limits.

Boiler Number 3 (EU 003)

5. The choice of venturi pressure differential and liquid flow rate through the scrubber are acceptable indicators to monitor. However, indicator ranges must be clearly stated in the monitoring approach table. The selection of the indicator ranges must also be clearly justified and demonstrate that operation at those levels is protective of the allowable emissions limitations. Please provide a table of test data that correlates the maximum and minimum pressure differentials and flow rates to the tested PM emissions levels.

6. Please identify the selected indicator ranges that are justified by the submitted data. Indicator ranges should be sufficiently protective of the emissions standards in order to prevent exceedences. Provide ample justification to show that the selected indicator ranges are sufficient for assuring that emissions from boiler number 3 will remain below it's emissions limit.

7. The permit contains statements recognizing the fact that the emissions from boilers number 1 and 2 will be ducted to venturi scrubber B on an "as needed" basis. Please describe how this action is documented and how the indicator ranges for venturi B will be impacted if an additional load is imposed on this scrubber from boilers number 1 and 2..

Recovery Boiler (EU 006)

8. This CAM plan is not approvable as submitted due to the proposed installation of the extractive beta gauge particulate monitor. A demonstration has not yet been presented that the Beta gauge monitor can continuously and accurately measure actual PM emissions from the recovery boiler. In order to complete this application, please provide a table of data that correlates PM test results to the concurrent Beta gauge monitor readings. In addition, please provide a particle size distribution chart that details the size of the particulate emitted from the recovery boiler.

9. Because the facility must be in compliance with the CAM regulations when the renewal permit is issued, if it is not going to be possible to provide the information requested in comment 7 in a reasonably short period of time, please provide a table of data that correlates VE test results to the concurrent PM tests that are conducted annually.

10. Based on the information provided in either comment 7 or 8, please identify the selected indicator ranges that are justified by the submitted data, and that are sufficiently protective of the emissions standards in order to prevent exceedences.

CAM Plan Table A

11. Table A contains a section of information about Abnormal Operations for periods of Fuel Transition, Cold Start-up, and Warm Start-up. The presented approach is not acceptable as 40 CFR 64 does not provide a means for ignoring monitoring data. The selected indicators must be monitored at all times the emissions unit is in operation.

Please update the CAM plans as requested above and resubmit them in both paper and electronic (Word) formats.

Responsible Official (R.O.) Certification Statement:

Rule 62-213.420, F.A.C. requires that a responsible official must certify all Title V permit applications. Due to the nature of the information requested above, the responsible official should certify your response. Please complete and submit a new R.O. certification statement page from the Application for Air Permit – Long Form, DEP Form No. 62-210.900(1), effective June 16, 2003 (enclosed).

Professional Engineer (P.E.) Certification Statement:

Rule 62-4.050(3), F.A.C. requires that a professional engineer registered in the State of Florida certify all applications for a Department permit. This requirement also applies to responses to Department requests for additional information of an engineering nature. As a result, a professional engineer registered in the State of Florida should certify your response. Please complete and submit a new P.E. certification statement page from the Application for Air Permit – Long Form, DEP Form No. 62-210.900(1), effective June 16, 2003 (enclosed).

The Department must receive a response from you within 90 (ninety) days of receipt of this letter, unless you (the applicant) request additional time under Rule 62-213.420(1)(b)6., F.A.C.

If you should have any questions, please call Rita Felton-Smith at (904) 807-3300, extension 3237.

Sincerely,

Christopher L. Kirts, P.E.
District Air Program Administrator

RFS
CLK:RFS

Enclosure: (x) Responsible Official Certification Statement
(x) Professional Engineer Certification Statement

Copy to:

David A. Buff, P.E.
David E. Tudor, Manager Environmental Affairs – Air
Jonathan Holtom, DARM

Owner/Authorized Representative or Responsible Official

1. Name and Title of Owner/Authorized Representative or Responsible Official:
2. Owner/Authorized Representative or Responsible Official Mailing Address: Organization/Firm: Street Address: City: State: Zip Code:
3. Owner/Authorized Representative or Responsible Official Telephone Numbers: Telephone: ( ) - Fax: ( ) -
4. Owner/Authorized Representative or Responsible Official Statement: *I, the undersigned, am the owner or authorized representative*(check here [ ], if so) or the responsible official (check here [ ], if so) of the Title V source addressed in this application, whichever is applicable. I hereby certify, based on information and belief formed after reasonable inquiry, that the statements made in this application are true, accurate and complete and that, to the best of my knowledge, any estimates of emissions reported in this application are based upon reasonable techniques for calculating emissions. The air pollutant emissions units and air pollution control equipment described in this application will be operated and maintained so as to comply with all applicable standards for control of air pollutant emissions found in the statutes of the State of Florida and rules of the Department of Environmental Protection and revisions thereof. I understand that a permit, if granted by the Department, cannot be transferred without authorization from the Department, and I will promptly notify the Department upon sale or legal transfer of any permitted emissions unit.* Signature Date

* Attach letter of authorization if not currently on file.

Professional Engineer Certification

1. Professional Engineer Name: Registration Number:
2. Professional Engineer Mailing Address: Organization/Firm: Street Address: City: State: Zip Code:
3. Professional Engineer Telephone Numbers: Telephone: ( ) - Fax: ( ) -

4. Professional Engineer Statement:

I, the undersigned, hereby certify, except as particularly noted herein, that:*

(1) To the best of my knowledge, there is reasonable assurance that the air pollutant emissions unit(s) and the air pollution control equipment described in this Application for Air Permit, when properly operated and maintained, will comply with all applicable standards for control of air pollutant emissions found in the Florida Statutes and rules of the Department of Environmental Protection; and

(2) To the best of my knowledge, any emission estimates reported or relied on in this application are true, accurate, and complete and are either based upon reasonable techniques available for calculating emissions or, for emission estimates of hazardous air pollutants not regulated for an emissions unit addressed in this application, based solely upon the materials, information and calculations submitted with this application.

If the purpose of this application is to obtain a Title V source air operation permit (check here [ ], if so), I further certify that each emissions unit described in this Application for Air Permit, when properly operated and maintained, will comply with the applicable requirements identified in this application to which the unit is subject, except those emissions units for which a compliance schedule is submitted with this application.

If the purpose of this application is to obtain an air construction permit for one or more proposed new or modified emissions units (check here [ ], if so), I further certify that the engineering features of each such emissions unit described in this application have been designed or examined by me or individuals under my direct supervision and found to be in conformity with sound engineering principles applicable to the control of emissions of the air pollutants characterized in this application.

If the purpose of this application is to obtain an initial air operation permit or operation permit revision for one or more newly constructed or modified emissions units (check here [ ], if so), I further certify that, with the exception of any changes detailed as part of this application, each such emissions unit has been constructed or modified in substantial accordance with the information given in the corresponding application for air construction permit and with all provisions contained in such permit.

_______________________________ _______________________

Signature Date

(seal)

* Attach any exception to certification statement.

--ATTENTION MAIL ROOM--

PLEASE ROUTE THIS DOCUMENT TO:

Jonathan Holtom - DARM

Name of Individual/Office

5505

Mail Station Number

Department of
Environmental Protection

Jeb Bush
Governor

Northeast District
7825 Baymeadows Way, Suite B200
Jacksonville, Florida 32256-7590

David B. Struhs
Secretary

April 16, 2003

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

Mr. W. M. Burch, General Manager
Rayonier, Inc.
Post Office Box 2002
Fernandina Beach, Florida 32035

RECEIVED
APR 24 2003
BUREAU OF AIR REGULATION

Dear Mr. Burch:

Nassau County –Air Permitting
Rayonier, Inc.
Final Title V Permit No. 0890004-005-AV
Request for Additional Time to Respond- Title V Permit Renewal Application

On March 24, 2003, the Department received a request from Mr. Richard Hopper, Environmental Operations Manager, for a two-month extension of time in which to respond to the Department's Request for Additional Information dated January 3, 2003.

Pursuant to Rule 62-213.420(1)(b)6.b., F.A.C., the Department hereby grants the request. The response shall be submitted no later than close of business on **June 6, 2003**.

If you should have any questions, please call Rita Felton-Smith at (904) 807-3300, extension 3237.

Sincerely,

Christopher L. Kirts, P.E.
District Air Program Administrator

CLK:RFS

Cc: David E. Tudor, Rayonier, Inc.
Jonathan Holtom, DARM

Holtom, Jonathan

From: Felton-Smith, Rita
Sent: Monday, March 03, 2003 4:59 PM
To: Holtom, Jonathan
Subject: RE: J-S Incompleteness Questions.doc

Jonathan,

The No. 4 Smelt Dissolving Tank is subject to the TRS requirements of the State Rule, 62-296.404. The No. 5 Smelt Dissolving Tank is subject to the requirements of NSPS, 40 CFR 60, Subpart BB. This is both for PM and TRS emissions.

I can't answer your question about the pre-control device TRS emissions.. I may be able to find something in the previous permit applications.

To answer your question about the pulping system MACT. The option that JSC chose is to duct the gases from the specified equipment to either the No. 5 Power Boiler or the No. 4 Lime Kiln. Destruction of the gases in a boiler or lime kiln was one of several "options" available to the facilities. The other options had specific limits or percent reductions. See below:

(d) The control device used to reduce total HAP emissions from each equipment system listed in paragraphs (a) and (b) of this section shall:

(1) Reduce total HAP emissions by 98 percent or more by weight; or

(2) Reduce the total HAP concentration at the outlet of the thermal oxidizer to 20 parts per million or less by volume, corrected to 10 percent oxygen on a dry basis; or

(3) Reduce total HAP emissions using a thermal oxidizer designed and operated at a minimum temperature of 871 oC (1600 oF) and a minimum residence time of 0.75 seconds; or

(4) Reduce total HAP emissions using one of the following:

(i) A boiler, lime kiln, or recovery furnace by introducing the HAP emission stream with the primary fuel or into the flame zone; or

They are also required to treat the liquid condensates from the pulping system to removed a certain lb of total HAP/ Ton of Oven Dried Pulp. This is a specific limit.

Let me know if this helps. I plan to include your questions in the RAI as you wrote them in the memo.

Thank you.

Rita
-----Original Message-----
From: Holtom, Jonathan
Sent: Monday, March 03, 2003 3:54 PM
To: Felton-Smith, Rita

Cc: Sheplak, Scott
Subject: J-S Incompleteness Questions.doc

January 3, 2003

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

Mr. W. M. Burch, General Manager
Rayonier, Inc.
Post Office Box 2002
Fernandina Beach, Florida 32035

Nassau County –Air Permitting
Rayonier, Inc.
Final Title V Permit No. 0890004-005-AV
Request for Additional Information Regarding Title V Permit Renewal Application

Dear Mr. Burch:

On November 6, 2002, the Department received your application for a Title V Permit Renewal for the referenced facility.

However, in order to continue processing your application, the Department will need the below additional information pursuant to Rule 62-213.420(1)(b)4., F.A.C., and Rule 62-4.070(1), F.A.C. Should your response to any of the following items require new calculations, please submit the new calculations, assumptions, reference material and appropriate revised pages of the application form.

1. Please address the applicability of MACT II to your facility.

2. Please review the List of Applicable Regulations for each emissions unit and the facility and update accordingly. It appears that several of the rules cited have been repealed, i.e. 62-297.411, F.A.C.

3. In the renewal application, it is requested that SO2 emissions limit for the No. 1 Power Boiler be increased from 1848 to 1927.2 tons per year. The basis of this request is that the unit is permitted to operate 8,760 hours per year, yet the annual limit appears to be based on 8,400 hours per year of operation. The 1848 tons per year SO2 emissions limit was established in a Stipulation dated March 10, 1982. The increasing of permitted emissions cannot be accomplished through the Title V Permitting process. Such a request can only be accomplished through the AC permitting process. Because the established limits were agreed upon in the Stipulation, additional ambient modeling may be necessary.

Department of Environmental Protection

Twin Towers Office Building
2600 Blair Stone Road
Tallahassee, Florida 32399-2400

Jeb Bush
Governor

David B. Struhs
Secretary

4. In the renewal application, it is requested that the PM emissions limit for the No. 2 Power Boiler be increased from 212.5 to 221.6 tons per year. The 212.5 ton per year PM emissions limit was established in a Stipulation dated March 10, 1982. The increasing of permitted emissions cannot be accomplished through the Title V Permitting process. Such a request can only be accomplished through the AC permitting process. Because the established limits were agreed upon in the Stipulation, additional ambient modeling may be necessary.

5. In the renewal application, it is requested that the SO2 emissions limit for the No. 2 Power Boiler be increased from 1756 to 1831 tons per year. The basis of this request is that the unit is permitted to operate 8,760 hours per year, yet the annual limit appears to be based on 8,400 hours per year of operation. The 1756 tons per year SO2 emissions limit was established in a Stipulation dated March 10, 1982. The increasing of permitted emissions cannot be accomplished through the Title V Permitting process. Such a request can only be accomplished through the AC permitting process. Because the established limits were agreed upon in the Stipulation, additional ambient modeling may be necessary.

6. In the renewal application, it is requested that the PM emissions limit for the No. 3 Power Boiler be increased from 212.5 to 221.6 tons per year. The 212.5 ton per year PM emissions limit was established in a Stipulation dated March 10, 1982. The increasing of permitted emissions cannot be accomplished through the Title V Permitting process. Such a request can only be accomplished through the AC permitting process. Because the established limits were agreed upon in the Stipulation, additional ambient modeling may be necessary.

7. In the renewal application, it is requested that the SO2 emissions limit for the No. 3 Power Boiler be increased from 1928 to 2010 tons per year. The basis of this request is that the unit is permitted to operate 8,760 hours per year, yet the annual limit appears to be based on 8,400 hours per year of operation. The 1928 tons per year SO2 emissions limit was established in a Stipulation dated March 10, 1982. The increasing of permitted emissions cannot be accomplished through the Title V Permitting process. Such a request can only be accomplished through the AC permitting process. Because the established limits were agreed upon in the Stipulation, additional ambient modeling may be necessary.

8. The current Title V states that for the Molten Sulfur storage and handling facility (EU 007), molten sulfur is transferred from the rail cars to the 99,500 gallon storage tank via an enclosed piping system. However, the renewal Title V Permit application states that the volume of the molten sulfur storage tank is 55,000 gallons. Please explain the difference in the tank volumes. Has this tank been replaced?

9. Please explain the Visible Emissions Comment, "Brinks can be offline when no liquor is being fired. FAC 62-296.410(1)(b)(1)." In accordance with Condition No. E.7., the Recovery Boiler may be operated with the Brinks Demister system bypassed due to an emergency situation. Such an emergency situation shall not exceed two (2) hours. If operations have not been restored after this two-hour emergency situation, Rayonier is to discontinue all fuel sources other than oil. If this occurs, Rayonier is to provide prompt notification to the department followed by a report to the Department of the event and any change in the volume of characteristics of visible emissions experienced during the period of oil-only emergency operation. Has such an emergency situation occurred? Conditions E.8. and E.9. identify specific times when the Brinks system may be bypassed due to startup and shutdown conditions. Has the Brinks been offline due to either startup and shutdown conditions? If so, please provide documentation that the Brinks systems was not bypassed longer than the durations specified within these conditions. Has the Brinks system been offline due to situations other than emergency, startup, or shutdown?

10. Please submit records of the annual, facility-wide pulp production rate for 2002 pursuant to Condition No. 3 of Permit No. 0890004-010-AC.

11. Please review the Emissions points and activities on the Unregulated and Insignificant Emission Unit lists to determine whether any are now subject to the requirements of 40 CFR 63 Subparts s and MM. Please update these lists as needed.

12. Attachment 11 discusses two alternate operating scenarios for the digesters. Scenario 1 discusses the operation of the digesters during the rebricking of the existing four brick-lined digesters, and Scenario 2 discussed the operation of the digesters for the time period prior the beginning of the rebricking and between the rebricking of each digester. It is stated in the attachment that the rebricking of the four brick-lined digesters occurred in 1994, 1999, and 2000, with the curing beginning in 1998. Please explain the need for these described Alternate Method of Operation given that Air Construction Permit No. 0890004-010-AC authorized the construction and installation of the 6th digester.

13. Attachment 18, B1, B2, & B3 Additional Applicable Requirements, identifies Specific Condition requirements from pre-Title V operation Permit Nos. AO45-183504, AO45-183506, and AO45-183507. It is not clear whey this attachment is included in this renewal permit application given that FINAL title V Permit No. 0890004-005-AV was issue don May 5, 1998. Please clarify.

14. Attachment 24, Re-identification of Additional Applicable Requirements, identifies Specific Condition requirements from pre-Title V operation Permit No. 0890004-003-AO. It is not clear whey this attachment is included in this renewal permit application given that FINAL title V Permit No. 0890004-005-AV was issue don May 5, 1998. Please clarify. In addition, reference is made to a Compliance Report – Attachment 11. However, Attachment 11 is the Alternative Methods of Operation.

15. Please update the permit references in Attachment 34 to reflect the FINAL title V Permit and air construction permits as opposed to the per-Title V Operation permits.

16. According to the Application for Air Permit – Title V Source instructions, a storage tank subject only to the recordkeeping requirements of 40 CFR 60 Subpart Kb, is to be identified as an unregulated emissions unit. Based on the Attachments provided in this application, it appears that the No. 6 Oil storage Tank has been omitted from this list. Please update the unregulated emissions unit list as needed.

17. In the application, the Vent Gas Scrubber is described as consisted of five sieve trays complete with weirs and downcomers. Please update the description of the emissions unit and Attachment 26 to reflect the changes made in converting it to a packed tower and including the methanol condenser system.

18. Please update Attachment 25 to reflect the changes made at the facility as a part of complying with Subpart S.

19. 40 CFR 63.440(d)(2) requires that each dissolving-grade bleaching system at sulfite pulping mills achieve compliance with the bleach plant provisions of 63.445 as expeditiously as practicable, but in no event later than 3 years after the promulgation of the revised effluent limitation guidelines and standards under 40 CFR 430.14 through 430.17 and 40 CFR 430.44 through 430.47. It appears that these revisions may have been promulgated on April 16, 1998, thus making the compliance deadline April 16, 2001. Please state Rayonier's status in complying with the bleach plant provisions of 40 CFR 63.445.

20. Rayonier, Inc. proposes the installation of extractive beta gauge particulate monitors for Nos. 1, 2, and 3 Power Boilers, and the Recovery Boiler for CAM purposes. These monitors would likely be acceptable for CAM purposes if they were already installed, calibrated, and certified. However, the facility must be in compliance with the CAM regulations when the Title V Renewal Permit is issued. Therefore, an approvable CAM plan must be submitted that specifies monitoring of the control devices for these boilers that is presently available and sufficient to satisfy CAM requirements. Please refer to the CAM Technical Guidance Document for example CAM Plans pertaining to Venturi scrubbers. This document may be located at the following website address:

    http://www/epa/gov/ttn/emc/cam/camsupp2.pdf

    Sulfur Dioxide from Pulping (This appears to be EU 005 – SO2 Vent) – This emissions unit has a CEMS required for compliance purposes, therefore, it is exempt from CAM for SO2 monitoring.

    Sulfur Dioxide Emissions from Recovery Boiler – This emissions unit has a CEMS required for compliance purposes, therefore, it is exempt form CAM for SO2 monitoring.

Department of
Environmental Protection

Twin Towers Office Building
2600 Blair Stone Road
Tallahassee, Florida 32399-2400

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Governor

David B. Struhs
Secretary

Methanol emissions from Digesters, etc. – These activities are exempt from CAM because they are subject to a post 1990 MACT.

Should you have any questions concerning approvable CAM Plans, please contact Jonathan Holtom, P.E., at (850) 921-9531.

Responsible Official (R.O.) Certification Statement:

Rule 62-213.420, F.A.C. requires that a responsible official must certify all Title V permit applications. Due to the nature of the information requested above, the responsible official should certify your response. Please complete and submit a new R.O. certification statement page from the Application for Air Permit – Title V Source, DEP Form No. 62-210.900(1), effective February 11, 1999 (enclosed).

Professional Engineer (P.E.) Certification Statement:

Rule 62-4.050(3), F.A.C. requires that a professional engineer registered in the State of Florida certify all applications for a Department permit. This requirement also applies to responses to Department requests for additional information of an engineering nature. As a result, a professional engineer registered in the State of Florida should certify your response. Please complete and submit a new P.E. certification statement page from the Application for Air Permit – Title V Source, DEP Form No. 62-210.900(1), effective February 11, 1999 (enclosed).

The Department must receive a response from you within 90 (ninety) days of receipt of this letter, unless you (the applicant) request additional time under Rule 62-213.420(1)(b)6., F.A.C.

If you should have any questions, please call Rita Felton-Smith at (904) 807-3300, extension 3237.

Sincerely,

Christopher L. Kirts, P.E.
District Air Program Administrator

CLK:RFS

Enclosure: (x) Responsible Official Certification Statement
(x) Professional Engineer Certification Statement

Copy to:

David A. Buff, P.E.
David E. Tudor, Manager Environmental Affairs – Air
Jonathan Holtom, DARM

Holtom, Jonathan

From: Holtom, Jonathan
Sent: Monday, December 23, 2002 3:45 PM
To: Felton-Smith, Rita
Cc: Sheplak, Scott
Subject: Rayonier CAM

Hi Rita,

I finally got a chance to really look at this submission along with the permit that you made available. My comments are as follows:

Sulfur Dioxide from Pulping (This appears to be EU 005 - SO2 vent) - This emissions unit has a CEMS required for compliance purposes, therefore, it is exempt from CAM for SO2 monitoring.

Sulfur Dioxide Emissions from Recovery Boiler - This emissions unit has a CEMS required for compliance purposes, therefore, it is exempt from CAM for SO2 monitoring.

Methanol Emissions from Digesters, etc. - These activities are exempt from CAM because they are subject to a post 1990 MACT.

Particulate Emissions from Boiler 1, Boiler 2, Boiler 3, and Recovery Boiler - The submission is not acceptable due to the proposed installation of extractive beta gauge particulate monitors. These would likely be acceptable if they were already installed, calibrated and certified. However, the facility must be in compliance with the CAM regulations when the renewal permit is issued. In order for this to work, the application will need to be put into an incompleteness status until the facility owner/responsible official submits an approvable CAM plan (within 90 days of your incompleteness letter) that specifies monitoring of their control devices that is currently available and sufficient to satisfy the CAM requirements. Please have the facility refer to the CAM Technical Guidance Document for example CAM plans pertaining to venturi scrubbers.

If you or the facility have any questions, please call me at (850) 921-9531.

Tracking:

Recipient	Delivery	Read
Felton-Smith, Rita	Delivered: 12/23/2002 3:45 PM	Read: 12/23/2002 4:00 PM
Sheplak, Scott	Delivered: 12/23/2002 3:45 PM	

COMPLIANCE ASSURANCE MONITORING PLAN (CAM PLAN)

FOR

Rayonier, Inc.

Fernandina Beach, Florida

Dissolving Sulfite Pulp Mill

June 4, 2003

TABLE OF CONTENTS

LIST OF ATTACHMENTS

1. **Table A**
2. **Specifications for the AMETEK Thermox Oxygen Monitor**
3. **Specification for Beta Gauge Particulate Monitor**
   - **MSI BetaGuard® PM**
   - **The MSI BetaGuard® PM**
   - **Beta Gauge Particulate Monitoring – Theory and Practice**

I. EMISSION UNITS REQUIRING CAM PLANS

A. Cam Rule Applicability Definition

Title V of the Clean Air Act Amendments of 1990 mandated a new permit program now referred to as Title V Permitting. Title V Permits were not to require additional emission limits. However these permits were to enumerate all applicable requirements and to establish a monitoring program to track compliance with all the applicable requirements. The monitoring must conform to the applicable requirement in form and averaging time and provide the basis for the annual certification of compliance.

EPA adopted rules governing these monitoring programs in 40 CFR Part 64. The monitoring required is referred to as Compliance Assurance Monitoring (CAM) and the Plans required are referred to as CAM Plans.

CAM Plans are required of all Title V permitted emission units using air pollution control equipment to meet emission limits (applicable requirements) if "before-control" emissions are greater than that level defining a major source, unless the source is specifically exempt.

Exempted emissions units include those with stratospheric ozone protection and acid rain requirements and those with other caps are included in the Title V Permit. Also exempted are all emission units subject to NSPS (40 CFR Part 60) and NESHAP (40 CFR Part 63) promulgated after 11/15/1990, as these sources have equivalent monitoring requirements included as part of the standard.

B. Fernandina Mill Emissions Units Requiring Cam Plans

The Fernandina mill has a Title V permit that expires May 5, 2003. Pursuant to 40 CFR Part 64 CAM Plans must be submitted with the permit renewal application. The required CAM provisions must be addressed in the Plan and included with the renewed permit.

Emission units at the Fernandina Mill have been examined and those Units to which the CAM Rule applies have been determined. This analysis has been conducted by emission unit and by pollutant because the CAM rule applies to each pollutant emitted in amounts greater than that amount which defines the unit as a major source. Generally this amount is 100 tons per year for the Fernandina Mill.

The following sources have "before-control" emissions greater than 100 tons per year, have emission limits in the Title V Permit and rely on equipment to achieve the permit limit.

Emissions Unit	Pollutant	Applicable Requirement	Max Potential Emission TPY	Control Equipment
No. 1 Boiler	Particulate	Title V Operating Permit 0890004-005-AV, Condition III(A)(4)	70.0	Standard variable throat venturi scrubber
No. 2 Boiler	Particulate	Title V Operating Permit 0890004-005-AV, Condition III(B)(4)	212.5	Standard variable throat venturi scrubber
No. 3 Boiler	Particulate	Title V Operating Permit 0890004-005-AV, Condition III(C)(4)	212.6	Standard variable throat venturi scrubber
Recovery Boiler	Particulate	Title V Operating Permit 0890004-005-AV, Condition III(E)(4)	295.6	Fiber type mist eliminator.

Other emission limitations apply to the Fernandina Mill, but these are not subject to the CAM rule:

1. The sulfur dioxide emissions from power boilers Nos. 1, 2 and 3 are limited based on 2.5 percent sulfur oil. While the sulfur dioxide emissions from each boiler exceed 100 tons per year, no control equipment is used to meet this limitation.

2. Many sources have opacity limitations. Since opacity is not emitted in terms of tons per year it is not a pollutant that is directly subject to the CAM rule. Opacity monitoring may be used to monitor compliance with a particulate emission standard. However, since the stacks subject to CAM for particulate matter at the Fernandina Mill have wet scrubbers, opacity is not used as a surrogate for particulate matter.

3. It is very difficult to estimate fugitive particulate emissions from the Molten Sulfur Handling System. But this system does emit particulate and this emission is controlled by work practices required in the regulation. The Cam Rule does not apply to the Molten Sulfur Handling System because there is no control equipment used to meet a specified emission limit. Also the emissions are expected to be much less than 100 tons per year.

II. PARTICULATE EMISSIONS FROM NO. 1 BOILER

A. Emissions Unit Identification

This Emission Unit is a #6 oil fired water tube boiler with a maximum heat input rate of 185 mmBTU per hour. The emissions from this boiler pass through "A" venturi scrubber along with the emissions from No. 2 boiler. No. 1 Boiler is Emission Unit ID No. 001 and designated B1 in the Title V permit for the Fernandina Mill.

B. Applicable Regulation, Emissions Limits, and Monitoring Requirements

In Air Operating Permit AO45-183504 particulate emissions were limited to 16.0 lb./hr. Subsequently Rayonier ask for an increase in operating rate from a heat input of 160 mmBTU per hour to 185 mmBTU/hr. However, it intended that this increase in heat rate not increase calculated emissions, thereby avoiding PSD permitting. Consequently the rate decreased from 0.1 lbs./mmBTU to 0.086 lbs./mmBTU, but the mass emission rate remained at 16.0 lbs./hr and 70 tons per year, as is contained in Title V permit [0890004-005-AV] Condition III(A)(4).

C. Control Technology Description

The emissions from this #6 oil fired boiler pass up through a standard venturi scrubber using pH controlled wastewater as the scrubbing media. The pH control reduces corrosion of the venturi scrubber body. Particulate emissions control is set by the effectiveness of the venturi scrubber and the combustion efficiency of the boiler. Oxygen meters and other operational instruments monitor the boiler combustion efficiency. The venturi scrubber effectiveness is determined by the pressure drop across the venturi and the volume of liquid recycled through the venturi nozzles.

D. Monitoring Approach

	Indicator No. 1	Indicator No. 2	Indicator No. 3
Indicator	**Venturi Pressure Differential.**	**Venturi Recycle Flow Rate**	**Oxygen Meter**
Measurement Approach	A differential pressure meter [Rosemont Model 3051 dp] is used to measure the pressure drop.	An orifice plate with differential pressure taps provides the flow rate. A differential pressure meter [Rosemont Model 3051 dp] is used to measure the pressure drop across the orifice plate.	An Ametek Thermox Model WDG-HPIIC Oxygen Monitor using an electrochemical cell.
Indicator Range	The indicator range is a minimum inches of water pressure differential for a running one-hour average as defined in Table A based on the ratio of oil and bark burned.	The indicator range is a minimum flow for a running one-hour average when using recycled water and a different flow for a running one-hour average when using fresh water. See Table A	The indicator range is a minimum % excess oxygen for a running one-hour average as defined in Table A.
Data Represen-tativeness	The pressure sensors are installed on either side of the venturi and directly measure the difference in pressure of the gas at those locations.	The pressure sensors are installed on either side of the orifice and directly measure the difference in pressure of the water at those locations.	The gas sample is taken directly out of the boiler utilizing convection. Since it is a gas sample, it should be completely representative of boiler combustion conditions.
Verification of Operational Status	Alarms are set at levels outside the normal operating range to alert the operators and have the meter serviced.	Alarms are set at levels outside the normal operating range to alert the operators and have the meter serviced.	Alarms are set at levels outside the normal operating range to alert the operators and have the meter serviced. The meter is accurate to within 0.05% O2.

	Indicator No. 1	Indicator No. 2	Indicator No. 3
QA/QC Practices and Criteria	The meter is set-up on the mill's preventative maintenance system for transmitter calibrations.	The meter is set-up on the mill's preventative maintenance system for transmitter calibrations.	The meter is calibrated monthly against a standard O2 span gas.
Monitoring Frequency	This is a continuous monitor. The operator has instantaneous and running hourly average readouts and alarms.	This is a continuous monitor. The operator has instantaneous and running hourly average readouts and alarms.	This is a continuous monitor. The operator has instantaneous and running hourly average readouts and alarms.
Data Collection Procedures	The meter provides input on a second-by-second basis. About once each month these data are downloaded, consolidated into 15-minute averages and stored in an Environmental Data Management Database.	The meter provides input on a second-by-second basis. About once each month these data are downloaded, consolidated into 15-minute averages and stored in an Environmental Data Management Database.	The meter provides input on a second-by-second basis. About once each month these data are downloaded, consolidated into 15-minute averages and stored in an Environmental Data Management Database.
Averaging Period	15-minute averages are stored for 5 years to comply with the CAM Rule and Title V record-keeping requirements. A running one-hour average is used for compliance.	15-minute averages are stored for 5 years to comply with the CAM Rule and Title V record-keeping requirements. A running one-hour average is used for compliance.	15-minute averages are stored for 5 years to comply with the CAM Rule and Title V record-keeping requirements. A running one-hour average is used for compliance.

E. *Justification*

1. Background

Particulate emissions are controlled by the venturi scrubber [A scrubber] provided for this boiler and No. 2 power boiler. Established combustion controls are provided for the boiler itself. To monitor the particulate emissions affected by the boiler combustion controls and the venturi scrubber operation, an oxygen meter, venturi recirculation flow meter and venturi differential pressure meter are used. Technical specifications for the oxygen meter are attached.

2. Rationale for Selection of Performance Indicators

Particulate testing indicate that the parameters selected will verify good control of the boilers and the scrubber.

3. Rationale for Selection of Indicator Ranges

The indicator ranges were selected through comparing the indicators to actual EPA method 5 tests. Alarms below the upper limit are provided for hourly averages as well as instantaneous test results.

III. PARTICULATE EMISSIONS FROM NO. 2 BOILER

A. *Emissions Unit Identification*

This Emission Unit is a combination #6 oil and wood waste (bark) fired water tube boiler with a maximum heat input rate of 184 mmBTU per hour on oil and 218 mmBTU per hour on wood waste. The emissions from this boiler pass through "A" venturi scrubber along with the emissions from No. 1 boiler. No. 2 Boiler is Emission Unit ID No. 002 and designated B2 in the Title V permit for the Fernandina Mill.

B. *Applicable Regulation, Emissions Limits, and Monitoring Requirements*

In Air Operating Permit AO45-183504 particulate emissions were limited to 50.6 lb. PM/hr. Subsequently Rayonier asked for an increase in operating rate from a heat input of 180 mmBTU per hour to 218 mmBTU per hour. However, it intended that this increase in heat rate not increase calculated emissions, thereby avoiding PSD permitting. Consequently the rate decreased from 0.280 lbs./mmBTU to 0.230 lbs./mmBTU for wood waste burning, but the mass emission rate remained at 50.6 lbs./hr and 212.5 tons per year, as is contained in Title V permit [0890004-005-AV] Condition III(B)(4). For oil the particulate matter emission rate limits are 15.2 lb./hr. and 63.9 tons per year.

C. *Control Technology Description*

The emissions from this boiler pass up through a standard venturi scrubber using pH-controlled water as the scrubbing media. The pH control reduces corrosion of the venturi scrubber body. Particulate emissions control is set by the effectiveness of the venturi scrubber and the combustion efficiency of the boiler. Oxygen meters and other operational instruments monitor the boiler combustion efficiency. The pressure drop determines the venturi scrubber effectiveness across the venturi and the volume of liquid recycled through the venturi nozzles.

D. Monitoring Approach

	Indicator No. 1	Indicator No. 2	Indicator No. 3
Indicator	**Venturi Pressure Differential**.	**Venturi Recycle Flow Rate**	**Oxygen Meter**
Measurement Approach	A differential pressure meter [Rosemont Model 3051 dp] is used to measure the pressure drop.	An orifice plate with differential pressure taps provides the flow rate. A differential pressure meter [Rosemont Model 3051 dp] is used to measure the pressure drop across the orifice plate.	An Ametek Thermox Model WDG-HPIIC Oxygen Monitor using an electrochemical cell.
Indicator Range	The indicator range is a minimum inches of water pressure differential for a running one-hour average as defined in Table A based on the ratio of oil and bark burned.	The indicator range is a minimum flow for a running one-hour average when using recycled water and a different flow for a running one-hour average when using fresh water. See Table A	The indicator range is a minimum % excess oxygen for a running one-hour average as defined in Table A.
Data Represen-tativeness	The pressure sensors are installed on either side of the venturi and directly measure the difference in pressure of the gas at those locations.	The pressure sensors are installed on either side of the orifice and directly measure the difference in pressure of the water at those locations.	The gas sample is taken directly out of the boiler utilizing convection. Since it is a gas sample, it should be completely representative of boiler combustion conditions.
Verification of operational Status	Alarms are set at levels outside the normal operating range to alert the operators and have the meter serviced.	Alarms are set at levels outside the normal operating range to alert the operators and have the meter serviced.	Alarms are set at levels outside the normal operating range to alert the operators and have the meter serviced. The meter is accurate to within 0.05% O2.
QA/QC Practices and Criteria	The meter is set-up on the mill's preventative maintenance system for transmitter calibrations.	The meter is set-up on the mill's preventative maintenance system for transmitter calibrations.	The meter is calibrated monthly against a standard O2 span gas.

	Indicator No. 1	Indicator No. 2	Indicator No. 3
Monitoring Frequency	This is a continuous monitor. The operator has instantaneous and running hourly average readouts and alarms.	This is a continuous monitor. The operator has instantaneous and running hourly average readouts and alarms.	This is a continuous monitor. The operator has instantaneous and running hourly average readouts and alarms.
Data Collection Procedures	The meter provides input on a second-by-second basis. About once each month these data are downloaded, consolidated into 15-minute averages and stored in an Environmental Data Management Database.	The meter provides input on a second-by-second basis. About once each month these data are downloaded, consolidated into 15-minute averages and stored in an Environmental Data Management Database.	The meter provides input on a second-by-second basis. About once each month these data are downloaded, consolidated into 15-minute averages and stored in an Environmental Data Management Database.
Averaging Period	15-minute averages are stored for 5 years to comply with the CAM Rule and Title V record-keeping requirements. A running one-hour average is used for compliance.	15-minute averages are stored for 5 years to comply with the CAM Rule and Title V record-keeping requirements. A running one-hour average is used for compliance.	15-minute averages are stored for 5 years to comply with the CAM Rule and Title V record-keeping requirements. A running one-hour average is used for compliance.

E. Justification

1. Background

Particulate emissions are controlled by the venturi scrubber [A scrubber] provided for this boiler and No. 1 power boiler. Established combustion controls are provided for the boiler itself. To monitor the particulate emissions affected by the boiler combustion controls and the venturi scrubber operation, an oxygen meter, venturi recirculation flow meter and venturi differential pressure meter are used. Technical specifications for the oxygen meter are attached.

2. Rationale for Selection of Performance Indicators

Particulate testing indicate that the parameters selected will verify good control of the boilers and the scrubber.

3. Rationale for Selection of Indicator Ranges

The indicator ranges were selected through comparing the indicators to actual EPA method 5 tests. Alarms below the upper limit are provided for hourly averages as well as instantaneous test results.

IV. PARTICULATE EMISSIONS FROM NO. 3 BOILER

A. Emissions Unit Identification

This Emission Unit is a combination #6 oil and wood waste (bark) fired water tube boiler with a maximum heat input rate of 207 mmBTU per hour on oil and 245 mmBTU per hour on wood waste. The emissions from this boiler pass through "B" venturi scrubber. No. 3 Boiler is Emission Unit ID No. 003 and designated B3 in the Title V permit for the Fernandina Mill.

B. Applicable Regulation, Emissions Limits, and Monitoring Requirements

In Air Operating Permit AO45-183504 particulate emissions were limited to 50.6 lb. PM/hr. Subsequently Rayonier asked for an increase in operating rate from a heat input of 180 mmBTU per hour to 245 mmBTU per hour. However, it intended that this increase in heat rate not increase calculated emissions, thereby avoiding PSD permitting. Consequently the rate decreased from 0.280 lbs./mmBTU to 0.207 lbs./mmBTU for wood waste burning, but the mass emission rate remained at 50.6 lbs./hr and 212.6 tons per year, as is contained in Title V permit [0890004-005-AV] Condition III(C)(4). For oil the particulate matter emission rate limits are 16.7 lb./hr. and 70.1 tons per year.

C. Control Technology Description

The emissions from this boiler pass up through a standard venturi scrubber using pH-controlled water as the scrubbing media. The pH control reduces corrosion of the venturi scrubber body. Particulate emissions control is set by the effectiveness of the venturi scrubber and the combustion efficiency of the boiler. Oxygen meters and other operational instruments monitor the boiler combustion efficiency. The venturi scrubber effectiveness is determined by the pressure drop across the venturi and the volume of liquid recycled through the venturi nozzles.

D. Monitoring Approach

	Indicator No. 1	Indicator No. 2	Indicator No. 3
Indicator	**Venturi Pressure Differential.**	**Venturi Recycle Flow Rate**	**Oxygen Meter**
Measurement Approach	A differential pressure meter [Rosemont Model 3051 dp] is used to measure the pressure drop.	An orifice plate with differential pressure taps provides the flow rate. A differential pressure meter [Rosemont Model 3051 dp] is used to measure the pressure drop across the orifice plate.	An Ametek Thermox Model WDG-HPIIC Oxygen Monitor using an electrochemical cell.
Indicator Range	The indicator range is a minimum inches of water pressure differential for a running one-hour average as defined in Table A based on the ratio of oil and bark burned.	The indicator range is a minimum flow for a running one-hour average when using recycled water and a different flow for a running one-hour average when using fresh water. See Table A	The indicator range is a minimum % excess oxygen for a running one-hour average as defined in Table A.
Data Represen-tativeness	The pressure sensors are installed on either side of the venturi and directly measure the difference in pressure of the gas at those locations.	The pressure sensors are installed on either side of the orifice and directly measure the difference in pressure of the water at those locations.	The gas sample is taken directly out of the boiler utilizing convection. Since it is a gas sample, it should be completely representative of boiler combustion conditions.
Verification of operational Status	Alarms are set at levels outside the normal operating range to alert the operators and have the meter serviced.	Alarms are set at levels outside the normal operating range to alert the operators and have the meter serviced.	Alarms are set at levels outside the normal operating range to alert the operators and have the meter serviced. The meter is accurate to within 0.05% O2.
QA/QC Practices and Criteria	The meter is set-up on the mill's preventative maintenance system for transmitter calibrations.	The meter is set-up on the mill's preventative maintenance system for transmitter calibrations.	The meter is calibrated monthly against a standard O2 span gas.

	Indicator No. 1	Indicator No. 2	Indicator No. 4
Monitoring Frequency	This is a continuous monitor. The operator has instantaneous and running hourly average readouts and alarms.	This is a continuous monitor. The operator has instantaneous and running hourly average readouts and alarms.	This is a continuous monitor. The operator has instantaneous and running hourly average readouts and alarms.
Data Collection Procedures	The meter provides input on a second-by-second basis. About once each month these data are downloaded, consolidated into 15-minute averages and stored in an Environmental Data Management Database.	The meter provides input on a second-by-second basis. About once each month these data are downloaded, consolidated into 15-minute averages and stored in an Environmental Data Management Database.	The meter provides input on a second-by-second basis. About once each month these data are downloaded, consolidated into 15-minute averages and stored in an Environmental Data Management Database.
Averaging Period	15-minute averages are stored for 5 years to comply with the CAM Rule and Title V record-keeping requirements. A running one-hour average is used for compliance.	15-minute averages are stored for 5 years to comply with the CAM Rule and Title V record-keeping requirements. A running one-hour average is used for compliance.	15-minute averages are stored for 5 years to comply with the CAM Rule and Title V record-keeping requirements. A running one-hour average is used for compliance.

E. Justification

1. Background

Particulate emissions are controlled by the venturi scrubber [B scrubber] provided for this boiler. Established combustion controls are provided for the boiler itself. To monitor the particulate emissions affected by the boiler combustion controls and the venturi scrubber operation, an oxygen meter, venturi recirculation flow meter and venturi differential pressure meter are used. Technical specifications for the oxygen meter are attached.

2. Rationale for Selection of Performance Indicators

Particulate testing indicate that the parameters selected will verify good control of the boilers and the scrubber.

3. Rationale for Selection of Indicator Ranges

The indicator ranges were selected through comparing the indicators to actual EPA method 5 tests. Alarms below the upper limit are provided for hourly averages as well as instantaneous test.

V. PARTICULATE EMISSIONS FROM RECOVERY BOILER

A. *Emissions Unit Identification*

Emission Unit ID No. 6 in the Title V Permit is a sulfite recovery boiler. This boiler burns evaporated spent cooking liquor. Liquor used to remove unwanted portions of the wood chip contains sugars, tannins and combined lignins. Evaporation concentrates this organic portion of the liquor to the point it will sustain combustion when fired into the recovery boiler. Steam generated by the recovery boiler is used to generate electricity and for process purposes. The evaporated liquor contains sulfur compounds, which are converted to sulfur dioxide during combustion. This sulfur dioxide is captured in a scrubber using ammonium hydroxide scrubbing media producing ammonium bisulfite that is recycled as fresh cooking liquor. Sulfur dioxide also reacts with ammonium hydroxide to produce ammonium sulfate and ammonium bisulfite. All of these ammonium compounds are dissolved in the carryover droplets from the scrubber. Reducing the emission of droplets reduces the particulate emissions. Capturing droplets carried over from the scrubber is accomplished by a Brinks mist eliminator, described below.

B. *Applicable Regulation, Emissions Limits, and Monitoring Requirements*

The Reasonably Available Control Technology (RACT) for this source is dated 7/12/76 and is based on State of Washington Sulfite Pulp Mill Rules. The consent order history was through OGC Case No. 90-0332, DOAH Case 90-2153, Air Construction permit 0890004-001-AC, Air Operations permit 0890004-003-AO and Florida Rule 62-212.400(6). The particulate emission requirement is presently part of Operating Permit No. 0890004-005-AV, condition No. .4. This Emission Limitation is that the particualte emission not exceed 2.5 pounds per ton of air dried unbleached pulp or 67.5 pounds per hour.

C. *Control Technology Description*

The combustion process produces very small amount of soot from incomplete combustion in the boiler. Also, in the sulfur dioxide recovery scrubber following the recovery boiler, a small portion of the sulfur dioxide and ammonium hydroxide react to form ammonium sulfate instead of the preferred ammonium bisulfite. A portion of the ammonium sulfate formed is emitted by the boiler as a fume. A Brinks mist eliminator treats all the exhaust gases and captures the mist containing dissolved and suspended solids including the ammonium sulfate that form particulate after the emitted droplet evaporates in the atmosphere.

A Brinks mist eliminator is comprised of a series of tubes wrapped in fiberglass or polyester fiber bats, through which the exhaust gases from the scrubber must pass. The fibers filter out the droplets of scrubber media carried over and drain to a tank leading to evaporator feed so that another attempt can be made to recover the sulfur. This also reduces the ammonia sewered, which aids in reducing ammonia discharged to the Amelia River.

D. Monitoring Approach

	Indicator No. 1
Indicator	Particulate concentration via an extractive beta gauge particulate monitor.
Measurement Approach	The monitoring system isokinetically collects a sample of particulate on to a filter tape and compares the amount of radiation absorbed with the sample and without the sample on the tape. The instrument readout can be converted to particulate concentration. The concentration can then be calibrated against EPA Method 5 particulate tests.
Indicator Range	The indicator range is based on EPA Method 5 testing.
Data Representativeness	The system is designed to collect a representative sample, which is repeatable as compared to Method 5. This has been verified and the sampling system will not be altered. The sample size on the tape can be controlled by the pressure drop across the tape or by timer.
Verification of operational Status	Each sample step provides a physical zero. The beta absorption using the C-14 source is virtually independent of the chemical composition, size or color of the collected particulate and shows no interference from water droplets or fogging in the stack. As a result there is no need for site-specific reference calibration.

	Indicator No. 1
QA/QC Practices and Criteria	As noted above there is a zero for each sample taken. In addition there is a monthly automatic beta calibration. This checks the repeatability of the Beta gauge measurement component of the instrument system by performing a zero check, a span check and a filter tape positioning check. At the same time there is a automatic flow calibration. This checks repeatability of the flow meter components of the instrument system by routing the same flow through all of the flow meters at two separate flow set points to perform a low span and a high span check.
Monitoring Frequency	There will be a particulate value provided at least every 15 minutes except for the monthly 30-minute calibrations.
Data Collection Procedures	The monitor is queried once each minute and the latest value is stored on a server with other process data. About once each month this data will be downloaded, consolidated into 15-minute averages, and stored in an Environmental Data Management Database.
Averaging Period	15-minute averages will be stored for 5 years to comply with the CAM Rule and Title V record-keeping requirements.

E. Justification

1. Background

There are few methods available for continuously, or semi-continuously, determining mass particulate emissions. Historically, opacity or light transmissivity through the plume has been used as a surrogate. For certain types of combustion the blackness of the plume was used as an indication of soot and therefore particulate emissions. Sources employing wet scrubbing technologies can sometimes relate liquid media flow and pressure drop to mass particulate emission. Liquid scrubbers emit saturated plumes and the condensing water droplets interfere with the opacity measurements.

The sulfite recovery boiler at the Fernandina Mill does not employ a scrubber to remove particulate, but does have a wet scrubber prior to emission to the atmosphere, thus it has a wet plume. Furthermore, the predominant specie of particulate is ammonium sulfate. Because ammonium sulfate particle has such a high reflectance, opacity type surrogates do not work on this type of plume.

Efforts have been made to find a surrogate parameter without success. These efforts involved trying to find other equipment operating parameters that could be measured and related to particulate emission compliance using statistics and neural networks. All these efforts have failed.

A method was found that may work. This method is based on an older method for ambient air pollution measurements called tape sampling. A small radioactive beta source is used. A baseline measurement of beta radiation passing through a clean portion of a fiberglass tape. The tape is moved to a position where a gas stream sample from the stack gases is passed through the filter tape. This sample is taken isokenetically from the stack gases to avoid biasing the size particulate sampled. The tape filters out particles down to about 0.3 micron in size. After filtering out the particulate in the gas stream the beta ray attenuation across the sampled area on the tape is measured again. The difference is used to relate to the quantity of particulate in the gas stream sampled.

2. Rationale for Selection of Performance Indicators

The performance indicator is the attenuation of beta radiation. Beta gauges have been used for a long time to measure thickness of various thin materials.

3. Rationale for Selection of Indicator Ranges

The ranges will be determined based on comparisons with EPA Method 5 particulate tests as proposed in the Construction Permit Application submitted on May 30, 2003.

Table A

Compliance Assurance Monitoring

CAM LIMITS

This Table provides the operating limits which assure compliance during normal operating conditions.

With Normal Recycle Water Make-up	Hourly Average Differential Pressure [inches water]	Hourly Average Recirculation Flow Rate [gpm]
A Scrubber	>12.0	>1300
B Scrubber	>9.5	>1300
With Fresh Water Make-up	Except when the boilers are on only oil	
A Scrubber	>9.0	>380
B Scrubber	>6.0	>250

		Hourly Average Excess Oxygen [%]
No. 1 Power Boiler	Oil Only	>3.0
No. 2 Power Boiler	Oil Only	>5.0
No. 2 Power Boiler	Bark & Oil	>3.0
No. 2 Power Boiler	Bark Only	>3.0
No. 3 Power Boiler	Oil Only	>8.6
No. 3 Power Boiler	Bark & Oil	>3.0
No. 3 Power Boiler	Bark Only	>3.0

Abnormal Operations Include:

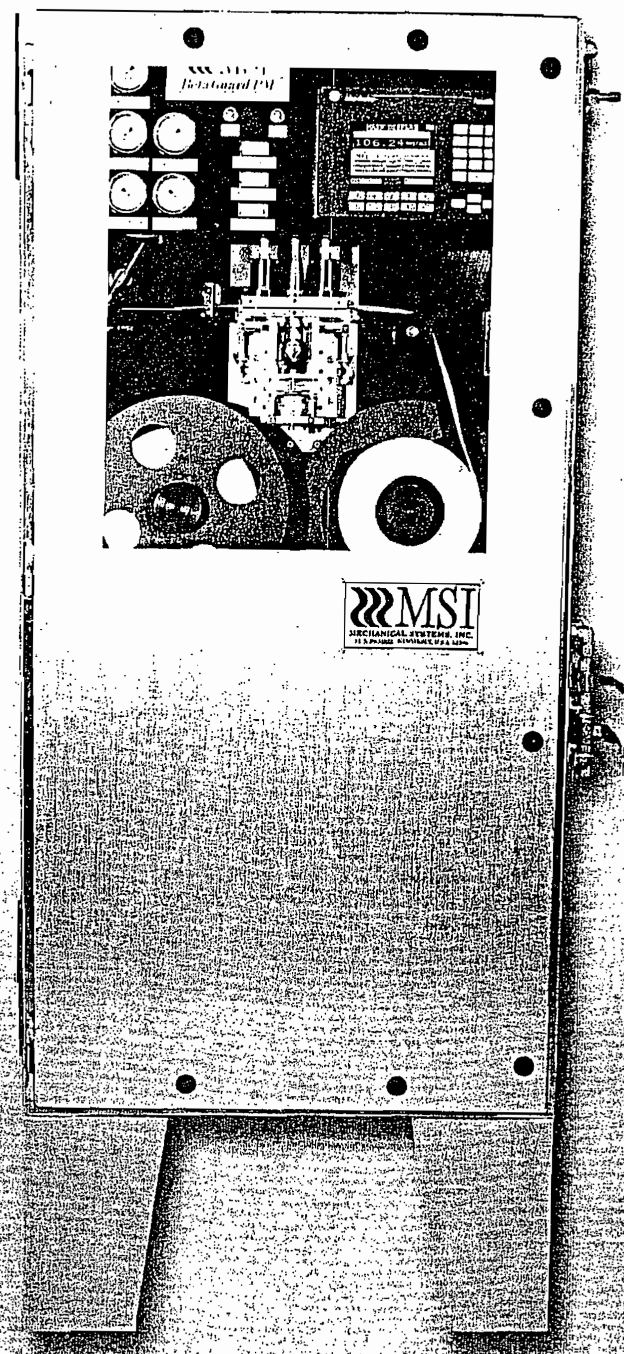
Fuel Transition When the fuel source is changed the hourly average will start averaging immediately for control, but will not be comparabl to the CAM limit until a full hour has passed.

Cold Start-up When the boiler has been down for an extended period of time there is a warm-up curve for the boiler refractory. During this period [24 hours] the boiler should have low emissions but is subject to major upsets. The hourly averages will begin as soon as fuel is added to the boiler for control, but the CAM limits will not apply until the end of the 24 hours.

Warm Start-up When the boiler is started up and a warm-up curve is not required there is a 6 hour period when the emissions should be low but the boiler is subject to upsets. The hourly averages will begin as soon as fuel is added to the boiler for control, but the CAM limits will not apply until the end of the 6 hours.

MSI

BetaGuard PM

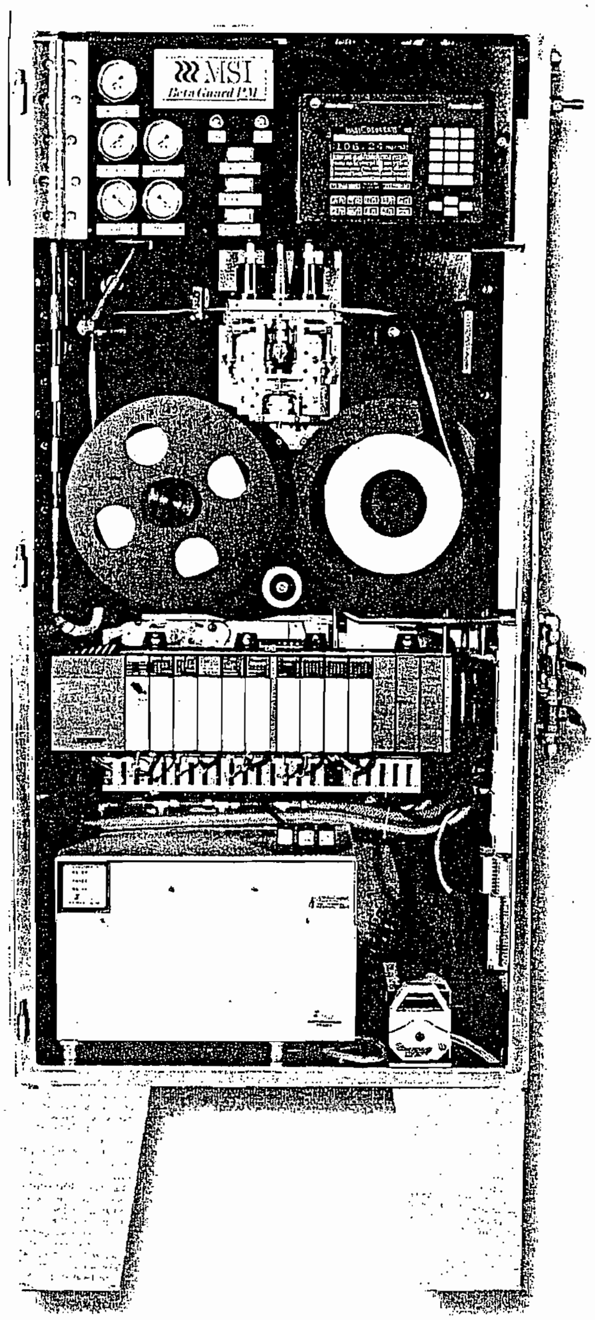


MSI BetaGuard PM Continuous Source Particulate Monitor

MADE IN U.S.A.

Description

The MSI BetaGuard PM beta gauge measures particulate emissions from all types of sources under all conditions. Stacks with changing particulate conditions (size, shape, color, density, composition) or varying operating parameters (flow rate, moisture concentration, temperature, pressure) are accurately measured. Wet basis, dry basis and process rate measurements are now available from a single instrument!



MSI BetaGuard PM

Applications

- Coal Fired Power Plants
- Cement Kilns
- Petroleum Refineries
- Hazardous Waste Incinerators
- Boiler Industrial Furnaces
- Municipal Waste Combustors

Capabilities

- Dual Beta Sensor Design
- Built-In Redundancy
- Dry Basis Measurement
- Wet Basis Measurement
- Process Rate Measurement
- Isokinetic Flow Sampling
- Isothermal Sampling

Certifications

- Method 5 Equivalence
- Method 5i Equivalence
- Method 17 Equivalence

Calibrations

- Seven Point Beta Characterization
- Seven Point Flow Characterization
- Automatic Daily Beta Calibration
- Automatic Daily Flow Calibration
- Quarterly Beta Audit
- Quarterly Flow Audit

Features

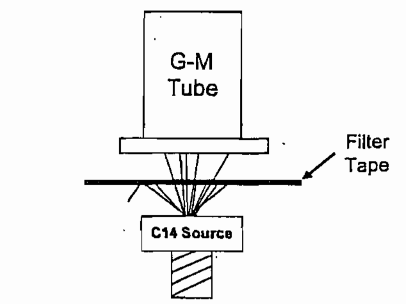
- NEMA 4X Construction
- Allen Bradley SLC 500 Control
- Heated Dilution Air
- Simplified Filter Tape Replacement
- Complete Alarms
- Complete Diagnostics
- Built-In Lightning Surge Protection
- 115 VAC Operation
- Manufactured in the U.S.A.

Options

- Remote Display and I/O to 10,000 Feet
- Outdoor Walk-In Enclosure
- Heavy Metals Monitoring Package
- Continuous Moisture Measurement

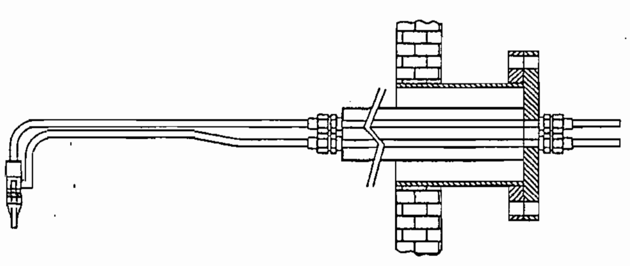
Principle of Operation

A low energy Carbon-14 source furnishes a constant supply of beta electrons which are detected by a Geiger-Mueller tube. A filter tape is interposed between the source and detector and the mass of the initial clean filter spot is recorded by measuring the counts of beta electrons reaching the G-M tube. This clean spot is then moved under a collection apparatus for sample extraction from the stack. A sample of stack gas is drawn through and deposits particulate on the filter tape. All particles above 0.1 microns (μ) are collected.



Beta Transmission Sensor Principle

Once a sufficient amount of sample is collected on the filter tape, the filter tape is moved back under the beta detector and remeasured. The difference in beta emission counts measured from the original clear spot to the collected sample is directly proportional to the mass on the tape.


BetaGuard PM Dilution Probe

The MSI BetaGuard PM extracts the sample isokinetically from the stack using a dilution probe to suppress moisture and increase sample transport velocity. During the time the mass is building up on the tape, the BetaGuard PM is measuring the sample volume extracted from the stack to produce that mass. Combining the collected mass with the drawn sample volume provides a measure of mass concentration.

The MSI BetaGuard PM measures the flow both wet and dry to provide mass concentration readings on both a wet and a dry basis.

BetaGuard PM Measures Accurately Under All Conditions Regardless Of:

Emission Control Technology

- Dry Electrostatic Precipitator
- Wet Electrostatic Precipitator
- Dry Scrubber
- Wet Scrubber
- Fabric Filter/Baghouse
- Quench Tower

Changes in Particle Properties

- Size
- Shape
- Color
- Chemical Composition
- Density

Changes in Stack Gas

- Velocity
- Water Vapor Content (Humidity)
- Pressure
- Temperature

Stack/Duct Construction

- Size
- Shape
- Internal Lining
- Materials of Construction

Equipment Changes Over Time

- Ball Mill/Pulverizer Wear
- ESP Degradation
- Fabric Filter Deterioration
- SO_3 Injection Rate
- Carbon Injection Rate

BetaGuard PM
General Specifications

Particulate Conc. Range (Selectable):	0 - 1000 mg/m^3
	0 - 0.5 grains/ft^3
Diluted Sample Flow Range:	0 - 3.5 m^3/hr, 0 - 60 1/min
	0 - 120 ft^3/hr
Minimum Batch Sampling Time:	140 seconds
Minimum Measurement Update Time:	6 minutes
Measurement Sources (2)	
Isotope:	Carbon-14
Activity:	<12 µCi
Half Life:	5700 years
Licensing:	None Required - Exempt
Measurement Detectors (2):	Geiger-Mueller (G-M) Tube
Filter Medium:	Glass Fiber, Low Heavy Metals
Digital I/O:	16 in / 16 out
Analog I/O:	10 in / 2 out
Warm-up Time:	30 minutes
Power Requirements	
Main Instrument:	115 Vac, 15 A max
Heated Sample Line:	115 Vac, 10 A max
Dilution Air Heater:	115 Vac, 6 A
Instrument Air Requirements:	80 psig, 6 scfm min
Dimensions:	72"h x 30"w x 12"d
Weight:	275 pounds
Environmental Rating:	NEMA 4X
	IP66
Operating Temperature:	50° - 120°F / 10° - 50°C
Storage Temperature:	-20° - 135°F / -30° - 60°C

MSI
MECHANICAL SYSTEMS, INC.
480 Progress Way
Sun Prairie, Wisconsin 53590
Telephone 608-825-2055
Facsimile 608-825-2295

The MSI BetaGuard® PM

Principles of Operation of a Beta Gauge Particulate Monitor

The BetaGuard PM is an instrument for measuring the concentration of particulate matter in combustion exhaust. It operates by drawing a sample of exhaust from a probe through a piece of filter tape. The filter tape is made of a glass fiber mesh, similar to fiberglass, and traps any dust particles larger than 0.3 microns. A mass measuring sensor called a Beta Gauge measures the mass of the filter tape first when the filter is clean, and again when the filter is loaded with particles. The instrument subtracts the filter mass before and after loading to calculate the mass of the particles in milligrams (mg). The instrument also measures the flow of the stack sample gas in cubic meters (m^3) used to extract the sample, and calculates the particulate concentration by dividing the mass by the volume in units of mg per m^3. This process emulates USEPA Methods 5, 5i and 17.

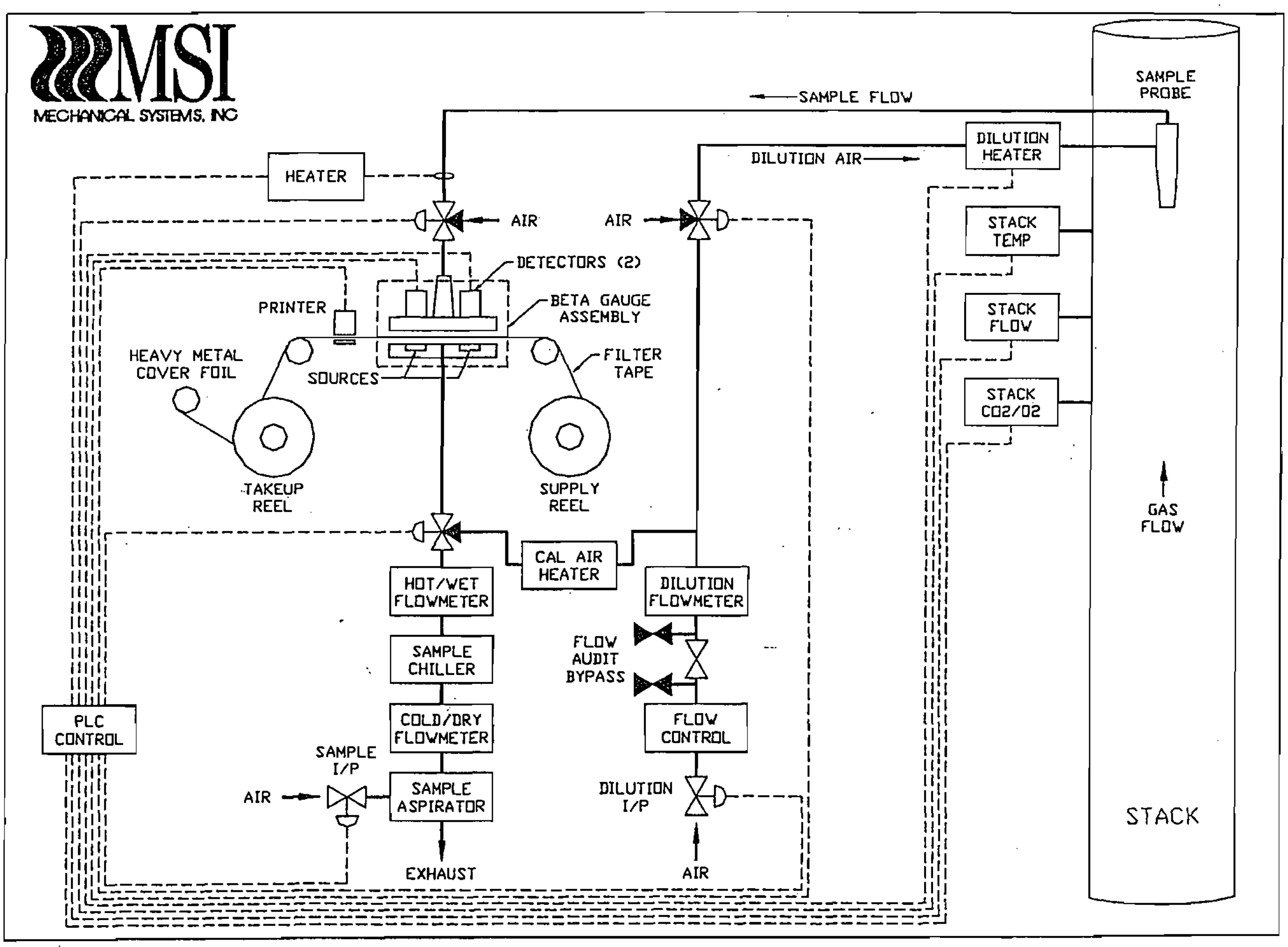


Figure 1.5: MSI BetaGuard PM Schematic Diagram

Beta Gauge

The Beta Gauge is a transmission-style sensor that transmits Beta particles through the filter tape and measures the Beta particles that get through the filter on the other side (see Figure 1.6).

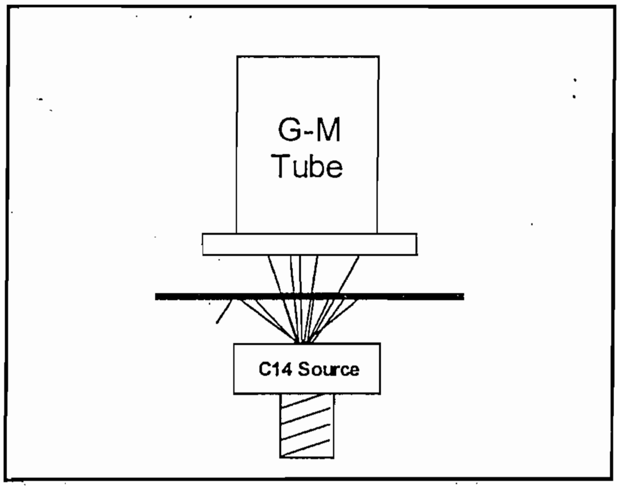


Figure 1.6: Beta Gauge Source and Detector

Beta particles are high energy electrons emitted from a radioactive isotope as it decays. They are not themselves radioactive, nor do they make anything they contact radioactive. The radioactive material, in this case Carbon-14 (C-14), is sealed in the source capsule and is not allowed to escape. The Beta particles are continuously being emitted through the source capsule window. Some are absorbed by the window itself, many are absorbed by the filter tape and the particulate particles, some are absorbed in the G-M Tube detector window and the rest are detected by the G-M Tube detector.

The Beta particles being emitted from the C-14 Source have an energy of 156 kev (kilo-electron volts), which is somewhat higher than the electrons striking the phosphor coating on the inside of a home television tube. The C-14 Beta particles can only travel about 10 inches in air before they are absorbed, and they are easily blocked by clothing and skin. The amount of radioactivity in the BetaGuard PM is similar to that in a household smoke detector, so no special labeling or licensing is required. It is recommended, however, that whenever any work is performed on the sources, filter tape holder or detectors, safety glasses must be worn.

The G-M Tube detector is a device that counts ionizing radiation (Alpha, Beta, Gamma) and is therefore called an ionization detector. A G-M, or Geiger-Mueller, Tube is a metal canister of gas with a thin window on one end and an electrode in the inside center (see Figure 1.7). A Beta particle that passes through the filter tape and the thin G-M Tube window will collide with the atoms of gas in the G-M Tube. Since a Beta particle is really a high energy electron, it has mass and an electrical charge and it is moving quickly. As the Beta particle collides with a gas atom, it gives some of its energy to an outer shell electron of that gas atom. If the outer shell electron now has enough energy to overcome the binding energy of the nucleus, it can escape from its atom. This results in an extra free electron in the G-M tube and an atom that has one fewer electron than it needs to be electrically neutral. This electron-deficient atom has an overall positive charge and is called an ion. This is the process of ionization and one Beta particle can ionize many hundreds of gas atoms. The gas in the G-M Tube is selected for its density and the ease with which its outer shell electrons can be stripped by the incoming Beta particle (ionization potential).

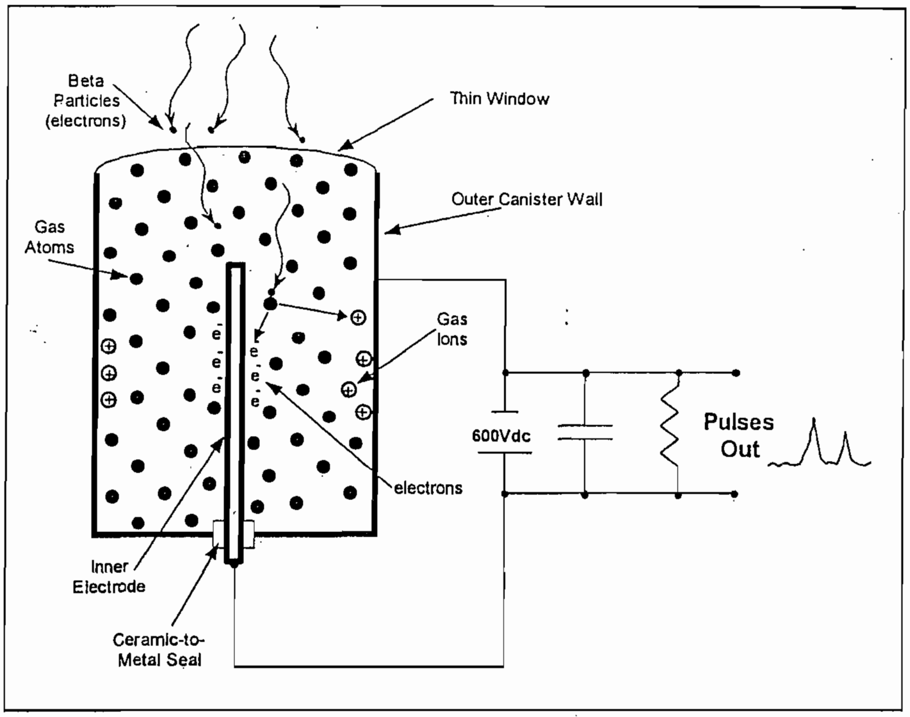


Figure 1.7: Geiger-Mueller Tube Schematic

An electrode is sealed into the G-M tube through the bottom but is electrically isolated from the outer canister by a ceramic-to-metal seal. A high voltage is applied across the inner electrode and the outer canister that creates a large radial electric field inside the G-M Tube. Since the free electrons caused by the Beta ionization have a negative charge, they are attracted to the high potential inner electrode and the positively charged ions are attracted to the low potential canister wall. Since the electric field is so high, these charged particles are accelerated fast enough to cause ionization in more gas atoms. This process known as secondary ionization results in a rush of flowing charge to the inner electrode and the outer canister wall. This rapid charged particle flow is seen as a burst of current on the conductors attached to the electrode and canister. A resistor placed across these conductors converts the current burst to a voltage pulse for each Beta particle entering the G-M tube. Counting these pulses determines how many Beta particles are passing through either the clean filter tape or the filter tape with particulate. The ratio between the two pulse counts determines the net mass on the filter tape.

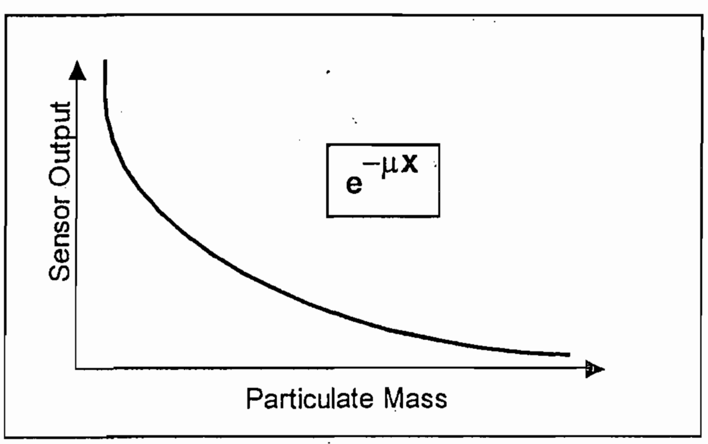


Figure 1.8: Inverse Exponential Beta Transmission Sensor Response

The response of the Beta transmission sensor to particulate mass is similar to that of an optical opacity sensor that shines light through the stack and measures its intensity after it has traveled through the stack gas where it has been partially scattered and absorbed. The sensor output is inversely proportional to the amount of mass between the source and detector and exhibits an exponential dependence as shown in Figure 1.8

Sample Flow

The stack gas is isokinetically drawn through a nozzle attached to a stainless steel ½" (12mm) diameter tube. The nozzle points against the direction of stack gas flow and has a well defined circular opening, typically 5 or 6mm diameter. A dilution tube, also ½" diameter stainless steel, connects to a mixing chamber just behind the rear of the nozzle and adds dry filtered ambient air in the dilution ratio set by the BetaGuard PM (typically between 1:1 and 10:1). The dilution flow is measured by a mass flowmeter in the instrument.

The total diluted sample is drawn through a heated ½" stainless steel sample line and passed through the filter tape where any particulates (dust) in the sample larger than 0.3 microns (0.01 thousandths of an inch diameter) are accumulated.

The filtered diluted sample gas then passes through a flowmeter that measures the diluted sample gas flow in the hot, wet state. If a dry basis particulate concentration measurement is needed, the diluted sample gas flows through a chiller where the water is removed, and then through another mass flowmeter to calculate the dry total flow. The sample gas is finally vented back into the stack or into open air.

Sample Heater

The sample line is actively heated by an electrical resistance heater that is controlled by the BetaGuard PM. The dilution line is optionally heated at the Probe flange by an electrical resistance in-line air heater. Additional closed loop controlled heaters are mounted in the filter holder and optionally in the cabinet sample gas circuit to insure that the sample remains hot. The BetaGuard PM can also be set to continuously vary the sample temperature to track the stack gas temperature if Isothermal Sampling mode is selected.

Particulate Measurement Cycle

The diluted stack gas sample is brought to the filter tape through a conical pipe that is mounted to the top half of the filter holder. The top and bottom half of the filter holder fit together tongue-in-groove style to trap the filter tape and seal around the conical pipe. A stainless steel tube is attached to the bottom half of the filter holder below the filter tape opposite the conical pipe. This assembly insures that the filter tape remains stationary while the sample gas is passed through it without allowing any of the sample gas to escape.

The sample gas is passed through the filter tape long enough to deposit a sufficient amount of mass for the BetaGuard PM measurement, typically 4 – 28 mg. The sample flow cycle is usually 7-15 minutes depending on stack particulate concentration. The filter tape is moved back and forth from under the sample gas flow to between the Beta gauge source and detector by a stepper motor and a friction wheel drive. Each time the filter tape is moved, a solenoid separates the two halves of the filter holder. When the filter tape stops moving, the filter holder halves are pressed tightly together by compression springs.

A typical measurement cycle is as follows:

Step 1	The stepper motor advances the filter tape to a clean section within the filter holder (about 92mm [3.6"])
Step 2	No sample is passed through the filter tape while the left-hand Beta Gauge measures a clean section of the filter tape for 2 minutes. This provides the zero measurement of that spot of the filter tape.
Step 3	The stepper motor reverses the filter tape until the spot measured in Step 2 is exactly beneath the conical pipe sample gas outlet (46mm [1.8"]).
Step 4	The valve opens to allow the sample gas to flow through the filter tape for the predetermined cycle time. At the same time, the right-hand Beta Gauge measures the clean section of filter tape between its source and detector for 2 minutes to obtain the zero measurement of that spot.
Step 5	The stepper motor advances the filter tape until the spot that just filtered the sample gas is again directly between the source and detector of the left-hand Beta Gauge (46mm [1.8"]).
Step 6	The left-hand Beta Gauge measures for 2 minutes the same spot of the filter tape where it measured the zero previously, only now it is loaded with particulates. Simultaneously, the valve opens to allow the sample gas to flow through the spot of filter tape that was measured for a zero reference with the right-hand Beta Gauge in Step 4 for the predetermined cycle time.
Step 7	After the left-hand Beta Gauge has measured the particulate-loaded spot for two minutes, the particulate concentration is displayed and the 4-20mA output is updated.
Step 8	When the sample gas flow cycle time of Step 6 is complete, the stepper motor reverses the filter tape until the spot measured in Step 4 by the right-hand Beta Gauge is returned, now loaded with particulates (46mm [1.8"]).
Step 9	The right hand Beta Gauge measures the particulate loaded filter spot for 2 minutes, the particulate concentration is displayed and the 4-20mA output is updated.
Step 10	Upon completion of the Step 9, the measurement process begins again at Step 1.

An important consequence of the BetaGuard PM measurement principle is that it always re-zeros the filter prior to depositing the particulate sample. This allows the instrument to reuse the filter spot a number of times before it begins to clog and the filter must be advanced. If this resampling option is selected, the life of a reel of filter tape can be extended from one month to two or three months.

Blowback

When compressed air is provided to the BetaGuard PM and the measurement cycle begins, the compressed air actuates a pneumatically actuated valve that allows the stack gas to be drawn into the instrument and the BetaGuard PM to operate. The position of the pneumatic actuator is sensed to always insure that compressed air is present so that the probe can be blown back on a regular basis to eliminate the possibility of dirt build-up and clogging. The interval between blowbacks is user selectable from the BetaGuard PM display and is usually eight (8) hours. When blowback is initiated, either automatically or manually, a valve is closed to stop sample gas from flowing through the filter tape and high pressure (≈70psig) air is forced through the sample and dilution lines, through the nozzle into the stack. The compressed air is pulsed in 2 second on, 2 second off cycles for about 20 seconds.

Automatic Beta Calibration

This routine is usually run daily and initiated by the data logger and lasts about 30 minutes. Automatic Beta Calibration checks the repeatability of the Beta Gauge measurement component of the BetaGuard PM by performing a zero check, a span check and a filter tape positioning check. During an Automatic Beta Calibration, the normal measurement mode of the BetaGuard PM is suspended. The Automatic Beta Calibration routine can also be initiated immediately through the BetaGuard PM display.

Automatic Flow Calibration

This routine is usually run daily and initiated by the data logger and lasts about 30 minutes. Flow Calibration can be run concurrent to the Automatic Beta Calibration. Automatic Flow Calibration checks the repeatability of the flowmeter components of the BetaGuard PM by routing the same flow through all of the flowmeters at two separate flow setpoints to perform a low span and a high span check. During an Automatic Flow Calibration, the normal measurement mode of the BetaGuard PM is suspended. The Automatic Flow Calibration routine can also be initiated immediately through the BetaGuard PM display.

THEORY OF NUCLEAR GAUGING

There are typically three types of radioactive emission used for industrial mass gauging, Alpha (α), Gamma (γ) and Beta (ß).

Alpha Emission

An Alpha particle is a ^4He nucleus and as such, is very large and heavy compared to the other forms of radioactive emission. They have very limited penetrating ability in solids and since Alpha gauging applications are used primarily for the measurement of gases, they will not be discussed further here.

Gamma Emission

Unlike Alpha (or Beta) radiation, Gamma radiation is not in the form of charged particles, but instead is electromagnetic radiation in and above the X-Ray spectrum. By analogy, a Beta source of, say, 500mCi activity emits as many Beta particles per second as the Gamma photons per second emitted by a 500mCi Gamma source. Unlike Beta particles, Gamma photons are emitted at a single energy determined by the particular isotope and interact with matter through fundamentally different mechanisms. Gamma photons have no charge and no mass, and are consequently much more penetrating than Beta particles in matter (like X-Rays) and are used primarily for quite thick targets and for fluorescence measurements.

Beta Emission

Beta particles are in fact high energy electrons ejected from the nuclei of certain radioactive materials. They are negatively charged, have energies ranging from zero to a maximum energy (units of electron Volts [eV]) determined by the specific radioactive isotope and are emitted in an average number per second defined by the Activity (units of Curies [Ci]) of the particular radioactive source.

Beta particles interact with matter through three primary mechanisms:

1) Inelastic collisions with electrons in the target (*Absorption*)

$$f_1\{k_1\rho(Z/A)\} \quad \textbf{eq. 11.1}$$

2) Elastic collisions with nuclei in the target (*Scatter*)

$$f_2\{k_2\rho(Z^2/A)\} \quad \textbf{eq. 11.2}$$

3) Inelastic collisions with nuclei in the target (*Bremsstrahlung*)

$$f_3\{k_3\rho(Z^2/A)\} \quad \textbf{eq. 11.3}$$

where k_n are constants proportional to the Beta energy,

ρ is target density,

Z is the target Atomic Number and

A is Atomic Mass.

Beta particles are particularly ideal for use in industrial gauging because of their relatively short range in matter and therefore high sensitivity to small changes in mass, and since the source / detector components are very long-term stable and industrially rugged. The Carbon-14 isotope used in most Beta Gauge Particulate Monitors has a half-life of over 5000 years, and therefore exhibits no measurable change in radiation output and thus no measurement drift throughout the life of the instrument. The G-M Tube detectors are simple gas-filled canisters with no moving parts. They exhibit no drift characteristics unless they are physically damaged, in which case their output goes to zero, an easily identifiable fault condition. In the unlikely event of a G-M Tube failure, the dual detector BetaGuard PM has the ability to sense the zero output condition and automatically switches its operating mode to that of a single detector Beta Gauge. In this way, the instrument will continue to measure properly with no loss of data, and repairs can be made in a non-emergency manner.

A consequence of the manner in which Beta particles interact with matter to determine mass is that there can be some measurement dependence on the chemical composition of the specific particulate. It is therefore worthwhile to investigate the extent to which the chemical composition dependence of the BetaGuard PM has on its ability to accurately measure the products of combustion. When considering the design of a Beta Transmission Sensor, a radioactive source is mounted on one side of the target and a Beta particle detector is mounted on the target's other side. The detector then measures the Beta particles that pass through the target.

Assuming that all the Beta particles that do not pass through the target and are not detected are in fact absorbed via mechanism 1, the response curve of the ß-Sensor would describe an exponential dependence (derived from Equation 1 above) on target mass and be independent of target chemical composition.

$$e^{-\mu x}, \text{ where } \mu = f1\{k_1\rho(Z/A)\}$$

If Equations 2 and 3 above are combined as

$$F\{K\rho(Z^2/A), \qquad \text{eq. 11.4}$$

then the total interactions of Beta particles with matter can be expressed by the following definition of μ, the absorption coefficient:

$$f_1\{k_1\rho(Z/A)\} + F\{K\rho(Z^2/A)\} \qquad \text{eq. 11.5}$$

where k and K include a dependence on the incident Beta energy,
Z is the target atomic number,
A is the target atomic mass, and
ρ is the target density.

Bear in mind that in the case of a Beta Transmission Sensor, any Beta particle that is not detected is assumed to be absorbed.

This implies that if some Beta particles that are not detected interact with the target by some mechanism other than absorption, such as backscatter from the target or deceleration and emission of X-Rays (Bremsstrahlung) that cannot be measured by the Beta detector, then a measurement error may occur. The practical threshold of the target atomic number below which K of equation 5 approaches zero, is a function of the Beta energy. In the case of the C14 Beta-emitting isotope used for particulate monitors, the beta energy (max) is 156kev and for target atomic numbers below 20, **K** of Equation 5 can be considered to be zero and the sensor is virtually insensitive to compositional changes.

If the target contains components of atomic number greater than 20, such as Iron, Chromium or lead, then **K** of Equation 5 is not zero, and any variation in the relative concentration of these elements may cause a measurement error proportional to the Z^2/A additive function (F) which becomes more pronounced with increasing concentration and increasing Z.

Compound	*Class F*	*Class C*
SiO_2	**48**	**33**
Al_2O_3	**20**	**18**
Fe_2O_3	**20**	**8**
CaO	**3**	**25**
MgO	**1**	**8**
K_2O	**2**	**1**
Na_2O_3	**1**	**3**
SO_3	**1**	**3**
LOI	**3**	**0.5**

Figure 11.1: Coal Fly Ash Composition by Class

It is important at this time to qualify the magnitude of any error due to changing chemical composition in stack gas effluent. One principle application of the BetaGuard PM is the measurement of airborne particulates from the stacks of coal-fired electric generating utilities. The typical fly ash chemistry will vary as a function of the fuel and can range from high Fe_2O_3, low CaO to high CaO, low Fe_2O_3 in the cases of various Lignite and Anthracite coals (see Figure 11.1).

Equation 5 can be rewritten in terms of the detected Beta particles passing through the target as:

$$I = I_0 \Sigma e^{-w_i \mu_i \rho x} \quad \textbf{eq. 11.6}$$

where I is the Beta particle intensity after passing through the target,
I_0 is the original intensity of Beta particles emitted from the source,
μ_i is the Beta attenuation coefficient of each element in the target (the i^{th} element; physically, μ can be viewed as the probability of interaction per unit distance),
w_i is the concentration by weight of the i^{th} element,
ρ is the homogeneous material density and
x is the homogeneous material thickness.

μ_i is a function of the Beta particle energy, **E**, and the electron density of the absorber and is of the form,

$$\mu_i = C_{i1}E(Z/A) + C_{i2}E(Z^2/A)$$

where **Ci_1** is an empirically derived constant for mechanism 1 above and **Ci_2** is an empirically derived constant for the combined mechanisms 2 and 3 above.

It is interesting to compare the energy lost by each of the two terms above. Dividing these terms,

$$\mathbf{[(dE/dx)_{2,3} \,/\, (dE/dx)_1\,] = [C_{i2}E(Z^2/A) \,/\, C_{i1}E(Z/A)] = C \cdot E \cdot Z,}$$

where **C** is a new constant, empirically derived as approximately 1/500 when **E** is in units of Mev.

At a maximum Beta energy for C14 of 0.156Mev, the amount of error created by a change in fly ash chemical composition of 15% Fe (Z = 26) is 0.8%. Substituting this effect into the exponential argument of equation 6, the effect of even this large a change in the higher atomic number composition of the fly ash chemistry will lead to at most a 1% measurement change not attributable to the consequent change in real particulate density.

For this reason, the BetaGuard PM is calibrated in the factory to a known, traceable set of mass standards. Upon installation on a stack, there is virtually no subsequent recalibration of the instrument required for the various application specific fly ash chemistry. The BetaGuard PM is virtually insensitive to chemical changes in the products of combustion. It will measure the particulate mass correctly and repeatably. In the cases of installation of the BetaGuard PM on other combustion or incineration processes that emit high atomic number pollutants, a correction factor may be required to bring the BetaGuard PM into calibration. This is facilitated by user-enterable scaling or offset factors stored in a comprehensive recipe in the Gauge electronics.

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Beta Gauge Particulate Monitoring - Theory and Practice

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Cincinnati, Ohio
May 12-14, 1999

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Continuous particulate monitoring is becoming an issue in the electric utility industry. Title V permitting, compliance assurance monitoring, and credible evidence rules are forcing the utility industry to look critically at the question of particulate emissions. The industry has known for some time that changing the operating parameters of electrostatic precipitators can result in changes in particulate emissions. What has become evident recently to both utilities and regulators is that there are other factors that can significantly influence particulate emissions independent of precipitator operation, and these factors are not well documented. Unless these factors can be characterized properly or somehow related to full load stack tests, monitoring may become necessary.

Few electrostatic precipitators operate at full power all of the time. It is standard practice to vary precipitator power on the basis of external parameters such as load, opacity, spark rate, etc. and take for granted that the emissions remain in compliance with permit conditions. Even though particulate tests are normally only done at full load and under one set of operating conditions, it is assumed that precipitator operating parameters can be varied from full load test conditions and not affect emissions. Many utilities are beginning to question this assumption. What is really happening when precipitator operation is optimized using some other parameter than actual emissions? Are the emissions going up or going down?

The introduction of low NOX burners on an industry wide basis has complicated the problem. Poor efficiencies and higher loss on ignition have plagued many plants and resulted in numerous changes in firing procedures and precipitator operating parameters. Every change affected particulate emissions, but little if any data has been collected to document the effect of the changes.

The use of different coals and other opportunity fuels has had even more effect on particulate emissions. The change from a high sulfur eastern bituminous coal to a low sulfur western subbituminous coal has well known effects on the amount of ash generated and the amount of particulate emissions produced. What has been surprising is the growing body of evidence suggesting that changing coal within the same classification can also noticeably affect emissions. Changing from one bituminous coal to another bituminous coal may noticeably change particulate emissions. Those plants that are constantly changing or blending fuels will not be able to use periodic performance testing to determine particulate emissions unless all combinations of coals are tested.

Continuous verification of acceptable particulate emissions will become necessary when either regulators or utility risk managers become uncomfortable with undocumented operation. When this happens plants need options as to how to monitor particulates. While there is a concerted effort to see if modeling will work to address these problems, there will be significant difficulty in the application of this approach for those plants that require flexibility in operation. Continuous particulate emission monitors will likely be the instrument of choice for those facilities that cannot operate within very narrow and well defined ranges.

Historically there have been four types of particulate monitors:

- Gravimetric (Reference method)
- Triboelectric (Broken bag detectors)
- Optical
    - Light Transmission (Opacity monitors)
    - Scintillation
    - Light Scatter
        - Back
        - Side
        - Forward
- Beta Gauge

The gravimetric method has been used as the reference method with little or no application for continuous particulate monitoring. Recent refinements in the reference methods to measure lower concentrations have resulted in much more complicated procedures. This has only made it less likely that any continuous gravimetric instrument will ever be developed.

Triboelectric instruments have been used extensively as a cost effective method of monitoring catastrophic failures in fabric filters and baghouses. Although there are notable efforts in both England and Germany at this time to use these devices for compliance monitoring, the application in North American utilities is not expected to be that significant where the vast majority of particulate control is done by electrostatic precipitators.

Precipitators impart a charge to the entrained particles which is similar to the effect the triboelectric devices are measuring. This makes measurements very difficult if not impossible to characterize for most utility applications with this technology.

Light transmission devices or opacity monitors have been used extensively for visible emission compliance in the United States for over twenty years. The technology has worked well in the utility industry when opacity limits were in the 20% to 40% range. As permit limits come down, the correlation between mass concentration and light transmission becomes very difficult to measure with opacity monitors. The technology becomes unreliable and unable to accurately measure particulate concentrations below 50 mg/scm (.02 gr/scf). The EPA has expressed significant doubts that this technology will be acceptable for continuous particulate monitoring. As a result, opacity monitors have not been included in most of the official EPA tests and are not expected to have a significant presence in the particulate monitoring market.

There is another optical technology which uses the ability of particles to scatter light instead of obscure light to produce more accurate measurements. Light scattering instruments as a group have been used in Europe for almost the same amount of time as opacity monitors have been used in the United States. The results have been uniformly good at emission detection limits significantly below those presently seen with opacity monitors.

There are three variations of this technology; forward scatter, side scatter, and back scatter. All of the scatter technologies can work well under the right conditions and generally have the same limitations and restrictions as opacity monitors with one exception. Most scatter instruments do not measure across the stack, but measure a point a set distance in from the stack wall. This point is normally less than one foot from the stack wall which can be a problem for large utility stacks. The boundary layer effects that have been found and documented in recent flow studies by EPRI and the EPA will affect the distribution of particulates near the stack walls. Analyzing the sample at a more representative location farther from the stack wall will help ensure more accurate measurements.

Scatter instruments are very similar to opacity monitors in terms of operation and maintenance and will likely be the instrument of choice where they can be certified. They solve the lower detection limit problem of opacity monitors and only need one stack opening to be installed. With optical based scatter instruments apparently working well in other parts of the world, why is there a need for another method to monitor particulate?

Beta transmission technology was developed to address three very specific applications; wet stacks, changing stack conditions, and changing particle properties. Optical instruments cannot measure in wet stacks. Entrained moisture refracts, reflects, and diffracts light making it impossible for optical technology of any kind to work correctly. For years the opacity readings reported for wet scrubber stacks were taken before the scrubbers to circumvent this problem. While this may continue to be allowed, there is an incentive to move the particulate monitor to the stack to report more accurate data and take advantage of a scrubber's natural ability to remove particulate from the exhaust gas stream.

It is also well documented that changing stack conditions and changing particle properties make optical measurements unreliable. Figure 1 shows the problem associated with changing the particle size distribution in a stack. As the particle size varies, optical instruments will produce different readings even though the actual mass emission is not varying. Particle size variations occur commonly as the operating parameters on an electrostatic precipitator are varied.

Figure 1: Optical Instrument Response

Measurement Output Versus Concentration - Various Particle Sizes

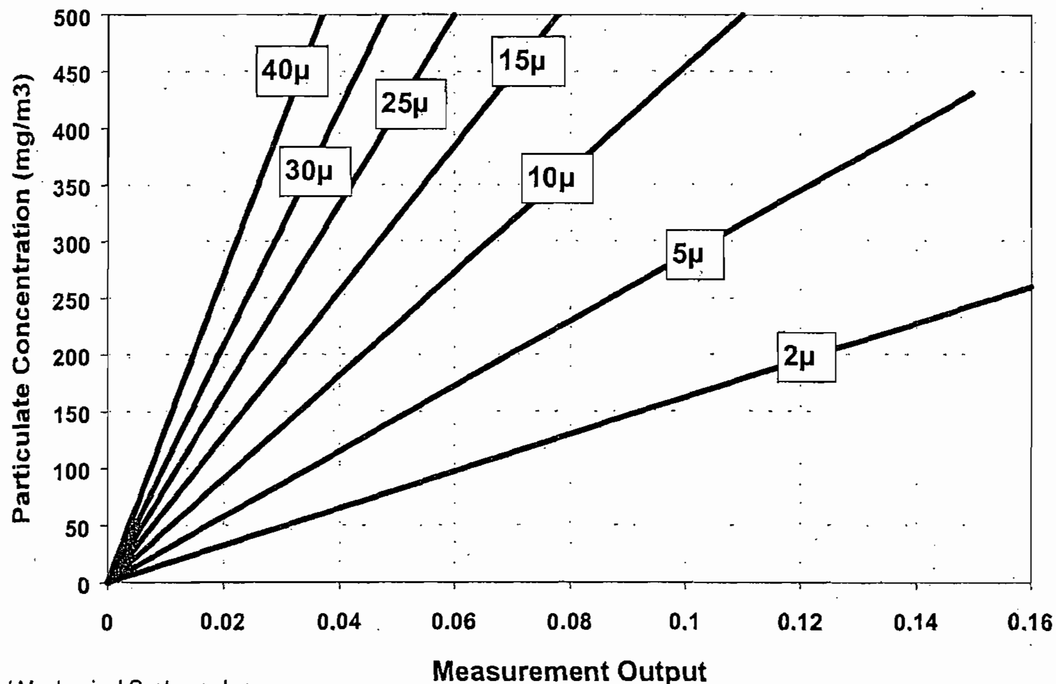

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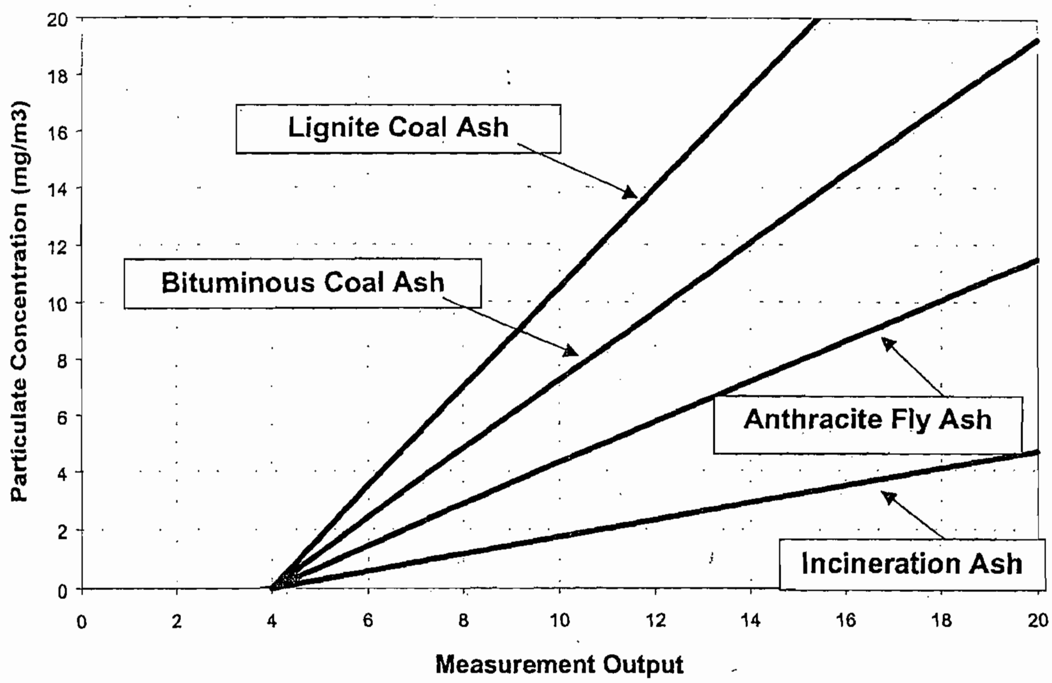
Figure 2 depicts a similar problem when the type of fuel changes. Here again optical instruments produce different outputs depending on the type of coal being burned and not on the amount of mass being emitted.

The difference in readings noted in Figure 2 are for several different types of coal but similar graphs can be produced for coals within the same classification. There are different optical responses between low sulfur and high sulfur eastern bituminous coal and between high sulfur West Virginia coal and high sulfur Illinois coal.

Figure 2: Optical Opacity Instrument

Measurement Output Versus Concentration - Various Ash Types



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Different coals produce different outputs for the same mass emission in optical instruments for many different reasons. The average size distribution could be changing. The color or refractive index of the coal could be changing. The moisture in the coal could be changing. The average heat content/velocity in the stack could be changing. Optical instruments work well and are a cost effective solution when things don't change. For utilities with changing conditions or utilities who do not want to be limited to a one set of operating conditions, another technology had to be found.

The beta gauge particulate monitor is uniquely suited for documenting compliance of source particulate emissions and for optimizing precipitator and fabric filter operation. Beta gauge measurements are not affected by stack conditions or by particle characteristics.

Beta gauge measurements show no sensitivity to stack velocity, temperature, and moisture, or to particle size, shape, color, and refractive index. This non-optical technology can be installed in wet or dry stacks and will measure reliably even when the characteristics of the particulate emissions are constantly changing.

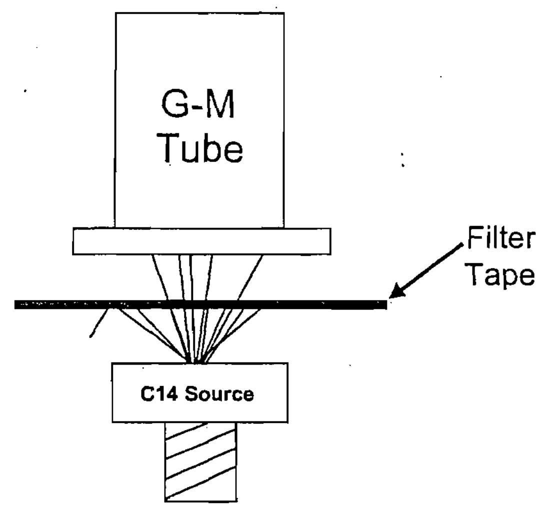


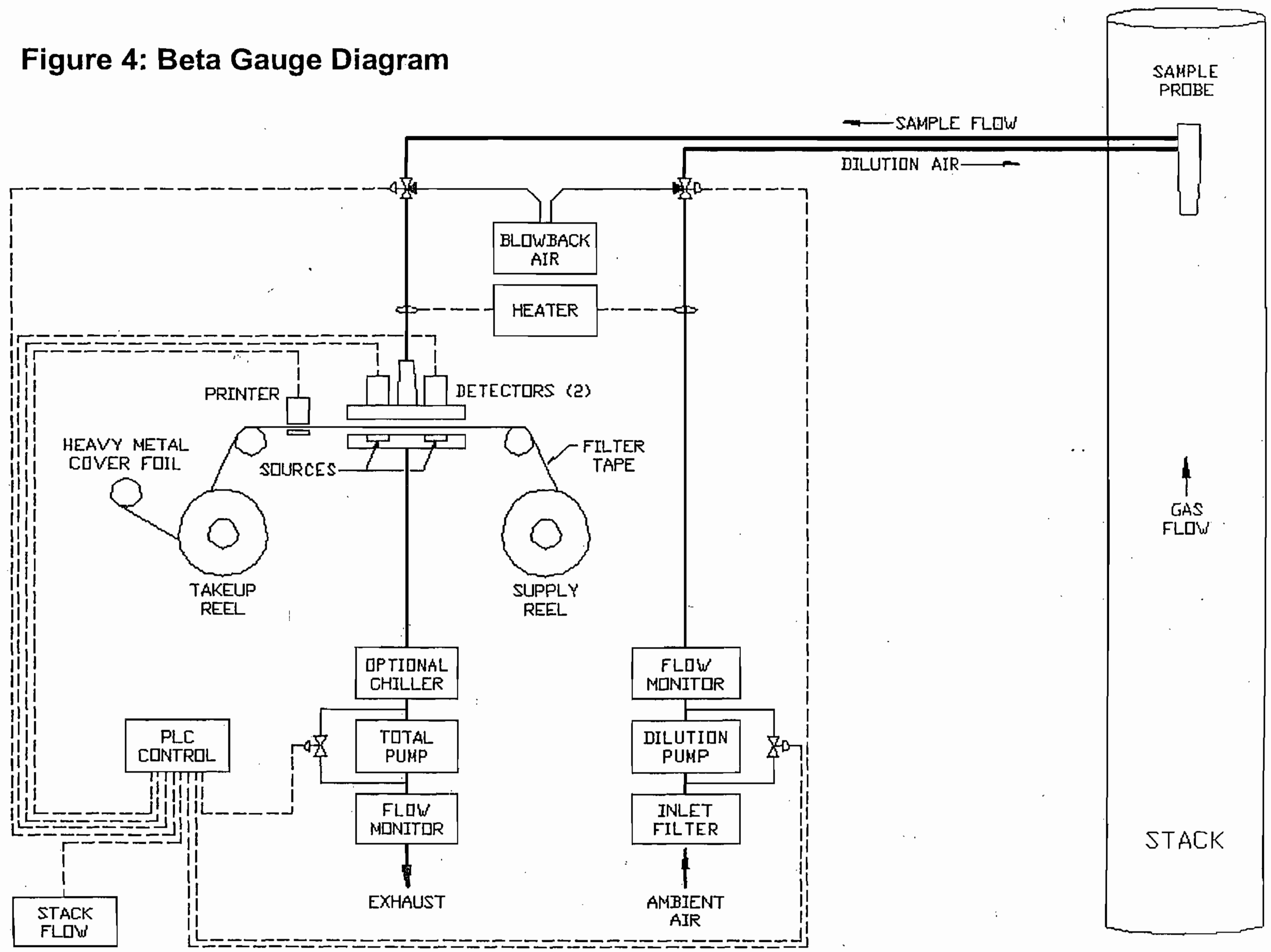
Figure 3: Beta Transmission Sensor

Figure 3 shows a typical beta gauge source and detector combination. A low energy Carbon-14 source furnishes a constant supply of beta electrons which are detected by a Geiger Mueller tube or photodiode array. A filter tape is interposed between the source and detector which produces an initial reduction in the number of beta electrons reaching the detector. The particulate measurement cycle begins by measuring a clean area (spot) on the tape for a fixed time period to determine a zero value. This clean spot is then moved under a collection apparatus for sample extraction from the stack. A sample of stack gas is drawn through and deposits particulate on the filter tape. All particles above 0.1 microns are collected. Once a sufficient amount of sample is collected on the filter tape, the tape is moved back under the beta source and remeasured. The difference in beta emissions measured from the original clear spot to the collected sample is directly proportional to the mass on the tape.

Figure 4 shows a diagram of the complete beta gauge. The beta gauge extracts a sample isokinetically from the stack using a dilution probe to suppress moisture and increase sample flow. The sample is transported through a resistance heated line at high velocity to maintain particulate entrainment and prevent sample loss. The particulate is drawn through and deposited on a filter tape in a heated collection holder (Figure 5). The tape is held in place and sealed from the surrounding atmosphere by the heated holder. Heating the holder prevents condensables from dropping out of the sample during the collection process.

The sample is collected for a set period of time or until a maximum pressure differential through the tape is detected. The tape is then moved back under the beta source and re-analyzed for total mass. During the time mass is building up on the tape, the beta gauge is also measuring the sample volume extracted from the stack to produce that mass. Combining the mass collected with the sample drawn provides an output for mass concentration.

Figure 4: Beta Gauge Diagram



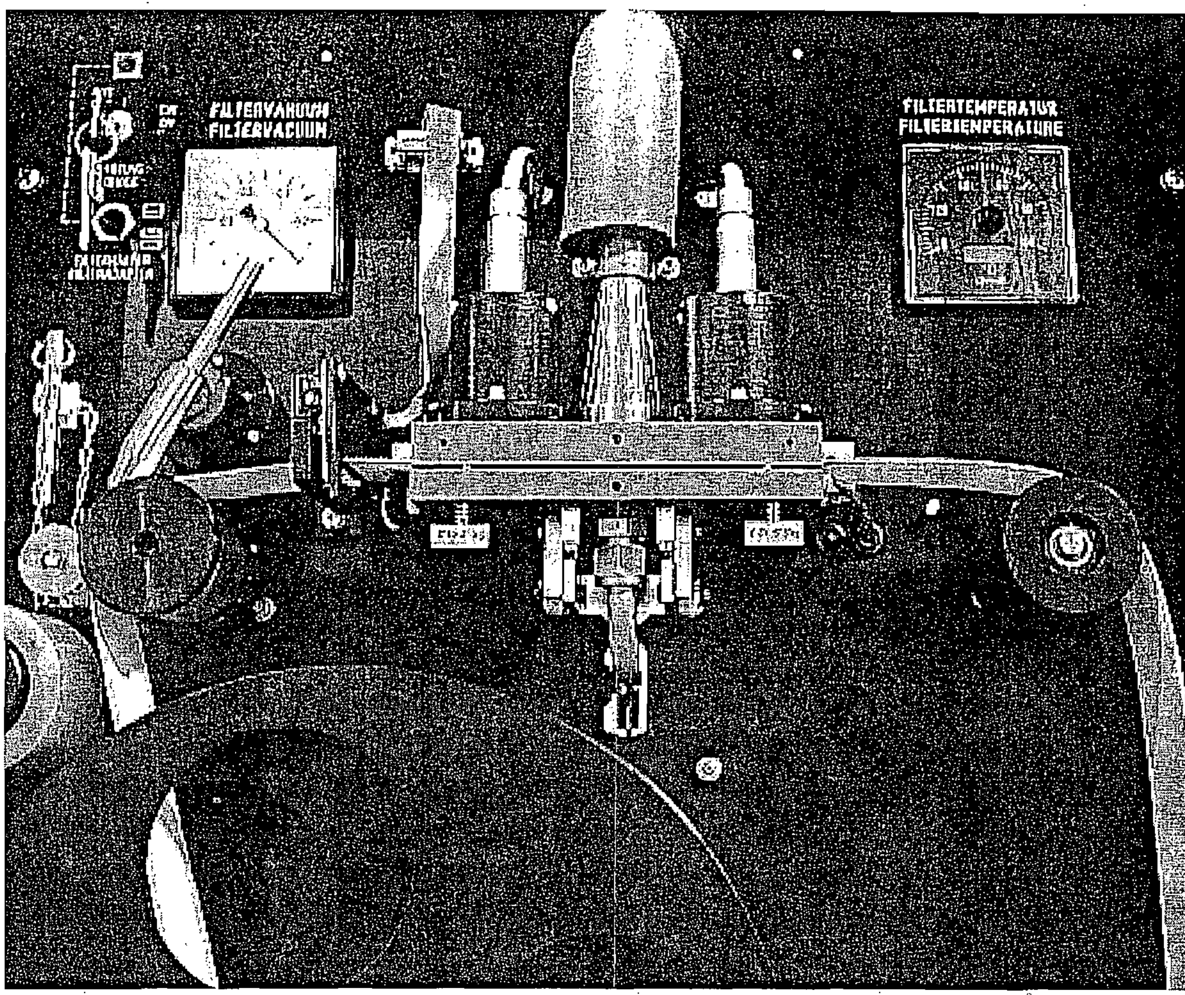


Figure 5: Beta Gauge Measuring Head

While relatively straightforward in concept, the actual sample extraction and measurement have proven much more difficult in practice. A great deal of time has been spent devising reliable methods for sample extraction and transport. Figure 6 shows the dilution probe used to extract the sample from the stack. As dilution technology addressed many of the sample conditioning problems with gas monitoring for the Acid Rain Program, dilution technology also addresses many of the sample conditioning problems with mass emission extraction.

Figure 7 shows the detail of the sample extraction nozzle at the end of the dilution extraction probe. Accurately measured dilution air is introduced into the probe at right angles to the extracted flow. The dilution air surrounds and envelopes the sample to minimize contact with the sampling system components. Rapid mixing of the dilution air and sample follows due to the turbulence produced in the mixing chamber.

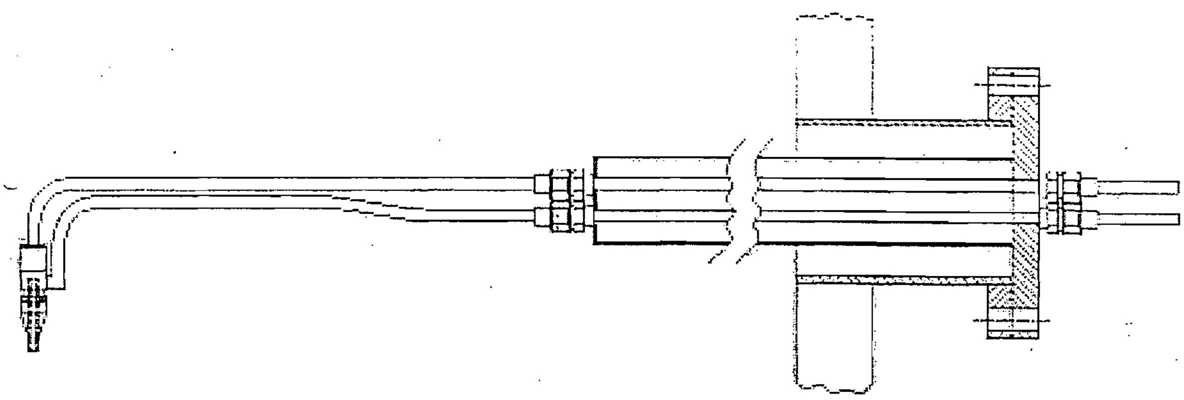


Figure 6: Beta Gauge Dilution Probe

This rapid mixing suppresses the moisture in the sample and eliminates the problem of condensation in the sample line. Moisture condensation trapping particulate in the sample line is one of the more difficult problem associated with particulate sample transport from saturated stacks. Without dilution the transport of the sample becomes progressively more unreliable as the moisture content of the sample increases.

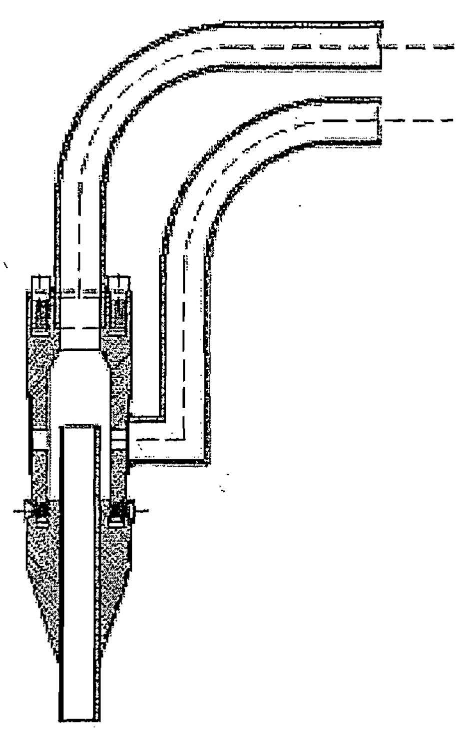


Figure 7: Dilution Probe Detail

Diluting the sample simplifies the transport of particulate samples from all types of stacks and allows wet scrubber stacks to be analyzed as accurately as dry stacks. Using dilution air also provides enough excess air so that there is more than enough flow to maintain a critical sample velocity. This is true even though the sample is extracted isokinetically from the stack and the amount of flow can change drastically from low load to high load operation. The total sample transported to the filter tape is maintained above critical sample velocity at all times by dilution air alone. The total sample flow is not dependent on the extracted sample flow to prevent sample loss during transport.

Maintaining a high sample velocity is absolutely critical to ensure that the sample is deposited on the tape and not in the sample tubing. At present sample tubing lengths up to fifty feet are possible under all stack conditions and could be longer on a case by case basis.

Flow monitors measure both the dilution air supplied to the probe and the total sample (dilution air plus extracted sample) drawn through the filter tape. The difference between the two measurements is the sample extracted from the stack. The sample extraction rate is controlled isokinetically by varying the dilution flow and maintaining constant the total sample drawn through the filter. This variation is based on an external flow measurement taken directly from the existing stack flow monitors or through the 40CFR75 data acquisition and handling system.

The beta gauge has a resistance heated sample line which is maintained at a constant temperature of 120° Celsius for Method 5/5i testing or allowed to vary slightly above stack temperature for Method 17 testing. Keeping the sample temperature slightly above stack temperature for Method 17 testing provides a more accurate measurement of front half particulate by ensuring that condensables are neither formed nor destroyed during sample transport. The resistance heated sample line is driven by low voltage AC transformers that operate at either 6 Vac or 12 Vac depending on the length of sample line. The heating circuit is formed by passing a current through the sample line, probe, and dilution line. The probe and connected sample and dilution lines are electrically insulated from the probe holder to allow the probe inside the stack to be heated.

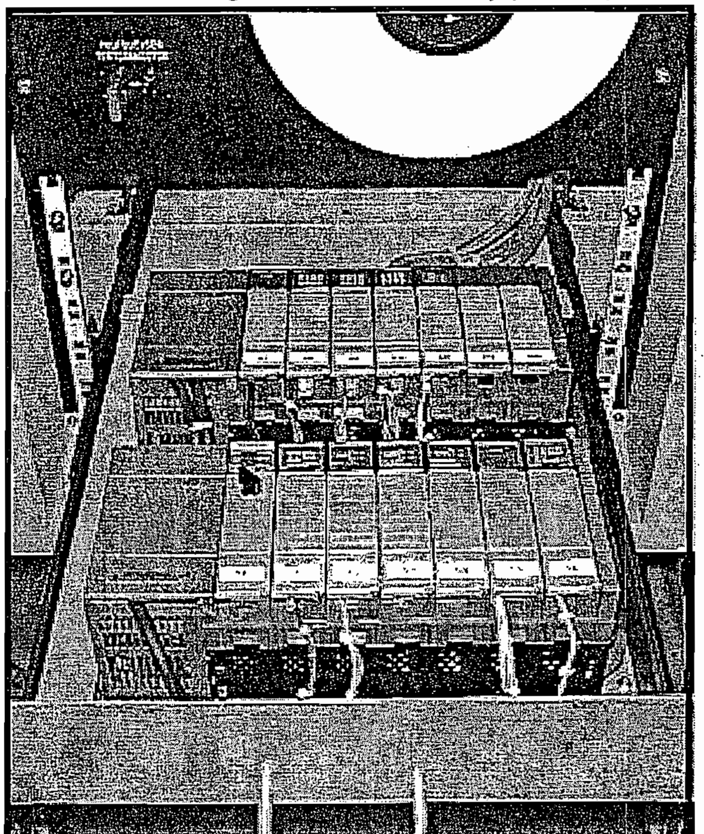


Figure 8: Allen-Bradley SLC500 PLC

The sample line is 0.50" diameter by 0.035" wall Type 316 seamless stainless steel tubing. The interior surface of the tubing is specially cleaned and polished to minimize particle entrapment. The fittings and valves in the sample line likewise are specially prepared to minimize turbulence and eddies that might allow particulate to fall out of the sample stream during transport to the filter tape.

The beta gauge is controlled by an Allen-Bradley SLC 500 programmable logic controller (Figure 8). The PLC controls the filter tape movement, pump operation, measurement cycles, and all aspects of instrument operation.

The PLC also calculates the concentration and mass emissions and outputs this information in analog (4-20 mA) or serial form (RS-232/485). Digital contact closures indicating system operations including calibrations, blowbacks, and alarms are also available. The PLC can accept digital inputs to control calibration or blowback cycles.

Other advantages of the beta gauge worth noting are:

1. The EPA calibration correlation between mass emissions and output is linear with a beta gauge. All optical instruments show decidedly non-linear operation which makes initial calibration and set up of the instruments for particulate monitoring difficult.
2. The collected samples can be protected for latter analysis by other techniques such as x-ray diffraction for heavy metals. A polyester cover foil dispenser used to protect the sample, and a dot matrix printer used to mark the filter tape with date and time and collected mass.
3. Automatic blowback of the sample lines during filter tape transport is standard to ensure the sample probe tip does not become plugged. Additional timed or manual blowbacks can also be initiated as required.
4. Quarterly audits using NIST traceable standards are possible.
5. Dual measurement heads minimize the amount of sample time lost to the batch process. Should a Geiger Mueller tube fail, the instrument automatically goes into single head sampling mode.
6. Multiple spot resampling extends the life of the filter tape. The measured amount of mass of one cycle becomes the zero of the next cycle.
7. An optional high capacity chiller is furnished for dry basis measurements. This chiller is rated at over 50 lpm and comes complete with integral temperature control and water carryover alarm.

Particulate concentration is rather unique in being one of the few Title V permit parameters that is not directly measured by utilities. It is not reasonable to assume that this situation will go on too much longer given the significant contribution utilities make to controllable particulate emissions in ambient air. The reference methods are being revised, and the performance specifications are being finalized at this time for particulate monitors. The process has been anything but easy or well controlled and is being driven by an industry, hazardous waste incinerators, that could not be more different in approach or application than the electric utility industry. Many utilities now face the installation of significant new capital equipment for controlling nitrogen oxides which will only make particulate monitoring more difficult for all instruments except beta gauges.

Beta gauge measurements can be used not only to monitor but also to control electrostatic precipitators and fabric filters. Performance of exhaust gas cleanup equipment in the future will likely be optimized based on actual emissions and not on other easier to measure, but less reliable and less accurate parameters. It is surprising this is not being done now and even more surprising that little attention is being given to this problem by the utility industry. The impact on the utility industry could be significant and deserves to be addressed in a more involved manner.

The technology is there to do the job. Beta gauges and other mass emission monitoring technologies have been in use for years. Beta gauge and scatter technologies in particular need to be applied and tested now by the utility industry to confirm applicability and long term viability. We suggest it is time for this process to begin before some unexpected event forces the issue on an unprepared industry.

4/13/03 InService

AMETEK

Thermox System Data

Customer Information

Name: Lewis & Associates
Address: P.O. Box 16518
Tampa, FL 33687

PO # 03041160
Serial #: 10206264
R #: Lewis & Associates
Order Date: 04/09/2003
Ship Date: 04/10/2003
Ship to: Lewis & Associates
Address: C/O Rayonier
Fernandina Mill
Foot of Gum Hill
Fernandina Beach, FL 32034
Attn: Mike Silva / PO #FC518092

WDG-HPIIC / CE Sensor Information

Input Voltage: 115 VAC
Enclosure: Stainless Steel Lift Off
Mounting: Wall
Calibration Accessories: None

Probe Mounting Accessories: None

2000 Controller Enclosure: NEMA4 / CE

Software Version: 3.63 / 88015QE K-Factor 1.12

Controller Accessories: Combustibles Card

Retrofit: No

General Information

Notes: None
Special Instructions: None
Drawings in Appendix G:
System Interconnect C131-002 Rev. E
Series 2000 Drawing A203-367 Rev. D
Sensor Mounting Drawing A202-489-14 Rev. C
Internal Wiring A115-546 Rev. B

Thermox® Series 2000
WDG-HPII and WDG-HPIIC

User Manual

NSAI
I.S. EN ISO 9001

PN 90270VE, Rev. L

AMETEK

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No. 30 Tian Yao Qiao Road
Shanghai, 200030
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Fax: 8621 6426 7054

3/17/03 called [illegible] to Roy Ritter - he said it takes 2 wks burn in time -

- SERVICE 2456 JOE STOWDEN.
2457 DON STEWART.

WAYNE From Tampa came in 1/13/03 to do Initial Calib.

TABLE OF CONTENTS

APPENDIX A SERIAL COMMUNICATIONS

APPENDIX B MENU OPTION CHARTS

APPENDIX C CURRENT OUTPUTS: OTHER APPLICATIONS

APPENDIX D DRAWINGS AND CUSTOM INSTRUCTIONS

Safety Notes

WARNINGS, CAUTIONS, and NOTES contained in this manual emphasize critical instructions as follows:

WARNING

An operating procedure which, if not strictly observed, may result in personal injury or environmental contamination.

CAUTION

An operating procedure which, if not strictly observed, may result in damage to the equipment.

NOTE

Important information that should not be overlooked.

Electrical Safety

Up to 5 **kV** may be present in the analyzer housings. Always shut down power source(s) before performing maintenance or troubleshooting. Only a qualified electrician should make electrical connections and ground checks.

Any use of the equipment in a manner not specified by the manufacturer may impair the safety protection originally provided by the equipment.

Grounding

Instrument grounding is mandatory. Performance specifications and safety protection are void if instrument is operated from an improperly grounded power source.

WARNING

Verify ground continuity of all equipment before applying power.

Important Notice to Users

No operator serviceable components inside any components of the WDG system. Do not remove the cover from any WDG component. Refer servicing to qualified personnel.

The following applies to the Series 2000 Control unit and the WDG-HPII series Division 2 Models:

Power, input, and output (I/O) wiring must be in accordance with Class I, Division 2 wiring methods [Article 501-4(b) of the National Electric Code, NFPA 70] and in accordance with the authority having jurisdiction.

WARNING

EXPLOSION HAZARD - SUBSTITUTION OF COMPONENTS MAY IMPAIR SUITABILITY FOR CLASS I, DIVISION 2.

WARNING

EXPLOSION HAZARD - WHEN IN HAZARDOUS LOCATIONS, TURN OFF POWER BEFORE REPLACING OR WIRING MODULES.

WARNING

EXPLOSION HAZARD - DO NOT DISCONNECT EQUIPMENT UNLESS POWER HAS BEEN SWITCHED OFF OR THE AREA IS KNOWN TO BE NONHAZARDOUS.

NOTE

THIS EQUIPMENT IS SUITABLE FOR USE IN CLASS I, DIVISION 2, GROUPS A, B, C, AND D OR NONHAZARDOUS LOCATIONS ONLY.

The maximum ambient temperature for the Series 2000 control unit is 50 °C (122 °F)

The Series 2000 Control Unit with WDG-HP sensor is a complex piece of equipment that should only be serviced by a qualified service technician with expertise in instrument technology and electrical systems. AMETEK recommends that all equipment requiring service be sent back to the factory. You should only attempt to repair or service this equipment after receiving training from an AMETEK/P&AI Division training representative. If you decide to service this equipment be aware that high voltages, high temperatures, and other potentially hazardous conditions may arise.

General Safety Summary

Review the following safety precautions to avoid injury and prevent damage to this product or any products connected to it.

Use Proper Wiring

To avoid fire hazards, use only the wiring specified in the Installation Chapter of this user's manual.

Avoid Electrical Overload

To avoid electrical shock or fire hazard, do not apply a voltage to a terminal that is outside the range specified for that terminal.

Ground the Product

Follow the grounding instructions provided in the Installation Chapter of this user's manual. Before making connections to the input or output terminals of this product, ensure that the product is properly grounded.

Do Not Operate without Covers

To avoid electric shock or fire hazard, do not operate this product with covers or panels removed.

Use Proper Fuse

To avoid fire hazard, use only the fuse type and rating specified for this product.

Do Not Operate in Explosive Atmosphere

To avoid injury or fire hazard, do not operate this product in an explosive atmosphere unless you have purchased options that are specifically designed for these environments.

Product Damage Precautions

Use Proper Power Source

Do not operate this product from a power source that applies more than the voltage specified.

Do Not Operate with Suspected Failures

If you suspect there is damage to this product, have it inspected by qualified service personnel.

Declaration of Conformity

Manufacturer's Name: AMETEK/Thermox®

Manufacturer's Address: Process & Analytical Instruments Division
150 Freeport Road
Pittsburgh, PA 15238

declares that the products:

Product Names: Thermox WDG series of Flue Gas Analyzers using Series 2000 Controller:

WDG-IV WDG-IVC WDG-IVCM
WDG-HPII WDG-HPIIC

O2 Only RCU
O2 & Comb RCU
O2, Combustibles & Methane RCU

Conform to the following standards:

EMC compliance:

EMC Directive 89/336/EEC

Immunity:

EN 50082-2:1995	Generic - Heavy Industrial Equipment
EN 50082-1:1997	Generic - Residential, Commercial, Light Industrial Equipment
EN 61326:1997	Measuring Equipment (Heavy Industrial)

Emissions:

EN 55011:1998	Class A, ISM Equipment

Safety Compliance:

UL 3101-1	UL Listed Inspection and Measuring Electrical Equipment
CAN/CSA 22.2 No. 1010.1-92	cUL Listed Inspection and Measuring Electrical Equipment

Low Voltage Directive 73/23/EEC:
EN61010-1:1993,
Amendment A2: 1995 — Electrical Equipment for Measurement, Controls, and Laboratory Use

Series 2000 Controller also has the following safety compliance:

UL 1604 — UL Listed Process Control Equipment for Use in Hazardous Location

WDG Series analyzers with the suffix Div. 2, O2 Only RCU, O2 & Comb RCU, and O2, Combustibles & Methane RCU also conform to the following safety standard:

UL 1604 — UL Listed Process Control Equipment for Use in Hazardous Locations

Manufacturer's Address in Europe:
AMETEK Precision Instruments Europe GmbH
Rudolf-Diesel-Strasse 16
D-40670 Meerbusch, Germany

Mark Coppler
Engineering Manager

July 2001

WARRANTY AND CLAIMS

We warrant that any equipment of our own manufacture or manufactured for us pursuant to our specifications which shall not be, at the time of shipment thereof by or for us, free from defects in material or workmanship under normal use and service will be repaired or replaced (at our option) by us free of charge, provided that written notice of such defect is received by us within twelve (12) months from date of shipment of portable analyzers or within eighteen (18) months from date of shipment or twelve (12) months from date of installation of permanent equipment, whichever period is shorter. All equipment requiring repair or replacement under the warranty shall be returned to us at our factory, or at such other location as we may designate, transportation prepaid. Such returned equipment shall be examined by us and if it is found to be defective as a result of defective materials or workmanship, it shall be repaired or replaced as aforesaid. Our obligation does not include the cost of furnishing any labor in connection with the installation of such repaired or replaced equipment or parts thereof, nor does it include the responsibility or cost of transportation. In addition, instead of repairing or replacing the equipment returned to us as aforesaid, we may, at our option, take back the defective equipment, and refund in full settlement the purchase price thereof paid by Buyer.

The warranty shall not apply to any equipment (or part thereof) which has been tampered with or altered after leaving our control or which has been replaced by anyone except us, or which has been subject to misuse, neglect, abuse or improper use. Misuse or abuse of the equipment, or any part thereof, shall be construed to include, but shall not be limited to, damage by negligence, accident, fire or force of the elements. Improper use or misapplications shall be construed to include improper or inadequate protection against shock, vibration, high or low temperature, overpressure, excess voltage and the like, or operating the equipment with or in a corrosive, explosive or combustible medium, unless the equipment is specifically designed for such service, or exposure to any other service or environment of greater severity than that for which the equipment was designed.

The warranty does not apply to used or secondhand equipment nor extend to anyone other than the original purchaser from us.

THIS WARRANTY IS GIVEN AND ACCEPTED IN LIEU OF ALL OTHER WARRANTIES, WHETHER EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION AND WARRANTIES OF FITNESS OR OF MERCHANTABILITY OTHER THAN AS EXPRESSLY SET FORTH HEREIN, AND OF ALL OTHER OBLIGATIONS OR LIABILITIES ON OUR PART. IN NO EVENT SHALL WE BE LIABLE UNDER THIS WARRANTY OR ANY OTHER PROVISION OF THIS AGREEMENT FOR ANY ANTICIPATED OR LOST PROFITS, INCIDENTAL DAMAGES, CONSEQUENTIAL DAMAGES, TIME CHANGES OR ANY OTHER LOSSES INCURRED BY THE ORIGINAL PURCHASER OR ANY THIRD PARTY IN CONNECTION WITH THE PURCHASE, INSTALLATION, REPAIR OR OPERATION OF EQUIPMENT, OR ANY PART THEREOF COVERED BY THIS WARRANTY OR OTHERWISE. WE MAKE NO WARRANTY, EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION ANY WARRANTIES OF FITNESS OR OF MERCHANTABILITY, AS TO ANY OTHER MANUFACTURER'S EQUIPMENT, WHETHER SOLD SEPARATELY OR IN CONJUNCTION WITH EQUIPMENT OF OUR MANUFACTURE. WE DO NOT AUTHORIZE ANY REPRESENTATIVE OR OTHER PERSON TO ASSUME FOR US ANY LIABILITY IN CONNECTION WITH EQUIPMENT, OR ANY PART THEREOF, COVERED BY THIS WARRANTY.

OVERVIEW

Designed for applications with high particulate levels in the gas stream, the sensor mounts directly on the combustion process to provide continuous measurement of oxygen (HPII), or oxygen and combustibles (HPIIC).

Since the sample inlet and return are inside the filter and at the same absolute pressure as the process, there is no flow through the filter. The sample in the filter flows through the sensor plumbing because of a convective motive force. The sample in the vertical cell housing is heated to 695°C, while the sample in the return vertical tube is at about 250°C. The temperature difference generates a density difference, which circulates the gas through the system. Process gas enters and replenishes the gas inside the filter by diffusion only. Thus the filter never blocks, making it ideal for high particulate applications.

Follow these precautions when working on the sensor:

WARNING

Remove AC power from the sensor and allow it to cool for at least one hour before performing any maintenance or troubleshooting activities.

WARNING

The outside of the sensor cover and all sensor assembly components are hot during normal operation (up to 500°F inside the furnace, 260°C inside the cover). Allow sensor components to cool for at least an hour before working inside the sensor. Use caution and wear appropriate gloves when handling components or when touching the sensor cover!

System Features

The Series 2000 Control Unit has many powerful new features. A few of the key features and benefits are listed below:

- Modular design for serviceability and future expandability.
- Four line x 20 character display, three lines of which can be used to view oxygen, cell temperature, time and date, thermocouple millivolts, cell millivolts or your own user defined text message. If you ordered the combustibles option, you can also view combustibles information. On-line help and system diagnostics messages are also available.
- Two isolated linear current outputs for oxygen. If you ordered the combustibles option, you will also have current output for combustibles. Each output can be scaled via software for a 4 to 20 mA or 0 to 20 mA current output, and can even be reversed to provide a 20 to 4 mA or 20 to 0 mA output.
- Two independent alarms, each high or low selectable. In addition, one of the oxygen alarms can be set to notify the user of the start of a calibration. Two high combustibles alarms are available if you ordered the combustibles option.
- Diagnostics capabilities, including a watchdog timer and service alarms. System tests for A/D, RAM, EEPROM, and keypad. Display line 4 is reserved for full text error and diagnostic messages. If these messages appear, they can be used to target troubleshooting efforts. In addition, an exception log is provided to help with diagnostics (see "Exception Log" in the Alarm key section for help).
- RS-485 two way communications.
- Oxygen cell lifetime extender capabilities.
- Multiple calibration options, including completely automatic, timed calibrations by using the optional remote calibration unit. This includes the ability to automatically verify that your system is within calibration without actually changing your calibration settings.

Basic Elements of the Sensor

The WDG-HPII analyzer consists of the following basic systems:

- **The Plumbing**
  All inlet and outlet tubing (cell housing), the sensing cell, the sensing cell fitting, and the combustibles flow block and detector (for combustibles).

- **The Measuring System**
  The sensing cell, combustibles detector, interconnecting wiring, and the control unit.

- **The Temperature System**
  The electrical cell heater (furnace), sensor case heaters with adjustable thermostat, the type "K" thermocouple (maintains cell operating temperature), and the sensor board containing cold junction compensation. The sensing cell operates at a constant temperature. The circuit board in the sensor terminal box switches power to the furnace from the AC mains connected to the sensor. This board also provides cold junction compensation to the thermocouple circuit.

The Oxygen Measuring Cell

The Electrochemical Cell

The working element of the gas sensor is a closed-end tube made of a ceramic oxide, Zirconium Oxide (Zirconia). When it is hot, it becomes a conductor of electricity because of the mobility of the oxygen ions in its crystal structure.

Cell Output

When the sensing cell is hot, a voltage is produced that is logarithmically proportional to the ratio of the oxygen concentration of the gas on the reference side of the cell (usually ambient air) and the oxygen concentration of the sample. The percent oxygen value will appear on the microprocessor control display. The sensing cell is a partial pressure device and responds directly to changes in sample partial pressure.

As An Oxygen Analyzer

When the two electrode coatings are in contact with gases (at the same nominal pressure) that have different levels of oxygen concentration (or different partial pressures), a voltage is produced that is dependent upon their ratio. If the oxygen in one gas is known (the reference gas is normally air - 20.9% O_2), the oxygen of the other then is indicated directly by the voltage from the cell.

For measuring oxygen in non-combustibles gases, the calibration of an analyzer is obtained from the formula:

$$E = AT \, Log \frac{20.9\% O_2}{O_2 \, Unk \, \%} \qquad AT = 48.0 \text{ at } 695^\circ C$$

where A is a constant, T is the cell temperature on an absolute (° C+273) scale and O_2 Unk % is the oxygen concentration of the gas to be analyzed.

The sensing cell does not produce a signal when air is on both sides, and the voltage increases as the oxygen concentration in the sample diminishes, relative to air.

Because of the high operating temperature of the cell, combustible gases that are present may burn. When this occurs, the cell will generate a higher than expected millivolts and cause the display to indicate less oxygen than is actually in the gas.

The Combustibles Detector

The Combustibles Detector is a dual element device; the elements differ only in that one is coated with a catalyst. The catalyst causes oxidation to occur at a lower than normal temperature. The temperature of the catalyzed element changes as the combustible mixture burns. The temperature change causes the resistance of the catalyzed element to change. The resistance change is interpreted by the microprocessor and the corresponding combustibles reading is displayed.

The Thermox catalytic combustibles detector will detect combustible gas present in a sample. The sample must, however, contain enough oxygen to fully burn the combustible present. The combustibles detector responds to all unburned combustibles gases, such as CO and H_2. We recommend using an even mixture of CO and H_2 as the combustibles component within your span gas, although you can also use all CO if needed.

Common Operator Errors

These are some common errors to avoid; if they are avoided, your analyzer will operate with a minimum of maintenance and troubleshooting.

- If your process is running and the analyzer is installed on the process, the analyzer must have power applied to it to prevent plugged plumbing and sensor component damage. The case heaters must be on if the process is running to maintain sensor plumbing above the process gas dewpoint.
- Do not use pipe dope or any other contaminant that gives off combustible vapor on any joints of the sample tubing.
- For O_2 calibration gases, do not use calibration gases if they contain a mixture of oxygen and combustibles. Note, however, that this is acceptable for combustibles span gases (used only if you purchased the combustibles option).
- Always introduce calibration gases at the recommended flow rate.
- When working on the plumbing inside the sensor cabinet, turn the power off - the oxygen cell heater has exposed windings and a short to the plumbing will blow the fuse and could damage the furnace or thermocouple.
- Do not handle the cell excessively. Do not try to clean the cell except by rinsing. If you need to handle the cell, grasp by touching the seal fitting at the top; never touch the bare part of the cell.
- Do not remove a cell or type "K" thermocouple that you may want to use again when the inside of the furnace is still hot - severe thermal shock can be destructive to either of them.
- Always replace the metal cell O-ring when replacing the oxygen cell.

Start Up Checklist

- Review the installation chapter before installing this system.
- Install the probe tubes (sample and exhaust) and filter assembly to the rear of the sensor.
- Install the sensor on the process. The ambient temperature must not exceed 70°C (160°F). If it does, the sensor board that is located in the sensor terminal box must be relocated to a junction box not more than 25 feet from the sensor, but in a location not to exceed 70°C.
    - If the sensor is on a pipe nipple, insulate the exposed portion of the pipe (insulate from the process wall to the mounting flange of the sensor).
- Install the control unit. The ambient temperature must not exceed 50°C. (120°F).
    - Do not create any additional conduit entries in the control unit enclosure.
- Interconnect the control unit and the sensor as described in the appropriate interconnecting drawing.
    - The specified cable must be used to ensure the proper operation of the system.
    - Keep the interconnecting located in the control unit as short as possible. A service loop need not be used.
    - Maintain the ordered wire pairs per the drawing.
    - Terminate the shields or drains of the cable properly.
- Connect AC power to the control unit and the sensor. Make sure that the AC voltage is within specified limits.

Technical Support

AMETEK/Thermox is committed to providing you the best technical support in the industry. If you need service or application assistance, please call AMETEK at (412) 828-9040, or your local AMETEK/Thermox representative. Before you call the factory for technical support, run test gases and record the following values (you may be asked by the factory to provide this information when receiving service):

- Cell millivolts
- Thermocouple millivolts
- Cell temperature
- Box temperature

See "Display" under the Setup key section in the Controller/User Interface chapter for help on how to get this information displayed on your Series 2000 control unit.

Return of Equipment

If you need to return equipment, you will be asked to provide the following information before obtaining a Return Material Authorization (RMA) number.

- Billing and shipping address
- Model number
- Serial number
- Purchase order number
- Telephone number

NOTE

Before returning material, you must get an RMA number from the factory.

SPECIFICATIONS

Series 2000 Control Unit

Display

4-line x 20-character vacuum fluorescent. Displays combinations of oxygen, time and date, cell temperature, user programmable text, thermocouple mV or cell mV. Password protection, programmable pressure compensation and context-sensitive help are also provided.

Recorder Output

Two isolated linear current outputs. Select O2, cell temperature, thermocouple mV or cell mV. Each output can be 4-20 mA, 0-20 mA, 20-4 mA or 20-0 mA and is fully scalable. Hold or track during calibration and select degree of damping. Maximum load 1200 ohms.

Alarms

Two independent oxygen alarms, each high or low selectable. One alarm can be assigned as oxygen, calibrate or verify. Set relays to energize or de-energize on alarm. Contact rating max 30VA, 30V max. noninductive load.

Diagnostics

Watchdog timer and service alarms. System test for A/D, RAM, EEPROM and keypad. Display line 4 reserved for full text error and diagnostic messages. Twenty entry event log.

Communications

RS-485 2-way addressable.

Environment
Ambient Temp: 14 – 122°F (-10 – 50°C)
IEC Installation (Overvoltage) Category: II
IEC Pollution Degree 2
Max. Altitude: 2000 meters
Relative Humidity: 0% to 80%, non-condensing

Hazardous Area
UL Listed for NEC Class I, Division 2 areas

Enclosure
General purpose wall mount, general purpose 19" rack mount, general purpose panel mount, weatherproof UL Type 4 (NEMA 4) (IP 56) wall/panel mount, and stainless steel weatherproof UL Type 4X (NEMA 4X) (IP 56) wall/panel mount. All are UL Listed for NEC Class I, Division 2 areas. Purged and explosion- proof versions available.

Calibration
Oxygen cell lifetime extender. Calibrate or verify calibration. Store last calibration and verification data. Selectable calibration gas run time and process recovery time. Timed automatic calibration with optional remote calibration unit.

Power Requirements
Nominal 95-230 VAC, ± 10%, 47-63 Hz. max.

Power Dissipation
75 VA max.

Sensor

Principle of Operation

Convective oxygen analyzer using a zirconium oxide electrochemical cell for oxygen measurement. Completely field serviceable. Combustibles option includes a catalytic combustibles detector.

Display Range

Oxygen: 0.1-100%
Comb: 0 - 10,000 ppm or 0 to 5%

Output Range

Oxygen: From 0-1% to 0-100%
Comb: From 0 to 2,000 ppm to 0 to 10,000 ppm or from 0 to 1% to 5%

Accuracy

Oxygen: ±0.75% of measured value or ±0.05% oxygen, whichever is greater.
Comb: ± 2% of full scale output range.

Response

Oxygen: 63% of a process step change <16 secs. with 24" probe
Comb: 63% of a process step change in < 25 secs. with 24" probe

Drift

<0.1% of cell output per month (<0.005% O_2 per month with 2% O_2 applied)

Flue Gas Temperatures/Probes

to 1300°F (704°C) with 316 SS
to 1875°F (1024°C) with RA330
to 2800°F (1537°C) with mullite

Probe Lengths

24" (standard, 316SS), 36" and 48" (0.60m, 0.91m and 1.21m)

Max. Sample Dewpoint

Oxygen only: 450°F (232°C) standard. High dewpoint sensors are available for sample dewpoints up to 700°F (371°C).
Oxygen and Comb.: 450°F (232°C)

Sample Pressure
±2 psig: no adjustments required
±2 to ±9 psig: software selectable
±10 psig and above: consult factory

Environment
Ambient Temp.:
-5°F to 160°F (-20°C to 70°C),
-5°F to 140°F (-20°C to 60°C) w/Div. 2 Option

Relative Humidity: 10% to 90%, non-condensing
Max Altitue: 2000
IEC Installation (Overvoltage) Category: II
IEC Pollution Degree 2

Enclosure
General purpose, weather resistant, stainless steel. Explosion-proof and purged versions are optional.

Power Requirements
115 VAC, ±10%, 47-63 Hz., 600 VA max.
230 VAC, ±10%, 47-63 Hz., 1850 VA max.

Power Dissipation: 1263 VA max.

Calibration Gas Requirements
Use calibration gases @ 10 psig (0.70 kg/cm^2)

O_2: 1 scfh (0.47 l/min)

O_2 /Comb: 1 to 2 scfh (0.47 to 0.94 l/min)

O_2 Span Gas: Air or from 1.0% to 100% O_2, balance N_2 (must be a factor of 10 higher than the zero gas)

O_2 Zero Gas: 2% or from 0.1% to 10% O_2, balance N_2

Comb. Span Gas: 60 to 80% (ppm ranges) or 40 to 60% (%ranges) of the selected comb. recorder output range in certified mixtures of CO + H_2, excess O_2, balanace N_2

NOTES:
1. All static performance characteristics are with operating variables constant.
2. System accuracy referenced to 0.1 to 10% calibrated range.

Remote Calibration Unit (RCU):

O2 Only RCU
O2 & Comb RCU
O2, Combustibles & Methane RCU

Enclosure
UL Type 4X (NEMA 4X) (IP56)

Environment
AmbientTemperature: -18°C to 70°C (32°F to 150°F)
Humidity: 0 to 90%, non-condensing
Max Altitude: 2000 Meters
IEC Installation (Overvoltage) Category: II
IEC Pollution Degree 2

EMC Compliance: 89/336/EEC

Safety Compliance: 73/23/EEC

INSTALLATION

> **WARNING**
>
> *The operations in this chapter should only be performed by qualified service personnel experienced with electrical safety techniques. There are no operator serviceable components inside the WDG-HPII/HPIIC system. Never service the sensor unless power has been removed and it has been allowed to cool for at least one hour. Also, always use gloves when working on the sensor.*

This chapter shows you how to install your sensor components, and includes the following sections:

- Inspect Shipping Contents
- Mechanical Installation
- Wiring
- Series 2000 Control Unit Option Card Installation

Inspect Shipping Contents

Remove any packing material from the sensor and check for damage. If any is found, notify the shipper.

Mechanical Installation

This section describes how to perform the mechanical installation portion of your system installation. This includes the following:

- Probe and Probe Filter Connection to Sensor
- Sensor Mounting
- Remote Calibration Unit Mechanical Installation (optional)

CAUTION

Observe the following guidelines when selecting an analyzer installation location:

1. Select a readily accessible position for the analyzer to allow for routine maintenance. Comfort levels for maintenance personnel should be considered in placement of the sensor and controls interface.

2. The installation location should be free from excessive vibration and the ambient temperature is required to be within the limits listed in the specifications appendix contained in this manual. If the ambient temperature is outside the specified limits or the vibration is excessive, please contact Thermox Sales or Service Department at 412.828.9040. Special options exist to address ambient temperatures outside the listed specifications and special-mounting solutions can be provided for excessive vibration installation locations.

Probe and Probe Filter Connection to Sensor

The sample probe must be attached to the back of the sensor before mounting the sensor to the process.

CAUTION

Do not use pipe dope or any other contaminant on any joints of the sample tubing that give off combustible vapor. Teflon tape is permissible if the joint temperature will not exceed 200° C.

To connect the inlet probe, exhaust tube, and probe filter to the sensor, do the following - see Figure 3-1 for help:

1. Remove all protective plastic caps and plugs from the probe filter and inlet probe.

2. Thread the 1/4" pipe inlet probe into the manifold block on the rear of the sensor. If a calibration tube is included in the manifold block, be sure not to bend or damage this tube as you insert the probe. The connection should be tight enough to prevent loosening by vibration, but does not need to be leak-tight. Coating the threads with a Neolube graphite coating or a similar non-silicone graphite material will also help prevent galling.

3. Thread the 3/4" pipe exhaust tube into the manifold block (it will be inserted over the inlet probe). Insert the exhaust tube into the manifold block with the insulated sleeve facing towards the sensor, and not facing towards the process. This insulating sleeve will help prevent the process gas from cooling below its dew point as it approaches the sensor.

4 Screw the filter assembly onto the end of the exhaust tube.

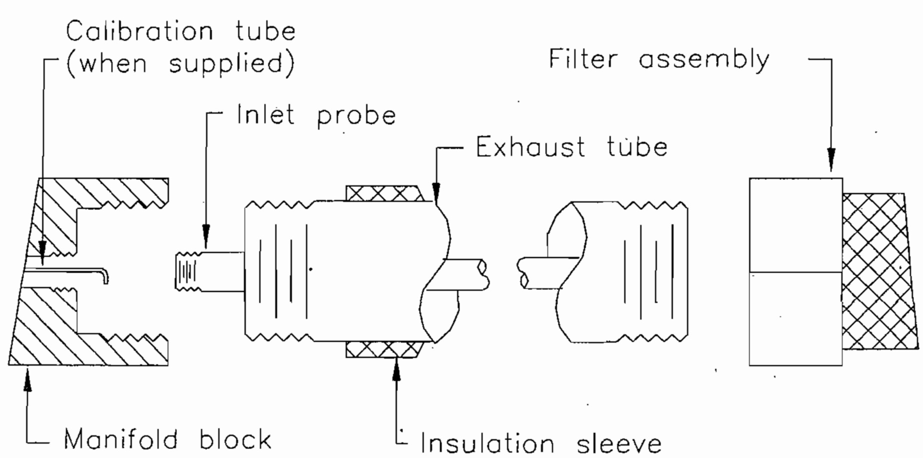

Figure 3-1.
Probe/Probe filter installation.

Mounting the Sensor

NOTE

You must attach the probe, exhaust tube, and probe filter assembly to the sensor before mounting the sensor to the process.

The ambient temperature range for the sensor is -20 to 70° C. Be sure to allow 10" above the sensor so you can remove the cover if you have a lift-off lid enclosure. Lift-off sensor mounting dimensions are provided in Figure 3-2. Hinged sensor mounting dimensions, including the Z-purge option, are provided in Figure 3-3.

The three methods of mounting the WDG-HPII to the process are as follows:

1. Directly weld the Thermox supplied mounting plate to the process. In this case, the pipe nipple attached to the mounting plate is inserted directly into the process. This is the preferred method of installation.
2. Weld the Thermox-supplied mounting plate with attached pipe nipple to a pipe nipple that you provide.
3. Mount the sensor using a flange that you provide. For this type of mounting, you don't need the Thermox supplied mounting plate.

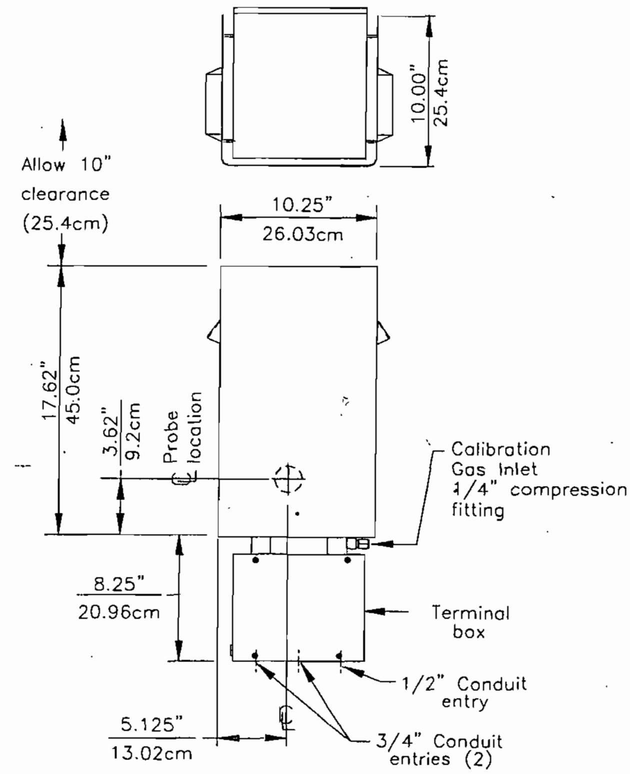

Figure 3-2.
Lift-off lid sensor dimensions.

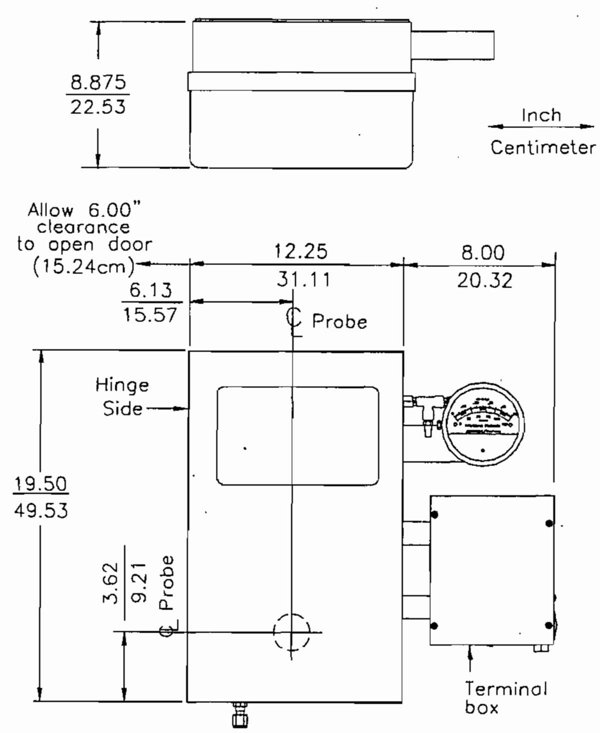

Figure 3-3.
Hinged enclosure dimensions.

Flush with process mounting method (Preferred)

This section describes how to directly weld the Thermox supplied mounting plate to your process so the attached pipe nipple extends completely through the refractory. If you are unable to mount the sensor in this fashion, refer to the other mounting methods described below.

To mount the sensor flush with the process, do the following (see Figure 3-4):

1. Create a 3 3/4" diameter hole in your process.

2. Insert the Thermox supplied pipe nipple, which is attached to the mounting plate, directly through the refractory. If the pipe nipple provided by Thermox extends past the inside of the refractory wall on a process which has a gas temperature over 650° C, the nipple should be cut down before installation so it is flush with the inside wall. Weld the Thermox supplied mounting plate to the process wall.

3 Weld the Thermox supplied mounting plate to the process wall.

4 Mount the sensor to the process as described in the "Mounting the Sensor to the Process" section later in this chapter.

NOTE

This method positions the sensor flush with the process and helps to ensure that the sample gas does not cool below its dewpoint. If the sample cools below its dewpoint, water and other liquids can form that could plug the exhaust line of the sensor.

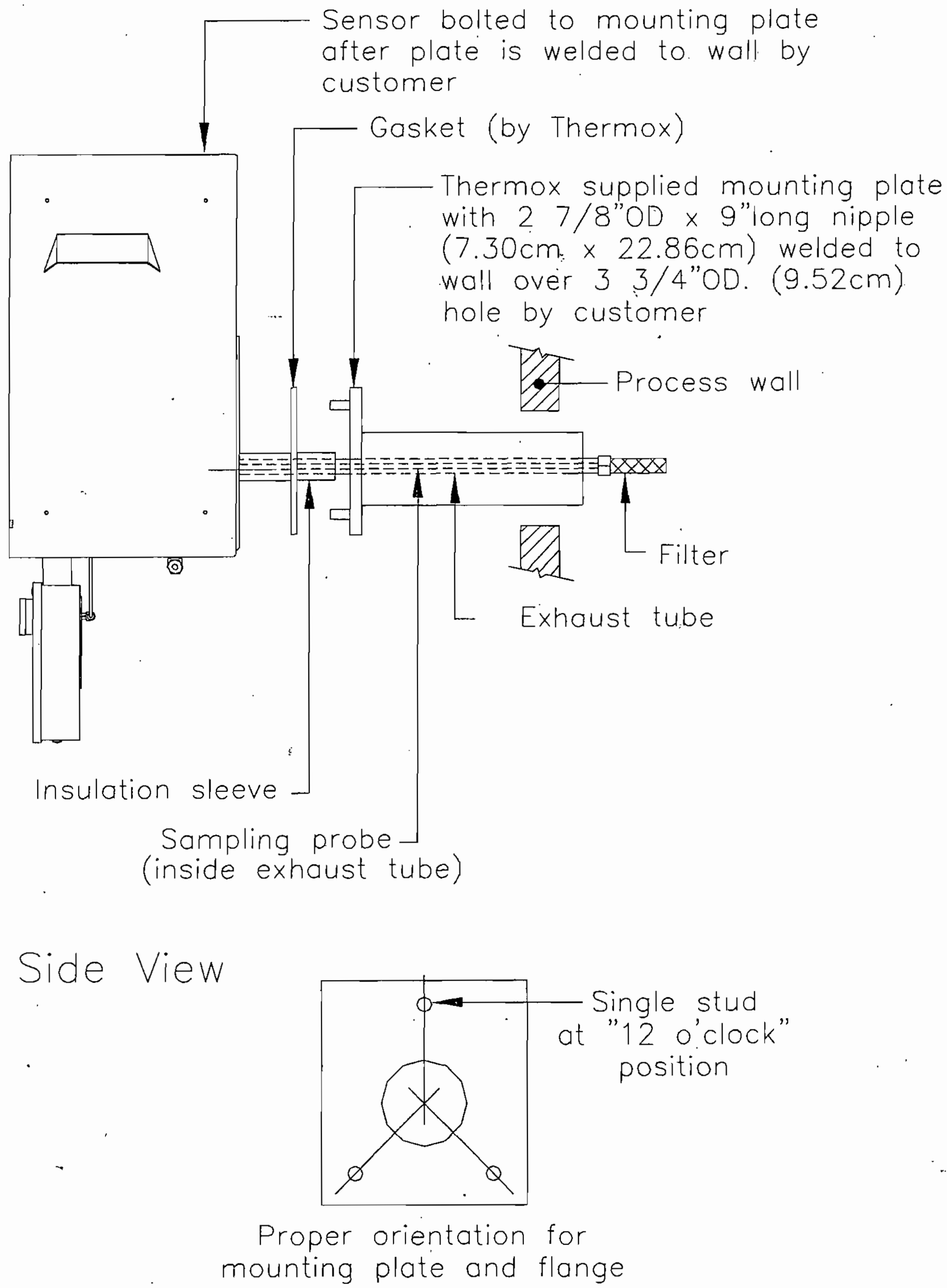

Figure 3-4.
Flush with process sensor mounting.

Customer-supplied pipe nipple mounting method

If you can't mount the sensor to the process directly because the wall is curved sharply, covered with insulation, or obstructed with reinforcing members, you can instead weld the Thermox supplied mounting plate with attached pipe nipple to a pipe nipple that you supply. To do this, follow these steps - see Figure 3-5 for help:

1. Weld a short 3 and 1/2" diameter pipe nipple to the duct and extend through the wall. The shorter you can make the pipe nipple, the better.
2. Insert the Thermox supplied pipe nipple (on the end of the Thermox supplied mounting plate) into your pipe nipple. If the Thermox supplied pipe nipple extends past the inside of the refractory wall on a process which has a gas temperature over 650° C, the nipple should be cut down before installation so it is flush with the inside wall.
3. Weld the Thermox mounting plate to your pipe nipple.
4. Wrap the exposed portion of your pipe nipple with a minimum of 1" thick weatherproof insulation and heat trace it. This will keep the sample gas above its dewpoint to prevent sample condensation that can plug sensor plumbing.
5. Mount the sensor to the process as described in the "Mounting the Sensor to the Process" section.

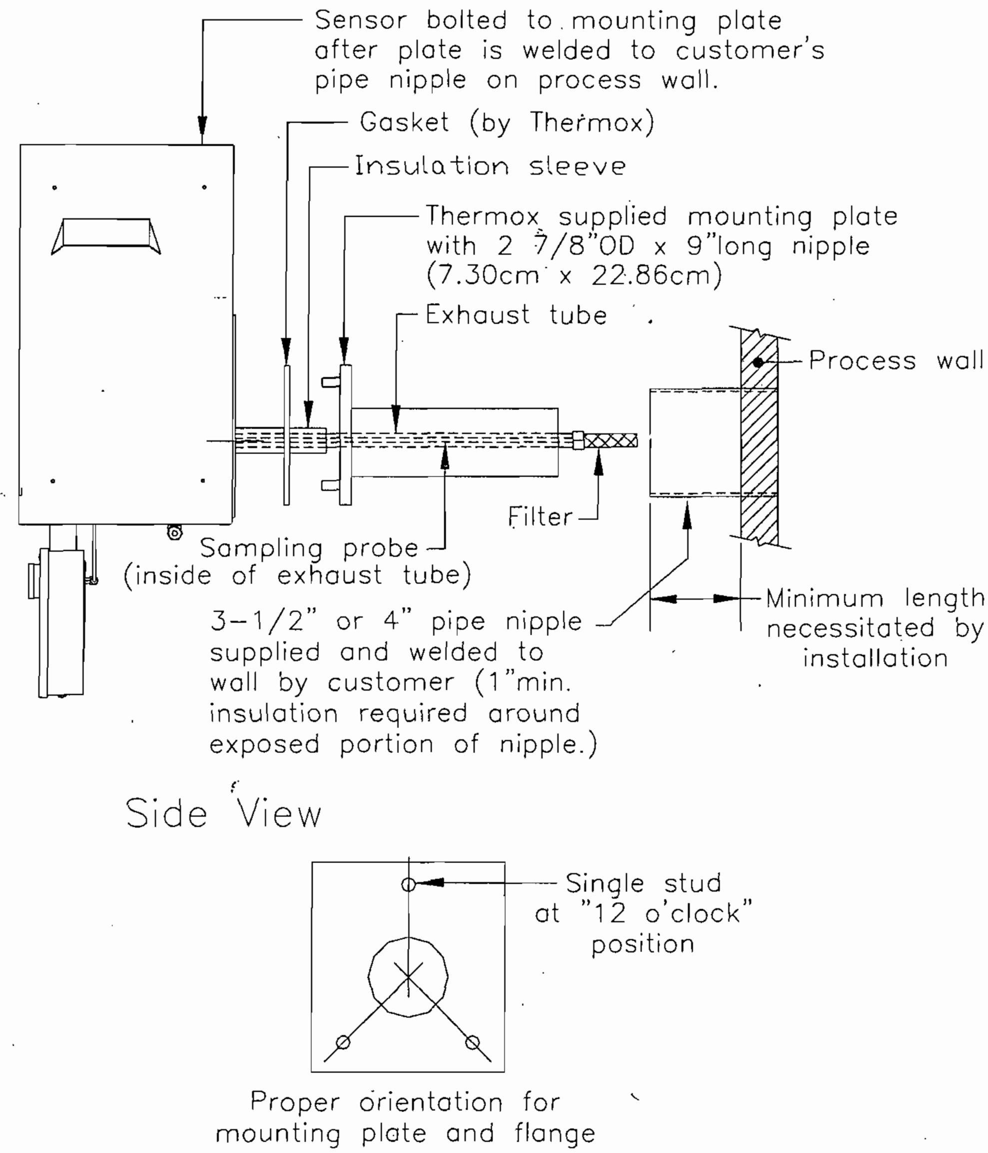

Figure 3-5.
Customer-supplied pipe nipple sensor mounting.

Customer flange mounting

The sensor may also be mounted to a 3" 300# customer-supplied flange as shown in Figure 3-6. In this case, you won't need to use the Thermox mounting plate with the attached pipe nipple. Then mount the sensor to the process as described in the "Mounting the Sensor to Process" section below.

CAUTION

Avoid overtightening mounting bolts if using a raised face flange. This will prevent damaging the backplate of the sensor.

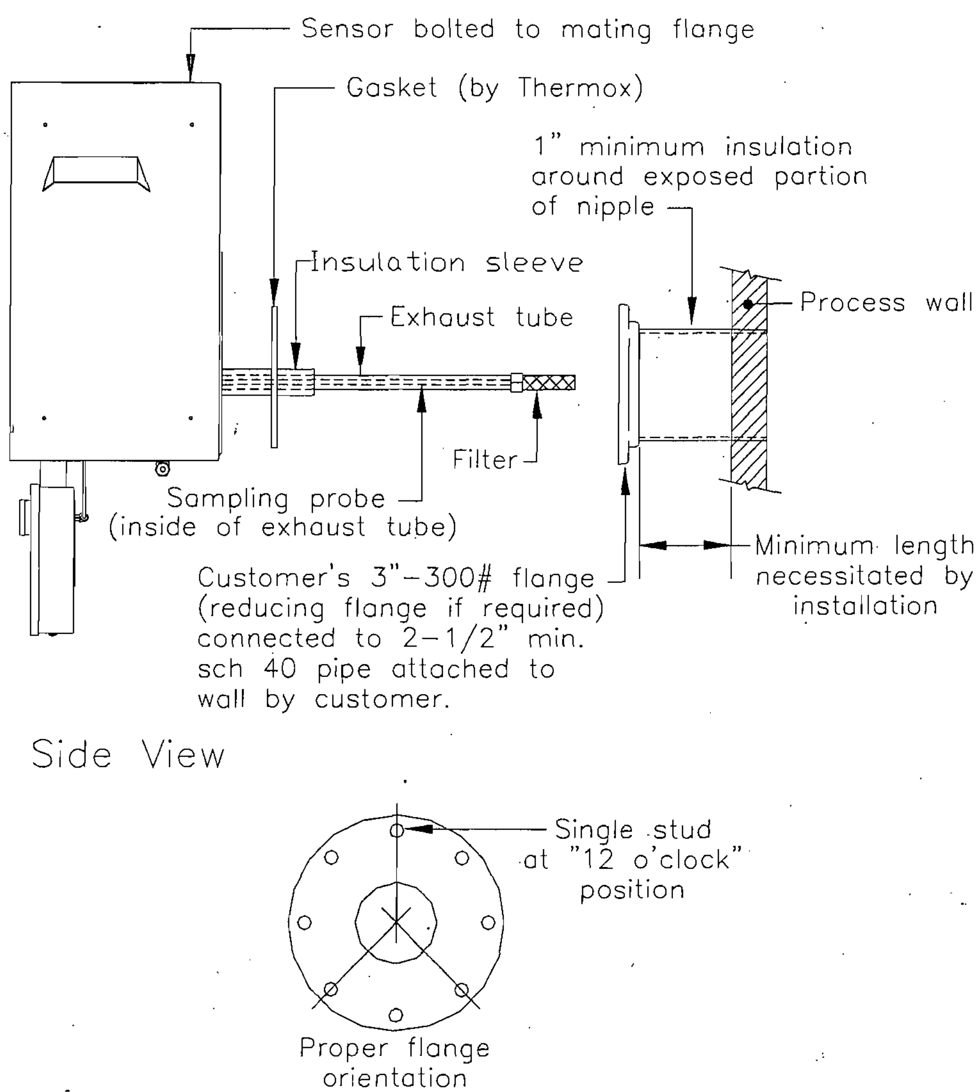

Figure 3-6. Customer flange mounting.

Mounting the Sensor to the Process

Do the following to mount the sensor to the process:

1. Make sure the gasket provided is on the mounting plate or customer-supplied flange. This gasket keeps the system sealed and leak tight.

2. Make sure that the probe, exhaust tube, insulation sleeve, and probe filter assembly are attached to the sensor - see the "Probe and Probe Filter Connection to Sensor" section earlier in this chapter for help.

3. Carefully slide the probe through the hole in the mounting plate as you hold the sensor. Be careful not to knock the filter against the pipe nipple as you insert the probe into the process.

4. Line up the three studs on the mounting plate with the three holes in the back of the sensor, then mount the sensor to the mounting plate studs.

5. Once the studs are through the backplate, install the mounting hardware, consisting of the washers, locks, and nuts on the studs. You may need to loosen the four nuts on the manifold block plate to gain access to the top mounting plate stud. These nuts should only be loosened, not removed. The sensor manifold block must be held level and still to keep the probe from banging into the pipe nipple.

6. Once the sensor is bolted to the mounting plate, tighten the four nuts on the manifold block plate.

Calibration/Z-Purge Connections

Required calibration gases and tubing

NOTE

See "Specifications" for required pressure/flow of calibration gases.

- **The span gas is the high gas.**
- **The zero gas is the low gas.**

The span gas must be 10 times greater than the zero gas. For example, if the zero gas is 1% O_2, the span gas must be 10% O_2 or higher. Use dry calibration gases that are free of oil and dirt. Stainless steel tubing is recommended.

O_2 span gas- air or from 1.0% to 100% O_2

O_2 zero gas - from .1 to 10% O_2, balance N_2

Combustibles span gas - 60 to 80% (ppm range) or 40 to 60% (percent range) of the full combustibles operating range in certified mixtures of equal parts CO + H_2, with an equal amount of O_2 or more, balance N_2.

For example, if using an operating range of 0 to 2000 ppm combustibles, use 800 ppm CO, 800 ppm H_2, 1 to 2% O_2, balance N_2. If using a 0 to 1% combustibles range, use 0.3% CO, 0.3% H_2, 1 to 2% O_2, balance N_2.

Z-Purge Option

NOTE

Z-Purge Shutdown Procedure: Hot internal parts are above the ignition temperature of combustible gases. Power must be removed from the sensor for 90 minutes while maintaining purge air flow before door is opened, unless the area is demonstrated to be nonhazardous.

Z-Purge Start-up Procedure: The purge flow to maintain 0.25" pressure inside the enclosure is 25 SCFH. This pressure must be maintained for at least 65 minutes before applying power to the sensor.

If you ordered the Z-purge option, you will also need to connect instrument air to the Z-purge inlet on the sensor. Maintain the pressure and flow as indicated on the Z-purge warning label.

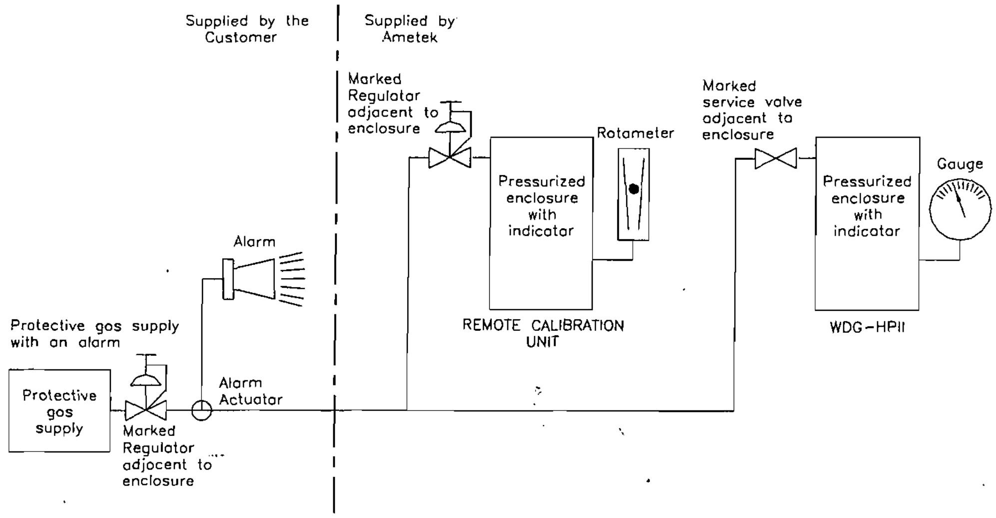

Figure 3-7. Z-Purge setup.

NOTE

The Z-purge apparatus provided by Thermox meets NFPA 496 under certain conditions (see Figure 3-7).

- You must provide a protective gas supply with an alarm for a loss of pressure indication in order to meet NFPA 496 requirements.
- Do not exceed the maximum temperature rating listed in the "Specifications" chapter.
- Process pressure is assumed to always be subatmospheric (vacuum)
- Your sample gas stream must contain no more than 25% of the LEL (lower explosive limit) for all combustible gases in your sample at any time. Otherwise, there is a possibility for the analyzer to be an ignition source for the process. See Figure 3-8 below for a list of combustibles gases, and their allowable limits, which is 25% of the LEL for each gas.

Figure 3-8. Combustibles gas allowable limits.

COMBUSTIBLE GAS	GAS ALLOWABLE LIMIT
Hydrogen	1%
Carbon Monoxide	3%
Methane	1.25%

Manual Calibration Connections

NOTE

If you have a Remote Calibration Unit (RCU), skip the remainder of this section and proceed to the "RCU Mechanical Installation" section that follows.

If you don't have an RCU, simply connect calibration gases to the calibration gas inlet port on the sensor (see Figure 3-9). For this manual calibration setup, you need to plug the calibration inlet port when not being used for calibrations.

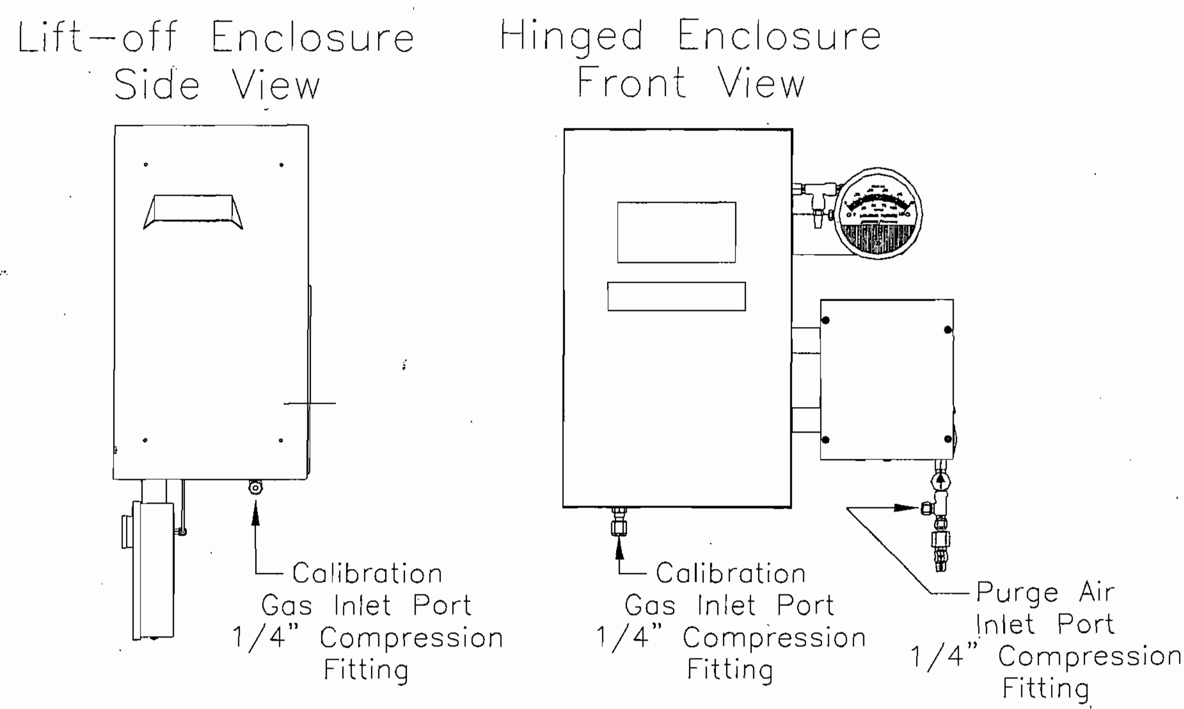

Figure 3-9.
Sensor inlet ports.

Remote Calibration Unit Mechanical Installation

Remote Calibration Unit (RCU) mechanical installation includes the following:

- Mount the RCU.
- Plumb calibration gases to the RCU.
- Connect tubing between the RCU and the sensor.

NOTE

For all RCU connections, use 1/4" O.D. tubing. Be sure to use tubing that is free of oil and direct; we recommend stainless steel tubing.

This section is divided into instructions for standard RCU (O_2 only) and combustibles RCU (O_2 and combustibles) mechanical installation. Use the instructions that apply to the type of RCU you purchased.

Standard RCU mechanical installation

The ambient temperature range for the RCU is -20 to 70° C. Mount the RCU as close to the sensor as possible. Shorter calibration plumbing improves response times, reduces calibration gas expense, and reduces the chance of contaminants in the calibration gas plumbing.

Figure 3-10 shows mounting dimensions for a standard RCU. Mount the RCU to a wall using two #10 screws. Remove the RCU lid to expose the mounting holes. Only the upper left and lower right holes are used; the other holes hold the RCU to its mounting plate.

Make the following calibration gas connections to the RCU - Figure 3-11 shows RCU calibration gas connections:

WARNING

Don't open a Z-purge RCU enclosure until you verify that the area has been classified as nonhazardous.

1. Connect the span calibration gas to the span gas inlet on the RCU.

   Also, if you ordered the Z-purge option, you will need to connect instrument air to the Z-purge inlet on the RCU. Maintain the pressure and flow as indicated on the Z-purge warning label.

2. Connect the zero calibration gas to the zero gas inlet on the RCU.

3. Connect the calibration gas outlet on the RCU to the calibration gas inlet on the sensor - see Figure 3-9 for the location of the sensor calibration gas inlet for the various types of sensor configurations. Install the supplied check valve in this line as close to the sensor as possible.

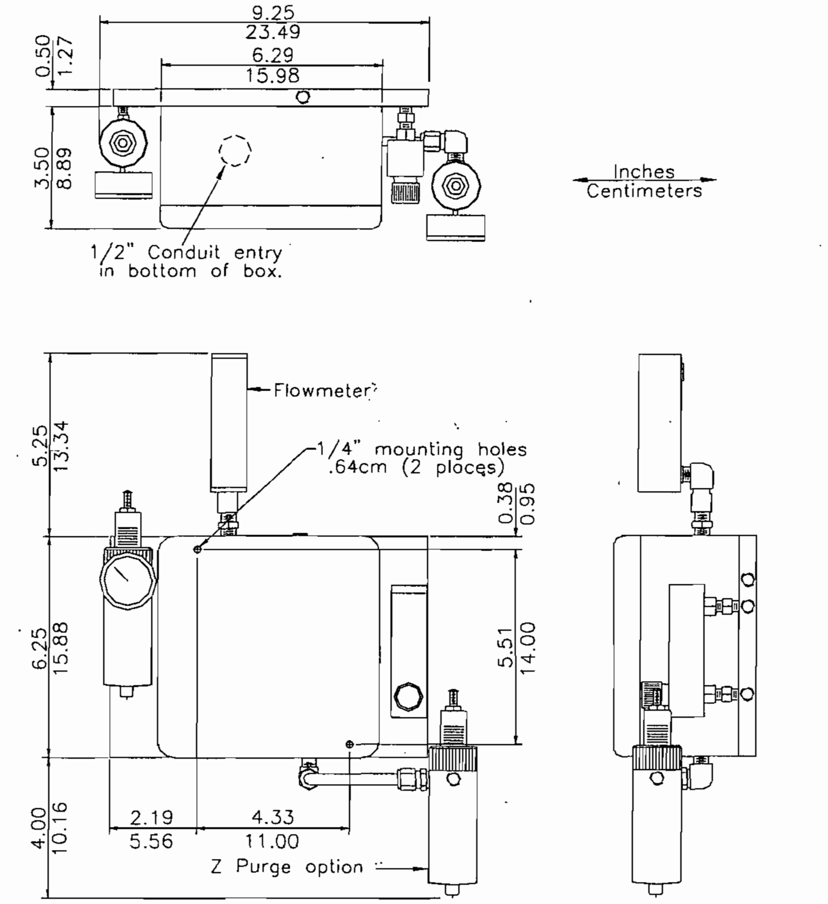

Figure 3-10.
Standard RCU mounting with Z-Purge.

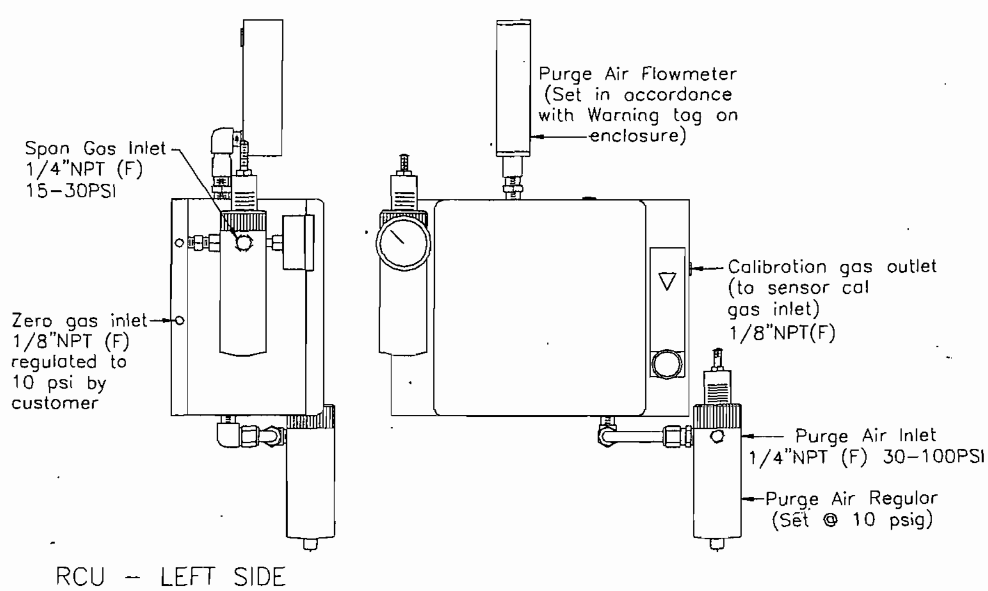

Figure 3-11.
Standard RCU plumbing with Z-Purge.

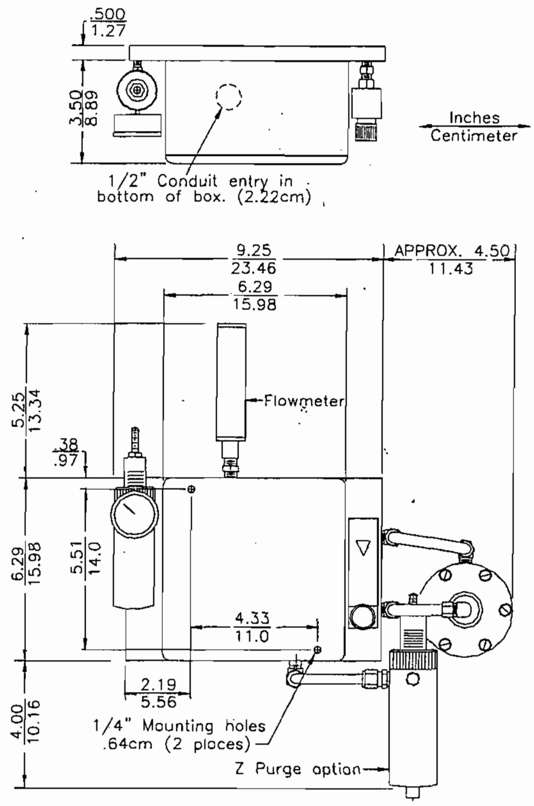

Figure 3-12. Combustibles RCU plumbing with Z-Purge.

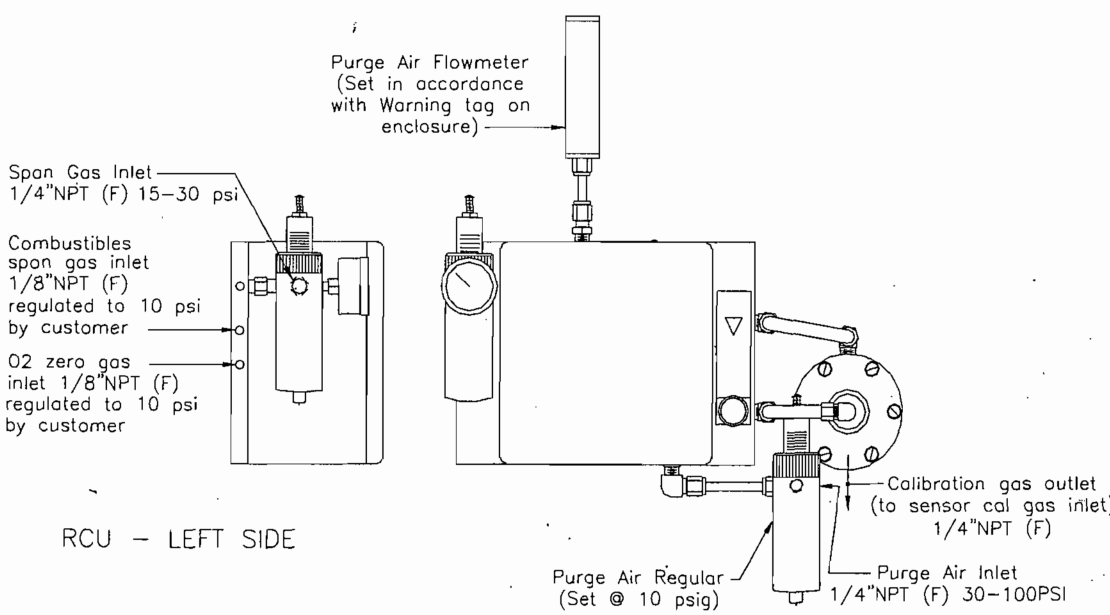

Figure 3-13. Combustibles RCU mounting with Z-Purge.

Combustibles RCU mechanical installation

The ambient temperature range for the RCU is -20 to 70° C. Mount the RCU as close to the sensor as possible. Shorter calibration plumbing improves response times, reduces calibration gas expense, and reduces the chance of contaminants in the calibration gas plumbing.

Figure 3-12 shows mounting dimensions for a Combustibles RCU. Mount the RCU to a wall using two #10 screws. Remove the RCU lid to expose the mounting holes. Only the upper left and lower right holes are used; the other holes hold the RCU to its mounting plate.

Make the following calibration gas connections to the RCU - Figure 3-13 shows combustibles RCU plumbing connections:

WARNING

Don't open a Z-purge RCU enclosure until you verify that the area has been classified as nonhazardous.

1. Connect the span calibration gas to the span gas inlet on the RCU.
2. Connect the zero calibration gas to the zero gas inlet on the RCU.
3. Connect the combustibles span gas to the RCU combustibles span gas inlet.
3. Connect tubing between the calibration gas outlet on the right side of the RCU to the calibration gas inlet on the sensor (see Figure 3-9 for sensor calibration as inlet connection). Install the supplied check valve in this line as close to the sensor as possible.

Figure 3-14 and Figure 3-15 provide flow diagrams for the different versions of RCUs.

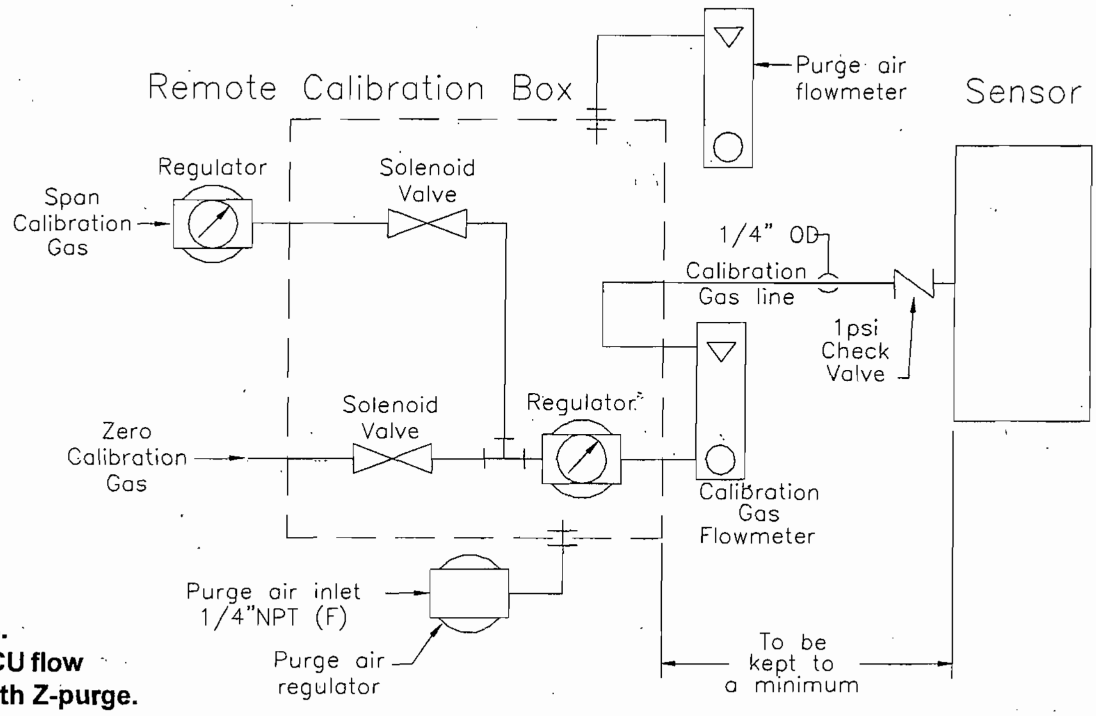

Figure 3-14.
O2-Only RCU flow diagram with Z-purge.

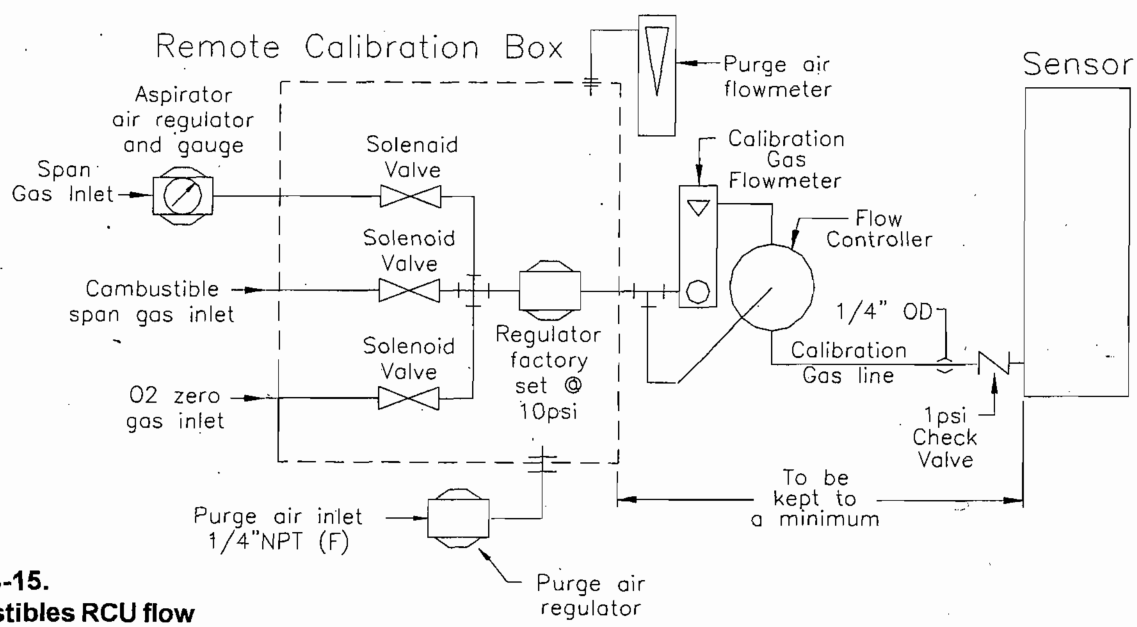

Figure 3-15.
Combustibles RCU flow diagram with Z-purge.

Z-Purge connection

If you ordered the Z-purge option, connect instrument air to the Z-purge inlet on the RCU. Maintain the pressure and flow as indicated on the Z-purge warning label.

The Z-purge apparatus provided by Thermox meets NFPA 496 under certain conditions (see Figure 3-7 for an illustration):

- You must provide a protective gas supply with an alarm for a loss of pressure indication in order to meet NFPA 496 requirements.
- Do not exceed the maximum temperature rating listed on the warning label on the Z-purge enclosure.

Control Unit Mounting

The Series 2000 Control Unit comes with different packaging options:

- Weatherproof Mounting Options
  - Panel
  - Wall/Pole
  - Wall/Z-Purge
- General Purpose Mounting Options
  - Panel
  - Rack
  - Wall

Find the section that corresponds to the type of control unit mounting configuration you ordered, then mount as shown in that section.

Weatherproof - Panel

Figure 3-16 shows the panel mounting dimensions for the Series 2000 weatherproof enclosure. Use 1/4" diameter fasteners to mount the control unit to the panel.

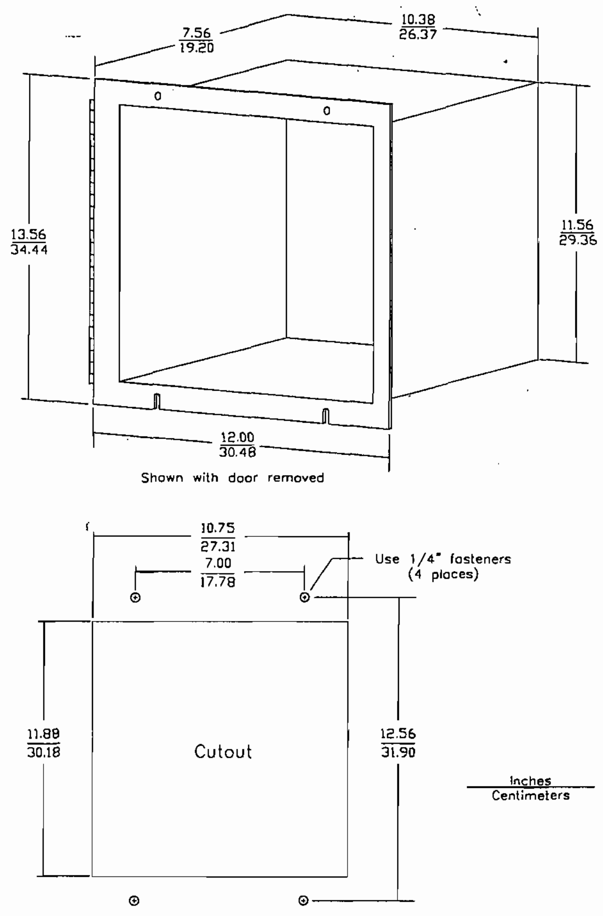

Figure 3-16.
Series 2000, weatherproof panel mount.

Weatherproof - Wall/Pole

Figure 3-17 shows the wall and pole mounting dimensions for the Series 2000 weatherproof enclosure. For wall mount installations, use 1/4" diameter fasteners to mount the control unit to a wall. For pole mount installations, the two slots on the backplate of the enclosure can be used to accommodate a customer supplied U-bolt of 3/8" or 1/2" diameter for a 2 1/2" to 4 1/2" pole diameter.

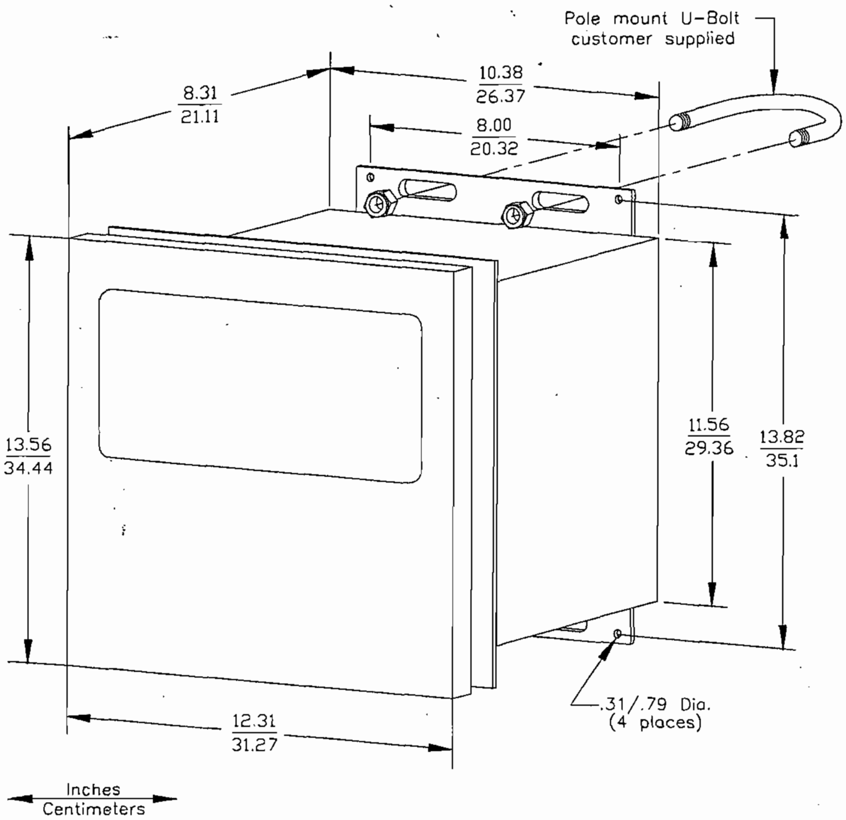

Figure 3-17.
Series 2000, weatherproof wall/pole mount.

Weatherproof Wall/Z-Purge Option

Figure 3-18 shows the wall and pole mounting dimensions for the Series 2000 weatherproof Z-purge enclosure. To mount this control unit version, you must also connect instrument air to the Purge Inlet and set the pressure and flow as indicated on the warning tag on the control unit.

NOTE

Z-Purge Shutdown Procedure: Hot internal parts are above the ignition temperature of combustible gases. Remove power from both the sensor and control unit for 1 hour while maintaining purge air flow before door is opened, unless the area is demonstrated to be nonhazardous.

Z-Purge Start-up Procedure: Power shall not be restored after the enclosure has been opened until the enclosure has been purged for 1 hour at a pressure of 0.4" of water.

WARNING

Don't open the Z-purge enclosure until you verify that the area has been classified as nonhazardous.

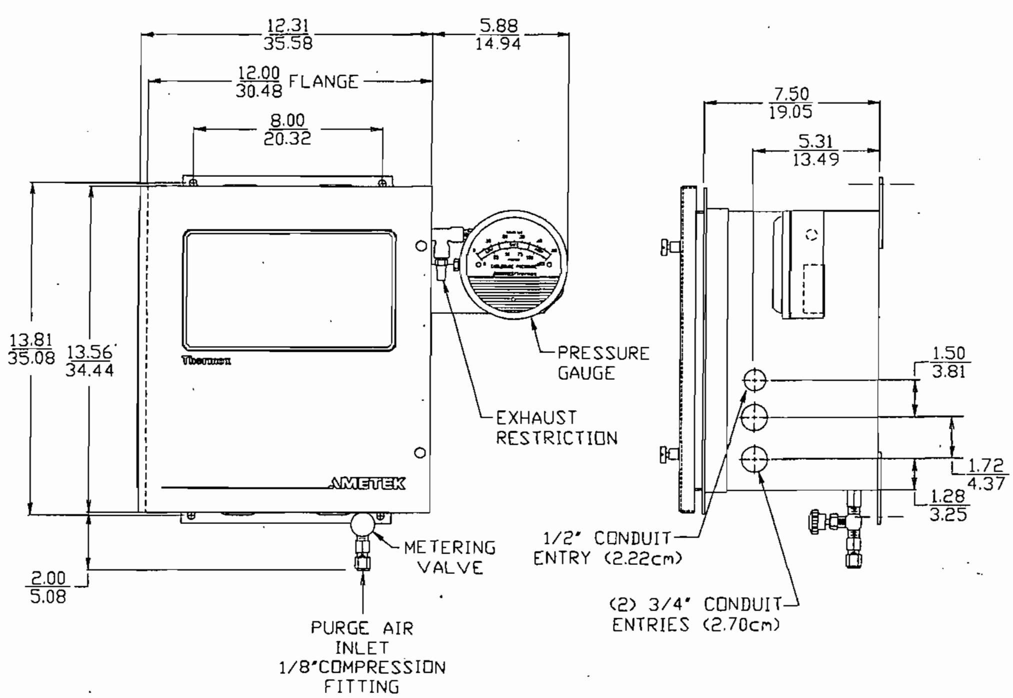

Figure 3-18.
Series 2000, weatherproof wall/Z-purge.

General Purpose - Panel

Figure 3-19 shows the panel mounting dimensions for the Series 2000 general purpose enclosure. This version can be mounted in panels up to 1" thick.

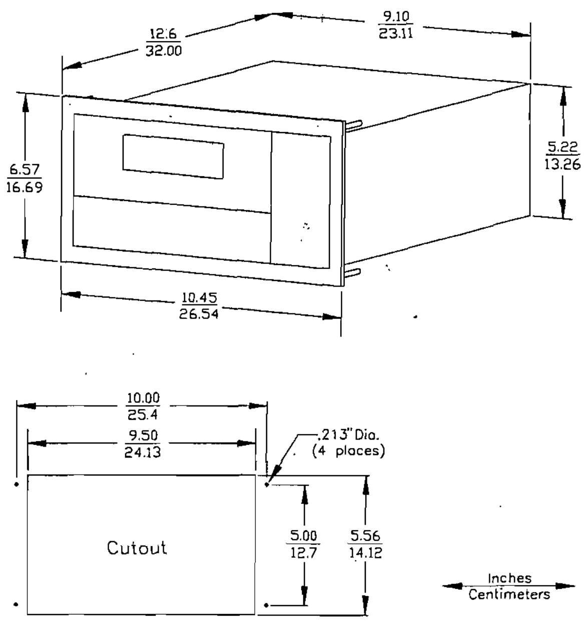

Figure 3-19.
Series 2000, general purpose panel mount.

General Purpose - 19" Rack

Figure 3-20 shows the mounting dimensions for the Series 2000 general purpose 19" rack mount enclosure. Use #10 screws to mount the control unit to a rack whose holes are spaced per E.I.A. standard RS-310-C (universal spacing).

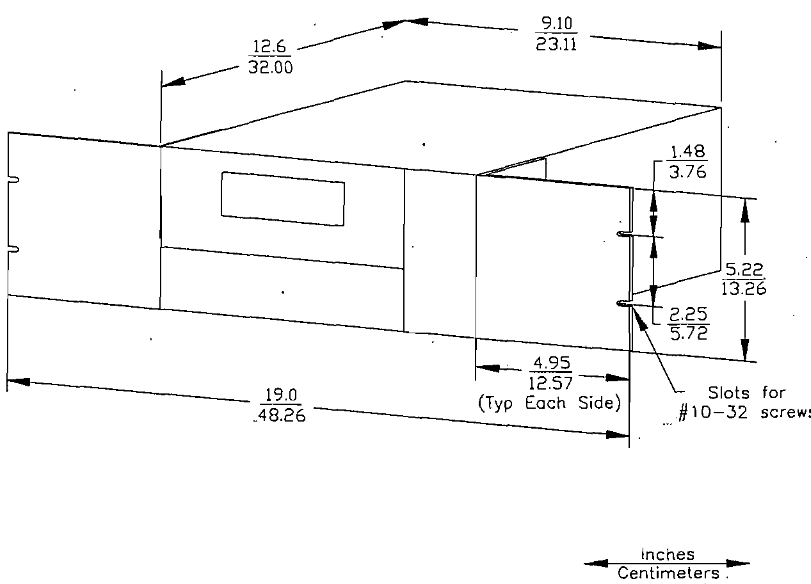

Figure 3-20
Series 2000, general purpose rack mount.

General Purpose - Wall

Figure 3-21 shows the mounting dimensions for the Series 2000 general purpose wall enclosure. Use 1/4" diameter fasteners to mount the control unit to the wall.

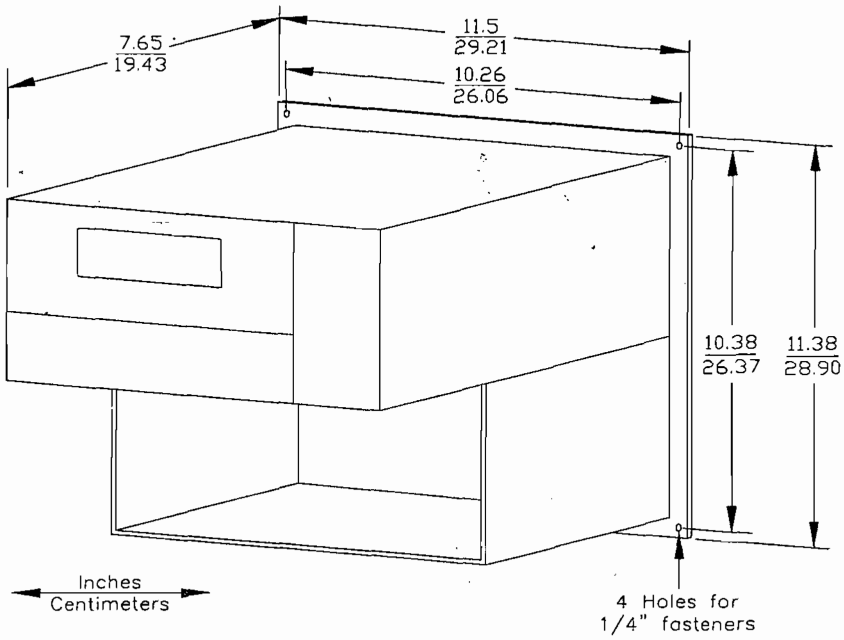

Figure 3-21.
Series 2000, general purpose wall mount.

Wiring

WARNING

Remove AC mains power from the controller and sensor before performing wiring.

Connections to the control unit are made through the wiring card (see Figure 3-22). The wiring card is located on the front, bottom of the control unit for all weatherproof versions and for the general purpose wall mount version (see the "Control Unit Mounting" Section earlier in this chapter for help). For the general purpose rack and panel mount versions, the wiring card is located on the rear of the control unit (Figure 3-14 shows the orientation of the wiring card for general purpose rack and panel mount versions - for all other versions, the wiring card is 180 degrees from this view).

To access the wiring card for all general purpose versions of the control unit, unscrew the four screws on the wiring card chassis cover plate. For the weatherproof versions of the control unit, first open the front door of the weatherproof enclosure to gain access to the wiring card shield. Remove the three screws on this shield to gain access to the wiring card.

NOTE

Any screw terminals on the wiring card not described in this section are reserved for future use.

This wiring section shows you how to make the following connections:

- AC mains supply wiring to control unit
- AC mains supply wiring to sensor
- Control unit to sensor
- Control unit to remote calibration unit
- Control unit to alarm devices
- Control unit to current output devices
- Control unit to host computer (RS-485 communications)

In addition, this wiring section provides mandatory EMC grounding, shielding, and noise protection requirements.

NOTE

If you are considering adding option cards at a later time, such as a combustibles card, you may wish to connect the required inter-connect wiring when you first install your analyzer, especially if running the wires over long distances through conduit.

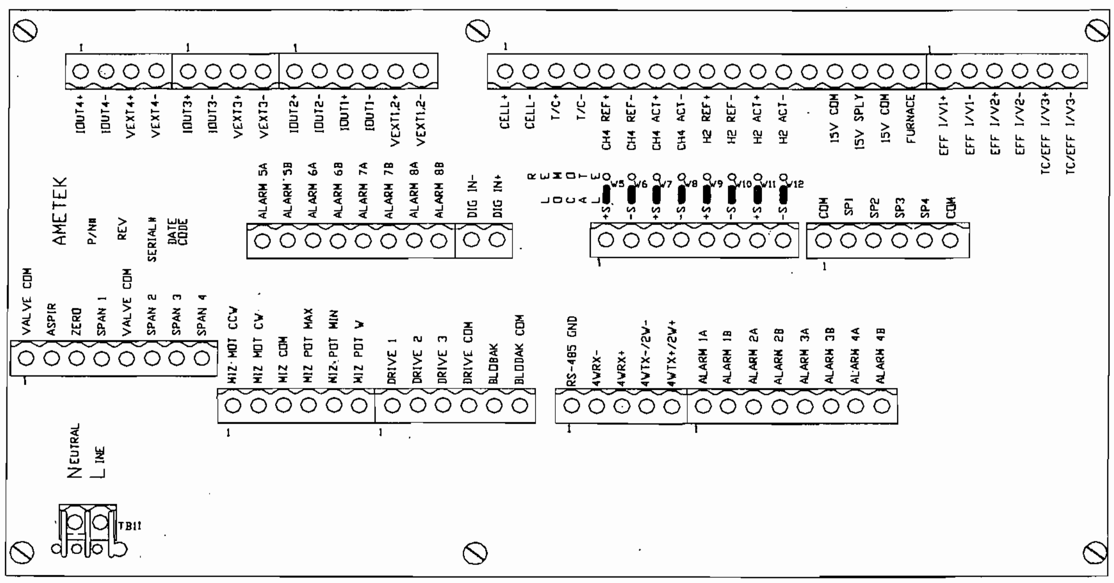

Figure 3-22.
Wiring card (rack/panel mount orientation).

General Wiring and Conduit Requirements

This section describes general wiring and conduit requirements:

- Sensor wiring conductors must be rated at a minimum of 80°C. All other wiring conductor ratings should be for the minimum temperature required for the equipment being connected to the analyzer, but not less than 60°C.
- Use only the applicable NEMA approved conduit fittings or cable fittings to maintain the NEMA rating for the Series 2000 controller or sensor enclosure. If not using a conduit entry, leave the factory NEMA-approved plugs intact. Never leave any holes unplugged.
- Follow all applicable electrical codes for your location.
- Follow proper grounding, shielding and noise protection practices as described in this section.
- Use twisted-pair cable with an overall braided shield, or twisted-pair cable in rigid metal conduit for all sensor and signal wiring.
- For AC mains supply wiring, use between 12 and 14 American Wire Gauge (AWG) or equivalent metric between 3.3 mm^2 and 2.1 mm^2. For all signal wiring, use 18 to 22 AWG (0.82 mm^2 to 0.33 mm^2). Figure 3-xx shows the required sensor cable types for various WDG-style sensors.
- Use the conduit entry point closest to the connections you are making. Do not add any additional conduit entry holes!
- You may use 1" conduit with a 3/4" adapter at the entry to the Series 2000 controller for signal and sensor wiring.

WDG SENSOR TYPE	NUMBER OF TWISTED PAIRS NEEDED	GAUGE OF WIRE
WDG HPII (O2 only)	4	22 AWG (to 250 ft.) 18 AWG (250 to 1000 ft.)
WDG HPIIC (combustibles)	6 (to 40 feet) 8 (to 1000 feet – must use remote sense)	18 AWG

Figure 3-23.
Required sensor cable wiring (minimum acceptable grades).

Control Unit Mains Supply Connections

CAUTION

Do not run control unit AC mains supply wiring in the same conduit with other AC line power wires. By keeping this wiring separated, you prevent transient signals from reaching the control unit.

The Series 2000 control unit can operate using between 85 to 250 volts AC, 47 to 63 Hertz. There is no power switch or circuit breaker on the control unit. We suggest you protect it by installing it on a circuit protected line, maximum 15 amperes, with a switch or circuit breaker in close proximity to the control unit and within easy reach of an operator. Mark the switch or circuit breaker as the control unit disconnecting device.

NOTE

AC (L) and (N) markings are provided by the terminal block for connection of AC power.

These markings are for reference purposes only such as for use on system wiring diagrams etc. The system/product has or needs no specific LINE or NEUTRAL connection for any function, safety or otherwise. The (N) terminal is not internally grounded, nor needs to be. The system will operate normally regardless of what AC input terminal (L or N) that AC Line or Neutral is connected to, or, if there is a Neutral used at all (i.e. 208 VAC US power connection).

Mains supply connections to the control unit are as follows:

Line - Line connection

Neutral - Neutral connection (USA)

Chassis Stud - Equipment ground (protective conductor)

Use the 1/2" conduit entry hole in the control unit for AC mains supply wiring. Use the chassis stud next to the 1/2" conduit entry hole for equipment ground (protective conductor).

EMC grounding, shielding, and noise protection

You must use twisted-pair cable in rigid metal conduit or use twisted pair cable with an overall braided shield. All cable shields or conduits connecting to the control unit must be chassis grounded.

CAUTION

Under no circumstances should you leave cable shields disconnected at one end or both ends of the cable (sensor or control unit or other device).

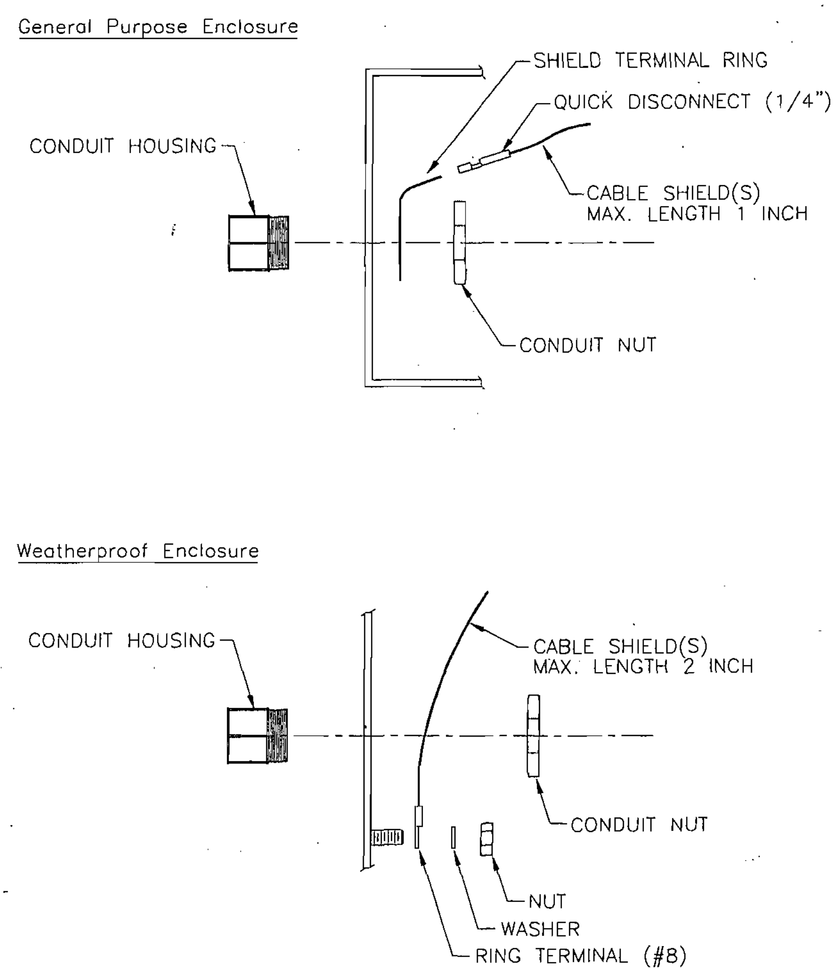

Figure 3-24. Direct shield grounding methods.

EMC grounding method

For the Weatherproof enclosure version of the control unit, connect all cable shields for that conduit entry to the grounding stud closest to that conduit entry hole. For General Purpose versions of the control unit, connect all shields for that conduit entry (other than power) to a supplied shield terminal ring (see Figure 3-24). This shield ring is a stainless steel ring with a metal tab. Place the shield ring under the conduit nut. Crimp the shields from all cables for that conduit entry to a 1/4" female quick disconnect, then push it onto the tab that sticks out of the conduit shield ring. Keep shields as short as possible.

Transient and RFI interference

This section describes transient and RFI interference precautions:

- Although there are transient and noise protectors on all control unit I/O connections (communications, current outputs, sensor, etc ...), this protection is intended to act as a last line of defense against unwanted transient and RFI interference. Proper installation practices to prevent the introduction of transients and noise into the system must be followed. Inductive loads connected to the control unit must have transient suppressers installed at the inductive loads. Be sure to place the transient suppresser as close to the load as possible. Examples of transient suppressers include MOVs, TRANSORBs, and RC snubbers.

- AC mains supply wiring should not be run in the same conduit with mains supply wiring that feeds heavy inductive loads.

- Avoid running signal wiring in the same cable or conduit with wires that power inductive loads unless all the cables within the conduit are shielded, the inductive loads are small, and transient suppressers are used at the loads.

- Do not run signal lines in the same cable or conduit with high voltage lines.

- For optimum noise protection, control unit mains supply wiring should be connected to a circuit separate from any circuit that could introduce transients into the system. As an example, do not run motors, blowers, or air conditioners using the same mains supply circuit or conduit as the control unit's mains supply circuit or conduit.

Sensor connections

This section describes required wiring connections between the control unit and the sensor. Follow the connection instructions for the applicable options for your analyzer. All sensor connections require that you access the sensor board (see Figure 3-25).

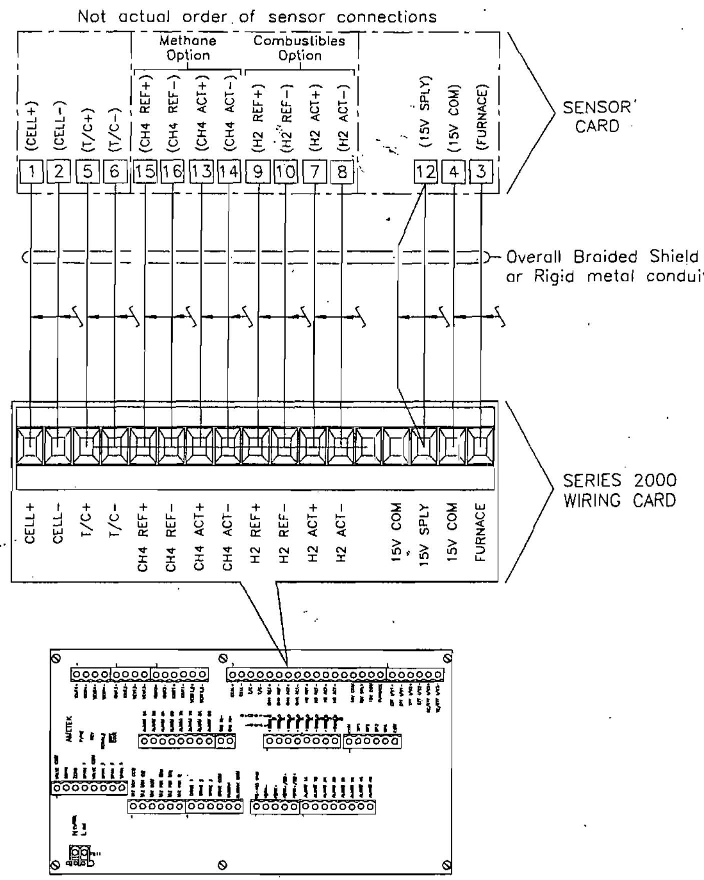

Figure 3-25.
Sensor connections with all sensor options.

Sensor AC mains supply connections

Connections for AC mains supply to the sensor are to the dry sensor board. They are labeled as follows:

L - Line Connection

N - Neutral (USA)

Chassis Stud -Equipment Ground (Protective conductor)

NOTE

AC (L) and (N) markings are provided by the terminal block for connection of AC power.

These markings are for reference purposes only such as for use on system wiring diagrams etc. The system/product has or needs no specific LINE or NEUTRAL connection for any function, safety or otherwise. The (N) terminal is not internally grounded, nor needs to be. The system will operate normally regardless of what AC input terminal (L or N) that AC Line or Neutral is connected to, or, if there is a Neutral used at all (i.e. 208 VAC US power connection).

There is no power switch on the sensor, and it must be protected by installing it on a circuit protected line, maximum 15 amperes, with a switch or circuit breaker in close proximity to the sensor and within easy reach of an operator. Mark the switch or circuit breaker as the sensor disconnecting device.

Standard sensor connections

All WDG sensors, regardless of the sensor type, required that you make the following connections from the control unit to the sensor using twisted pair cable (see Figure 3-26).

CONTROL UNIT LABEL	SENSOR TERMINAL NUMBER
Cell + Cell -	1 Blk 2 Blue (one pair)
Furnace 15V COM	3 Blk 4 Red (one pair)
T/C + T/C -	5 Blk 6 Yellow (one pair)
15V SPLY 15V SPLY	12 Blk 12 wht (one pair)

Figure 3-26.
Sensor connections.

Blk / wht
Blk / Blue
Blk / Green
Blk / Red
Blk / Yellow
Blk / Brown

Combustibles connections

If you have a combustibles detector in your sensor, also make the following connections between the control unit wiring card and the sensor board on the sensor (H2 represents the hydrogen/carbon monoxide style of combustibles detector. This detector can measure both CO and H2). - refer to Figure 3-27.

CONTROL UNIT LABEL	SENSOR TERMINAL NUMBER
H2 Act + Blk H2 Act - Brown	7 8 (one pair)
H2 REF + Blk H2 Ref - Green	9 10 (one pair)

Figure 3-27. Combustibles connections.

Remote sense setup wiring for combustibles

If you do not have the combustibles option, skip this section.

If the distance between the controller and the sensor is over 40 feet, and you are using the combustibles option, you must use the **remote sense setup**. With the remote sense setup, you can obtain the best accuracy of your combustibles detector readings. See Figure 3-23 for the number of pair required and the type of wire required.

To use the remote sense setup, you must first set the Remote/Local jumpers to the Remote Position (see Figure 3-28). Then you need to make another set of wiring connections between the control unit wiring card and sensor as shown in Figure 3-28. (you will end up having two wires connected to each combustible detector screw terminal on the sensor board.

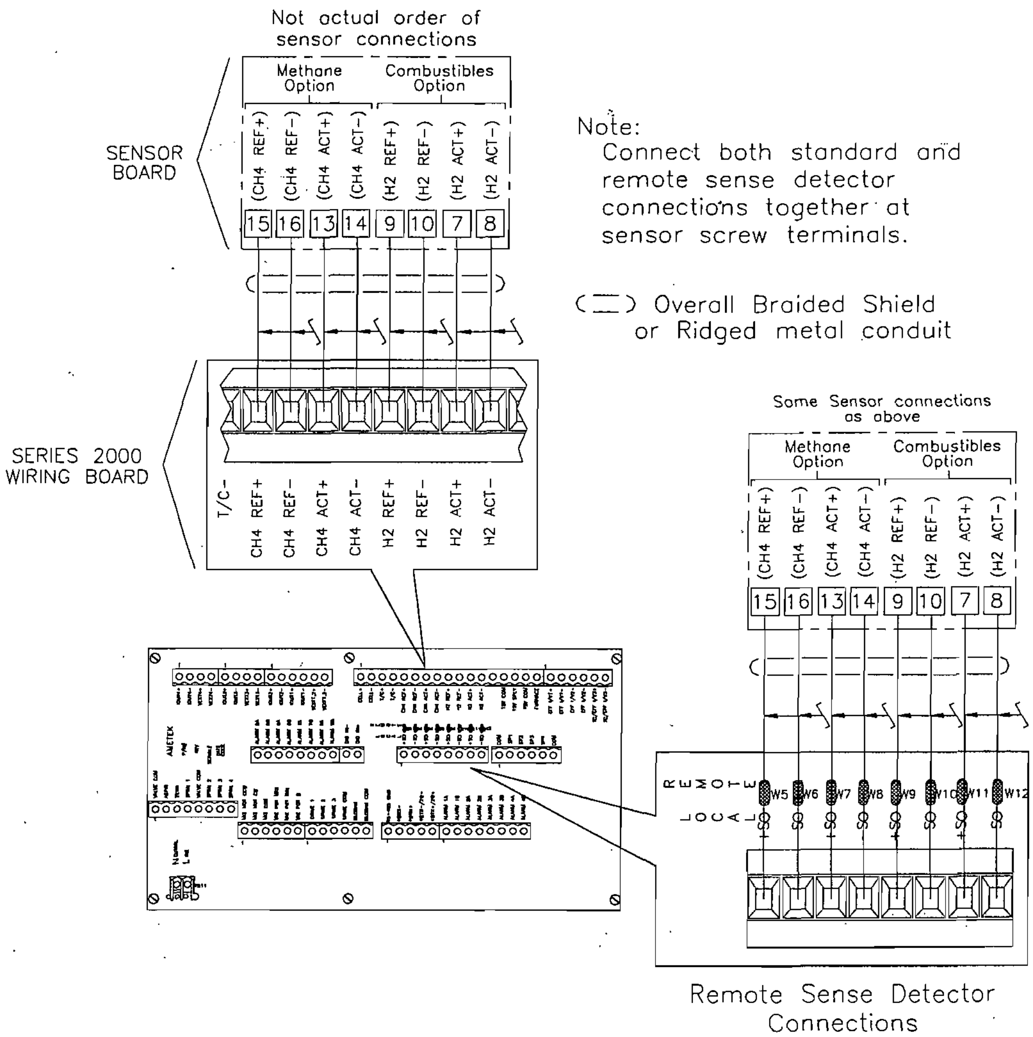

Figure 3-28.
Sensor connections with all sensor

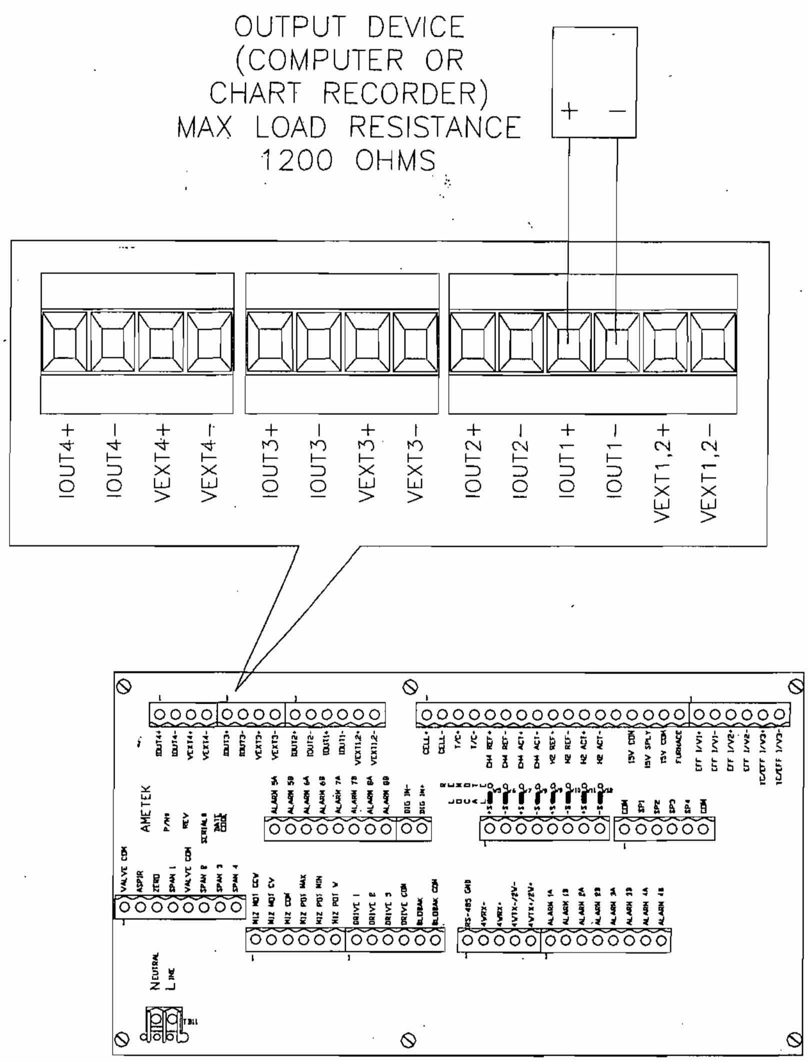

Figure 3-29.
Current output connections example.

Current output connections

Standard current outputs

Current output connections are labeled as follows on the wiring card of the Series 2000 control unit (see Figure 3-29):

IOUT1+ IOUT1-

IOUT2+ IOUT2-

These current outputs are referenced as current outputs 1 and 2 in software (see the Analog Range Key section for help on defining current output settings in software). Be sure to observe polarity when connecting current output devices to these terminals.

Current outputs 1 and 2 are capable of driving up to 1200 ohm loads.

The standard control unit with no options provides two current outputs. These two current outputs (1 and 2) are isolated from the control unit, but are not isolated from each other. If you have the combustibles option, current outputs 3 and 4 are also isolated from the control unit and from current outputs 1 and 2.

NOTE

If you intend to power current outputs from an external power supply, see the "external Powering and Modulation of External Power Using Current Outputs" appendix.

Combustibles option current outputs

If you have the combustibles option, the connections for current outputs 3 and 4 on the wiring card allow you to monitor combustibles information. They are labeled as follows:

IOUT3+ IOUT3-

IOUT4+ IOUT4-

These current outputs are referenced as current outputs 3 and 4 in software (see the Analog Range Key section for help on defining current output settings in software). Be sure to observe polarity when connecting current output devices to these terminals. These current outputs are only active if you have the combustibles card installed in your control unit. See the "option Card Installation" section in this chapter for help on adding option cards to the control unit.

These combustibles current outputs are cable of driving up to 1200 ohm loads.

NOTE

Current outputs 3 and 4 are isolated from the control unit as are isolated from current outputs 1 and 2, but not from each other.

If you intend to power current outputs from an external power supply, see the "External Powering and Modulation of External Power Using Current Outputs" appendix.

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Alarm contact connections

This section describes how to make wiring connections for any alarm devices you wish to connect to the control unit. Information on how to set up alarms in software is described in the Alarms Key section.

Alarm connections

The Series 2000 control unit provides six sets of standard alarm contacts, which are labeled as follows (see Figure 3-30):

ALARM 1A	ALARM 2A	ALARM 3A	ALARM 4A
ALARM 1B	ALARM 2B	ALARM 3B	ALARM 4B

The **Watchdog Timer Alarm** connections are labeled as follows on the control unit:

ALARM 1A   ALARM 1B

See the "Watchdog "Relay" in the Alarm Key section for complete information on the watchdog timer alarm. The watchdog alarm contacts are normally closed during system operations (deactivated). A watchdog event triggers these alarm contacts to an open condition. If you have a watchdog event, and the system returns to normal operations, then the watchdog alarm will reset. The system will retain in memory the last time the watchdog condition occurred (see the "Exception Log" section in the Alarm Key section for help on how to view this information).

The **Service Alarm** connections are labeled as follows:

ALARM 2A

ALARM 2B

See the "Service Alarm" in the Alarm Key section for complete information on what events trigger the transfer of the service alarm. The service alarm contacts are normally closed during system operations (deactivated). A service alarm event triggers these alarm contacts to an open condition.

Oxygen Alarm connections are configurable in software to activate under a variety of user defined conditions, and are labeled as follows:

ALARM 3A	ALARM 4A
ALARM 3B	ALARM 4B

See the Alarm Key section for complete information on all alarms, including what they can track and how they operate.

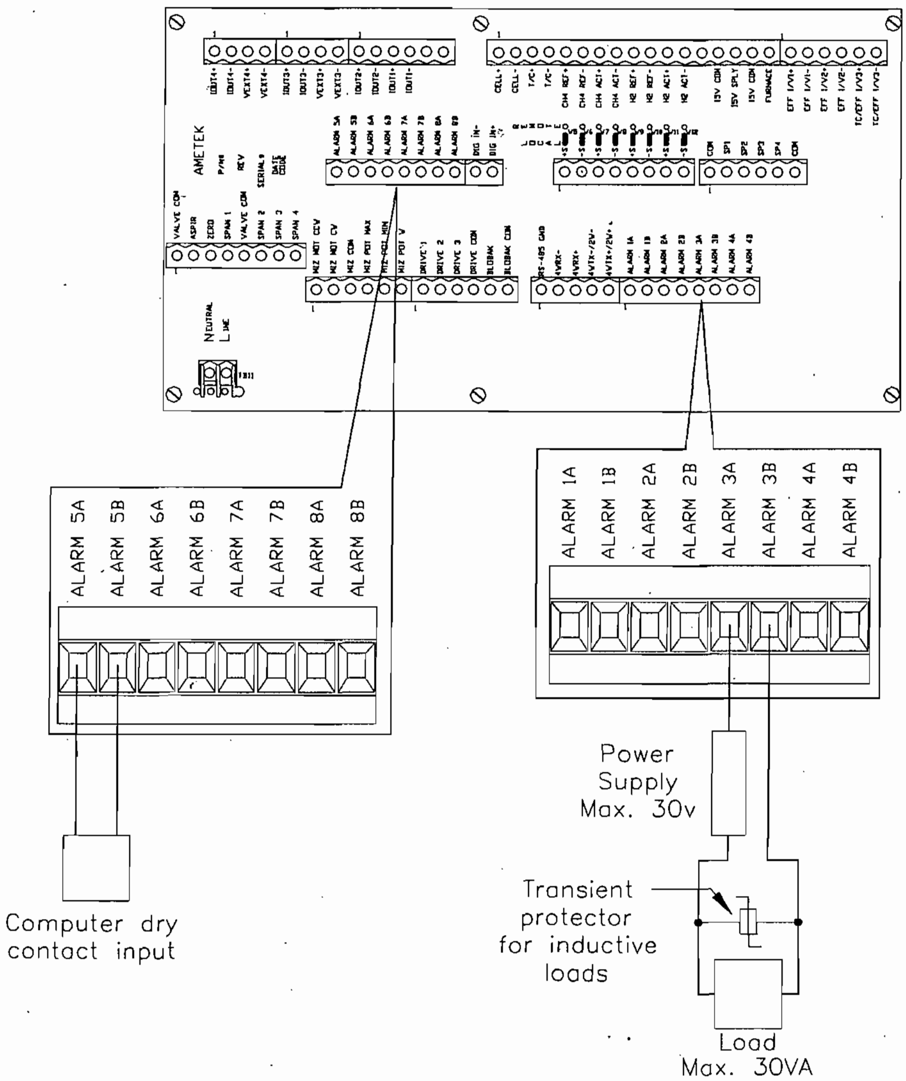

Figure 3-30. Series 2000 alarm connections example.

Combustibles detector alarm connections

If you have the combustibles option, two sets of alarm relay contact are available to activate for high combustibles levels, and are labeled as follows (see Figure 3-30).

ALARM 5A	ALARM 6A
ALARM 5B	ALARM 6B

Remote Calibration Unit Connections

If you don't have the remote calibration unit (RCU) option, skip this section.

Oxygen-Only remote calibration unit connections

Remote Calibration Unit (RCU) connections on the Series 2000 control unit wiring card, and their RCU connections, are as follows (see Figure 3-31):

ZERO - 13 on RCU
SPAN1 -15 on RCU
VALVE COMMON - 16 on RCU

Combustibles remote calibration unit connections

If you have the combustibles option (and a combustibles RCU) you must also make the following connection (see Figure 3-31.)

SPAN2 - 17 on RCU

Digital input to initiate Remote Calibration Unit

The digital input connections on the wiring card allow you to initiate a remote calibration from a location other than the control unit (see Figure 3-31). For this option to work, you must have a remote calibration unit and an auto calibration card. The system monitors the digital input, and when the switch closes, it sends the system into an automatic calibration. The switch you connect to this digital input must be a normally open switch.

Digital input connections are labeled as follows on the wiring card:

DIGIN +
DIGIN -

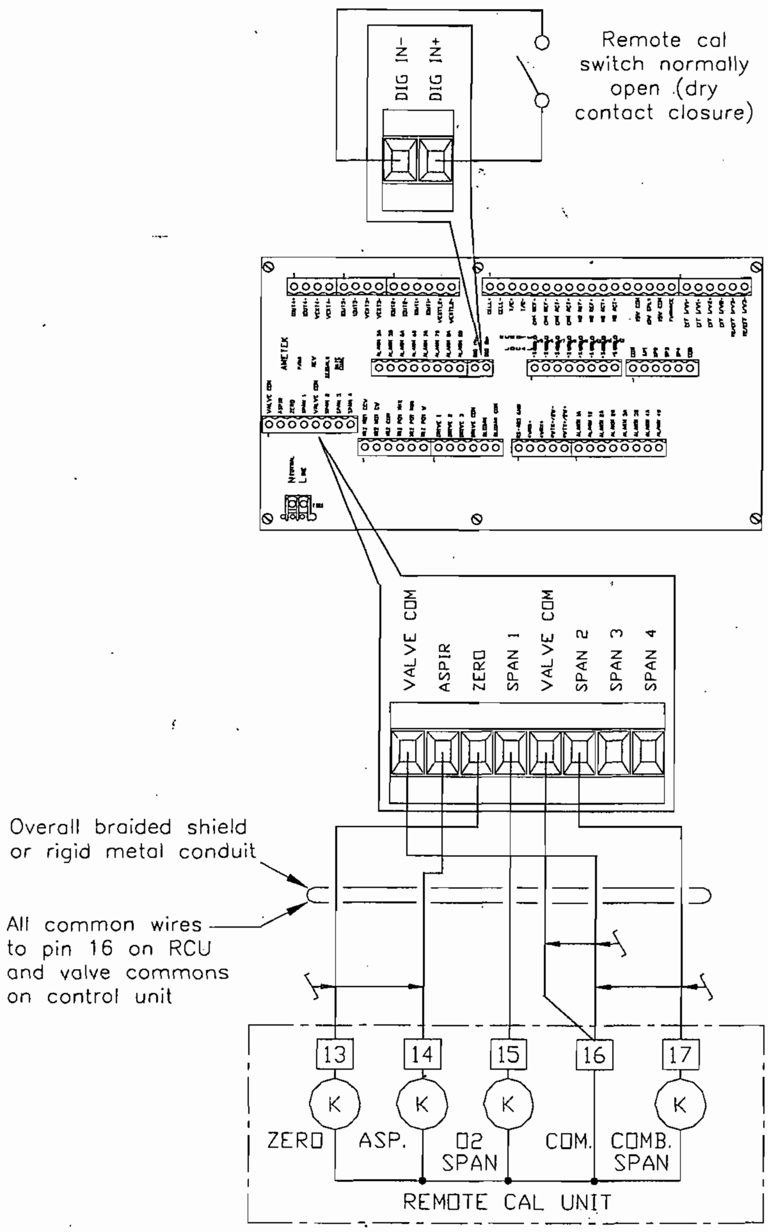

Figure 3-31.
Series 2000 controller RCU connections.

RS-485 Communications Connections

The Series 2000 control unit has the ability to communicate with other computers that use the same protocol and have the same hardware interface. See the "Serial Communications" Appendix in the back of this manual for information on the RS-485 serial communications protocol.

2-Wire connections

The connections used for RS-485 2-wire communications on the wiring card are labeled as follows:

4WTX+/2W+

4WTX-/2W-

Connect all the 2-wire pluses (+) and all the 2-wire minuses (-) in parallel with all the devices in a daisy chain fashion, including all the control units on the network and the host computer. In addition, on the host computer connect the receive and transmit terminal block connections (see Figure 3-32s). Be sure to use twisted-pair cable for all connections.

2-Wire termination resistor

The Series 2000 control unit is equipped with a termination resistor that can be used for the last control unit on the network. Switch 3 on SW1 of the display module allows you to place a 120 ohm termination resistor into the RS-485 circuit:

Switch 3 of SW1 = On (Termination Resistor In Circuit)

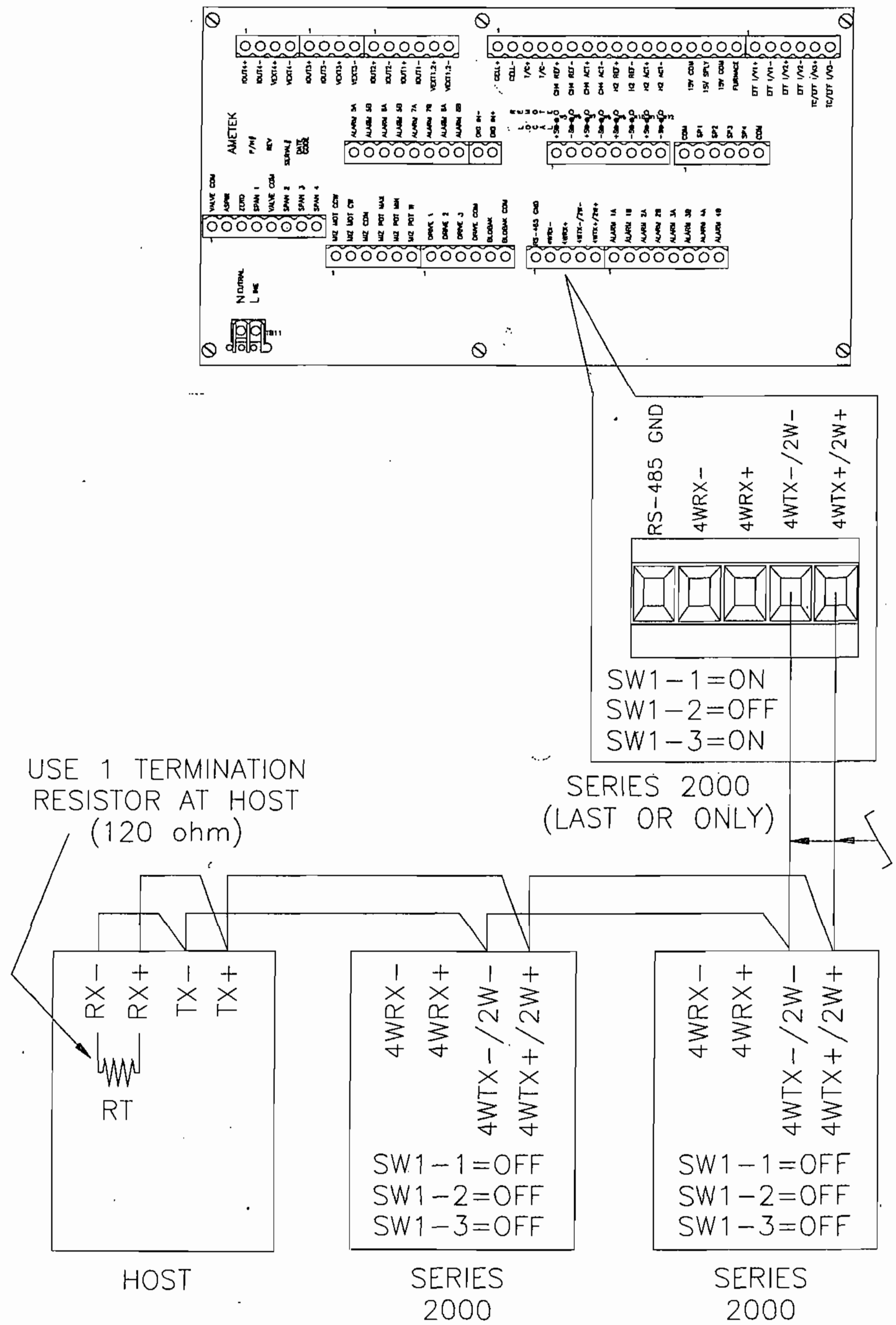

Figure 3-32.
Series 2000, 2-wire RS-485 communication connection.

4-Wire connections

The connections used for the RS-485 4-wire communications on the wiring card are labeled as follows:

4WTX+/2W+
4WTX-/2W-
4WRX+
4WRX-

Connect all control unit 4WTX+, 4WTX-, and all 4WRX+ and 4WRX- connections in parallel in a daisy chain fashion. Make the following connections between the host computer and the controller in a daisy chain fashion (see Figure 3-24):

Host Computer TX- to Controller 4WRX-
Host Computer TX+ to Controller 4WRX+
Host Computer RX- to Controller 4WTX-
Host Computer RX+ to Controller 4WTX+

Be sure to use twisted-pair cable for all connections.

4-Wire termination resistor

The Series 2000 Control Unit is equipped with termination resistors that can be used for the last control unit on the network.

SW1-1 = On
SW1-2 = Off
SW1-3 = On

This provides 125 ohm termination resistors in the RS-485 circuit.

NOTE

See the "Option Card Installation" section at the end of this Installation chapter for help on how to remove and access the display module.

You may need to experiment to get optimum performance over long lengths of communications wiring to see if having a termination resistor on the last control unit of the network improves communications. Remember, though, only to insert a termination resistor on the last control unit on the network, and not on all control units on the network. The factory default setting is to have Switch 3 off with no termination resistor in the circuit.

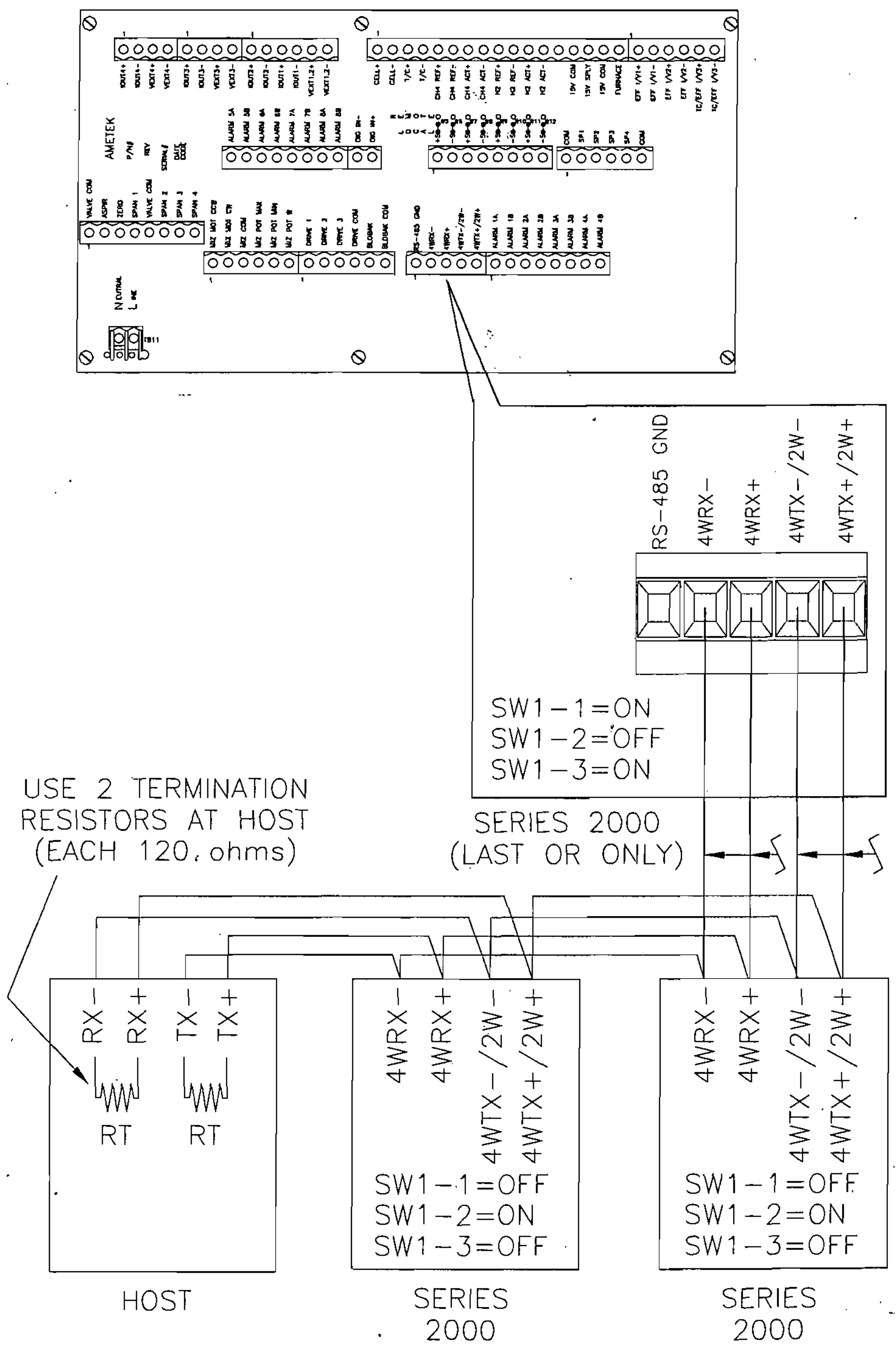

Figure 3-33.
Series 2000, 4-wire RS-485 communication connections.

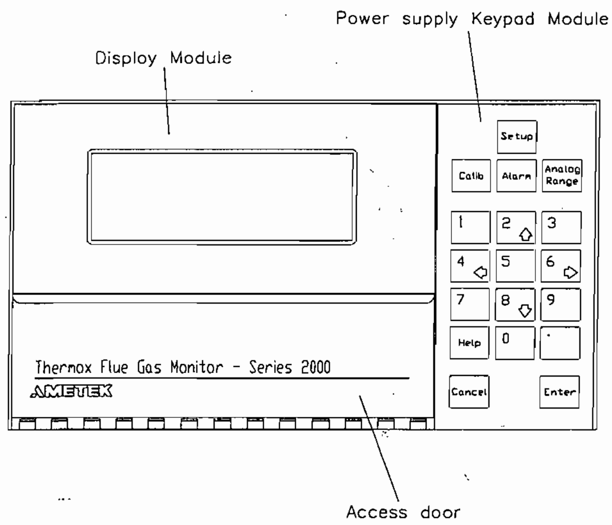

**Figure 3-34.
Front view of
Series 2000 Control Unit.**

Option Card Installation

This section shows you how to add option cards to the control unit. This includes the following option cards:

- Auto Calibration Card - requires remote calibration unit

This section also shows you how to access the display module and power supply/keypad module on the control unit in case you need to replace these modules or change a component in them (for example, install new software).

CAUTION

Remove power from the control unit before working on it.

Removing display module or power supply/keypad module

This section describes how to remove or replace the display module or power supply keypad module on the control unit (see Figure 3-34):

1. Open the access door below the display module (hinges down).
2. Pull on the handle of the power supply/keypad module and remove this module from the control unit (it slides out). Note that the power supply/keypad module must be removed before you can remove the display module.

3. Pull on the display module handle to then pull out the display module.

4. Reverse these steps to reinstall the display module or power supply/ keypad module.

NOTE

Should you need to replace fuse F1 on the display module, it is a Littlefuse type 273 microfuse or equivalent, voltage rating: 125V AC, ampere rating: 50 mA.

Should you need to replace fuse F1 on the wiring card, it is a Littlefuse type 273 microfuse or equivalent, voltage rating 125V AC, ampere rating: 250 mA. See the beginning of this Wiring section for the location of the wiring card on the controller.

Adding an option card

Do the following to add an option card to the Series 2000 control unit:

1. Open the access door below the display module (hinges down).

2. Pull on the handle of the power supply/keypad module and remove this module from the control unit (it slides out).

3. Insert the option card into any of the three available slots underneath the display module. Make sure the card is properly seated by pressing on both sides firmly. If the card is not properly seated, the access door may not close.

4. Reinstall the power supply/keypad module.

Removing an option card

Do the following to remove an option card:

1. Remove the power supply/keypad module.

2. Pull with your left hand on the left of the option card while pulling on the ejector lever on the right of the option card with your right hand to remove the option card. The ejector will help apply extra force to make is easier to release the card.

CONTROLLER / USER INTERFACE

This chapter provides a brief overview on how to use the Series 2000 control unit. This includes the following topics:

- Areas of the Control Unit
- Setup Key Functions
- Analog Range Key Functions
- Alarm Key Functions

Areas of the Control Unit

Figure 4-1 shows you the various areas of the control unit, including the locations of the power supply/keypad module and display module. The control unit is operated by pressing keys on the keypad and by viewing information on the main display.

Password Restrictions

For menu options where you can change system settings, and a password exists, you will be required to first enter the password to access that menu's functions. See the "Setup Key" section for help on how to create a system password.

Control Unit Display

The main control unit display allows you to view different types of information. You define which information to place on the first three lines of the display using the Display option from the Setup key. Note that you can also use the Display menu option to place your own text messages on one of the first three lines. The last display line is reserved for system and error messages.

If an alarm condition exists, alarm information in the form of an Up or Down arrow (corresponding to a high or low alarm) will appear next to the process reading on that display line. See "Alarm Setpoints" in the Alarm Key section for details.

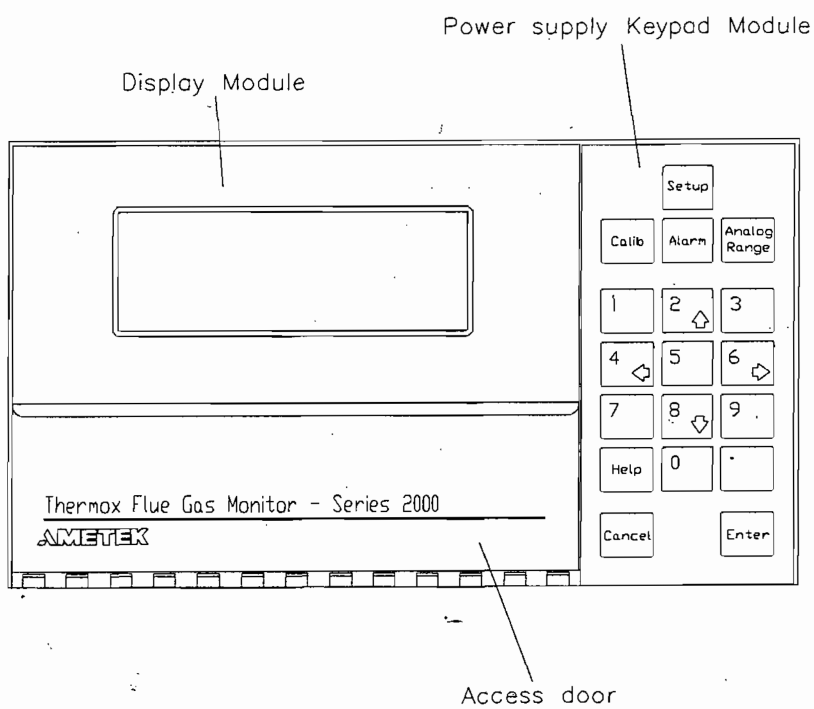

Figure 4-1.
Front view of Series 2000 control unit.

Control Unit Keys

This section provides an introduction to the main Series 2000 control unit keys. Each of these keys provides you a menu of choices you can select.

- *Setup* key - Allows you to set the control unit for your specific application.
- ***Calibrate*** key - Allows you to set calibration parameters and to start calibrations.
- *Analog Range* key - Allows you to define parameters that control analog current outputs.
- *Alarm* key - Allows you to define parameters that control the alarm relays.
- *Help* key - Allows you to access control unit on-line help.
- *Cancel* key - Cancels you out of menu options.
- *Enter* key - Allows you to confirm menu choices and values.

Selecting Menu Options

To select a menu option, press the Down arrow key until the arrow pointers are pointing at the menu option, then press the **Enter** key.

If you are in a menu where you are asked to select from choices, the currently selected choice will have an asterisk (*) in front of it. For example, if you select the Display option from the Setup key, then select Display Line 1, the current choice to appear on display line 1 will appear with the asterisk in front of it (for example, % oxygen).

If menu options can't all be listed on the display, you will see a Down arrow key on the far right of the last line of the display. This Down arrow key indicates that there are more menu options below the listed ones. Once the Down arrow key disappears, it indicates that there are no more menu options below the bottom menu item on the display. Conversely, if an Up arrow key appears on the far right of the first line of the display, it indicates that there are more menu options available if you press the Up arrow key.

Exiting Menu Options

To cancel out of a specific menu, press the Cancel key. To cancel out of all menus, continue to press the Cancel key until all menus disappear from the display and only process readings remain.

NOTE

Pressing the Cancel key does not delete any settings you have set while in that menu.

Automatic Menu Exit Feature

If you don't press a key after 15 minutes, the system exits the menu you were in and returns the system to normal operations (exits out of all menus).

On-Line Help

When you select a menu, you can press the Help key to get a description of what function any of the menu options within that menu performs. Press the Help key again to exit on-line help and return to the menu options (or press the Cancel or Enter key). For example, to get on-line help on the Passwords option from the Setup key, you would select the Setup key, then move the arrow pointers to the Passwords option and press the Help key. You would then receive on-line help on the Password option.

Setup Key

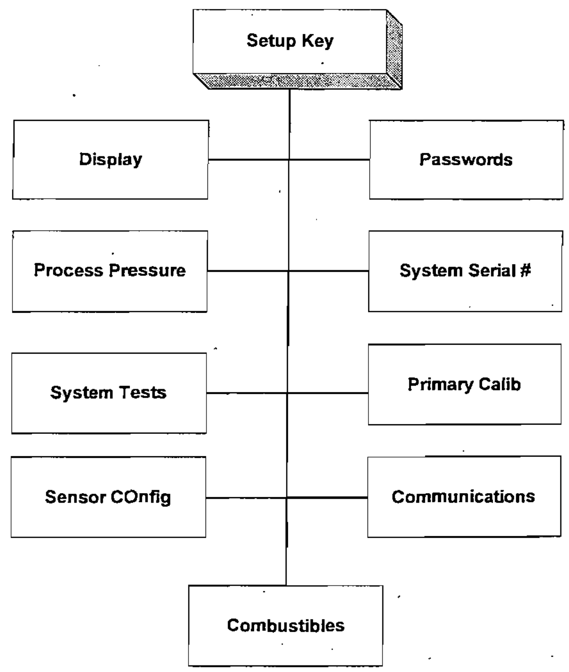

Figure 4-2.
Setup Key menu options.

The **Setup** key allows you to do the following:

- Define what information to place on each display line (Display).
- Define a system password that limits control unit access to authorized personnel (Passwords).
- Define the pressure at which your system will operate (Process Pressure).
- Perform system tests (System Tests).
- View the serial and manufacturing number for your control unit (System Serial #).

- Perform a primary calibration on the sensor (primary calibration). This is not a typical calibration. A primary calibration is intended to extend the life of your sensor. Do not perform this type of calibration unless specifically instructed to do so.
- Select the type of sensor you are using (Sensor Configuration).
- Define Series 2000 communication parameters (Communication).
- Select combustible detector options (Combustibles). This only applies if you purchased a combustibles detector(s).

Setup Key Menu Options	Functions/Options
Display	Select info for Display Line 1. Select info for Display Line 2. Select info for Display Line 3.
Passwords	Create a system password.
Process Pressure	Select a positive or negative process pressure. Enter process pressure value.
System Tests	Perform internal diagnostics on Series 2000.
System Serial #	View serial number for Series 2000. View manufacturing number for Series 2000.
Primary Calibration	Perform an automatic, remote, or manual primary calibration.
Sensor Configuration	Select sensor type.
Communications	Define communications parameters.
Combustibles	Define combustibles scale (% or PPM) Define combustible detector type.

Figure 4-3.
Overview of setup key functions.

Display

This menu option allows you to define what information should appear on the top three display lines of your Series 2000 control unit. Choices for each line are as follows:

- Percent oxygen (% O_2)
- Cell temperature
- Cell millivolts
- Thermocouple millivolts (T/C millivolts)
- Current date/time
- User text
- Turn off (leave display line blank)
- Combustibles (optional)

NOTE

When you access menus, menu options can occupy display lines 3 and 4, and sometimes display line 2. Therefore, we recommend that you place the information that is most critical for you to view on the topmost display lines.

Setting up the display

1. Select **Display** from the Setup menu.
2. Select **Display Line #1**, **Display Line #2**, or **Display Line #3**, depending on where you want to place the information.
3. Select the type of information you want to place on the display line.

Entering User Text

The Down arrow key appearing on the third line of the display allows you to see your current position when entering your user-text message. When you first select the User Text option, this Down arrow key will appear above the first position.

To enter text, use the Up and Down arrow keys on your control unit keypad to scroll through the ASCII text characters. Once the letter you want to enter appears in that position, press the Right arrow key to move to the next position. You can also press the Left arrow key to move back one position in your text message. When you are finished entering your message, press the Enter key.

NOTE

User text can be up to 20 characters long.

In addition, the following keys can be used to help you move quickly to a specific location in the ASCII text table:

- Pressing the number 1 key scrolls you to the capital letter A.
- Pressing the number 3 key scrolls you to the capital letter Z.
- Pressing the number 7 key scrolls you to the small letter a.
- Pressing the number 9 key scrolls you to the small letter z.
- Pressing the number 5 key scrolls you to the space character.
- Pressing 0 takes you to the number zero character.

Combustibles scale shown on display

If you select to display Combustibles, the display will show % combustibles or PPM combustibles, depending on what you selected for the Combustibles Option from the Setup key.

The full scale range for % combustibles is 0 to 5 %; for PPM combustibles, the full scale range is 0 - 10,000 PPM.

System Password

By default, the system password is disabled. If you don't want to enable a system password, you can skip this section.

This menu option allows you to define a *system password*. A system password limits access to certain menu options to authorized personnel only. You can also use this menu option to disable the password requirement.

Setting up a system password

NOTE

If you have forgotten the correct password, you can call AMETEK/Thermox and a service password will be provided so that you can access the Password option and enter a new system password.

1. Select Passwords from the Setup key menu.

   You will be prompted to enter a new system password:

   ```
   Enter NEW Password
   ```

2. Enter a four digit password. To protect the identification of the password, the numbers you enter are displayed as blocks rather than as text.

   You are then prompted to reenter the password to verify it.

   ```
   Reenter to Verify
   ```

3. Reenter the password. To protect the identification of the password, the numbers you enter will be displayed as blocks rather than as text.

NOTE

To later disable or change the system password, you must first enter the old password to access this menu option, then change or disable the password (0000 disables the password).

Process Pressure

This menu option allows you to define your process pressure. It also allows you to define whether your process is operating under a positive or negative pressure. Setting this value corrects oxygen measurements for the defined pressure.

Setting up process pressure

1. Select **Process Pressure** from the Setup key menu.

2. Select **Positive Pressure** or **Negative Pressure**.

You are then prompted to enter your system process pressure:

```
Pressure = xx.x PSIG
    New Value?
```

3. Enter your process pressure (up to one decimal point is allowed - for example, 1.5 PSIG), then press the Enter key. If you select a positive pressure, a plus sign (+) will appear before your value. If you select a negative pressure, a negative sign (-) will appear before your value.

The process pressure you entered will now appear on the third display line.

4. If the correct pressure has been entered into the system, press the Enter key without entering a new value to exit this menu option. If the pressure was incorrectly entered, you can reenter it at this point.

System Tests

This menu allows you to check the Series 2000 control unit for possible problems and to isolate the problem. You may be asked by AMETEK/Thermox personnel to access this menu option to perform system diagnostics.

NOTE

Performing these tests is not required under normal operations.

The following tests can be run using this menu option:

Calibrate A/D
Forces an A/D converter calibration. This is automatically done during system start-up.

Test RAM
Checks the functionality of the control unit's internal Random Access Memory (RAM).

Test Keyboard
Tests that each key is functioning correctly.

Test EEPROM
Tests the electrically erasable programmable read-only memory.

Module Detect
Allows the control unit to check for the presence of option modules. This test is used to ensure that the control unit is recognizing any option modules you have installed on the control unit. This is done automatically during system start-up.

Test Digital In
Allows you to test the system digital input.

Erase RAM
Allows you to erase all RAM memory locations.

Erase EEPROM
Allows you to erase internal EEPROM memory locations if your control unit is not operating properly. Be careful, though, because selecting this option will erase all settings in your control unit and the default values will be reinstalled.

Watchdog Timer

Allows you to test that the watchdog timer and alarm circuit is working properly. (See the "Watchdog Timer" section at the end of Chapter 7 for more information on the watchdog timer).

Serial output

Sends the string "Test Message" through the serial port until stopped by the user. This is used to test communication settings and wiring.

Read Memory Location

This is used to view internal software variables used for system operation and troubleshooting.

System Serial

This menu option allows you to view your system serial # and manufacturing #. You may be asked by AMETEK/Thermox personnel to provide this information upon request.

Setting up the serial number

1. Select **System Serial #** from the Setup menu.
2. Select **System Serial #** or **Manufacturing #**.
3. The system displays the system serial # or manufacturing #.

Primary Calibration

This menu option allows you to perform a primary calibration on the zirconium oxide oxygen sensor. You will want to perform a primary calibration on your system rather than a regular calibration (from the Calibrate key) in the following cases:

- when you replace the zirconium oxide oxygen cell or thermocouple,
- when you replace the thermocouple, and
- when your system fails a regular calibration due to a deteriorating cell.

NOTE

You should always attempt to perform a regular calibration before resorting to a primary calibration for all cases other than when you install a new cell.

- If you find that a regular calibration isn't working correctly, first check that your calibration gas values match the values written on the gas cylinders; also be sure that the correct flow of gases has been set and that the gases are allotted enough time to flow through the sensor. Only if these checks have been done and the system still can't be properly calibrated should you perform a primary calibration.

Setting up a primary calibration

Make sure you have properly entered your calibration gas values by using the Cal Gas Values option from the Calibrate key before starting your primary calibration.

1. Select **Primary Calib** from the Setup key.
2. If you have the auto calibration card option (and a remote calibration unit), you will be prompted to select Auto Calibrate, Remote Calibrate, or Manual Calibrate. If you don't have the auto calibration option, you will be placed into a manual calibration, where you will be told to inject your span gas into the calibration gas inlet port.

From this point, operations work as they do for a regular calibration. Please see the "Initiate Cal/Initiate Verify" section in Chapter 5 for help on how to perform the calibration. Note that if you have the combustibles option, during a primary calibration the system will not use the combustible span gas to calibrate the system.

- Upon completion of the primary calibration, the system will notify you that a standard calibration is required by displaying a Calibration Required message (see chapter 5 for help on how to perform a standard calibration).
- Oxygen readings on the display will not be accurate until the regular calibration is performed.
- In addition, a 15 minute recovery time follows the primary calibration to allow the cell to stabilize. After this 15 minute stabilization period, perform the regular calibration.

NOTE

During the recovery time immediately following the primary calibration, you may see some temperature related error messages. You can ignore these messages and assume no problem exists. This is because after a primary calibration, the cell temperature is adjusted.

Sensor Config.

Use this menu to select the sensor you will be using with the Series 2000.

When selecting a sensor, use the table below to see the temperature each type of sensor uses. If your type of sensor is not listed, find the operating temperature for your sensor, then choose the sensor below that uses that operating temperature.

CAUTION

Use caution when selecting the type of sensor used with the Series 2000 Control Unit. Selecting the wrong sensor will damage sensor components and could invalidate your warranty coverage.

Sensor	Operating Temperature °C
Insitu Probe	
Normal Cell Range	615
High Cell mV Range	650
WDG IV or HP Series	
Normal Cell Range	695
High Cell mV Range	824
3-in-i (WDG-IVCM)	824
CEM/O_2	
Normal Cell Range	695
High Cell mV Range	824

Figure 4-4. Sensor temperatures by analyzer type.

Configurating the sensor

1. Select **Sensor Config.** from the Setup menu.

2. Select the sensor you will use with the Series 2000 control unit (see the list of options in the table above). If your sensor is not listed, call the factory for the correct operating temperature for your sensor type.

Communication

This menu option allows you to define RS-485 communications parameters between the Series 2000 control unit and a host device. This includes the following:

Baud Rate
Allows you to define the baud rate that the control unit and the host computer are using to communicate. Choices are 300, 600, 1200, 2400, 4800, and 9600 baud.

Node Address
Allows you to define the physical address for the control unit (between 0 and 255) on a network so the host computer can identify the control unit if using network communications (see below). Note that each control unit must be assigned a unique address; otherwise, communication results will be unpredictable.

Enable Serial
Allows you to temporarily disable control unit serial communications.

Combustibles Option

The combustibles option allows you to define the following (only applies if you have the combustibles option installed):

- Combustibles scale you want to use (Combustibles Scale).

  Choices are % combustibles or PPM combustibles. The % combustibles full scale range is 0 to 5 %. The PPM combustibles full scale range is 0 - 10,000 PPM. Note that if you have the methane option, the range is always in % methane (not selectable), and the full scale range is 0 to 5 %. If you have a methane detector, the combustibles detector must be used in the PPM range.

- Type of combustibles detector you are using with the Series 2000 control unit (Combustibles Type).

  Choices are Hot Wire and RTD detector. If not sure, check your customer configuration sheet, which is included in the front of this manual.

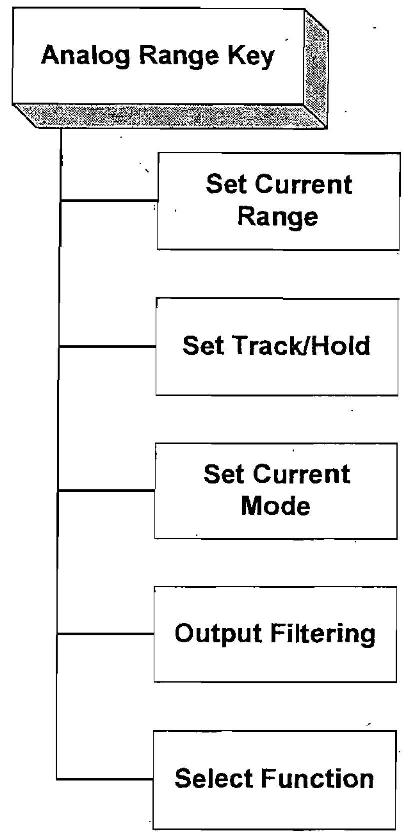

Figure 4-5.
Analog Range Key menu.

Analog Range Key

The Series 2000 control unit allows you to direct process readings to either of the two analog output ports on the rear of the control unit. If you have the combustibles option, you can also have process readings directed to the two extra analog output ports that are activated if you have the combustibles option. Analog output parameters are defined using the **Analog Range** Key menu.

See the "Select an Analog Output Port" section in this chapter for help on how to select an analog output port. All functions in this chapter are directed to a specific analog output port.

The Analog Range key (Figure 4-5) of this chapter provides help on how to do the following:

- Define what information should be sent to the analog output port during a calibration. Decide whether to hold the output at the last process reading taken before the start of calibration or track the calibration readings (Set Track/Hold).
- Define analog output range as 0-to-20 mA or 4-to-20 mA (Set Current Mode).

- Define what type of information the analog output should track (Select Function). Choices are % O_2, cell temperature, cell millivolts, and thermocouple millivolts. If you have the combustibles option, you can also track combustibles.

- Once you select what type of process readings the analog output should track using the Select Function menu option, decide what range of these readings the analog output range will cover (Set Current Range).

- Decide whether to enable output filtering, and if enabled, how much to smooth out abrupt changes in readings (Output Filtering). Analog Range key menu options are presented in the order in which they appear on your control unit screen, from top to bottom. Figure 4-6 provides an overview of the functions covered by each Analog Range key menu option.

ANALOG RANGE KEY MENU	FUNCTION/OPTIONS
Set Track/Hold	- Hold output at last process reading during a cal or verify - Track calibration readings during a cal or verify
Set Current Mode	- 0 to 20 mA - - 4 to 10 mA
Select Function	- % O2 - Cell Temperature - Cell Millivolts - Thermocouple Millivolts - Combustibles (option)
Set Current Range	Range of readings that the analog output represents. (for example: 4% O2 = 4 mA 10% O2 = 20 mA)
Output Filtering	Smooth out variations in readings.

Figure 4-6.
Overview of Analog Range Key functions.

System Password

NOTE

System passwords are created using the Setup key. Please see the "Setup Key" section for information on defining or disabling a system password.

If a system password is enabled, you will be required to correctly enter this password before accessing Analog Range key functions.

Entering the password

When you select the Analog Range key, you will be prompted to enter your system password:

```
Enter password
```

1. Enter the four digit system password. To protect the identification of the password, the numbers you enter will not be displayed.

You will then be able to access Analog Range key functions.

Analog Output Port

Before you can define any Analog Range key functions, you must first choose whether they will apply to analog output ports 1 or 2 on the rear of the control unit. In addition, if you have the combustibles option, you can also use analog output ports 3 and 4. Analog output port 1 is labeled IOUT 1; analog output port 2 is labeled IOUT 2. In addition, if you have the combustibles card option, analog output port 3 is labeled IOUT 3 and analog output port 4 is labeled IOUT 4. Analog output ports 3 and 4 can only be used for combustibles.

Selecting an analog output port

Do the following to select an analog output port:

1. Select the Analog Range key.
2. Select Current Output #1 or Current Output # 2. If you have the combustibles option, you can also select Current Output # 3 or Current Output # 4.

You can then select any of the menu options described in the remainder of this chapter, and they will apply to your selected analog output port.

Set Current Range

This menu option allows you to define the range of readings that the 0-to-20 or 4-to-20 mA (milliamp) output will represent. You can also choose to set a reverse analog output range, so, for example, 0 mA can correspond to the high end of the oxygen range, and 20 mA can correspond to the low end of the oxygen range.

The range of readings the current output represents is also a function of what type of process readings the analog output port tracks (see the "Select Function" section later in this chapter for the types of readings the current output can represent).

NOTE

See the "Set Current Mode" section for help on choosing either a 0-to-20 mA or 4-to-20 mA scale.

Setting the current range

To set the range of readings that the selected current output represents, do the following:

1. Select Set Current Range from the Analog Range key menu after selecting an analog output port.

You will be prompted to define the new value to correspond to the 20 mA analog output:

```
Out # y 20 ma = xx
   New Value?
```

where y is the analog output port, and xx is the present value that the current output currently represents (for example, 10 % O_2). Although we use output port #1 for this example, the output port that will appear depends on the analog port you selected.

2. Type the value to correspond to the 20 mA analog output.

You will then be prompted to define the value to correspond to the 0 or 4 mA analog output:

```
Out # 1 4 ma = xx
   New Value?
```

where *xx* is the value that the current output currently represents.

3. Type the value to correspond to the 4 (or 0) mA analog output.

Set Track/Hold Option

This menu option allows you to decide what signals to send to the selected analog output port during a calibration or verification. You have the option to either hold the last process reading or track calibration readings. Separate decisions can be made for verify and calibrate operations, so you can hold the last process readings during verifications, but track calibration gas readings during calibrations.

Setting track or hold

1. Select **Set Track/Hold** from the Analog Range key after selecting an analog output port.

2. You can choose to either *hold* process readings or *track* calibration readings on the analog output port. Separate choices can be made for calibration and verify operations.

For calibration operations, select one of the following:

```
Hold during cal
```

or

```
Track during cal
```

After you select one of these options, your choice will be confirmed on the display:

```
Out # 1 will TRACK
during Calibration
```

or

```
Out # 1 will HOLD
during Calibration
```

For verify operations, select one of the following:

```
Hold during verify
```

or

```
Track during verify
```

After you select one of these options, your choice will be confirmed on the display:

```
Out # 1 will TRACK
  during Verify
```

or

```
Out # 1 will HOLD
  during Verify
```

Set Current Mode

The **Set Current Mode** menu option allows you to define either a 0-to-20 or 4-to-20 mA analog output range for the selected analog output port. This output is dependent on both the range of readings you define (see the "Set Current Range" section) and on the function you track on the analog output (see the "Select Function" section).

Setting the current mode

1. Select the **Set Current Mode** menu option from the Analog Range key after selecting an analog output port.

2. Select **4-to-20 mA Mode** or **0-to-20 mA Mode.**

The following will then appear on the display:

```
Out # 1 is set for
    4 - 20 ma
```

or

```
Out # 1 is set for
    0 - 20 ma
```

Default Selection: 4-to-20 ma

Output Filtering Option

The Output Filtering menu option allows you to filter out quick transitions in readings to allow a smoother analog output.

Setting output filtering

1. Select **Output Filtering** from the Analog Range key after selecting an analog output port.

You will be prompted to enter an output filtering value:

```
[100 =FAST 1 = SLOW]
  Fltr = XX New #?
```

where XX is the current filter value. Note that 100 equals no filtering, and 1 equals the highest possible filter value.

2. Type a number between 1 and 100, then press the **Enter** key. Note that you should enter 01 to enter 1, 07 to enter 7, 70 for 70, etc.

NOTE

The default value is 100 (no filtering).

Select Function

The **Select Function** menu option allows you to select what type of information the analog output port should track. Choices are as follows:

- % oxygen
- Cell temperature
- Thermocouple millivolts (T/C mv)
- Cell millivolts
- Combustibles (optional)

The combustibles option is available only for current outputs 3 and 4, and cannot be set for analog output ports 1 or 2.

Selecting the function

1. Choose **Select Function** from the Analog Range menu after selecting an analog output port.
2. Select the function you want the selected analog output port to track (see bullets in Description section above).

The Series 2000 control unit then prompts you with the Set Current Range menu option where you choose the range of readings that the 0-to-20 mA or 4-to-20 mA analog output represents (see the "Set Current Range" section in this chapter for details).

Alarm Key

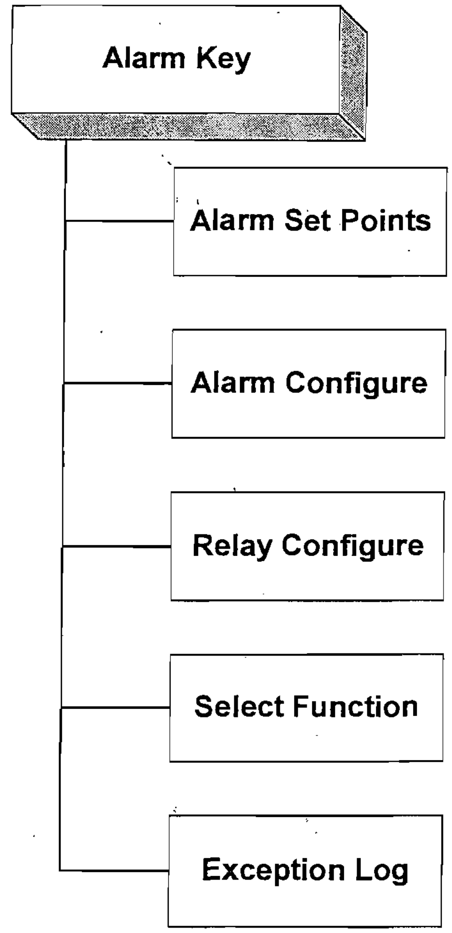

Figure 4-7.
Alarm Key menu.

NOTE

Alarms 1 and 2 are hard wired for the watchdog timer and service alarms and are therefore not software-selectable.

Oxygen and combustibles alarms are all disabled during a primary or regular calibration. In addition, alarms are disabled during start-up until the sensor reaches its proper operating temperature.

See the "Wiring" section in the Installation chapter for help on alarm connections and how alarms are labeled on the control unit wiring card.

The Alarm key allows you to do the following:

- Define whether Alarm 3 activates based on oxygen levels, the start of a calibration, or the start of a verification (Select Function). All other alarms are set to activate based on only a single condition; for Alarm 4 this condition is levels of oxygen, for Alarms 5 and 6 this condition is high combustible levels (% or PPM scale).
- Define for each oxygen alarm (Alarms 3 and 4) whether the alarm should be a high or low alarm (Alarm Configure). If you have the combustibles option, the combustibles alarms (Alarms 5 and 6) always act as high alarms, and can't be configured as low alarms.
- Define whether alarm relays should energize or de-energize on alarm (Relay Configure). The selection you make using the Relay Configure menu option applies to all alarms except the watchdog and service alarms, which always de-energize on alarm.
- Define alarm set point values (Alarm Set Points). For oxygen alarms, these values depend on the Alarm Configure menu option for whether they are high or low alarms.
- View exception log data (Exception Log). The exception log provides a history of events, such as system or error messages, alarm conditions, and the start of calibrations or verifications.

Overview of Alarm Functions

Figure 4-8 provides an overview of how alarms can be set:

- Alarms 1 and 2 are reserved for the watchdog alarm (Alarm 1) and the service alarm (Alarm 2). These alarms are not software selectable.
- Different alarms are limited in terms of what functions they can perform (see Figure 4-7). For example, combustibles alarms (Alarms 5 and 6) can only be used for combustibles. These alarms are only available if you have the combustibles card installed in your Series 2000 control unit and the appropriate sensors.
- The Select Function menu option applies only to Alarm 3. All other alarms are restricted to activate based on process reading levels.
- The combustible alarms (5 and 6) can only be high alarms.
- The Relay Configure menu option applies to all alarms except for the watchdog and service alarms, which always de-energizes on alarm (fail safe).

Alarm Number	* Select Function	Alarm Configure	Relay Configure
Alarm 3	- % O_2 - Cal Start - Verify Start - Cal/Verify Start	- High O_2 alarm - Low O_2 alarm (Only selectable if Select Function is % O_2)	- Energize on alarm
Alarm 4	Not selectable (% O_2 only)	- High O_2 - Low O_2 alarm (disabled during calibration cycle)	- De-energize on alarm
Alarm 5	Not selectable (combustibles only)	Not selectable (high alarms only)	
Alarm 6		(disabled during calibration cycle)	

Function

* Note: Alarms 1 and 2 are reserved for the watchdog timer and service alarms and are not software-selectable.

Figure 4-8.
Alarm Key overview.

Alarm Set Points

This menu option allows you to set your alarm limits. Whether these limits represent high or low alarms is defined using the Alarm Configure menu option, although certain restrictions apply (See the "Alarm Configure" section later in this chapter for further help on defining high/low alarms). Also note that oxygen and combustibles alarms are disabled during calibration cycles.

If an alarm triggers, an up or down arrow (depending on whether a high or low alarm) will appear to the right of the process reading on the display. For example, if the first display line is showing % O_2 values, and a high alarm occurs, an up arrow will appear to the right of the O_2 value. If, for example, you set alarm 3 for a high O_2 alarm and alarm 4 for a high/high O_2 alarm, and the O_2 value exceeds both the high and high/high alarm set points, two up arrows will appear next to the O_2 value on the display.

Defining alarm set point

Do the following to set your alarm set points.

1. Select **Alarm Set Points** from the Alarm menu.

NOTE *Once you select the Alarm Set Points menu option, the system alerts you that alarms 1 and 2 are reserved for the watchdog and service alarms, and are therefore not software selectable. Press the Enter key to continue to the configurable alarms.*

You will be prompted to define the Alarm 3 set point value (this option won't appear if Alarm 3 is not set to activate based on a % O_2 reading, but rather is set to activate based on the start of a calibration or verification - see the "Select Function" section in this chapter for details):

```
Alarm #3= xx %O2
   New Value?
```

2. Enter the Alarm 3 set point value, then press the **Enter** key (just press the **Enter** key if you don't want to change the current value).

You are then prompted to enter the Alarm 4 set point value:

```
Alarm #4 =xx %O2
   New Value?
```

3. Enter the Alarm 4 set point value.

If you don't have the combustibles option installed, you are done (press the Cancel key to then exit this menu option). If you do have the combustibles option installed, you are then prompted to enter the alarm 5 set point value:

```
Alarm #5=xx yy
  New Value?
```

where xx is the current value and yy is either PPM combustibles or % combustibles, depending on the scale you are using (see the "Combustibles" section in the Setup Key Chapter for details on setting combustibles scale).

4. Enter the Alarm 5 set point value. Note that combustibles alarms are always high alarms (can't be set up as a low alarm).

You are then prompted to enter the alarm 6 set point value:

```
Alarm #6=xx yy
  New Value?
```

where xx is the current value and yy is either PPM combustibles or % combustibles, depending on the combustibles scale you are using (see the "Combustibles" section in the Setup Key Chapter for details on setting the combustibles scale).

5. Enter the Alarm 6 set point value. Note that combustibles alarms are always high alarms. So, for example, Alarm 5 can be high and Alarm 6 can be high/high.

6. Press the **Cancel** key or the **Enter** key to then exit this menu option.

Alarm Configure

This menu option allows you to define whether alarms should trigger based on a high alarm or a low alarm condition. See the "Alarm Set Points" section for help on how to define alarm set point values. If you have the combustibles option, Alarms 5 and 6 are not configurable in this fashion because they always act as high alarms. So, for example, Alarm 5 could be a high combustibles alarm, and Alarm 6 could be a high/high combustibles alarm.

NOTE

Whether alarm 3 is set high or low only applies if it is set to track oxygen levels (% O_2). If alarm 3 is set to trigger at the start of a calibration or verification, this option does not apply.

Configuring the alarms

1. Select **Alarm Configure** from the Alarm menu.
2. Define Alarm 3 and Alarm 4 as high or low alarms. (See the "Alarm Set Point" section in this chapter for information on setting alarm set points.)
3. Press the **Cancel** key to then exit this menu option.

Relay Configure

All Series 2000 control unit relays are Form A, normally open contacts. You can, however, use the software to set whether your alarms should close on an alarm condition (energize on alarm) or open on an alarm condition (de-energize on alarm). This menu option applies to all alarms except for the service and watchdog alarms, which are always set to de-energize on alarm (fail-safe).

Configuring the relay

1. Select **Relay Configure** from the Alarm menu.
2. Select **De-energize on Alarm or Energize on Alarm**.

If you select Energize on Alarm, the following message will appear:

```
Relays are set to
ENERGIZE on Alarm
```

If you select De-energize on Alarm, the following message will appear:

```
  Relays are set to
DE-ENERGIZE on Alarm
```

Select Function

This menu option allows you to select which function alarm 3 should track:

- % Oxygen
- When the system starts a calibration
- When the system starts a verification
- When the system starts a calibration **or** a verification (dual function)

If tracking the start of a calibration or verification, the alarm will deactivate once the calibration or verification has been completed, including any recovery time you have specified (see the Calibrate Key Chapter for further details on calibrations and verifications).

Defining the select function

1. Choose **Select Function** from the Alarm menu.
2. Select **Alarm3= Oxygen**, **Alarm3= In Cal.**, **Alarm3= In Verify**, or **Alarm3= Cal/Verify**, depending on whether alarm 3 should be associated with % oxygen levels, or with the start of a calibration or verification, or with the start of a calibration or verification (dual function).

The control unit automatically exits you from this menu after you make your selection.

Service Alarm

NOTE

The service alarm operates as normally closed (service alarm condition causes open contacts).

The service alarm provides an alarm that alerts you of possible system problems that require attention. Events that can trigger the service alarm to activate are as follows:

- Error condition (detected by software)
- System operational variance (such as an over-temperature or under-temperature condition)
- Calibration failure
- Verification failure
- Control unit power failure

Watchdog Relay

NOTE

During normal system operation, the watchdog relay operates as normally closed (system failure causes open contacts).

The watchdog alarm relay de-energizes when the system watchdog timer times out. The watchdog timer will time out and cause the control unit to reset itself to prevent the control unit from becoming "lost" due to such things as noise spikes or power surges. You can use this relay to activate a remote indicator to notify you if the watchdog timer times out.

In addition, the control unit reads the watchdog after reset, and beeps for a brief time if the reset was caused by a watchdog condition. Pressing the reset keys simultaneously (hidden keys to the left and right of the Setup key) for a long enough time will in turn cause a watchdog, which will indicate as a beep after the system restarts upon release of the reset keys.

Exception Log

The exception log provides a history of the following types of events:

- System or error messages
- Alarm conditions
- Reset conditions
- Start of calibrations or verifications

Accessing the exception log

- Choose **Exception Log** from the Alarm menu.

The system shows you the most recent exception log entry on line four of the display, and shows when this event was recorded on line three. Line three of the display also shows the order in which events are recorded into the log, with number 1 indicating the most recent entry into the log. The system is able to store the 20 most recent entries into this exception log.

Pressing the Down arrow key shows later exception log entries. Pressing the Up arrow key shows more recent exception log entries. Press the Cancel key at any time to exit this menu option.

CALIBRATION

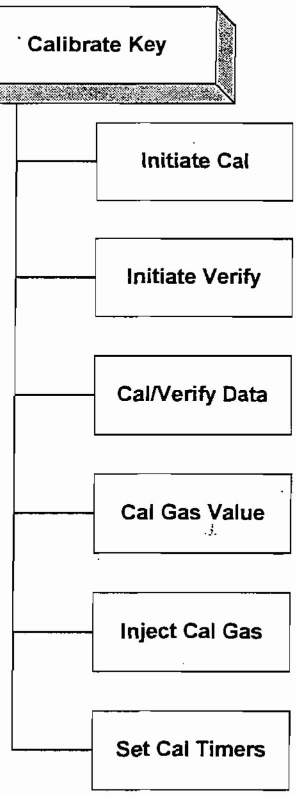

Figure 5-1. Calibrate Key menu options.

The **Calibrate** key allows you to use the Series 2000 control unit to calibrate your analyzer. The Series 2000 control unit provides features that make calibrating your analyzer easy, and even includes a way for the system to periodically calibrate itself.

NOTE

Sensor alarms are disabled during calibrations and the recovery time after a calibration. You can set whether analog outputs should follow the calibration readings or hold at the last process reading before the calibration.

Definitions

Calibrations vs. Verifications

The Series 2000 control unit software refers to both *calibrations* and *verifications*. During a verify operation, the calibration gas readings are taken, and the difference between what the system records for the gas values and their known values is recorded. Internal calibration parameters are not changed. Verify operations are often used to check that the instrument is running within required tolerances.

On the other hand, during a calibration software algorithms adjust the difference between the current readings and the known calibration gas values until they are equal. When we speak in this chapter about a *calibration* in a general sense, we are actually referring to either a verification or a calibration.

Span and Zero Calibration Gas Definitions

This chapter also refers to the terms *span* and *zero* calibration gases. The span gas is the high calibration gas. The zero gas is the low calibration gas.

Types of Calibrations

The Series 2000 control unit allows you to perform *automatic*, *remote*, or *manual* calibrations. Automatic and remote calibrations require a factory-provided remote calibration unit (RCU) that automatically switches the calibration gases for you; manual calibrations are performed without a RCU, and you switch the gases.

- *Automatic calibrations* allow the system to calibrate itself. You define the calibration gas values, the time each gas will flow through the sensor, and the frequencies at which automatic calibrations will be performed (for example, every four hours, every two days, etc.). Then the system calibrates itself at those predefined times. You can also use a digital input to activate an automatic calibration (see the "Remote Calibration Unit Connections" section in the Chapter 2 for help on how to use a digital input to initiate an automatic calibration). With the digital input method, you can initiate an automatic calibration only, not an automatic verification. You can also start an auto calibration using the keypad - the calibration gas run times are predetermined.

- For *remote calibrations*, you define the calibration gas values, but you interactively determine how long each calibration gas should flow from the RCU and into the sensor (by pressing a key on the control unit).

- For a *manual calibration*, you must physically switch the gases because you are not using an RCU. However, you still define the calibration gas values.

Overview

Setup Key Menu Options	Functions/Options
Initiate Cal/Initiate Verify	Start an automatic, remote, or manual calibration or verify.
Cal/Verify Data	View latest calibration and verify data. - Cal data - Verify data
Cal Gas Values	Enter calibration gas values.
Inject Cal Gas	Set pressure and flow of RCU gases without performing a calibration.
Set Cal Timers (applies only for auto cal operations with RCU, except for setting time and date)	- Set control unit time/date. - Enable or disable auto cal cycles. - Set cal gas times for auto cal/verify operations. - Define recovery durations after a cal/verify.

Figure 5-2. Overview of calibrate key functions.

The Calibrate key allows you to do the following (see Table 5-1 for a summary):

- Initiate an automatic, remote, or manual calibration or verification. Although automatic calibrations can be set to run at predetermined frequencies, you can also force the system into an automatic calibration (Initiate Cal and Initiate Verify).
- View previously collected calibration or verify data (Cal/Verify Data).
- Define calibration/verify gas values to match known values of calibration gas cylinders (Cal Gas Value).

- Set the pressure and flow of remote calibration unit (RCU) gases without performing a calibration or verification (Inject Cal Gas).
- Define cycle times for automatic calibrations or verifications (Set Cal Timers/Set Auto Timers).
- Set the current date and time (Set Cal Timers/Set Time and Date).
- Temporarily enable or disable auto calibrations or verifications (Set Cal Timers/Auto Cal On/Off).
- Define how long calibration gases should be applied to the sensor during an auto calibration or verification (Set Cal Timers/Cal Gas Duration).
- Define recovery duration times (Set Cal Timers/Recovery Duration).

Information in this chapter is presented to you in the order in which the menu options appear in the Calibrate key menu, from top to bottom. Where applicable, calibration and verification operations have been consolidated.

Aborting a Calibration

If you press the **Calibrate** key while the system is performing a calibration or verification, you will be provided with the option to abort the calibration or continue the calibration. All other menu functions are temporarily disabled during a calibration or verification. Oxygen and combustibles alarms are also disabled during a calibration.

Password

If a system password is enabled, you will be required to correctly enter this password before accessing certain Calibrate key functions.

Entering a Password

When you select the Calibrate key, you will be prompted to enter your system password (assuming a password has been defined):

```
Enter password
```

1. Enter the four digit system password. To protect the identification of the password, the numbers you enter will not be displayed.

You will then be allowed to access Calibrate key functions.

Initiate Cal and Initiate Verify

The **Initiate Cal** menu option allows you to perform an automatic, remote, or manual calibration. The **Initiate Verify** menu option allows you to perform an automatic, remote, or manual verification. Because these menu options function almost identically, we discuss them together. See the introduction to this chapter for more information on the difference between a calibration and a verification.

Automatic calibrations and verifications can also be set to run at predetermined frequencies using the cycle times you define using the **Set Cal Timers/Set Auto Timers** menu option (see later in this chapter for details). Once you've set these cycle times, you don't need to select the Initiate Cal or Initiate Verify menu options for an automatic calibration to occur.

The Auto Calibrate/Auto Verify and Remote Calibrate/Remote Verify selections are only available if you have installed an Auto Calibrate Card in your Series 2000 control unit and have a Remote Calibration Unit (RCU). If the Series 2000 control unit detects that these options are not installed, it will automatically prompt you with a manual calibration or verification operation when you select either the **Initiate Cal** or **Initiate Verify** menu options.

This section is divided into discussions on automatic, remote, and manual calibrations or verifications. See the headings below to locate the type of calibration or verification that applies to you, then follow those instructions.

Auto Calibrate/Auto Verify

Before you can start an auto calibration or verification, you must do the following:

- Create auto cal timers to tell the system when to perform the automatic calibrations. Note that by doing this you don't have to select the Calibrate key later to run the calibration, it does it automatically for you at the frequencies you defined. This is not required if initiating the auto calibration using a digital input (see the "Remote Calibration Unit Connections" section in the Installation chapter for help on how to trigger an automatic calibration using a digital input).
- Enter the calibration gas values to match the span and zero calibration gas cylinders you will use to calibrate or verify your system (see the "Cal Gas Values" section later in this chapter).
- Define how long you want each calibration gas to flow through the sensor before switching the gases (see the "Set Cal Timers/Cal Gas Duration" section). Remember that with an auto calibration or verification, the RCU automatically switches the span and zero calibration gases based on the calibration gas duration times you specify. Be sure to allow enough time for the gases to stabilize when you define these times. You may want to use the "Inject Cal Gases" option from the Calibrate menu to determine how long it takes for gases from the remote calibration unit (RCU) to reach the sensor and stabilize and then use these times.
- Define a time period for the system to recover from reading calibration gas values to reading process gases (see the "Set Cal Timers/ Recovery Duration" section later in this chapter).

Then you can start the auto calibrate cycle as follows:

1. Select the **Initiate Cal** or **Initiate Verify** option from the Calibrate key menu, depending on whether you want to perform a calibration or verification.
2. Select the **Auto Calibrate** or **Auto Verify** option. The system will begin the automatic calibration, and will notify you how long the span gas will be applied to the sensor from the RCU:

```
  Span Gas xx:xx
System Calibrating
```

Then the following message will appear on your display:

```
  Zero Gas xx:xx
System Calibrating
```

During this time, the RCU has switched the solenoid valves and has introduced the zero gas to the sensor.

If you have the combustibles option, the following message appears on your display:

```
Comb Span Gas xx:xx
System Calibrating
```

During this time, the RCU has switched the solenoid valves and has introduced the combustibles span gas to the sensor.

Then, if you specified a recovery time, the system will display the recovery time remaining:

```
Recovery xx:xx
```

The system then returns to monitoring process readings and the calibration or verify operation is complete. You can view the results of the last calibration or verification using the Cal/Verify Data menu option from the Calibrate key menu.

Remote Calibrate/Remote Verify

To initiate a remote calibration or verification, do the following:

1. Enter the calibration gas values to match the span and zero calibration gas cylinders you intend to use to calibrate/verify your system (see the "Cal Gas Values" section later in this chapter for help on how to do this). These values are referred to in this section as setpoint values.

2. Select **Initiate Cal** or **Initiate Verify** from the Calibrate key menu, depending on whether you want to perform a calibration or verification.

3. Select **Remote Calibrate** or **Remote Verify**.

The following then appears on your display (display line 2 will only appear if you have the combustibles option):

```
O2 xx.x % Set xx.x %
Cmb y

Press ENTER to Span
```

4. Press the Enter key once the O_2 reading on the far left of the first display line stabilizes. The reading on the far right of the first display line shows the setpoint value you entered using the Cal Gas Values menu option. This setpoint value should match the cal gas cylinder value.

- If your O_2 reading on the far left of the display has stabilized, yet is not near the setpoint value on the far right of the display, you should check the cal gas value you entered and ensure that this value matches the cal gas cylinder for that gas in the RCU.

NOTE

When performing a primary calibration or the first calibration after a primary calibration, the reading and the setpoint values often won't match. Once the first regular calibration after a primary calibration is performed, the readings should match.

You are then prompted to calibrate the zero gases:

```
O2 xx.x % Set xx.x %
Cmb yyyy Set 0

Press ENTER to Zero
```

5. Press the Enter key once the zero gas reading(s) on the left of the display has stabilized. If you don't have the combustibles option, you only need to wait until the O_2 zero gas value stabilizes. If you have the combustibles option, wait until all readings stabilize. The reading on the far right of the first display line shows the setpoint value you entered for the O_2 zero gas using the Cal Gas Values menu option. This O_2 zero gas setpoint value should match the cal gas cylinder for the O_2 zero gas connected to your RCU.

If you have the combustibles option, you are also prompted to calibrate the combustibles span gas:

```
O2 xx.x %
Cmb yyyy Set yyyy

Press ENTER to Span
```

6. Press the Enter key once the combustibles span gas reading(s) stabilize on the far left of the display.

Then, if you specified a recovery time, the system will display the recovery time remaining:

```
  Recovery xx:xx
System Calibrating
```

The system then returns to monitoring process readings.

Manual Calibrate/Manual Verify

To perform a manual calibration or verification, follow these steps:

1. Enter the calibration gas values to match the span and zero calibration gases you intend to use to calibrate or verify your system (see the "Cal Gas Values" section later in this chapter for help on how to do this).

2. Select Initiate Cal or Initiate Verify from the Calibrate key menu, depending on whether you want to perform a calibration or verification.

3. Select Manual Calibrate or Manual Verify.

You are then prompted to apply the O_2 span gas to the calibration gas inlet port on the sensor (tubing must be free of oil and dirt):

```
 Inject Span Gas
ENTER to Continue
 CANCEL to Abort
```

4. Press the Enter key once you have applied this calibration gas. The span display then appears (display line 2 will only appear if you have the combustibles option):

```
O2 xx.x % Set xx.x %
Cmb y

Press ENTER to Span
```

5. Press the Enter key once the O_2 reading on the far left of the first display line stabilizes. The reading on the far right of the first display line shows the setpoint value you entered using the Cal Gas Values menu option. This setpoint value should match the cal gas cylinder for the O_2 span gas.

- If your O_2 reading on the far left of the display has stabilized, yet is not near the setpoint value on the right of the display, you should check the cal gas value you entered and ensure that this value matches the cal gas cylinder for the gas you applied to the cal gas inlet port of the sensor.

You are then prompted to apply the O_2 zero gas to the calibration inlet port of the sensor:

```
Inject Zero Gas
ENTER to Continue
CANCEL to Abort
```

6. Press the Enter key once you have applied this cal gas.

The zero gas display then appears (display line 2 will only appear if you have the combustibles option):

```
O2 xx.x % Set xx.x %
Cmb yyyy Set 0

Press ENTER to Zero
```

7. Press the Enter key once the zero gas reading(s) on the left of the display have stabilized. If you don't have the combustibles option, you only need to wait until the O2 zero gas value stabilizes. The reading on the far right of the first display line shows the setpoint value you entered for the O_2 zero gas using the Cal Gas Values menu option. This O_2 zero gas setpoint value should match the cal gas cylinder for the O_2 zero gas.

If you have the combustibles option, you are also prompted to apply the combustibles span gas to the calibration gas inlet port of the sensor (tubing must be free of oil and dirt):

```
Inject Comb Span Gas
ENTER to Continue
CANCEL to Abort
```

8. Press the Enter key once you have applied this calibration gas. You are prompted to calibrate the combustibles span gas:

```
O2 xx.x %
Cmb yyyy Set yyyy

Press ENTER to Span
```

9. Press the Enter key once the combustibles span gas reading(s) stabilize on the far left of the display.

Then, if you specified a recovery time, the system will display the recovery time remaining:

```
Recovery xx:xx
System Calibrating
```

The system then returns to monitoring process readings.

NOTE

Be sure to reinsert the 1/4" tube cap on the calibration inlet port on the sensor once you have completed the manual calibration. This prevents air from getting into the sample gas line during normal operations.

Cal/Verify Data

This menu option allows you to view the results of the latest calibration or verification. This includes the following:

- O_2 span calibration gas value vs. O_2 span calibration gas reading
- Zero calibration gas value vs. zero calibration gas reading
- Span calibration gas drift
- Zero calibration gas drift

The terms Span Gas and Zero Gas used in this section refers to the calibration gas values you enter using the Cal Gas Values menu option. These values are fixed. Span Value or Zero Value is the value the system reads from the cal gas. The term Span Drift or Zero Drift is the difference between the entered calibration gas value and the calibration gas values read by the system.

NOTE

Both the latest calibration and verification data will be stored in memory.

1. Select **Cal/Verify Data** from the Calibrate key menu.
2. Select **Calibration Data** or **Verify Data**, depending on whether you want to see the latest calibration or verification results.

The display then shows the span gas calibration data:

```
Span Value: xx % O2
Span Gas: xx % O2
Span Drift: xx %O2
```

Note that the term span value on the display is the value the system read during the calibrate/verify operation, and the term span gas is the set-point value entered using the Cal Gas Values option from the Calibrate key menu.

3. Press the **Enter** key to then view the zero gas values.

The following then appears on the display:

```
Zero Value: xx % O2
Zero Gas: xx % O2
Zero Drift: xx %O2
```

The term zero value on the display is the value the system read during the calibrate/verify operation, and the term zero gas is the setpoint value entered using the Cal Gas Values option from the Calibrate key menu.

4. Press the **Enter** key.

The time when the calibration or verification was completed will then appear on the display:

```
End time hr:mn
End date mm/dd/yr
```

If the date or time has not been set, random characters will appear instead of the time and date when the calibration or verification was completed. If this occurs, reset the control unit's time and date.

Cal Gas Value

This menu option allows you to enter span and zero calibration gas values to match the calibration gas cylinders you use to calibrate or verify your system. These values will be used for all automatic, remote, or manual calibrations and verifications.

- O_2 span gas - high calibration gas
- Zero gas - low calibration gas
- Combustibles span gas (optional)
- Methane span gas (optional)

NOTE

The O_2 span gas value you enter must be higher than the O_2 zero gas value.

1. Select **Cal Gas Value** from the Calibrate key menu.

   You are prompted to enter the span gas value:

```
Span Gas = xx.x% O2
   New Value?
```

2. Enter the span gas value, then press the **Enter** key. You can also include a decimal point (for example, 20.9% O_2). If you want to keep the current span gas value unchanged, press the **Enter** key without entering a value.

   You are then prompted to enter the zero gas value:

```
Zero Gas = xx.xx% O2
   New Value?
```

3. Enter the zero gas value, then press the **Enter** key. You can enter up to two decimal points (for example, 2.00% O_2). If you want to keep the current zero gas value unchanged, press the **Enter** key without entering a value.

If you have the combustibles option, you are then prompted to enter the combustibles span gas value:

```
Comb Span = xxxx YY
   New Value?
```

4. Enter the combustibles span gas value, then press the **Enter** key. If you want to keep the current combustibles span gas value unchanged, press the **Enter key** without entering a value.

Inject Cal Gas

This menu option allows you to manually adjust the pressure and flow of your calibration gases (pressure of calibration gas cylinders and flow into sensor) by cycling through the solenoid valves on the RCU. No calibration or verification data is collected while in this menu option. See the "Mechanical Installation" section in Chapter 2 for recommended calibration gas pressure and flow requirements.

NOTE

This menu option requires that an auto cal card and RCU are installed.

1. Connect the span and zero gas cylinders to the RCU.
2. Select the **Inject Cal Gas** menu option from the Calibrate key menu.

The following message will then appear on your display, indicating that the RCU has introduced the span gas to the sensor:

```
Span gas is flowing
```

You will be prompted to press the **Enter** key once you have manually set the pressure and flow for the span gas:

```
ENTER for next Gas.
  CANCEL to quit.
```

3. When you have adjusted the pressure and flow for the span gas to the desired levels, press the **Enter** key.

The following message will then appear on your display, indicating that the RCU has now switched the solenoid valves and has introduced the zero gas to the sensor:

```
Zero gas is flowing
```

4. Adjust the pressure and flow for the zero gas to the desired levels. If you don't have the combustibles option, proceed to Step 6 below. Otherwise, continue with the following instructions.

If you have the combustibles option, you will be prompted to press the **Enter** key once you have set the pressure and flow for the zero gas:

```
ENTER for next Gas.
CANCEL to quit.
```

5. When you have adjusted the pressure and flow for the zero gas to the desired levels, press the **Enter** key.

The following message will then appear on your display, indicating that the RCU has introduced the combustibles span gas to the sensor:

```
Comb gas is flowing
```

Once you have set the pressure and flow for the span gas, the system prompts you to press the Cancel key to end the cycle:

```
CANCEL to quit
```

6. Press the **Cancel** key to end the cycle.

Then, if you specified a recovery time, the system will display the recovery time remaining:

```
Recovery xx:xx
```

The system then returns to monitoring process readings.

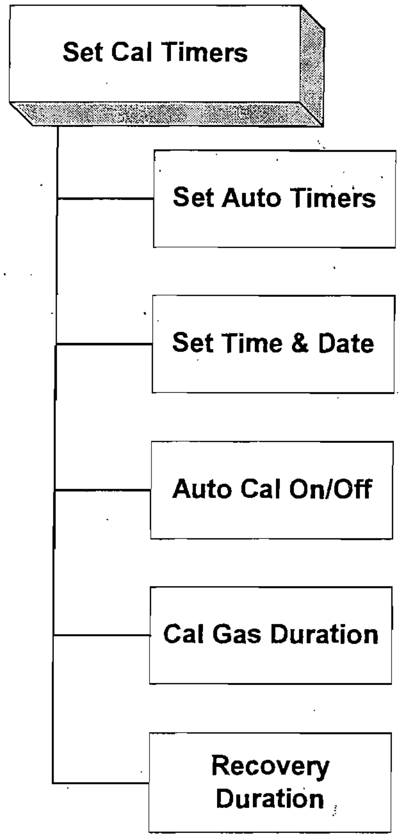

Figure 5-2.
Set Cal Timers menu options.

Set Cal Timers

The Set Cal Timers submenu from the Calibrate key allows you to do the following:

- Set auto timer for desired auto calibration/verification cycle times (Set Auto Timers).
- Set the current time and date (Set Time and Date).
- Enable or disable the auto calibration cycle (Auto Cal On/Off).
- Define how long cal gases should flow through the sensor during automatic calibrations or verifications (Cal Gas Duration).
- Define a recovery duration, during which time the sensor switches from measuring calibration gas readings to measuring process readings without affecting the analog output or triggering of alarms (Recovery Duration).

Set Cal Timers - Set Auto Timers

This menu option allows you to set the frequencies for automatic calibrations or verifications, including the time when the first calibration or verification should begin. You have the option of setting the cycle in either hours or days.

NOTE

If you schedule a verification and calibration at the same time, the verification will be performed first, then the calibration.

1. Select **Set Auto Timers** from the Set Cal Timers menu.

2. Select **Auto Cal Cycle** if defining an automatic calibration cycle. Select **Auto Verify Cycle** if defining an automatic verification cycle.

3. Select **Set Cycle in DAYS** or **Set Cycle in HOURS**, depending on whether you want to set the frequency of calibrations or verifications in days or hours.

NOTE

If you are setting the auto timers for the first time, the Series 2000 software will automatically prompt you to enter the current time and date.

You will then be prompted to enter the frequency for the calibration or verification cycle (either in days or hours, depending on what you selected in Step 3 above):

```
Cal Cycle = 01 days
  New Value = xx
```

4. Enter the number of days (or hours) for the automatic calibration or verify cycle. As you enter the values, they overwrite the XXs on the display. To enter 1 day or 1 hour, enter 01; otherwise, the system will assume you are entering 10 days (or hours).

   You will then be prompted to enter the time of day when the first calibration of the cycle should begin:

```
  Cal time is YY:YY
Enter new time Hr: Mn
```

5. Enter the time you want the first calibration or verification to begin, then press the **Enter** key. The system uses military time, so to enter 4:00 p.m., you would type 16:00. If, for example, you set the cycle frequency at 8 hours, and specify the first calibration to take place at 4:00 p.m., the next automatic calibration or verification will take place at midnight.

Set Cal Timers - Set Time and Date

This menu option allows you to set the date or time for the internal control unit clock.

NOTE

Make sure the current time and date are correct before setting any auto cal/auto verify parameters.

1. Select **Set Time & Date** from the Set Cal Timers menu.

   You are prompted to enter the new time:

   ```
    The time is: YY:XX
   Enter new time: HR: Mn
   ```

2. Enter the new time, then press the **Enter** key. As you type the new time, it overwrites the Hr: Mn text. The Series 2000 control unit uses military time so 16:00 equals 4:00 p.m., and 04:00 equals 4:00 a.m. If the current time is correct, press the **Enter** key without changing the value.

   You are then prompted to enter the correct date:

   ```
   The date is: YY/XX/ZZ
   Enter date: Mo/Da/Yr
   ```

3. As you type the new date, it overwrites the mo/da/yr text on the display. Enter the month, the day, the year, then press the Enter key. If the current date is correct, press the **Enter** key without changing the value.

Set Cal Timers - Auto Cal On/Off

This menu option allows you to disable or re-enable the auto calibration or auto-verification cycle. If you know your process will be down for an extended period of time, you may want to temporarily disable the automatic calibration or verification cycle. When the process is back on-line, you can re-enable the auto calibration or verification cycle and retain all your timer settings.

1. Select **Auto Cal On/Off** from the Set Cal Timers menu.

2. Select **Auto Cal On/Off** or select **Auto Verify On/Off**, depending on whether you want to enable or disable the auto verify or auto calibrate cycle.

3. Select **Disable Auto Cal** (or **Disable Auto Verify**) to disable the auto calibration or auto verification cycle. Select **Enable Auto Cal** (or **Enable Auto Verify**) to enable the auto calibration or verification cycle.

The system will confirm your enabling or disabling selection:

```
Auto Cal is ENABLED
```

or

```
Auto Cal is DISABLED
```

and will then exit this menu option.

Set Cal Timers - Cal Gas Duration

This menu option allows you to define how long the RCU should apply the span and zero calibration gases to the sensor during an automatic calibration or verification. You can also set a calibration gas duration time to 0 if you don't want to include it in your automatic calibration sequence.

To find out how long it takes for your calibration gases to reach the sensor and stabilize, select the Inject Cal Gas menu option and time the gas stabilization period. Then use this time frame as your calibration gas duration (we suggest that you also add a buffer to this time frame to be certain that the gas has stabilized).

1. Select **Cal Gas Duration** from the Set Cal Timers menu option.

You will be prompted to enter the new span gas duration time:

```
O2 Span Time = xx:yy
Enter new time: Mn:Sc
```

2. Enter the new span gas duration time, then press the **Enter** key. **Mn** equals minutes and **Sc** = seconds. As you type the new span gas duration time, it overwrites the Mn:Sc text. If you want to use the currently displayed time, press the **Enter** key without entering a new value.

At this point, you will be prompted to enter the zero gas duration time:

```
O2 Zero time = xx:yy
Enter new time: Mn:Sc
```

3. Enter the new zero gas duration time, then press the **Enter** key. Mn equals minutes and Sc = seconds. As you type the new zero gas duration time, it overwrites the Mn:Sc text. If you want to use the currently displayed time, press the **Enter** key without entering any text.

If you have the combustibles option, you will be prompted to enter the new combustibles span gas duration time:

```
Comb Span Time = xx:yy
Enter new time: Mn:Sc
```

4. Enter the new combustibles span gas duration time, then press the **Enter** key. **Mn** equals minutes and **Sc** = seconds. As you type the new combustibles span gas duration time, it overwrites the Mn:Sc text. You can also set this calibration gas time to 0 if you don't want to include it in your automatic calibration sequence. If you want to use the currently displayed time, press the **Enter** key without entering a new value.

Set Cal Timers - Recovery Duration

This menu option allows you to define a recovery time so the control unit can return to reading process gases after reading calibration gases without affecting the analog outputs or the triggering of alarms.

If, for example, your process gas is 6%, and your last calibration gas is 2%, this option gives the system time to recover back to reading the 6% process gas. This menu option also can be used to prevent triggering of alarms if, for example, your low alarm is set to activate if readings fall below 3%, and your calibration gas is 2%.

NOTE

This menu option applies to all automatic, remote, and manual calibrations and verifications.

1. Select **Recovery Duration** from the Set Cal Timers menu.

   You will be prompted to enter a calibration recovery duration:

   ```
    Cal Recovery = xx:yy
   Enter new time: Mn:Sc
   ```

2. Enter the recovery time, then press the **Enter** key. If you want to use the currently displayed recovery time, press the **Enter** key without entering any text.

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MAINTENANCE AND TROUBLESHOOTING

WARNING

The operations in this chapter should be performed only by qualified service personnel experienced in electrical safety techniques.

There are no operator-serviceable components inside the WDG system. Never service the controller or sensor unless power has been removed from the controller and sensor, and the sensor has been allowed to cool for at least one hour. Also, always use gloves when working on the sensor.

This chapter describes Series 2000 control unit system and error messages. It also provides troubleshooting assistance. System and error messages appear on the fourth line of the display at three second intervals until the condition is corrected or has ended. If there is more than one message, the messages will alternate on the display at three second intervals. These system and error messages are listed in this chapter alphabetically to make them easier to locate.

NOTE

System or error messages will not appear on the display when you are using the control unit keys to access menu functions..

System Messages

Auto Cal Pending

This message indicates that an automatic calibration is pending. Once the current calibration or verification is completed, the automatic calibration will begin. This message will only appear if the Auto Calibration option is installed and enabled.

Auto Verify Pending

This message indicates that an automatic verification is pending. Once the current calibration or verification is completed, the automatic verification will begin. This message will only appear if the Auto Calibration option is installed and enabled.

Calibration Aborted

This message indicates that the calibration has been aborted by the user, or the calibration failed because the span gas or zero gas was out of range.

Calibration Required

Once you complete a primary calibration, this message is displayed to inform you that a regular calibration is required (after a primary calibration is performed, you must always then perform a regular calibration). This message will not clear from the display by removing and restoring power to the control unit. If you see this message, select the **Calibrate** key and perform a calibration.

Cal Verify Aborted

This message notifies you that the verification was successfully aborted by the system as you requested.

Power Down Detected

The system detected that power was removed. For example, a power outage would cause this message to display. You can acknowledge this system message by setting or reading any user programmable value, and this will clear the message from the display. This message will not clear by removing and restoring power to the unit.

Primary Calibration

This message appears when the system is performing a primary Calibration (see the Setup key for further information on primary calibration). The message continues to be displayed during the recovery period after the primary calibration.

System Calibrating

This message indicates that a system calibration is in progress. It will appear during the entire automatic calibration cycle or during the recovery period of a remote or manual calibration.

System Verifying Cal

This message indicates that a system verification is in progress. It will appear during the entire automatic verification cycle or during the recovery period for a remote or manual verification.

Error Messages

Error messages on the control unit display indicate problems with the operation of the analyzer. Use this section to see the types of problems your error message indicates, then go to the "Diagnostic Checks" section at the end of this chapter for help on how to perform diagnostic checks to pinpoint the problem area. Note that you should always perform the easiest checks first. Only perform the more difficult checks if the easiest checks don't locate the problem.

Cell is Over Temp

This error message indicates that the sensor temperature is 30 °C or more over its correct operating temperature. The software shuts off the furnace until the temperature returns to a normal operating range.

If this message soon goes away, it indicates that the temperature has returned to an acceptable range. If there is a problem with the sensor temperature control system, you will see another error message after this message appears.

Combustibles Cal Error

This error message indicates that the combustibles detector calibration failed because of an abnormally low signal. Once this error occurs, calibration of the system is aborted. This message indicates a problem either with your calibration setup or the combustibles detector.

Excessive Cal Error

If a primary calibration cannot correct the sensor temperature within the software's allowable limits, this message is displayed to indicate the primary calibration has failed. This message could indicate one of the following problems:

- Calibration gas setup problem
- Process pressure incorrectly entered
- Failed cell
- Leak or plug in plumbing

Memory is Corrupted

This error message indicates that the control unit's internal EEPROM memory has been corrupted, or a significantly new version of software has been installed in the control unit. Under these conditions, the software will reprogram the EEPROM with the factory default values. You can acknowledge this error message by setting or reading any user programmable value, and this will clear the message from the display. This message will not clear by removing and restoring power to the unit.

If you receive this message, you should reset your control unit to the values required for your application, including Setup key parameters, Calibrate key parameters, etc...

Span Gas Range Error

This error message occurs if the calibration span gas does not read within the software's allowable limits. Once this error occurs, calibration of the system is aborted.

This message could indicate one of the following problems:

- Calibration gas setup problem
- Process pressure incorrectly entered
- Aspirator air not turned off during calibration (WDG-IV only)
- Failed cell
- Cell wiring reversed (Cell + and Cell - wires)
- Leak in plumbing
- Plugged plumbing

Temp Rise Failure

This error message indicates that the sensor has failed to increase in temperature a minimum of 10 °C in a 60-second time frame during start-up. Once the system reaches the operating set point, this message will only occur if the sensor falls below the set point by 15 °C and fails to recover within 60 seconds. The problems that can cause this error are as follows:

- AC line power problem at the sensor
- Open furnace
- Over-temperature protection circuit trip on the sensor board
- Sensor board failure
- Loss of furnace drive signal
- Interconnecting wiring problem

T/C (Thermocouple) Circuit Failure

This message appears when the control unit recognizes a sudden drop in temperature (greater than 100 °C). The thermocouple circuit failure message can be the result of one of the following problems:

- Shorted thermocouple
- Faulty interconnecting wiring
- Control unit display module failure
- Sensor board failure

If this message is soon followed by a "Thermocouple Failure" message, see that message for troubleshooting instructions.

Thermocouple Failure

This error message occurs when the indicated sensor temperature falls below -70 °C. This error message can be the result of one of the following:

- Open thermocouple
- Faulty interconnecting wiring
- Control unit display module failure

Zero Gas Range Error

This error message occurs if the calibration zero gas does not read within the software's allowable limits. Once this error occurs, calibration of the system is aborted. This error indicates one of the following problems:

- Calibration gas setup problem
- Process pressure incorrectly entered.
- Cell wiring reversed (Cell + and Cell - wires)
- Aspirator air not turned off during calibration (WDG-IV only)
- Failed cell (primary calibration should be run at this time)
- Leak or plug in plumbing

Diagnostics Checks

This section shows you how to check different sensor areas for possible problems. See the "Error Messages" section for help on what checks you should perform based on the error message you see. In addition, if you don't see an error message, yet feel your readings are inaccurate, you may also want to check the "General Troubleshooting" section that follows. We recommend that the thermocouple millivolts and cell millivolts be displayed during troubleshooting as a troubleshooting aid (see the "Display" section in Chapter 4 for help on how to display these items). This information will be helpful should you need to contact the factory for assistance. Be sure to always include your analyzer model and serial number when calling the factory for technical support.

Diagnostic checks are broken down as follows:

- Wiring Checks
- Thermocouple Checks
- Calibration/Aspirator Setup Checks
- AC Power Checks
- Furnace Checks
- Process Pressure Checks
- Cell Checks

WARNING

Exercise care when working on the sensor. Turn off power, allow the unit to cool, and wear gloves.

Wiring Checks

Interconnecting wiring problem

Make sure all wiring connections between the control unit and the sensor are terminated to the proper locations and are seated properly. This includes ensuring that sets of wires are not reversed, and that the cable is not damaged or melted.

Thermocouple Checks

Open thermocouple

Remove power to the control unit and the sensor. Measure across terminals "C" and "D" on the sensor board with an ohm meter. If an open is measured, replace the thermocouple.

Shorted/Failed thermocouple

Check that the thermocouple leads are not shorted to chassis ground. To do this, use an ohm meter to measure between terminal C on the sensor board and chassis ground, and between terminal D on the sensor board and chassis ground. If shorted, replace the thermocouple.

To verify that the interconnecting cable for the thermocouple is not shorted together, remove the thermocouple wires from terminals C and D on the sensor board and measure across terminals 5 and 6 on the sensor board. If shorted, correct the interconnecting problem.

To verify the operation of the thermocouple itself, remove the thermocouple from the sensor and heat its ceramic tip to a known temperature. Measure the millivolt output with a proper temperature indicating meter (type K thermocouple). If the thermocouple reads inaccurately, replace it.

Reversed thermocouple wires

First, have one of the control unit display lines show the sensor cell temperature. If the thermocouple leads are reversed, the displayed temperature will be decreasing as the sensor warms up (this will usually happen at start-up or after you replace a thermocouple). This indicates that the thermocouple wiring is reversed. If you just replaced a thermocouple, check the leads from the thermocouple to the sensor board - yellow wire connects to terminal C (+), red wire connects to terminal D (-).

Thermocouple compensation circuit check

With a volt meter, measure across terminals 2 (-) and 12 (+) on the sensor board. If approximately 15 volts is not present, check that interconnecting wiring is correct. If interconnecting wiring is correct, check across 15V Sup and 15V Com on the control unit for approximately 15 volts. If 15 volts is not present, check fuse F1 on the wiring card. If this fuse is OK, replace the control unit power supply/keypad module. If this fuse is not OK, replace the fuse (1/4 amp, 125 volts, IEC speed type FF). Check the interconnecting wiring for short circuits before applying power to the control unit.

If you do measure 15 volts at terminals 2 (-) and 12 (+) of the sensor board, measure across terminals D (+) and 6 (-) on the sensor board. Twelve millivolts should be measured (this signal is a function of ambient temperature and may vary up to 2 millivolts at extreme ambient temperatures). If you don't measure this voltage, replace the sensor board.

Calibration/Aspirator Setup Checks

Calibration gas check

- Check that the correct calibration gas values have been entered into the control unit. To do this, select the Cal Gas Value menu option from the Calibrate key on the control unit and check that the calibration gas values entered match the analyzed concentration of the cylinders.
- Check that the calibration gas cylinders are turned on and are not empty.
- Check for the proper flow rate and proper delivery pressure of calibration gases when the remote calibration unit has been activated (see the Inject Cal Gas menu option from the Calibrate key chapter for help on how to do this).

Calibration line check

Ensure that your calibration line is not contaminated with such things as pipe dope, cutting fluid, oil, or solvents. All these contaminants produce hydrocarbon vapors that interfere with the proper calibration of your analyzer. The result of this will be lower than expected oxygen readings. To test for contaminated lines, you must temporarily bypass your current calibration line with a clean calibration line (directly from cylinder to the sensor calibration inlet port, using a flow meter to set the proper flow) and compare the response with that from the possibly contaminated line. The best calibration gas to use for this check is an O_2 zero calibration gas.

Aspirator not turned off during calibration

NOTE

This check only applies if you are a WDG-IV user.

Verify that the aspirator air is turned off during calibration (manual or through the RCU). If the problem is with the RCU, refer to the next section, "Remote Calibration Unit Problem."

Remote calibration unit (RCU) problem

The RCU contains one normally open solenoid-the aspirator air solenoid. All other solenoids are normally closed. Problems with the RCU are usually as follows:

- Plumbing leaks
- Solenoids not energizing

Plumbing Leak

To check for plumbing leaks, disconnect power from the RCU and pressurize the inlets. Apply a leak detecting liquid along the base of the solenoids and any plumbing fittings. Repair any leaks found.

Solenoid Not Energizing

The solenoid drive signal is a 12 VDC signal. This is used to close the aspirator solenoid and open the appropriate calibration gas solenoid. To test a solenoid valve, select the Inject Cal Gas option from the Calibrate key menu to energize that solenoid. Verify that the solenoid drive signal is present. The aspirator air solenoid is closed when the drive signal is applied. Other solenoids are open when the drive signal is applied (cal gas flowing). With the drive signal present, verify the proper flow. If no signal is present, check the interconnecting wiring between the control unit and the RCU. If wiring is correct, replace the Auto Cal Card. If the solenoid drive signal is present, it indicates a problem with one of the solenoid valves. Replace the solenoid valve, being sure that the solenoid O-ring seals are properly positioned.

To check if a calibration gas solenoid is stuck open, verify that no drive signal is present and check for flow on the RCU flow meter. If flow is indicated when no solenoids are energized, a solenoid is stuck open. Shut off your calibration gases (one at a time) until the flow drops to zero. This identifies the defective solenoid valve (replace the solenoid valve, being sure that the solenoid O-ring seals are properly positioned).

Calibration gas time inadequate

If you are having problems running an auto calibration, you may not have allowed the calibration gases enough time to flow through the sensor and stabilize. To correct this problem, select the Inject Cal Gas option from the Calibrate key menu. Turn on each calibration gas and determine how long it takes for each gas to stabilize on the control unit display. Then add a one minute buffer to each of these times. Also make sure the cylinder regulators are set to the correct pressure. See the Flow Section of the System Interconnect Drawing for the system flow and pressure requirements. This drawing is included with your Installation package.

Select the Cal Gas Duration option from the Calibrate/Set Cal Timers menu to set calibration gas times.

NOTE

If performing a manual calibration, ensure that you are waiting for the reading to stabilize on the display before switching to the next calibration gas. You should wait a minimum of two minutes.

AC Power Checks

Loss/Inadequate AC voltage to the sensor

Measure the AC voltage to the sensor board at terminals L1 and L2. Ensure that this voltage is sufficient. Check the measurement technique used by the volt meter (for example, RMS, average, peak, etc.). Specifications are based on RMS measurements.

Furnace Checks

Open furnace

Disconnect power to the control unit and the sensor. With ohm meter, measure across Terminals "R" and "S" on the sensor board. The resistance of the furnace should be as follows:

32 ohms (±10%)

If the furnace resistance is not within allowable tolerances, replace the furnace.

Loss of AC power to the furnace

Verify the correct line voltage at L1 and L2 of the sensor board.

With line voltage present, check the voltage at terminals R and S on the sensor board. If voltage is present and the system is not heating, remove power and check the furnace resistance (see "Furnace Checks" section). If no voltage is present at terminals R and S on the sensor board, check for the DC furnace drive signal at terminals 3 (+) and 4 (-) at the sensor board. The furnace drive is a 15 VDC pulse train, and depending on the frequency of the pulse train, the measured voltage will be between 5 and 15 VDC. If this furnace drive signal is present, reset the power to the control unit and see if this solves the problem. If this doesn't solve the problem, replace the sensor board.

If the furnace drive signal is not present, check the interconnecting wiring. If the interconnecting wiring is correct, check across FURNACE and 15V COM on the control unit wiring card for the furnace drive signal. If the signal is not present, check fuse F1 on the wiring card. If this fuse is OK, replace the control unit power supply/keypad module. If this fuse is not OK, replace the fuse (1/4 amp, 125 volts, IEC speed type FF). Check the interconnecting wiring for short circuits before applying power to the control unit.

Process Pressure Checks

To check that you entered the process pressure correctly, select the Process Pressure menu option from the Setup key. Also ensure that the calibration process pressure equals normal operating process pressure. Calibration should only be performed under these conditions for highest accuracy.

Cell Checks

If the cell fails when you first begin to use the analyzer, it is likely that there is a leak in the sensor plumbing or an improper calibration gas setup, and there is not a problem with the cell itself (see the "Leak Check" section later in this chapter for help on how to check for leaks; see the "Calibration/Aspirator Air Checks" section earlier in this chapter for help on checking your calibration gas setup).

If the analyzer has been operating for some time and you feel the oxygen reading is inaccurate, first check by running a known calibration gas to verify the analyzer's response. If the analyzer responds to the calibration gas correctly, it indicates either leaking or plugged plumbing.

If your analyzer doesn't respond properly to the calibration gas, then it may indicate a problem with the cell. Before replacing the cell, put the analyzer through a primary calibration and see if this improves the response of the analyzer. If this doesn't work, check for leaks or plugged plumbing.

If this doesn't solve the problem, replace the cell, then run another primary calibration.

General Troubleshooting

Your system may pass calibrations, yet still seem to be reading incorrect oxygen levels. If this is the case, you may want to check the following:

Leak Check

This check does not apply to Insitu users.

Leaks can lead to inaccurate readings, especially if operating under a significant pressure or vacuum. Check that all compression fitting and pipe thread connections are leak tight. Also be sure that the mounting plate or mounting flange gasket on the rear of the sensor is in place (see the "Sensor Mounting" section in Chapter 2 for details on the placement of the gasket).

For processes under vacuum, you can check for leaks by sniffing the fittings with another gas (for example, nitrogen or pure oxygen), being sure to avoid the area over the top of the cell. Use a piece of tygon or plastic tubing with a 1/8" stainless steel nozzle to apply the gas from a cylinder (using stainless steel prevents any problems that might occur with plastic melting the nozzle on hot sensor components). Monitor the response from the cell. When the cell millivolt reading changes, it indicates a leak in that area of the plumbing (the vacuum of the process pulls in the gas). If not convenient to view the control unit display, you can also apply a volt meter to terminals 1 and 2 on the sensor board (Cell + and Cell -) to see if the cell millivolts change, indicating a leak.

If you want, you can also remove the sensor from the process (after allowing sensor to cool) and pressurize it with 5 lbs. of air, plugging any exiting ports, the inlet probe, and exhaust tube holes. Then go over the sensor fittings with a leak detector fluid.

If you see bubbles, it indicates a leak. If using this method be sure to prevent the liquid from reaching the furnace. If the furnace does get wet, allow it sufficient time to thoroughly dry. Note that the WDG-IV style sensor has intentional leaks in the aspirator air inlet fitting and the screw in the back of the aspirator block. If you are having problems and your process is under positive pressure, these intentional leaks will need to be sealed.

Plugged Plumbing Check

CAUTION

Exercise care when working on the sensor. Allow the unit to cool and wear gloves.

This check does not apply to Insitu users.

Examine the inlet and exhaust for plugging problems. When possible, rod out the probe and exhaust. If this doesn't solve the problem, disassemble the analyzer to locate the plug. Clean the plumbing using hot water and a bottle brush. When assembly is complete, check for leaks using a leak detecting liquid.

Aspirator Air Not Pulling Sample from Process

This check only applies for WDG-IV users.

To check the aspirator vacuum level, remove the inlet hook and turn off the aspirator air. Attach a vacuum gauge to the aspirator inlet and apply aspirator air. The aspirator should pull 2 to 3 inches WC at 5 psig. If the aspirator doesn't pull a vacuum, disassemble sensor plumbing and clean the nozzle and venturi in the back of the aspirator. You will need a new metal O-ring when installing the venturi.

Series 2000 LEDs

This section describes how to interpret information on the LEDs in the Series 2000 controller auto calibration card and combustibles card.

Auto Calibration Card LEDs

All auto calibration card LEDs denote that the Series 2000 has sent out a 15-volt signal to the RCU to activate the appropriate solenoid. LEDs are clearly labeled on the auto calibration card - 1 is on the far right of the card as you look at it.

1 - *In Calibration* - when lit, indicates that the system is in calibration. This LED remains on for the entire calibration cycle, then turns off during the calibration recovery time.

2 - *O_2 span* - when lit, indicates that the O_2 span gas solenoid is energized and the O_2 span gas should be flowing into the sensor.

3 - *O_2 Zero* - when lit, indicates that the O_2 zero gas solenoid is energized and the zero gas should be flowing through the sensor.

4 - *Combustibles span* - when lit, indicates that the combustibles span gas solenoid is energized and the combustibles span gas should be flowing into the sensor.

5 through 12 - Not used

Combustibles Card LEDs

NOTE

Combustibles alarm relays are labeled on the wiring card and in software as Alarms 5 & 6. LED number 1 is on the far right of the card as you look at it; LED number 2 is to the left of LED 1. All LEDs denote an Alarm relay is energized (contact closed).

1 - *Combustibles 1* - when lit, indicates that the Combustibles alarm #1 relay is energized (contact closed). This corresponds to Alarm 5 in software.

2 - *Combustibles 2* - when lit, indicates that the Combustibles alarm #2 relay is energized (contact closed). This corresponds to Alarm 6 in software.

Chapter 7

SERVICE AND PARTS

WARNING

The operations in this appendix should be performed only by qualified service personnel with a knowledge of electrical safety techniques. There are no operator-serviceable components inside the WDG system.

WARNING

Never service the controller or sensor unless power has been removed from the controller and sensor, and the sensor has been allowed to cool for one hour.

This chapter is divided into the following sections:

- Cell Replacement
- Thermocouple Replacement
- Combustibles Detector Replacement (optional)
- Furnace Replacement
- RCU (Remote Calibration Unit) Solenoid Valve Replacement
- Replacement Parts List

See the Installation chapter for help on how to remove or replace Series 2000 control unit modules or option cards.

You can clean the outside of the sensor or controller (or Remote Calibration Unit) using normal household or commercial general purpose cleaners, cloths, or sponges. You can also use water. Always turn off power before attempting to clean the enclosure.

A wiring diagram for a standard sensor is provided in Figure 7-1. This figure shows the locations of all wiring connections on the sensor. If your sensor requires different wiring, this is provided in an appendix.

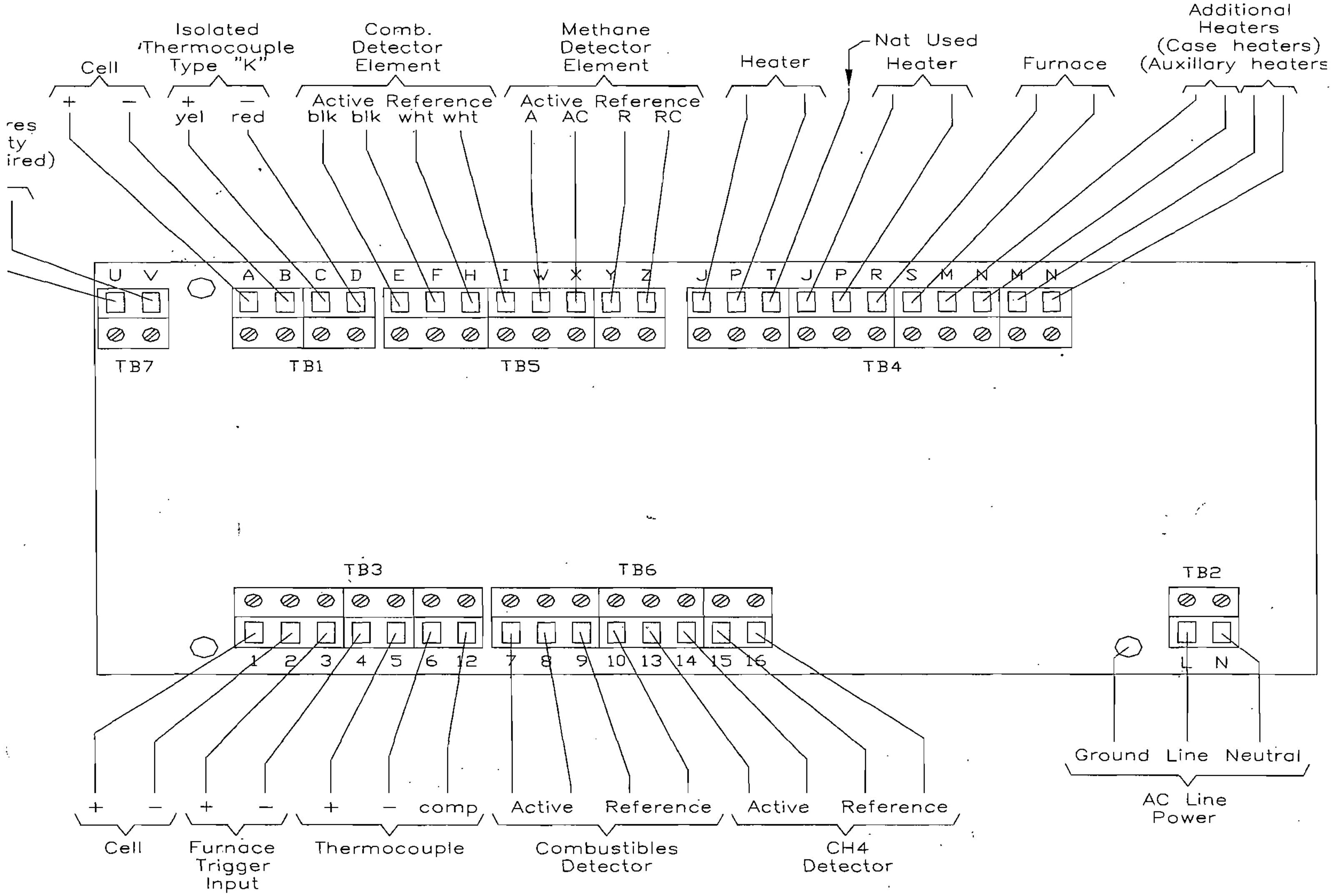
Warnings

- The outside of the sensor cover and all sensor assembly components are extremely hot (up to 500°F, 260°C inside the cover), even after a considerable period from shutdown. Turn off the power to the sensor and control unit when working inside the sensor. Use caution and wear appropriate gloves when handling components!
- Be extremely careful when performing maintenance on the sensor while the process is running, especially if the process is under significant positive pressure. Removing any part of the sensor plumbing can allow process gases and gases of high temperature to escape into the sensor.

Cautions

- Always use a backup wrench when working on sensor plumbing. This helps to prevent damaging welds and distorting sensor plumbing.
- Never use pipe dope or any other contaminant that gives off combustible vapor on any joints of the sample tubing. Combustible vapor in the sample tubing can lead to erroneous readings.

Figure 7-1. Wiring diagram for standard sensor.



Cell Replacement/Cleaning

To replace or clean the cell, do the following (see Figure 7-2):

CAUTION

Disconnect power from the sensor and control unit and allow the sensor to cool before replacing parts inside the sensor.

1. Remove the sensor cover to expose sensor components.
2. Remove the cell clips.
3. Loosen the lower hex nut (not the top hex nut) while holding the top of the cell housing with a backup wrench, then remove the entire cell assembly. Note that loosening the cell may require a good deal of torque.
4. If cleaning the cell, wash with water or alcohol. Dry the cell thoroughly before reinstalling and always use a new cell O-ring.

   If replacing the cell, discard the old cell and cell O-ring and retrieve the new cell with supplied cell O-ring. Avoid touching the bare cell. Instead, hold the cell by one of its hex nuts.
5. Place the cell O-ring on top of the cell housing as shown in Figure 7-2.
6. Insert the new cell into the cell housing. Do not touch the bare cell when reinserting. Tighten the cell into the cell housing using the lower hex nut (the upper hex nut is pre-tightened at the factory). The cell O-ring provides a seal for the system. Make sure it is evenly crushed when tightening the cell.

NOTE

Before performing a primary calibration, first connect power to the sensor and allow it to heat up and stabilize (approximately one hour).

7. Perform a primary calibration if you replaced the cell.

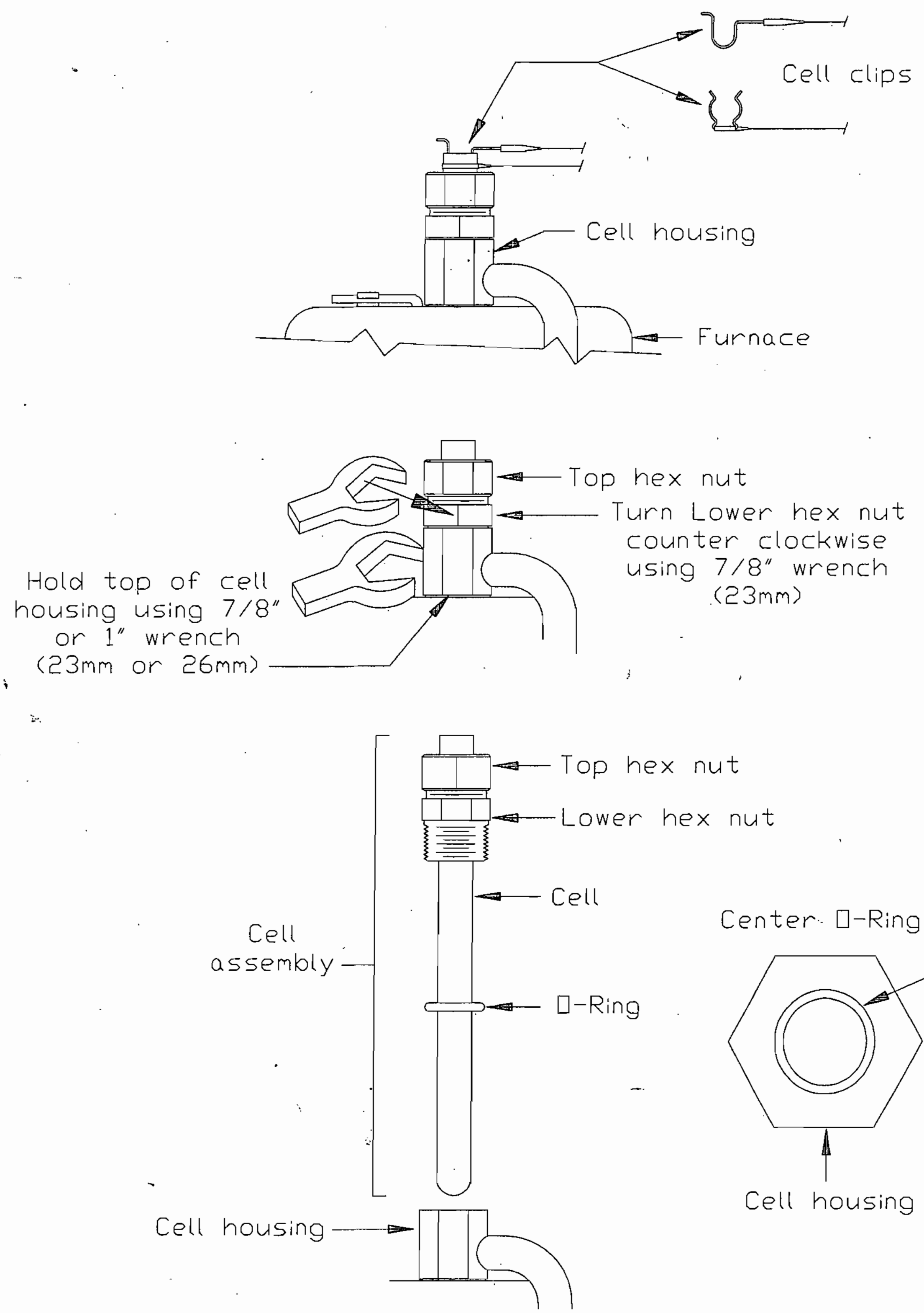


Figure 7-2.
Cell replacement.

Thermocouple Replacement

NOTE

The tip of the thermocouple is positioned in the furnace so that it is near, but not touching, the cell housing or the furnace heater coil.

To replace the thermocouple, do the following (see Figure 7-3):

1. Remove the sensor cover to expose sensor components.
2. Disconnect thermocouple wires from terminals C and D on the sensor board.
3. Remove the screw from the thermocouple mounting tab (save the screw for installing the new thermocouple).
4. Pull the thermocouple straight up and remove it from the furnace.
5. Insert the new thermocouple into the slot in the top of the furnace. It should go in freely; if necessary, wiggle a little to position without forcing it in. The thermocouple should be near, but not touching, the cell housing or furnace heater coil.
6. Put the screw back in to the thermocouple mounting clamp. This secures the thermocouple to the furnace
7. Attach the thermocouple wires to terminals C and D on the sensor board, observing polarity (yellow wire to terminal C, red wire to terminal D).
8. Disconnect the furnace wires from sensor board terminals R and S. Using an ohm meter, check for short circuits of the heater coil to the metal thermocouple sheath. Check that neither furnace lead is short circuited to the metal furnace cover. The resistance should be infinite. If you measure a short circuit, loosen the screw that secures the thermocouple and relocate slightly until resistance is infinite.

NOTE

Before performing a primary calibration, first connect power to the sensor and allow it to heat up and stabilize (approximately one hour).

9. Perform a primary calibration.

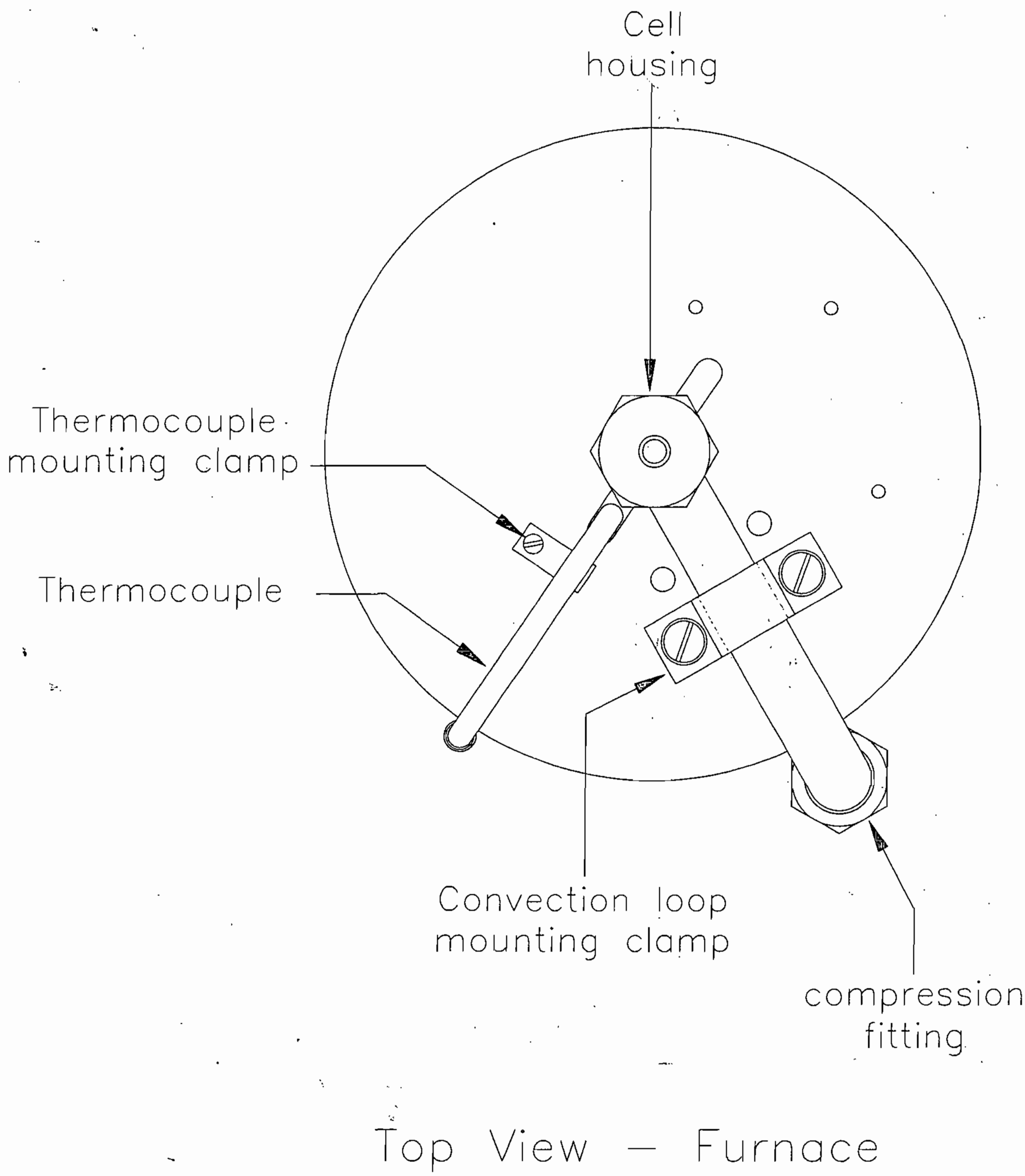


Figure 7-3. Thermocouple replacement.

Furnace Replacement

CAUTION

Disconnect power from the sensor and control unit and allow unit to cool before replacing parts inside the sensor.

To replace the furnace, do the following (see Figure 7-4):

1. Disconnect cell clips.
2. Remove the thermocouple from the furnace (see the "Thermocouple Replacement" section in this chapter for help).
3. Disconnect the furnace leads from terminals R and S on the sensor board.
4. Loosen the compression fitting on the underside of the cell housing and the union fitting on the convection loop return. To prevent stripping threads on any of the fittings, we suggest that you loosen each in turn at small increments - don't completely loosen the one fitting and then try to loosen the other fitting.
5. While holding the furnace in one hand, remove the convection loop mounting clamp being sure to save the mounting clamp for when you install the new furnace.
6. Gently pull the cell housing out of the furnace and remove the furnace.
7. Slip the new furnace onto the cell housing and attach the cell housing using the convection loop mounting clamp.
8. Remount the cell housing (reverse the actions taken in Step 4).
9. Reinstall the thermocouple (reverse the actions taken in Step 2).
10. Using an ohm meter, check for short circuits of the heater coil to the metal thermocouple sheath. Check that neither furnace lead is short circuited to the metal furnace cover. The resistance should be infinite. If you measure a short circuit, loosen the screw that secures the thermocouple and relocate slightly until resistance is infinite.
11. Reattach cell clips.
12. Reattach furnace leads (reverse the actions taken in Step 3).

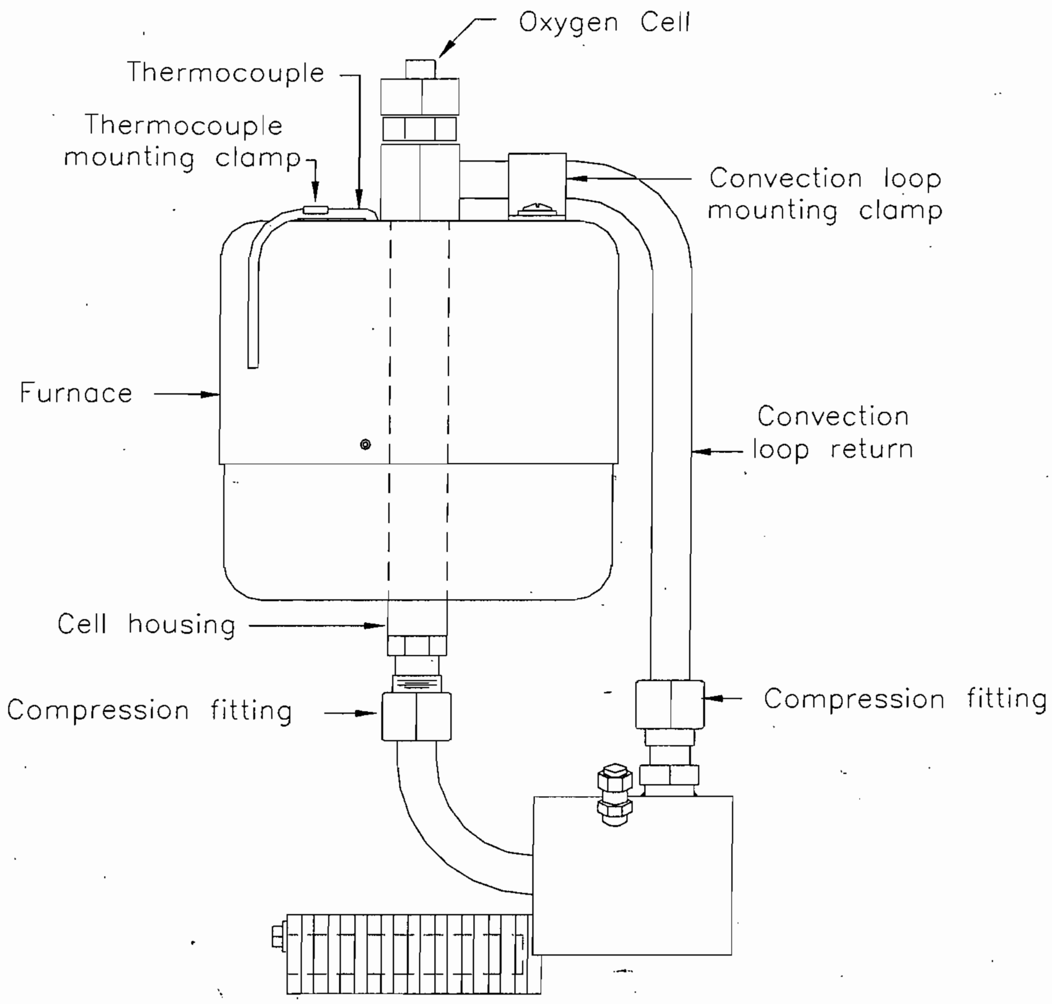


Figure 7-4.
Furnace replacement.

Combustibles Detector Replacement

NOTE

Always use a backup wrench when working on sensor plumbing.

This section shows you how to replace a hot-wire style combustibles detector.

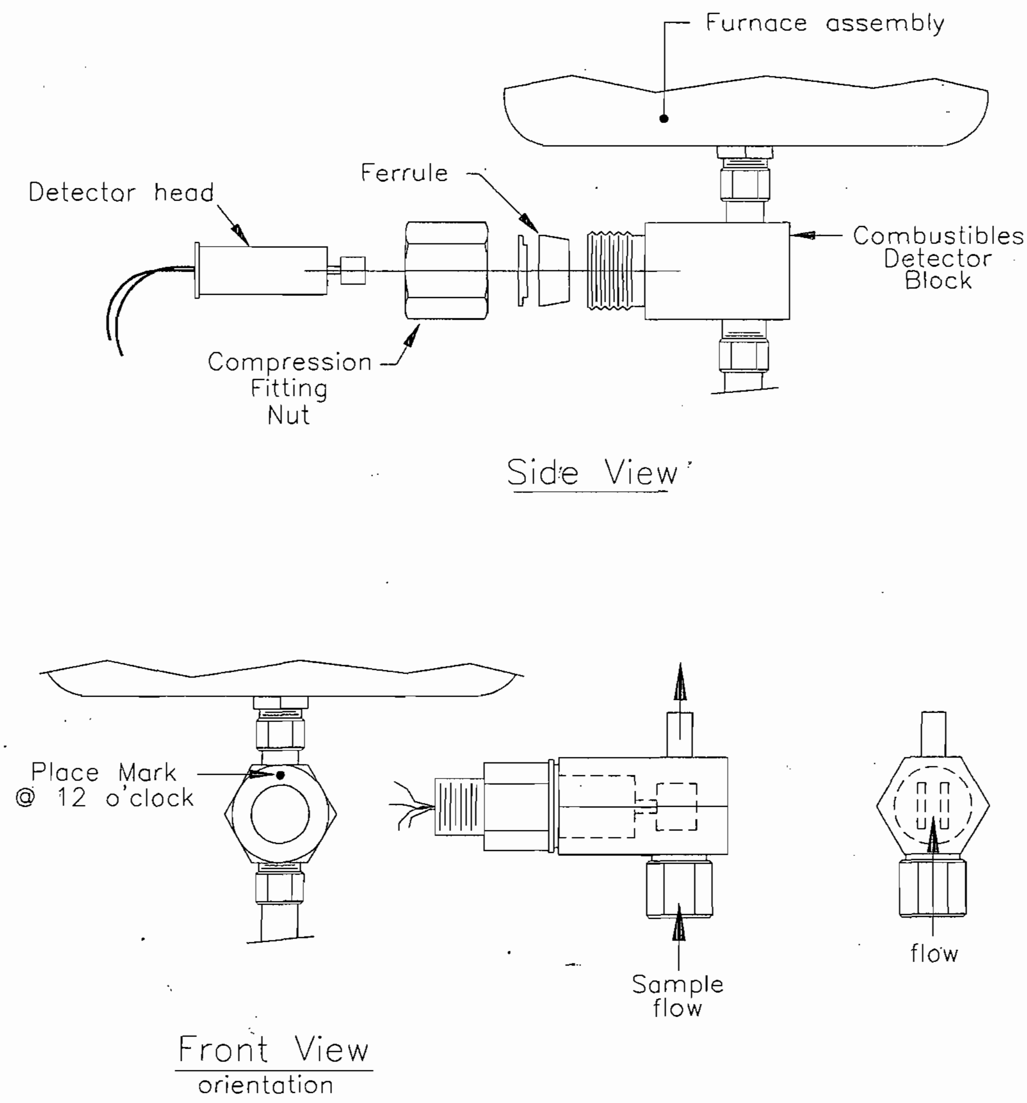


Figure 7-5.
Combustibles detector replacement (Hot-Wire).

Hot-Wire Combustibles Detector Replacement

To replace a hot-wire style combustibles detector, do the following (see Figure 7-5):

1. Remove the detector leads from terminal strips E, F, H, and I on the sensor board.

2. Loosen the compression fitting nut that holds the combustible detector in place and remove the detector from its housing. Save the nut from the detector because you will need it when installing the new combustibles detector.

3. It is very important that you orient the new combustibles detector correctly inside the combustibles detector block (sample flow path must contact both detector leads at the same time). To do this, place a mark on the edge of the combustibles detector at the 12 o'clock position once you have determined the correct orientation (see Figure 7-5 for correct orientation - detector elements should be placed in detector block vertically).

4. Install the new combustibles detector with nut and ferrules. Be extremely careful not to damage the detector elements when installing. Ensure that the mark you made in Step 3 is in the 12 o'clock position to ensure proper orientation of the combustibles detector in the combustibles detector block.

5. Reconnect the detector leads to the sensor board. The active element wires are labeled "A" and "AC", and they connect to terminals E and F on the sensor board (polarity not required).

Box Heater Diagram

Figure 7-6 shows how to wire box heaters using the sensor board.

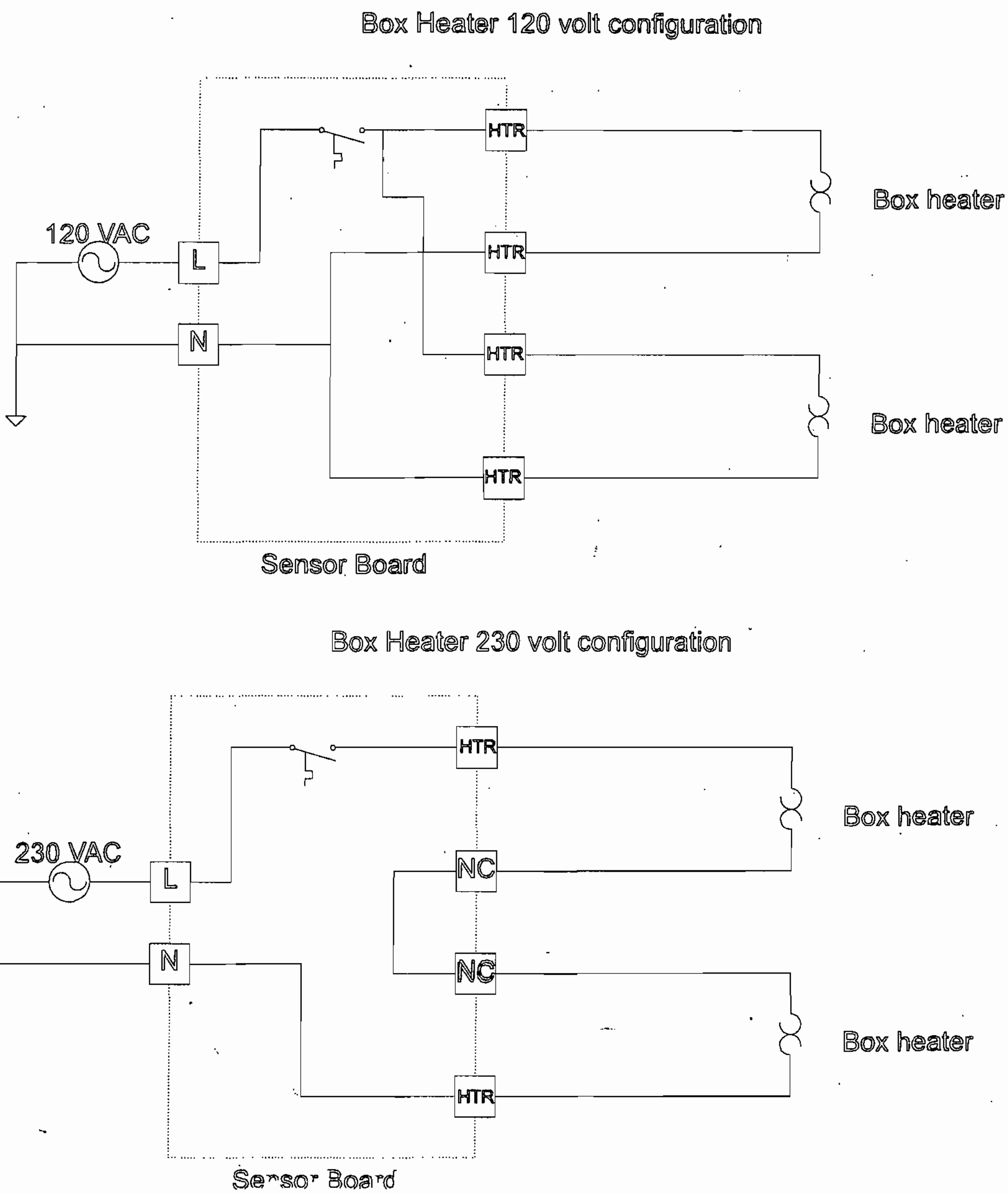


Figure 7-6.
Box heater diagram.

RCU Solenoid Valve Replacement

Figures 7-7 and 7-8 show the location of the zero and span solenoid valves on the O_2-only and combustibles remote calibration unit.

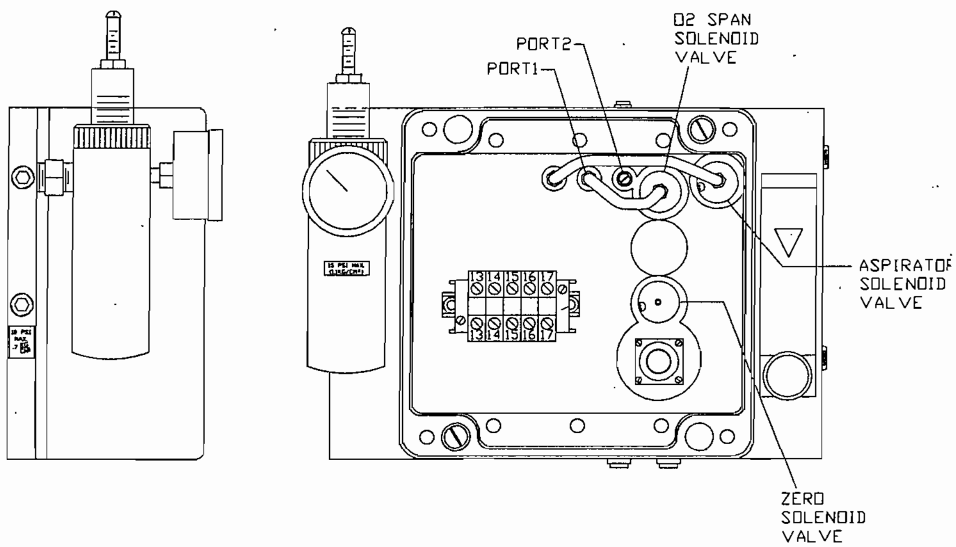


Figure 7-7. Solenoid valves on O_2-only RCU.

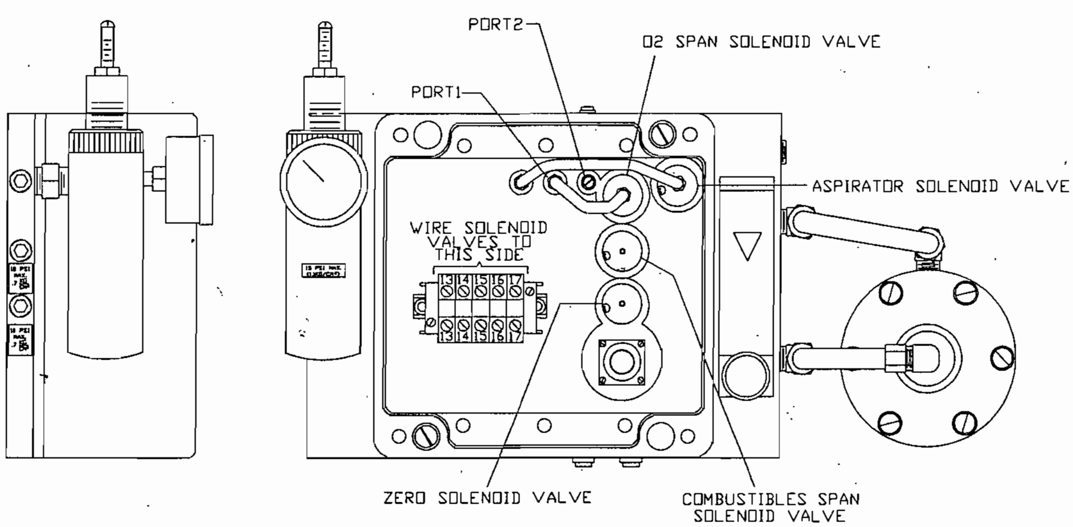


Figure 7-8. Solenoid Valves on combustibles RCU.

Replacement Parts List

Sensor

Furnace Assembly	P/N 70409SE
Type "K" Thermocouple	P/N 71697KE
Combustibles Detector Kit (hot wire)	P/N 70986TE
Sensor Board	P/N 80471SE
Zirconium Oxide Cell	P/N 71063SE

Remote Calibration Unit (RCU)

Air Regulator	P/N 39003JE
Regulator Gauge	P/N 37013JE
Aspirator Air Solenoid Valve	P/N 36022JE
Oxygen Span Gas Solenoid Valve	P/N 36034JE
Calibration Gas Solenoid Valve	P/N 36023JE
Flow Meter (O2-Only RCU)	P/N 37030JE
Flow Meter (Combustibles RCU)	P/N 37020JE

Control Unit

Display Module	P/N 90219VE
Power Supply/Keypad Module	P/N 90253VE
Auto Calibration Card	P/N 80436SE
Backplane Assembly	P/N 80439SE
Wiring Card (O2 Only)	P/N 80457SE
Wiring Card (O2 & Comb)	P/N 80466SE
Processor Board	P/N 80440SE
Display	P/N 42373JE

When ordering, provide the serial number of your analyzer to ensure proper parts are ordered:

AMETEK
Process & Analytical Instruments Division
150 Freeport Road
Pittsburgh, PA, USA 15238
Phone: (412) 828-9040 Fax: (412) 826-0399

SERIAL COMMUNICATIONS

Communication Protocol

Communicating to the Series 2000 control unit through the RS-485 connection requires the following communication parameter settings:

- 8 data bits
- 1 stop bit
- No Parity

In addition, the baud rate of the Series 2000 must match the baud rate of the host device. Baud rates are user-programmable. See the "Communication" section in Chapter 4 for help on defining control unit baud rates.

The communication protocol is a basic master/slave, command/response protocol. The master initiates each communication transfer. There is one master on the communication line, but there can be multiple Series 2000s acting as slaves. Up to 32 sensors can be connected on one network.

Command Message Format

Start Character	Node Address	Command Letter	Data	Checksum	End Character
">" (ASCII character 3E Hex)	2 hex ASCII characters (00 to FF)	(See Command Section for list of commands)	(n characters- depends on command)	2 hex ASCII characters (sum of all preceding characters except the ">" character)	carriage return ASCII character 00 Hex)

The command message format is as follows:

Where:

The **Start Character** is the greater than character (">", which is ASCII hexadecimal character 3E).

The **Node Address** is from 00-FF, and is represented as two hex ASCII characters. Each Series 2000 has a unique node address (see the "Communication/Node Address" section in Chapter 4 for help on specifying node addresses for Series 2000 control units). Note, however, that the maximum number of Series 2000 control units that can be connected on the network is 32.

The **Command Letter** is from ASCII A-Z (upper case only).

Data is a string of characters whose meaning depends on the command (see below) and where the number of characters returned also depends on the command. Limit is 20 characters. The **Checksum** is the sum of all the preceding characters (excluding the >> character) - modulo 256.

The **End Character** is a carriage return (equivalent to ASCII character 00 hex).

NOTE

The system disables any checking of the checksum if the checksum character is equal to ?? (?? is equivalent to 2 ASCII 3FH hex characters). This makes testing by the programmer easy, but it is strongly recommended that the integrity check is enabled in the final system.

General Serial Communication Commands

This section provides general serial communication commands. Programming commands and factory setup commands are provided later in this chapter. Normally, you will use these general serial communications commands.

Read Number (F)

This command allows you to read the value of a variable stored in the Series 2000. The data section of this command is a number from 00-FF. These numbers correspond to the type of variable you want to read. The Variable Table shown in FigureA-1 provides a list of these variables and their location codes. If a variable is selected beyond the end of the Variable Table shown, an error will be returned. The value returned is followed by a text string for the units, where applicable.

Example:

Request oxygen with the following string: >FEF0536<CR>
Returned string : A20.9 %O2D4

Write Number (H)

This command allows you to set a value for the Series 2000 control unit. The data section of this command is a two digit hex number (00-FF) to point to the location to write from the variable table (see Figure A-1), followed by the value of the variable. A simple acknowledge is returned if the command was accepted.

Read Date and Time (M)

This command is used to read the dates and times stored in the Series 2000. The data consists of a single digit where 0 is used to read the current date and time, 1 is used to read the date and time of the last calibration, and 2 is used to read the date and time of the last verification. Date and time is returned as mm/dd/yy hh:mm in 24 hour (military) time.

Set Date and Time (N)

This command is used to set the Series 2000 current date and time. The data string is of the form: mm/dd/yy hh:mm in 24 hour (military) time. Leading zeroes are required, for example: 03/18/93 20:02.

Development Serial Communication Commands

These commands are used during initial serial communication design.

Echo (A)

The echo command is used to test the serial protocol and line integrity. Any text sent to the Series 2000 is echoed back to the host.

Bad Command (B)

Just returns a bad command (error code 01) reply.

Acknowledge (C)

Returns a simple acknowledge. This command can also be used later to check that the Series 2000 is on-line and ready to communicate.

Data Format (J)

This command is used to check how data is output through the serial link. For each variable that is accessible through the Read Number and Write Number commands, a string is returned that describes the format of the number. This response data consists of three characters:

Format	Access	Location

Where format is:

F Float
H Hexadecimal
U Unsigned decimal

Access is as follows:

r read only
w write only
b read/write

Location is:

r RAM
e EEPROM

Due to the nature of EEPROM memory, each location in the memory has a limited number of writes allowed (approximately 10,000). The location character can be used to determine where the data is stored internally to the Series 2000 and act accordingly.

Command List

This section provides the command letters you can use.

Letter	Description
A	Echo
B	Bad Command
C	Acknowledge
F	Read Number
G	Calibrate
H	Write Number
J	Data Format
M	Read Date and Time
N	Set Date and Time

Responses

A Series 2000 returns a variety of responses that can be broken into two categories: success and failure.

Success

All successful responses start with an A. If there is data returned, it will follow the A and have a checksum after it. All responses end with a carriage return.

Success A	End <CR>

Success	**Data**	**Checksum**	**End** Character
A	(n characters)	(2 hex ASCII characters)	<CR>

Examples:

A <CR>
Simple acknowledge

AFF0050<CR>
Acknowledge with data

Failure

All failure responses start with a N followed by a two hex digit failure code and a carriage return.

Failure	**Failure Code**	**End Character**
N	(2 hex ASCII characters)	<CR>

Failure Codes are as follows:

Failure Code	Description
01	Bad command letter
02	Bad checksum
03	Input overrun in serial communication
05	Parameter out of range
08	Error in receipt of a character
09	Cannot calibrate/verify now
0A	Internal error
0B	Illegal access (read-only variable)

Variable Table

Figure A-1 provides a summary of the variable locations, names, and descriptions available. If you need access to more advanced variables, please call AMETEK.

Location	Name	Description	Read/Write	*Format
00	Flags_3	(see Table A-2)	Read Only	H (1 byte)
01	Inf_mess_flag...	(see Table A-3)	Read Only	H (2 bytes)
02	Config_flags	(see Table A-4)	Read/Write	H (2 bytes)
03	Iout_flags	(see Table A-5)	Read/Write	H (2 bytes)
04	Probe_type	Type of probe connected to system	Read/Write	U (0 = Insitu 1 - WDG-IV 2 = HP 3 = TM2000
05	Line1_flg	Display Line #1	Read/Write	U (0 = off 2 = % O2 4 = cell temp 6 = cell mv 8 = t/c mv 10 = date/time 12 = user text 14 = methane 16 = comb 18 = cmb/meth)
06	Line2_flg	Display Line #2	Read/Write	
07	Line3_flg	Display Line #3	Read/Write	
08	Oxygen	% oxygen reading	Read Only	F (2 dp)
09	(reserved)			
0A	(reserved)			
0B	Cell_temp	Cell temperature	Read Only	F (1 dp)
0C	Cell_mv	Cell millivolts	Read Only	F (2 dp)
0D	Tc_mv	Thermocouple mv	Read Only	F (2 dp)
OE - 5E	(reserved)			
5F	Gas_Ctr	(see Table A-6)	Read Only	H
60	CalFlag	(see Table A-7)	Read Only	H

* F = Float, H = Hex, U = Unsigned decimal, dp = decimal places

Figure A-1.
Main Variable Table.

Bit	Description	Read/Write	Format
0	sensor at op temp	Read Only	1 = true 0 = false
1	over/under temp	Read Only	1 = true 0 = false
2	inject cal gas active	Read Only	1 = true 0 = false
3	auto cal is active	Read Only	1 = true 0 = false
4	auto verify is active	Read Only	1 = true 0 = false
5	reserved	Read Only	1 = true 0 = false
6	reserved	Read Only	1 = true 0 = false
7	cal/verify not permitted	Read Only	1 = true 0 = false

Figure A-2.
Flags_3 variable table.

Bit	Description	Read/Write	Format
0	temperature rise failure	Read only	1 = true 0 = false
1	cell is over temperature	Read only	1 = true 0 = false
2	zero gas range error	Read only	1 = true 0 = false
3	span gas range error	Read only	1 = true 0 = false
4	primary calibration	Read only	1 = true 0 = false
5	memory is corrupted	Read only	1 = true 0 = false
6	excessive cal error	Read only	1 = true 0 = false
7	calibration required	Read only	1 = true 0 = false
8	thermocouple failure	Read only	1 = true 0 = false
9	thermocouple compensation failure	Read only	1 = true 0 = false
10	verify aborted	Read only	1 = true 0 = false
11	calibration aborted	Read only	1 = true 0 = false
12	system verifying	Read only	1 = true 0 = false
13	system calibrating	Read only	1 = true 0 = false
14	auto verify pending	Read only	1 = true 0 = false
15	auto cal pending	Read only	1 = true 0 = false

Figure A-3.
Inf_Mess_flag variable table.

Bit	Description	Read/Write	Format
0	relay energize on alarm	All Read / Write	1 = true
1	auto cal time is set		1 = true
2	auto cal timer enabled		1 = false
3	real time clock is set		1 = true
4	reserved		N/A
5	auto verify time is set		1 = true
6	auto verify timer enabled		1 = false
7	auto cal cycle programmed in hrs/days		1 = hours 0 = days
8	auto verify cycle programmed hrs/days		1 = hours 0 = days
9	auto cal option is installed		1 = true
10	combustibles module installed		1 = true 0 = false
11	reserved		N/A
12	reserved		N/A
13	type of combustibles detector		1 = RTD 0 = Hot Wire
14	hplI/wdg style sensor		1 = WDG 0 = HP
15	combustibles is ppm or %		1 = percent 0 = ppm

Figure A-4.
Config_flags variable table.

Bit	Description	Read/Write	* Format
0	track/hold output #1 during cal	All Read/Write	1 = track 0 = hold
1	track/hold output #1 during verify		1 = track 0 = hold
2	current mode select for output #1		1 = 0-20 mA 0 = 4-20 mA
3	reserved		N/A
4	track/hold output #2 during cal		1 = track 0 = hold
5	track/hold output #2 during verify		1 = track 0 = hold
6	current mode select for output #2		1 = 0-20 mA 0 = 4-20 mA
7	reserved		N/A
8	track/hold output #3 during cal		1 = track 0 = hold
9	track/hold output #3 during verify		1 = track 0 = hold
10	current mode select for output #3		1 = 0-20 mA 0 = 4-20 mA
11	reserved		N/A
12	track/hold output #4 during cal		1 = track 0 = hold
13	track/hold output #4 during verify		1 = track 0 = hold
14	current mode select for output #4		1 = 0-20 mA 0 = 4-20 mA
15	reserved		N/A

Figure A-5.
I_out Flags variable table.

0	In Span
1	In Zero
80	Recovery time after calibration
7F	Delay period after a primary calibration

Figure A-6.
Gas_Ctr variable table (Position in cal/verify state)

0	In Calibration
1	In Verify
2	In primary calibration
3	Normal System Operation (no calibration)

Figure A-7.
Cal Flag variable table (Cal/Verify state)

Sample Program

This section provides a sample Quick Basic program that reads and writes to the serial port.

```
DECLARE FUNCTION Checksum$ (M$)
Serial test routine' Continuously sends a message and prints the string
returned
CLS
'Open the communications port
OPEN "COM2: 9600,N,8,1 " FOR RANDOM AS #1
'String to be echoed
T$ = "Test Message"
'Address of the Series 2000
Address% = 254
'Build the message
M$ = ">>" + HEX$(Address%) + "A" + T$
M$ = M$ + Checksum$(M$)
'Continue sending message until key pressed
' (Assumes that Series 2000 analyzer is connected)
WHILE (INKEY$ = "")
PRINT #1, M$
LINE INPUT #1, A$
'Show results
PRINT "Sent......"; M$
PRINT "Returned..."; A$
PRINT
WEND
CLOSE #1
STOP
FUNCTION Checksum$ (M$)
DIM Sum AS LONG
Sum = 0
'Skip FOR i% = 2 TO LEN(M$)
Sum = Sum + ASC(MID$(M$, i%, 1))
NEXT i%
'Get low byte of checksum
Checksum$ = HEX$(Sum MOD 256)
END FUNCTION<P255D>
```

Starting/Monitoring a Calibration: An Example

This section provides an example of how to initiate and then monitor a calibration.

1. Check that no calibration or verification is currently occurring by checking the Calflag variable- see Figure A-7 (Calflag=3).

2. Send the Calibrate command to the Series 2000 (GO).

3. If an acknowledge is returned (A<cr>), the calibration command is accepted. If not accepted the sensor may not be at a proper operating temperature or may already be performing a system calibration.

4. Read the Gas_ctr variable (see Figure A-6) to determine the position in the calibration cycle. Use this variable to determine when to activate solenoids (if not controlling solenoids using the Series 2000).

5. Read the Cal_flag variable (see Figure A-7) to determine when the cal cycle is finished (Calflag=3).

6. Read the calibration values (for example, cal_span and cal_zero variables).

MENU OPTION CHARTS

SETUP KEY MENU OPTIONS	FUNCTION/OPTIONS
Display	Select info for Display line 1. Select info for Display line 2. Select info for Display line 3.
Passwords	Create a system password.
Process Pressure	Select positive or negative process pressure. Enter process pressure value.
System Tests	Perform internal diagnostics on Series 2000.
System Serial #	View Serial # for Series 2000. View Mfg. # for Series 2000.
Primary Calibration	Performa an automatic, remote, or manual primary calibration.
Sensor Configuration	Select sensor type.
Communications	Define communication parameters.
Combustibles	Define combustibles scale (% or PPM). Define combustible detector type.

Figure B-1.
Setup Key Menu

CALIBRATE KEY MENU	FUNCTION/OPTIONS
Initiate Cal/Initiate Verify	Start an automatic, remote, or manual calibration.
Cal/Verify Data	View latest calibration and verify data.
Cal Gas Values	Enter calibration gas values
Inject Cal Gas	Set pressure and flow of RCU gases without performing a calibration.
Set Cal Timers (applies only for auto cal operations with RCU, except for setting time and date)	- Set control unit time/date. - Enable or disable auto cal cycles. - Set cal gas times for auto cal/verify operations. - Define recovery durations after a cal/verify.

Figure B-2.
Calibrate Key menu.

ANALOG RANGE KEY MENU	FUNCTION/OPTIONS
Set Track/Hold	- Hold output at last process reading during a cal or verify - Track calibration readings during a cal or verify
Set Current Mode	- 0 to 20 mA - - 4 to 10 mA
Select Function	- % O2 - Cell Temperature - Cell Millivolts - Thermocouple Millivolts - Combustibles (option)
Set Current Range	Range of readings that the analog output represents. (for example: 4% O2 = 4 mA 10% O2 = 20 mA)
Output Filtering	Smooth out variations in readings.

Figure B-3.
Analog Range Key menu.

Alarm Key Menu	Menu Options	
Alarm Set Points	Alarm 3 Value Alarm 5 Value	Alarm 4 Value Alarm 6 Value
Alarm Configure (for alarms 3 and 4)	High O_2 Low O_2	
Relay Configure	Energize on Alarm De-energize on Alarm	
Select Function (for alarm 3)	% Oxygen Start of Calibration Start of Verify Start of a Calibration or Verify	
Exception Log	N/A	

Figure B-4.
Alarm Key menu.

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CURRENT OUTPUTS: OTHER APPLICATIONS

This appendix describes how to do the following:

- Modulate external power loop using current outputs.
- Power current outputs from an external power supply.

Powering Current Outputs from an External Power Supply

The Series 2000 control unit wiring card contains a set of terminals that can be used to connect an external voltage source to power the standard current outputs:

VEXT1, 2 +
VEXT1, 2 -

Jumper JP2 on the Series 2000 control unit display module is used to allow you to define which power source to use. If JP2 is in (factory default), the control unit uses the internal supply to power the current output circuits. If you try to use an external voltage at this time, the system will use whichever voltage is higher - control unit voltage is normally about 28 volts. If the JP2 jumper is removed, the external voltage source must be used to power the current output circuits. The external voltage source must be no greater than 30 volts DC. See the "Option Card Installation" section in the Installation Chapter for information on how to access or remove the display module.

To determine the minimum external voltage supply required to power the current outputs, use the following formula:

VEXTmin = .02 amps (RLoad + Rwires) + 4 volts

where:

VEXTmin = the minimum external voltage required to power current output circuit
RLoad = the load resistance of the current output device
Rwires = the resistance of the wires

NOTE

Skip this section if you don't measure combustibles.

In addition, both of the combustibles current outputs have external voltage options:

VEXT3+	VEXT4+
VEXT3-	VEXT4-

Jumper JP1 on the combustibles card allows you to define which power source to use for current output 4. Jumper JP2 on the combustibles card allows you to define which source to use to power current output 3. If the jumper is in (factory default), the control unit uses its own power supply to power the current output circuits. If you try to use an external voltage at this time, the system will use whichever voltage is higher - control unit voltage is normally about 28 volts. If the jumper is removed, the external voltage source must be used to power the current output circuits. The external voltage source must be 30 volts DC or less.

To determine the minimum external voltage supply required to power these circuits, use the same formula as provided for the O2 current output external voltage source described in the previous section. Modulation can also be done in the same manner as IOUT1 or IOUT2.

Modulation of External Power Loop Using Current Outputs

Figure C-1 shows an example of the connection method when you want to produce a modulated current loop from an external power supply and a load device. All current output channels (IOUT1 and IOUT2) can be connected in the same manner as shown in this figure.

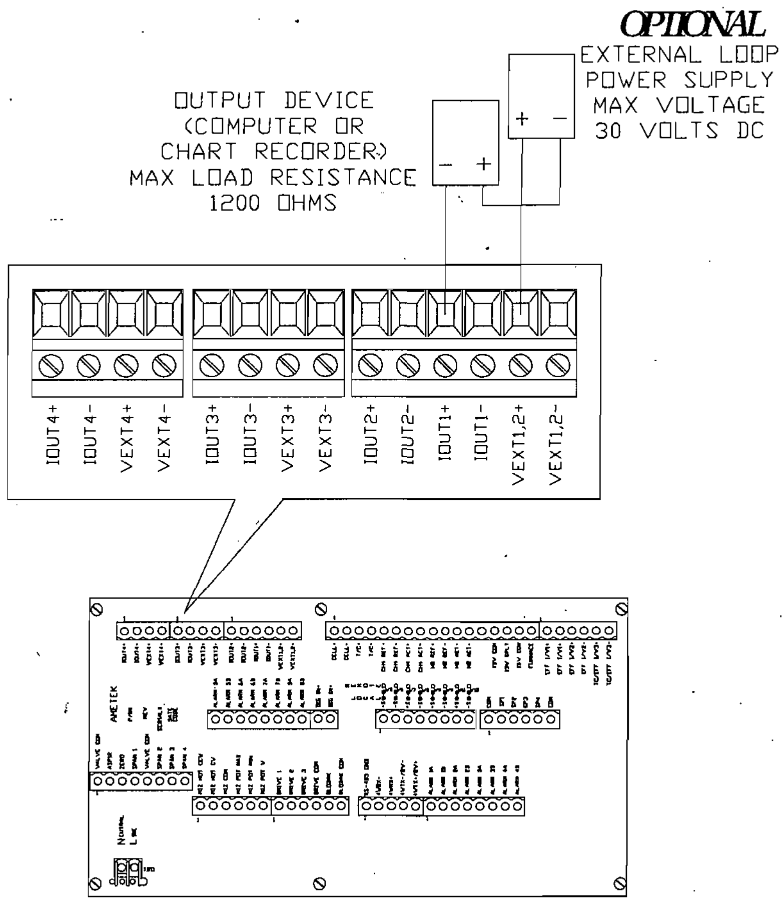


Figure C-1. Modulation of external power supply.

IOUT1 and IOUT2 must share the same power supply if both of these channels are used, or two power supplies can be "ORed" together using a diode from each power supply positive terminal (diode anode to power supply) to the VEXT1,2+ terminal. The power supply minuses would be tied together and connected to one side of the both loads. The other side of one of the loads would be connected to IOUT1+ terminal, and the other side of the other load would be connected to the IOUT2+ terminal.

For each current output channel used in a current loop modulation application, the jumpers should be removed for that channel.

NOTE

Skip this section if you don't measure combustibles.

In addition, both of the combustibles current outputs can be used in a modulation scheme using the following:

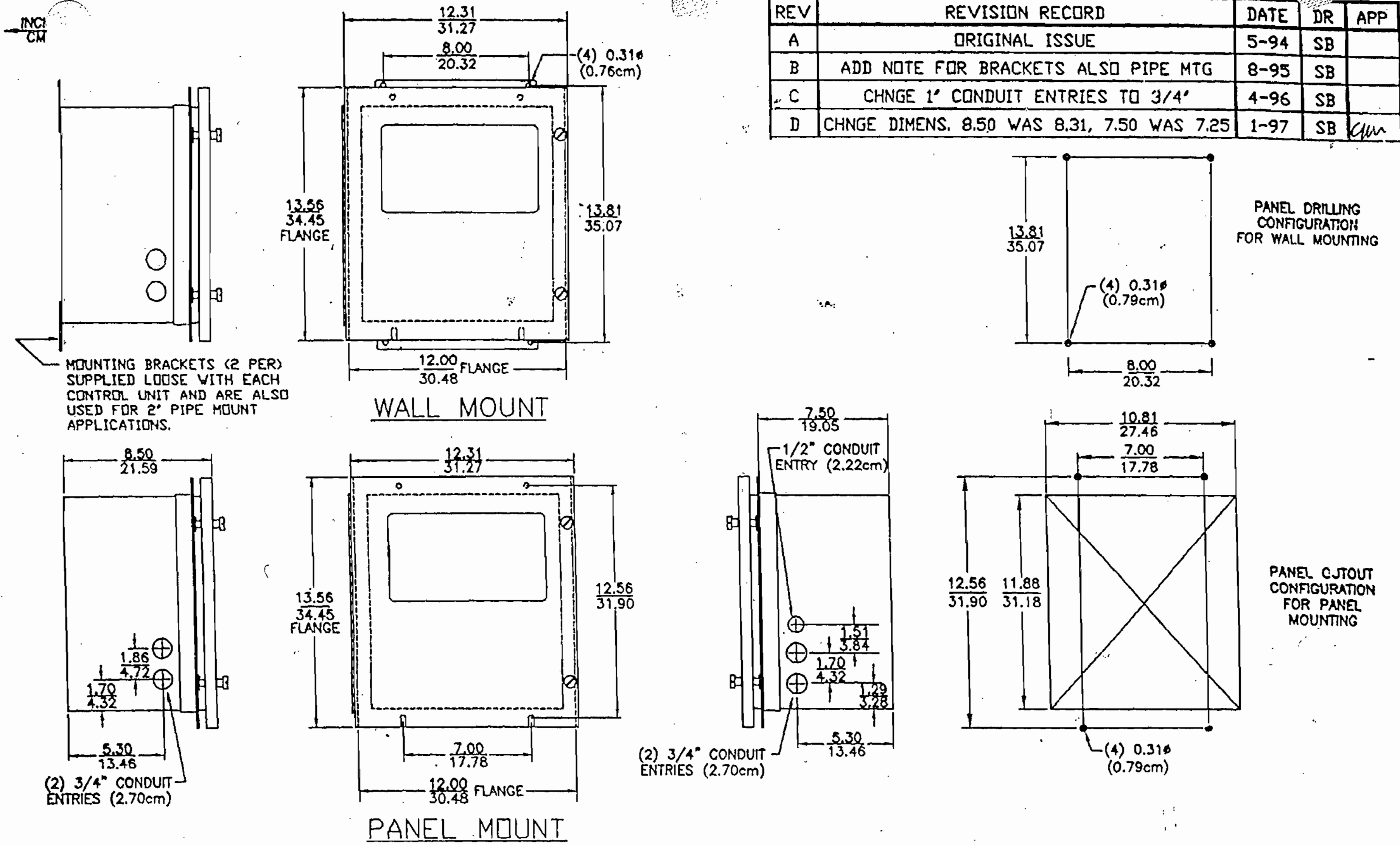
VEXT3+	VEXT4+
VEXT3-	VEXT4-

DRAWINGS AND CUSTOM INSTRUCTIONS

This appendix provides any custom drawings or instructions you may have ordered in addition to the standard WDG analyzer. If you didn't order any custom options, the standard Interconnect Drawing is provided.

If you did order any special options, the drawings or special instructions provided here supercede any drawing or options provided elsewhere in this manual.

REV	REVISION RECORD	DATE	DR	APP
A	ORIGINAL ISSUE	5-94	SB	
B	ADD NOTE FOR BRACKETS ALSO PIPE MTG	8-95	SB	
C	CHNGE 1" CONDUIT ENTRIES TO 3/4"	4-96	SB	
D	CHNGE DIMENS. 8.50 WAS 8.31, 7.50 WAS 7.25	1-97	SB	Cm

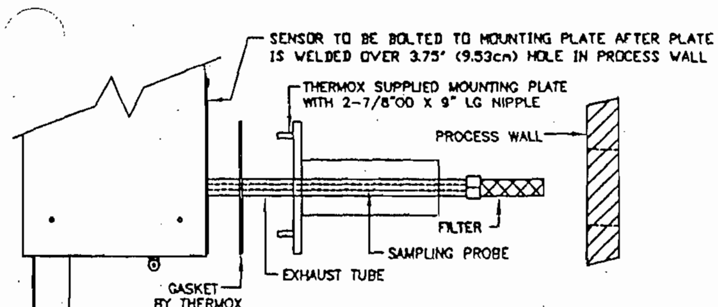


PRODUCT LINE THERMOX	CONFIDENTIAL REPRODUCTION PROHIBITED WITHOUT PERMISSION BY AMETEK P & AI DIVISION		AMETEK PROCESS & ANALYTICAL INSTRUMENTS DIVISION — AMETEK PROCESS & ANALYTICAL INSTRUMENTS DIVISION, 150 FREEPORT ROAD, PITTSBURGH, PENNSYLVANIA 15238 USA
	DRAWN BY	SB	5-19-94
	DOC. CONT.	SP	1-30-97
TOLERANCES ANGLE ± 30'	ENGR. APPR.	Cm	1-30-97
INCH/CM = ±1/8"/.125 / .3175	ORIG. ISSUE	CM	5-19-94
	SCALE NTS	SHEET 1 OF 1	

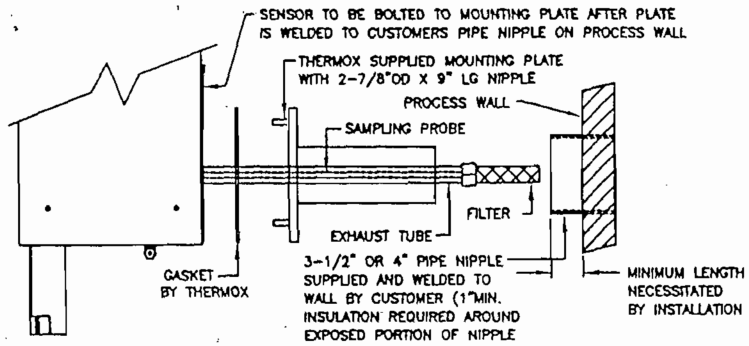
2000 CONTROL ENCLOSURE WALL/PANEL MOUNT

SIZE A — DRAWING NO. 203-367 — REV. D

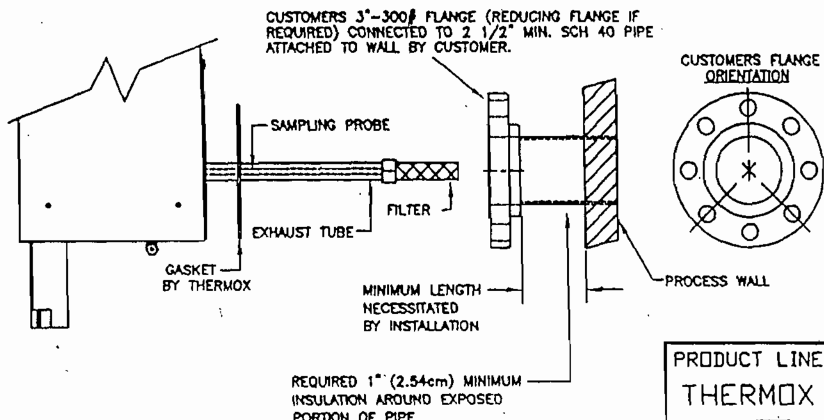
REV	REVISION RECORD	DATE	DR	APP
A	ORIGINAL ISSUE	3-96	SB	
B	REMOVE ASP AIR REG AND GAUGE	4-97	SB	
C	ADD 3"-300# MOUNTING FLANGE DETAIL	8-10-01	SB	[signature]



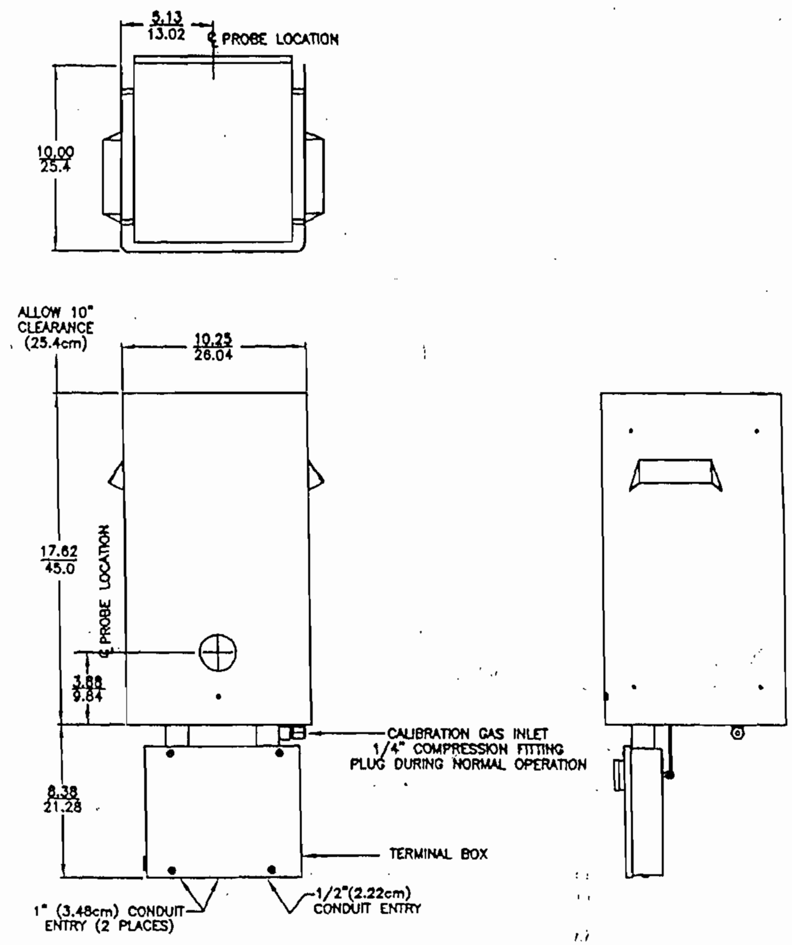
DIRECT MOUNTING



PIPE NIPPLE MOUNTING



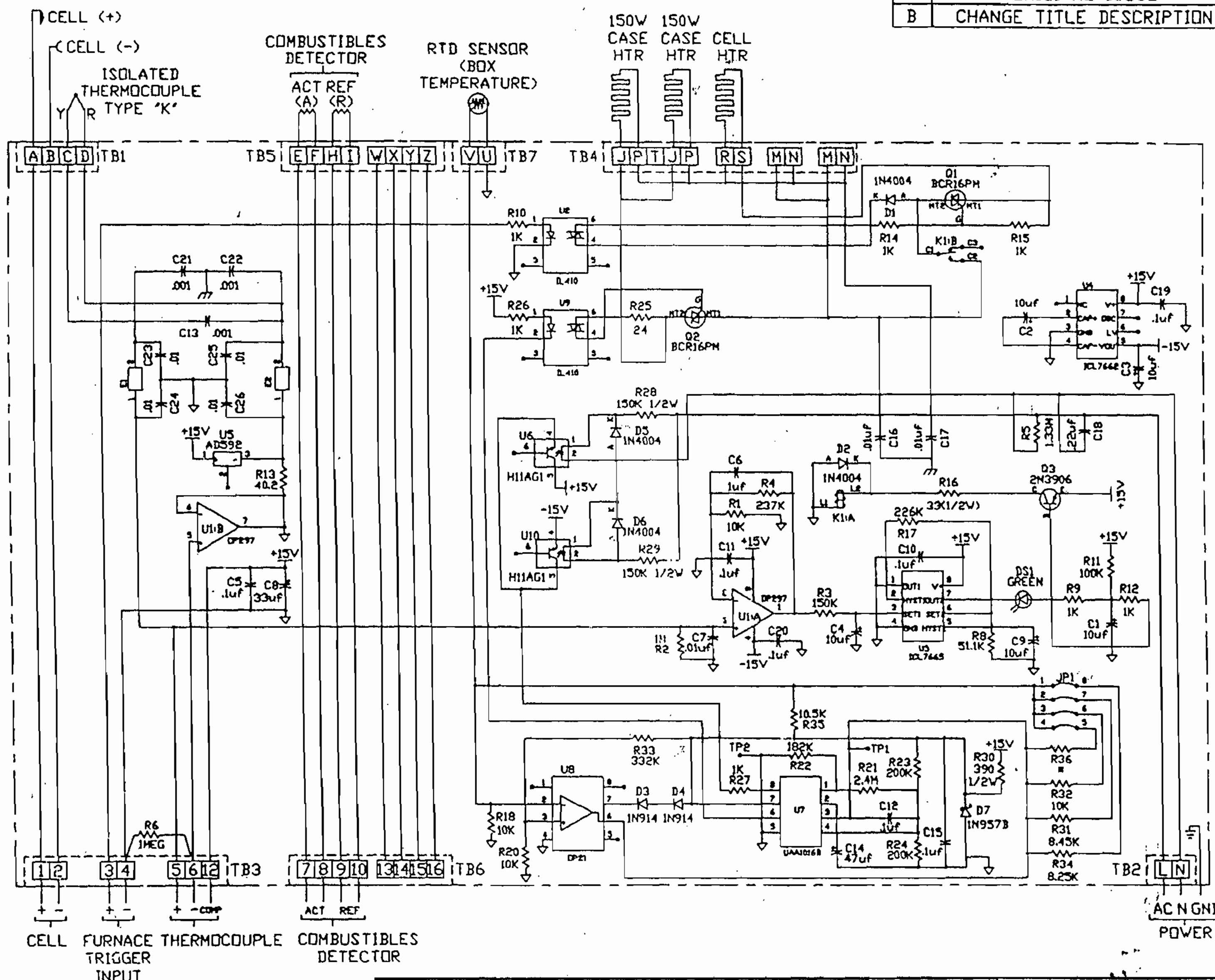
3"-300# FLANGE MOUNTING



INCH / CM

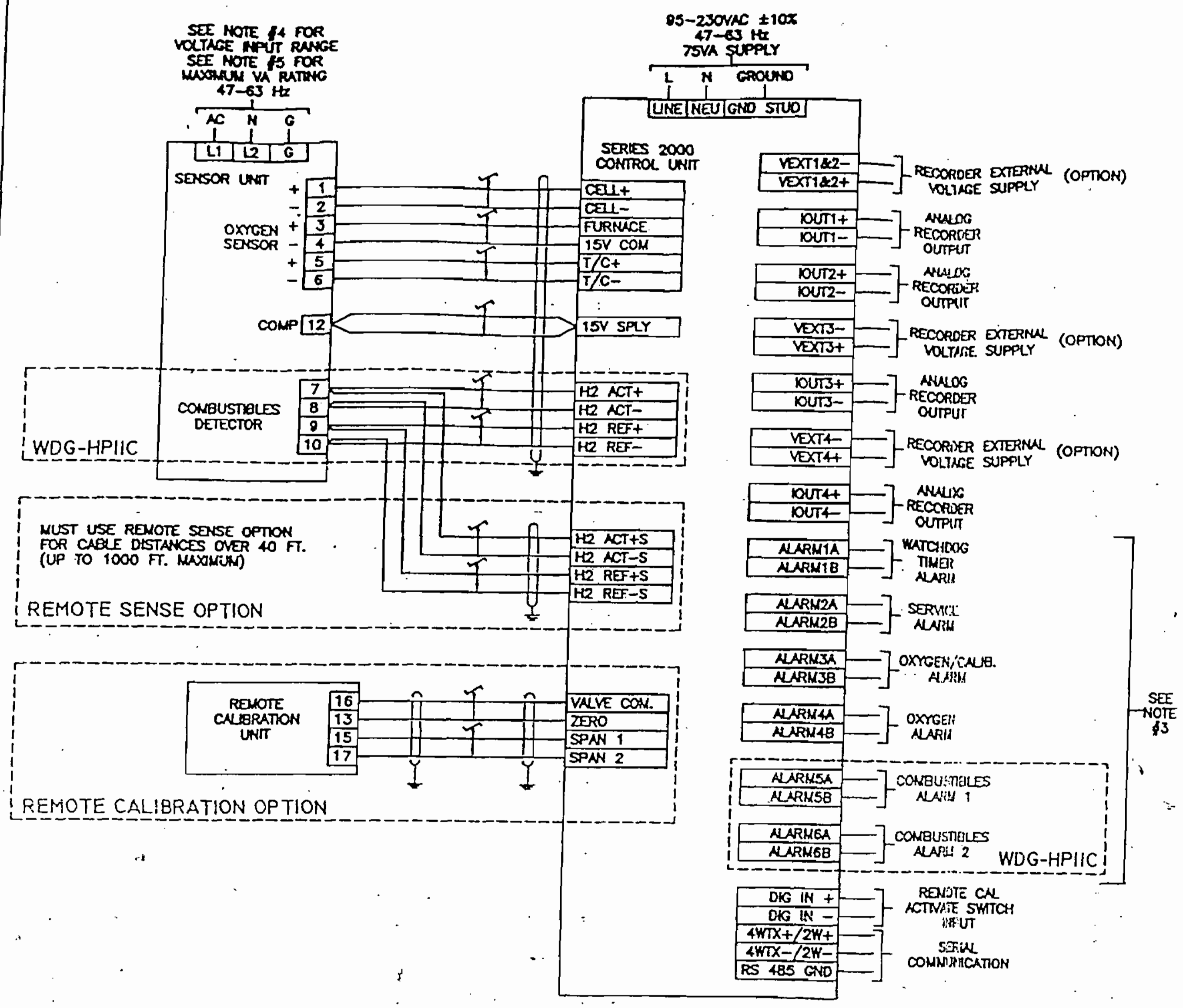
PRODUCT LINE	CONFIDENTIAL		AMETEK PROCESS & ANALYTICAL INSTRUMENTS DIVISION
THERMOX	REPRODUCTION PROHIBITED WITHOUT PERMISSION BY AMETEK P & AI DIVISION		AMETEK PROCESS & ANALYTICAL INSTRUMENTS DIVISION 150 FREEPORT ROAD PITTSBURGH, PENNSYLVANIA 15238 USA
	DRAWN BY SB	3-25-96	SENSOR, HP, FILTER PROBE MOUNTING AND DIMENSIONS
	DOC. CONT. [signature]	8-10-01	
TOLERANCES ANGLE ± 30' INCH/CM ± 1/8"/.125 .3175	ENGR. APPR. [signature]	08-10-01	
	ORIG. ISSUE CM	3-25-96	SIZE A — DRAWING NO. 202-489-14 — REV. C
	SCALE NTS	SHEET 1 OF 1	

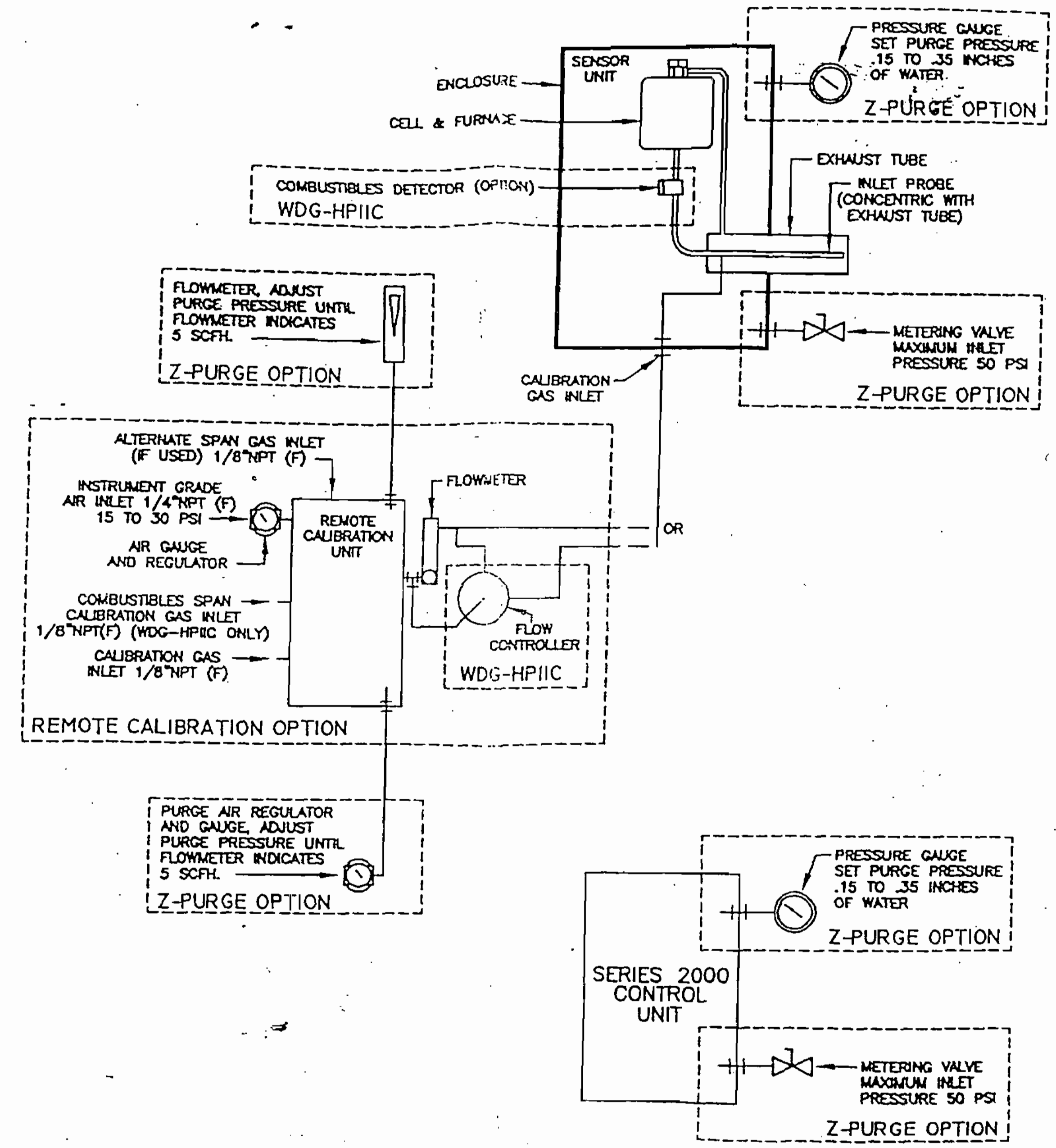
REV	REVISION RECORED	DATE	DR	APP
A	ORIGINAL ISSUE	3-25-96	SB	
B	CHANGE TITLE DESCRIPTION	7-12-96	SB	



PRODUCT LINE THERMOX	TOOL/FIXTURE-IN HOUSE ONLY	CONFIDENTIAL REPRODUCTION PROHIBITED WITHOUT PERMISSION BY AMETEK P & AI DIVISION	AMETEK PROCESS & ANALYTICAL INSTRUMENTS DIVISION — AMETEK PROCESS & ANALYTICAL INSTRUMENTS DIV. 150 FREEPORT ROAD PITTSBURGH, PENNSYLVANIA 15238 USA
TOLERANCES FRACTION ± 1/32 XX ± .010 XXX ± .005 ANGLE ± 30' SURFACE ROUGHNESS 125		DRAWN BY SB 3-25-96	WDG-HPIIC, CE, 115V WIRING INTERNAL SENSOR
		DOC. CONT. 7-15-96	
REMOVE BURRS AND BREAK SHARP EDGES		ENGR. APPR. 7-15-96	
MATERIAL		ORIG. ISSUE CM 3-25-96	SIZE A — DRAWING NO. 115-546 — REV. B
		SCALE NTS — SHEET 1 OF 1	

REV	REVISION RECORD	DATE	DR	APP
A	ORIGINAL ISSUE	1-29-96	SB	
B	CHANGE HZ AND VA SUPPLY	4-26-96	SB	
C	REMOVE "PURGE" FROM RCU REGULATOR	9-3-96	SB	
D	ADD VA RATING NOTE (NOTE #5)	11-18-99	SB	
E	CHANGE VA RATINGS (NOTE #5)	6-27-00	SB	





NOTES:

1. SEE INSTALLATION INSTRUCTIONS FOR WIRING CONSIDERATIONS.
2. PAIRS MUST BE KEPT TOGETHER AS SHOWN.
3. ALL ALARM CONTACTS ARE RATED AT 30V.
4. THE SENSOR IS CONFIGURED FOR EITHER 200-230VAC ±10% OR 95-120VAC ±10% AND NOT BOTH. THE SERIES 2000 CONTROLLER IS A UNIVERSAL DEVICE (95-230VAC ±10%, 47-63 Hz) SEE INSTRUCTION MANUAL FOR VOLTAGE INPUT RANGE.
5. MAXIMUM VA SUPPLY BY UNIT TYPE:
   - 120V LIFTOFF WDG-HPII, WDG-HPIIC = 600VA
   - 120V HINGED WDG-HPII, WDG-HPIIC = 600VA
   - 120V DIV.2 WDG-HPII = 600VA
   - 120V DIV.2 WDG-HPIIC = 650VA
   - 120V LIFTOFF FLOOR MOUNT WDG-HPII, WDG-HPIIC = 650VA
   - 230V LIFTOFF WDG-HPII, WDG-HPIIC = 1850VA
   - 230V HINGED WDG-HPII, WDG-HPIIC = 1850VA
   - 230V DIV.2 WDG-HPII, WDG-HPIIC = 1900VA
   - 230V LIFTOFF FLOOR MOUNT WDG-HPII, WDG-HPIIC = 1900VA
6. WDG-HPII IS OXYGEN ONLY SYSTEM
   WDG-HPIIC IS AN OXYGEN AND COMBUSTIBLES SYSTEM
7. DASHED LINES DENOTE INCLUDED OPTIONS. SEE INSTRUCTION MANUAL FOR INCLUDED OPTIONS

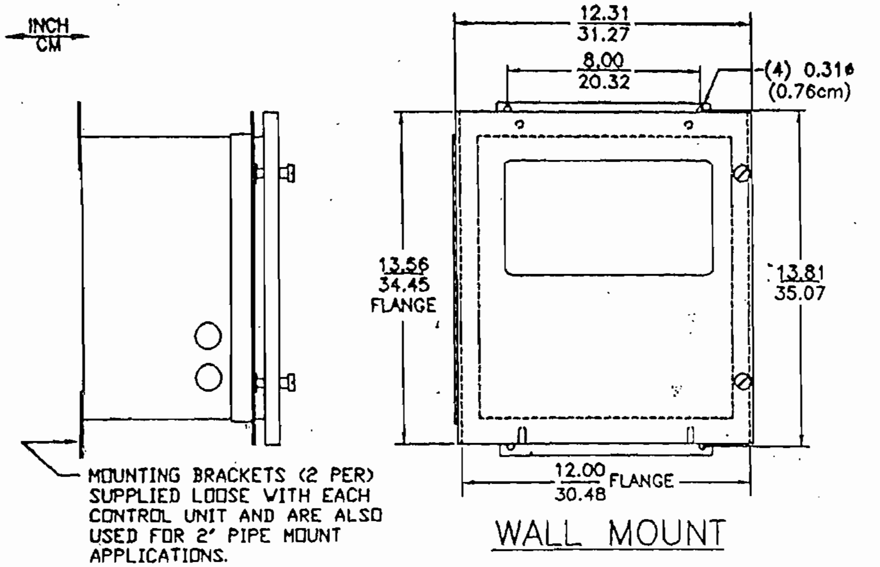
PRODUCT LINE: THERMOX	TOOL/FIXTURE-IN HOUSE ONLY	CONFIDENTIAL — REPRODUCTION PROHIBITED WITHOUT PERMISSION BY AMETEK P & A DIVISION	AMETEK PROCESS & ANALYTICAL INSTRUMENTS DIVISION
TOLERANCES: FRACTION ±1/64, XX ±.010, XXX ±.005; ANGLE ±30'; SURFACE 125 ROUGHNESS		DRAWN BY SB 1-29-96	CE WDG-HPII, -HPIIC SYSTEM INTERCONNECT
REMOVE BURRS AND BREAK SHARP EDGES		DOC. CONT. 7-7-00	
MATERIAL		ENGR. APPR. 07-7-2000	
		ORIG. ISSUE CN 1-29-96	SIZE C — DRAWING NO. 131-002 — REV. E
		SCALE NTS — SHEET 1 OF 1	

START UP CHECKLIST

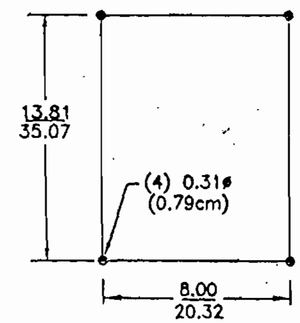
SERIES 2000
WDG HPII/HPIIC ANALYZERS

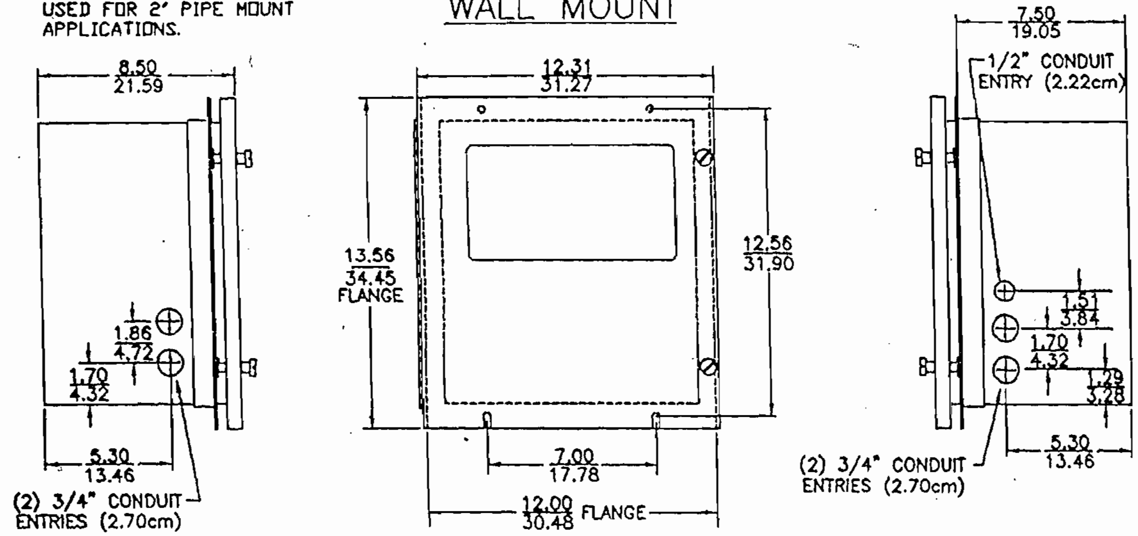
- Review the installation chapter and installation drawing, which is provided in this packet and also in the User's Manual.
- Install the probe tubes (sample and exhaust) and filter assembly to the rear of the sensor.
- Install the sensor on the process.
  - If the sensor is on the pipe nipple, insulate the pipe from the process wall to the mounting flange on the sensor.
- Install the control unit
  - Do not create any additional conduit entries in the enclosures.
- Interconnect the control unit and the sensor per the appropriate interconnecting drawing.
  - The specified cable must be used in order to insure proper operation of the systems.
  - Keep the interconnecting located in the control unit as short as possible. A service loop need not be used.
  - Maintain the ordered wire pairs per the drawing.
- Connect AC mains supply to the sensor. Make sure that the AC voltage is within specified limits.

REV	REVISION RECORD	DATE	DR	APP
A	ORIGINAL ISSUE	5-94	SB	
B	ADD NOTE FOR BRACKETS ALSO PIPE MTG	8-95	SB	
C	CHNGE 1" CONDUIT ENTRIES TO 3/4"	4-96	SB	
D	CHNGE DIMENS. 8.50 WAS 8.31, 7.50 WAS 7.25	1-97	SB	CMM

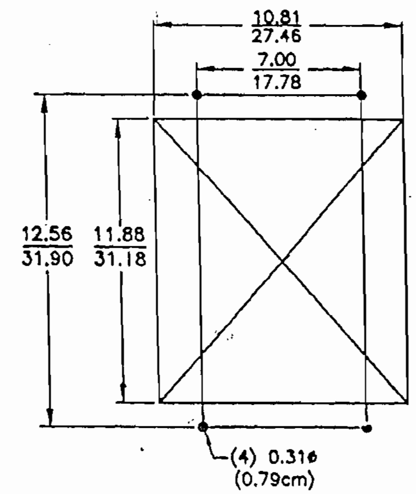


WALL MOUNT



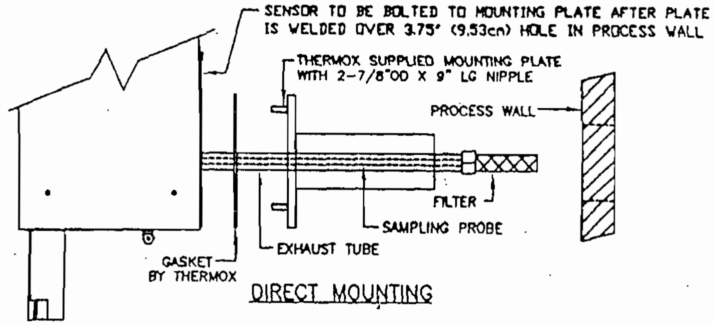


PANEL MOUNT

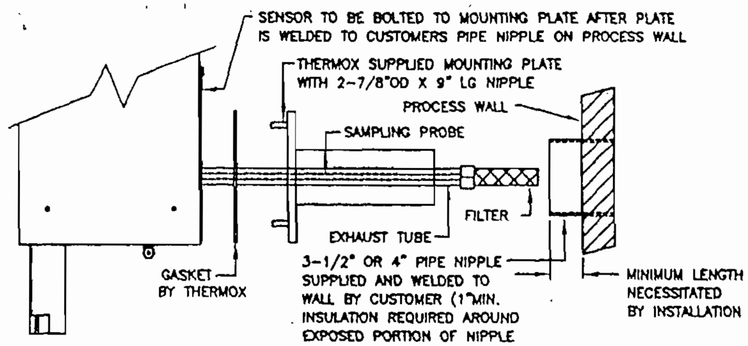


PRODUCT LINE	CONFIDENTIAL			AMETEK
THERMOX	REPRODUCTION PROHIBITED WITHOUT PERMISSION BY AMETEK P & AI DIVISION			AMETEK PROCESS & ANALYTICAL INSTRUMENTS DIVISION, 150 FREEPORT ROAD, PITTSBURGH, PENNSYLVANIA 15238 USA
	DRAWN BY	SB	5-19-94	2000 CONTROL ENCLOSURE WALL/PANEL MOUNT
	DOC. CONT.	SP	1-30-97	
TOLERANCES ANGLE ± 30'	ENGR. APPR.	CMM	1-30-97	
INCH/CM = ±1/8"/.125, .3175	ORIG. ISSUE	CM	5-19-94	SIZE A · DRAWING NO. 203-367 · REV. D
	SCALE NTS	SHEET 1 OF 1		

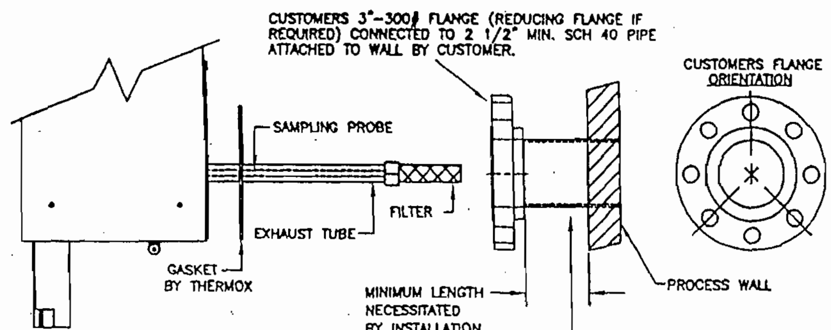
REV	REVISION RECORD	DATE	DR	APP
A	ORIGINAL ISSUE	3-96	SB	
B	REMOVE ASP AIR REG AND GAUGE	4-97	SB	
C	ADD 3"-300# MOUNTING FLANGE DETAIL	8-10-01	SB	[signature]



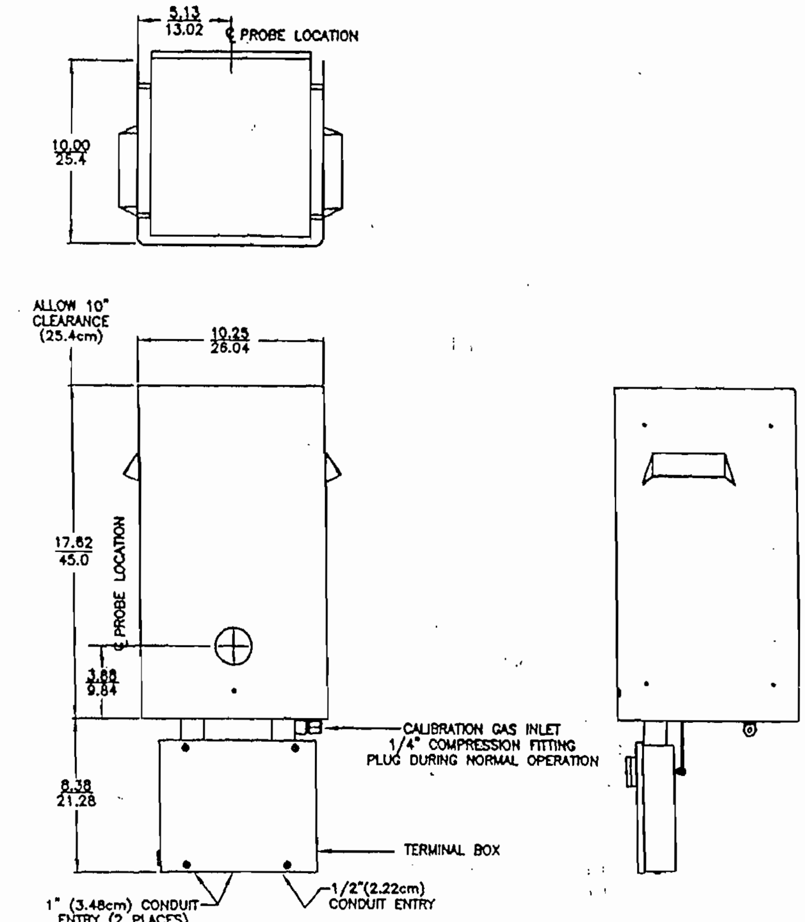
DIRECT MOUNTING



PIPE NIPPLE MOUNTING



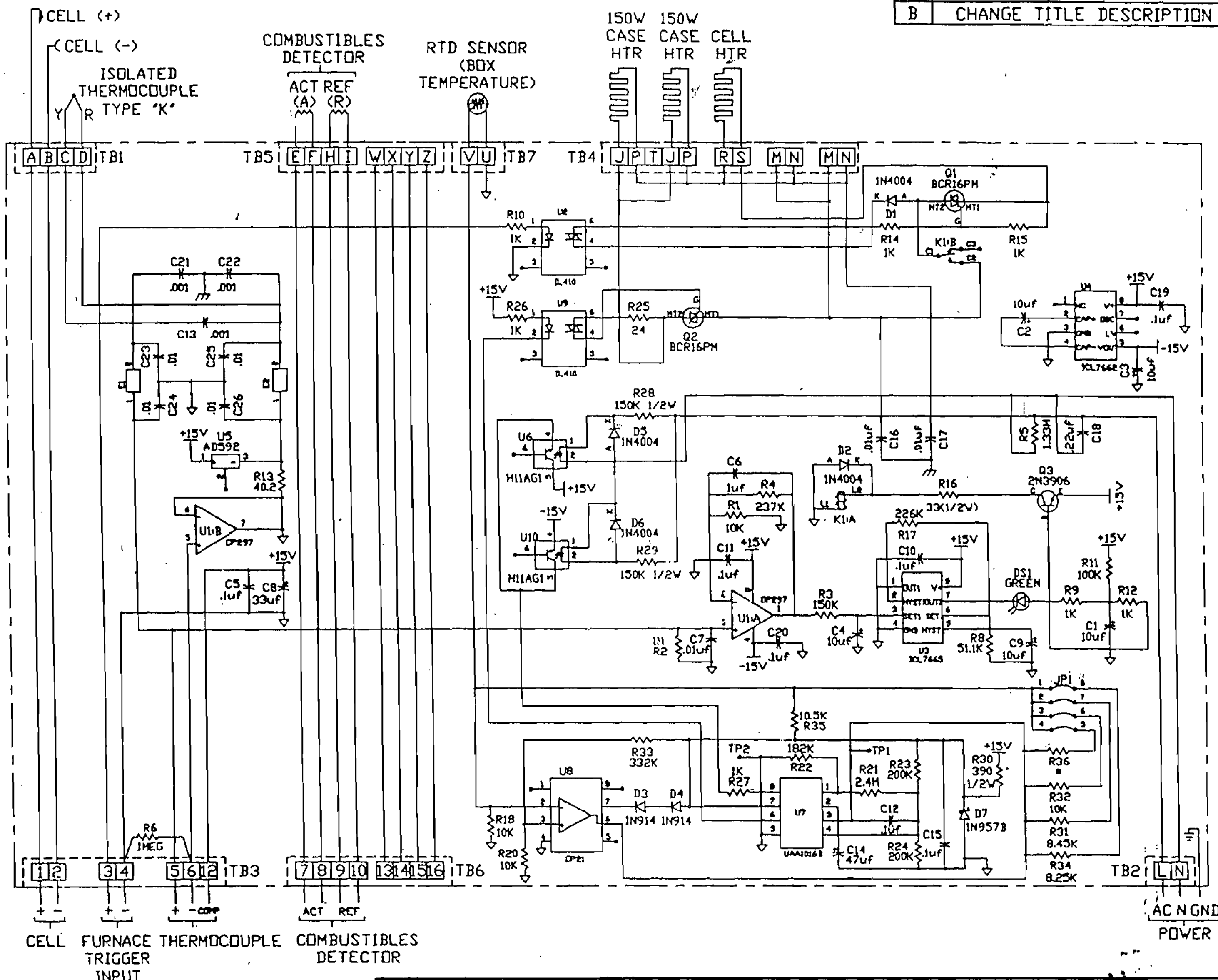
3"-300# FLANGE MOUNTING



INCH / CM

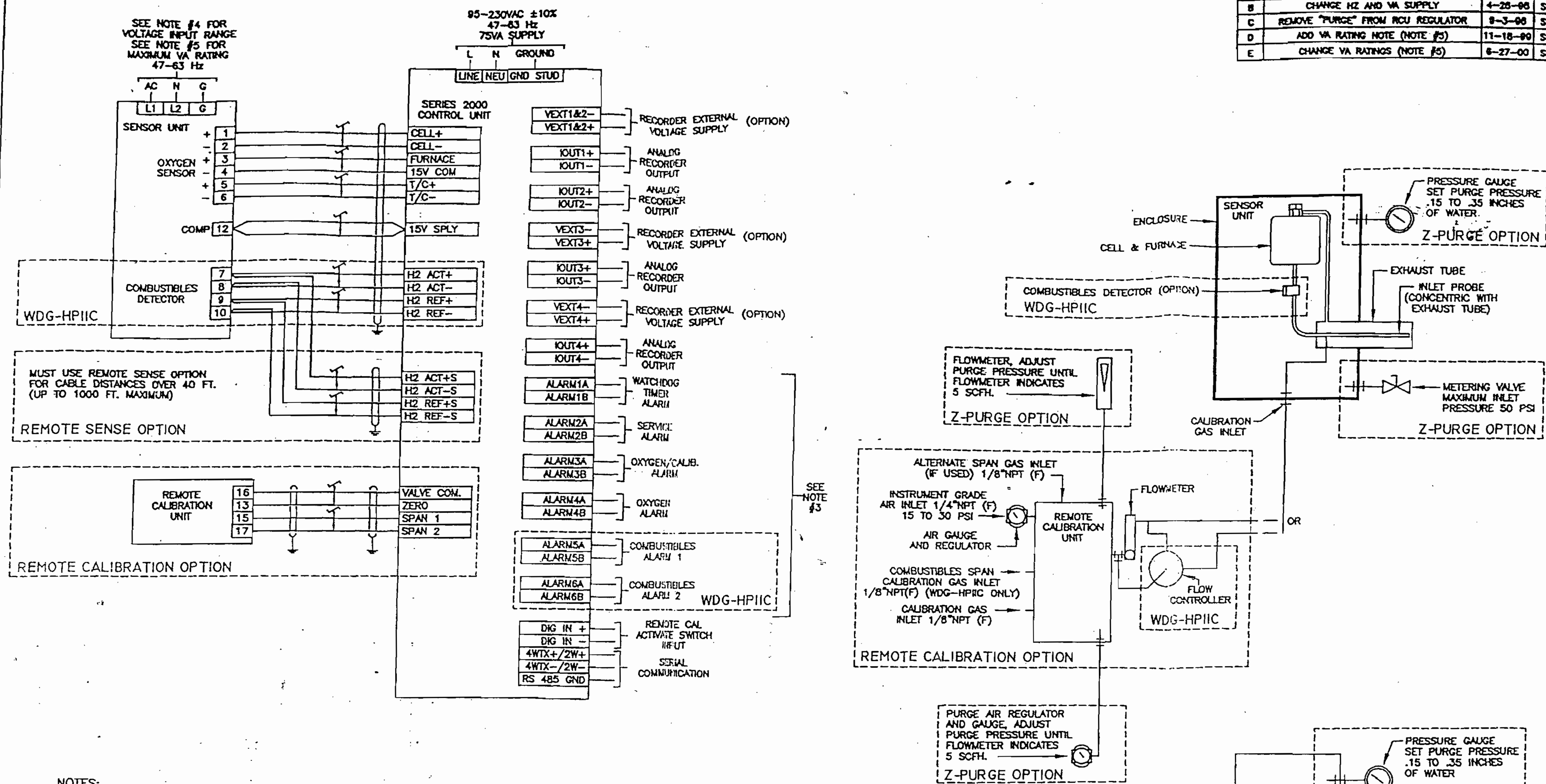
PRODUCT LINE THERMOX	CONFIDENTIAL REPRODUCTION PROHIBITED WITHOUT PERMISSION BY AMETEK P & AI DIVISION		AMETEK PROCESS & ANALYTICAL INSTRUMENTS DIVISION — AMETEK PROCESS & ANALYTICAL INSTRUMENTS DIVISION 150 FREEPORT ROAD PITTSBURGH, PENNSYLVANIA 15238 USA
	DRAWN BY SB	3-25-96	SENSOR, HP, FILTER PROBE MOUNTING AND DIMENSIONS
	DOC. CONT. [signature]	8-10-01	
TOLERANCES ANGLE ± 30'	ENGR. APPR. [signature]	08-10-01	
INCH / CM = ±1/8"/.125 / .3175	ORIG. ISSUE CM	3-25-96	SIZE A — DRAWING NO. 202-489-14 — REV. C
	SCALE NTS	SHEET 1 OF 1	

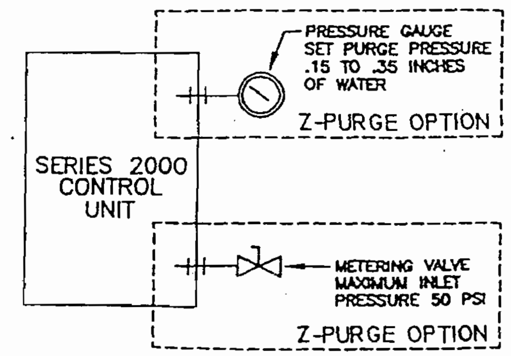
REV	REVISION RECORD	DATE	DR	APP
A	ORIGINAL ISSUE	3-25-96	SB	
B	CHANGE TITLE DESCRIPTION	7-12-96	SB	Cam



PRODUCT LINE THERMOX	TOOL/FIXTURE-IN HOUSE ONLY	CONFIDENTIAL REPRODUCTION PROHIBITED WITHOUT PERMISSION BY AMETEK P & AI DIVISION	AMETEK PROCESS & ANALYTICAL INSTRUMENTS DIVISION; AMETEK PROCESS & ANALYTICAL INSTRUMENTS DIV. 150 FREEPORT ROAD PITTSBURGH, PENNSYLVANIA 15238 USA
TOLERANCES FRACTION ±1/32 XX ±.010 XXX ±.005; ANGLE ±30' SURFACE ROUGHNESS 125		DRAWN BY SB 3-25-96; DOC. CONT. N/A 7-15-96; ENGR. APPR. Cam 7-15-96	WDG-HPIIC, CE, 115V WIRING INTERNAL SENSOR
REMOVE BURRS AND BREAK SHARP EDGES		ORIG. ISSUE CM 3-25-96	
MATERIAL		SCALE NTS; SHEET 1 OF 1	SIZE A; DRAWING NO. 115-546; REV. B

REV	REVISION RECORD	DATE	DR	APP
-	ORIGINAL ISSUE	1-29-96	SB	
A	CHANGE HZ AND VA SUPPLY	4-26-96	SB	
B	REMOVE "PURGE" FROM RCU REGULATOR	9-3-96	SB	
C	ADD VA RATING NOTE (NOTE #5)	11-18-99	SB	
D	CHANGE VA RATINGS (NOTE #5)	6-27-00	SB	





NOTES:

1. SEE INSTALLATION INSTRUCTIONS FOR WIRING CONSIDERATIONS.
2. PAIRS MUST BE KEPT TOGETHER AS SHOWN.
3. ALL ALARM CONTACTS ARE RATED AT 30V.
4. THE SENSOR IS CONFIGURED FOR EITHER 200-230VAC ±10% OR 95-120VAC ±10% AND NOT BOTH. THE SERIES 2000 CONTROLLER IS A UNIVERSAL DEVICE (95-230VAC ±10%, 47-63 Hz) SEE INSTRUCTION MANUAL FOR VOLTAGE INPUT RANGE.
5. MAXIMUM VA SUPPLY BY UNIT TYPE:
   120V LIFTOFF WDG-HPII, WDG-HPIIC = 600VA
   120V HINGED WDG-HPII, WDG-HPIIC = 600VA
   120V DIV.2 WDG-HPII = 600VA
   120V DIV.2 WDG-HPIIC = 650VA
   120V LIFTOFF FLOOR MOUNT WDG-HPII, WDG-HPIIC = 650VA
   230V LIFTOFF WDG-HPII, WDG-HPIIC = 1850VA
   230V HINGED WDG-HPII, WDG-HPIIC = 1850VA
   230V DIV.2 WDG-HPII, WDG-HPIIC = 1900VA
   230V LIFTOFF FLOOR MOUNT WDG-HPII, WDG-HPIIC = 1900VA
6. WDG-HPII IS OXYGEN ONLY SYSTEM
   WDG-HPIIC IS AN OXYGEN AND COMBUSTIBLES SYSTEM
7. DASHED LINES DENOTE INCLUDED OPTIONS. SEE INSTRUCTION MANUAL FOR INCLUDED OPTIONS

PRODUCT LINE: THERMOX
TOOL/FIXTURE—IN HOUSE ONLY

TOLERANCES: FRACTIONS ±1/64; .XX ±.010; .XXX ±.005; ANGLE ±30'; SURFACE ROUGHNESS 125

REMOVE BURRS AND BREAK SHARP EDGES

MATERIAL

DRAWN BY	SB	1-29-96
DOC. CONT.		7-7-00
ENGR. APPR.		07-7-2000
ORIG. ISSUE	CH	1-29-96
SCALE NTS	SHEET 1 OF 1	

AMETEK PROCESS & ANALYTICAL INSTRUMENTS DIVISION

CE WDG-HPII, -HPIIC SYSTEM INTERCONNECT

SIZE C | DRAWING NO. 131-002 | REV. E