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AN OGDEN PROJECTS COMPANY

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Bureau of Air Regulation

**VIA FIRST CLASS MAIL**

February 4, 1994

Bureau of Air Regulation
2600 Blair Stone Road
Tallahassee, FL 32399-2400

Attention: C. H. Fancy, P.E.

Florida Department of
Environmental Regulation
South District Office
2295 Victoria Avenue
Suite 364
Ft. Myers, FL 33901

Attention: Philip Barbaccia

Reference: Lee County Solid Waste Resource Recovery Facility
Ft. Myers, Florida
Project C-1033, Our Ref. LE0896L

Subject: INFORMATION OF THE CONTINUOUS EMISSION MONITORING SYSTEM
POWER PLANT SITE CERTIFICATION NO. 90-3942 EPP (PPSC)
PSD PERMIT NO. PSD-FL-151 (PSD)

Gentlemen,

On behalf of Lee County, the permittee of the above reference PPSC and PSD, Ogden Martin Systems of Lee, Inc. has prepared and herewith submits to the Bureau of Air Regulation and to the South District Office of the Florida Department of Environmental Regulation four (4) copies of information covering the opacity monitors for the continuous emissions monitoring (CEM) system for the Lee County Solid Waste Resource Recovery Facility in accordance with the subject PPSC and PSD. This submittal supplements our July 7, 1993 submission of the required information for the balance of CEM system devices.

The Specific Conditions in the PPSC and the PSD that specifically require the submittal of the information provided herein are as follows:

PPSC: Sections XIV.A, and XIV.A.2(b)

PSD: Sections 3.b

pja/3097

The information and plans provided herein are consistent with approved design concepts, regulations, and the Conditions of Certification.

This completes the submittals required to satisfy the above listed Sections of the PPSC and PSD.

Do not hesitate to call at (201) 882-7246 if you have any questions or further needs.

Very truly yours,

L. Peter Young

L. Peter Young
Assistant Vice President -
Project Management

cc: D. Cerrato - MP (w/1 set)
D. Markley - MP (w/1 set)
L. Sampson - Lee County (w/1 set)
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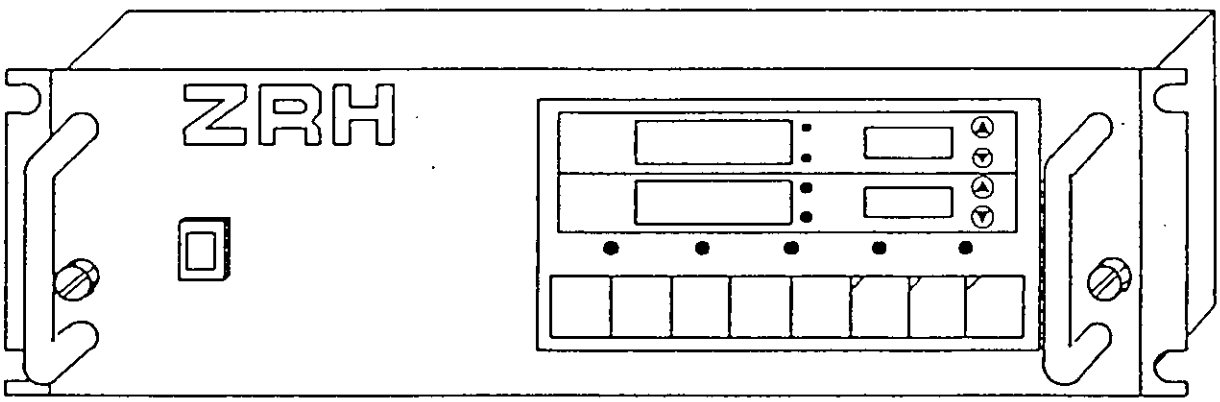
# INFRARED GAS ANALYZERS

## MODEL : ZRH



# TABLE OF CONTENTS

# 1. GENERAL DESCRIPTION

FUJI Model ZRH Infrared Gas Analyzer is a multi-functional and easy-handling non-dispersive type infrared gas analyzer, employing a highly sensitive and reliable mass-flow sensor and microprocessor to measure concentrations of gaseous components like $CH_4$, $CO_2$, CO etc.

FEATURES

(1) Both zero calibration and span calibration can be performed by simple key operation.

(2) Function of self-diagnosis is provided.

(3) Function of automatic calibration can be added. (Option)

(4) Function of remote selection of measuring ranges can be added. (Option)

NOTE

Prior to operation of this analyzer, it is recommendable to the user to read through this Instruction Manual in order to ensure efficient operation and accurate measuring results

## 2. SPECIFICATIONS

- Repeatability : The 1st range(low range) ±0.5% of full scale
  The 2nd range(high range) ±1.0% of full scale

- Zero drift : ± 2% of full scale/week

- Span drift : ± 2% of full scale/week

- Response time : Electronic system response time (90%): 2 sec.
  Response time including gas replacing time of sample cell (90%): within 15 sec.
  (depending on cell length)

- Power source : AC 100V, 115V or 220V ±10%, 50/60 Hz
  (Note: Refer to designation of TYPE NO.)

- Power consumption: 37VA max.

- Ambient temperature: -5 ~ +45°C

- Ambient humidity: Less than 90% RH

- Enclosure : Steel plate case, indoor use.

- Measurable gas components and measuring ranges : <Single gas component, dual ranges measuring>
  $CO_2$, CO, $CH_4$ (Low range/High range) ;
  0~0.05/0.1% (unavailable for $CH_4$),
  0~0.1/0.2%, 0~0.2/0.5%, 0~0.5/1%
  0~1/2%, 0~2/5%, 0~5/10%, 0~10/20%
  0~20/50%, 0~50/100%,

  <Dual gas components, single range measuring>
  $CO_2$/CO ;
  0~20%/0~0.05%, 0~20%/0~0.1%

- Measuring principle: Infrared ray absorption, non-dispersive type deflection method, single IR source single beam system.

| | | |
|---|---|---|
| ∘ Output signal | : | Output 1; DC 0 ~ 1V<br>Output 2; DC 4 ~ 20mA (allowable load resistances less than 550Ω).<br>To-order production of either DC 0 ~100mV or DC 0 ~10mV (output resistance less than 100 Ω to be available as non-standard. |
| ∘ Contact output | : | 1'a'contact at analyzer fault<br>Rating: AC250V, 2A (resistance load) |
| ∘ Overall dimensions (H x W x D) | : | Rack mounted type 133 x 483 x 448 mm<br>Panel flush mounted type 133 x 443 x 448 mm<br>Desk top type 145 x 443 x 448 mm |
| ∘ Weight | : | Approx. 12 kg |
| ∘ Color of finish | : | MUNSELL 5Y8/1 |
| ∘ Indication | : | Concentration indication(main display screen)<br>4-digit LED display<br>Parameter indication (sub-display screen)<br>4-digit LED display |
| ∘ Hold of output signal | : | Output signal just prior to calibration are held during either manual or automatic calibration.<br>Hold or non-hold both selectable. |
| ∘ Sample gas temperature | : | 0 ~ 50 ℃ |
| ∘ Warm-up time | : | Approx. 4 hours after power switch on |
| ∘ Materials of gas contacting parts | : | Measuring cell: stainless steel type 304<br>NEOPRENE® rubber<br>Window for infrared ray: $CaF_2$ or Sapphire<br>Internal piping TEFLON® tube<br>TOALON® tube |

- Inlet & outlet dia.: of sample gas and purging gas inlet : Rc 1/4 (PT 1/4) female threads or NPT 1/4 female threads.

- Measuring gas flow rate : 1 ℓ/min. ±0.5 ℓ/min.

- Purging gas flow rate : Approx. 1 ℓ/min. (by occasional demands)

ADDITIONAL SPECIFICATIONS

- Remote selection of measuring range : Selection of measuring range by external signal available.
  1st range selection signal:voltage input DC5V

- Contact output of range identification signal : 1'a'contact output for 1st(low) range rating: AC250V, 2A (resistance load)

- Automatic calibration : Automatic zero & span calibration at preset cycle time and due to external start signal. Calibration gases flow orderly by sequential driving of external solenoid valves.

  Nos. of components for calibration : Simultaneous calibration of max.2 gas components available.

- Zero calibration point : Fixed at 0%.

- Span calibration point : Setting available in range of 0～ 100% of full scale

- Calibration start : To be started by either built-in timer or remote start signal.

- Flowing mode of calibration gas at calibration : (1) Zero gas
  (2) Zero gas - span gas 1
  (3) Zero gas - span gas 2
  (4) Zero gas - span gas 1 - span gas 2

- Calibration gas flowing time at calibration : Setting range from 100 to 599 sec.

- Cycle time of automatic calibration : Setting range from 1 to 199 hours (pitch by 1 hour)

- Automatic calibration error alarm : Output signal at error during automatic calibration.

- Contact outputs : 1'a'contact during calibration
  Rating : AC250V, 2A (resistance load)
  1'a'contact at calibration error
  Rating : AC250V, 2A (resistance load)
  1'a'contact for each solenoid valve drive
  Rating : AC250V, 2A (resistance load)

- Remote starting of automatic calibration : Remote starting signal: voltage input DC5V

## 3. MEASURING PRINCIPLE

The principle of composition of the FUJI Model ZRH Infrared Gas Analyzer is shown in Fig.3.1.

Infrared light emitting from an Infrared Source① is intermitted by a Chopper② driven by a Chopper Motor③ in a certain frequency, then led into a Measuring Cell④. The infrared light beam is partially absorbed into the measured component in the Measuring Cell and the unabsorbed portion reaches a Detector⑤, which is provided with a Front Chamber and a Rear Chamber, both normally being filled with the same gas component as the gas to be measured.

When infrared light is led into the detector, the gases filling in both chambers absorb the light and expand.

Since the Detector is so designed as to produce an expansion difference between the Front and Rear Chambers, a slight gas flow is produced in a Mass-flow Sensor⑥ and this slight flow generates output voltage in the sensor as shown in Fig.3.2.

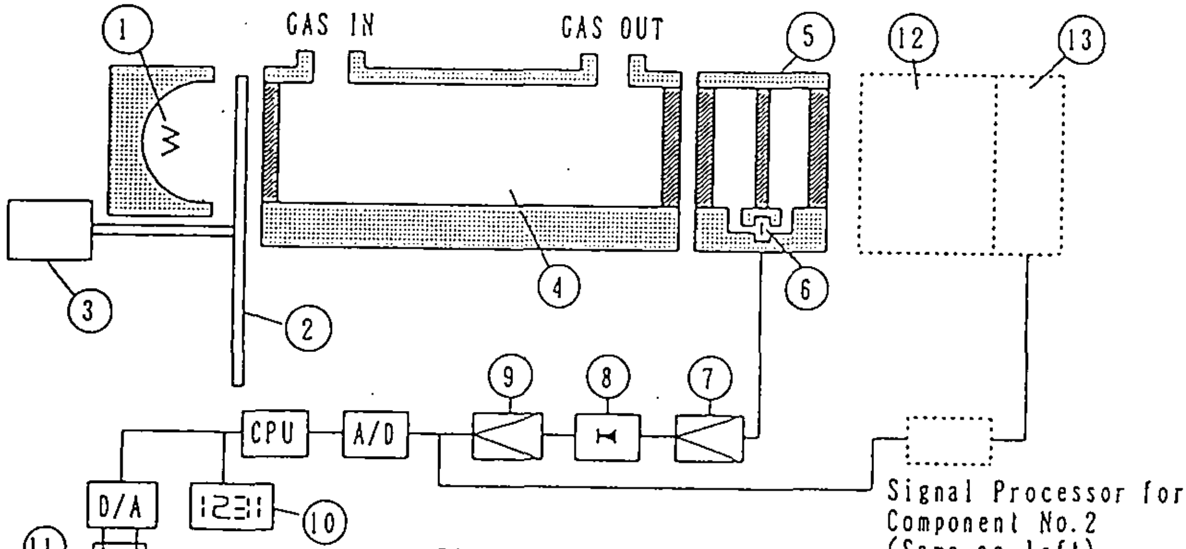



Fig.3.1

①:Infrared Source
②:Light Chopper
③:Chopper motor
④:Measuring Cell
⑤:Detector
⑥:Mass-flow Sensor
⑦:AC Amplifier
⑧:Rectifier
⑨:DC Amplifier
⑩:Display Panel
⑪:Output Terminal
⑫:Measuring cell for No.2 component
⑬:Detector for No.2 Component

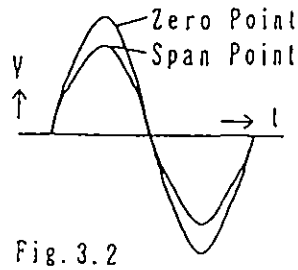



Fig.3.2

Output signal generated in the sensor is amplified by an AC Amplifier ⑦, then converted to DC voltage by a Rectifier⑧.
The converted DC signal is amplified by a DC Amplifier⑨, then converted by an A/D Converter and after being processed through concentration computing, temperature compensation and linearizing in a micro-processer, the concentration of measured component is displayed in 4-digit on a Display panel⑩ in digital form and simultaneously a D/A converted signal is transmitted from an Output Terminal⑪ as an analog output signal.
When sample gas contains such interfering gas components as absorption range partially overlapping with the gas component to be measured, the same expansion as mentioned above is produced in both chambers of the detector, however, since both expansions are designed for almost the same volume, mutual influence owing to interfering gas component can be minimized.
A dual components analyzer has additional Measuring Cell⑫, Detector⑬ and signal processing electronics the same as for the 1st component. As shown in Fig.3.1, they proceed with the same measuring process.

# 4. INSTALLATION

**WARNINGS**

- Dangerous voltages are present at power supply terminals and inside the instrument assembly.
- Be careful with gas leakage, especially in case of toxic gas and other hazardous gas to people.

**CAUTIONS**

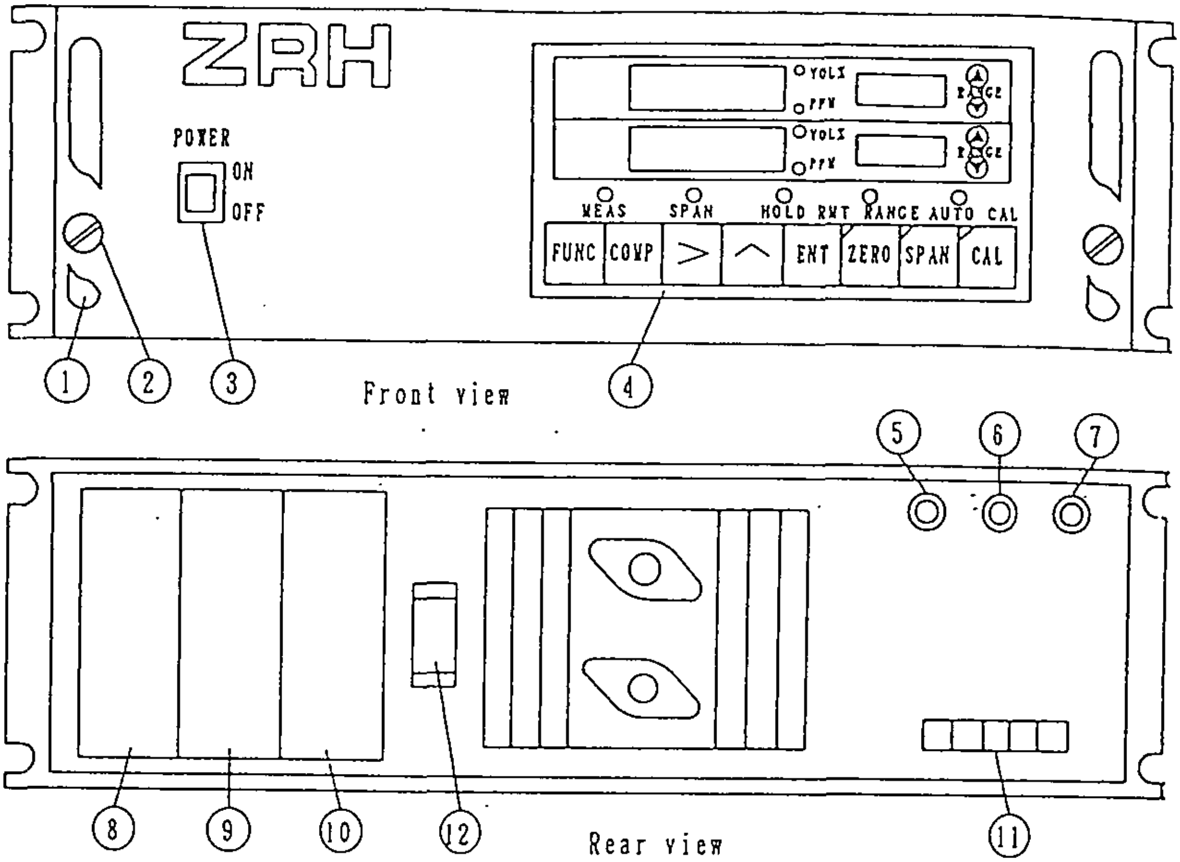
- Select an adequate installing location.
  Install the analyzer so as not to be subjected to high and/or fluctuating temperature, strong heat radiation or direct sun light exposure.
  In case when the instrument is installed outdoors, select weather protected area.
- Avoid the location with frequent and/or severe vibration.
- Avoid the location with corrosive and flammable gas in atmospheric air.

**NOTES**

- Check whether the followings are contained or not at time of unpacking.

| Item | Quantities |
|---|---|
| Instrument | 1 |
| Power Source Fuse | 2 |
| Test report | 1 |
| Instruction Manual | 1 |
| Mounting Screw | 4 (in case of panel mounting type) |

## 4.1 DESCRIPTIONS OF COMPONENTS




① Handle

② Set Screw

③ Power Switch

④ Display & Control Panel

⑤ Sample Gas Inlet

⑥ Sample Gas Outlet

⑦ Purge Gas Inlet

⑧ COMP 1 Terminals

⑨ COMP 2 Terminals
Attached to the dual components analyzer

⑩ AUTO CAL. Terminals
Attached to the analyzer with auto-calibration option

⑪ Power Supply & Grounding Terminals

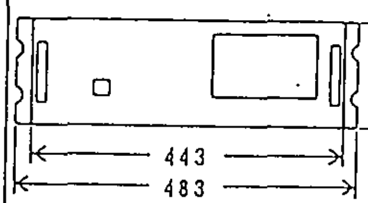
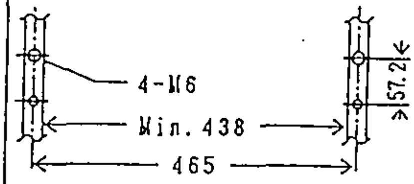
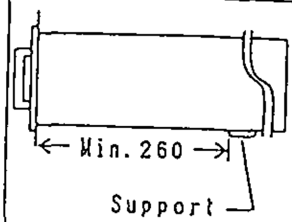
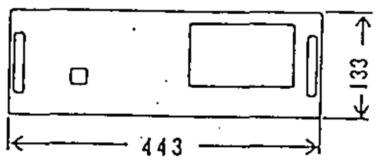
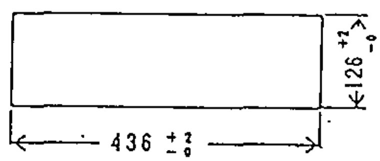
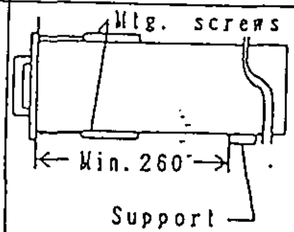
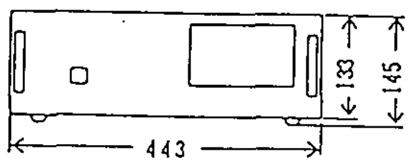
⑫ Pin connector (for manufacturer's internal use)

**NOTE**

The Pin connector⑫ is intended to be used only in the manufacturing process. Do not remove the cover and do not make any electrical connections on it.

## 4.2 MOUNTING

3 ways of mounting (19" rack mount, panel flush mount and desk top) are available. Prepare for mounting referring to data listed in a table below (Dimensions in mm).

| | Ext. Dimensions of Analyzer | Dimensions for Mounting | Mounting Method |
|---|---|---|---|
| 19" Rack Mount |  |  |  |
| Panel Mount |  | <br>Panel cut dimensions |  |
| Desk top |  | | |

CAUTIONS

- Mount front side of the analyzer so as to be vertically positioned.
- In case of both mounting on panel and 19" rack, hold the rear side with such support as to be able to hold 10kg or more weight.

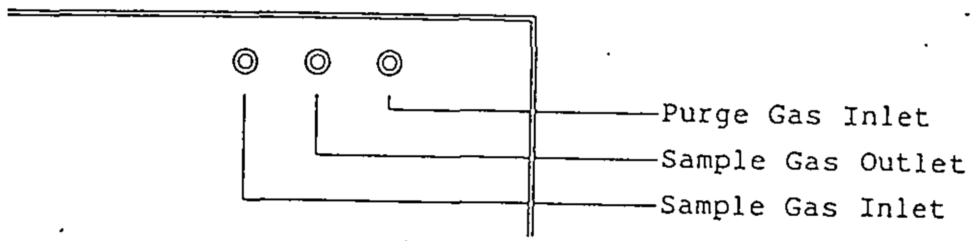
## 4.3 PIPING

Connect piping with gas inlet-outlet on the rear upper side of the analyzer. Connect the analyzer with a sampling system by means of corrosive-resistant tubing like TEFLON®, stainless steel or polyethylene etc. Do not use rubber or soft vinyl tubing even in any uncorrosive case to avoid incorrect indication due to adsorption of gas onto piping materials. Rc1/4 (PT1/4) or NPT1/4 female threads connectors are equipped for piping connection.

Be sure to minimize piping length as short as possible in order to ensure quicker response. Adequate tubing bore is 4 mm.

Use clean tubings and connections as dust inhaling may cause improper operation.

Location of pipe connectors on the rear panel of the analyzer is shown below.




## 4.4 SAMPLING

### 4.4.1 SAMPLE GAS CONDITIONING

(1) Remove dust in sample gas completely through filters.
For final stage filtering, use a filter capable of removing particles of dust larger than 0.3 $\mu$.

(2) Dew point of sample gas must be lower than ambient temperature in order to prevent moisture inside the analyzer.

In case that moisture is contained in sample gas, bring dew point of the sample gas down to about 0℃ through a dehumidifier.

(3) When $SO_3$ mist is contained in sample gas, remove it through a mist-filter and cooler etc. Remove other mist by similar procedures.

(4) Note and take care, the life of the analyzer is to be shortened when such heavy corrosive gases as $Cl_2$, $F_2$ & HCl etc. are much contained in sample gas.

(5) Allowable temperature range of sample gas is 0℃～50℃.
Be careful not to bring hot gas into the analyzer directly.

### 4.4.2 FLOW RATE OF SAMPLE GAS

Keep flow rate of sample gas at 1ℓ/min. ±0.5ℓ/min.
Prepare flowmeter so as to measure flow rate.

### 4.4.3 PREPARATION OF CALIBRATION GASES

Prepare calibration gases for zero and span calibration.

| | |
|---|---|
| zero gas | $N_2$ gas |
| span gas | Each component should have concentration more than 80% of full scale. |

### 4.4.4 PURGING INTERIOR OF THE ANALYZER CASE

Purging inside the analyzer is generally unneeded, however, proceed purging with instrumentation air or $N_2$ gas for the following cases.
Purging flow rate is to be approximately one l/min.
When dust & mist are contained in purge gas, utilize it after their complete removal.

(1) When corrosive gas exists in the environmental air of the installing location.
(2) When the same or interfering gas component with the gas to be measured, exists in the environmental air of the installing location.

### 4.4.5 PRESSURE AT THE OUTLET OF SAMPLING GAS

Keep pressure at the outlet of sample gas so as for it to be atmospheric pressure.

## 4.5 WIRING

**CAUTION**

Do not locate analyzer near to the electric apparatus to generate electric noises. (Induction furnace & electric welder etc.).
When the analyzer is operated near to such electric apparatus be sure to separate the power source to avoid noise.
In case the noise from relay or solenoid valve etc. influences the analyzer through the power source, provide a balistor(example: Fuji Electric Type No.ENA211-2) or a spark-killer(example: Okaya Type No.S1201) with the noise generating apparatus as shown in Fig.4.5.1
Be sure to mount the above as close as possible to such noise generating sources.

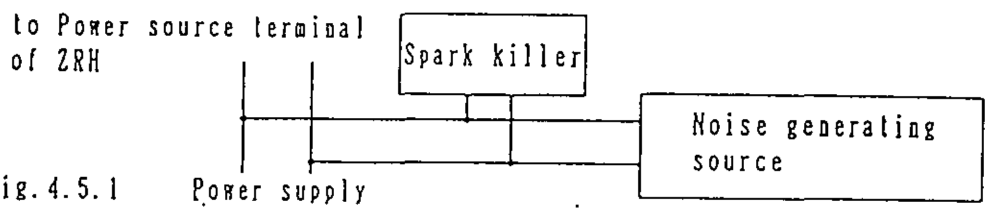



Fig.4.5.1

All input & output terminals are on the rear panel of the analyzer.
Proceed wiring of each terminal as shown in Fig.4.5.2.
Terminal screw is M3.5.(Power source terminal is M4.)
Use shield wire for wiring of output signal in order to reduce the influence of noise.

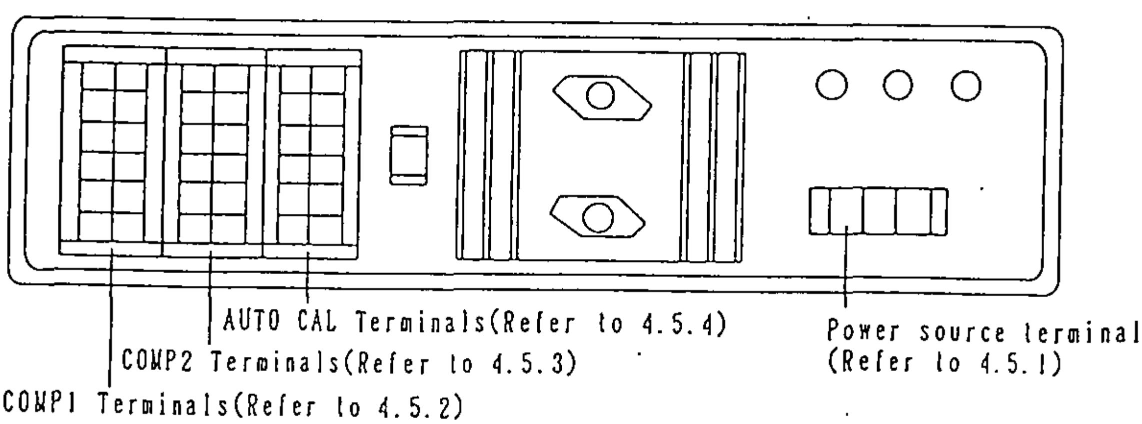



Fig.4.5.2 Rear panel

### 4.5.1 POWER SOURCE TERMINALS

**CAUTION**

Ensure to check voltage of power source to be identical with the one specified on the name plate of the analyzer, otherwise it may be broken.
Proceed ground earthing with earth terminal to eliminate electrical hazards.

Layout of power source terminals are shown in Fig. 4.5.3.
Proceed earthing of earth terminal and connect power source terminals to a power source.
Use crimp terminals (for M4 screw) for connecting.

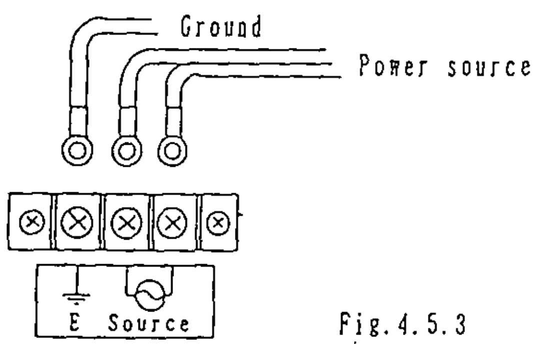



Fig.4.5.3

## 4.5.2 COMP1 TERMINALS

COMP1 Terminals are input & output terminals for the 1st measuring component. Connection is to be referred to Fig. 4.5.4.

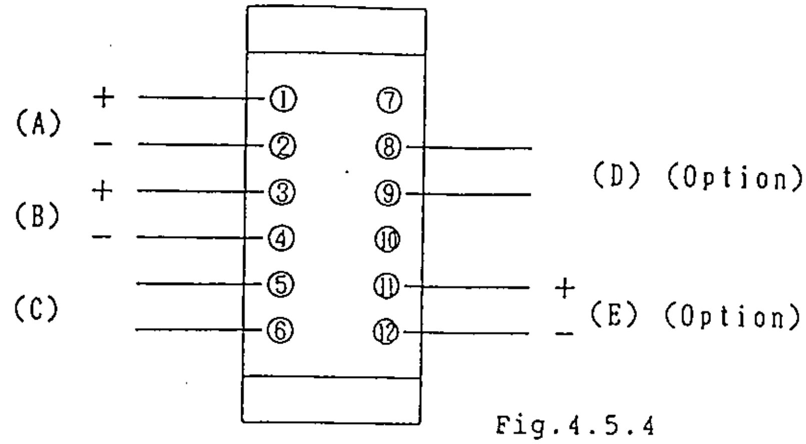



Fig.4.5.4

| | | | |
|---|---|---|---|
| (A) | Voltage output signal | : | DC 0～ 1V |
| (B) | Current output signal | : | DC 4～20mA |
| (C) | FAULT contact output | : | 1'a'contact<br>Rating: AC 250V, 2A (resistance load)<br>Make-contact output for occasional error in analyzer. Refer to 7.3 Error codes & how to recover regarding details of fault. |
| (D) | Contact output of measuring range identification | : | 1'a'contact<br>Rating: AC 250V, 2A (resistance load)<br>At selection of the 1st range:<br>⑧ & ⑨ close<br>At selecting of the 2nd range:<br>⑧ & ⑨ open |
| (E) | Remote range selection input | : | DC 5V<br>During DC 5V is input to terminals ⑪ & ⑫, the 1st range is selected.<br>When terminals ⑪ & ⑫ are opened or given 0V, the 2nd range is selected. |

### 4.5.3 COMP2 TERMINALS

COMP 2 Terminals are input & output terminals for 2nd measuring component. Connection is to be referred to Fig. 4.5.5.

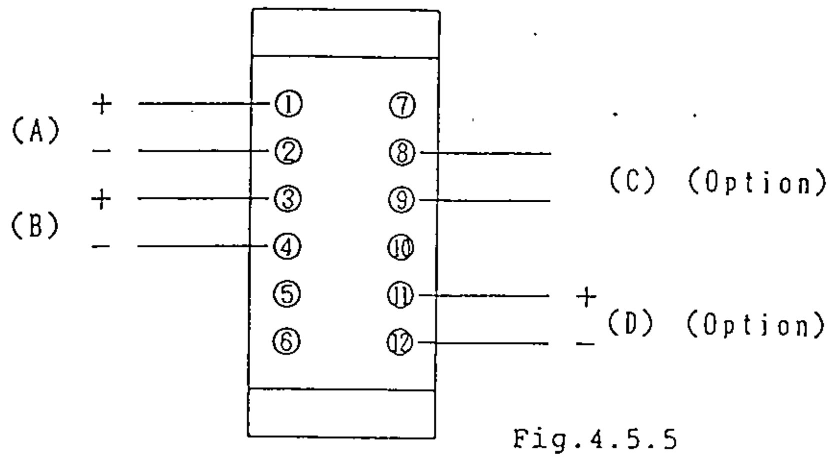


Fig.4.5.5

| | | |
|---|---|---|
| (A) | Voltage output signal | : DC 0～ 1V |
| (B) | Current output signal | : DC 4～20mA |
| (C) | Contact output of measuring range identification | : 1'a'contact<br>Rating: AC 250V, 2A (resistance load)<br>At selection of the 1st range; ⑧ & ⑨ close<br>At selecting of the 2nd range; ⑧ & ⑨ open |
| (D) | Remote range selection input | : DC 5V<br>During DC 5V is input to terminals ⑪ & ⑫, the 1st range is selected.<br>When terminals ⑪ & ⑫ are opened or given 0V, the 2nd range is selected. |

## 4.5.4 AUTO CAL TERMINALS (OPTION)

AUTO CAL Terminals are input & output terminals for automatic calibration and the connection is shown in Fig. 4.5.6.

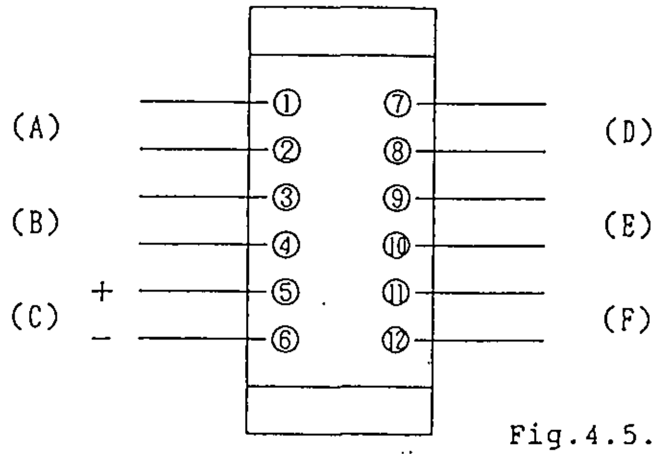
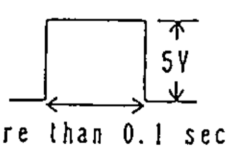



Fig.4.5.6

(A) Contact output during calibration : 1'a'contact
Rating: AC 250V, 2A(resistance load)
Make-contact output to indicate automatic calibration taking place.

(B) Contact output of error in automatic calibration : 1'a'contact
Rating: AC 250V, 2A(resistance load)
Make-contact output for error occurring in analyzer during automatic calibration, which works simultaneously with the contact output FAULT.
If error occurs, corresponding error code is displayed.
For details of error codes refer to 7.3 Error codes & how to recover.

(C) Remote start input : DC 5V square signal longer than 100msec. in duration.
Input to start automatic calibration by external signal. When the pulse shown left is input to terminals ⑤ & ⑥ automatic calibration is to start.




Input pulse

(D) Contact output for zero gas : 1'a'contact
Rating: AC 250V, 2A(resistance load)
Make-contact output to open solenoid valve for zero gas flowing.

(E) Contact output for span gas 1 : 1'a'contact
Rating: AC 250V, 2A (resistance load)
Make-contact output to open solenoid valve for span gas of the 1st component flowing.

(F) Contact output for span gas 2 : 1'a'contact
Rating: AC 250V, 2A (resistance load)
Make-contact output to open solenoid valve for span gas of the 2nd component flowing.

**CAUTION**

Keep each unused terminal open so as not to make damage to analyzer by short-circuit or misconnection etc.

# 5. OPERATION

## 5.1 OPERATION PROCEDURES

Proceed the followings for getting an analyzer into operation

(1) Check of piping

⇩

(2) Purging inside analyzer — Carry out purging if needed.

⇩

(3) Power switch on

⇩

(4) Warming up

⇩

| | | |
|---|---|---|
| (5) | Set or review analog output signal holding | Refer to 5.5.2 |

⇩

| | | |
|---|---|---|
| (6) | (Option)<br>Set or review remote range setting | Refer to 5.5.3 |

⇩

| | | |
|---|---|---|
| (7) | (Option)<br>Set or review parameters for automatic calibration | Refer to 5.6.1, 5.6.2, 5.6.3 5.6.4 and 5.6.5 |

⇩

| | | |
|---|---|---|
| (8) | Set or review span gas concentration & independent/dependent calibration | Refer to 5.5.1 |

⇩

| | | |
|---|---|---|
| (9) | Initial calibration | Refer to 5.4.4,5.4.2,5.4.3 and 5.5.1 |

⇩

| | | |
|---|---|---|
| (10) | Set or review key lock ON/OFF | Refer to 5.5.4 |

⇩

| | |
|---|---|
| (11) | Introduction of sample gas |

(Start of measuring)

⇩

(End of measuring)

| | |
|---|---|
| (12) | Stop sample gas and purge the analyzer |

Supplemental explanations to above described items

(1) Check of piping

Check that piping is connected correctly.

(2) Purging inside analyzer

Check flow rate of purging gas when purging is needed. (Refer to 4.4.4.)

(3) Power switch on

When power source is switched on, analyzer is operating in function mode "Measuring".

(4) Warming up

After power source is switched on, warm up the analyzer.
Approx. 4 hours are needed for warming up to obtain the specified performances in the specifications, but indication come to be stabilized approx. 2 hours after.
During warming up, reviewing all configuration parameters is recommended to get well acquainted with analyzer performance.

(9) Initial calibration

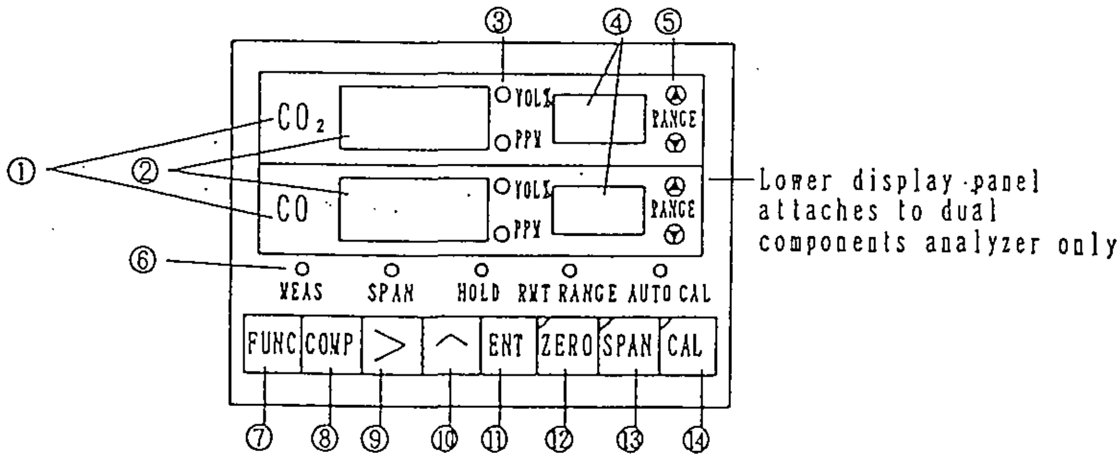
Proceed zero & span manual calibration according to 5.4.4.
If initial calibration has been surely completed in manufacturer or distributor, proceed ordinary zero & span calibration instead, either automatic or manual and either independent or dependent.

(12) Stop flowing-in of sample gas then proceed purging of measuring cell inside with dry nitrogen gas for 10 minutes.
If switching off power source, refer notes on the next page.

NOTES

Even after switching off the power source, all preset parameters is stored and kept in non-volatile memory. However, time until the next automatic calibration stored in a timer expires after 4 hours from power source turned off. In this case, reset the timer again at re-staring.

## 5.2 DESCRIPTIONS OF DISPLAY AND CONTROL PANEL




| NAME | DESCRIPTIONS |
|---|---|
| ① Name of measured components | Indicating measured components |
| ② Main display screens | Indicating measured concentration, and also indicating each parameter of automatic calibration etc. in set mode |
| ③ Indicating light of measuring unit | Measuring unit of concentration display to be indicated. |
| ④ Sub display screens | Besides displaying of measuring range, error code & parameters etc. also to be displayed. |
| ⑤ Measuring range selection keys | To be utilized for range selection.<br>▲ :Selection button for high range<br>▼ :Selection button for low range |

| | |
|---|---|
| | In case of single range, both do not work even if depressed. |
| ⑥ Function indicating lights | Each light shows the following status.<br>MEAS : Lighting in measurement mode.<br>SPAN : Blinking in function mode of span gas concentration setting<br>HOLD : Blinking in hold setting mode, and remains lit while hold function enabled.<br>RMT RANGE: Blinking in remote range setting mode, remains lit while remote range function enabled.<br>AUTO CAL : blinking in automatic calibration setting mode, and remains lit while automatic calibration function enabled. |
| ⑦ [FUNC] key | Setting mode to be changed-over at every key depression. |
| ⑧ [COMP] key | Change-over of components for parameter setting in set mode. |
| ⑨ [ > ] key | A changeable digit on the display shifts down by every key depression. |
| ⑩ [ ∧ ] key | Value of the chosen digit to be increased by every key depression. |
| ⑪ [ENT] key | Set parameters to be stored and become effective by key depression. |
| ⑫ [ZERO] key | To be used for zero calibration (zero key indicating light on up-left corner of key blinking during zero calibrating.) |
| ⑬ [SPAN] key | To be used for span calibration (span key indicating light on up-left corner of the key blinking during span calibration.) |
| ⑭ [CAL] key | To be used for starting of manual calibration.<br>While zero key indicating light blinking, CAL key depression leads to zero calibration, while span key indicating light blinking, it leads to span calibration. |

## 5.3 OUTLINE OF OPERATION FLOW

As under-shown, function to be changed-over by FUNC key pressing down.

| Key | Function (Reference pages) | Main/Sub display | Function display light |
|---|---|---|---|
| FUNC | [Mesurement mode] Measuring (P.5-7) | Measuring value/ Measuring range | MEAS lighting on |
| ⇩ | [Set mode] Span gas concentration setting (P.5-13) | Span value/ Measuring range | Span blinking |
| FUNC ⇩ | Hold setting (P.5-15) | "HoLd"/ "ON"or"OFF" | HOLD blinking |
| FUNC ⇩ | Remote range setting(option) (P.5-17) | "r.rAG"/ "ON"or"OFF" | RMT RANGE blinking |
| | Automatic calibration (option) | | |
| | Calibration start timer (P.5-21) | "Strt"/Time | AUTO CAL blinking |
| FUNC ⇩ | Calibration Cycle time setting (P.5-22) | "CyCL"/Time | AUTO CAL blinking |
| FUNC ⇩ | Calibration gas flowing time setting (P.5-23) | "F.SEC"/Time | AUTO CAL blinking |
| FUNC ⇩ | | | |

| | | | |
|---|---|---|---|
| | Calibration gas flow mode setting (P.5-24) | "FLno."/ Mode No. | AUTO CAL blinking |
| FUNC ⇩ | Automatic calibration on/off (enabling or not) (P.5-25) | "A.CAL"/ "ON"or"OFF" | AUTO CAL blinking |
| FUNC ⇩ | Key lock on/off (enabling or not) (P.5-18) | "LOC."/ "ON"or"OFF" | |
| FUNC ⇩ (To function mode measuring) | | | |
| ZERO | [Measurement mode] Zero calibration | Measuring value/ Measuring range | Zero key indicating light blinking |
| SPAN | Span calibration | Measuring value/ Measuring range | Span key indicating light blinking |

NOTES

- When the analyzer operating in set mode, the analog output signal is held at the value just prior the mode change.
- In case of no addition of optional function, the relating parameters of un-added optional function are not displayed.

## 5.4 MEASUREMENT MODE

The measurement mode consists of three function modes of "Measuring", "Zero calibration", and "Span calibration".

When the analyzer operates in the measurement mode, the indicating light MEAS is lit.

The analyzer operates in the function mode "Measuring" when power switch is turned on.

When the indicating light RMT RANGE is not lit in the measurement mode, high and low measuring ranges are selectable by depressing range selection keys.

The selected range value (max. value of the selected measuring range) is displayed on the sub-display screen.

### 5.4.1 MEASURING

Concentration reading of the measured component is displayed on the main display screen.

The selected measuring range value is displayed on the sub-display screen.

The measuring unit of concentration display is indicated by the unit indicating lights.(Fig.5.4.1)

When the measuring range is selectable by an external signal, the indicating light RMT RANGE is lit.

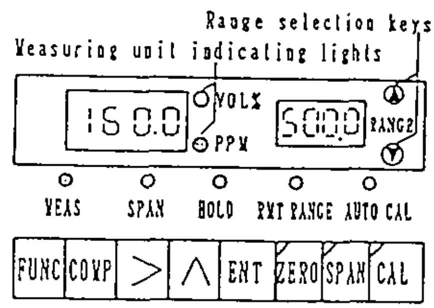



Fig.5.4.1

### 5.4.2 ZERO CALIBRATION

Depress [ZERO] key.

The ZERO key indicating light at the up-left corner of [ZERO] key blinks and it indicates that the analyzer is ready for zero calibration.

The indicating light HOLD is lit when the holding function is set as ON and the analog output signal is kept constant at the value immediately before [ZERO] key is depressed. (Fig. 5.4.2 a)

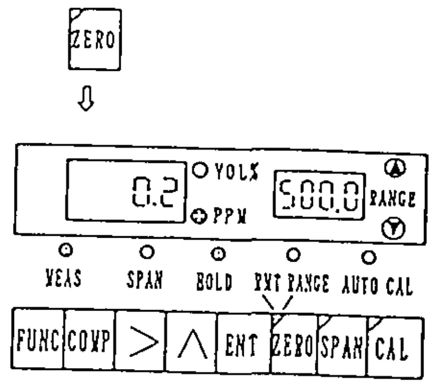




Fig. 5.4.2a

If the analyzer with automatic calibration option is used, the output signal for energizing a solenoid valve is turned on and zero gas is introduced into the analyzer.

The zero gas should be introduced into the analyzer manually if the analyzer without automatic calibration option is used.

If the dual ranges analyzer is used, select the range for zero calibration.

When displayed concentration reading on the main display screen reaches its final value, depress [CAL] key.

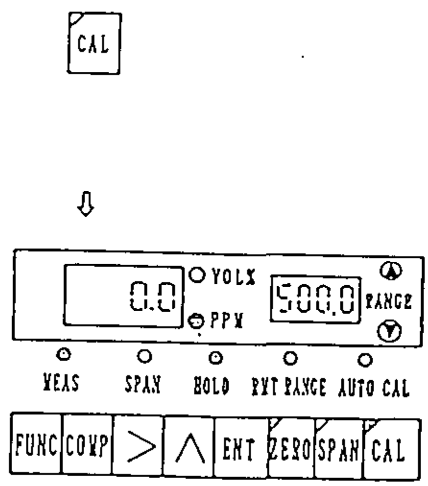




Fig. 5.4.2b

The CAL key indicating light at the up-left corner of [CAL] key is lit and it indicates that the calibration is taking place.

The ZERO key indicating light changes simultaneously from blink to continuous lighting. (Fig. 5.4.2 b)

In the dual components analyzer, zero calibration is performed for both measured components simultaneously.

Lighting interval of the CAL key indicating light is normally very short, but if displayed concentration does not reach it's final value the analyzer waits for a maximum 30 seconds for stabilization of measured value.

If displayed concentration is not stabilized in 30 seconds,

the calibration is cancelled.
After finishing zero calibration, the ZERO key indicating light and the CAL key indicating light are turned off and if the indicating light HOLD was lit, it is also turned off and then return to the function mode "Measuring".

NOTE

If zero calibration should be discontinued after starting, press [ZERO] key again.
The ZERO key indicating light is turned off and the analyzer returns to the function mode "Measuring" without performing zero calibration.
When [ZERO] key is depressed, and the holding function is set as ON, the analog output signal is kept constant at the value immediately before [ZERO] key is depressed.
When the zero calibration ends, the holding function is released. Therefore, before the sample gas is fully introduced into the analyzer, the analyzer transmits an analog signal different from measured component concentration for a short duration.

### 5.4.3 SPAN CALIBRATION

Concentration of span gas(span value) should be set before getting the analyzer into operation.
If not, span value should be set before calibration.
For this purpose, function mode "Span gas concentration(span value) setting and independent/dependent calibration selection" in set mode, should be selected by depressing [FUNC] key, and span value should be set beforehand. (Refer to 5.5.1, P.5-13)

Depress [SPAN] key.
The SPAN key indicating light at the up-left corner of [SPAN] key blinks and it indicates that the analyzer is ready for span calibration.
The indicating light HOLD is lit when the holding function is set as ON and the analog output signal is kept constant at the value immediately before [SPAN] key is depressed. (Fig. 5.4.3 a)
If the analyzer with automatic calibration option is used, the output signal for energizing a solenoid valve is turned on and span gas is introduced into the analyzer.
Span gas should be introduced into the analyzer manually if the analyzer without automatic calibration option is used.
If the dual components analyzer is used, the main display screen of one component to be calibrated blinks.
The component to be calibrated can be changed by depressing [COMP] key.
Select the correct component.
If the dual ranges analyzer is used, the range for calibration must be selected.
When displayed concentration on the main display screen reaches its final value, depress [CAL] key.
The CAL key indicating light at the up-left corner of [CAL] key is lit and it indicates that the calibration is taking place.
The SPAN key indicating light changes simultaneously from blink to continuous lighting.(Fig. 5.4.3 b)

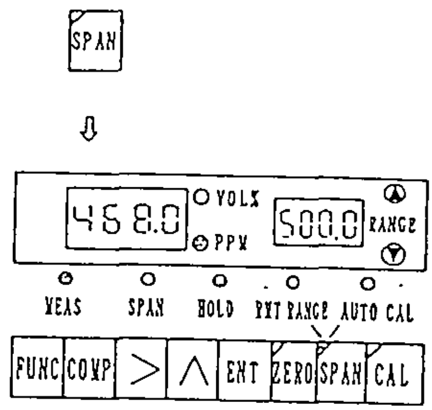


Fig.5.4.3a

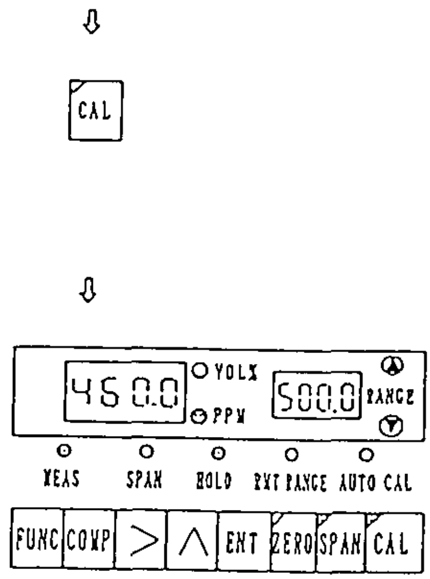


Fig.5.4.3b

Lighting interval of the CAL key indicating light is normally very short, but if displayed concentration does not reach it's final value the analyzer waits for a maximum 30 seconds for stabilization of measurement.
If displayed concentration is not stabilized in 30 seconds, the calibration is cancelled.

After finishing span calibration, the SPAN key indicating light and the CAL key indicating light are turned off and if the indicating light HOLD was lit, it is also turned off and then return to the function mode "Measuring".

NOTE

If span calibration should be discontinued after starting, press [SPAN] key again. The SPAN key indicating light is turned off and the analyzer returns to the function mode "Measuring" without performing span calibration.
When [SPAN] key is depressed, and the holding function being set as ON, the analog output signal is kept constant at the value immediately before [SPAN] key is depressed.
When span calibration ends, the holding funnction is released.
Therefore, before the sample gas is fully introduced into the analyzer, the analyzer transmits an analog signal different from measured component concentration for a short duration.

### 5.4.4 INITIAL CALIBRATION

Before getting the analyzer into operation, zero/span calibration should be completed in each range and for each measured component. Calibration for this purpose is called the initial calibration. Select function mode "Span gas concentration setting and independent/ dependent calibration selection".

Set correct span gas concentration and select independent calibration for the dual ranges analyzer.(Refer to 5.5.1, P.5-13 )
After finishing up the above-mentioned preparation, return to the function mode "Measuring" by depressing [FUNC] key repeatedly, and perform manual zero and span calibration.
For the dual ranges analyzer, zero and span calibration should be performed in each range independently.
For the dual components analyzer, perform zero calibration and span calibration of each component.
Move to set mode after completion of the initial calibration, and set or review various configuration parameters except span gas concentration setting.

## 5.5 SET MODE

Set mode is operating mode in which configuration parameters & data of the analyzer is reviewed or set.

This mode consists of following 3 basic function modes;

5.5.1 span gas concentration setting and independent/dependent calibration selection

5.5.2 Hold(Freeze) of analog output signal setting

5.5.4 Key lock ON/OFF setting

For the analyzer with remote range option,

5.5.3 Remote range setting

and further, for the analyzer with automatic calibration option,

5.6.1 Setting of automatic calibration start timer

5.6.2 Setting of automatic calibration cycle time

5.6.3 Setting of calibration gas flowing time duration

5.6.4 Setting of calibration gas flowing mode

5.6.5 Setting of automatic calibration ON/OFF are added.

In set mode the indicating light MEAS is turned off and the analog output signal is kept constant at the value immediately before moving to set mode.

Though many optional functions are included in set mode, parameters and data concerning them are not displayed for the analyzer without a corresponding option.

In the dual components analyzer, there are data and parameters to be set for each measured component.

In the function mode to set or review data and parameters for each component respectively, the main display of the currently selected component blinks.

Depressing [COMP] key, another component is selected and the display on the main display screen of the corresponding component starts blinking. (Fig. 5.5)

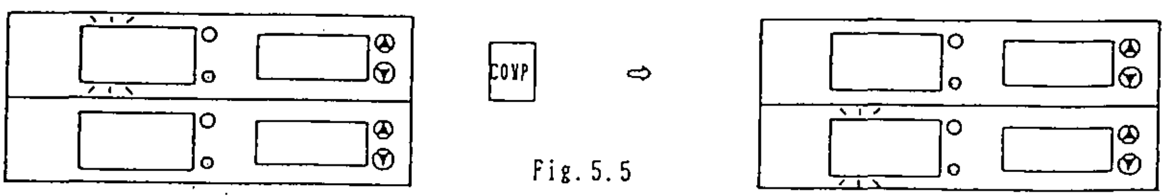



Fig. 5.5

**NOTE**

Configuration parameters and data are stored in a non-volatile memory in the analyzer and kept while the power is off.

## 5.5.1 SPAN GAS CONCENTRATION(SPAN VALUE) SETTING AND INDEPENDENT/DEPENDENT CALIBRATION SELECTION

In this function mode, concentration value of span gas and the calibration method for the dual ranges analyzer are set or reviewed.
The setting or reviewing procedure of span gas concentration is as follows.
Depress [FUNC] key (repeatedly if necessary) until indicating light SPAN starts blinking.
Blink of the indicating light indicates that the analyzer is functioning in this mode.
Span value **currently** used is displayed on the main display screen. (Fig. 5.5.1 a)
If the dual ranges analyzer is used, depress range selection keys, the span value for selected range appears on the main display screen.
If the current setting is applicable, move to other function by depressing [FUNC] key or select independent or dependent calibration.(Refer next page)
Follow the procedure described below when span value setting should be changed.
Depress [ > ] or [ ∧ ] or [COMP] key.
The number of the digit which can be changed blinks on the main display screen.(Fig. 5.5.1b)
Select the measuring range or the component to be changed.
Depress [COMP] key to select the component.
The digit which can be changed shifts according to every depress of [ > ] key.

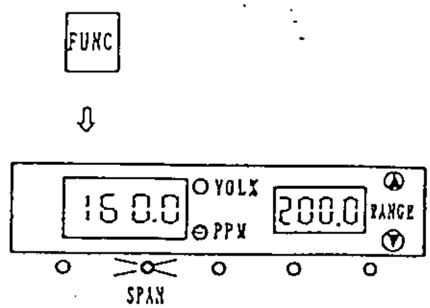



Fig.5.5.1a

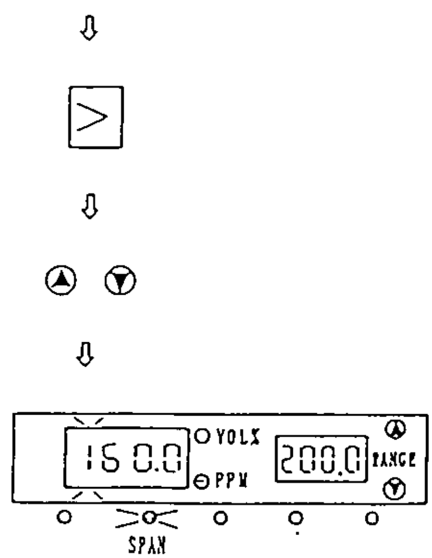



Fig.5.5.1b

In every depression of [ ∧ ] key, the digit on the screen increases one by one (1,2 ····· 9→0).
After setting a new span value for each

component or for each range, depress [ENT] key to write the new values into the memory.
Blink of the main display screen stops when the new value is stored.
There are two methods of performing calibration for high and low measuring ranges of the dual ranges analyzer.
One is performing calibration independently in each range and the other is performing calibration in one range with dependent calibration calculation for the other range.
In dependent calibration, calibration only in one range is necessary.
The other range is calibrated automatically by calculation.
The dependent calibration is mostly used, but in the initial calibration independent calibration must be chosen.
(Refer to 5.4.4, P.5-11)
Change setting according to the following procedure.

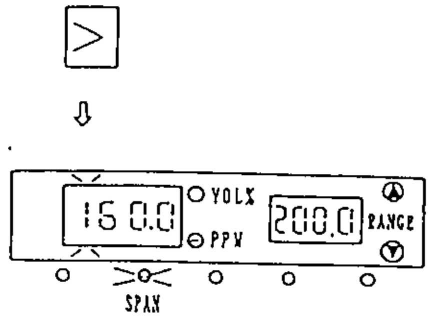



Fig. 5.5.1c

Depress [ > ] or [ ∧ ] or [COMP] key.
Displayed value on the main display screen blinks. (Fig. 5.5.1 c)
Depress [CAL] key. Message "S.CAL" appears on the main display screen, and "on" or "oFF" is displayed on the sub-display screen. "on" denotes dependent calibration and "oFF" denotes independent calibration. (Fig. 5.5.1d)

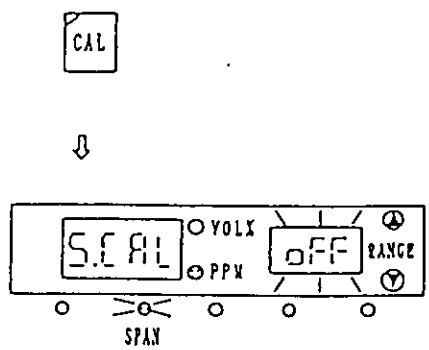



Fig. 5.5.1d

When [ ∧ ] key is depressed, displayed number "on" changes to "oFF" or vice versa. Depress [ENT] key to store the new parameter into the memory.
Blink of the sub-display screen stops after storing.

High or low range selection does not affect this setting.

## 5.5.2 SETTING OF ANALOG OUTPUT SIGNAL HOLDING

This function is to hold the analog output signal at the value immediately before beginning of the calibration.
On the other hand, the displayed value on the main display screen is not held.
Holding can be set for each component respectively in the dual components analyzer.

Depress [FUNC] key repeatedly until message " HoLd" is displayed on the main display screen.
The indicating light HOLD blinks and it indicates that the analyzer is operating in the function mode "Setting of analog output signal holding". Message "on" or "oFF" is displayed on the sub-display screen.(Fig. 5.5.2 a)
"on" denotes that the holding function is effective.
"oFF" denotes that the holding function is ineffective.
Depress [FUNC] key if the current setting is applicable and move to other function mode.
Follow the procedure described below when current setting is to be changed.
Depress [ > ] or [ ∧ ] or [COMP] key.
The display on the sub-display screen blinks and it indicates that the setting is ready for change.(Fig. 5.5.2 b)
Choose the component for the dual components analyzer with [COMP] key.
Depress the [ ∧ ] key, and select either ON or OFF.
After setting a new parameter, depress [ENT] key and store it into the memory.

Blink of the sub-display screen stops when the new parameter is stored. (Fig.5.5.2c)
When holding is set as "ON", indicating light HOLD is lit during calibration.

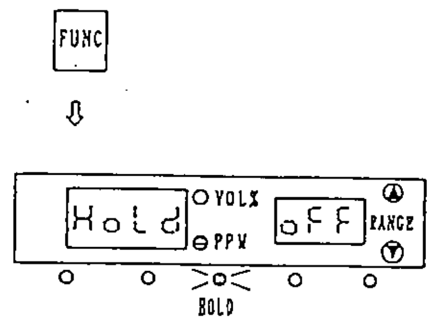



Fig.5.5.2a

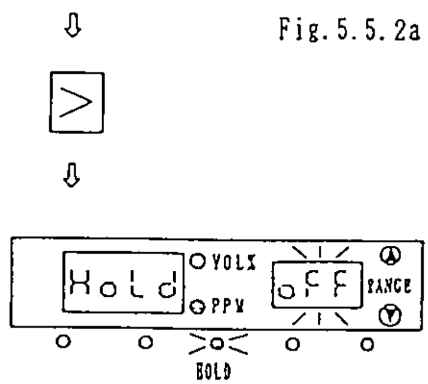



Fig.5.5.2b

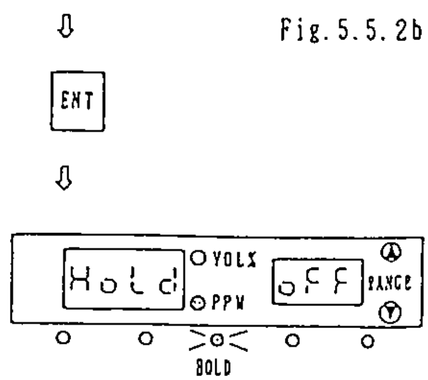



Fig.5.5.2c

NOTE

When [ZERO] key or [SPAN] key is depressed and calibration is taking place, holding of the analog output signal is effective until the end of calibration.
When calibration ends, the holding function is released. Therefore, before the sample gas is fully introduced into the analyzer, it transmits an analog signal different from measured component concentration for a short duration. On the other hand, in automatic calibration, holding is released after analog output signal representing measured component concentration.
Besides, notwithstanding setting of the holding function ON or OFF, the analog output signal is held while the analyzer is operating in set mode.

### 5.5.3 SETTING OF REMOTE RANGE(OPTION)

In this function mode, either of 2 ways for selecting measuring ranges of the dual components analyzer can be selected or reviewed. The one is to perform range selection by external signal, the other is to perform it by depressing range selection keys on the front panel of the analyzer.

Depress [FUNC] key repeatedly until message "r.rAG" appears on the main display screen. Message "on" or "oFF" appears on the sub-display screen.

The indicating light RMT RANGE blinks, and it indicates that the analyzer is operating in this function mode.

"on" denotes that measuring ranges are selectable by external signal.

"oFF" denotes that measuring ranges are selectable manually by depressing range selection keys on the front panel of the analyzer. (Fig. 5.5.3a)

If the current setting is applicable, depress [FUNC] key and move to other function mode.

When the current setting should be changed, follow the procedure described below.

Depress [ > ] or [ ∧ ] or [COMP] key, display on the sub-display screen blinks and it indicates that the setting is ready for change.(Fig. 5.5.3b)

By depressing [ ∧ ] key, change the displayed message from "oFF" to "on" or vice versa.(Fig. 5.5.3c)

Depress [ENT] key, and store the new parameter into the memory.

After the new parameter being stored, display on the sub-display screen stops blinking.(Fig. 5.5.3d)

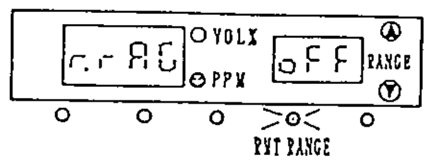



Fig.5.5.3a

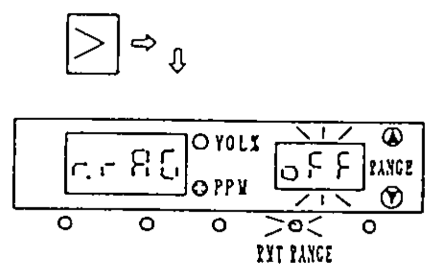



Fig.5.5.3b

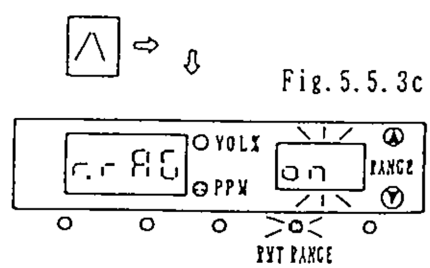



Fig.5.5.3c

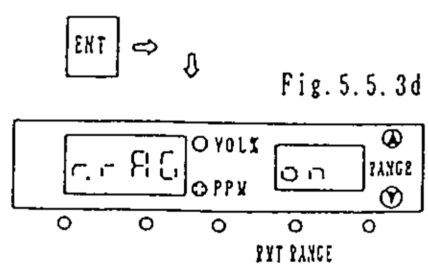



Fig.5.5.3d

**NOTE**

If "Remote range" is set as ON the indicating light RMT RANGE is lit & manual range selection is not feasible.

## 5.5.4 KEY LOCK ON/OFF SETTING

The key lock ON/OFF function intends to protect various settings from careless alteration.

When the key lock is set as ON, all key operations except [FUNC] key becomes invalid, that is, various parameters and data can be reviewed in the state of key lock "on", but the setting cannot be changed.

Set the key lock "oFF" before setting change and manual calibration.

Depress [FUNC] key repeatedly until message "LOC" being displayed on the main display screen.

The current setting "on" or "oFF" is displayed on the sub-display screen. (Fig. 5.5.4 a)

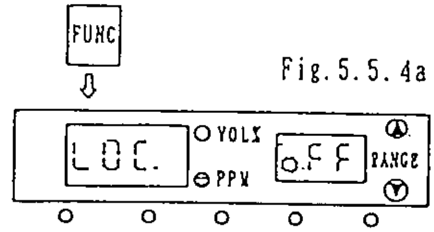



Fig.5.5.4a

Follow the procedure described below when the setting should be changed.

Depress [ > ] or [ ∧ ] or [COMP] key.

Display on the sub-display screen blinks and it indicates that the setting is ready for change. (Fig. 5.5.4 b)

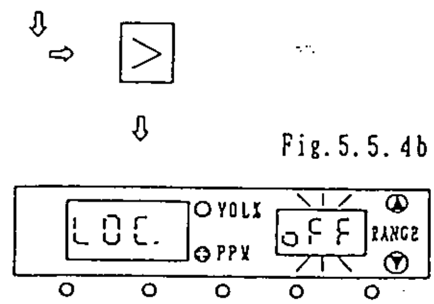



Fig.5.5.4b

Depress [ ∧ ] key and set "on" or "oFF" on the sub-display screen. (Fig. 5.5.4 c)

After setting a new parameter, depress [ENT] key and store it into the memory.

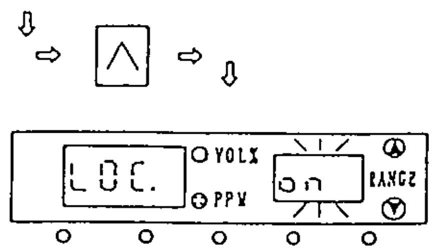



Fig.5.5.4c

Blink of the sub-display screen stops when the new parameter is stored. (Fig. 5.5.4 d)

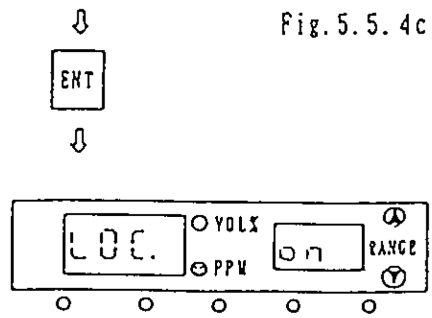



Fig.5.5.4d

## 5.6 AUTOMATIC CALIBRATION (OPTION)

The automatic calibration is performed periodically and also performed at any time by an external start signal (remote start).
When automatic calibration starts, the signal outputs for solenoid valves energizing at the automatic calibration input-output terminals turn on in preset sequence.
Zero gas and span gas are introduced into the analyzer in order and calibration of zero points and calibration of span points are automatically performed.
If the dual ranges analyzer is used, automatic calibration must be performed at the measuring range in which span gas is prepared and its concentration(span value) is set beforehand.
Automatic calibration is handled as top priority. When automatic calibration starts, all other functions are interrupted.
All key operations and an external range selection signal become invalid while the automatic calibration is taking place.

NOTE

The automatic calibration initiated by an external signal (remotely started automatic calibration) handled with more priority than the periodic automatic calibration.
Periodic automatic calibration does not start at it's starting time if the automatic calibration due to a remote start signal is being performed.
Moreover, when a remote start signal is given during periodic automatic calibration, the automatic calibration is interrupted and the automatic calibration initiated by the remote start signal starts.
Even if the setting of automatic calibration ON/OFF is OFF, automatic calibration due to remote signal can be performed.

The DC voltage signal to be given to the remote start signal input terminal should be 5V and longer than 100msec. in duration.
To decide how automatic calibration operates, the following parameters should be set properly.

- Setting of automatic calibration start timer (5.6.1)
- Setting of automatic calibration cycle time (5.6.2)
- Setting of calibration gas flowing time (5.6.3)
- Setting of calibration gas flowing mode (5.6.4)
- Setting of automatic calibration ON/OFF (5.6.5)

If an automatic calibration should be interrupted after it's starting, [ENT] key and [CAL] key must be simultaneously depressed.
The automatic calibration is discontinued and the analyzer returns to operate in the function mode "Measuring".
If an error occurs during automatic calibration, a contact signal is transmitted from the automatic calibration input-output terminal.
The corresponding error code is displayed on the sub-display screen. (Refer to P.7-13 )
The calibration is not performed for the calibration gas in which error occurs and it moves to the introduction of the following calibration gas or sample gas determined in the calibration program.
Fig.5.6.1 is a timing chart of typical automatic calibration.

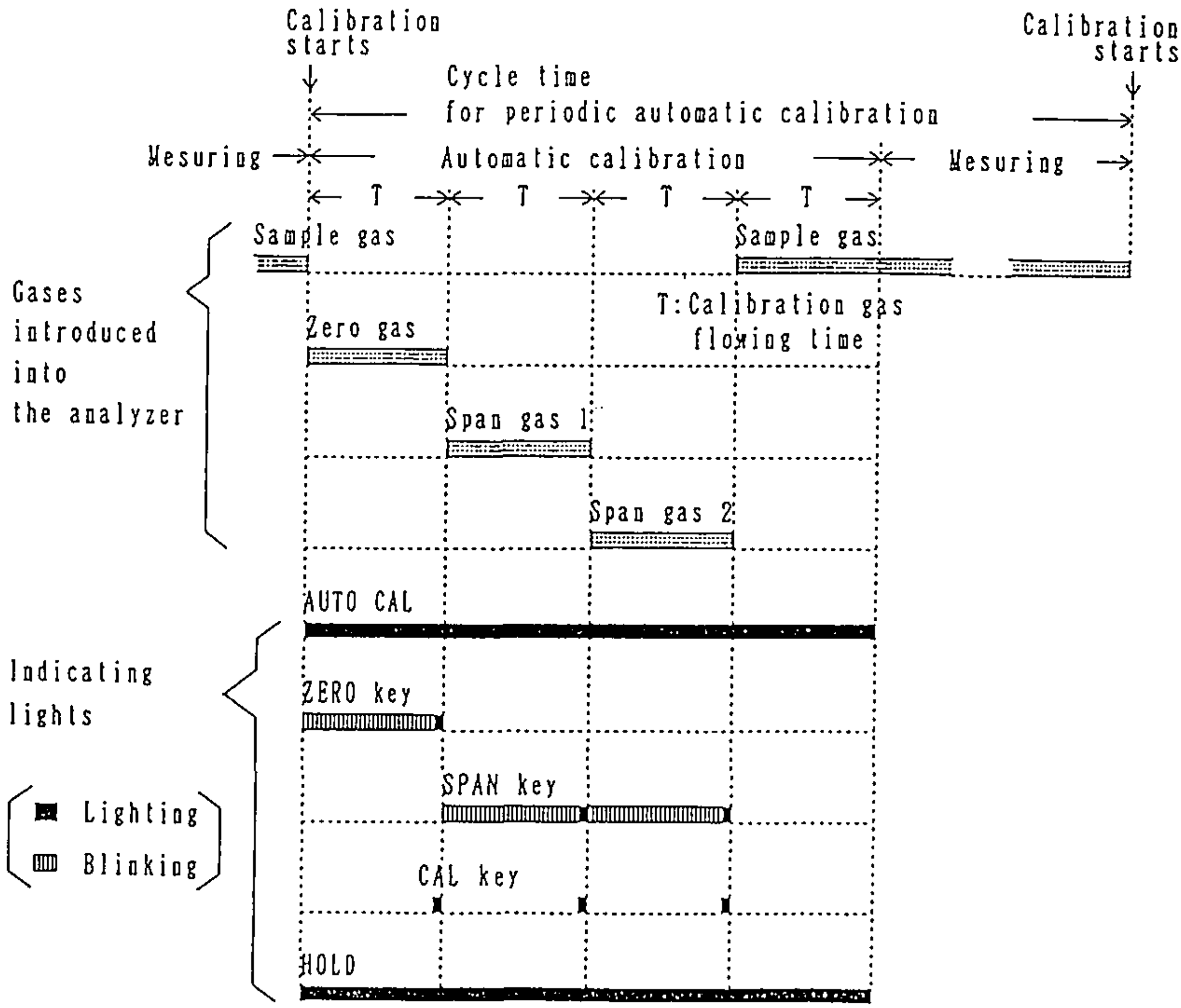



Fig.5.6.1 Timing chart of an automatic calibration

## 5.6.1 SETTING OF AUTOMATIC CALIBRATION START TIMER

The start timer sets starting time of the next periodic automatic calibration.

The next periodic automatic calibration begins after time set in the start timer elapsed.

This setting should be renewed at the new installation or if the time at which the periodic automatic calibration is performed deviates from desirable range because of interruption of power supply etc.

Depress [FUNC] key repeatedly until message "Strt" appears on the main display screen. The indicating light AUTO CAL blinks and the time until the next periodic automatic calibration is displayed on the sub-display screen in counting down mode.(Fig.5.6.2a)

If the current setting is applicable, depress [FUNC] key and move to other function mode.

When the start time should be changed, follow the procedure described below.

Depress [ > ] or [ ∧ ] or [COMP] key.

The display on the sub-display screen blinks and it indicates that the setting is ready for change.(Fig.5.6.2b)

The first digit below decimal point means time in 10 minutes.

Numbers upper than decimal point mean time in hours.

Depress [ > ] key and choose the digit to be changed.

The display of the chosen digit blinks.

Depress [ ∧ ] key and change the number.

The time can be set from 10 minutes to 199 hours in 10 minutes step.

After setting, depress [ENT] key and store the new start time into the memory.

Time until the next periodic automatic calibration is displayed in counting down mode on the sub-display screen after [ENT] key depressed.(Fig.5.6.2c)

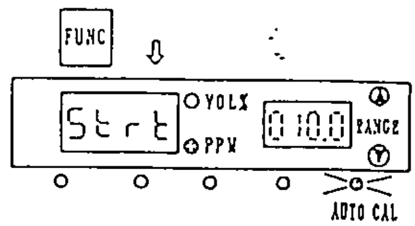


Fig.5.6.2a

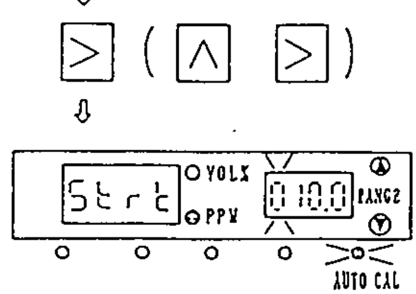


Fig.5.6.2b

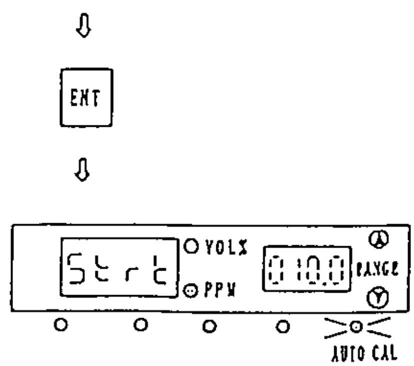


Fig.5.6.2c

> **NOTE**
>
> Time until the next periodic automatic calibration is displayed on the sub-display screen either the setting of automatic calibration ON/OFF is ON or OFF.
> But, the periodic automatic calibration is not performed if the automatic calibration ON/OFF is set as OFF .

## 5.6.2 SETTING OF AUTOMATIC CALIBRATION CYCLE TIME

In this function mode, The time interval that the periodic automatic calibration is performed is reviewed or set.

The time interval can be set 1 to 199 hours in one hour step.

Depress [FUNC] key repeatedly until message "CyCL" appears on the main display screen.

The indicating light AUTO CAL blinks.

The automatic calibration cycle time currently set is displayed on the sub-display screen.(Fig.5.6.3a)

Depress [FUNC] key and move to other function mode if the current setting is applicable.

If the setting value should be changed, follow the procedure described below.

Depress [ > ] or [ ∧ ] or [COMP] key.

The most significant digit on the sub-display screen blinks. It indicates that the setting is ready for change. (Fig.5.6.3b)

Choose the digit to be changed by depressing [ > ] key. The display of the chosen digit blinks

Depressing [ ∧ ] key, the digit chosen increases one by one.(Fig.5.6.3c)

After setting, Depress [ENT] key and store the new cycle time into the memory.(Fig.5.6.3d)

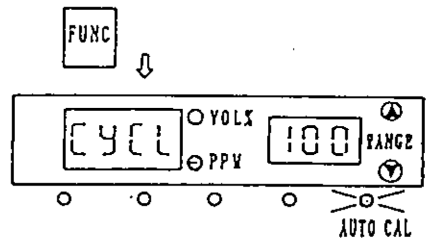


Fig.5.6.3a

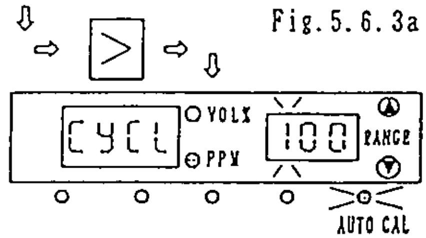


Fig.5.6.3b

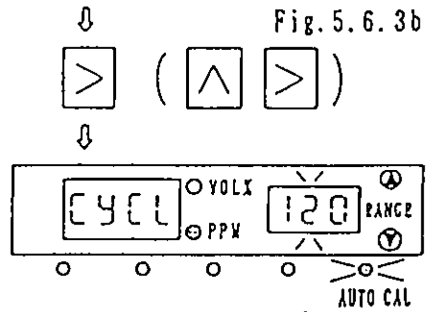


Fig.5.6.3c

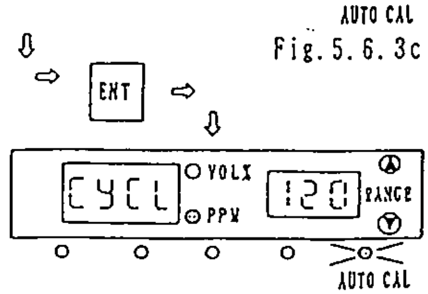


Fig.5.6.3d

## 5.6.3 SETTING OF REFERENCE GAS FLOWING TIME

The gas flowing time should cover the time necessary for complete substitution of gas inside the analyzer from sample gas to calibration gas or vice versa and the concentration reading reaching to it's final value.

The time can be set from 100 to 599 seconds in one second step.

Depress [FUNC] key repeatedly until message "F.SEC" appears on the main display screen.

The indicating light AUTO CAL blinks, and the calibration gas flowing time currently set is displayed on the sub-display screen.(Fig.5.6.4a)

If the current setting is applicable, depress [FUNC] key and move to other function mode.

If it is to be changed, depress [ > ] or [ ∧ ] or [COMP] key, the analyzer becomes the state that the setting is ready for change.

Depress [ > ] key to choose the digit to be changed. The display of the chosen digit blinks.

Depress [ ∧ ] key and change the digit. (Fig.5.6.4b)

After setting, store the new calibration gas flowing time by depressing [ENT] key.(Fig.5.6.4c)

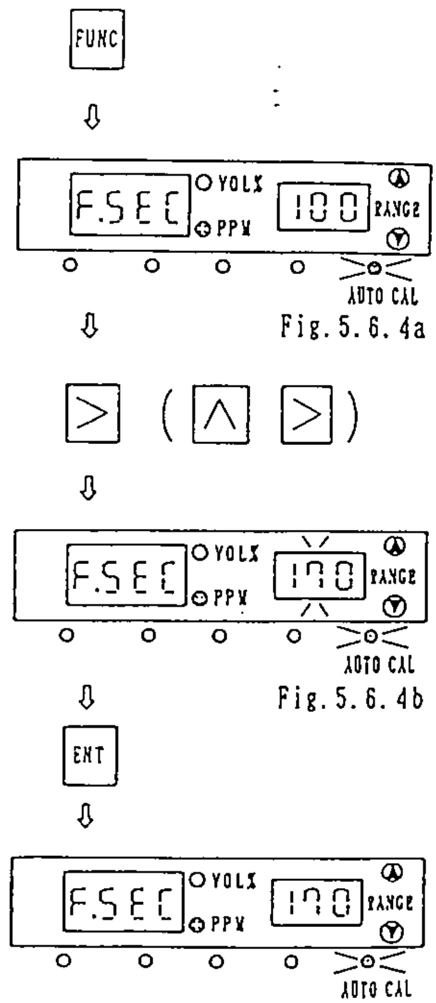


Fig.5.6.4a
Fig.5.6.4b
Fig.5.6.4c

### 5.6.4 SETTING OF CALIBRATION GAS FLOWING MODE

In this function mode the calibration gases to be introduced into the analyzer and their order of introduction are set.

Depress [FUNC] key repeatedly until message "FLno." appears on the main display screen.

The indicating light AUTO CAL blinks.

The number from 0 to 3 which indicates the flowing mode currently set is displayed on the sub-display screen. (Fig.5.6.5a)

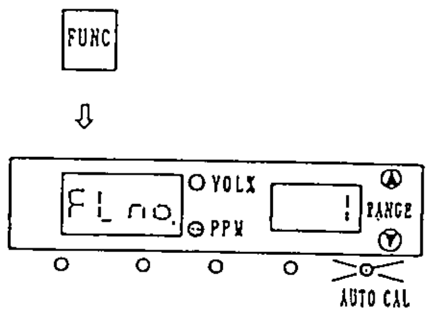



Fig.5.6.5a

These numbers correspond to flowing modes as follows.

No.0:Zero gas

No.1:Zero gas-The span gas for the first component

No.2:Zero gas-The span gas for the second component

No.3:Zero gas-The span gas for the first component-the span gas for the second component

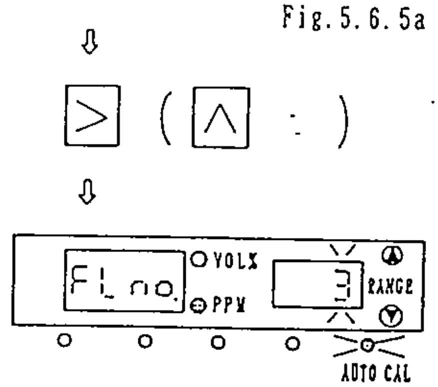



Fig.5.6.5b

NOTE

Choose mode number 1 when zero and span automatic calibration is to be performed in single components analyzer.

Depress [FUNC] key and move to other function mode, if the current setting is applicable.

If setting should be changed, follow the procedure described below.

Depress [ > ] or [ ∧ ] or [COMP] key, the analyzer becomes the state that the setting is ready for change.

Depress [ ∧ ] key and change the mode number.(Fig.5.6.5b)

Store the new mode number by depressing [ENT] key.(Fig.5.6.5c).

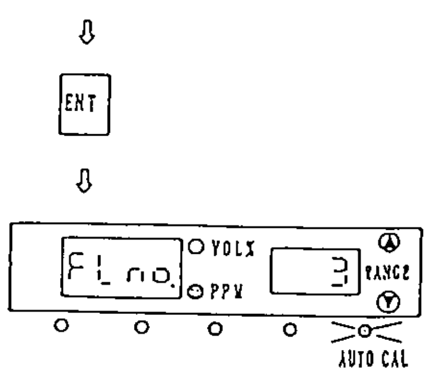



Fig.5.6.5c

### 5.6.5 SETTING OF AUTOMATIC CALIBRATION ON/OFF

This setting is to choose either the periodic automatic calibration is performed or not.

When periodic automatic calibration is to be performed, it should be set as ON and when not, it should be set as OFF.

Periodic automatic calibration is not performed if it is set as OFF. However, the remote start automatic calibration is possible in spite of setting as OFF.

Depress [FUNC] key repeatedly until message "A.CAL" appears on the main display screen.

The indicating light AUTO CAL blinks and "on" or "oFF" currently set is displayed on the sub-display screen.(Fig.5.6.6a)

Depress [FUNC] key and move to other function mode if the current setting is applicable.

Follow the procedure described below if the current setting should be changed.

Message "on" or "oFF" on the sub-display screen blinks when [ > ] or [ ∧ ] or [COMP] key is depressed and it indicates that the setting is ready for change. (Fig.5.6.6b)

Depress [ ∧ ] key and change the setting (Fig.5.6.6c)

Depress [ENT] key and store the new setting.(Fig.5.6.6d)

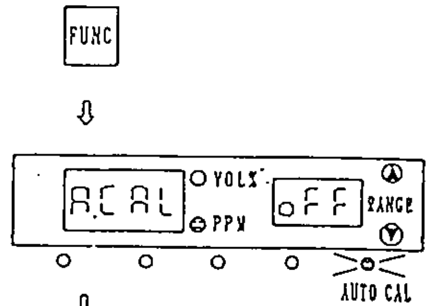


Fig.5.6.6a

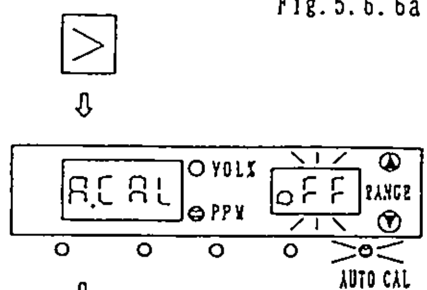


Fig.5.6.6b

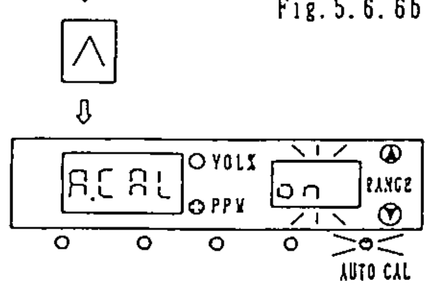


Fig.5.6.6c

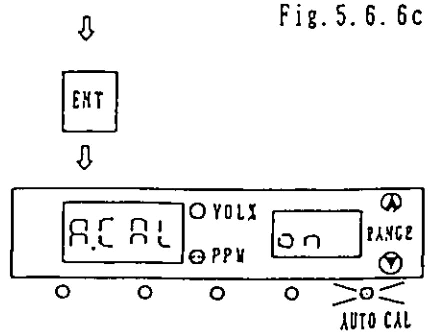


Fig.5.6.6d

# 6. MAINTENANCE

WARNINGS

- Dangerous voltages are present inside the instrument assembly.
- Be careful with the gas leakage, especially in case of toxic gas.

To ensure normal operation of analyzer, carry out daily, weekly and yearly checks & maintenance according to the following table.

Points of daily check

| Check points | Troubles | Causes | Adjustments |
|---|---|---|---|
| Digital display of concentration | Large indicating error | 1) Dust is contained in measuring cell | 1) Clean the cell. Check sampling systems, especially gas filter. |
| | | 2) Leaking of air into sampling piping. | 2) Find leaking part & repair. |
| Flow rate of sample gas & purge gas (in case of interior purging) | Deviating from allowable range 0.5～1.5 ℓ/min. | | Adjust flow rate. |
| Dust filter (membrane filter) | Severe contamination | Breakage of primary filter etc. | 1) Replace primary filter.<br>2) Replace membrane filter. |

Points of weekly check

| | | | |
|---|---|---|---|
| Analyzer zero point | Zero shift | | Carry out calibration of zero point |
| Analyzer span point | Span shift | | Carry out calibration of span point |

Point of yearly check

| | | | |
|---|---|---|---|
| Analyzer | | Preventive maintenance | Overhaul analyzer |

## 6.1 MEASURING CELL CLEANING

When measuring cell inside is contaminated by dust or mist, a drift of measured value may be caused.

Clean the interior of the measuring cell if contaminated. At the same-time, check sampling system devices, especially filter, in order to eliminate any cause of contamination of cell interior by dust & mist.

### 6.1.1 HOW TO DISASSEMBLE AND REASSEMBLE MEASURING CELL

There are 2 types of measuring cell, one is a block cell(cell lengths:4mm, 8mm, 16mm & 32mm) and the other is a pipe cell(cell lengths:64mm, 125mm & 250mm). In case of a dual components analyzer, there is a combination cell type, which is composed of both types of cells in the optical system. For this type, disassemble pipe cell first then the block cell.(refer to Fig.6.3)

(1) How to disassemble pipe cell(refer to Fig.6.1)

a. Shut sample gas flow down. When toxic gas is contained, purge measuring cell interior with zero gas sufficiently.

b. Turn power switch off.

c. Loosen 2 fixing screws of the front panel and draw out the inner part until stopped by stoppers inside the case. When complete drawing-out of the inner part from the case is needed, hold the front panel up and draw it out beyond stop carefully.

d. Detach piping connection to the measuring cell.

e. Displace the infrared source unit(No.5 in Fig. 6.1) by loosening

2 fixing screws(No.1 in Fig. 6.1) to base plate so as to make a gap between pipe cell(No.12 in Fig.6.1) and IR source unit.

f. Loosen and detach 4 screws(No.7 in Fig.6.1) of the cell holders (No.11 in Fig. 6.1).

g. Remove the cell from measuring unit then detach both windows (No.14 Fig. 6.1) by rotating the window holders anticlockwise.

h. A window plate made of calcium-fluoride is fixed to the window holder and reflector plate inside cell is fixed to cell wall, therefore both are unremovable.

i. Proceed reassembling in reverse to disassembling procedures. In reassembly, make a space of approx. 0.5 mm both between infra-red source unit & cell and between cell & detector.

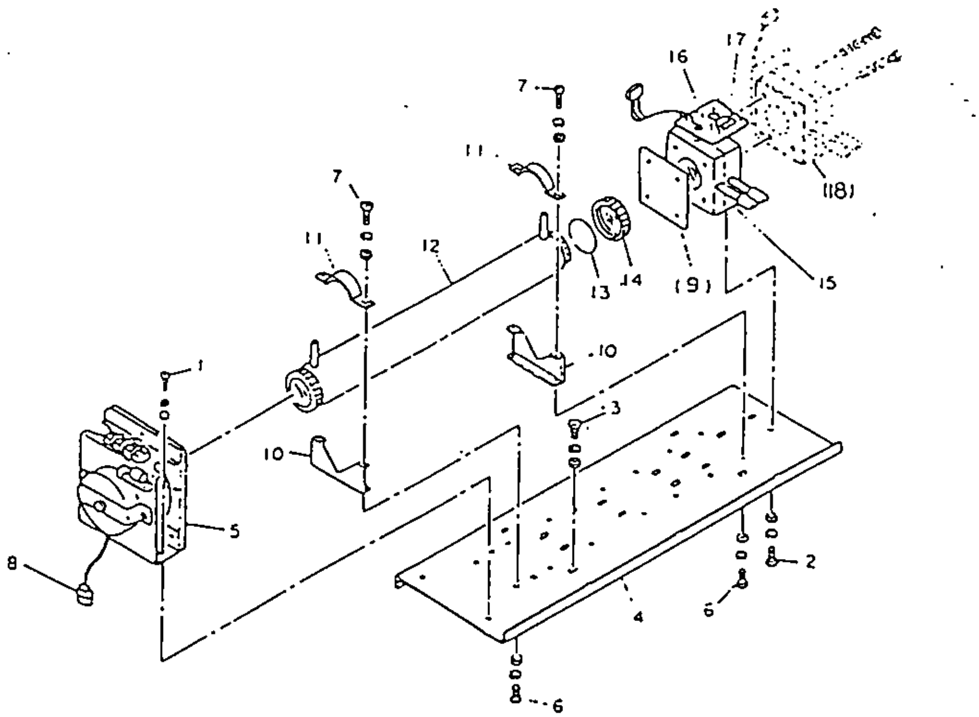



Fig.6.1 Exploded view of measuring unit (Pipe cell)

| | |
|---|---|
| 1. Screw(for infrared source unit fixing) | 10. Support |
| 2. Screw(for detector fixing) | 11. Holder |
| 3. Screw(for base plate fixing) | 12. Pipe cell |
| 4. Base plate | 13. O-ring |
| 5. Infrared source unit | 14. Window |
| 6. Screw(for support fixing) | 15. Detector |
| 7. Screw(for holder fixing) | 16. Bridge cct. board |
| 8. Connector for chopper motor | 17. Bridge resistor |
| 9. [Filter(provided if necessary)] | 18. [Detector for the 2nd component] |

(2) How to disassemble block cell(refer to Fig.6.2 next page)

a. Proceed the same procedures described in a.～d. of (1)how to disassemble pipe cell.

e. Remove connector a of detector output cord from p.c.b..
In case of the dual components analyzer, remove connector of output cord of the 2nd component detector(No.13 in Fig.6.2) from the 2nd component printed cct. board, then remove the 2nd component detector by loosening 2 screws(No.14 in Fig.6.2).

f. Loosen 2 screws(No.10 in Fig.6.2), with which the detector and the infrared source unit are mounted together, then remove the detector from the measuring unit.
In this removal, the cell is also removed together with detector.

g. Remove the cell from the detector by loosening 2 fixing screws (No.6 in Fig.6.2).
A window(No.8 in Fig.6.2) on one side of block cell is not fixed but only inserted between detector and block cell, therefore hold the detector upside while disassembling not so as to drop the window down.

h. Proceed reassembling in reverse to disassembling procedures.
Locate an O-ring between the window holder and detector.
Be sure not to mislocate the O-ring.
For the dual components analyzer, the 2nd component detector should be assembled after finishing assemble of the 1st component detector.
Make sure not to make space between 1st and 2nd detectors.
Also, make sure that 2 connectors of detector output cord are connected properly to the 1st and 2nd component printed cct. boards.

**CAUTION**

The window on one side of block cell is not fixed. Be careful not to break it by careless falling down.(Refer to (2)g)

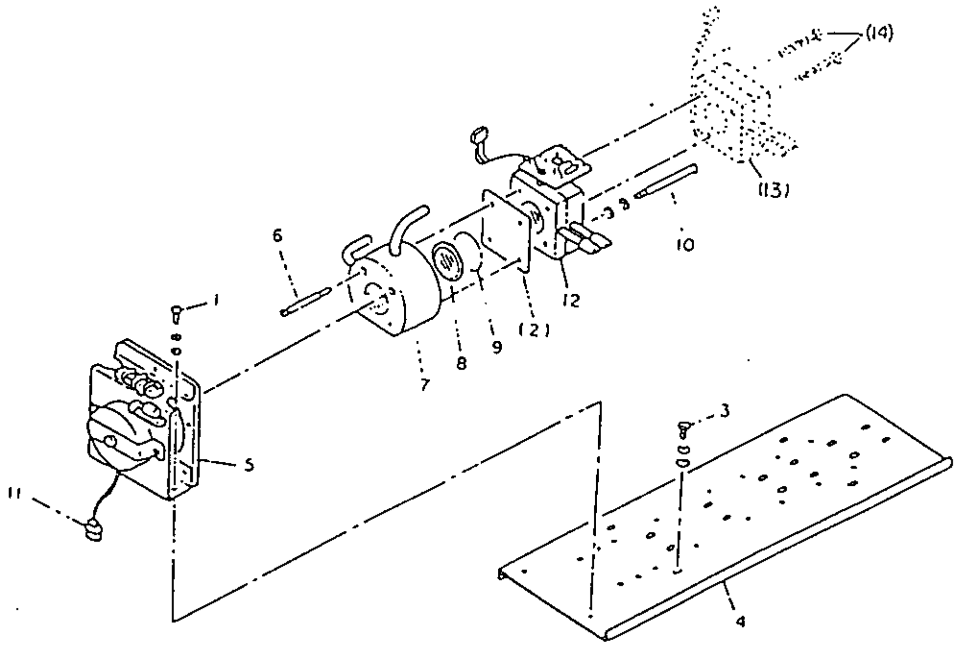



Fig.6.2 Exploded view of measuring unit (Block cell)

1. Screw(for infrared source unit fixing)
2. [Filter(provided if necessary)]
3. Screw(for base plate fixing)
4. Base plate
5. Infrared source unit
6. Screw(for block cell fixing)
7. Block cell
8. Window
9. O-ring
10. Screw(for detector fixing)
11. Connector of chopper motor
12. Detector
13. [Detector for the 2nd component]
14. [Screw(for the 2nd component detector fixing)]

(3) How to disassemble combination cell: (Refer to Fig.6.3 next page)

a. Proceed the same procedures described in a.~d. of (1) how to disassemble pipe cell.

e. Remove connectors of output cord of detector from printed cct. boards.

f. Remove both wiring to 2 pin terminals of the infrared source unit and 2 pin connectors(No.19 in Fig.6.3) of the chopper motor.

g. Remove 4 screws(No.20 in Fig.6-3) for fixing the base plate(No.3 in Fig.6.3) and take out the measuring unit.

## CAUTIONS

- Do not give any rough handling to both pipings of detector and infrared source unit during disassembling & reassembling measuring cell. Pipe deforming may lead to irregular action due to leakage of sealed gas.
- Window(No.7 in Fig.6-3) on one side of block cell is not fixed, therefore, care not to break it by falling down.

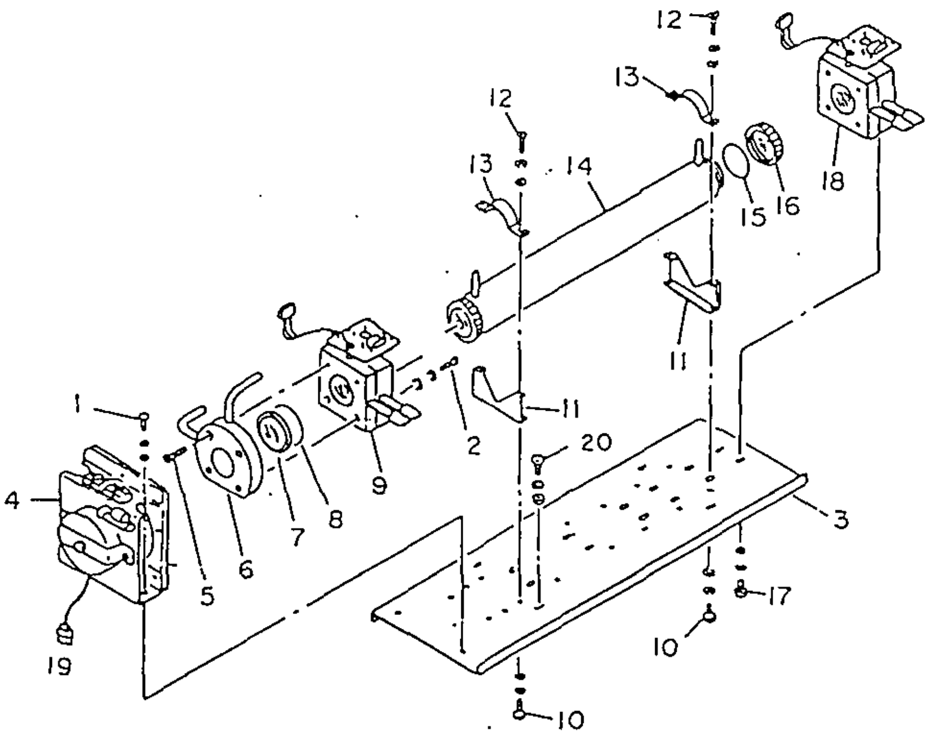



Fig.6.3 Exploded view of measuring unit (Combination cell)

1. Screw(for infrared source fixing)
2. Screw(for detector fixing)
3. Base plate
4. Infrared source unit
5. Screw(for block cell fixing)
6. Block cell
7. Window
8. O-ring
9. Detector
10. Screw(for support fixing)
11. Support
12. Screw(for holder fixing)
13. Holder
14. Pipe cell
15. O-ring
16. Window
17. Screw(for detector fixing)
18. Detector
19. Connector of chopper motor
20. Screw(for base plate fixing)

## 6.1.2 HOW TO CLEAN CELL

**CAUTIONS**

- Be careful to handle cell windows as it is very fragile and easily scratched on surface.
- Be careful not to make scratch or crack on cell interior because it is utilized as optical reflection mirror face.

(1) At cleaning of cell inside and infrared ray window, firstly wipe out with soft brush etc. for rather big particles of dust, then with soft cloth lightly.
Do not use hard cloth for cleaning.

(2) In case of a heavily dirty window, clean it with alcohol or acetone moistened soft cloth.

(3) If a window were lightly corroded, remove corrosion by rubbing with chromium oxide powder on soft cloth.
However, if heavily corroded, replace it with a new one.

(4) After cleaning of cell and window, reassemble them according to disassembling & reassembling procedures of cell.
Connect piping tightly so as not to leak during operation.
Also, be sure to connect piping rightly without forced bent portion.

# 7. TROUBLE-SHOOTING

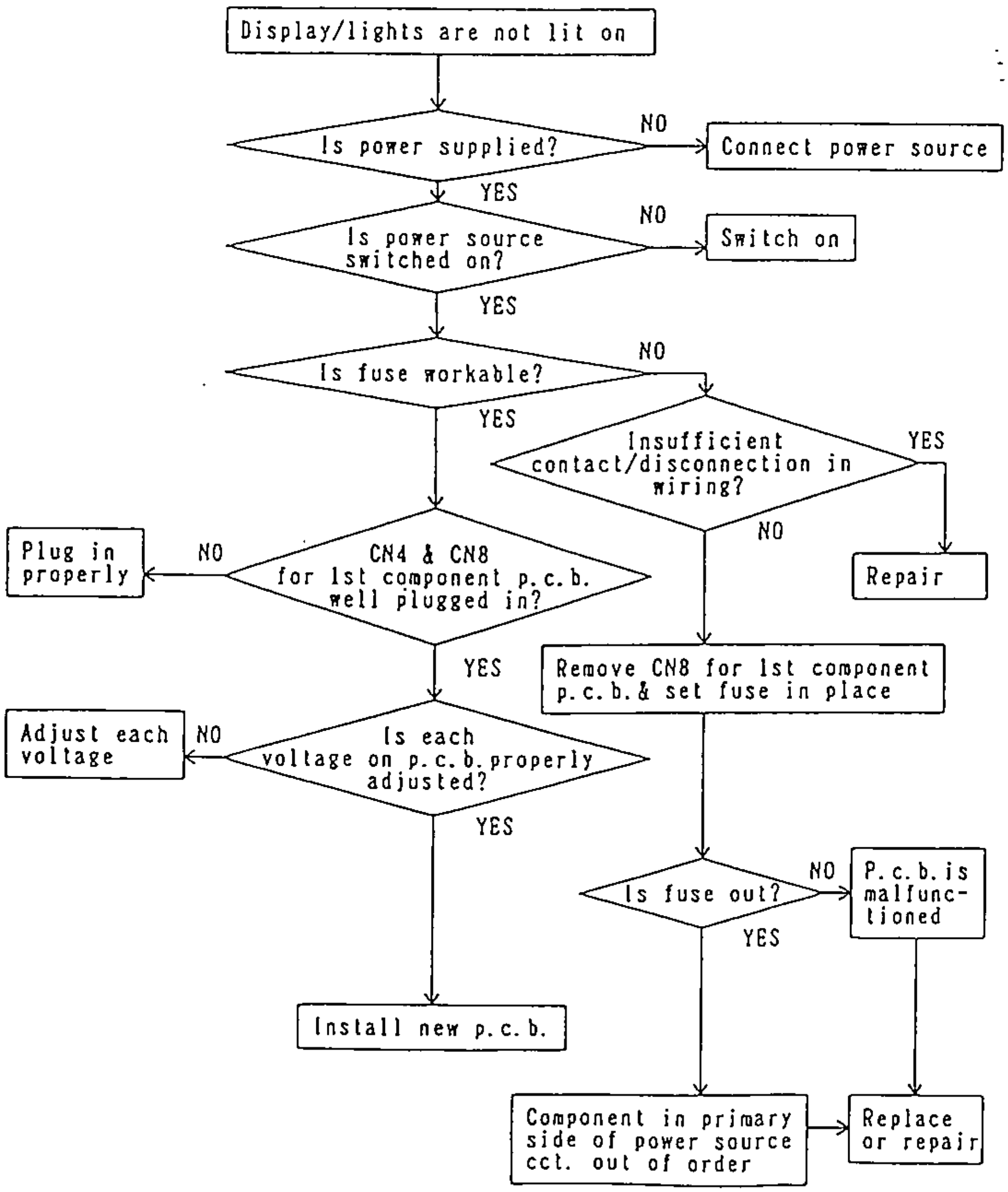
WARNINGS

- Dangerous voltages are present inside the analyzer.
- Be careful for gas leakage, especially for toxic gas.

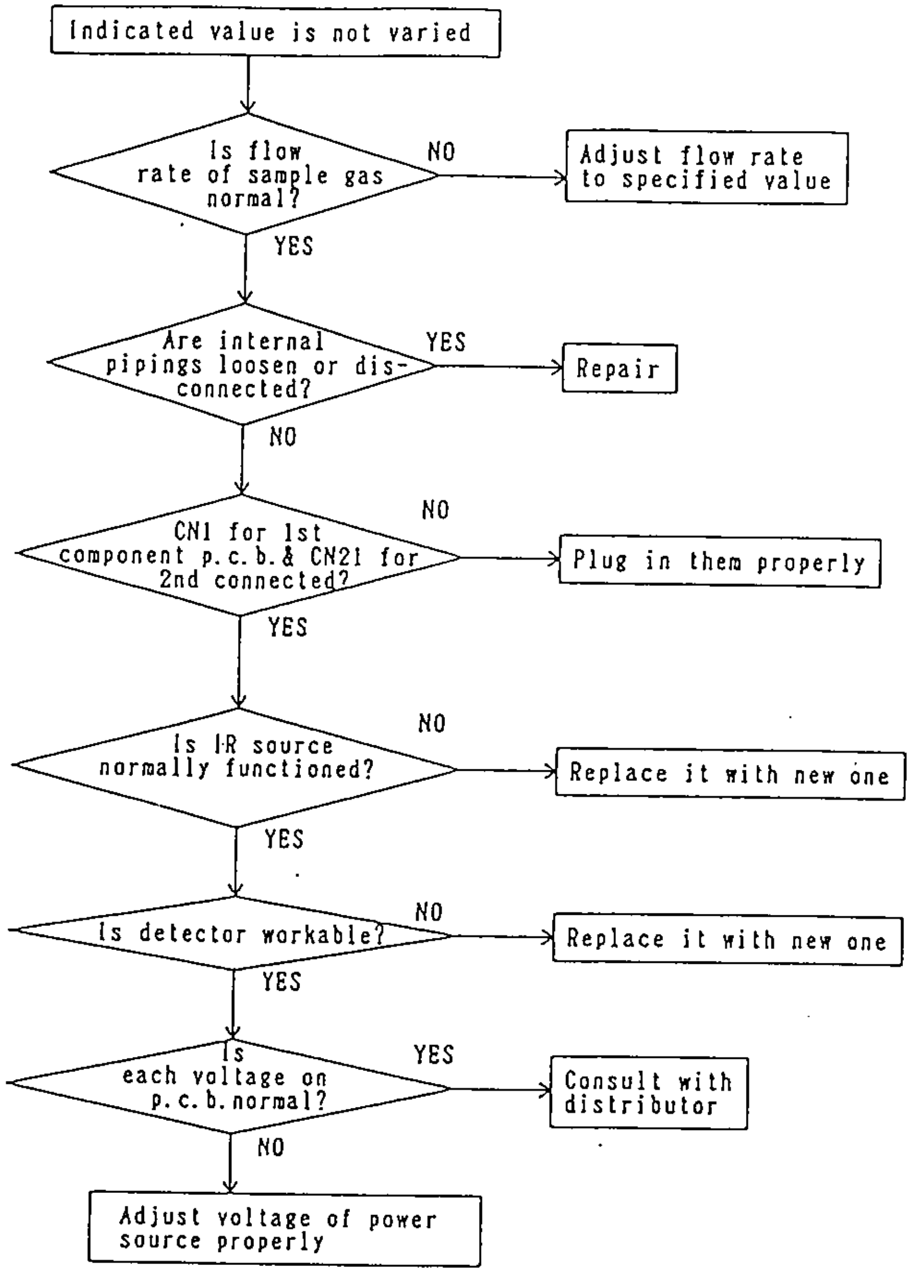
## 7.1 TROUBLE-SHOOTING

Proceed trouble shootings according to flow-charts in this paragraph and referring to Fig.7.1 on page 7-6.

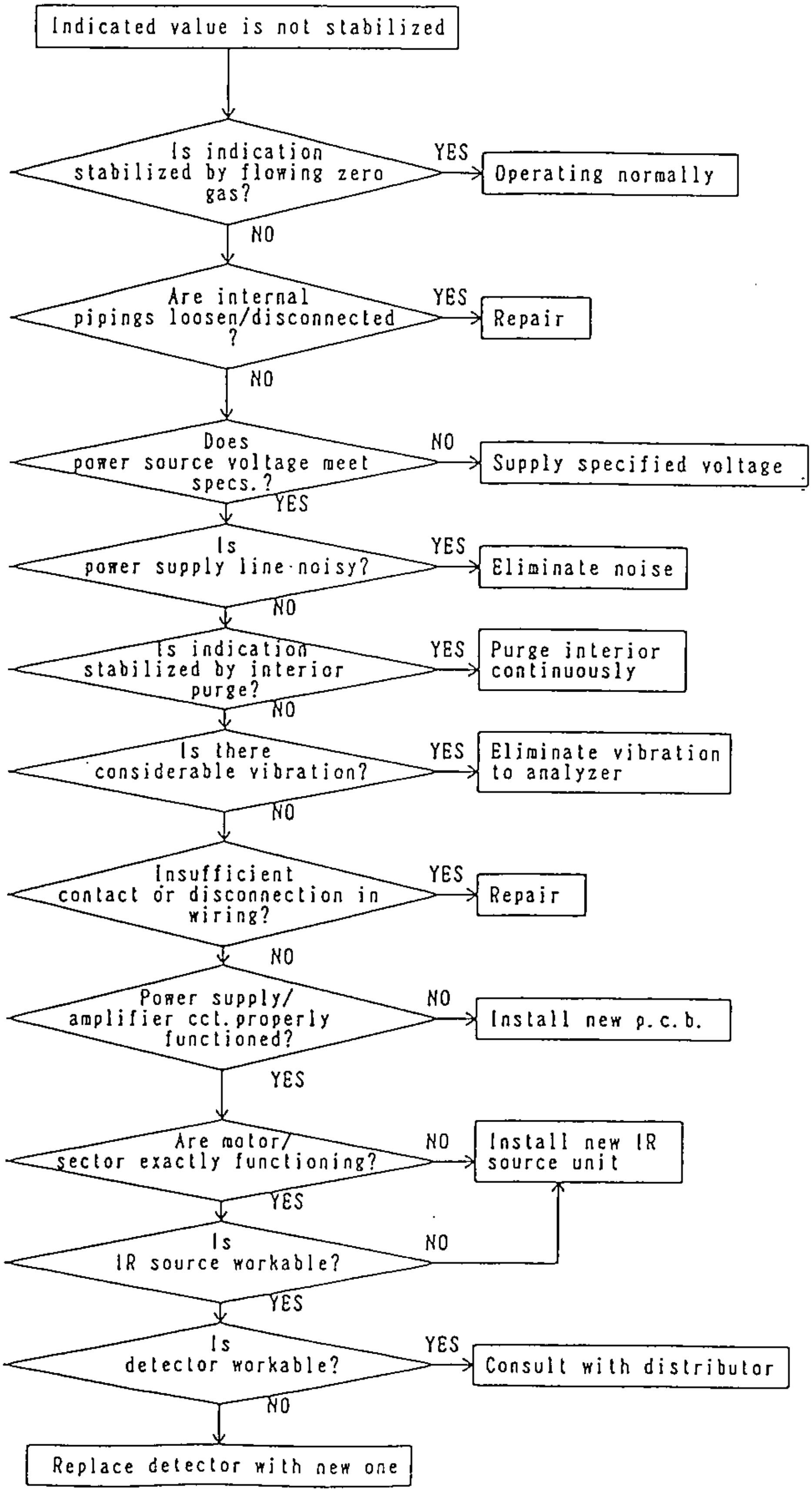
### 7.1.1 DISPLAY OR INDICATING LIGHTS ARE NOT LIT ON



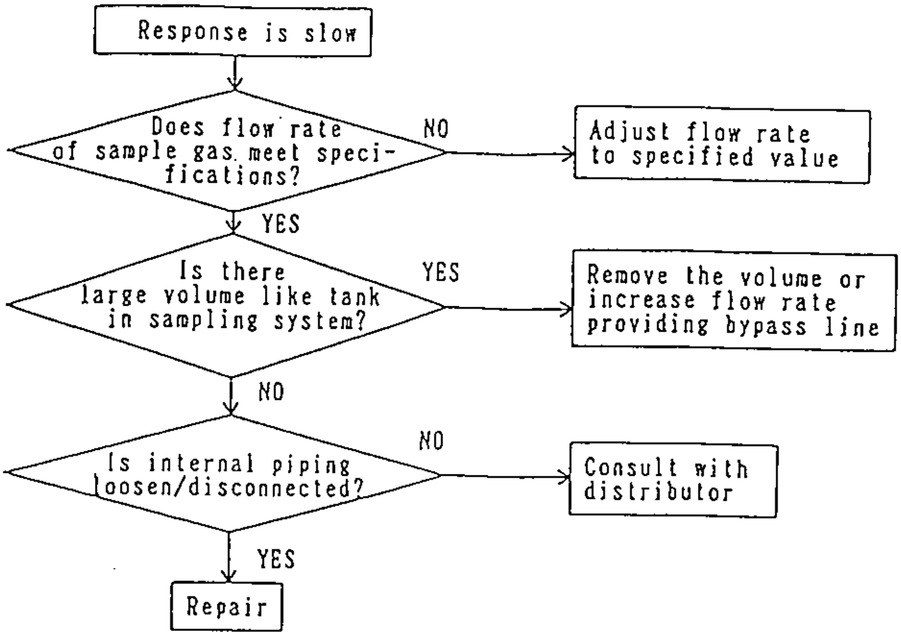
## 7.1.2 INDICATED VALUE IS NOT VARIED



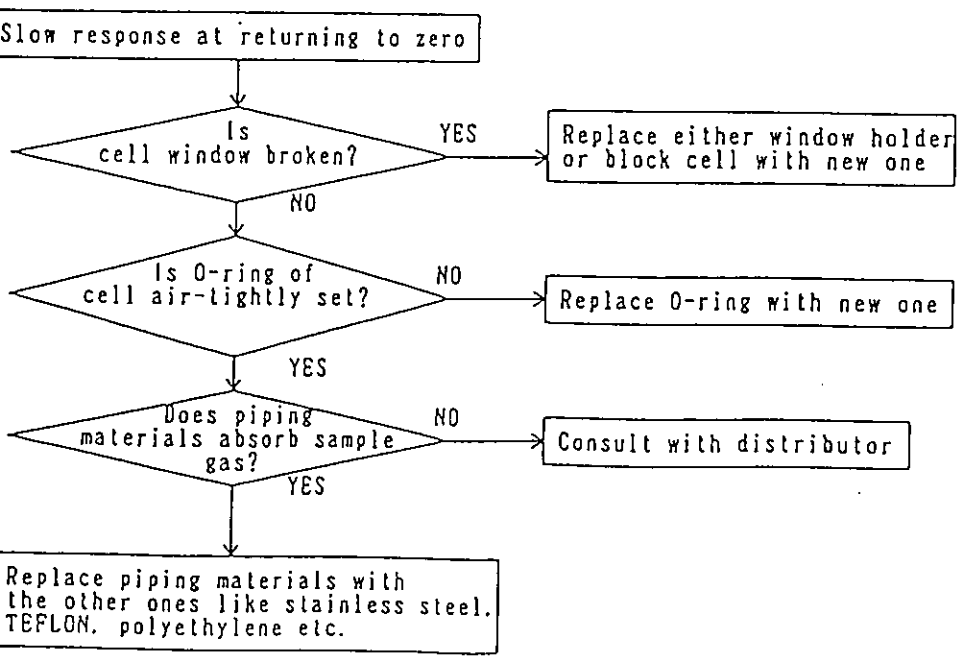
## 7.1.3 INDICATED VALUE IS NOT STABILIZED



### 7.1.4 RESPONSE IS SLOW

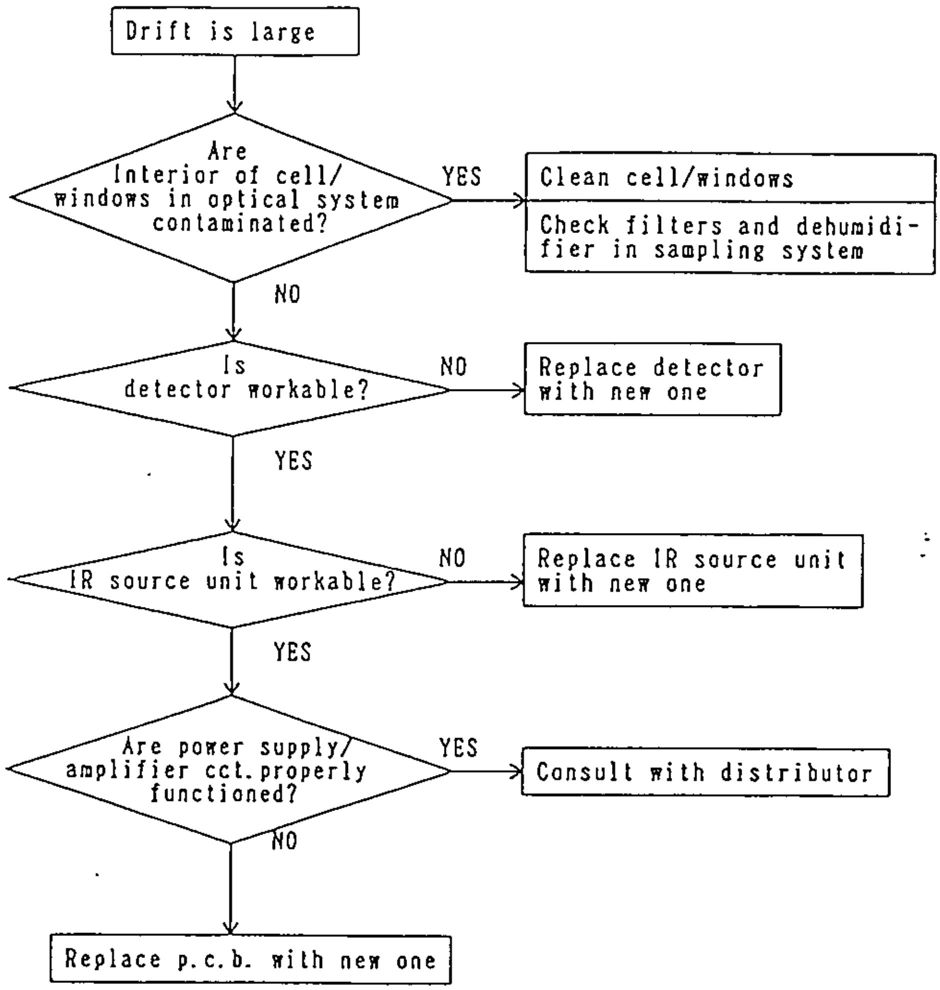


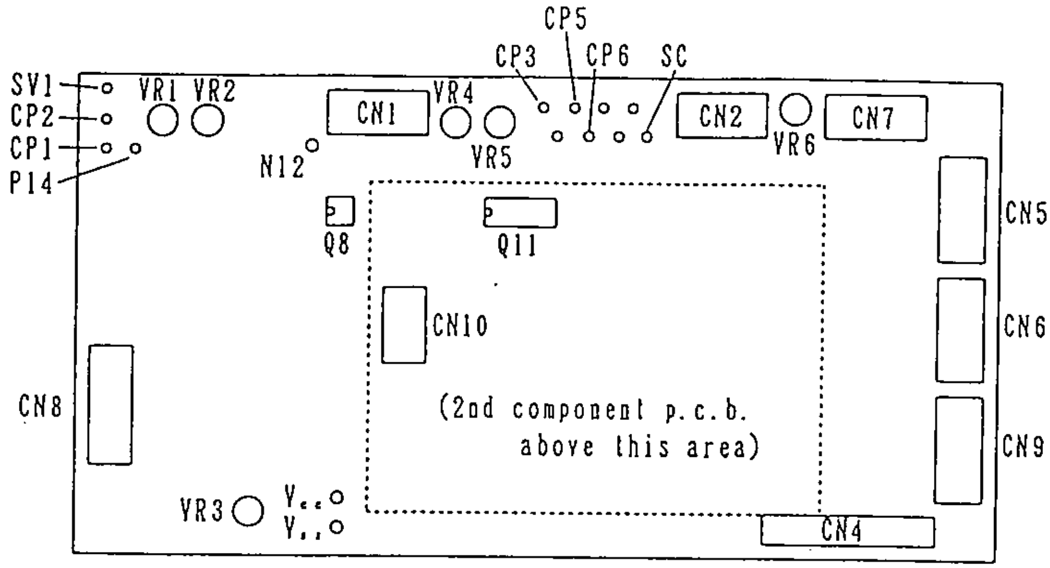

### 7.1.5 RESPONSE IS SLOW AT RETURNING TO ZERO



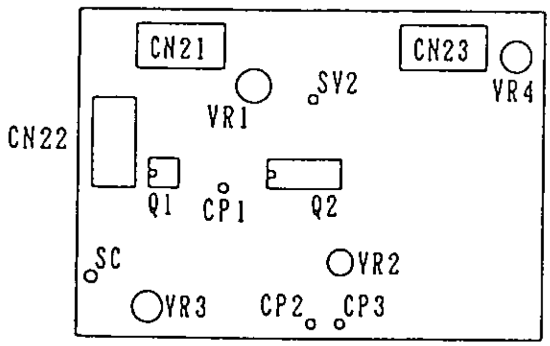

NOTE: TEFLON is a registered trade name of DuPont Inc.

### 7.1.6 LARGE DRIFT






1st component p.c.b.




2nd component p.c.b.

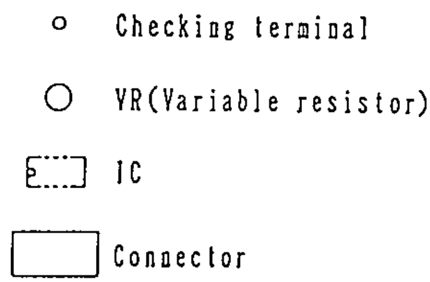



Fig.7.1 Parts lay out on p.c.bs.

## 7.2 CHECKING AND REPAIRING

### 7.2.1 DETECTOR(No.15 IN FIG. 6-1)

Symptom: Zero adjustment not feasible

Causes of trouble: Breakage of mass-flow sensor or trouble of bridge resistances or leakage of detector sealed gas.

Checking:a) There are approx. 1.5V～2V DC voltages on between 1 & 3 and 2 & 3 terminals of bridge p.c.b. of detector (No.16 in Fig.6-1) and when the differences between both voltages are within 0.1V, the mass-flow sensor and bridge resistors (No.17 in Fig.6.1) operate properly.

b) Connect a synchroscope between CP6 & SC check terminals on the 1st component p.c.b..
When AC waveform($8^{1}/_{3}$ or 10 HZ) at the check terminals is not observed although a) above is correct and the IR source unit & chopper operate properly, leakage of detector sealed gas is most probable.(Refer to 7.2.6(2))
Regarding checking of the 2nd component, proceed checking between CP2 & SC check terminals of the 2nd component p.c.b.. Checking procedures are the same with those of the 1st component.

c) When measured voltages are abnormal in checking a), switch off power source and remove both connector of detector & bridge resistors, then check resistance of mass-flow sensor.
Measure resistance value both between 1 & 3 and 2 & 3 terminals on bridge p.c.b.. When measured resistance ranges between 25 to 50 Ω, mass-flow sensor is in normal condition and bridge resistor may be damaged.
If resistance values are infinite, mass-flow sensor is broken.

Replacement
of detector:a) Replace detector with a new one by referring to 6.1.
In case of pipe cell, replace the detector after removal of the measuring unit because it is fixed by screws on the under side of the base plate.

b) After replacing the detector, adjust voltage between SV1 & SC terminals on the 1st component p.c.b. to specified detector voltage through VR2, and for the 2nd component, adjust voltage between SV2 & SC on the 2nd component p.c.b. through VR1 in the same manner as the 1st component.

c) Proceed both zero & span adjustment.

### 7.2.2 INFRARED SOURCE UNIT(No.1 IN FIG.6.1)

Symptom: Indicated value exceeds it's range value or output signal is unstable.

Causes of trouble: Breakage of infrared source and/or leakage of infrared source unit sealed gas.

Checking:a) Switch off power source and measure resistance between 2-pin terminals after removal of lead wires from 2-pin terminal block. The normal resistance value is 37 $\pm$3 $\Omega$. When infrared source is broken, the resistance value is extremely high.
Increase of resistance make output drift towards plus side.

b) Although both detector & amplifier p.c.b. are properly operating, if IR source unit sealed gas leaks, atmosphere may influence the output signal to drift.
Keep in mind, however, that atmospheric $CO_2$ existing in air gaps of the measuring unit may cause the output signal of low-concentration $CO_2$ analyzer to drift. in this case interior purge of the analyzer is the right solution.

Replacement of the unit:a) Remove both wiring of 2-pin terminals and disconnect motor connector and then remove 2 fixing screws of the infrared source unit to base plate.
Carry out replacement by referring to Fig.6.1 or Fig.6.2..

b) After replacement, carry out both zero & span adjustment.

### 7.2.3 CHOPPER

Symptom: Unstable output signal and/or indicated value exceeds it's range value

Cause of trouble: Irregular rotation

Checking:
a) Listen to note if a hitting noise of chopper blade on other components occurs when the power is switched on. If the hitting noise is emitted, take out the infrared source unit and remove the enclosure. Then adjust position of the chopper blade carefully so as not to touch other components. Be sure not to damage the chopper blade because it is made of very thin plate.
If the analyzer is operating properly, do not make any adjustment on the chopper blade.
b) In case the motor does not start in spite of the power being switched on, disconnect motor power supply cord and check whether the specified power source voltage is supplied. When the motor does not rotate despite the right power source voltage supplied, check if the motor shaft or other motor parts might be touching other components.
If the motor does not rotate even without any touching, the motor is out of order.

Replacement: Replace the whole infrared source unit with motor assembly with a new one.
Refer to 7.2.2

### 7.2.4 WINDOWS OF MEASURING CELL, DETECTOR & INFRARED SOURCE UNIT

Symptom: Zero adjustment is not feasible because of excess plus-sided drift.

Causes of trouble: Cell & windows are heavily contaminated.

Checking: After removing the cell, check whether cell and all windows are contaminated or not.
When contaminated, clean them by wiping with alcohol moistened soft cloth.

Be sure to handle windows carefully because they are easily damaged. Refer details to 6.2.

### 7.2.5 PIPING

Symptom: Unstable output signal and/or slow response

Causes of trouble: Loosening, disconnecting, contaminating & clogging

Checking: a) Proceed tight and firm repiping when piping is loosen or disconnected.

b) When inside piping is contaminated or clogged, remove contaminant inside then blow out them with compressed air.

### 7.2.6 PRINTED CCT. BOARD OF THE 1ST COMPONENT

Replacement of printed cct. board of the 1st component is needed when it is judged to be not functional through the following checkings.

(1) Power supply circuits

Checking: a) Secondary voltage of transformer

The output voltages of secondary windings of transformer are approx.AC 18V, approx.AC 17V, approx.AC 8V and aprox.AC 100V respectively.

b) Positive 14V power supply voltage

Proceed checking using P14 & SC check terminals.

The right voltage is DC 14V $\pm$0.05V.

(Adjustable through VR1. However, be very careful not to exceed the specified voltage.)

c) Positive 5V power supply voltage

Proceed checking using $V_{cc}$ & $V_{ss}$ check terminals.

The right voltage is DC 5V$\pm$0.1V.

(Adjust the voltage with VR3.)

d) Negative 12V power supply voltage

Proceed checking using N12 & SC check terminals.

The right voltage is DC -12V$\pm$1V.

e) Negative 5V power supply voltage

Proceed checking using CP1 & SC check terminals.

The right voltage is DC -5V $\pm$0.5V.

f) Detector voltage

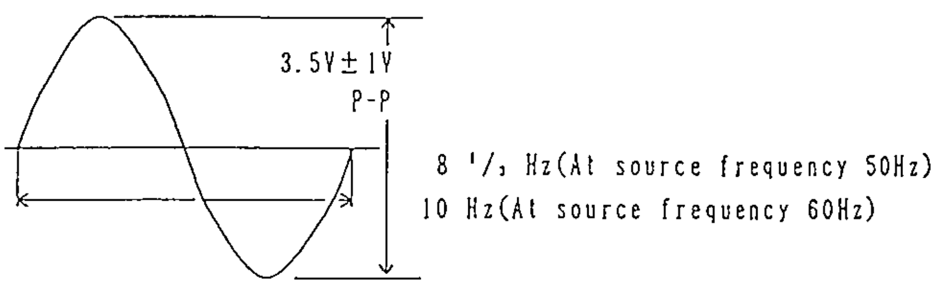
Check the voltage using SV1 & SC check terminals.
The right voltage is written on the detector body.
(Adjust the voltage with VR2.)

(2) Amplifier circuits

Check amplifier cct. after making sure that the power supply circuits function properly.

Checking: AC amplifier circuits

a)Check AC waveform with a synchroscope connected between CP6 & SC check terminals.
Amplitude of waveform is adjusted to be approx. 3.5 ± 1Vp-p by VR4 while zero gas introduced.




b)In case when AC waveform can not be observed in a) above, check AC wave form between CP5 & SC check terminals.
When 8 1/3 or 10 Hz AC waveform is observed, AC amplifier Q8 operates properly, and in this case, Q11 amplifier or VR4 is defective.

c)In case when AC waveform is not observed on CP5 and SC check terminals, check the detector according to 7.2.1.

(3) Rectifying circuits

Checking: a)Check voltage to be approx. DC 2.3 ± 0.2V between CP3 & SC checking terminals with volt meter while zero gas being introduced.

b)In case when the voltage are much different from above described value, Q11 is defective.

## 7.2.7 PRINTED CCT. BOARD OF THE 2ND COMPONENT

(1) Power supply circuits

Checking:a) Check and adjust each circuit voltage according to the same checking procedures of p.c.b. of the 1st component described in 7.2.6.

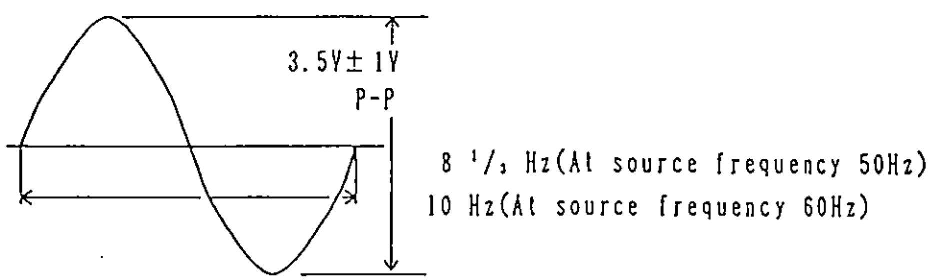
b) Detector voltage(for the 2nd component)
Check the voltage using SV2 and SC checking terminals.
The right voltage is written on the detector body.
(Adjust the detector voltage with VR1.)

(2) Amplifier circuits

The amplifier circuits are to be checked after making sure that the power supply circuits function properly.

Checking: AC amplifier circuits

a)Connect a synchroscope between CP2 & SC checking terminals and observe AC waveform. While zero gas is introduced, amplitude of waveform is adjusted to be approx.3.5$\pm$1Vp-p by VR2.




b)In case AC waveform cannot be observed in the above a), observe AC waveform on CP1 and SC checking terminals. When AC waveform of 8 $^1/_3$ Hz or 10 Hz is observed, AC amplifier Q1 is normal but AC amplifier Q2 or VR2 is defective.

c)In case AC waveform is not observed on CP1 and SC checking terminals, check detector according to 7.2.1.

(3) Rectifying circuits

Checking: a) While zero gas is introduced, check voltage between CP3 & SC checking terminals with a voltmeter.
The right voltage is approx. DC 2.3 $\pm$ 0.2V.

b) In case the voltage is much different from above described value, Q2 is defective.

## 7.3 ERROR-CODES AND HOW TO REPAIR

As self diagnostic functions are provided in the analyzer, an error-code is displayed on occasion of error.

In case an error is displayed, carry out checking and/or repairing according to the following table.

| Error code | Error details | State of analyzer | Check or repair procedure |
|---|---|---|---|
| E - 0<br>E - 1 | Error of digital part | Analyzer wouldn't work until recovered. | · Turn off the power and turn on again. |
| If the error code doesn't appear again, the analyzer is normal. If the error code appears again after trying the power off and on, it is necessary to replace the 1st comp. p.c.b.. | | | |
| E - 2<br>E - 3 | Error of temperature signal procedure | Analyzer's operative but indication is incorrect. | · Turn off the power and turn on again.<br>· Depress [ENT] key. |
| If the error code appears again after that disappears once, replacement of the 1st comp. p.c.b. or the temperature sensor is necessary. | | | |
| E - 4<br>E - 5 | Correction amount in calibration is out of allowable range | Measuring is possible but zero or span calibration of the range is not performed | · Clean measuring cell.<br>· Check the flowing gas concentration and the set value of span. |

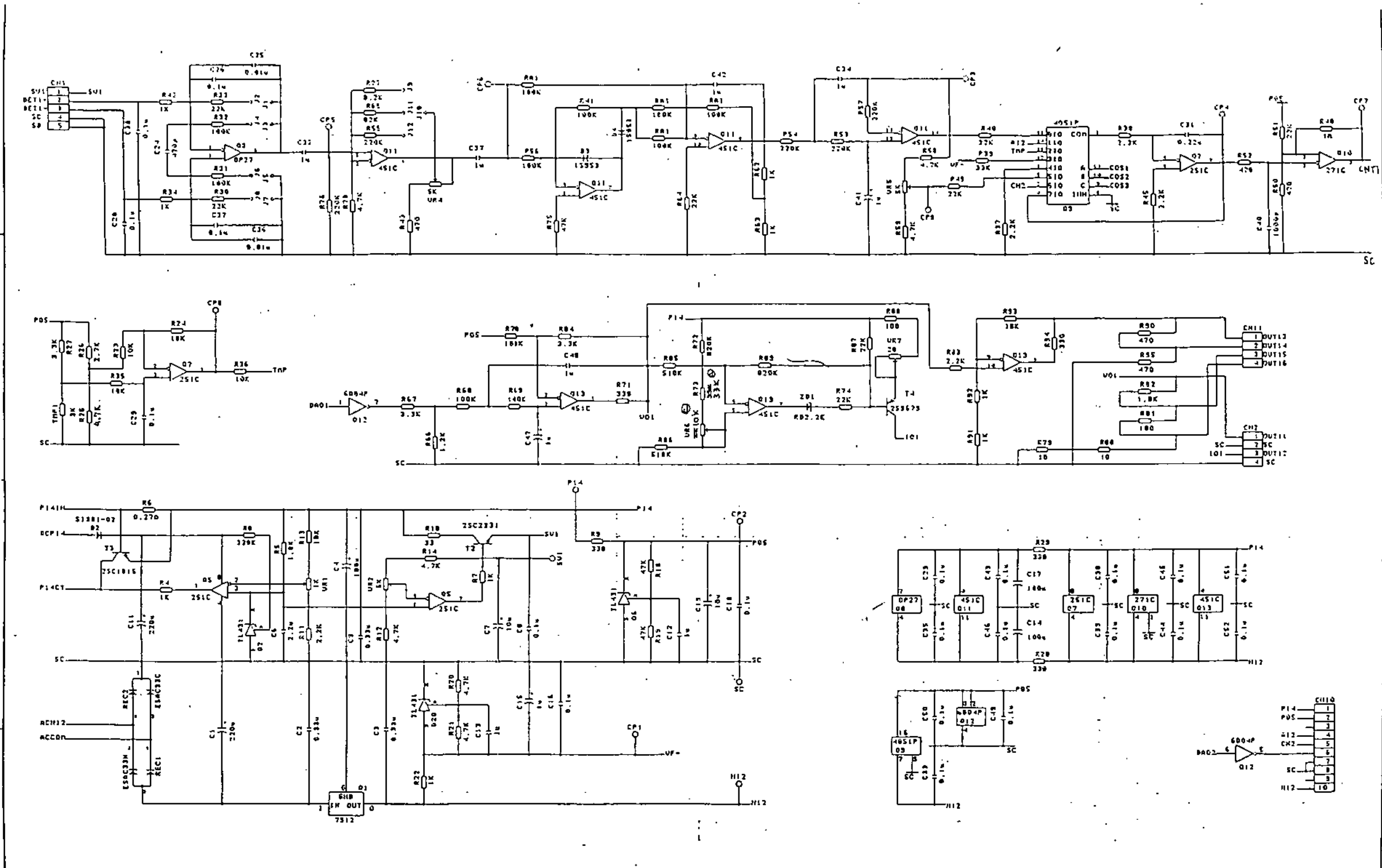
(continues to the next page)

| | | | |
|---|---|---|---|
| | | | · Check optical system |
| E - 6<br><br>E - 7 | Correction amount in calibration exceeds 50% of measuring range | Calibration cannot be performed. | Carry out the same as above. |

Supplemental explanations on error codes

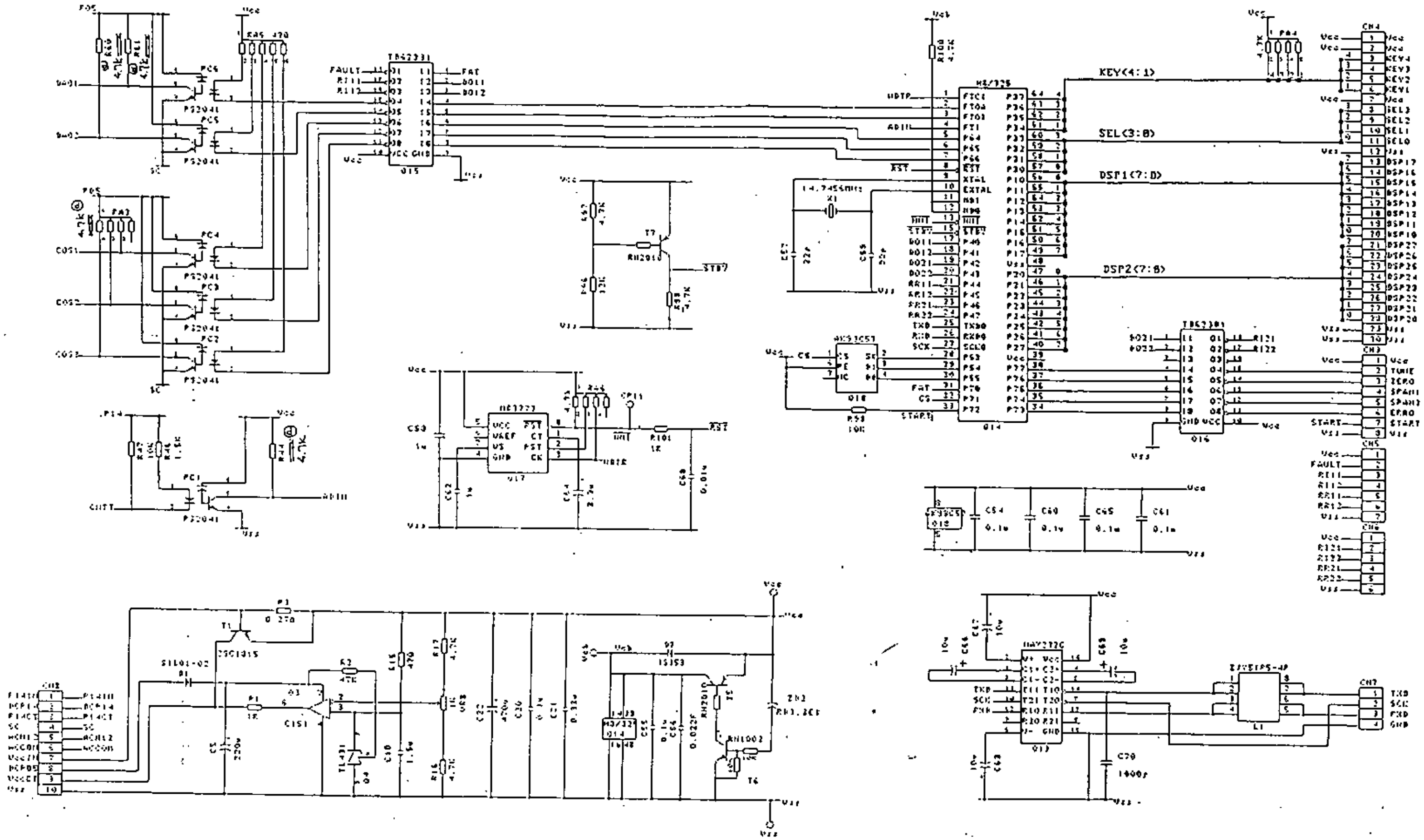
1. Error-code is displayed on the sub-display screen in the single component analyzer and on the sub-display screen of the 1st component in the dual components analyzer.
2. At the occasion of plural errors, the error codes are to be displayed in turn from the lower error-code No. by depressing [ENT] key.

   After displaying all error codes, the error codes display is once off by further depression of [ENT] key, however, the error codes appear again while the error state continues.
3. In case an error-code is displayed, firstly check whether power supply and gas piping are in good order or not.
4. At occasion of error, the contact output of FAULT closes.
5. At occasion of error during automatic calibration, the contact output of automatic calibration error closes together with the contact output of FAULT.





| REVISIONS | | DATE | NAME | APPROVED | SCALE | TITLE | |
|---|---|---|---|---|---|---|---|
| | DRAWN | - - | | | | 1st COMP. P.C.B | DWG.CODE |
| | CHECKED | - - | | | | | DRAWING NO. 1/2 |
| | Fuji Electric Co.,Ltd. | | | REF. | | (ZRH) -8.1- | |



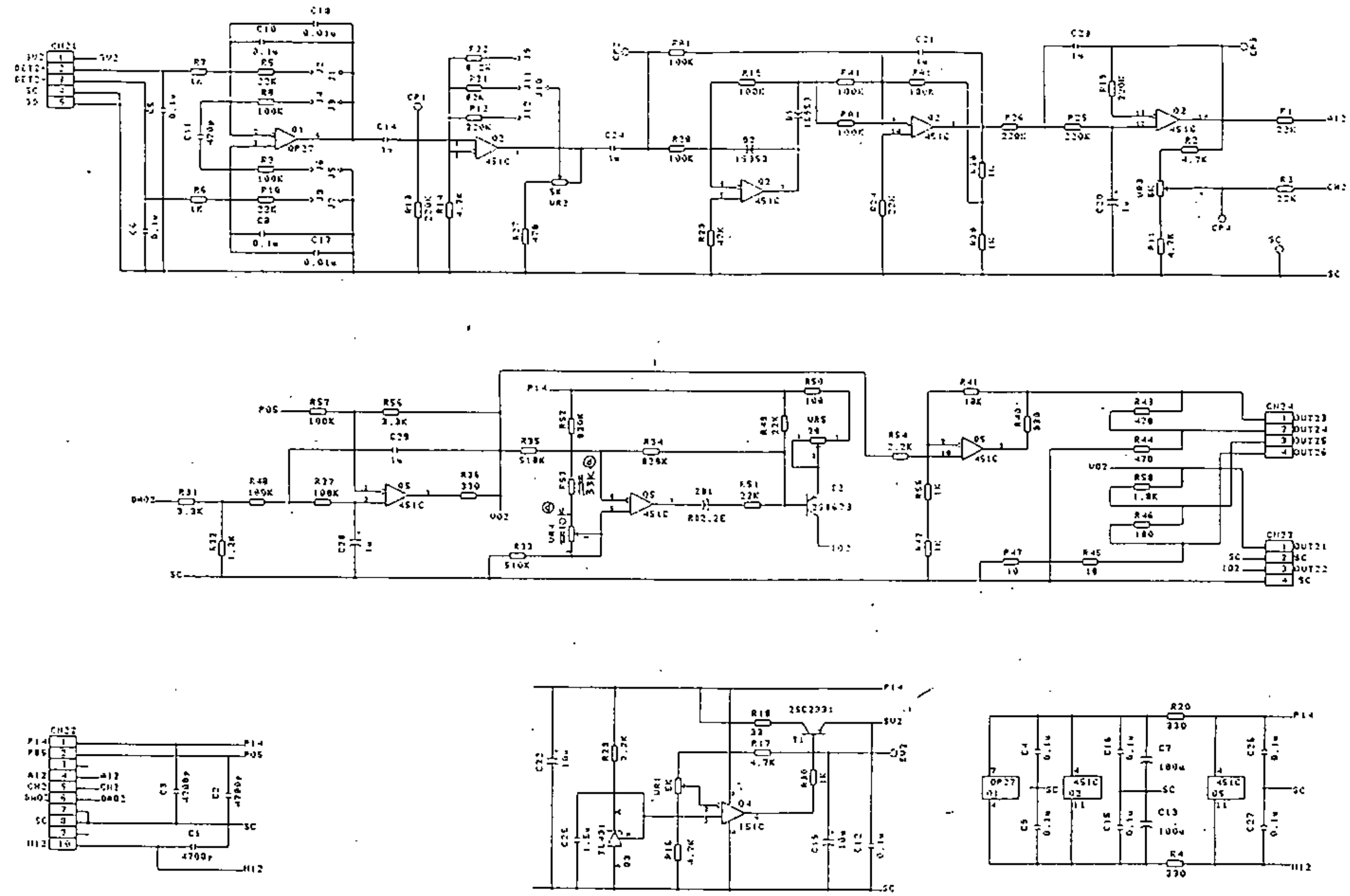
| REVISIONS | | DATE | NAME | APPROVED | SCALE |
|---|---|---|---|---|---|
| | DRAWN | - - | | | |
| | CHECKED | - - | | | |
| | Fuji Electric Co.,Ltd. | | | REF. | |

TITLE: 1st COMP. P.C.B (ZRH)

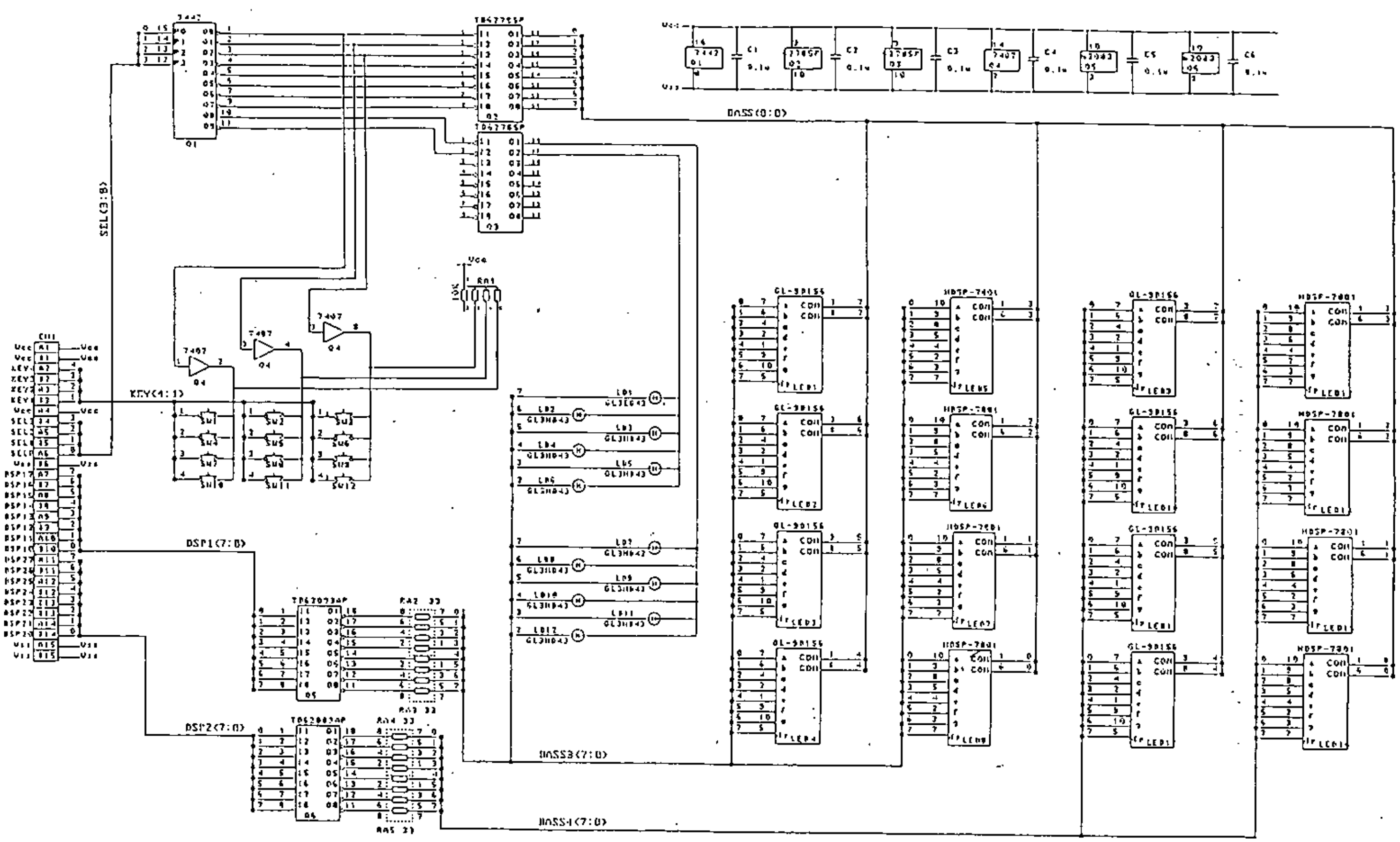
-8.2-

DWG.CODE

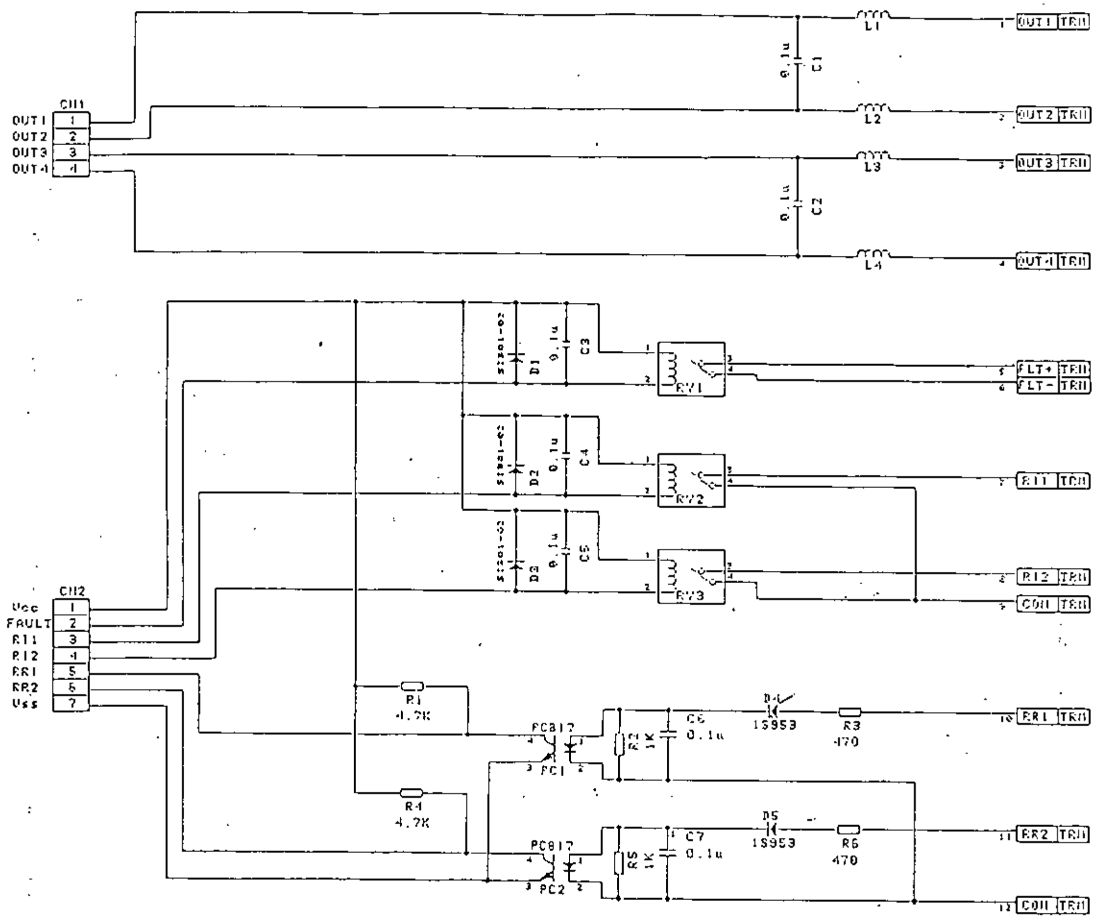
DRAWING NO. 2/2



| REVISIONS | | DATE | NAME | APPROVED | SCALE | TITLE | DWG.CODE |
|---|---|---|---|---|---|---|---|
| | DRAWN | - - | | | | 2nd COMP. P.C.B | |
| | CHECKED | - - | | | | (ZRH) -8.3- | DRAWING NO. |
| | Fuji Electric Co.,Ltd. | | REF. | | | | |




| REVISIONS | | DATE | NAME | APPROVED | SCALE | TITLE | DWG.CODE |
|---|---|---|---|---|---|---|---|
| | DRAWN | - - | | | | DISPLAY P.C.B. | |
| | CHECKED | - - | | | | (ZRH) -8.4- | DRAWING NO. |
| | Fuji Electric Co.,Ltd. | | | REF. | | | |




A

B

C

D

| REVISIONS | | | | |
|---|---|---|---|---|
| | DATE | NAME | APPROVED | SCALE |
| DRAWN | - - | | | |
| CHECKED | - - | | | |

Fuji Electric Co.,Ltd.

REF.

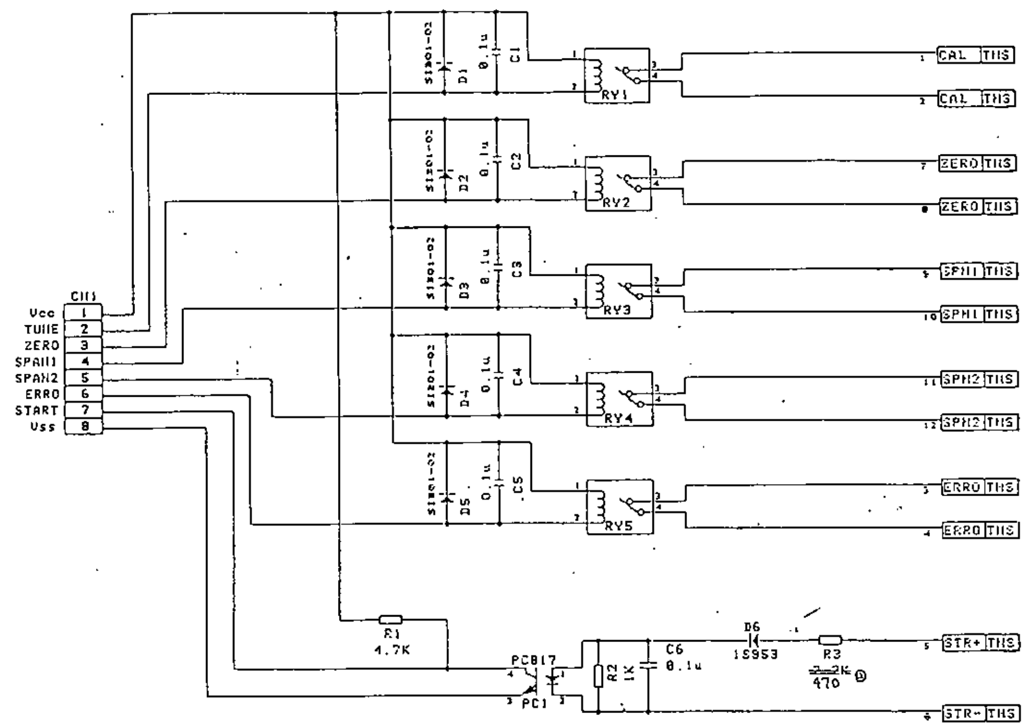
TITLE: OUTPUT P.C.B (COMP1 / COMP2)

(ZRH)

-8.5-

DWG CODE

DRAWING NO.




| REVISIONS | DATE | NAME | APPROVED |
| --- | --- | --- | --- |
| DRAWN | - - | | |
| CHECKED | - - | | |

Fuji Electric Co.,Ltd.

SCALE

REF.

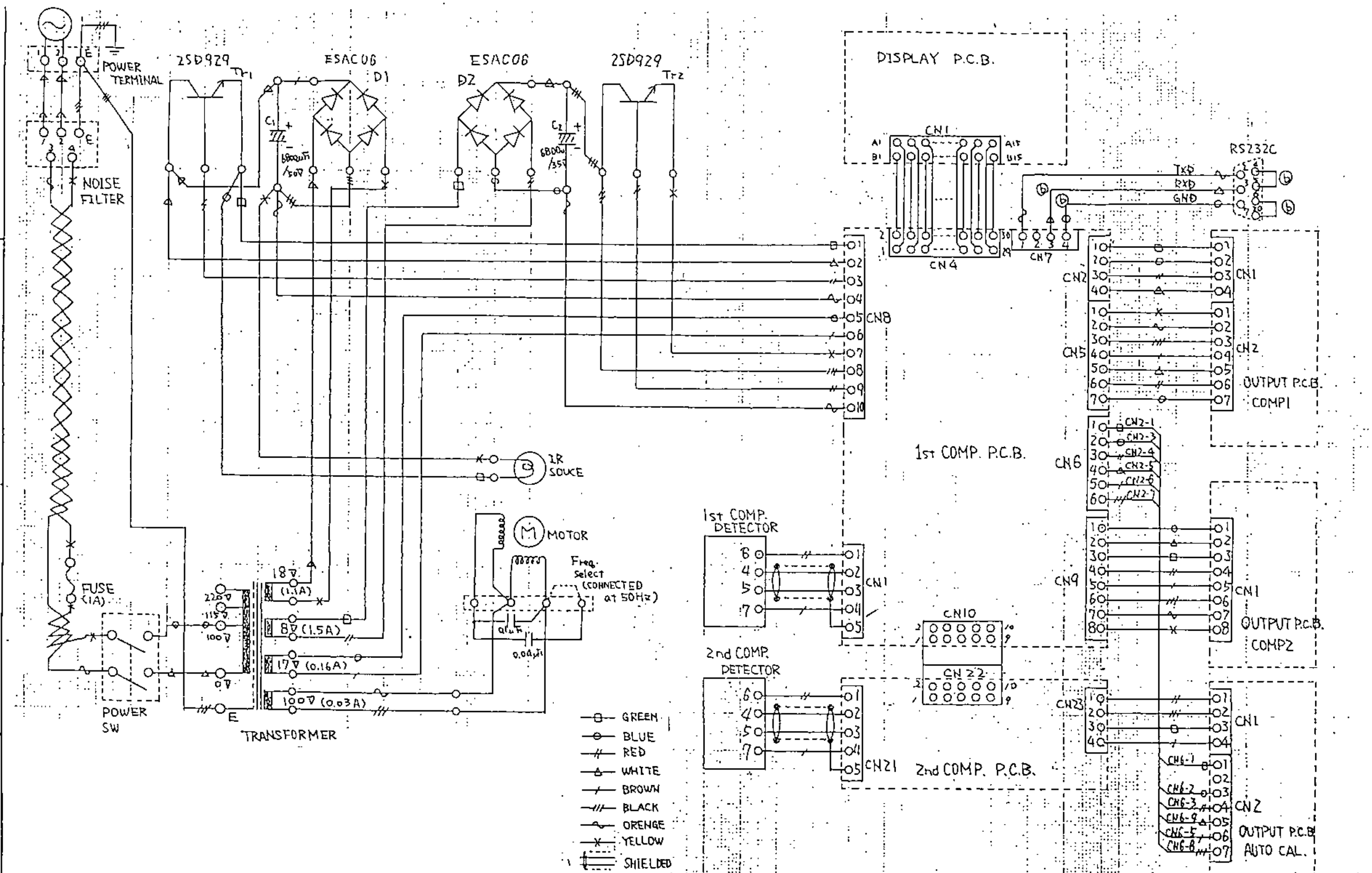
TITLE

OUTPUT P.C.B (AUTO CAL.)

(ZRH)

-3.6-

DRAWING NO.




| REVISIONS | | DATE | NAME | APPROVED | SCALE |
|---|---|---|---|---|---|
| | DRAWN | - - | | | |
| | CHECKED | - - | | | |
| | Fuji Electric Co.,Ltd. | | | REF. | |

TITLE: CONNECTION DIAGRM (FULL OPTION) (ZRH)

DWG CODE

DRAWING NO.

# MODEL 400A

## REMOTE DISPLAY PANEL

## INSTRUCTION MANUAL

Thermo Environmental Instruments Inc.

INSTRUCTION MANUAL

FOR THE

MODEL 400A
REMOTE DISPLAY PANEL

IM-5321

# Table of Contents

IM-5321

## Table of Contents

## 1.0 INTRODUCTION

This manual describes the Model 400A Remote Display Panel and is to be used as a reference in its calibration, installation, and maintenance. Included in this section is a discussion of the basic principles of operation, together with a definition of the instrument units of measurement and its application in industry. Subsequent sections include a technical and functional description of the basic Model 400A and the accessories which comprise the total system. Calibration procedures, installation methods, and maintenance requirements are also included. Because many installations have special requirements, a factory representative should be consulted to ensure selection of the optimum system and its installation location.

## 1.1 MODEL 400A REMOTE DISPLAY PANEL

The Model 400A Remote Display Panel is an accessory to the basic Model 400 Transmissometer. The two main functions of the Model 400A are to linearize and time-average the opacity signals received from a stack mounted Model 400 Transmissometer. In duct or tapered stack installations, the Model 400A is capable of correcting the opacity data at the point of Transmissometer installation to represent opacity at the stack exit.

An analog panel meter is used to display opacity data in an accurate, easy-to-read form. Permanent records of opacity data may be obtained by connecting strip chart recorders or data logging equipment to the current-driver outputs of the Model 400A Panel. Both the instantaneous and integrated stack exit values are output.

Monitor circuits in the Model 400A Panel check various Transmissometer operating functions and test the level of measured opacity. Panel indicators alert operating personnel when equipment malfunctions or opacity exceedances are detected.

## 1.2 APPLICATION OF THE MODEL 400 TRANSMISSOMETER

A beam of light, generated in the Optical Head of the Model 400, is directed across the stack to the Retroreflector that returns the beam back on itself to the Optical Detector System. Because the beam traverses the stack twice, the Transmissometer is a double-pass intrument, and the basic electrical output signal from the detector is proportional to $t^2$, the square of the signal-pass stack transmittance. Subsequent electronics process the condition the signal with the output appearing as a 0 to 10-milliampere current proportional to $1 - t^2$. Because opacity is defined as $1 - t^2$, where t is single-pass transmittance, the scale on the display meter is non-linear. Table 1 shows the relationship between single-pass transmittance t, optical density (O.D.), $t^2$, $1 - t^2$, and $1 - t$ (opacity). The graph in Figure 1 shows the relationship between the $1 - t^2$ signal and $1 - t$.

If the stack diameter at the location of the Transmissometer is different from that at the stack exit, the data accumulated must be corrected. Theoretically, the particulate concentration in terms of mass per unit of volume is constant even though stack geometry and flow velocities vary, therefore, the correction can be determined by applying either of two equations, which are easily developed using the single-path transmittance at each location:

$$\log_{10} t_e = \frac{(\ell_e)}{(\ell_m)} \log_{10} t_m \qquad (1)$$

or

$$t_e = t_m \frac{(\ell_e)}{(\ell_m)} \qquad (2)$$

where

$t_e$ = the transmittance at the stack exit

$t_m$ = the transmittance at the Transmissometer measurement location

$\ell_e$ = stack internal diameter at the exit

$\ell_m$ = stack internal diameter at the Transmissometer measurement location.

Equation (2) may also be rewritten in terms of opacities as below:

$$(1 - op_e) = (1 - op_m)^{\ell_e/\ell_m}$$

or

$$op_e = 1 - (1 - op_m)^{\ell_e/\ell_m} \qquad (3)$$

where

$op_e$ = the opacity at the stack exit

$op_m$ = the opacity at the Transmissometer measurement location.

For conditions where the measurement path length, $\ell_m$, is greater than the exit path length, $\ell_e$, the measurement path opacity $op_m$, will be greater than the exit path opacity, $op_e$. The opposite is true when the exit path length is greater than the measurement path length. These relationships may be summarized as follows:

For $\ell_e < \ell_m$ or $\ell_e/\ell_m < 1$, then $op_e < op_m$

For $\ell_e > \ell_m$ or $\ell_e/\ell_m > 1$, then $op_e > op_m$

Given the ratio of the two internal diameters, $\ell_e/\ell_m$ (stack taper ratio), a corrected calilbration curve can be generated (Table 2). A family of correction curves, based on the values for different stack taper ratios, is shown in Figure 2.

Table 1.

Transmittance, Optical Density, Signal, and Opacity Relationships

| Single Pass Transmittance t | Optical Density O.D. | Double Pass Transmittance $t^2$ | Signal Relationship $1 - t^2$ | Output Signal ma | Opacity $1 - t$ |
|---|---|---|---|---|---|
| 0.00 | ∞ | 0.0000 | 1.0000 | 10.000 | 1.00 |
| 0.01 | 2.000 | 0.0001 | 0.9999 | 9.999 | 0.99 |
| 0.05 | 1.3010 | 0.0025 | 0.9975 | 9.975 | 0.95 |
| 0.10 | 1.0000 | 0.0100 | 0.9900 | 9.900 | 0.90 |
| 0.15 | 0.8239 | 0.0225 | 0.9775 | 9.775 | 0.85 |
| 0.20 | 0.6990 | 0.0400 | 0.9600 | 9.600 | 0.80 |
| 0.25 | 0.6021 | 0.0625 | 0.9375 | 9.375 | 0.75 |
| 0.30 | 0.5229 | 0.0900 | 0.9100 | 9.100 | 0.70 |
| 0.35 | 0.4559 | 0.1225 | 0.8775 | 8.775 | 0.65 |
| 0.40 | 0.3979 | 0.1600 | 0.8400 | 8.400 | 0.60 |
| 0.45 | 0.3468 | 0.2025 | 0.7975 | 7.975 | 0.55 |
| 0.50 | 0.3010 | 0.2500 | 0.7500 | 7.500 | 0.50 |
| 0.55 | 0.2596 | 0.3025 | 0.6975 | 6.975 | 0.45 |
| 0.60 | 0.2218 | 0.3600 | 0.6400 | 6.400 | 0.40 |
| 0.65 | 0.1871 | 0.4225 | 0.5775 | 5.775 | 0.35 |
| 0.70 | 0.1549 | 0.4900 | 0.5100 | 5.100 | 0.30 |
| 0.75 | 0.1249 | 0.5625 | 0.4375 | 4.375 | 0.25 |
| 0.80 | 0.0969 | 0.6400 | 0.3600 | 3.600 | 0.20 |
| 0.85 | 0.0706 | 0.7225 | 0.2775 | 2.775 | 0.15 |
| 0.90 | 0.0458 | 0.8100 | 0.1900 | 1.900 | 0.10 |
| 0.95 | 0.0223 | 0.9025 | 0.0975 | 0.975 | 0.05 |
| 1.00 | 0.0000 | 1.0000 | 0.0000 | 0.000 | 0.00 |

Table 2.

Corrected Opacity Values* for given Stack Taper Ratios $\ell_e/\ell_m$

| $op_m$ | $op_e$ | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.70 | 0.75 | 0.80 | 0.85 | 0.90 | 1.00 | 1.05 | 1.10 | 1.15 | 1.20 | 1.25 | 1.30 |
| 0.00 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 0.05 | 0.036 | 0.038 | 0.040 | 0.043 | 0.046 | 0.05 | 0.052 | 0.055 | 0.057 | 0.060 | 0.062 | 0.065 |
| 0.10 | 0.071 | 0.076 | 0.088 | 0.086 | 0.091 | 0.10 | 0.105 | 0.109 | 0.114 | 0.119 | 0.123 | 0.128 |
| 0.15 | 0.108 | 0.115 | 0.122 | 0.129 | 0.136 | 0.15 | 0.157 | 0.164 | 0.171 | 0.177 | 0.184 | 0.190 |
| 0.20 | 0.145 | 0.154 | 0.163 | 0.173 | 0.182 | 0.20 | 0.209 | 0.218 | 0.226 | 0.235 | 0.243 | 0.251 |
| 0.25 | 0.182 | 0.194 | 0.206 | 0.217 | 0.228 | 0.25 | 0.261 | 0.271 | 0.282 | 0.292 | 0.302 | 0.312 |
| 0.30 | 0.221 | 0.235 | 0.248 | 0.262 | 0.275 | 0.30 | 0.312 | 0.325 | 0.336 | 0.348 | 0.360 | 0.371 |
| 0.35 | 0.260 | 0.276 | 0.292 | 0.307 | 0.321 | 0.35 | 0.364 | 0.377 | 0.391 | 0.404 | 0.416 | 0.429 |
| 0.40 | 0.301 | 0.318 | 0.335 | 0.352 | 0.369 | 0.40 | 0.416 | 0.430 | 0.444 | 0.458 | 0.472 | 0.485 |
| 0.45 | 0.342 | 0.361 | 0.380 | 0.398 | 0.416 | 0.45 | 0.466 | 0.482 | 0.497 | 0.512 | 0.526 | 0.540 |
| 0.50 | 0.384 | 0.405 | 0.426 | 0.445 | 0.464 | 0.50 | 0.517 | 0.533 | 0.549 | 0.565 | 0.580 | 0.594 |
| 0.55 | 0.428 | 0.451 | 0.472 | 0.493 | 0.513 | 0.55 | 0.568 | 0.585 | 0.601 | 0.616 | 0.631 | 0.646 |
| 0.60 | 0.473 | 0.497 | 0.520 | 0.541 | 0.562 | 0.60 | 0.618 | 0.635 | 0.651 | 0.667 | 0.682 | 0.696 |
| 0.65 | 0.520 | 0.545 | 0.568 | 0.590 | 0.611 | 0.65 | 0.668 | 0.675 | 0.701 | 0.716 | 0.731 | 0.745 |
| 0.70 | 0.569 | 0.595 | 0.618 | 0.641 | 0.662 | 0.70 | 0.718 | 0.734 | 0.750 | 0.764 | 0.778 | 0.791 |
| 0.75 | 0.621 | 0.646 | 0.670 | 0.692 | 0.713 | 0.75 | 0.767 | 0.782 | 0.797 | 0.811 | 0.823 | 0.835 |
| 0.80 | 0.676 | 0.701 | 0.724 | 0.745 | 0.765 | 0.80 | 0.815 | 0.830 | 0.843 | 0.855 | 0.866 | 0.877 |
| 0.85 | 0.735 | 0.759 | 0.781 | 0.801 | 0.819 | 0.85 | 0.864 | 0.876 | 0.887 | 0.897 | 0.907 | 0.915 |
| 0.90 | 0.800 | 0.821 | 0.842 | 0.859 | 0.874 | 0.90 | 0.911 | 0.921 | 0.929 | 0.937 | 0.944 | 0.950 |
| 0.95 | 0.877 | 0.894 | 0.909 | 0.922 | 0.933 | 0.95 | 0.937 | 0.963 | 0.968 | 0.973 | 0.977 | 0.980 |
| 1.00 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

*To express in percent opacity move the decimal two places to the right.

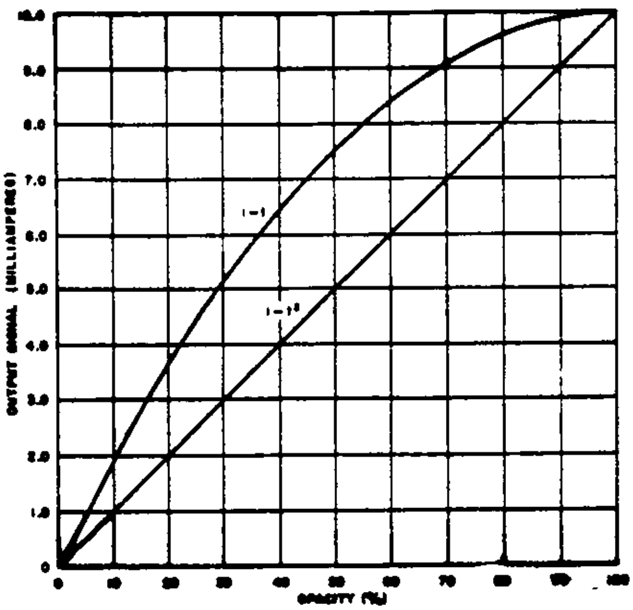


*Figure 1. Output Signal vs. Opacity*

If the Remote Control Unit and optional Linearizer to 400A are used with the Transmissometer, this correction can be made automatically. Additional information concerning the Remote Control Unit and Linearizer is included in Sections 2.0 and 4.0.

Federal and many state and local regulatory agencies specify both opacity and particulate emission limits for various sources, both new and old. The opacity limits are generally between 10% and 20% depending upon the type of source, while particulate emission rates, in terms of pounds or kilograms per hour, vary widely depending upon both the type of particulate and source. If opacity is the controlling parameter, the output of the Transmissometer, corrected for any stack taper ratio, can be used directly to determine regulatory compliance. For particulates, the relationship between various mass emission rates and optical density is a linear function with a constant of proportionality that must be determined by some appropriate sampling method. If the mass emission rate is the controlling parameter, the Model 400A can also be set to provide the Transmissometer output directly in terms of optical density, where optical density is defined as:

$$O.D. = \log_{10} \frac{1}{t}$$

The Transmissometer is an effective and precise regulatory compliance device on stacks with particulate effluents. If water vapor is present in the effluent, it is transparent to4 the optical beam and of no effect provided the stack gas temperature is high enough to keep the water in vapor form. If condensed water droplets are present, however, these will be detected and will affect the reading. The Transmissometer must, therefore, be used either at a position where the water is in vapor form, or where a suitable sample of the stack effluent has been reheated to vaporize the water.

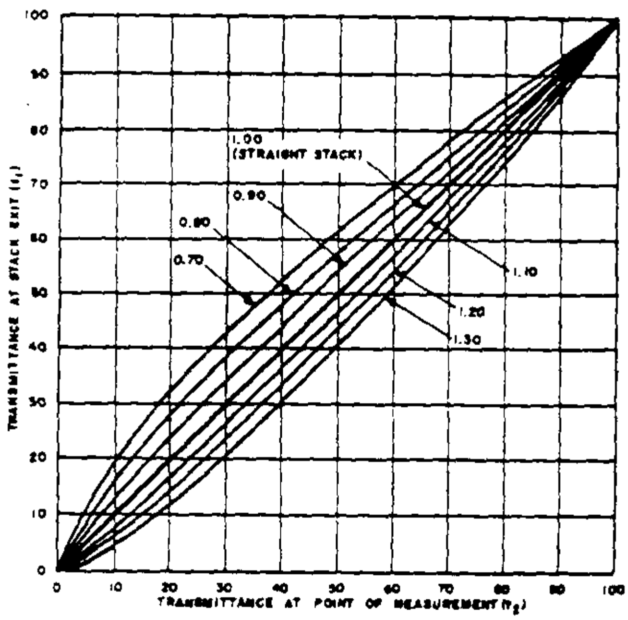



*Figure 2. Correction Curves for Different Stack Taper Ratios*

## 2.0 GENERAL DESCRIPTION

The basic Model 400A Remote Display Panel and its accessories comprise a complete 400A Control System. They are available individually, however, to satisfy particular customer requirements and consist of the following items:

1. Remote Control Unit
   No. 715-0055

2. Linearizer/Integrator
   No. 007-0181

3. Remote Control Unit Enclosure
   No. 400-1104

4. Data Cable
   No. 400-0012

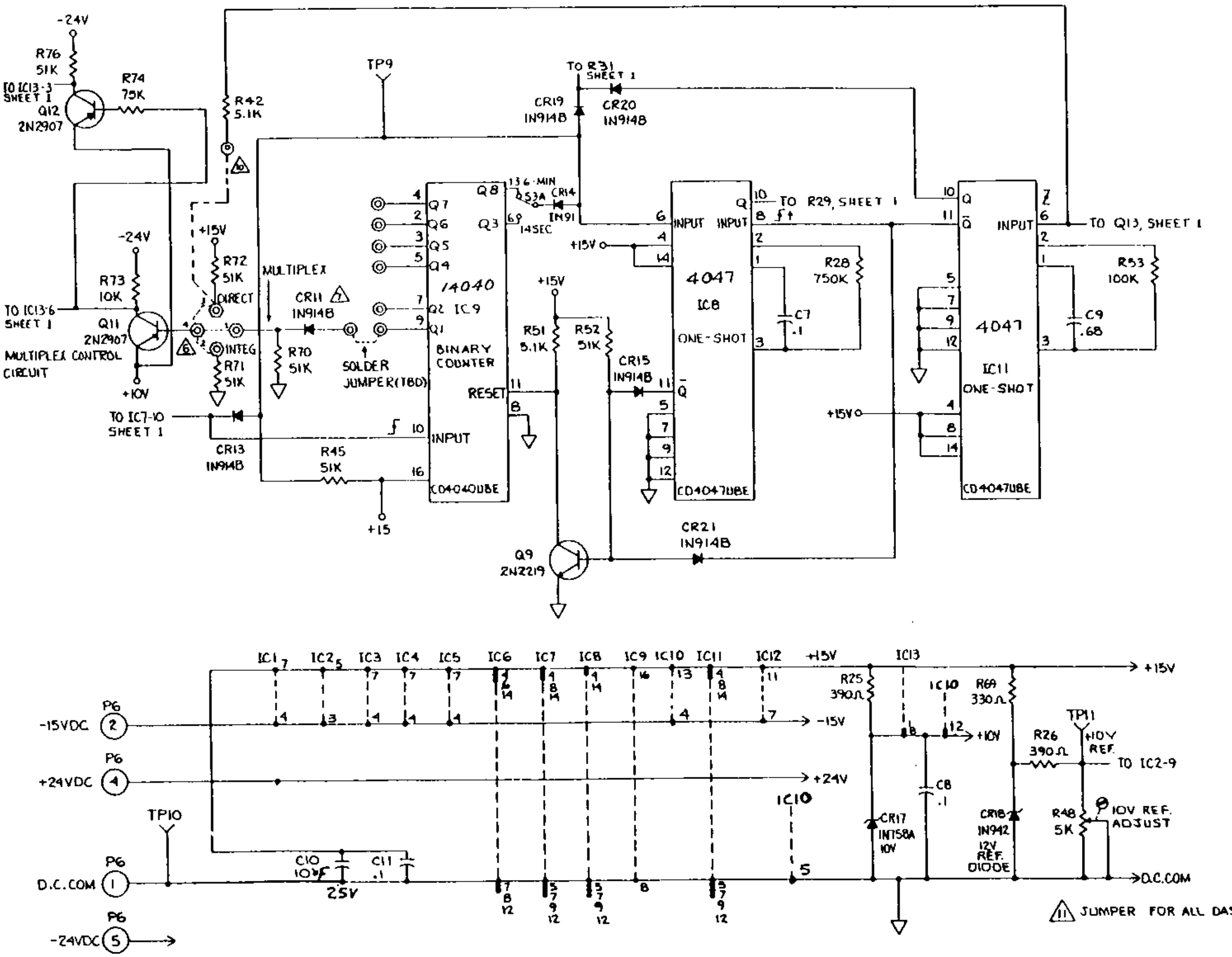
5. Recorder, 1-Pen
   No. 715-0055-01

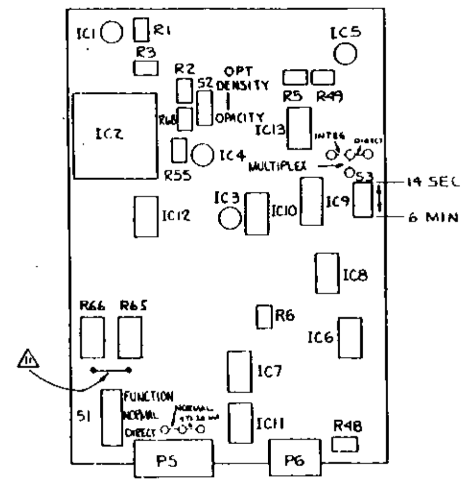
6. Recorder, 2-Pen
   No. 715-0055-02

The Basic 400A Remote Display Panel includes the Remote Control Unit and the Linearizer/Integrater (Items 1 and 2); Items 3 through 6 are optional.

## 2.1 SUMMARY OF FEATURES

- Analog Display
- Alarm; with an adjustable exceedance level, variable time delay, and output relay.
- Individual panel indicators for:
  - Window Dirty/Window Clean (LED)
  - In Calibration Status (LED)




NOTES:
1. ALL RESISTOR VALUES IN ( ) ARE 1%.
2. CAPACITOR VALUES ARE IN MFD UNLESS OTHERWISE NOTED.
3. ALL RESISTORS ARE 1/4 WATT UNLESS OTHERWISE NOTED.
4. ◎ SYMBOL INDICATES SOLDER PAD WITH A HOLE TO ACCOMODATE A #20 SOLID WIRE
5. ◎ SYMBOL INDICATES JUMPER JACKS PER: ITEM 171 ON PARTS LIST.

6 PHYSICAL LAYOUT OF JACKS TO BE AS SHOWN BY DOTTED LINES, SPACING MUST BE SUCH THAT JUMPER CANNOT BE INSERTED INTO THE WRONG JACKS.

* REDRAWN FROM E 007-0181 SHEET 1 WAS 1 SHEET NOW 2 SHEETS

7 REMOVE FOR DASH-4 W/2-PEN ONLY

8 JUMPER FOR DASH-4 W/2-PEN ONLY

9 USED ON UNITS BUILT AFTER 6-1-78 ONLY

10 ADD JUMPER FOR SINGLE PEN 4-20MA (BASE PAD OF DELETED TRANSISTOR Q2)

11 JUMPER FOR ALL DASH-4

INTEGRATING LINEARIZER P.C. BOARD

Dash 3 & 4

007-0181 Sheet 2 of 2

Rev. T

- Manual Calibration Controls
- Choice of Integration Times
- Variable Stack Taper Compensation
- 4-20ma Current Drivers for Output of Instantaneous Exit and Integrated Exit Parameters
- 50 HZ or 60 HZ Operation (117 VAC)
- All critical controls and adjustments are behind the panel avoid accidental changes or tampering
- Chassis and slides for front access of (optional):
    - Conversion to Optical Density
    - Stack Taper Adjustment
- Controls for Display of:
    - Path or Exit output parameters
    - Instantaneous or Average Values

## 2.2 DATA CABLE

The Data Cable is used to connect the output of the Model 400 Transmissometer Optical Head Assembly to the M400A. The cable assembly and wiring diagram are shown in Figure 3. The Data Cable has a connector which mates with that on the Optical Head Assembly and is spade-lug terminated at the M400A end. all of the lugs are number-coded to match the connections on the control unit panel at TB2. This cable is made to order for individual installation requirements. The cable is electrically shielded, but it is suggested that it be routed in conduit to avoid adverse electrical environments such as the immediate vicinity of welders, brush type electric motors, transmitting equipment, and other similar devices. A factory representative should also be consulted if cable runs longer than 5000 feet (1524 meters) are required.

## 2.3 REMOTE CONTROL UNIT

The Remote Control Unit can be supplied with or without a Linearizer/Integrator as an option. This item will linearize and integrate the stack opacity to give a corrected average exit value. The front panel of the Remote Control Unit is shown in Figure 4 and contains a meter, reading in 0 to 100% opacity, a two-speed strip chart recorder for continuously recording the Transmissometer output data, and LED indicators for Transmissometer exit window status and calibration. The panel contains controls for the Transmissometer NORMAL, ZERO, and SPAN modes. It also includes an alarm set and time delay adjustment, a two-position chart speed switch, and recorder full scale calibration and scale expansion adjustments.

The schematic for the Remote Control Unit is shown in Figure 5. The input signal enters at TB2, Pins 7 and 8, and is directed to the meter which indicates the opacity as measured at the Transmissometer site. The signal is taken across the meter, amplified, and then routed through Pins 5 and 6 of J5 to one side of R32. Potentiometers R2 and R3 control the amplitude of the signal received by the recorder. R2 allows approximately a 10 to 1 scale expansion capability while R3 is a fine adjustment for full scale.

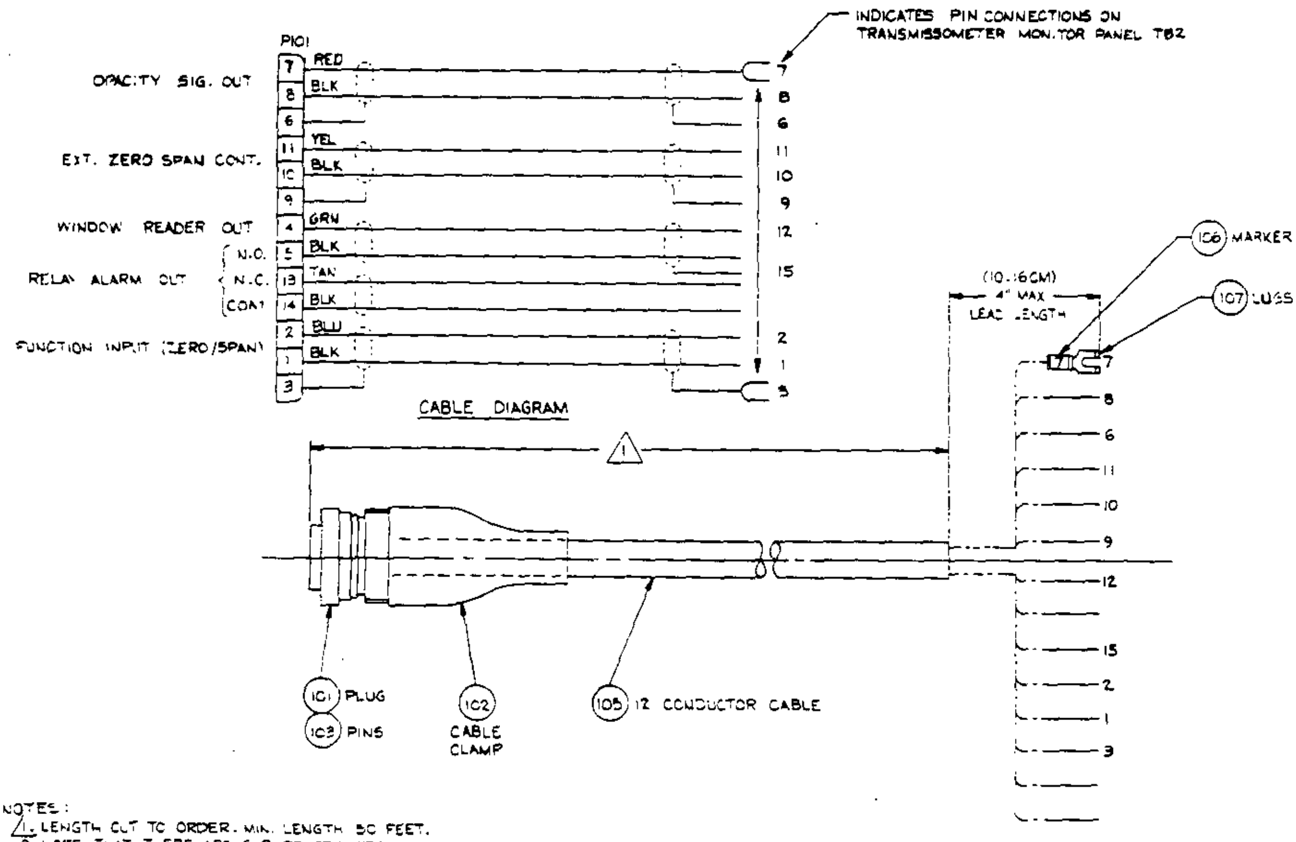
The amplified signal also goes to the alarm circuit where potentiometer R5 on the front panel (called the alarm delay) controls the time for which the signal must exceed the values set by potentiometer R4 before the alarm is tripped. The alarm set point is adjusted by moving the momentary switch S3 to the ALARM SET position and adjusting R4. With switch S3 in this position the meter will read the current passing through R14 and R14A. The gain through the IC1 stage along with the values of R10, R11, and R28 ensures that when the opacity reaches the level set on the meter (with S3 in the ALARM position), that IC2, Pin 4, will go to +15 volts.

Zener CR13 lowers this voltage to 2.4 volts, which is integrated by the following stage at a rate controlled by the alarm delay potentiometer R5. When the output of the integrator, IC3, Pin 3, reaches a sufficiently high negative value, IC2, Pin 12, will go positive. This positive voltage will result in Q2 being turned on and relay K1 being energized. TB1, Pins 6, 7, and 8 output the two normally opened contacts of K1 which are rated at 115 VAC, 5 amperes.

Transistor Q1 if used to prevent the alarm system from activating during the ZERO and SPAN calibration cycles. During normal operation, Q1 is off, since +15 volts is present on TP2, Pin 2. If the unit is either manually or automatically placed into the ZERO or SPAN mode, this 15 volts will disappear and Q1 will turn on, preventing the opacity signal from reaching the alarm circuit. The 15 volt signal at Pin 2 of TB2 also controls the conduction of Q4 and CR18. When the Transmissometer is in either calibration mode, Q4 will turn off and the yellow CAL STATUS LED on the front panel will be illuminated.

The circuit consisting of IC3, Q5, and associated components is used only when the optional Linearizer/Integrator is supplied in conjunction with an optional two-pen recorder. The circuit is a 4-20 ma current driver whose output (pins 13 and 14 of TB2) is connected to the second channel of the two-pen recorder to monitor the instantaneous opacity signal. R50 and R47 are used for adjustment of the zero and full scale signals, respectively.

The red and green LED indicators (CR16 and 17), located on the front panel, are controlled by the voltage signal from Pin 12 of TB2. This signal is provided by the window status circuitry in the Optical Head Assembly. A -15 volt signal at Pin 12 will illuminate the green LED (CR17). A +15 volt signal will illuminate the red LED (CR16) and indicates a need for Transmissometer exit window cleaning.




NOTES:
1. LENGTH CUT TO ORDER. MIN. LENGTH 50 FEET.
2. NOTE THAT THERE ARE 6 PAIRS OF WIRES IN THIS CABLE. THE WHITE BLACK PAIR ARE NOT USED AND ARE TO BE CUT AT BOTH ENDS AT THE OUTER INSULATION EXITS.
3. ALL SHIELDS & DRAIN WIRE TO BE INSULATED FROM EACH OTHER. USE APPROPRIATE HEAT SHRINK TUBING.

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DATA CABLE (DASH 2)

400-0012

Figure 3. Data Cable

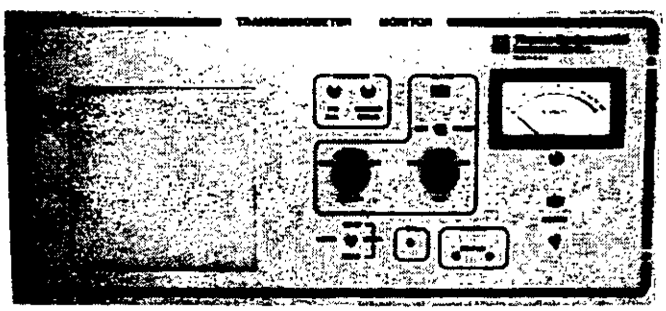
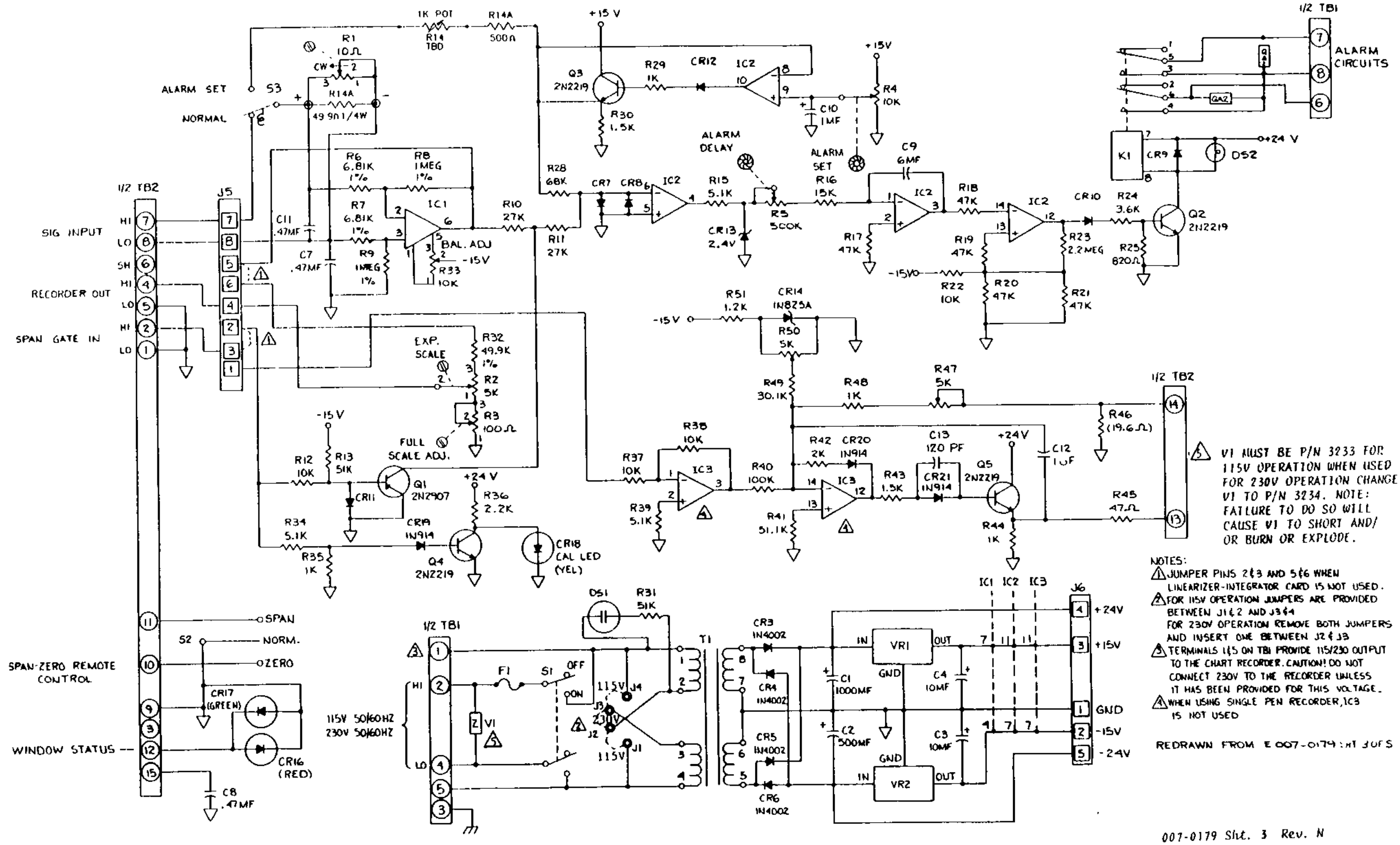


Figure 4. Remote Control Unit




REMOTE CONTROL UNIT SCHEMATIC

007-0179 Sht. 3 Rev. N

Connectors J5 and J6 are provided for the Linearizer/Integrator option. The power supply used in the Remote Control Unit may be connected to either 115 or 230 VAC, 50/60 Hz. If the unit is connected to 115 VAC, the jumper plugs (shown in the lower left-hand portion of Figures 5 and 6) are connected between J1 and J2 and between J3 and J4. For 230-volt operation, only one jumper plug is used between J2 and J3.

NOTE

IF THE OPTIONAL RECORDER IS PURCHASED WITH THE REMOTE CONTROL UNIT, IT MUST BE FACTORY-WIRED TO ACCEPT THE PROPER LINE VOLTAGE. IF NOT SPECIFIED, IT WILL BE WIRED FOR 115 VOLTS.

The Remote Control Unit is made to receive the optional recorder complete with its door assembly. This recorder is a 100-millivolt full scale unit wired to run at two speeds, 3 cm/hour and 30 cm/hour. A set of optional scales can be attached to the recorder that read in either opacity, optical density, or Ringelmann. These are shown in Figure 7. The normal scale used for single-pass opacity measurement will be nonlinear as $1 - t^2$, Scale "C".

## 2.4 LINEARIZER/INTEGRATOR MODULE (Figure 6)

The Remote Control Unit can be supplied with an optional plug-in module to perform the following functions:

1. To linearize the opacity $(1 - t^2)$ signal from the Transmissometer for output to a strip chart recorder.

2. To provide output to the strip chart recorder in terms of either:

    a) Linear Opacity or
    b) Linear Optical Density

3. To correct the recorder information for stack taper ratios from 0.2 to 5.0 (see Section 1.2).

4. To provide 6-minute integrated readings for automatic averaging of the instantaneous opacity values in accordance wth the EPA requirements appearing in the Federal Register (consult the factory for other integration times).

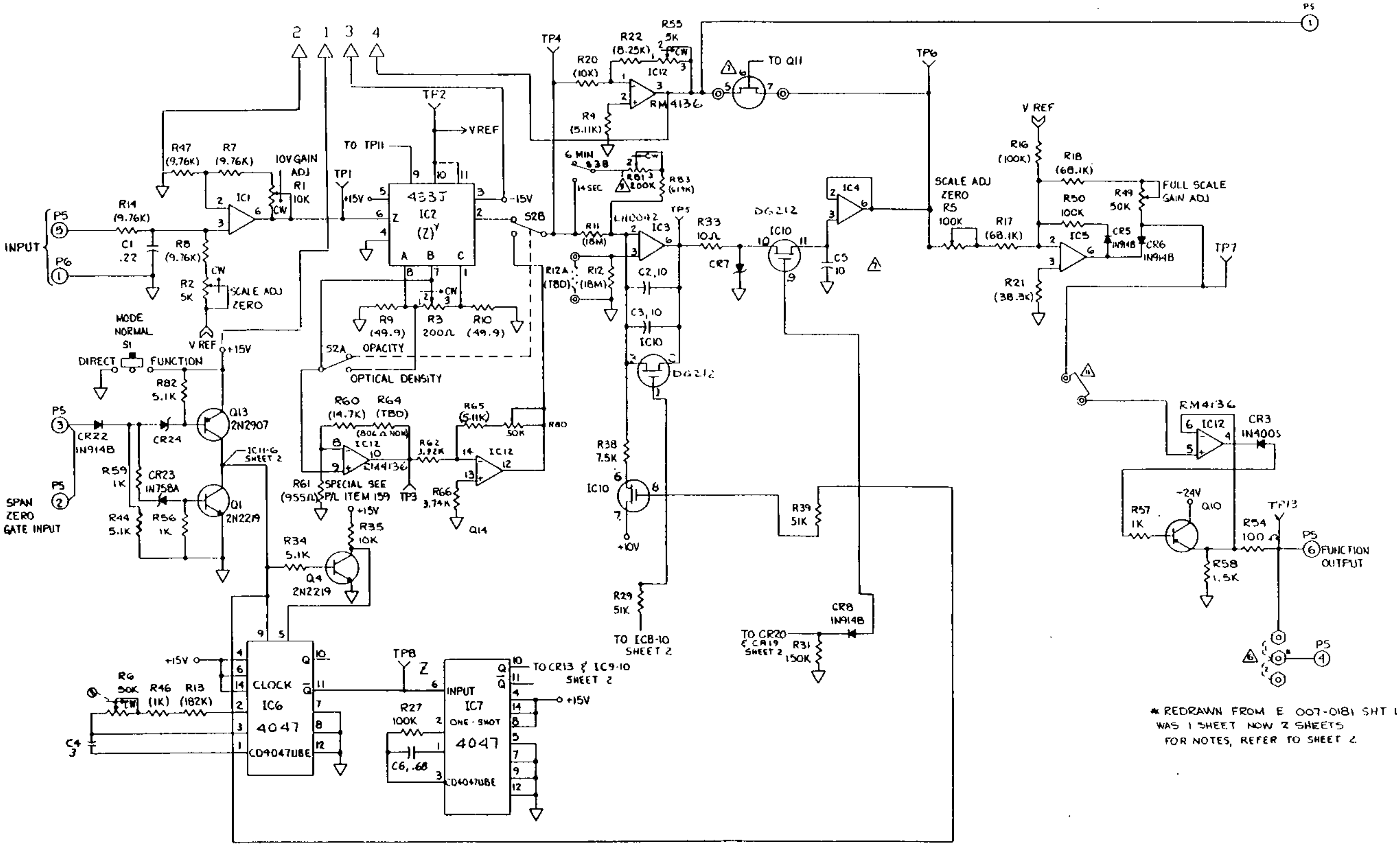
A switch is provided on the Linearizer/Integrator card which allows the output to be displayed as either linear opacity (o to 100%), or linear optical density (0 to 1). Both the instantaneous and integrated output must operate in the same mode (opacity or O.D.).

If the single-pen strip chart recorder is to be used with the system, placement of a jumper plug on the Linearizer/Integrator board will select either the instantaneous or integrated readings for output. Both the instantaneous and integrated signals may be obtained simultaneously for output to a two-pen recorder; however, the optional simultaneous output requirement should be specified at the time the system is ordered to ensure proper wiring of the Remote Control Unit.

The Linearizer/Integrator cannot be used without the Remote Control Unit. The unit must be plugged into the motherboard on the back of the Remote Control Unit. The motherboard provides both power and signal inputs for system operation.

### 2.4.1 SIGNAL PROCESSING SECTION (Figure 6) -

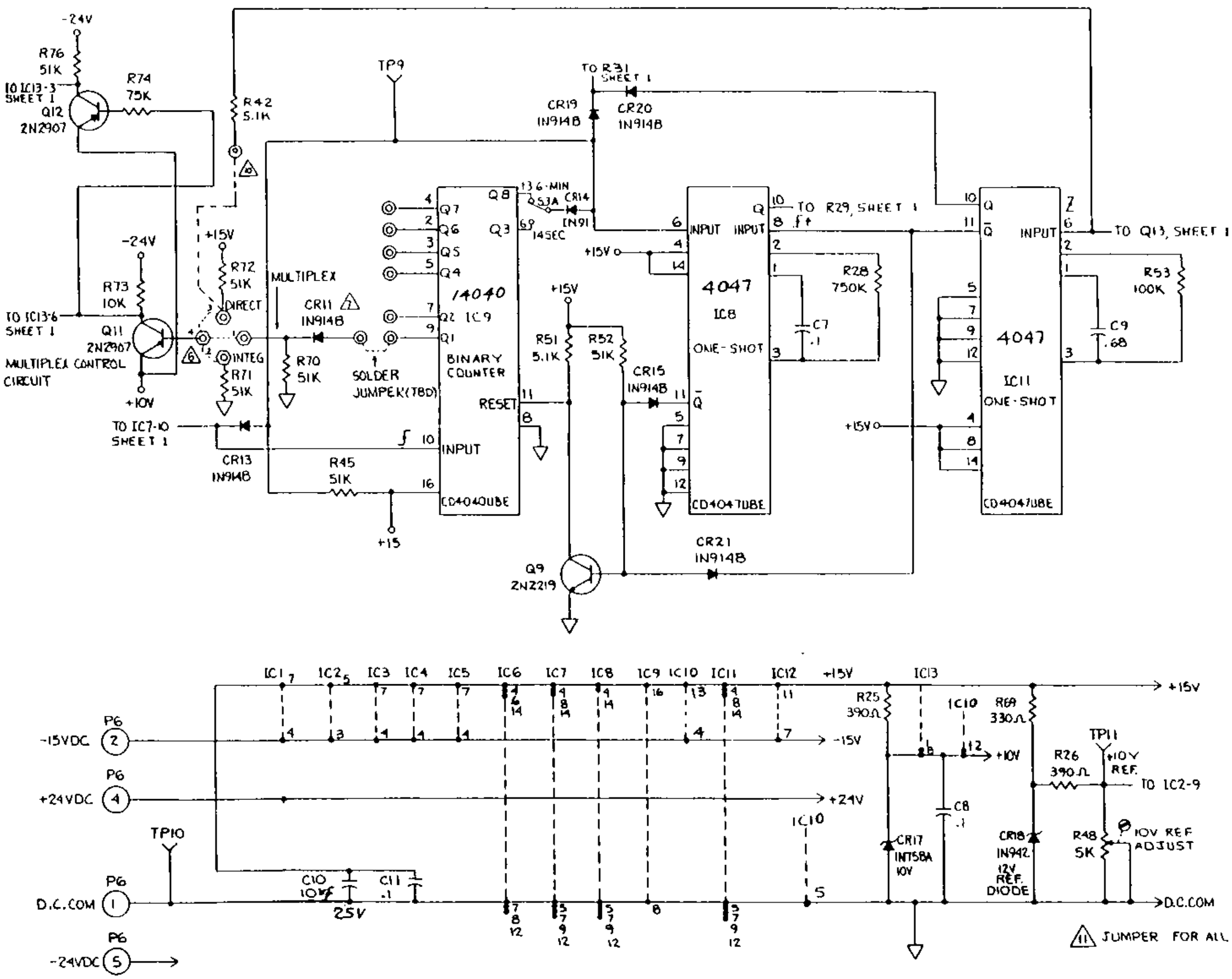
The nonlinear $(1 - t^2)$ signal from the Transmissometer is fed into P5-5 (via the Remote Control Unit) into scaling amplifier IC1. Amplifier IC1 serves two functions: one is for scaling, and the other is to invert the signal to the input of IC2. The output voltage as seen on TP1 will be +10.0 VDC when the input voltage is equal to 0% opacity and 0.0 VDC when the Transmissometer is indicating 100% opacity. This scaling must be set accurately for proper linearized operation. To ensure accuracy a digital voltmeter should be used for set-up and periodic checks.

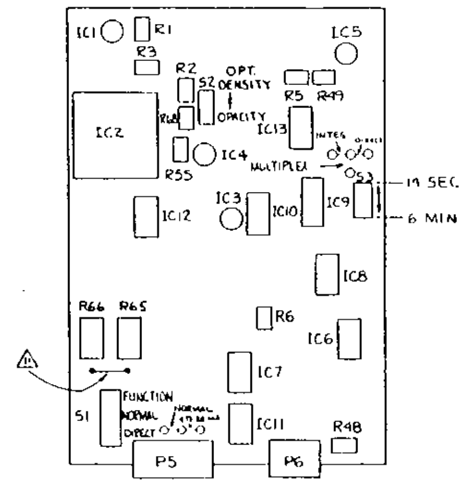



INTEGRATING LINEARIZER P.C BOARD

007-0181 Sheet 1 of 2

Rev. U




NOTES:
1. ALL RESISTOR VALUES IN ( ) ARE 1%.
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3. ALL RESISTORS ARE 1/4 WATT UNLESS OTHERWISE NOTED.
4. ◎ SYMBOL INDICATES SOLDER PAD WITH A HOLE TO ACCOMODATE A #20 SOLID WIRE
5. ◎ SYMBOL INDICATES JUMPER JACKS PER: ITEM 171 ON PARTS LIST.
6. PHYSICAL LAYOUT OF JACKS TO BE AS SHOWN BY DOTTED LINES, SPACING MUST BE SUCH THAT JUMPER CANNOT BE INSERTED INTO THE WRONG JACKS.

* REDRAWN FROM E 007-0181 SHEET 1 WAS 1 SHEET NOW 2 SHEETS

7. REMOVE FOR DASH-4 W/2-PEN ONLY
8. JUMPER FOR DASH-4 W/2-PEN ONLY
9. USED ON UNITS BUILT AFTER 6-1-78 ONLY
10. ADD JUMPER FOR SINGLE PEN 4-20MA (BASE PAD OF DELETED TRANSISTOR Q2)
11. JUMPER FOR ALL DASH-4

INTEGRATING LINEARIZER P.C. BOARD

Dash 3 & 4

007-0181 Sheet 2 of 2
Rev. U

## 2.4.2 LINEARIZATION MODULE IC2 -

The operation of this module provides both log and anti-log circuits interconnected for an output:

$$e_o = \frac{10}{9} V_y \left(\frac{V_2}{V_x}\right)^m$$

The log circuit provides the log of Vx/Vz to terminals A, B, and C where, for exponents other than unity, it is scaled by external programming resistors R3, R9, and R10. The scaled log ratio from terminal C(1) is subtracted from a signal proportional to the log of $V_y$. The resulting expression is operated on by the anti-log circuit, yielding the output equation shown above. The reference voltage at Pin 11 is a highly stable (0.005%/$^\circ$C) voltage source which is generated internally and is used as a constant connected to $V_y$ (Pin 10). R3 can be adjusted to vary the exponent m from 0.2 t 5 which is used to compensate for stack taper ratios. This is normally factory set for a specific installation and should not be changed unless the instrument is placed on another stack with a different stack taper ratio.

Another circuit is placed around IC2 and its purpose is to provide an output in units of optical density. This is accomplished by switch S2 and two sections of IC12. The switch (S2) is in the OPACITY mode of operation when its slide handle is toward the connector end of the board. Moving the switch toward the outside edge of the board will change the function to optical density. With the switch in this position, the first section of IC12 is a voltage follower and the second section of IC12 is a scaling amplifier which inverts the signal to provide the proper output for optical density. It should be noted that when operating in the OPACITY mode, the strip chart recorder will display 0 to 100% opacity with 0 being on the <u>righthand</u> margin of the chart paper. However, when operating in the OPTICAL DENSITY mode, the recorder displays 0 to 1 optical density with a lefthand zero. From switch S2B the signal is fed in two directions. The input signal tot IC3 is the integrated path, while the input to IC12 is the instantaneous path.

The integrator, IC3, C2, C3, R11, and R11a is a precision high Q circuit with a linear charging rate. FET switches are provided at the output of IC3 and across the capacitors. The timing is designed to dump the integrated voltage into the sample-and-hold circuit (C5 and IC4) on the falling edge of the pulse from TP9. The FET across the capacitors shorts out any residual voltage remaining on the capacitors after the sample-and-hold has been updated. This assures that with each cycle of integration time, the integrator starts at zero. The FET that feeds 10 volts into the summing junction of IC3 is turned on only during the ZERO and SPAN modes.

The time constant of the integrator is:

$$t = 1/RC$$

R1 is 18 megohms and C1 is 20µfd (standard RC values for a normally selected 6-minute integration period).

## 2.4.3 SAMPLE-AND-HOLD -

The sample-and-hold circuit is comprised of C5 and precision FET operational amplifier IC4. After the integration time has lapsed, the FET switch between the integrator and the sample-and-hold to accept the voltage from the integrator and store it. After C5 has stored the voltage generated by the integrator, it will hold this voltage level until the next integration interval has lapsed.

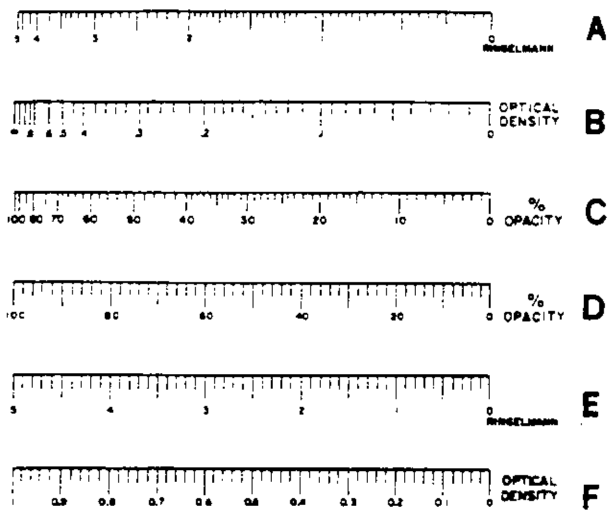



*Figure 7. Scales for Indicator*

## 2.4.4 INSTANTANEOUS SIGNAL PATH -

Pin 1 of IC12 also receives the signal from TP4. This path is the instantaneous or non-integrated section. This is a simple DC amplifier with variable gain. Its primary function is to scale and provide the instantaneous output of the signal.

If a two-pen recorder is to be used with the system to monitor both the integrated and instantaneous signals, IC13 is removed and the instantaneous signal is provided at Pin 1 of connector P5 for output to the current driver located on the Remote Control Card (Figure 5). A jumper is also placed between Pins 2 and 4 of IC13 to allow the integrated signal to be supplied to the IC5 scaling circuit and driver IC12 and Q10 for output on Pin 6 P5 to the Remote Control Unit.

The FET switches IC13, gates 3 and 6, located on the direct signal output and the output of the sample-and-hold, are provided for the purpose of selecting either output when using a single-pen recorder. Note that all the FET switches are OFF when a positive voltage is applied to the gate, and ON when a negative voltage is applied. Refer to IC9; you will note an output line from Pin 9 through a jumper wire to diode CR11 and onto a jumper selecting circuit. This jumper circuit is for the purpose of selecting three (3) modes of operation. These modes are MULTIPLEX, DIRECT, and INTEGRATE. The MULTIPLEX mode, which is used when making initial adjustments of the Linearizer/Integrator, provides both instantaneous and integrated signals at P5, Pin 6 alternately every 2.8125 seconds.

In the DIRECT mode, the jumper at Q11 is placed between resistor R72 and the base of Q11. Because R72 is connected to +15 VDC, Q11 will be turned off activating Q12. With Q12 activated the FET switch IC13-3 will be opened preventing the integrated signal from being fed through. At the same time, IC13-6 is ON and the signal path is open. In this state, only the direct information is output to the recorder.

If the jumper is placed in the INTEGRATE mode, everything is reversed and the recorded output will be the integrated information only, with the direct information being blocked.

The final stage of the signal path is amplifier IC5. As previously stated, the outputs of the integrator and the direct signals will be present at TP6, which is the input to IC5. IC5 provides two functions; one is scaling and the other is gain. This stage, along with the follower output stage, can be adjusted to compensate for the many types of recorders including the 4 to 20 ma units. Adjustment of R54 output resistor may be necessary to achieve the 20 ma output depending on the recorder's input impedance. The output of Q10 will safely provide 10 volts at 30 ma which means a minimum impedance of 330 ohms. For any load greater than this, the factory should be consulted prior to hook-up.

## 2.4.5 TIMING SECTION -

The purpose of this section is to clock the integrator and gate the multiplexing circuit in proper sequence.

The timing section is comprised of IC6, IC7, IC8, IC9, and IC11. The timer IC6 operates as an astable multivibrator requiring a high level input at Pin 5. The frequency of the output square wave at IC6, Pin 11, is determined by the external capacitor and resistors connected to Pins 1, 2, and 3. The timer is gated on and off by the Gating Control Circuits Q1, Q13, and Q4.

The Transmissometer has three modes of operation: NORMAL, ZERO, and SPAN. In the NORMAL mode of operation, a positive voltage level comes from the Transmissometer and is present at P5, Pin 3. This positive voltage turns on Q1 putting a ground potential at the collectors of Q1 and Q13. This ground is present at IC6-9 (the reset input). The ground present at the base of Q4 causes the collector that feeds to Pin 5 of IC6 to go to +15 VDC. This condition allows the multivibrator to operate. As can be seen on the schematic in Figure 6, the lines feeding IC6-9 and Q4 base also feed other circuits. These functions will be explained later in the Gating Section.

In the NORMAL mode a ground level must be on Pin 9 and a plus level must be on Pin 5 of IC6 to set the multivibrator into operation. When the Transmissometer mode changes to either ZERO or SPAN, the voltage level at P5-3 changes from positive to ground. This reverses both levels at the multivibrator and will inhibit its operation. The purpose of inhibiting the multivibrator in the ZERO and SPAN modes is to ensure a full 6-minute integration time when the instrument returns to the NORMAL mode.

The remaining sections of the timing circuit are a series of one shots and monostable multivibrators with one binary counter, IC9. The output signal of IC6 (Pin 11) is a 0 to approximately 15 volt square wave, the period of which is factory set at 2.8125 seconds. This signal is present at TP8.

The output of IC6 is fed into IC7-6 and can be monitored at TP8. The output of IC7 is an asymmetrical square wave with a period of 2.8125 seconds. This signal is fed into the binary counter IC9 and into the AND gate diode CR13.

The binary counter IC9 is a 12-stage ripple-carry type device with reset. The integrating time may be changed by removing the jumper between IC9-13 and CR-14, and using one of the other binary outputs connected to CR-14. This is only the coarse adjustment. The fine adjustment is accomplished by changing the values of the resistors and capacitor C4 located on IC6. The timing is factory set for 6 minutes which is specified in the EPA reporting procedure.

Switch S3, which is connected to Pins 13 and 6 of IC9, allows adjustments of the integrated circuitry to be made with the integration time set at 14 seconds. This will reduce check-out time since adjustments can only be made after one full integration period has been completed. After all adjustments have been made with S3 in the 14-second position, S3 may be placed in the 6-minute position for operation.

The binary counter IC9 output at Pin 13 is 0 volts during the 6-minute counting period. This zero state is also seen at TP9 and is fed to IC8 and diode CR19. CR19 feeds the base of Q5 which controls the FET switch IC10-10. IC10-10 gates the integrated voltage from IC3 to the sample-and-hold circuit C5 and IC4.

Assuming that ground potential is on both anodes of the two diodes, CR19 and CR20, this indicates that Q5 is conducting and providing the necessary positive 10 volts to hold the FET switch OFF. If either the anode of CR19 or CR20 should go to the +15 volt level, Q5 will turn OFF and cause the FET IC10-10 to turn ON. This happens at the end of each timing cycle and also with a mode change. Referring back to the output of IC9, Pin 13, the output is zero during the integration period and feeds into CR14. CR13, CR14, and R45 make up an AND gate circuit which controls the timing sequence between dumping and resetting of the integrator. IC10-3 (FET) across the two integrating capacitors C2 and C3 applies a momentary short after the voltage has been dumped into the sample-and-hold. Its purpose is to assure a zero voltage starting point for each successive integration period.

### 2.4.6 GATING CIRCUIT -

In addition to the timer control, the gating circuit controls the Transmissometer signal path during mode changes. It should be noted that the Linearizer/Integrator does not process the Transmissometer signal during the ZERO or SPAN modes of operation (also called the CALIBRATE mode). The Transmissometer signal enters P5-5 which is shown connected to the open contact of relay K1 and also to R14 resistor at the input to amplifier IC1. In the NORMAL mode, K1 is deenergized and K2 is energized thus providing a complete signal path into IC1 and out of IC12.

When the mode changes to CALIBRATE, ZERO or SPAN, relay K1 energizes and K2 deenergizes changing the Transmissometer signal path. Even though the signal path is not broken to IC1, it has no effect on the recorded output. This is because K2 has opened the output between IC5 and IC12.

Since the mid-span signal has a value of opacity which comes from the Transmissometer, and is neither linearized nor integrated, it will not be displayed linearly on the recorder chart. This is to prevent false integration. The recorder paper and recorder were designed to accept a linear input from the Linearizer/Integrator. The difference in the reading of the chart paper and the opacity meter is of no consequence unless the value varies.

Another function performed by the gating circuit is to condition the Integrator to produce zero output after the ZERO or SPAN mode has been switched back to NORMAL. This prevents random recorder information at the beginning of each start in the NORMAL mode. This function is accomplished be Q7 and IC11. Both Q7 and IC11 are connected to the gating control line from the collectors of Q1 and Q13. This line changes voltage level with changes in mode of operation. In NORMAL mode, the voltage is at ground potential and changes to +15 volts when in ZERO or SPAN mode. The mode switching is controlled automatically by the Transmissometer or manually by the control switches on either the Remote Control Unit or the Transmissometer.

Assuming the mode to be NORMAL, the voltage on the control line from Q1 and Q13 is at ground potential. A ground at the base of Q7 will cause the transistor to conduct putting a +10 volt level on FET switch IC10-6. This positive voltage holds the FET switch open, preventing the +10 volts connected to it from passing through to the input of the Integrator. When the mode changes to ZERO or SPAN, the positive voltage at the base of Q7 turns off the transistor by applying -24 volts to FET switch IC10-6. This -24 volts on the FET gate will close the switch allowing the integrator to charge very rapidly to 10 volts. The time constant of the Integrator is made small by the input resistor R38 which is 7.5K. The Integrator will remain charged until the mode is changed back to NORMAL.

When the mode changes to NORMAL, first the signal line goes from +15 volts to ground causing the FET switch IC10-6 to open via Q7. At the same time the level changes at IC11-6 which causes the output IC11-10 to momentarily go to zero volts turning off Q5. Q5 controls FET switch IC10-10 which closes dumping the 10 volts from the Integrator into the sample-and-hold which represents zero opacity on the recorder. When the mode changes back to NORMAL after a calibration check of ZERO or SPAN, the recorder will always indicate zero opacity for the integrated value. The integrated value will remain at the zero reading until a 6-minute period has elapsed.

IC11 performs two additional functions when the mode changes back to NORMAL. Following the signal path from IC11-11, it goes in two directions. One line goes to CR21 which is part of an AND gate used to reset the binary counter, and the other line feeds IC8. IC8 is used to short out the residual charge across the Integrator capacitors and to reset the binary counter. This always assures that after a calibration check, either automatic or manual, the Integrator output will always read zero and be reset ready to accept new data.

Regardless of the type of signal response curve the output can be taken from the Remote Control Unit with the Linearizer/Integrator as either a 0 to 10 ma signal or a 4 to 20 ma signal.

## 2.5 REMOTE CONTROL UNIT ENCLOSURE

An enclosure for the Remote Control Unit is available to permit desk or table mounted installation where the normal rack type control room console is not used. The enclosure is shown in Figure 4 with the Remote Control Unit in place. It is of all aluminum construction, 10-5/16" (26.19 cm) deep, 19-3/4" (50.17 cm) long, and 9-3/4" (24.77 cm) high, and will accept a standard 8-3/4" (22.23 cm) x 19" (48.26 cm) rack mounted panel. Four rubber pads protect the mounting surface from being marred or scratched.

## 2.6 RECORDER

The optional Remote Control Unit can be supplied with either a single-pen or two-pen strip chart recorder to record the Transmissometer system output. If the Linearizer/Integrator has been supplied with the system, the two-pen recorder may be used to record both the instantaneous and integrated stack information simultaneously. The recorders use a 10-cm wide Z-fold chart. The chart speed is selectable on the monitor front panel. On the low setting the chart speed is 3 cm/hr, while on the high setting the chart speed is 30 cm/hr. Chart speeds from 1.5 cm/hr to 300 cm/hr can be obtained if the factory is consulted prior to shipment.

The writing system uses a disposable cartridge pen which contains both the ink and stylus.

The recorder power requirement is 117 VAC, 50/60 Hz. 230 VAC, 50/60 Hz is optional but must normally be wired at the factory. The recorder is supplied with a complete operations manual. Optional scales arer available in terms of nonlinear or linear opacity, and nonlinear or linear optical density.

## 3.0 BASIC CALIBRATION AND CHECKOUT

Pre-installation calibration ensures precise operation of the 400A Control Panel when installed. This is normally done at the factory prior to shipment and when the true flange to flange mounting distance is known. It can also be performed on-site by the customer if a VTVM is available or by CGC Field Service personnel (see Section 7.3, Field Service).

## 3.1 LINEARIZER/INTEGRATOR SET-UP (Figure 6)

With the Model 400 Transmissometer and Model 400A Remote Control Unit adjusted and operating properly, the Linearizer/Integrator card should be installed into connectors J5 and J6 on the rear of the Remote Control Unit printed circuit card. The recorder to be used should be installed and be in proper operating condition. Reference to recorder output will assume that the 0 to 100 mv recorder typically supplied with the system has been used.

The Transmissometer and Remote Control Unit should be assowed an initial warmup period of at least 15 minutes before any adjustments are attempted. In making Linearizer/Integrator adjustments, it will be necessary to provide zero, 100%, and some mid-scale opacity values to the Remote Control Unit. The Calibration Test Kit is convenient for this purpose.

Percent opacity signals to the Remote Control Unit may be obtained in two ways:

(1) using the Transmissometer Calibration Test Kit, or
(2) using the ALARM SET switch on the Remote Control Unit.

When the momentary ALARM SET switch is depressed, a signal is generated within the Remote Control Unit that is switched into the signal path causing deflection of the panel meter. The amount of deflection is determined by the setting of the alarm set adjustment potentiometter on the front panel. Although it is normally used to check and adjust the alarm set point, this circuit may also be used in making quick checks of Remote Control Unit and Linearizer/Integrator performance. If the spring return ALARM SET switch is activated, a simulated opacity reading of any value may be produced by adjusting the ALARM SET potentiometer. The Linearizer/Integrator operates on the signal output after the panel meter, therefore, the signals for linearization, integration, and stack taper ratio compensation are displayed on the strip chart recorder only. The recorder output can either be in optical density or opacity units. The panel meter, however, only indicates the instantaneous opacity at the Transmissometer sampling path, or alarm set information when the ALARM SET switch is depressed. These are displayed on a 1 - t! basis, which expands the lower portion of the scale so that 30% opacity is about 1/2 full scale.

## 3.2 ADJUSTMENT OF +10-VOLT REFERENCE

Connect a digital voltmeter from DC common (TP10) to thte +10 volt reference (TP11) and adjust R48 until the voltage at TP11 is +10.0 volts DC.

## 3.3 ADJUSTMENT OF IC1 CIRCUIT

1. Place the Transmissometer in NORMAL

2. Place Linearizer/Integrator mode switch S1 in the NORMAL (center) position.

3. Set the multiplex control jumper (single-pen recorder) in the MULTIPLEX position. (See card layout in Figure 6.)

4. Place Linearizer/Integrator switch S2 in the OPACITY position (See card layout in Figure 6.)

With the system operating as above, obtain a 100% opacity reading on the Remote Control Unit meter by blocking the light path of the Transmissometer or by holding the ALARM SET switch and adjusting the set control for 100% on the panel meter. Adjust R2 on the Linearizer/Integrator board so the voltage at TP1 is 0.00 volts DC. Now obtain a 0% opacity reading from the Transmissometer and adjust the voltage at TP1 to +10.00 volts DC using R1. Repeat these steps as required to ensure proper adjustment.

## 3.4 ADJUSTMENT OF THE INTEGRATOR

1. Place the Transmissometer in NORMAL mode of operation.

2. Place Linearizer/Integrator mode switch S1 in the NORMAL (center) position.

3. Set the multiplex control jumper (single-pen recorder) in the MULTIPLEX position. (See card layout in Figure 6.)

4. Place Linearizer/Integrator switch S2 int he OPACITY position (toward the panel).

5. Place Linearizer/Integrator switch S3 in the 14-SECOND position.

6. Continue IC1 circuit adjustments for the one- or two-pen recorder systems as follows:

A. <u>Two-Pen Recorder</u>

Adjustments to the Integrator on two-pen recorder systems should be done only after instantaneous linearization adjustments have been completed. Proceed to Section 3.5.

B. <u>Single-Pen Recorder</u>

With the system operating as above, introduce an opacity reading of from 20% to 50% using either the Calibration Test Kit and filters or the Remote Control Unit ALARM SET switch. This reading should be left unchanged for at least 30 seconds to allow one full 14-second integration period. The strip chart recorder will display either an erroneous level or zero output until the integrator goes through two cycles. At the end of the 30-second period adjust R55 on the Linearizer/Integrator card until there is no visible movement in the recorder pen. Place switch S1 in the 6-MINUTE position and then change the opacity reading and allow it to remain unchanged for 12 minutes. After 12 minutes there should be no movement of the pen. The magnitude of the signal displayed on the recorder is of no concern at this point, only the fact that the instantaneous and integrated signals are equal. Further adjustments are necessary to properly linearize the Transmissometer signal.

## 3.5 ADJUSTMENT OF 0% AND 100% INSTANTANEOUS OPACITY

1. Place the Transmissometer in NORMAL mode of operation.

2. Place Linearizer/Integrator MODE switch S1 in the NORMAL (center) position.

3. Place the multiplex control jumper (single pen recorder) in the DIRECT position (See card layout in Figure 6.)

4. Place Linearizer/Integrator switch S2 in the OPACITY position (toward the panel).

5. Continue opacity adjustments for the one- or two-pen recorder as follows:

A. Single-Pen Recorder

With the system operating as above, adjust R49 on the Linearizer/Integrator board so that with a 100% opacity signal from the Transmissometer the recorder will indicate full scale. Now generate a 0% opacity signal to the Remote Control Unit and adjust the recorder zero using potentiometer R5 on the Linearizer/Integrator card. Care must be taken in making the zero adjustment to avoid below zero readings due to the clamping effect of the recorder. Proper zero adjustment requires that R5 be adjusted counterclockwise until some upscale movement is noticed, then turned clockwise until the recorder indicator just falls on the 0% opacity mark. This procedure should be repeated until no further adjustments are necessary. Proceed ot Section 3.6.

B. Two-Pen Recorder

Generate a 100% opacity reading on the panel meter and adjust R47 on the Remote Control Unit printed circuit card (Figures 5 and 6) until the pen of the instantaneous channel indicates full scale. Then generate a 0% opacity signal and adjust R50, also on the

Remote Control Unit board, until a recorder zero is obtained. Repeat this procedure until no further adjustments are necessary.

## 3.6 ADJUSTMENT OF LINEARIZATION AND STACK TAPER RATIO

1. Place the Transmissometer in NORMAL mode of operation.
2. Place Linearizer/Integrator MODE switch S1 in the NORMAL (center) position.
3. Place the multiplex control circuit jumper (single-pen recorder) in the DIRECT position. (See card layout on Figure 6.)
4. Place Linearizer/Integrator switch S2 in the OPACITY position.

Linearization and stack taper ratio adjustments are made using potentiometer R3 on the Linearizer/Integrator card. For direct linearization (no taper ratio connection) of the opacity signal, several up-scale readings must be provided to the Remote Control Unit. With the Remote Control Unit panel meter indicating an opacity reading of 50%, for example, R3 should be adjusted until the strip chart recorder indicates 50% on its linear scale. The 0% and 100% readings must now be rechecked and adjusted. Several other opacity readings should be checked to ensure linearization is correct throughout the scale.

If the stack exit diameter is different from that of the instrument measurement path, the stack taper ratio adjustments must be made to have the system read in terms of exit opacity. Calculations of stack exit opacity and measurement path opacity must be made using the information provided in Section

1.2. With the Remote Control Unit panel meter indicating the opacity at the measurement path, R3 should be adjusted until the recorder indicates the corresponding calculated value for the stack exit opacity. Example:

| Measurement Opacity, $op_m$ (Remote Control Unit Meter) | Stack Taper Ratio, $\ell_e/\ell_m$ | Exit Opacity, $op_e$ (Recorder) |
|---|---|---|
| 50% | 0.5 | 29.3% |
| 50% | 0.5 | 16.3% |

At least four points should be calculated and checked. If difficulties are experienced in making linearization or stack taper ratio adjustments that are correct throughout the scale, it may be necessary to recheck the zero and full scale adjustments described in the previous section.

## 3.7 ADJUSTMENT OF THE INTEGRATOR (TWO-PEN RECORDER ONLY)

1. Place the Transmissometer in NORMAL mode of operation.
2. Place Linearizer/Integrator MODE switch S1 in the NORMAL (center) position.
3. Place Linearization/Integrator switch S2 in the OPACITY position.
4. Place Linearizer/Integrator switch S3 in the 14-SECOND position.

NOTE

THESE ADJUSTMENTS MUST NOT BE ATTEMPTED UNTIL THE INSTANTANEOUS OPACITY ADJUSTMENTS OF THE PREVIOUS SECTION HAVE BEEN COMPLETED.

Generate a 0% opacity signal through the system. The recorder channel, monitoring the instantaneous opacity, should indicate 0%. Allow this signal to remain unchanged for at least 30 seconds. Then adjust R5 on the Linearizer/Integrator circuit board until the integrated channel also indicates a 0% reading. Proper zero adjustment requires that R5 be adjusted counterclockwise until some upscale movement is noticed, then turned clockwise until the indicator just falls on the 0% opacity mark.

Generate an up-scale opacity reading between 30% and 60% and allow this reading to remain unchanged for at least 30 seconds. R49 may then be adjusted until the integrated channel of the recorder indicates the same reading as the instantaneous channel.

## 3.8 ADJUSTMENT OF OPTICAL DENSITY

1. Place the Transmissometer in NORMAL mode of operation.

2. Place Linearizer/Integrator MODE switch S1 in the NORMAL (center) position.

3. Place the multiplex control circuit jumper in the DIRECT position. (See card layout on Figure 6.)

4. Place Linearizer/Integrator switch S2 in the OPTICAL DENSITY position (away from the panel).

If stack effluent information is required in terms of optical density, the system should be connected as above and a 0% opacity reading should be provided to the Remote Control Unit. Potentiometer R80 is then adjusted to produce a 0 optical density reading on the strip chart recorder. If R80 is not capable of producing a 0 optical density signal, R5 and R49 may be used for additional control. Note that when operating in the optical density mode that 0 optical density is displayed on the left side of the strip chart recorder and an optical density of one (1) is displayed on the right. Several values of optical density should be calculated according to the equation:

$$\text{Optical density} = \log \frac{1}{10t}$$

where

$t$ = transmittance,

then checked through its operating range. Example:

| Measured Opacity (Remote Monitor Meter) | Optical Density, O.D. (Recorder) |
|---|---|
| 50% | 0.30 |
| 30% | 0.155 |

An optical density of 0.30 would be indicated by the recorder pen being three major divisions from the left margin of the recorder strip chart.

# 4.0 INSTALLATION

These procedures are to be followed in the installation of the Transmissometer System after selection of the measurement site.

## 4.1 SITE PREPARATION

Prior to installation, certain information must be known to assure proper calibration, adjustment, and electrical connection of the system.

The required information should be recorded in the checklist and should be provided to the factory so that proper installation drawings can be prepared. This is normally done in the early stages of ordering the Transmissometer System.

## 4.2 MODEL 400A CONTROL PANEL INSTALLATION CHECKLIST

Electrical Power:
(all power must be single phase)

Remote Monitor, 115 Volt, 15W

Data Cable:

a) Length

b) Conduit Size
(minimum 1 in. diameter)

Stack Taper Ratio
(if linearizer is supplied):

a) Stack inside diameter at
transmissometer location

b) Stack inside diameter
at exit

Tighten the gasket ring hex head screws then attach the weather cover to the hinges on top of the blower mounting plate, close the cover, and fasten the latches.

## 4.3 REMOTE CONTROL UNIT

The output from the Transmissometer Optical Head Assembly is connected to the Remote Control Unit through the optional data cable (Figure 3). The connector end of the cable mates with J101 on the Optical Head Assembly. The terminal end is fitted with labeled spade lugs that attach to the corresponding terminals of TB2 in the Remote Control Unit shown in Figure 8 and the back of the panel shown in Figure 9.

### 4.3.1 ADJUSTING THE RECORDER ZERO AND FULL SCALE SET POINTS -

A two-speed strip chart recorder is offered as an option to the Remote Control Unit (Figure 4). The proper connections of the recorder to the Remote Control Unit are shown in Figures 8 and 9. Two chart speeds, 3.0 cm/hr and 30.0 cm/hr, are standard with this recorder although others are available.

Normally the zero and full scale readings for the recorder are factory set. Should adjustments be necessary, allow the unit to operate for at least 30 minutes.

To adjust the zero set point, disconnect the input led to Pin 7 on TB2 of the Remote Control Unit. The meter on the front of the panel should read 0. Place a jumper from Pin 5 of J5 to ground and adjust the recorder zero. Remove the jumper from J5 and adjust potentiometer R33, see Figure 9, until the recorder pen also reads 0 on the strip chart. Reconnect the input lead to Pin 7 on TB2.

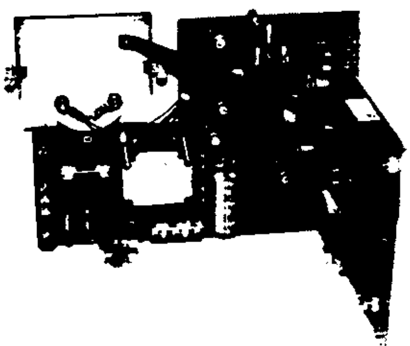


*Figure 9. Rear View of Remote Control Unit Panel*

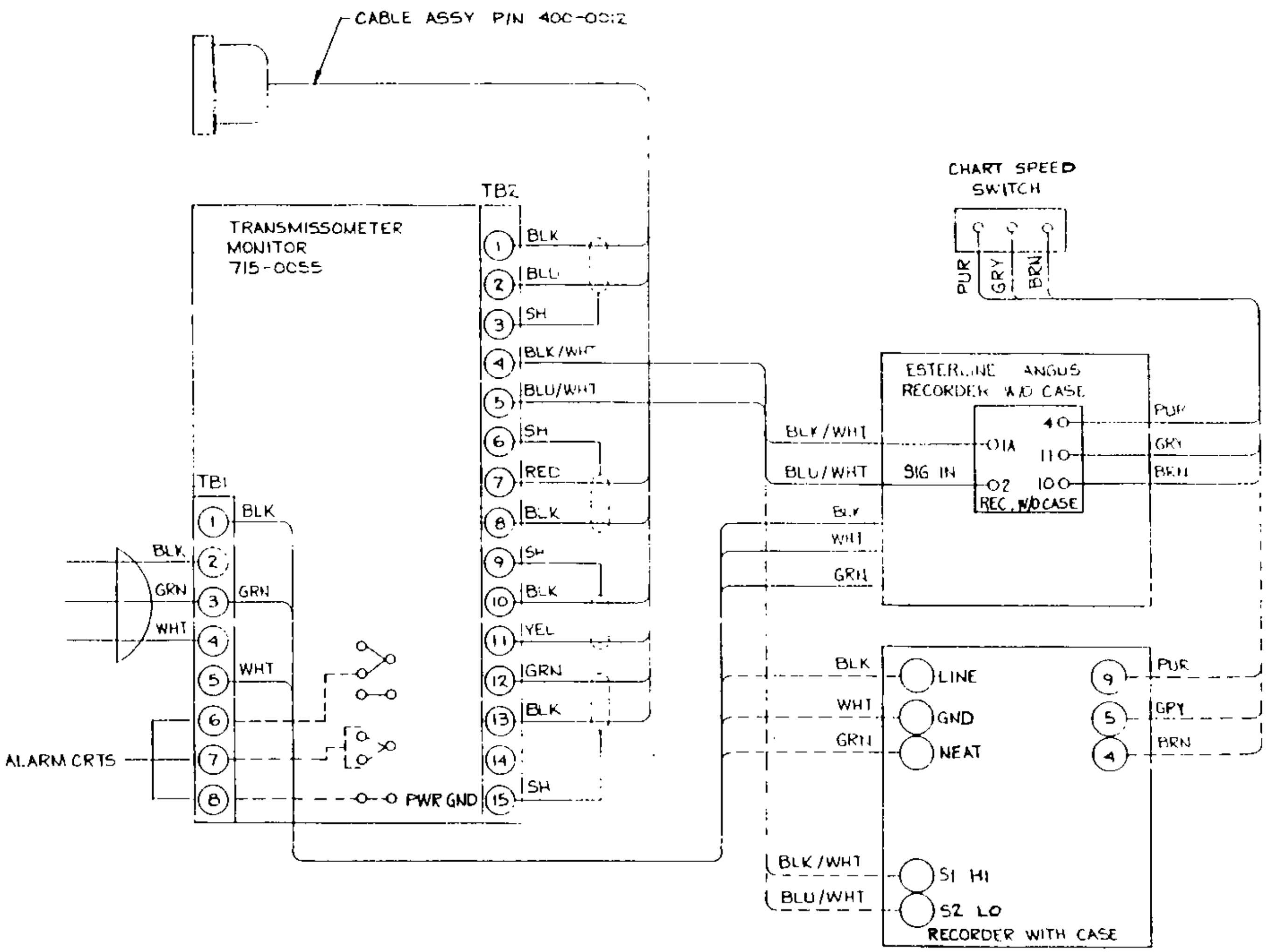



Figure 8. Remote Control Unit Wiring Diagram

To adjust the full scale set point, hold the alarm switch on the front face of the panel in the SET position and adjust the alarm set potentiometer (Figure 9) until the meter reads exactly 100% opacity. While still holding the switch in the SET position, adjust the recorder full scale potentiometer until the recorder pen reads full scale on the strip chart, then release the switch to the NORMAL position.

The recorder display may also be expanded to set its full scale reading to any point between 10% and 100% opacity. To accomplish this, hold the ALARM SET switch in the SET position and adjust the alarm set potentiometer until the meter reads the opacity value desired to be full scale on the recorder chart. While still holding the switch in the SET position, adjust the EXPAND SCALE potentiometer on the front face of the panel until the recorder pen reads full scale on the strip chart. Release the switch to the NORMAL position.

### 4.3.2 ADJUSTING THE ALARM SET POINT AND TIME DELAY -

To adjust the alarm set point, hold the ALARM SET switch in the SET position and adjust the alarm set potentiometer until the meter reads the desired opacity value, then release the switch to the NORMAL position.

The alarm time delay is variable from 0 to a maximum of 30 seconds. Turn the alarm delay potentiometer fully counterclockwise for the 0 position and fully clockwise for the 30-second limit. Since the potentiometer is approximately linear, any point in between can be set by turning the potentiometer knob a proportional amount of the full distance (i.e., 1/4 of the way from zero toward the 30-second maximum would be approximately 7.5 seconds delay, etc.).

# 5.0 MAINTENANCE

The basic 400A Control Panel is designed to operate unattended for extended periods. Very little maintenance is required although it is suggested that a routine inspection schedule be adopted to monitor the condition of the system since the physical environment will vary from one installation site to another. As part of the inspection schedule, the following items should be checked for cleanliness or serviceability. After initial installation, there should be no need for adjustments to the system unless electronic settings have been disturbed. A factory representative should be consulted for equipment and component failures, warranty repairs, and field service.

There are four levels of maintenance for the transmissometer system:

Level 1 - Routine Maintenance

Level 2 - Parts Replacement with No adjustment

Level 3 - Parts Replacement with Adjustment or Recalibration

Level 4 - Factory Repair

## LEVEL 1. Routine Maintenance

This level of maintenance is preventative and diagnostic in nature, and should be conducted on a regular schedule determined by environmental conditions at the instrument site. This maintenance, however, should be conducted at least quarterly.

## LEVEL 2. Parts Replacement with No Adjustment

At this level of maintenance, certain basic parts and system components can be replaced without adjusting or recalibrating the system.

LEVEL 3. Parts Replacement with Adjustment or Recalibration

This level of maintenance must be done using the instructions and/or schematics of this manual.

LEVEL 4. Factory Repair

This level of maintenance covers all other phases of maintenance to parts that have been disturbed or severe physical damage has been sustained. Under these conditions, factory tooling and adjustment systems should be used to properly effect the repairs.

In this section replacement of the most common routine maintenance items are discussed which is a Level 3 maintenance item.

## 6.0 SPARE PARTS LIST

The following list, which is arranged by maintenance level category, covers major assemblies and parts that are normally replaced in accordance with routine maintenance procedures, or in the case of equipment component failure. Field repairs by the customer should not be attempted without consulting a factory representative or the equipment warranty will be void. However, upon factory recommendation failed components should be immediately replaced, and the defective item, if salvageable, returned to the factory for repair or replacement.

Items marked with an asterisk (*) are recommended spare parts which will probably require replacement during the normal course of equipment maintenance. The other items listed are recommended to minimize down-time in the event of unexpected component failure.

Level 2, Parts Replacement with No Adjustment

| Part No. | Item |
|---|---|
| 007-0179/156 | Fuse |
| 007-0179/151<br>007-0179/152 | Lamp |
| 007-0179/187<br>007-0179/188<br>007-0179/189 | L.E.D |

Level 3, Parts Replacement with Adjustment or Recalibration

| Part No. | Item |
|---|---|
| 007-0181 | Linearizer/Integrator Board |
| 715-0055/107 | Panel Meter |

## 7.0 WARRANTY AND FIELD SERVICES

All goods sold hereunder are warranted to be free from harmful defects in material and workmanship and to conform to the specifications, if any, agreed upon between the Purchaser and Thermo Environmental Instruments T.E.I. or in the absence of such specifications, to the catalogued description. This express warranty is in lieu of and excludes all other warranties, express or implied, by operation or law or otherwise. In no event shall CGC be liable for consequential or special damages. T.E.I. agrees to reword or replace, at its option, any defective goods provided we are notified of such defects within ninety (90) days after receipt of the goods, by the Purchaser or such other period as may be mutually agreed upon. Transportation charges on goods claimed to be defective will be allowed only in case defects are found by T.E.I. to exist, and not otherwise. All goods claimed to be defective should be returned to the point of manufacture unless otherwise advised.

## 7.1 FACTORY SERVICE

Defective equipment not covered by the above warranty will be repaired at the factory on a time and material basis. Equipment received for repair will be inspected and the cost for all requested and/or necessary repairs will be quoted to the customer. No repair work will be initiated without the customer's written authorization to proceed. All shipping charges will be paid by the customer.

## 7.2 FIELD SERVICE

The costs of maintenance or repair of T.E.I. equipment not covered by the above warranty and conducted on the customer's site will be charged on a time and material basis. The time charges will include travel time to and from the customer's facility and actual on-site service time. Premium labor rates will be charged for overtime, Saturday, and Sunday work. Material charges will include the cost of replacement parts not covered by the warranty and any additional parts or materials requested by the customer for that particular installation. Equipment not repairable on site will be removed by Field Service Personnel upon customer's authorization and returned to the factory for the required work. Repaired equipment will be returned to the customer for reinstallation. Assistance in reinstallation by T.E.I. Field Service Personnel will be charged on a time and material basis. Additional on-site service of the repaired or replaced equipment required within 30 days of the reinstallation will be provided at no extra charge, and will be considered as part of the original service call.

Calibration for a given installation is normally completed at the factory prior to shipment of the instrument. Should the instrument be required at a different location within the customer's facility or at a different facility, where the flange to flange distance is different than that at the initial installation, the instrument must be recalibrated. Assistance in this effort can be provided on a time and material basis. The site must also be wired for power. FAILURE TO DO THIS WILL RESULT IN ADDITIONAL CHARGES. Factory personnel should be consulted in the case of unusual installation requirements.

## 7.3 MAINTENANCE SERVICE

A maintenance contract is also offered by T.E.I. for the inspection and service of installed Transmissometer equipment. Due to the individual nature of each installation, the maintenance contract cost is based on the amount, location, and type of equipment at each site and any local labor requirement conditions. The service includes periodic visits to the installation site to perform all routine maintenance required, to make any system adjustments considered necessary, and to replace or repair faulty or failed parts, that are still under warranty. Equipment under warranty that _must_ by returned to the factory will be repaired and failed parts replaced at no charge.

Equipment or parts failed or damaged not under warranty will be replaced with only a material charge to the customer, provided the repairs can be made on-site. Equipment that must be removed from the site and returned to the factory for repair will be subject to the normal factory service time and material charges. Reinstallation and any further service work on-site will be considered covered under the maintenance contract currently in force.

## 8.0 INTERFACE PC Board 715-0167 (OPTIONAL)

The Interface PC Board was developed to provide isolated status and isolated 4-20 MA signal to the user's DAS system. There are two versions of this module and are referred to as DASH-1 Version and DASH-2 Version. (Refer to Drawing C715-0167)

## 8.1 DASH-1 VERSION

The Dash-1 Version is to be used when the Model :00 System includes a Model 400A Remote Display. The Interface Module will provide isolated status inputs to a DAS while causing minimum loading effect on the Model 400 status signal output circuits.

The window dirty and function inputs are parallel connected with the window dirty and function inputs to the Model 400A. The window dirty input (TB-IN 4) will be loaded by LED's in the Model 400A so that the status input to the interface module will be ≈ 1.4 VDC neg. when normal and ≈ 1.4 POS. when window is dirty. The gain of the interface buffer IC4 will insure that IC1 isolator has a sufficient level of voltage applied. A power fail is indicated when both IC1 and IC2 are in the high state (non-conducting). IC1 through IC3 must be connected remotely to a DC power source through pull-up resistors, this power source is normally +5 VDC.

The function input (TB-IN 2) is normally at a +12 VDC level which will override the negative bias applied to buffer stage IC4 pin 6. IC3 will therefore be in a conductive state during normal mode. When the Model 400 unit goes into a calibration mode, the function input level goes to zero volts. With zero volts input, the negative biased buffer stage IC4-6 will shift the IC4-10 output to a negative 15 volts. IC3 will then be in a non-conducting state, indicating a calibration mode status.

## 8.2 DASH-2 VERSION

The Dash-2 Version is to be used when the Model 400 System has no remote display panel and is to be interfaced to a Model 910 Data Acquisition System or the user's DAS. The interface module will provide isolated status inputs to the DAS. Included as a separate item is an isolating transmitter used to convert the non-linear 0-10V opacity signal to a non-linear 4-20 MA current signal, the output of which is connected to the DAS input.

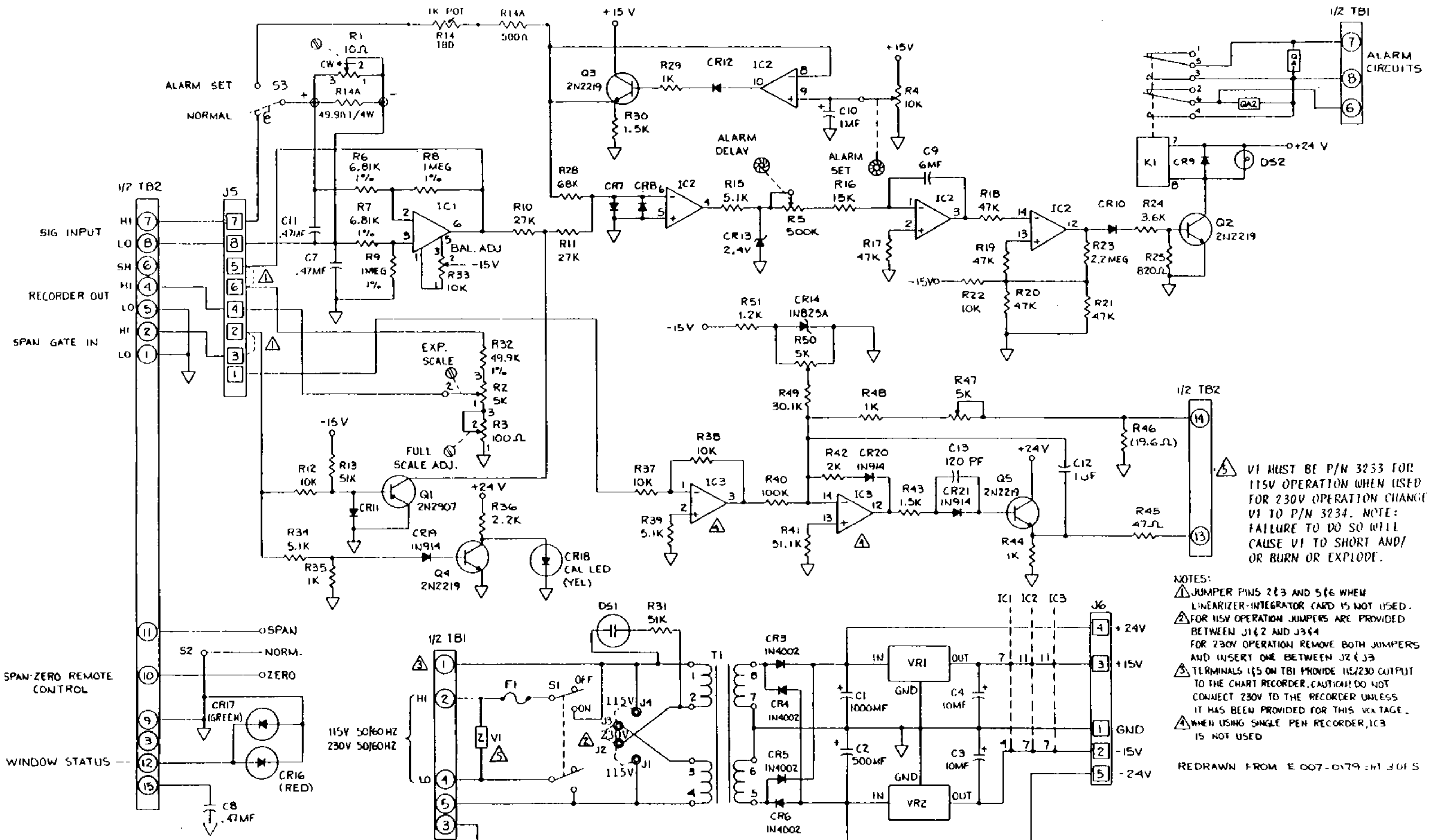
The buffer stages of IC4 and its associated resistive components and power supply are not required and therefore not provided with the DASH-2 Version.

IC1, IC2, and IC3 will provide the status outputs to the DAS when connected to a power source (normally +5VDC) through separate pull-up resistors.

The function and window dirty status lines from the Model 400 are to be directly connected to the input of the interface module. The window dirty input (TB-IN 4) will be at a -15VDC level in normal operation, +15VDC when the window is dirty, and zero volts if ever a power fail occurs at the Model 400 Unit. Therefore, if neither IC1 and IC2 are conducting (high voltage output state), there has occurred a power fail status.

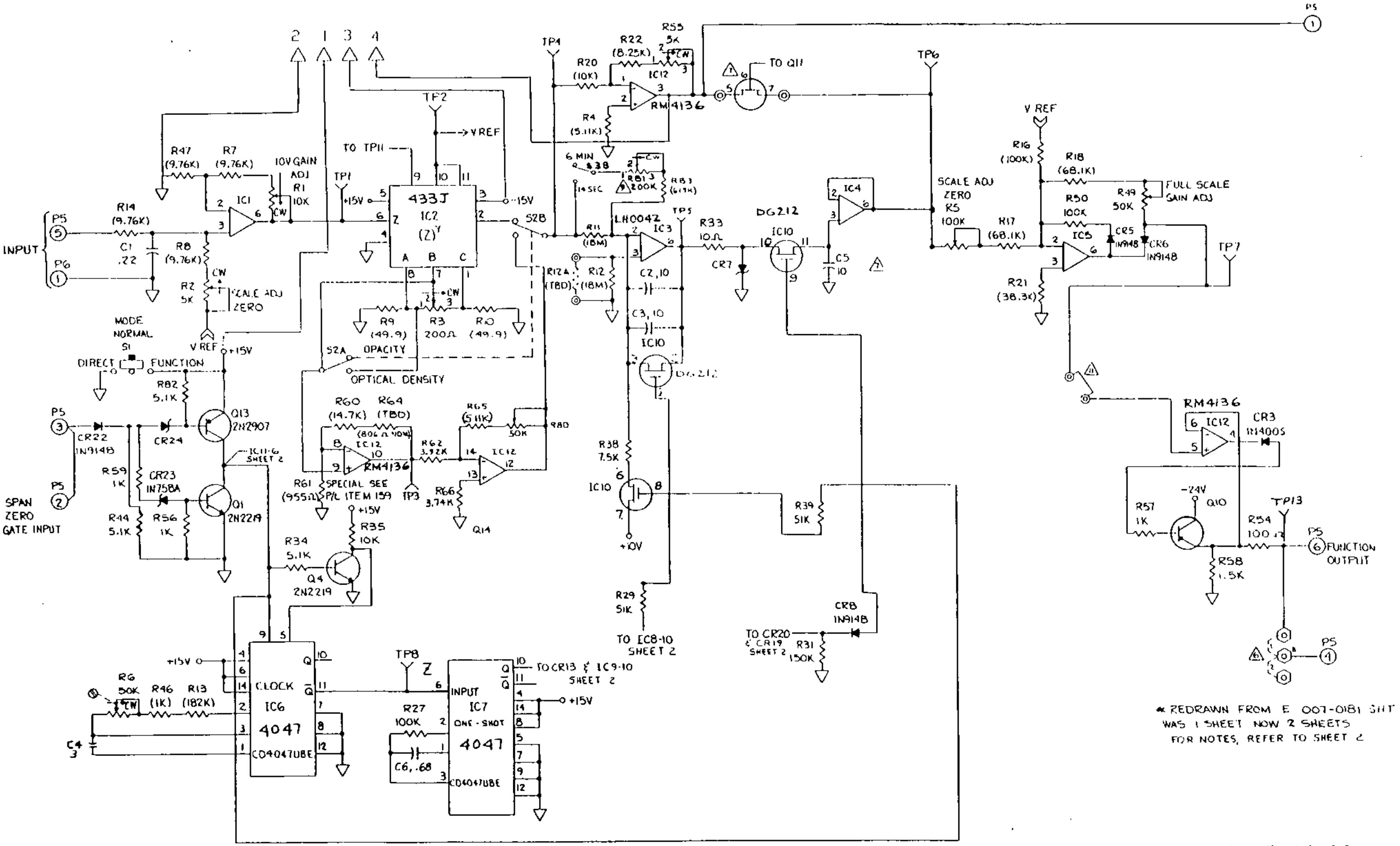
The function input (TB-IN 2) is normally at a +12VDC level which places IC3 in the conducting state. When the Model 400 Unit goes into a calibration mode, the function input level drops to zero volts. With zero volts input IC3 goes to a non-conducting state (high level output) indicating a calibration mode status.

The isolating transmitter supplied for the 4-20 MA conversion required 115VAC 5 watts line power. The unit provides input to output isolation of 600VDC or peak AC. Top accessed screwdriver adjustments provide +/- 15% typical zero and span adjustability for fine in-field calibration.




007-0179 Sht. 3 Rev. N

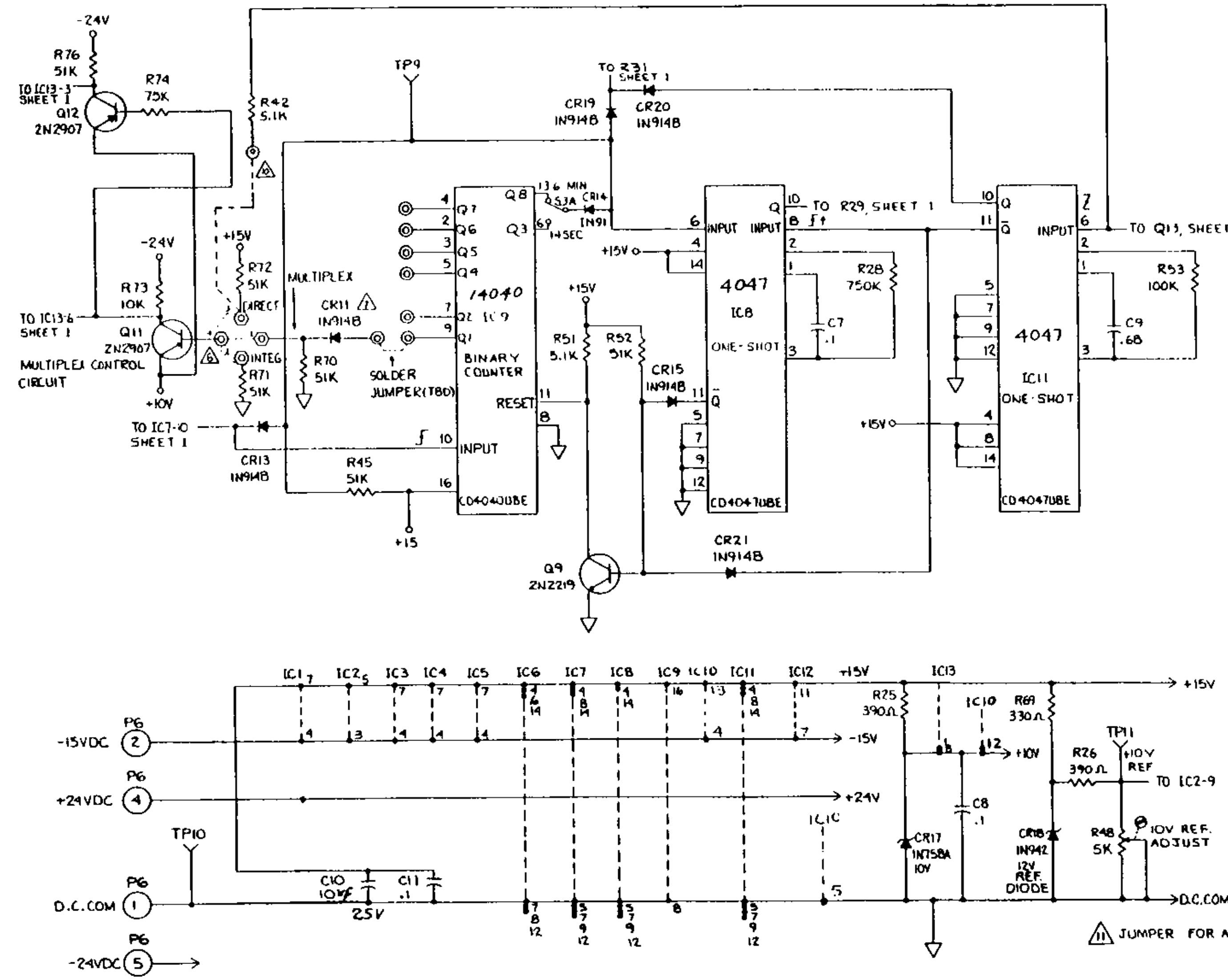
REMOTE CONTROL UNIT SCHEMATIC

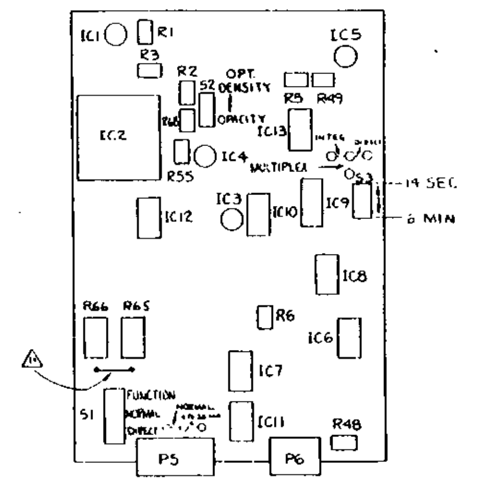



INTEGRATING LINEARIZER P.C BOARD

* REDRAWN FROM E 007-0181 SHT 1
WAS 1 SHEET NOW 2 SHEETS
FOR NOTES, REFER TO SHEET 2

007-0181 Sheet 1 of 2
Rev. U




NOTES:

1. ALL RESISTOR VALUES IN ( ) ARE 1%.
2. CAPACITOR VALUES ARE IN MFD UNLESS OTHERWISE NOTED.
3. ALL RESISTORS ARE 1/4 WATT UNLESS OTHERWISE NOTED.
4. ◎ SYMBOL INDICATES SOLDER PAD WITH A HOLE TO ACCOMODATE A #20 SOLID WIRE
5. ◎ SYMBOL INDICATES JUMPER JACKS PER: ITEM 171 ON PARTS LIST.

6. PHYSICAL LAYOUT OF JACKS TO BE AS SHOWN BY DOTTED LINES, SPACING MUST BE SUCH THAT JUMPER CANNOT BE INSERTED INTO THE WRONG JACKS.

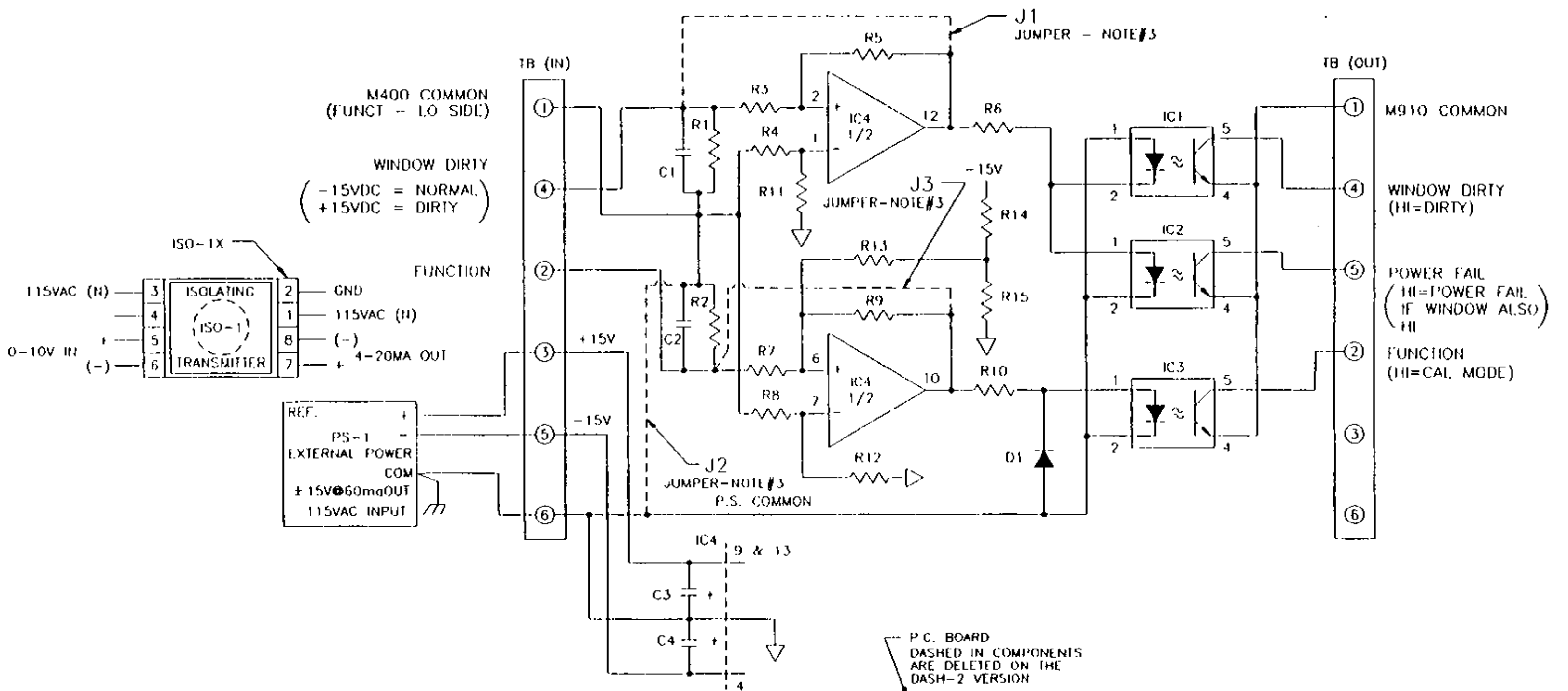
* REDRAWN FROM E 007-0181 SHEET 1 WAS 1 SHEET NOW 2 SHEETS

7. REMOVE FOR DASH-4 W/2-PEN ONLY
8. JUMPER FOR DASH-4 W/2-PEN ONLY
9. USED ON UNITS BUILT AFTER 6-1-78 ONLY
10. ADD JUMPER FOR SINGLE PEN 4-20MA (BASE PAD OF DELETED TRANSISTOR Q2)
11. JUMPER FOR ALL DASH-4

007-0181 Sheet 2 of 2
Rev. U

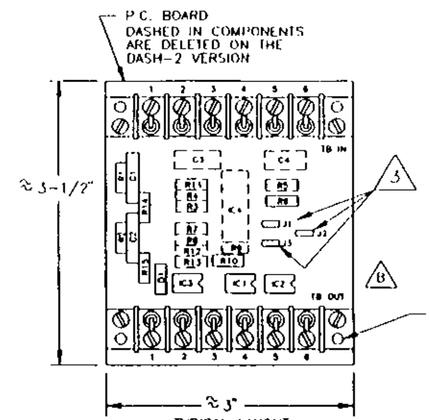
INTEGRATING LINEARIZER P.C. BOARD

Dash 3 & 4




| | | | | | |
|---|---|---|---|---|---|
| P.C.B. | 1 | P.C. BOARD 715-0167 | P.C.B. | 1 | 2463 |
| ISO 1X | --- | SOCKET, 8 PIN, EAGLE SIGNAL P/N 60SR2P06 | ISO 1X | 1 | 5229 |
| ISO 1 | --- | ISOLATOR, ACTION INST. P/N AP4300 | ISO 1 | 1 | |
| ~~PS-1~~ | ~~1~~ | ~~POWER SUPPLY #902-100MA~~ | ~~PS-1~~ | ~~1~~ | ~~4982~~ |
| TB | 2 | TERMINAL BLOCK, 6 CKTS | TB | 2 | 6895 |
| R15 | 1 | 10K, 5%, 1/4W | R15 | --- | 6008 |
| R14 | 1 | 68K, 5%, 1/4W | R14 | --- | 6051 |
| R5 | 1 | 2.2 MEG | R5 | --- | 6109 |
| C1,2 | 2 | .01μf, 500V | C1,2 | 2 | 8209 |
| P.C.BOARD | 1 | ICB-935 | P.C.BOARD | 1 | 5567 |
| D1 | 1 | 1N4002 | D1 | 1 | 4268 |
| C3,4 | 2 | 10μf, 50V | C3,4 | --- | 5617 |
| R6,10 | 2 | 330Ω, 5%, 1/4W | R6,10 | 2 | 2649 |
| R9,11,12 | 3 | 1M, 5%, 1/4W | R9,11,12 | --- | 6104 |
| R,3,4,7,8,13 | 5 | 100K, 5%, 1/4W | R,3,4,7,8,13 | --- | 6055 |
| R1,2 | 2 | 22K, 5%, 1/4W | R1,2 | 2 | 6016 |
| IC4 | 1 | MC1747 | IC4 | --- | 4656 |
| IC1,2,3 | 3 | 4N26 | IC1,2,3 | 3 | 2523 |
| REF. | QTY. | DESCRIPTION | REF. | QTY. | STOCK No |
| DASH-1 | | BILL OF MATERIALS | DASH-2 | | TECO |

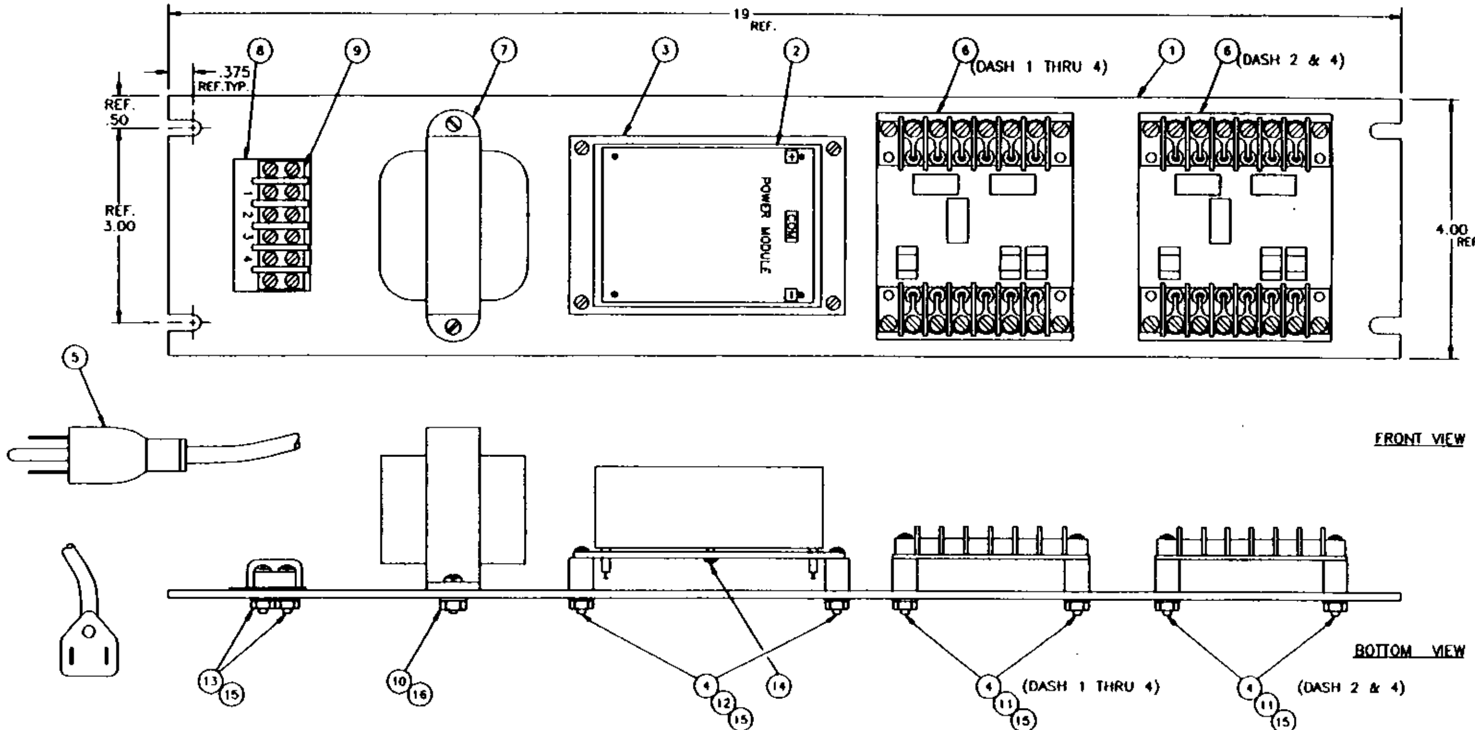
B




TYPICAL LAYOUT

NOTES:
1. DASH-1 VERSION IS FOR M400A INTERFACE TO M910 /DAS P/N 9045
2. DASH-2 VERSION IS FOR M400 INTERFACE TO M910. /DAS
3. JUMPERS FOR DASH-2 VERSION ONLY DELETE ON DASH-1 VERSION

M400/M400A TO M910DACS
INTERFACE P.C BOARD
C715-0167 (SHT#6of6) REV.C



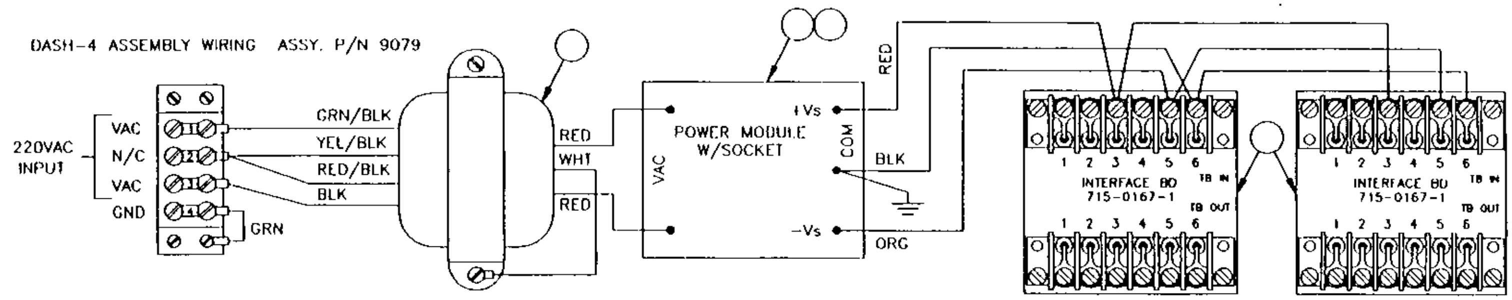

| ITEM | DESCRIPTION | PART NO. | QTY. | | | |
|---|---|---|---|---|---|---|
| | | | DASH-1 | DASH-2 | DASH-3 | DASH-4 |
| 1 | PANEL (C715-1031) | 3103 | 1 | 1 | 1 | 1 |
| 2 | POWER SUPPLY +/-15V SUPPLY | 4981 | 1 | 1 | 1 | 1 |
| 3 | SOCKET +/-15V SUPPLY | 4897 | 1 | 1 | 1 | 1 |
| 4 | STANDOFF | 9516 | 8 | 12 | 8 | 12 |
| 5 | POWER CORD | 6675 | 1 | 1 | | |
| 6 | INTERFACE BOARD (715-0167-1) | 9045 | 1 | 2 | 1 | 2 |
| 7 | STEPDOWN TRANSFORMER N68X | 5409 | | | 1 | 1 |
| 8 | MARKER STRIP | 5281 | 2 | 2 | 2 | 2 |
| 9 | TERMINAL STRIP | 5275 | 1 | 1 | 1 | 1 |
| 10 | SCREW #8-32 X 3/8 LG. PAN HD | 5858 | | | 2 | 2 |
| 11 | SCREW #6-32 X 1 1/2 LG. BIND HD | 5838 | 4 | 8 | 4 | 8 |
| 12 | SCREW #6-32 X 1 1/4 LG.BD HD | 8442 | 4 | 4 | 4 | 4 |
| 13 | SCREW #6-32 X 3/4 LG. BIND HD | 5839 | 4 | 4 | 4 | 4 |
| 14 | SCREW #4-40 X 1/4 LG. BIND HD | 5814 | 2 | 2 | 2 | 2 |
| 15 | LOCK NUT #6-32 | 8460 | 16 | 12 | 16 | 12 |
| 16 | LOCK NUT #8-32 | 5690 | | | 2 | 2 |
| 17 | HEX NUT SMALL PATTERN #6-32 | 5801 | 4 | 4 | 4 | 4 |

| ASSY. | PART No. |
|---|---|
| DASH-1 | 9076 |
| DASH-2 | 9077 |
| DASH-3 | 9078 |
| DASH-4 | 9079 |

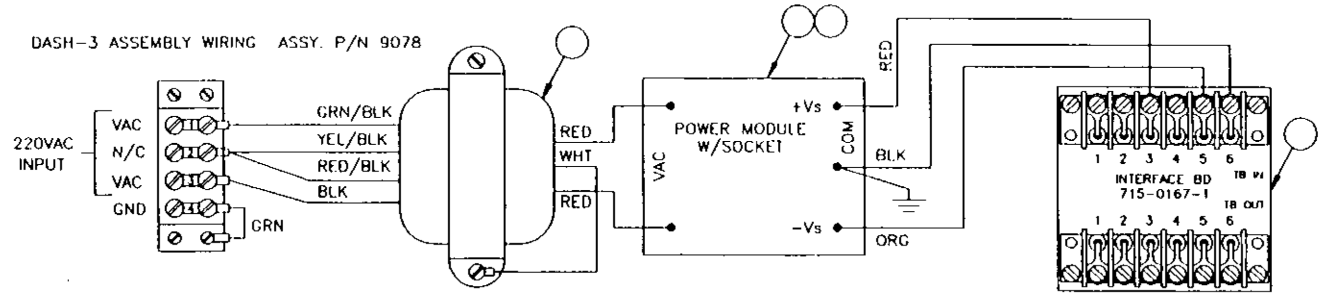
*INTERFACE PANEL ASSY MODEL 400A*

*715-0168 REV D  Sheet 1 of 2*

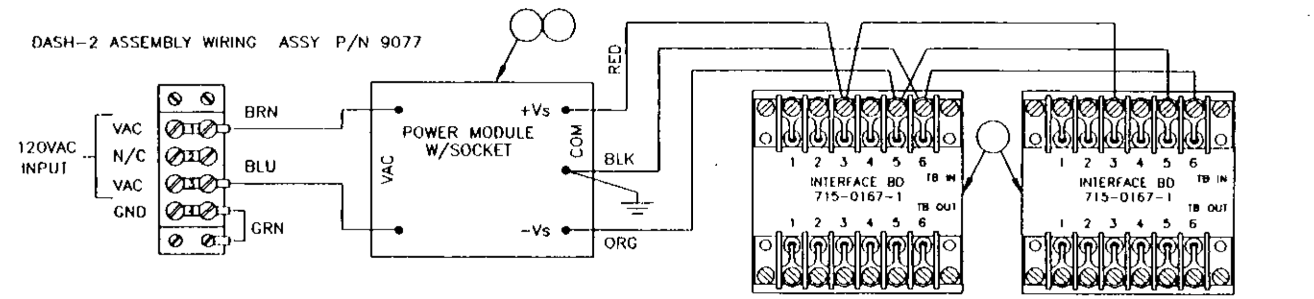
DASH-4 ASSEMBLY WIRING ASSY. P/N 9079



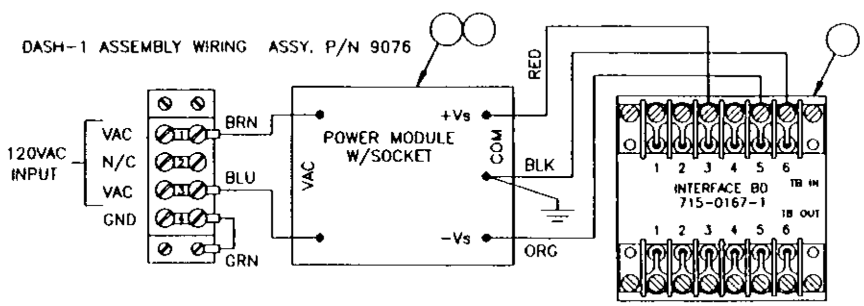

DASH-3 ASSEMBLY WIRING ASSY. P/N 9078




DASH-2 ASSEMBLY WIRING ASSY P/N 9077



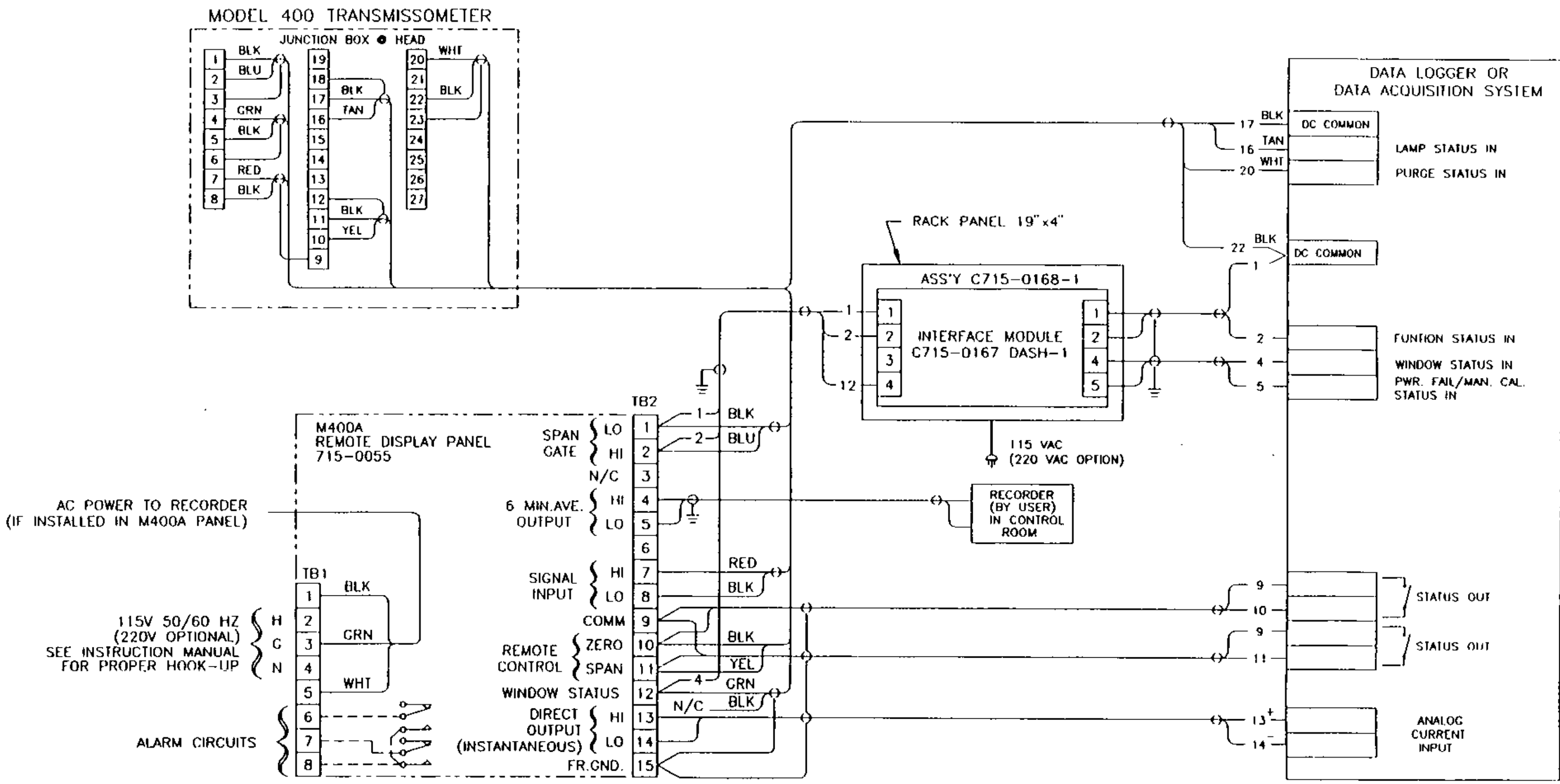

DASH-1 ASSEMBLY WIRING ASSY. P/N 9076




*WIRING DIAGRAM*

*INTERFACE PANEL ASSY MODEL 400A*

*715-0168 REV D Sheet 2 of 2*




INTERCONNECTION
M400/M400A TO DAS
(REFERENCE DRAWING)
C703-0076

# MODEL 400B

## TRANSMISSOMETER

## INSTRUCTION MANUAL

Thermo Environmental Instruments Inc.

# MODEL 400B
## TRANSMISSOMETER

INSTRUCTION MANUAL

PART NO. 7675

THERMO ENVIRONMENTAL INSTRUMENTS INC.
8 WEST FORGE PARKWAY
FRANKLIN, MASSACHUSETTS 02038
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FACSIMILE: (508) 520-1460

7/21/92

## TABLE OF CONTENTS

## TABLE OF CONTENTS

# TABLE OF CONTENTS
## FIGURES

## TABLE OF CONTENTS
## FIGURES

# TABLE OF CONTENTS
## FIGURES



## TABLES

## 1.0 INTRODUCTION

This manual describes the Transmissometer System and is to be used as a reference in its calibration, installation, and maintenance. Included in this section is a discussion of the basic Transmissometer principles of operation, together with a definition of the instrument units of measurement and its application in industry. Subsequent sections include a technical and functional description of the basic Transmissometer and the accessories which comprise the Transmissometer System. Calibration procedures, installation methods, and maintenance requirements are also included. Because many installations have special requirements, a factory representative should be consulted to ensure selection of the optimum system and its installation location.

## 1.1 SYSTEM OPERATION AND DESIGN FEATURES

The basic Transmissometer (U.S. Patent No. 3,885,162), consisting of the Optical Head and Retro Assemblies shown schematically in Figure 1, is essentially a photometer that measures the attenuation of a light beam which traverses an intervening medium twice. The Optical Head Assembly contains an incandescent quartz-halogen light source and a Beam Projection Optical System. The beam is internally chopped to provide a modulated carrier signal. This beam is projected through the medium to the Retroreflector unit, returned through the medium, and focussed by the optical system onto the main detector. The detector has an optical filter which restricts the spectral interval of the system to the visible portion and eliminates errors that can be encountered in the infrared region. This system also contains a unique external chopper which allows the detector system to alternately look across the stack at the Retroreflector Assembly, and then at this chopper for a zero opacity reference and a mid-span opacity value through a cycle that repeats itself 10 times per second. Using this technique the system continuously compensates for light fluctuations, temperature changes, aging and drift of electronics, fluctuations in line voltage, and soiling drift due to dirt accumulation on the Transmissometer window. This technique also makes the instrument insensitive to ambient light.

The Optical Head Assembly Control Panel, located on the back of the Optical Head under a removable access cover, has a meter which directly displays percent opacity. This output is also available for remote readout on a strip chart recorder in an optional Remote Control Unit. When the MODE switch on the control panel is set in the NORMAL position, the signal processing electronics compares the signal from the reference channel with that from the Retroreflector across the medium, and the result is displayed on the meter in measured opacity.

When the switch is in either the ZERO or SPAN position, a zero reference or mid-span signal is generated through the entire electro-optical system and is displayed on the meter. An automatic, solid-state timing circuit provides a zero and mid-span cycle sequentially for a 4 minute period, approximately once every two hours.

Connections are available for manual operation of the Normal, Zero, and Mid-Span output functions from the Remote Control Unit.

The Transmissometer Optical Head and Retroreflector Unit are contained in rugged, cast aluminum housings with a hard, weather-resistant finish. The system is compact, lightweight, and handled easily by one person. The Optical Head is equipped with lift-off hinges between the main case casting and the mounting flange section to allow the main optics and electronics to be removed for ease of installation, coarse alignment of the mounting flange, or maintenance of the system. An alignment window is built into the Optical Head to assist in fine alignment of the system. Alignment is accomplished by using a positively locked, external, threaded, alignment mechanism that is insensitive to vibration.

The Transmissometer is a precision instrument with a calibration error of less than +/- 3% full scale (+/- 2% from 0 to 30% opacity) and will operate unattended for prolonged periods of time. The instrument is typically capable of continuous operation for 60 to 90 days between maintenance periods; this assumes normal installation conditions and ambient factors consistent with the Specification summary, Section 2.1.1. Air Valve Unit Assemblies are included in all installations; optional Blower assemblies are required for certain installations which do not have a normally negative draft. (Purge Fail Assemblies are optional for the -5 and -6 units.)

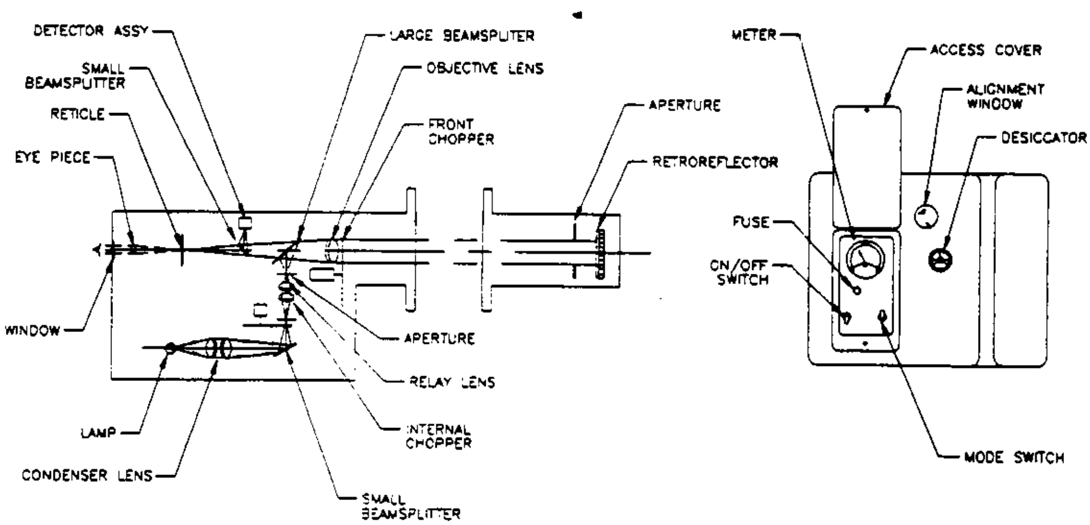



Figure 1
Basic Transmissometer Schematic

* -1 through -4 units only; -5 and -6 units don't have these functions.

## 1.2 INSTRUMENT UNITS OF MEASUREMENT AND APPLICATIONS

A beam of light, generated in the Optical Head is directed across the stack to the Retroreflector that returns the beam back on itself to the Optical Detector System. Because the beam traverses the stack twice, the Transmissometer is a double-pass instrument and the basic electrical output signal from the detector is proportional to $t^2$, the square of the single-pass stack transmittance. Subsequent electronics process and condition the signal with the output appearing as a 0 to 10 milliampere current proportional to $1 - t^2$. Because opacity is defined as $1 - t$, where t is a single-pass transmittance, the scale on the display meter is non-linear. Table 1 shows the relationship between single-pass transmittance t, optical density (O.D.), $t^2$, $1 - t^2$, and $1 - t$ (opacity). The graph in Figure 2 shows the relationship between the $1 - t^2$ signal and $1 - t$.

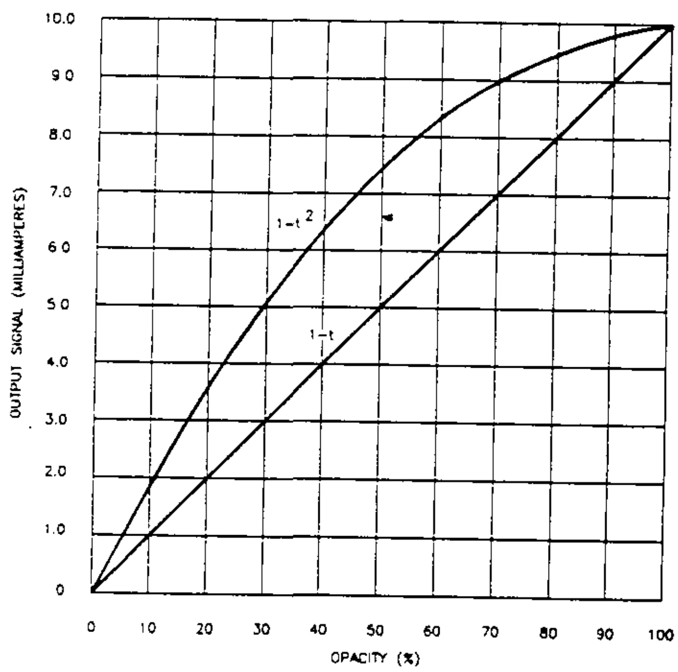



Figure 2

Output Signal vs. Opacity

| Single Pass Transmittance $t$ | Optical Density O.D. | Double Pass Transmittance $t^2$ | Signal Relationship $1 - t^2$ | Output Signal ma | Opacity $1 - t$ |
|---|---|---|---|---|---|
| 0.00 | ∞ | 0.0000 | 1.0000 | 10.000 | 1.00 |
| 0.01 | 2.000 | 0.0001 | 0.9999 | 9.999 | 0.99 |
| 0.05 | 1.3010 | 0.0025 | 0.9975 | 9.975 | 0.95 |
| 0.10 | 1.0000 | 0.0100 | 0.9900 | 9.900 | 0.90 |
| 0.15 | 0.8239 | 0.0225 | 0.9775 | 9.775 | 0.85 |
| 0.20 | 0.6990 | 0.0400 | 0.9600 | 9.600 | 0.80 |
| 0.25 | 0.6021 | 0.0625 | 0.9375 | 9.375 | 0.75 |
| 0.30 | 0.5229 | 0.0900 | 0.9100 | 9.100 | 0.70 |
| 0.35 | 0.4559 | 0.1225 | 0.8775 | 8.775 | 0.65 |
| 0.40 | 0.3979 | 0.1600 | 0.8400 | 8.400 | 0.60 |
| 0.45 | 0.3468 | 0.2025 | 0.7975 | 7.975 | 0.55 |
| 0.50 | 0.3010 | 0.2500 | 0.7500 | 7.500 | 0.50 |
| 0.55 | 0.2596 | 0.3025 | 0.6975 | 6.975 | 0.45 |
| 0.60 | 0.2218 | 0.3600 | 0.6400 | 6.400 | 0.40 |
| 0.65 | 0.1871 | 0.4225 | 0.5775 | 5.775 | 0.35 |
| 0.70 | 0.1549 | 0.4900 | 0.5100 | 5.100 | 0.30 |
| 0.75 | 0.1249 | 0.5625 | 0.4375 | 4.375 | 0.25 |
| 0.80 | 0.0969 | 0.6400 | 0.3600 | 3.600 | 0.20 |
| 0.85 | 0.0706 | 0.7225 | 0.2775 | 2.775 | 0.15 |
| 0.90 | 0.0458 | 0.8100 | 0.1900 | 1.900 | 0.10 |
| 0.95 | 0.0223 | 0.9025 | 0.0975 | 0.975 | 0.05 |
| 1.00 | 0.0000 | 1.0000 | 0.0000 | 0.000 | 0.00 |

Table 1

Transmittance, Optical Density, Signal, and Opacity Relationships

If the stack diameter at the location of the Transmissometer is different from that at the stack exit, the data accumulated must be corrected. Theoretically, the particulate concentration in terms of mass per unit of volume is constant even though stack geometry and flow velocities vary, therefore, the correction can be determined by applying either of two equations, which are easily developed using the single-path transmittance at each location:

$$\log_{10} t_e = \frac{(l_e)}{(l_m)} \log_{10} t_m \qquad (1)$$

or:

$$t_e = t_m^{\frac{(l_e)}{(l_m)}} \qquad (2)$$

$t_e$ = the transmittance at the stack exit

$t_m$ = the transmittance at the Transmissometer measurement location

$l_e$ = stack internal diameter at the exit

$l_m$ = stack internal diameter at the Transmissometer measurement location

Equation (2) may also be rewritten in terms of opacities as below:

$$(1 - op_e) = (1 - op_m)^{le/lm}$$

or:

$$op_e = 1 - (1 - op_m)^{le/lm} \qquad (3)$$

where:

$op_e$ = the opacity at the stack exit

$op_m$ = the opacity at the Transmissometer measurement location

For conditions where the measurement path length, $l_m$ is greater than the exit path length, $l_e$, the measurement path opacity $op_m$, will be greater than the exit path opacity, $op_e$. The opposite is true when the exit path length is greater than the measurement path length. These relationships may be summarized as follows:

For $l_e < l_m$ or $l_e/l_m < 1$, then $op_e < op_m$

For $l_e > l_m$ or $l_e/l_m > 1$, then $op_e > op_m$

Given the ratio of the two internal diameters, $l_e/l_m$ (stack taper ratio), a corrected calibration curve can be generated (Table 2). A family of correction curves, based on the values for different stack taper ratios, is shown in Figure 3. Stack taper ratio correction and linearization are accomplished at the Remote Panel, which is covered in a separate manual.

If the optional Remote Control Unit and Linearizer are used with the Transmissometer, this correction can be made automatically. Additional information concerning the Remote Control Units is presented in their specific instruction manuals. (The beginning of Section 2 presents a list of Transmissometer accessories which includes the various control panels. For your specific application, consult the factory representative for the appropriate instruction manual.)

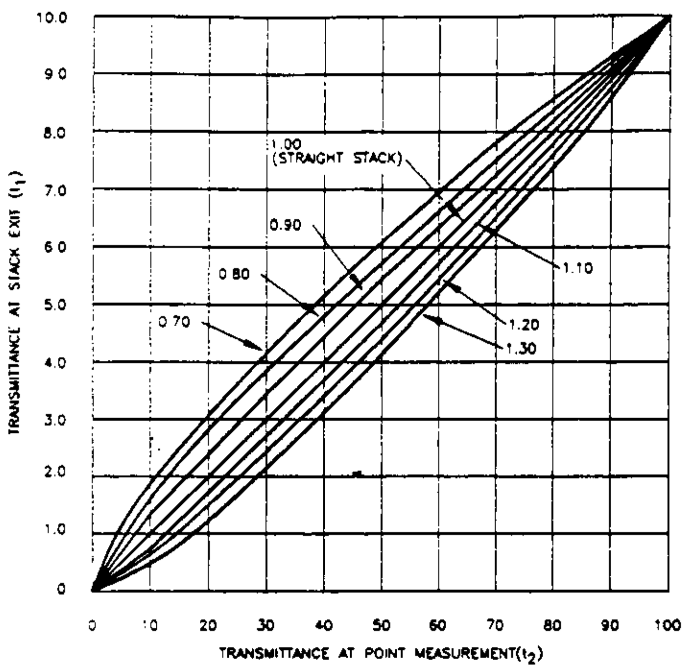



*Figure 3. Correction Curves For Different Stack Taper Ratios*

Federal and many state and local regulatory agencies specify both opacity and particulate emission limits for various sources, both new and old. The opacity limits are generally between 10% and 20% depending upon the type of source, while particulate emission rates, in terms of pounds or kilograms per hour, vary widely depending upon both the type of particulate and source. If opacity is the controlling parameter, the output of the transmissometer, corrected for any stack taper ratio, can be used directly to determine regulatory compliance.

| $op_m$ | $op_e$ | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **0.70** | **0.75** | **0.80** | **0.85** | **0.90** | **1.00** | **1.05** | **1.10** | **1.15** | **1.20** | **1.25** | **1.30** |
| **0.00** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **0.05** | 0.036 | 0.038 | 0.040 | 0.043 | 0.046 | 0.05 | 0.052 | 0.055 | 0.057 | 0.060 | 0.062 | 0.065 |
| **0.10** | 0.071 | 0.076 | 0.088 | 0.086 | 0.091 | 0.10 | 0.105 | 0.109 | 0.114 | 0.119 | 0.123 | 0.128 |
| **0.15** | 0.108 | 0.115 | 0.122 | 0.129 | 0.136 | 0.15 | 0.157 | 0.164 | 0.171 | 0.177 | 0.184 | 0.190 |
| **0.20** | 0.145 | 0.154 | 0.163 | 0.173 | 0.182 | 0.20 | 0.209 | 0.218 | 0.226 | 0.235 | 0.243 | 0.251 |
| **0.25** | 0.182 | 0.194 | 0.206 | 0.217 | 0.228 | 0.25 | 0.261 | 0.271 | 0.282 | 0.292 | 0.302 | 0.312 |
| **0.30** | 0.221 | 0.235 | 0.248 | 0.262 | 0.275 | 0.30 | 0.312 | 0.325 | 0.336 | 0.348 | 0.360 | 0.371 |
| **0.35** | 0.260 | 0.276 | 0.292 | 0.307 | 0.321 | 0.35 | 0.364 | 0.377 | 0.391 | 0.404 | 0.416 | 0.429 |
| **0.40** | 0.301 | 0.318 | 0.335 | 0.352 | 0.369 | 0.40 | 0.416 | 0.430 | 0.444 | 0.458 | 0.472 | 0.485 |
| **0.45** | 0.342 | 0.361 | 0.380 | 0.398 | 0.416 | 0.45 | 0.466 | 0.482 | 0.497 | 0.512 | 0.526 | 0.540 |
| **0.50** | 0.384 | 0.405 | 0.426 | 0.445 | 0.464 | 0.50 | 0.517 | 0.533 | 0.549 | 0.565 | 0.580 | 0.594 |
| **0.55** | 0.428 | 0.451 | 0.472 | 0.493 | 0.513 | 0.55 | 0.568 | 0.585 | 0.601 | 0.616 | 0.631 | 0.646 |
| **0.60** | 0.473 | 0.497 | 0.520 | 0.541 | 0.562 | 0.60 | 0.618 | 0.635 | 0.651 | 0.667 | 0.682 | 0.696 |
| **0.65** | 0.520 | 0.545 | 0.568 | 0.590 | 0.611 | 0.65 | 0.668 | 0.675 | 0.701 | 0.716 | 0.731 | 0.745 |
| **0.70** | 0.569 | 0.595 | 0.618 | 0.641 | 0.662 | 0.70 | 0.718 | 0.734 | 0.750 | 0.764 | 0.778 | 0.791 |
| **0.75** | 0.621 | 0.646 | 0.670 | 0.692 | 0.713 | 0.75 | 0.767 | 0.782 | 0.797 | 0.811 | 0.823 | 0.835 |
| **0.80** | 0.676 | 0.701 | 0.724 | 0.745 | 0.765 | 0.80 | 0.815 | 0.830 | 0.843 | 0.855 | 0.866 | 0.877 |
| **0.85** | 0.735 | 0.759 | 0.781 | 0.801 | 0.819 | 0.85 | 0.864 | 0.876 | 0.887 | 0.897 | 0.907 | 0.915 |
| **0.90** | 0.800 | 0.821 | 0.842 | 0.859 | 0.874 | 0.90 | 0.911 | 0.921 | 0.929 | 0.937 | 0.944 | 0.950 |
| **0.95** | 0.877 | 0.894 | 0.909 | 0.922 | 0.933 | 0.95 | 0.937 | 0.963 | 0.968 | 0.973 | 0.977 | 0.980 |
| **1.00** | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

* To express in percent opacity, move the decimal two places to the right

Table 2

Corrected Opacity Values* For Given Stack Taper Ratio $l_e/l_m$

For particulates, the relationship between various mass emission rates and optical density is a linearity that must be determined by some appropriate sampling method. If the mass emission rate is the controlling parameter, the remote monitor can also be set to provide the Transmissometer output directly in terms of optical density, where optical density is defined as:

$$\log_{10} \frac{1}{t}$$

The transmissometer is an effective and precise regulatory compliance device on stacks with particulate effluents. If water vapor is present in the effluent, it is transparent to the optical beam and of no effect provided the stack gas temperature is high enough to keep the water in vapor form. If condensed water droplets are present, however, these will be detected and will affect the reading. The transmissometer must, therefore, be used either at a position where the water is in vapor form, or where a suitable sample of the stack effluent has been reheated to vaporize the water.

## 2.0 TRANSMISSOMETER SYSTEM

The basic Transmissometer, accessories, and options shown in Figure 4 comprise a complete transmissometer system. They are available individually, however, to satisfy particular customer requirements and consist of the following items:

1. Optical Head Assembly, dwg. no. 400-0010
2. Standard Retro Assembly, dwg. no. 400-0011-1
3. Long Range Retro Assembly, dwg. no. 400-0011-2
4. Short Range Retro Assembly, dwg. no. 400-0011-3
5. Blower Assembly, dwg. no. 400-0013
6. Air Valve Unit, dwg. no. 400-0016
7. Calibration Test Kit, dwg. no. 400-0014
8. Maintenance Kit, dwg. no. 400-0015
9. M400A Control Unit, dwg. no. 715-0055
10. M500 Control Unit, dwg. no. 400-0051
11. M700 Control Unit, dwg. no. 400-0052
12. M701 Control Unit, dwg. no. 400-0053
13. Data Cable, dwg. no. 400-0012
14. Mounting Flanges, dwg. no. 400-1003
15. Retro Alignment Tool, dwg. no. 400-0017
16. Purge Fail Assembly, dwg. no. 400-0042

## 2.1 BASIC TRANSMISSOMETER

The basic Transmissometer includes the Optical Head Assembly, Item 1, and either the Standard Retro Assembly, Item 2, the Long Range Retro Assembly (Figure 5), Item 3, or the Short Range Retro Assembly, Item 4. For stack diameters up to 24 feet (7.3 meters), the Standard Retro Assembly with a plastic or Scotchlite retroreflector should be used. For distances beyond 24 feet, the Long Range Retro Assembly must be used. A series of optional accessories, Item 5 through 20, is also offered and, together with the basic Transmissometer, comprise the total system.

### 2.1.1 SPECIFICATIONS

The following specifications apply to the Optical Head and Retro Assemblies and include power requirements for the optional Blower Assemblies. These performance specifications meet or exceed those specified by the Environmental Protection Agency (EPA) as listed in the Federal Register concerning Transmissometer Systems for continuous measurement of stack effluent opacity.

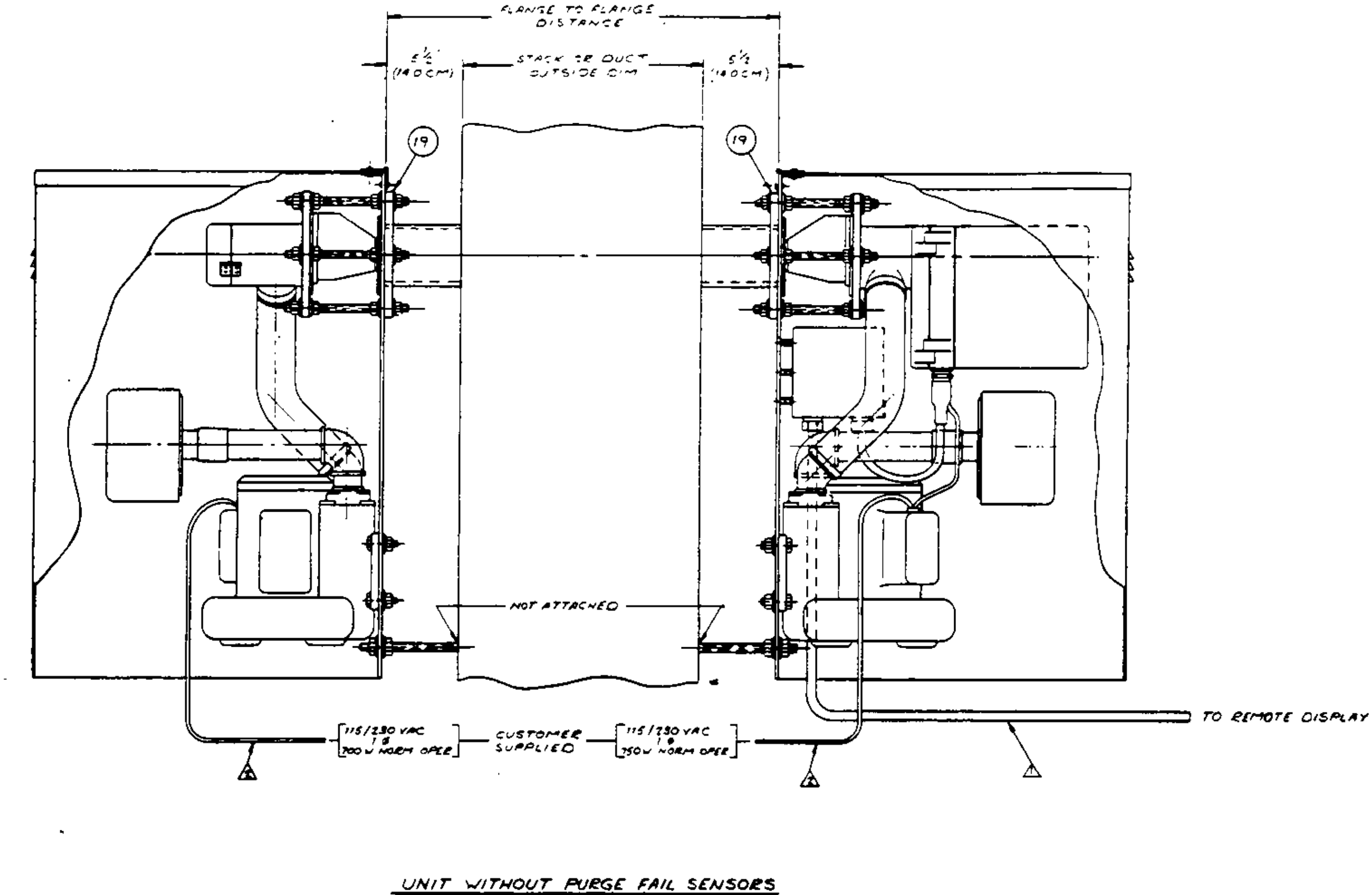



Figure 4

Transmissometer System

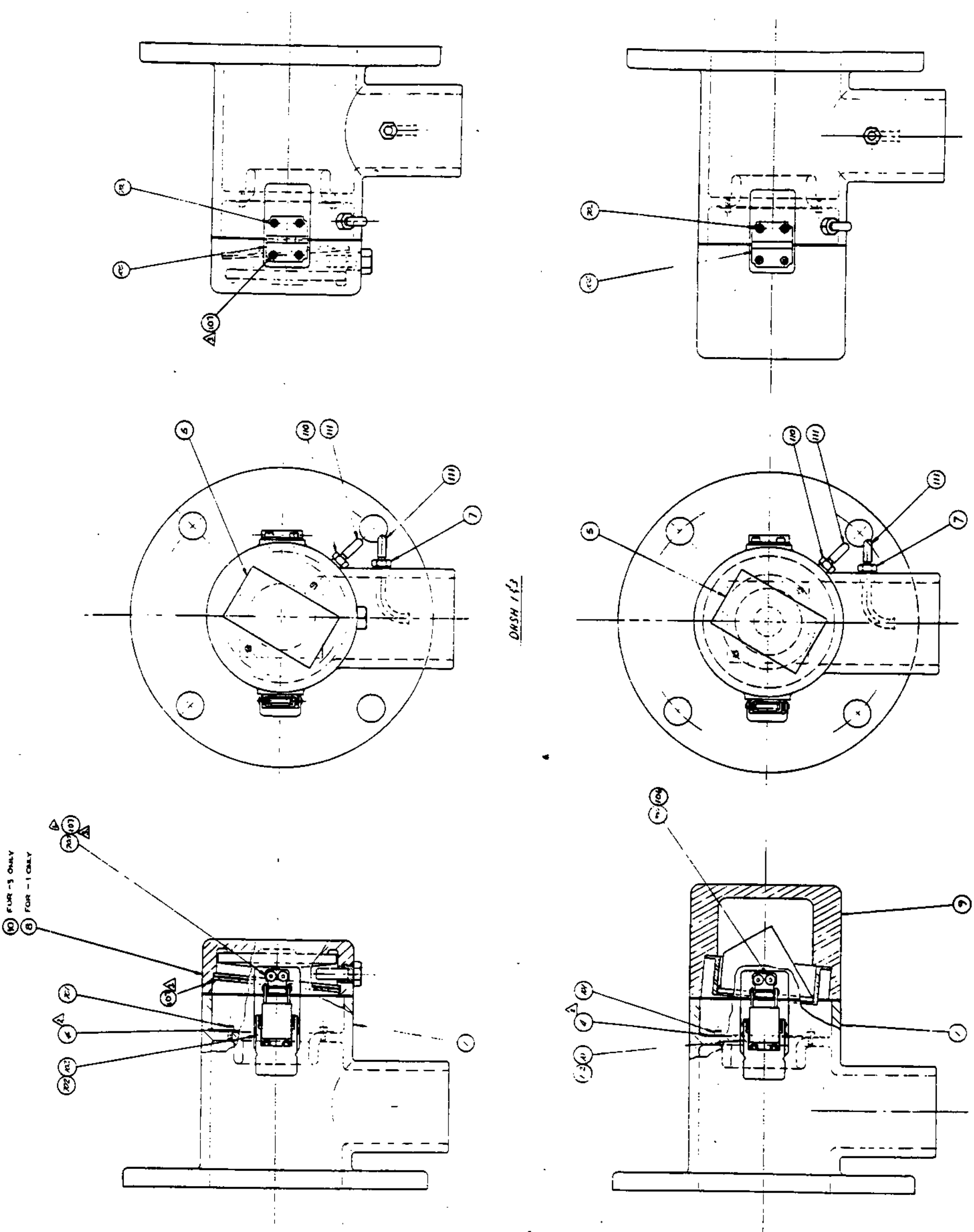



Figure 5

Retro Assembly

## DIMENSIONS

| | |
|---|---|
| Optical Head Assembly | 16" L x 9.5 W x 9.5" D |
| Retroreflector Assembly | 8.375" dia. x 8" L |

## WEIGHT

| | |
|---|---|
| Optical Head | 31 pounds |
| Retroreflector | 6 pounds |

## ELECTRICAL REQUIREMENTS

| | |
|---|---|
| Standard System | 115/230V, 50/60 Hz, 35W single phase |
| Optional Blower (ea.) | 115V (230V special order), single phase, 700W |
| Opacity Range | 0 to 100% |
| Calibration Error | ≤3% opacity |
| Zero Drift (24 Hours) | ≤1% opacity |
| Calibration Drift (24 Hours) | ≤1% opacity |
| Spectral Response | 500 - 600 nm peak ** |
| Angle of Projection | 5 degrees, maximum |
| Angle of View | 5 degrees, maximum |
| Optical System Aperture | 1.5" diameter |
| Allowable Alignment Drift | +/-0.5 degree |
| Allowable Line Voltage Variation | 105-130/210-260 VAC |

## RESPONSE TIMES

| | |
|---|---|
| Normal | 5 seconds (factory set) |
| Maximum | 10 seconds |
| Minimum | 1 second |
| Ambient Light Sensitivity | None |

## AUTOMATIC CALIBRATION CYCLES

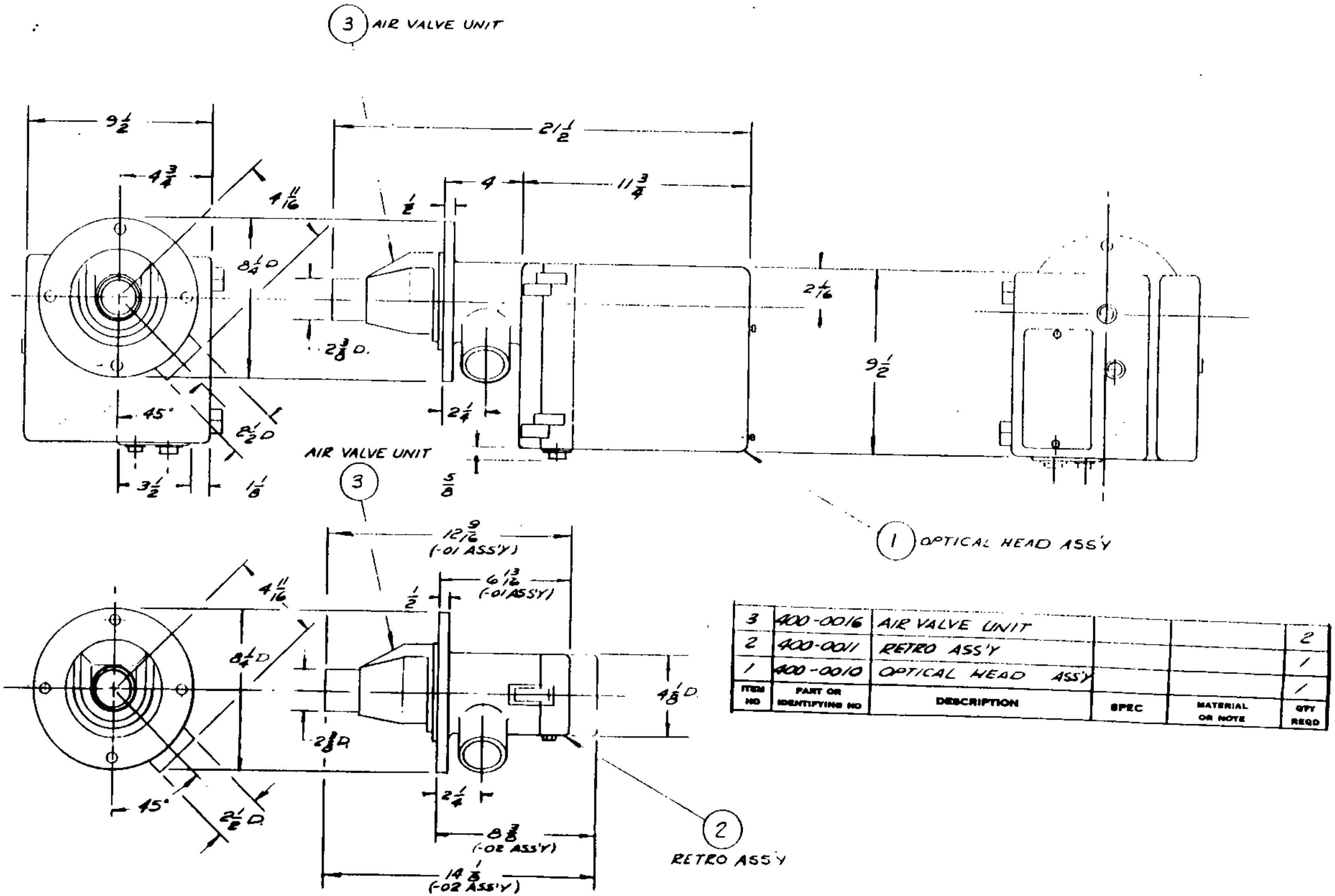
| | |
|---|---|
| Internal Calibration Data | ~ 0.1 second |
| External Output "Zero" and "Span" Value | ~ every 2 hours standard (other values by adjustment) |
| Ambient Temperature Range | -22 degrees to +125 degrees F |
| Operational Distance | 0 to 50 feet (flange to flange) |
| Output (as $1 - t^2$) | 0 to 10 mA at head or remote location or 4 to 20 mA from Remote Control Unit (t = transmittance) |
| Output Form | 0 to 100% opacity (other expanded ranges available from special Remote Control Unit) |
| Lamp Life Expectance | 30,000 + hours |
| Alignment | External, threaded with positive locking. Built-in optical alignment check included. |
| Loss of Transmission Detection | Window status detector is adjustable between 3 to 12% loss. Typically set at the Federal specified value of 4%. |

* Expressed as sum of absolute mean value and the 95% confidence interval of a series of tests. Double-Pass.

** Responses below 400 nm or above 700 nm shall be less than 10% of the peak response. The mean spectral response is 500 nm - 600 nm.

The physical dimensions of the Optical Head and Retro Assemblies are shown in Figure 6. Opening the captive door on the back of the Optical Head Assembly provides access to the controls on the meter panel which include an ON-OFF switch, percent opacity readout meter, and three-position MODE operation switch. (-1 through -4 units also have an ALARM SET switch and adjustment as part of the controls.) One quick release latch permits access to the front chopper and optical system window for cleaning as necessary. On the bottom of the unit are the input power and output data cable connectors. A 5 foot (1.5 meter) long power cord with mating connector for the Optical Head is standard equipment. This three-conductor cord is bare wire terminated for connection to customer supplied input power. A data cable with mating connector for the optical head is an optional accessory.

The Retro Assembly is a passive unit that requires no electrical connections except for the optional Blower System. A quick release latch located on the side of the unit permits easy access to the retroreflector protective window for cleaning, and for the initial installation or changing of aperture plates for different operating distances. The hexagonal threaded fitting on the bottom of the hinged reflector housing contains a replaceable desiccant cartridge for the Retroreflector cavity and is easily inspected through the protective window. The selection of the correct aperture plate and retroreflector (plastic, Scotchlite, or glass prism type) combination for any given stack flange to flange distance is discussed in Section 3.0, Basic Transmissometer Calibration and Checkout.




| ITEM NO | PART OR IDENTIFYING NO | DESCRIPTION | SPEC | MATERIAL OR NOTE | QTY REQD |
|---|---|---|---|---|---|
| 3 | 400-0016 | AIR VALVE UNIT | | | 2 |
| 2 | 400-0011 | RETRO ASS'Y | | | 1 |
| 1 | 400-0010 | OPTICAL HEAD ASS'Y | | | 1 |

Figure 6

Optical Head, Retro, and Air Valve Unit Assemblies

## 2.1.2 OPTICAL SYSTEM DESCRIPTION

The Optical Head Assembly contains the optics and the signal processing electronics, while the Retro Assembly contains only a passive Retroreflector. The two units are mounted on opposite sides of an exhaust stack to monitor the opacity of the stack effluent. These items and their interior components are shown schematically in Figure 7.

The Optical Head projects a uniformly illuminated beam of light with a two degree angular width. The retroreflector unit is placed in the center of this projected image and intercepts a uniformly illuminated portion of the beam by means of a fixed optical aperture. (The apertures are selected as a function of the operating distance.) Because of the properties of the retroreflector, this uniformly illuminated portion of the projected light beam is returned directly to the main electro optical unit regardless of the retroreflectors angular orientation. The intensity of the returned beam is compared with a reference signal derived from the main beam before it traverses the stack.

The reference signal comes from one of the reflective portions of the large chopper mounted in front of the projection objective.

The intensity of the beam returned to the optical head is sensed by a silicon detector, filtered to approximate a photopic response. The color filter selected for this purpose limits the system response to the visible portion of the spectrum. A field stop and field lens are incorporated into the Detector Assembly. The field stop limits the detector field of view by 2 degrees and the field lens ensures that all the signal light that enters the objective within the allowable field of view is uniformly placed on the detector.

The return light is divided between the detector and the visual alignment optics, which consist of a cross hair reticle and an eyepiece. The alignment optics are used to precisely align the Optical head Assembly within the Retro Assembly across the stack and also provide a means of visually checking alignment during normal maintenance.

## 2.1.3 SYSTEM BLOCK DIAGRAM

The block diagram in Figure 8 illustrates how the Transmissometer electro-optical system functions. An output signal of 0 to 10 milliamperes is generated as a function of the measured opacity. The system light source is a quartz-halogen lamp of approximately 20 watts. The light produced by this lamp is modulated at 1000 Hz. This light is reflected off a beamsplitter through the objective lens and the front chopper, then is projected across the stack to the Retroreflector. The beam is returned through the stack, passes through the front chopper, objective lens, and beamsplitter, and is then reflected off a small beamsplitter into the detector.

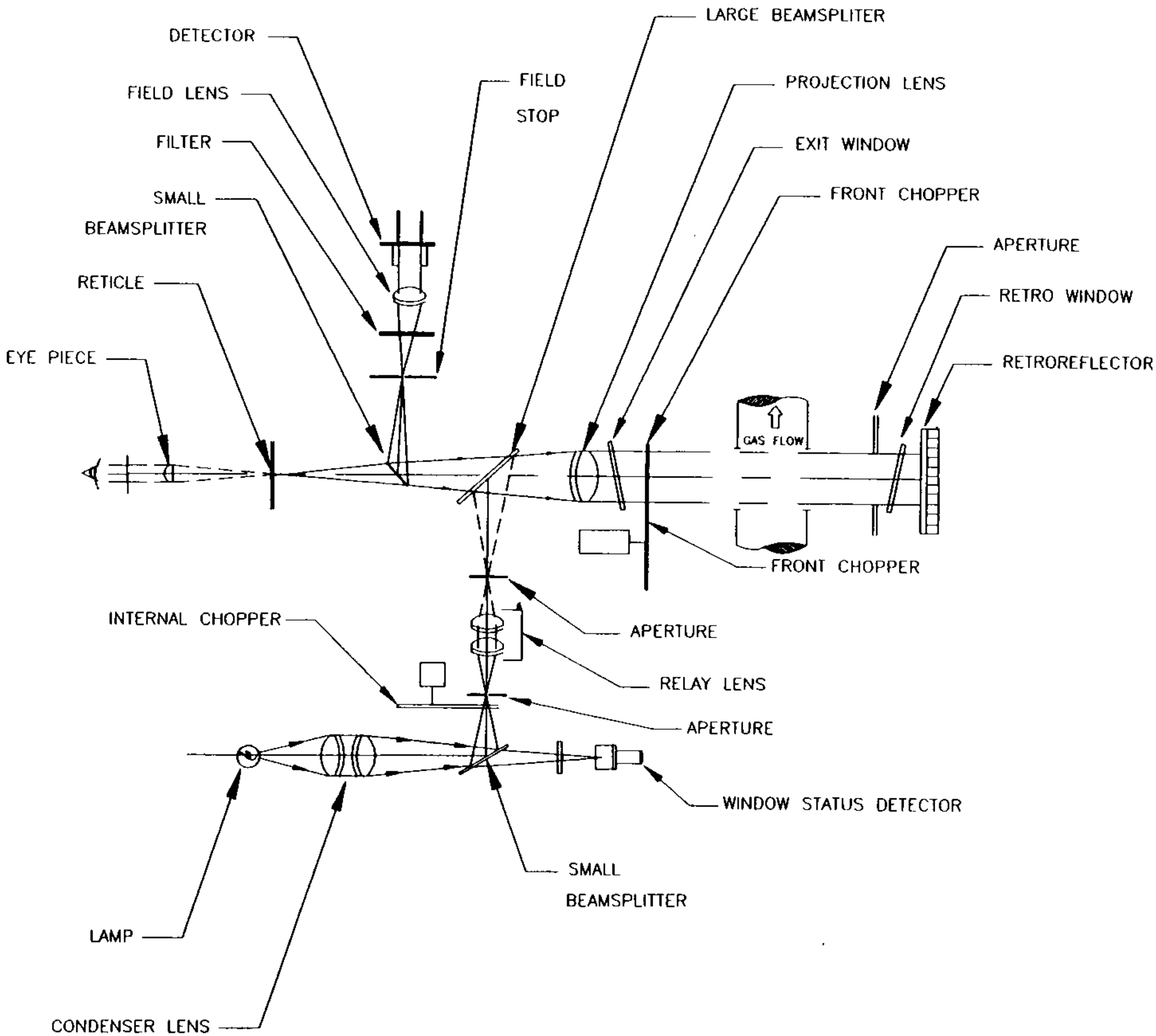



Figure 7
Optical System Schematic

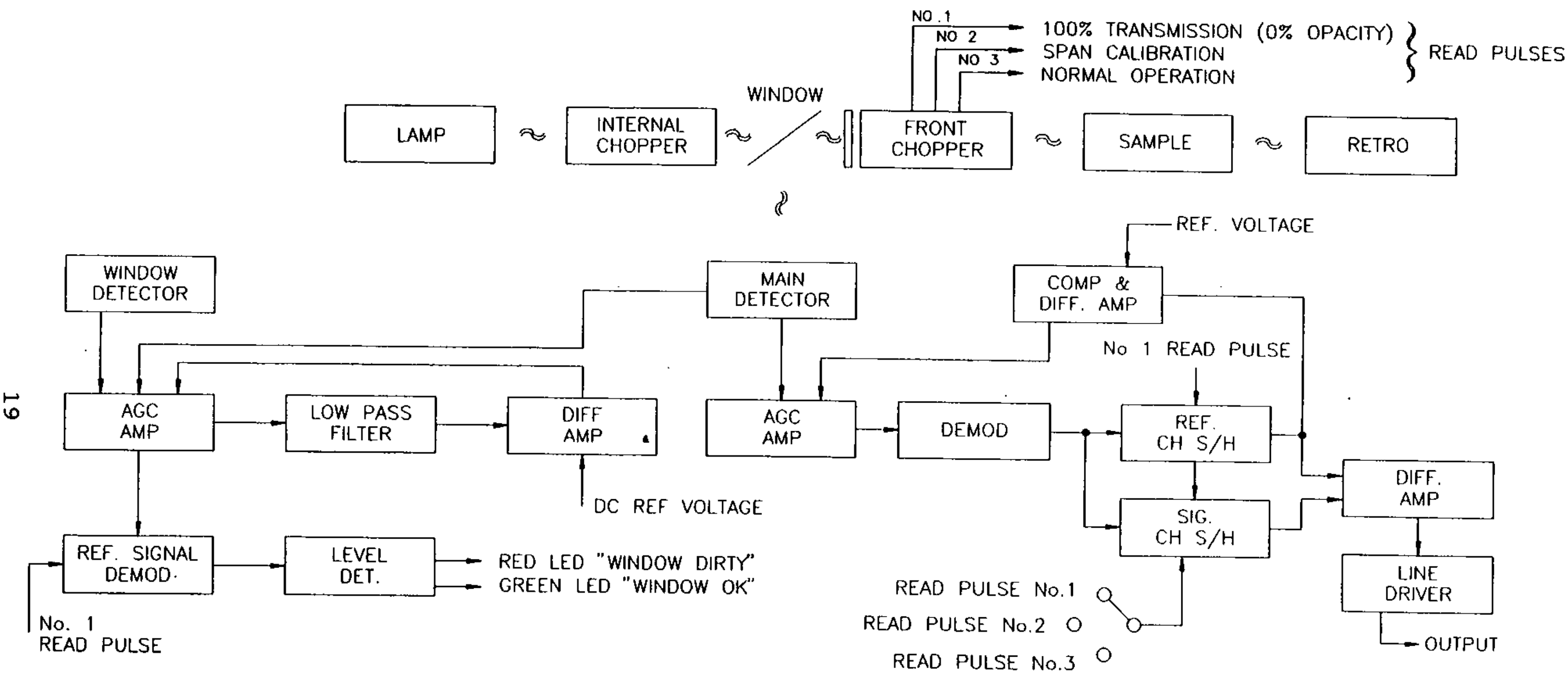



FIGURE 8
TRANSMISSOMETER ELECTRO-OPTICAL SYSTEM BLOCK DIAGRAM

The reflecting side of the front chopper is shown in Figure 9. As the front chopper rotates, a reference section, a mid-span section, and then an open section alternately appear before the exit window. The light from the source is reflected from the reference and mid-span sections back through the optical system into the detector which generates the reference and mid-span signals. The electronics, using a feedback system combined with a subtraction process, compares the ratio of the stack signal returning from the Retroreflector to the signal received from the reference portion of the front chopper.

The signal that passes through the automatic gain control (AGC) amplifier is demodulated and then divided into two separate sample-and-hold channels, one for the reference and one for the stack signal. The signal in the reference sample-and- hold channel represents the amount of energy reflected from the zero opacity reference section of the front chopper. This signal is compared with a reference voltage and is fed back to the AGC amplifier which maintains the output of the reference channel at a constant level. The gain that is set by the zero reference channel is maintained for all subsequent portions of the stack signal that pass through the ACG amplifier and demodulator. Because of this feedback process, the signals from the two sample-and-hold circuits can be fed to the differential amplifier. This output, through the driver, becomes the ratio of the stack signal to the reference signal.

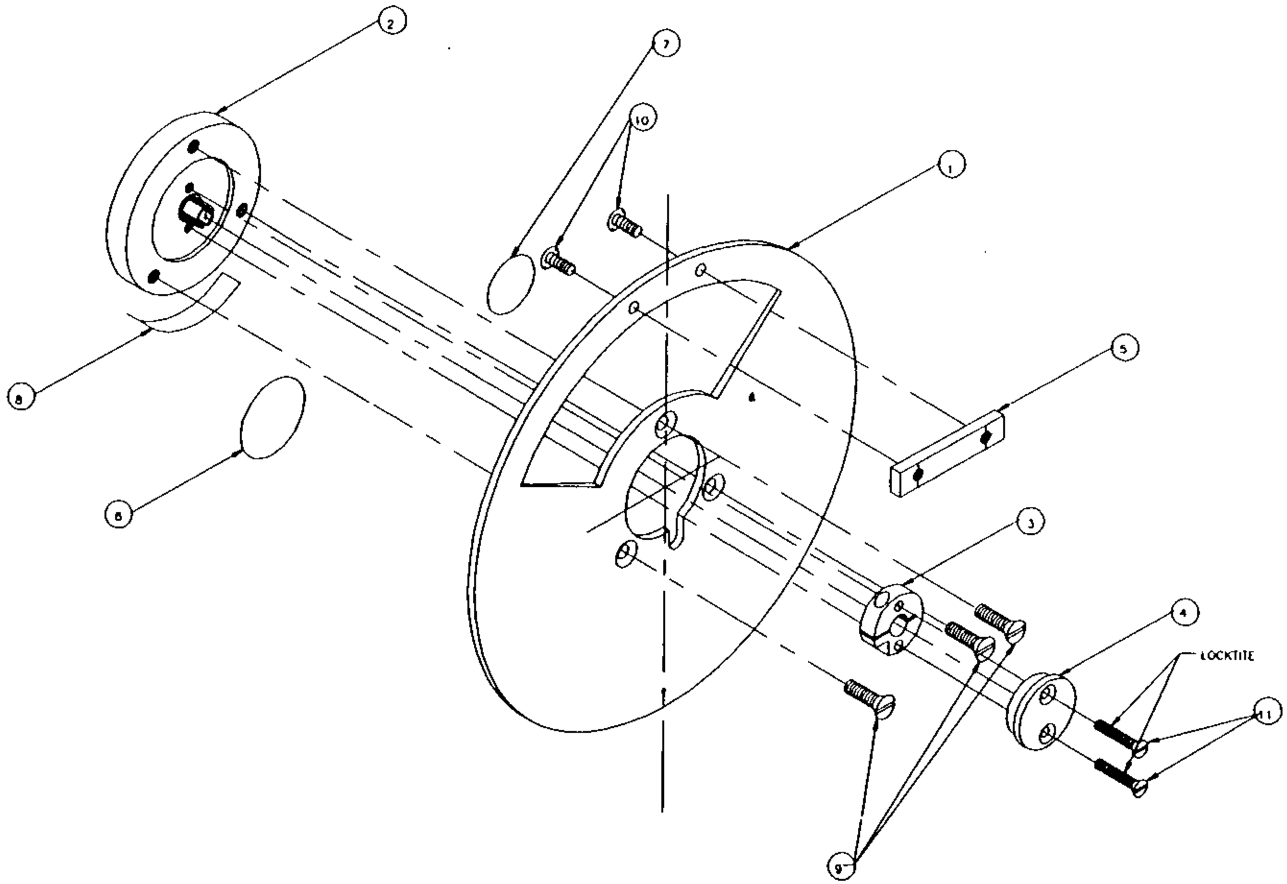
A measure of the amount of dirt accumulation on the Transmissometer window is achieved by comparing the light amplitude returned form the reference portion of the front chopper to a signal amplitude derived by observing the light source directly. The light source amplitude is sensed by the window reader detector. This detector is matched in characteristics with the main detector.

When the system is placed in the SPAN mode, either through its automatic timer or by manual operation, the system takes the ratio of the signal from the mid-span section of the front chopper to the signal from the reference section.

When the system is placed in the ZERO mode, both the reference channel sample-and-hold circuit and the signal channel sample-and-hold circuit sample simultaneously when the reference section of the front chopper is in front of the exit window. The electronics thus process two signals of the same level which results in a zero differential signal and represents 0% opacity on the output.

The output of the electronics for the SPAN, ZERO, and NORMAL modes is electronically connected to the Remote Control Unit through the Data Cable. The SPAN, ZERO, and NORMAL mode functions can also be activated from the Remote Control Unit.

| MATERIAL LIST | | | | |
|---|---|---|---|---|
| ITEM | PART NO | DESCRIPTION | | QTY. |
| 1 | 1070 | CHOPPER DISK | | 1 |
| 2 | 1071 | CHOPPER HUB | | 1 |
| 3 | 1074 | CLAMP | | 1 |
| 4 | 1075 | CHOPPER END STOP | | 1 |
| 5 | 1073 | BALANCE WEIGHT | | 1 |
| 6 | 1089 | REFERENCE TAPE | | 1 |
| 7 | 1090 | SPAN TAPE | | 1 |
| 8 | 1091 | TIMING TAPE | | 1 |
| 9 | 5848 | 10-32 X 1/2 FLAT HD S.S MACH SET | | 3 |
| 10 | 8419 | 8-32 X 5/16 FLAT HD S.S MACH. SET | | 2 |
| 11 | 8420 | 6-32 X 7/8 FLAT HD. S.S MACH. SET | | 2 |
| 12 | 5661 | LOCKTITE | | |
| | | | | |



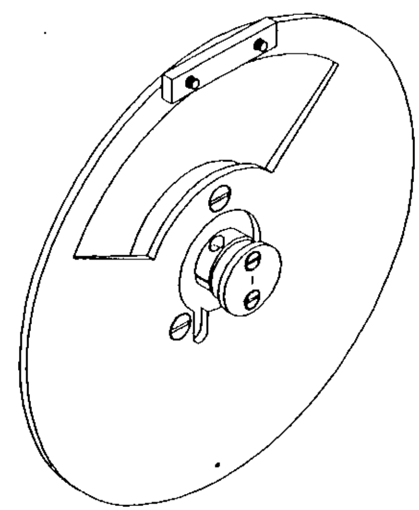



*Figure 9. Front Chopper Assembly Reflecting Side*

REF. DWG D400-0078

## 2.1.4 ELECTRICAL SYSTEM

The electrical system consists of the power supply board, the main electronics board, two motors, one quartz-halogen lamp, two silicon photodetectors, four connectors, and a Meter Panel Assembly. The electronic circuits perform the proper mathematical functions to develop an output current proportional to opacity. The system electrical schematic, including the power supply, is shown in Figures 10A and 10B.

B1, in Figures 10A and 10B is the high speed chopper motor which modulates the light at a carrier frequency of 1000 Hz. B2 is the low speed chopper motor which drives the three sectioned front chopper at approximately 600 rpm. The particular section that is in front of the light beam is determined through logic using phototransistors OT2 through OT4.

### 2.1.4.1 POWER SUPPLY BOARD

The Power Supply Board (Figure 11) uses prime power of 230/115 VAC, 50/60 Hz and establishes the following voltages at the listed pins of the board:

| | |
|---|---|
| Pin C | +24 VDC Unregulated |
| Pin E | +15 VDC Regulated |
| Pin F | -15 VDC Regulated |
| Pin H | -24 VDC (held to -24 VDC max.) |
| Pin D | +9.1 VDC Regulated |
| Pins J, K, L, M | DC Common |
| Pin A | 5 VAC |
| Pin B | 5 VAC Return |

The prime power is connected to Pins Z and U from the meter panel POWER ON-OFF switch and fuse. For 115 VAC operation, the jumper plugs on the power supply board are connected between jacks J1 and J2 and between jacks J3 and J4. For 230 VAC operation, only one jumper plug is used which connects jacks J2 and J3. This system of jumpers ensures 115 VAC on Pins S to V and Pins R to Y if the prime power is either 230 VAC or 115 VAC. The 115 VAC on these pins is used to drive the two chopper motors, B1 and B2.

Transformer T2 provides the 5 VAC that appears on Pins A and B of the connector and is used to power the quartz-halogen lamp, L1.

Diodes CR1 through CR4 form the full wave rectifiers for the positive supply voltages. Capacitor C1 is a coarse filter which reduces the ripple on the full wave voltage. The voltage at Pin C is therefore unregulated +24 VDC coming directly from the filter capacitor, C1.

CR5 is a constant current diode which supplies the base current for Q1. If the output voltage attempts to exceed the zener voltage of CR7, base current is allowed to flow through Q3 which turns Q3 "on", shunting away the base current from Q1. Thus, the output of the emitter of Q1 is a controlled voltage determined by the zener voltage of CR7 and the adjustable divider of R9 and R3. R7 controls the operating point of CR7 and ensures that it is in the proper conduction area. C3 is the output filter capacitor. The negative regulator works in a similar manner; however, both Q2 and Q4 transistors are of the PNP type to accommodate the negative voltages. Resistors R1 and R2 limit the current in the output and protect the series pass transistors Q1 and Q2, should there be an inadvertent short circuit of the output.

R9 prevents the voltage at Pin H from exceeding -24 volts. CR10 forms the positive voltage necessary for the field effect transistor operation.

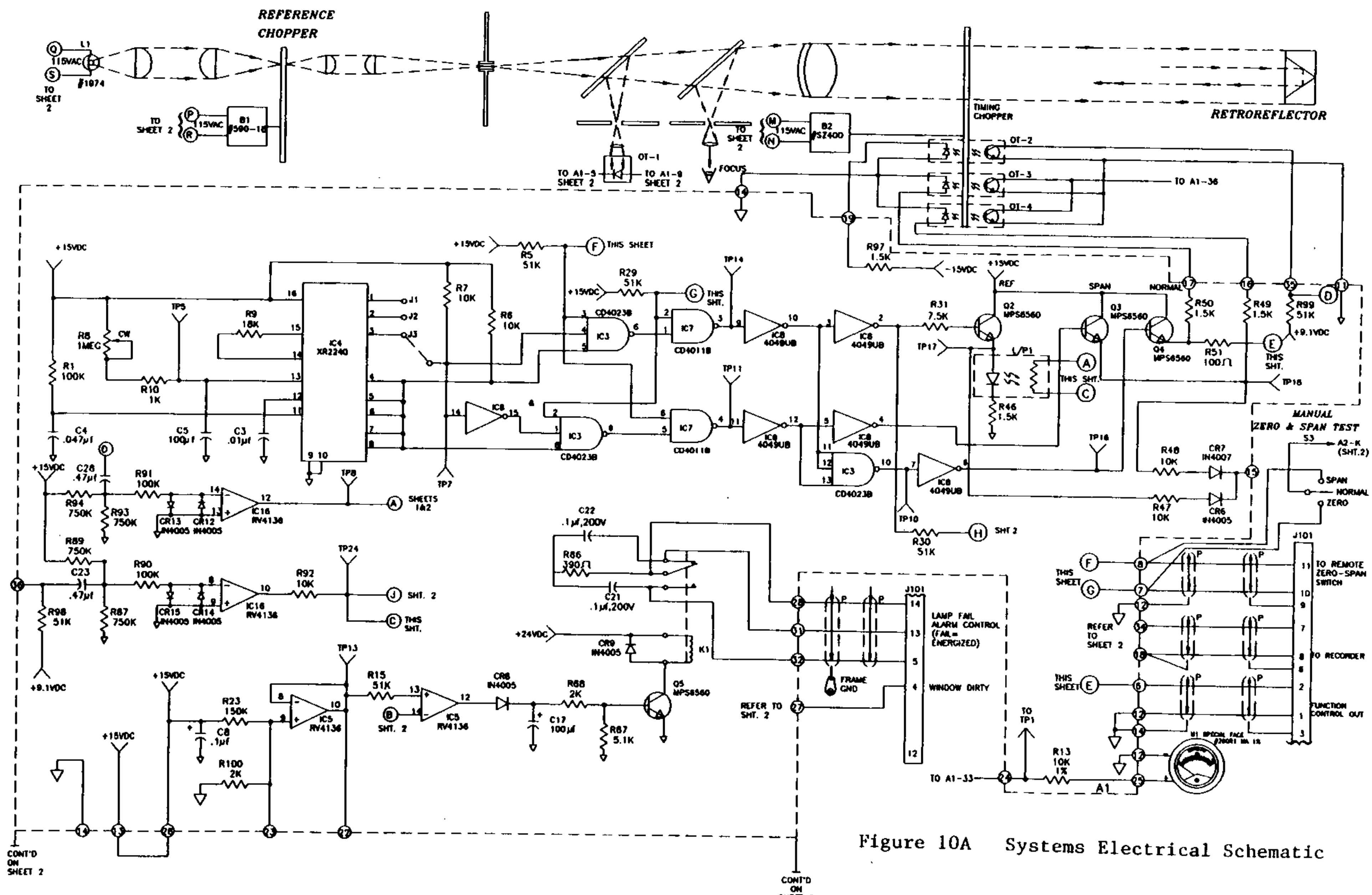



Figure 10A Systems Electrical Schematic

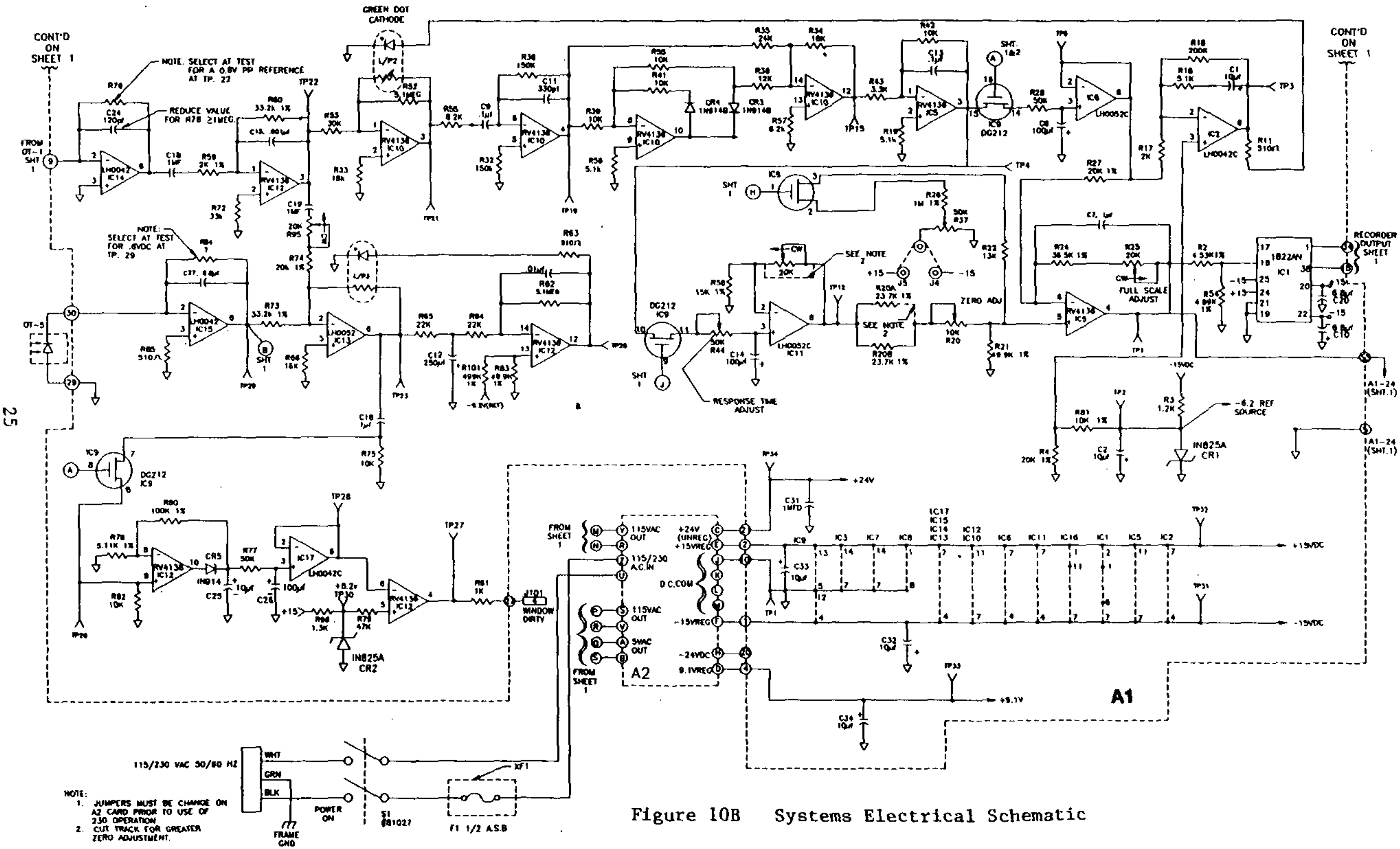
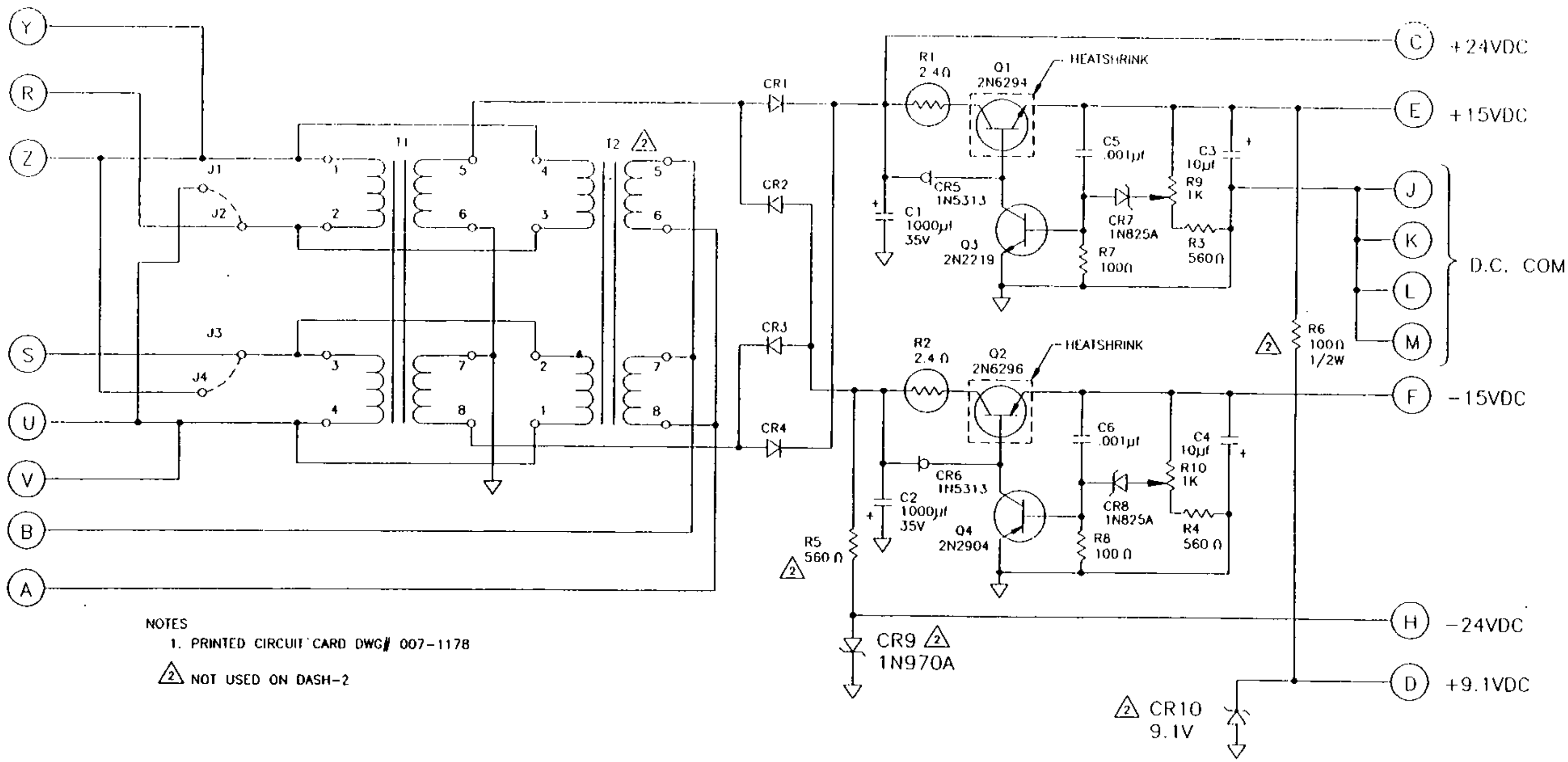



Figure 10B Systems Electrical Schematic




NOTES
1. PRINTED CIRCUIT CARD DWG# 007-1178

△2 NOT USED ON DASH-2

Figure 11
POWER SUPPLY BOARD

## 2.1.4.2 MAIN ELECTRONICS BOARD

The Main Electronics Board is shown in Figures 10A, 10B, 12A, and 12B. The main signal path for the system begins with OT1, a silicon photodiode. The current produced in this diode is a function of the light received by the optical system. This current enters the board at Pin 9, is amplified in IC14, and then further amplified through the next two stages. Under normal operation, TP19 will show a 1000 Hz amplitude modulated waveform. The next four stages modify this waveform to produce a full wave rectified, signal that appears on TP15. The signal on TP4 is an inverted and filtered version of the signal that is seen on TP15.

At TP4 the signal is divided into a reference and a signal path. The reference path is through a field effect transistor portion of IC9, Pins 14, 15, and 16. The signal path goes through another field effect transistor portion of IC9, Pins 1, 2, and 3. The intensity of the reference section of the front chopper is measure at TP6. The reference signal is then compared with a reference voltage created by CR1 and voltage divider R4, R81. IC2 then amplifies the difference between the reference signal and the reference voltage and feeds this difference to L/P2 which modifies the gain of the second stage to maintain the signal on TP6 at a constant level. The signal field effect transistor portion of IC9 is turned on when the open section of the low speed chopper is in front of the exit window.

This signal, as seen at TP12, represents the energy level returning from the Retroreflector.

The control signals for the reference field effect transistor and the signal field effect transistor can be seen on TP8 and TP24, respectively. These signals are an amplified and level-shifted version of the signal present on OT2 through OT4. In normal operation, OT3 is used and OT4 is not. When the system is placed in the SPAN mode, OT4 is on and OT3 is off. The reference signal on TP6 is compared to the signal present on TP12 in the differential amplifier made up of 1/4 of IC5. The output of this amplifier is converted to an isolated current in voltage to current converter IC1. This current leaves the printed circuit board on Pins 34 and 38. It also leaves the system on Pins 7 and 8 of J101, through the Data Cable to the Remote Control Unit. (The output of the differential amplifier also leaves the board at Pin 33 and returns to the board on Pin 24). Here it passes through R13 and out to the opacity meter located on the front panel.

The Signal Processor Board also contains all the electronics required for automatic calibrate cycle (ZERO and SPAN operations). They are located in the upper left-hand corner of the printed circuit board section of the schematic in Figures 10A and 10B.

IC4 is a large scale integrated circuit which contains a multivibrator and a counter. The counter is decoded through IC7 and IC3 to turn on transistors Q2, Q3, and Q4 one at a time for the proper period. With a normal setting of resistor R8, the system will first turn on Q3 for two minutes, and then turn Q4 back on for normal operation. The system will go through this calibrate cycle approximately every two hours. These three transistors control the field effect transistor, Pins 9, 10, and 11 of IC9, and determine which signal is to be sampled: stack, mid-span, or reference.

The window status circuitry is shown in the lower left hand corner of Figures 10A and 10B. It is designed to give a status signal to the Remote Control Unit when the Transmissometer exit window requires cleaning. The chopper surfaces must be cleaned at the same time.

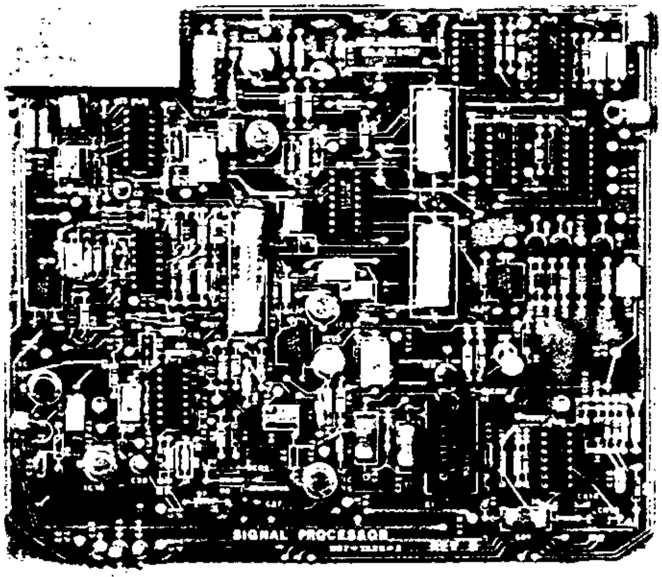


Figure 12A

Main Electronics Board (-1)

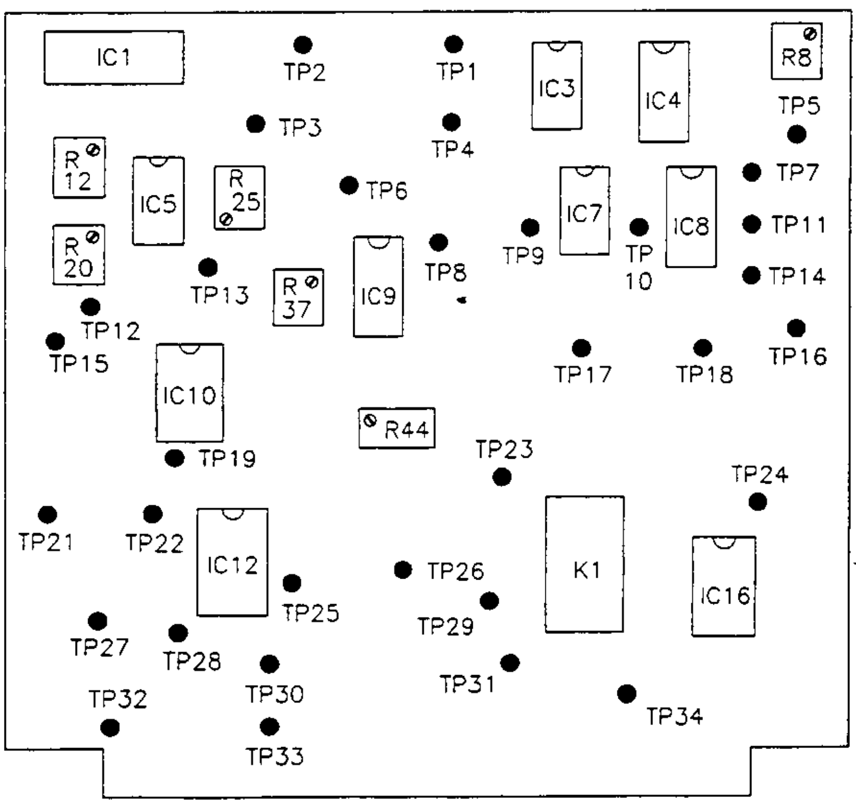



Figure 12B

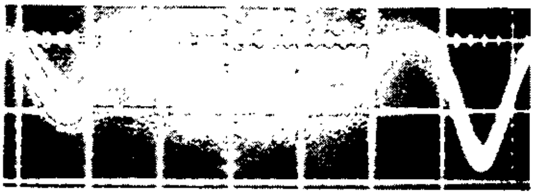
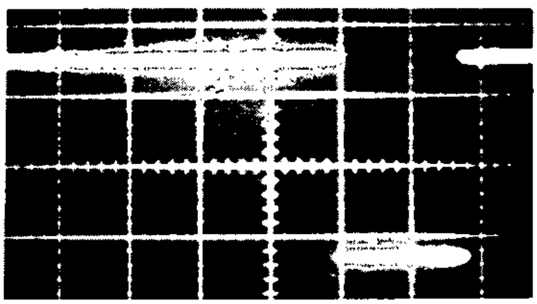
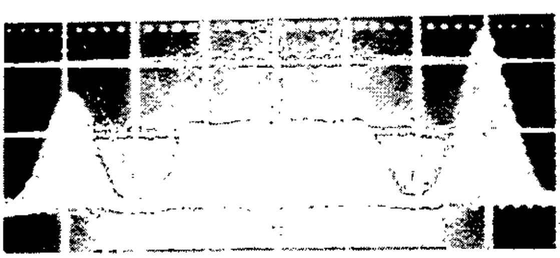
Main Electronics Board, Test Point Locations

IC15 receives a DC signal from a silicon photodiode which is proportional to the lamp intensity. This DC level is used to vary the gain of IC13 by maintaining a constant level when compared to the reference at Pin 13 of IC12. The amplitude modulated signal from TP22, which also passes through IC13 is independent of lamp intensity variations at Pin 7 of IC9. IC9, Pins 6, 7, and 8 allows only the reference portion of the waveform to be applied to the detector circuit of IC12, Pins 8, 9, and 10 and associated components. TP28 shows a DC level proportional to the peak to peak value of the reference signal. This voltage is compared to the trip level signal at TP30 and produces a +15 volt signal at TP27 when the TP28 voltage falls below the TP30 voltage. As long as the TP28 signal exceeds the voltage at TP30, TP27 will produce a -15 volt status to the Remote Control Units.

Table 3 lists the test points and the approximate level that should be seen at these points. All test points noted with an * should not be changed without factory approval.

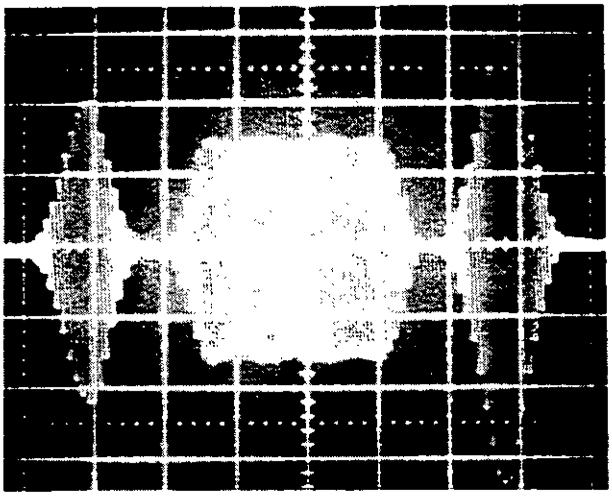
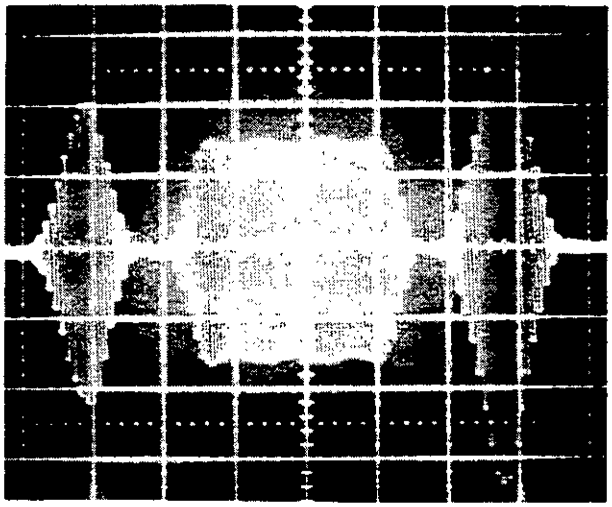
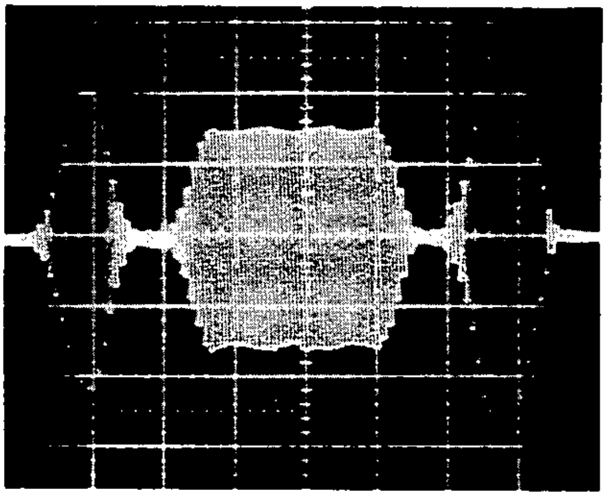
# TABLE 3

## TEST POINT CALIBRATION GUIDE

| T.P. | APPROXIMATE SIGNAL LEVEL | SPECIAL NOTATION |
|---|---|---|
| 1 | 0 - 10 VDC | Varies with opacity |
| 2 | -6.2 VDC reference | |
| 3 | ~ 2 volts | |
| 4 |  | |
| 5 | 0 to 11 VDC | Ramp |
| 6 | ~ 4.1V | |
| 7 | 0 or 15 VDC | |
| 8 |  | |
| 9 | ground | |
| 10 | 0 or 15 VDC | 0 = NORMAL mode, 15 = other mode |
| 11 | 0 or 15 VDC | 0 = NORMAL mode, 15 = SPAN mode |
| *12 | 0 or -10 VDC | Dependent on MODE switch position |
| 13 | Approx. 0.2 VDC | |
| 14 | 0 or 15 VDC | 0 = NORMAL mode, 15 = REF mode |
| 15 |  | |
| 16 | 0 or 15 VDC | 0 = other mode, 15 = NORMAL mode |
| 17 | 0 or 15 VDC | 0 = other mode, 15 = REF mode |
| 18 | 0 or 15 VDC | 0 = other mode, 15 = SPAN mode |

## TABLE 3

## TEST POINT CALIBRATION GUIDE

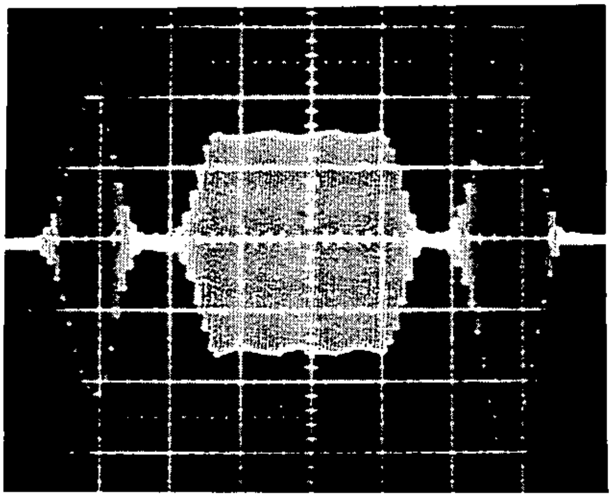
| T.P. | APPROXIMATE SIGNAL LEVEL | SPECIAL NOTATION |
|---|---|---|
| 19 |  | Same as TP22 but filtered and amplified 20 times. |
| 21 |  | Same as TP19 but 20 times smaller |
| 22 |  | Approximately 0.8 Vp-p for refernce section |

## TABLE 3

## TEST POINT CALIBRATION GUIDE

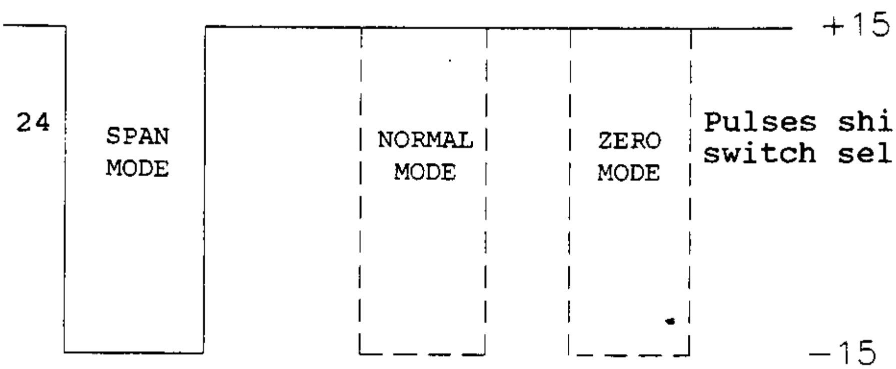
| T.P. | APPROXIMATE SIGNAL LEVEL | SPECIAL NOTATION |
|---|---|---|

23



Approximately 0.8 Vp-p at reference on -.6 VDC level

24




Pulses shift with MODE switch selection

| T.P. | APPROXIMATE SIGNAL LEVEL | SPECIAL NOTATION |
|---|---|---|
| 25 | ≃ 2V DC | |
| 27 | -15 to +15 VDC | -15 = clean window<br>+15 = dirty window |
| 28 | 1.15 x TP30 | |
| 30 | Approx. 6.5 V | |
| 31 | -15 VDC | |
| 32 | 15 VDC | |
| 33 | 9.1 VDC | |

## 2.2 MOUNTING FLANGES

Two mounting flanges are required to mount the Blower Assemblies, Optical Head, and Retro Assemblies to the stack. No other mechanical connections or mounting points are required to place the Transmissometer System in operating position. The flange is a steel ring with an eight hole mounting bolt pattern as shown in Figure 13. These flanges are welded to a 4 inch (10.16 cm) diameter section of Schedule 40 steel pipe, supplied by the customer, which is in turn fixed to the stack wall. Two basic mounting methods, one for a steel wall and one for a masonry wall, are shown in Figure 14. Larger diameter mounting pipe will be required whenever the distance between the stack inner wall and the Transmissometer flange exceeds one foot in total length. This is to prevent reflections from the pipe walls from affecting the Transmissometer readings. Consult the factory for details.

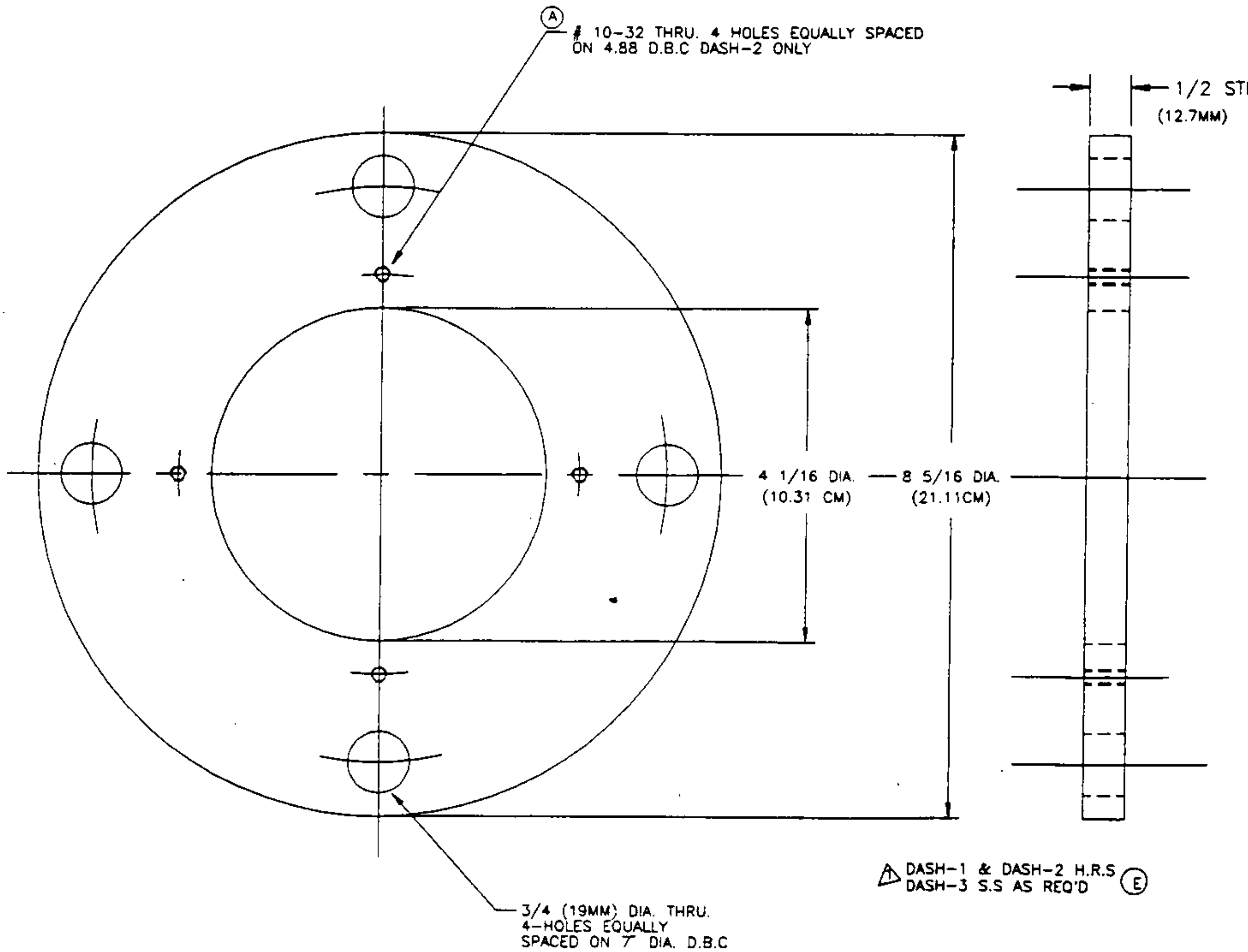
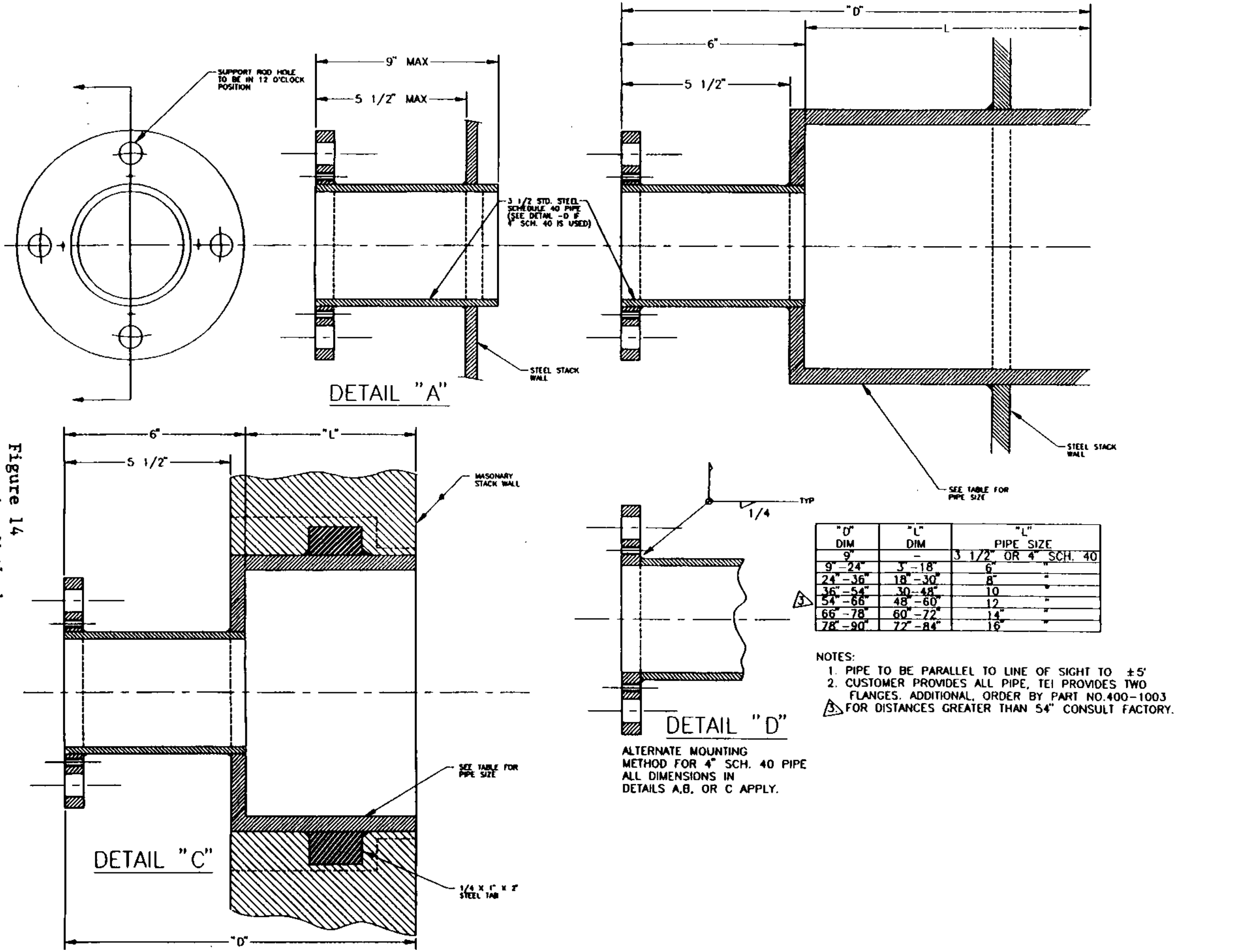



Figure 13

Mounting Flanges




| "D" DIM | "L" DIM | "L" PIPE SIZE |
|---|---|---|
| 9" | – | 3 1/2" OR 4" SCH. 40 |
| 9"–24" | 3"–18" | 6" " |
| 24"–36" | 18"–30" | 8" " |
| 36"–54" | 30–48" | 10 " |
| 3 54"–66" | 48"–60" | 12 " |
| 66"–78" | 60"–72" | 14" " |
| 78"–90" | 72"–84" | 16" " |

NOTES:
1. PIPE TO BE PARALLEL TO LINE OF SIGHT TO ±5'
2. CUSTOMER PROVIDES ALL PIPE, TEI PROVIDES TWO FLANGES. ADDITIONAL, ORDER BY PART NO.400-1003
3. FOR DISTANCES GREATER THAN 54" CONSULT FACTORY.

Figure 14
Flange Mounting Methods

## 2.3 BLOWER ASSEMBLY

The Blower Assembly, shown in Figure 15, is recommended for use with both the Optical Head and Retro Assemblies even though the stack itself may normally have a negative pressure. Two units are required, one for the Optical Head Assembly and one for the Retro Assembly, and are fixed directly to the mounting flange. The blower itself is a regenerative centrifugal type capable of developing a maximum static pressure of 60 inches (152.4 cm) ($H_2O$). The input air is drawn through a filter system with approximately 130 square inches (840 square cm) of surface area. Filter cartridges are used which are easily replaced by removing a single wing nut and retainer hood. The output air is directed through a flexible hose to the inlet port of the Optical Head and Retro Assemblies, forming and air barrier in front of the optics, and then into the stack itself. The Blower Assembly will provide adequate purging of the Transmissometer for stack operating pressures of 8 to 10 inches $H_2O$.

A sturdy shield is provided to protect the Transmissometer System from the weather. This shield can be lifted and locked in place or completely removed, if desired, for access to the Optical Head, Retro Assemblies, or blower filter equipment. Two stand off rods are provided to brace the main plate against the stack wall. Other than the mounting flange, no other fixed mechanical connections to the stack are required.

## 2.4 AIR VALVE UNIT

The Air Valve Unit, shown in Figure 16, is an all mechanical device engineered to respond to the lack of proper air flow from the Blower Assembly. Two valve units are required, one for the Optical Head Assembly and one for the Retro Assembly. The Air Valve Unit consists of a rugged, cast aluminum housing and flow duct assembly which contains a hinged valve plate. The valve plate is counter-balanced to remain open as long as there is flow into the stack. Should the air flow from the Blower Assembly stop for any reason, and a positive stack pressure (back flow) develop, the valve plate will immediately snap shut effectively stopping the stack gases from getting to the Transmissometer Optical System. Resumption of air flow by the Blower Assembly will again open the valve plate, and normal Transmissometer operation can continue.

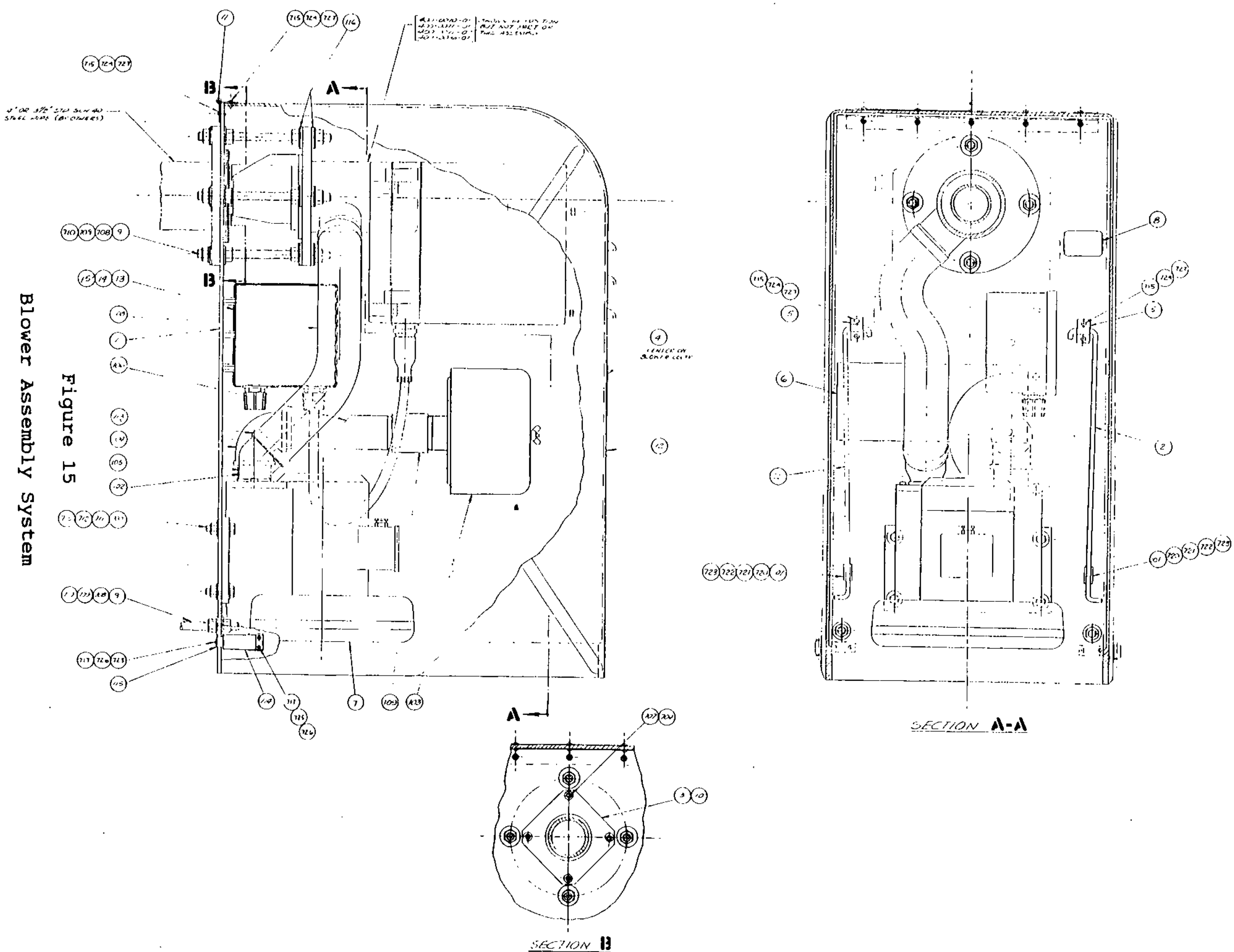



Figure 15
Blower Assembly System

It should be noted that the Air Valve Unit has been designed to protect the instrument only for short duration purge failures. The Air Valve Unit and Transmissometer should not be exposed to stack effluents for extended periods. Normal high opacity alarms will be activated whenever the Air Valve Unit closes.

On -5 and -6 units, the purge fail alarm option is available. This provides a contact closure to the control room from a differential pressure switch located on each of the Blower Plate Assemblies. Purge air failures must be returned to service as soon as possible or within 24 hours.

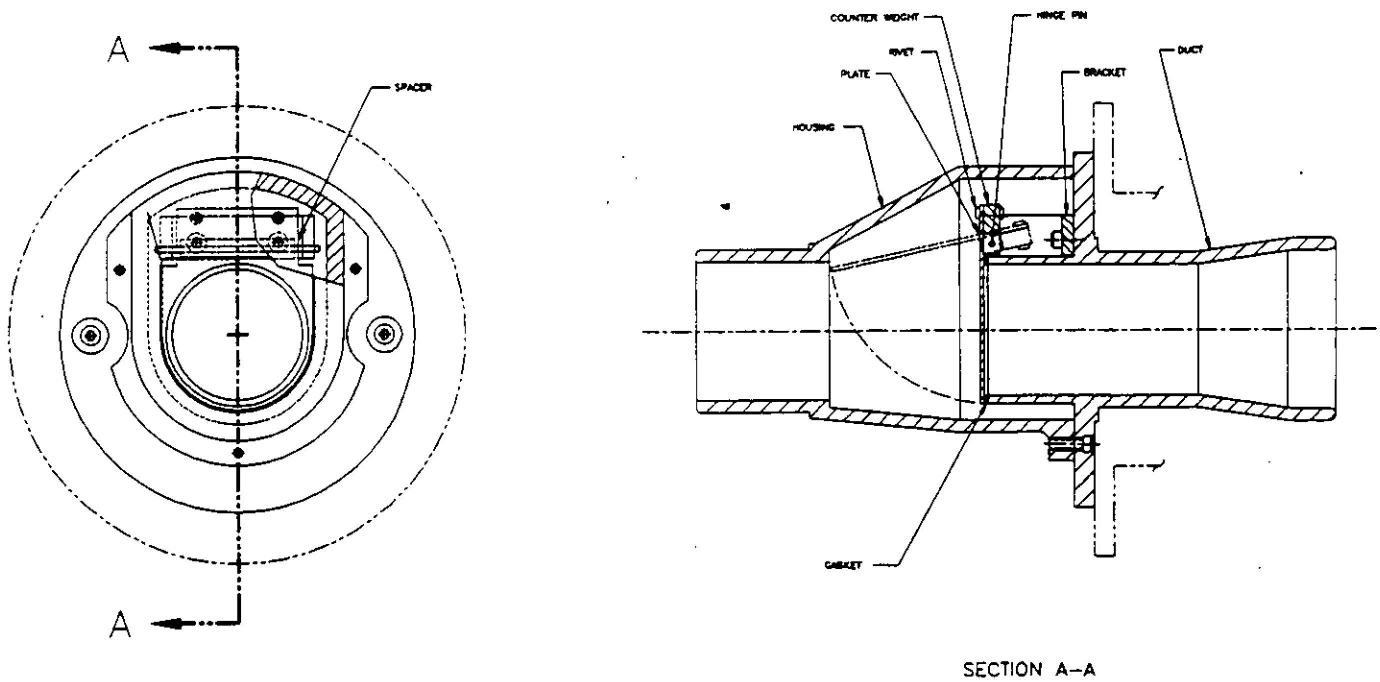



Figure 16

Air Valve Unit

## 2.5 CALIBRATION TEST KIT

The Calibration Test Kit, shown in Figure 17, is designed to serve two functions. The first is to verify that the performance of the Transmissometer Optical Head Assembly adheres to the basic instrument calibration curve. The second is to provide an on-stack zero point reference in lieu of a clear stack condition to check the adjustment of the electronics after replacement of electronic or optical components. The unit has a heavy cast aluminum mounting bracket that supports the filter and adjusting screw. When the Transmissometer is first adjusted and focussed for the correct stack flange to flange distance at initial system setup, the Calibration Test Kit is adjusted and locked at an equivalent zero opacity clear stack set point. It then becomes a zero reference available for subsequent on-stack system testing, should a clear stack condition be unattainable at the measurement site.

Note: Normal clear stack conditions are not truly clear because of draft induced dirt and dust flow within the stack.

Four neutral density filters are supplied with each Calibration Test Kit which establish fixed points on the basic operating range. The filter values are nominally 0.1, 0.2, 0.4, and 0.9 in neutral optical density, and are calibrated photopically in percent opacity to the third decimal place. These calibration figures are traceable to the National Bureau of Standards. With the Calibration Test Kit, the performance of the basic Transmissometer can be demonstrated in a quick and convenient manner.

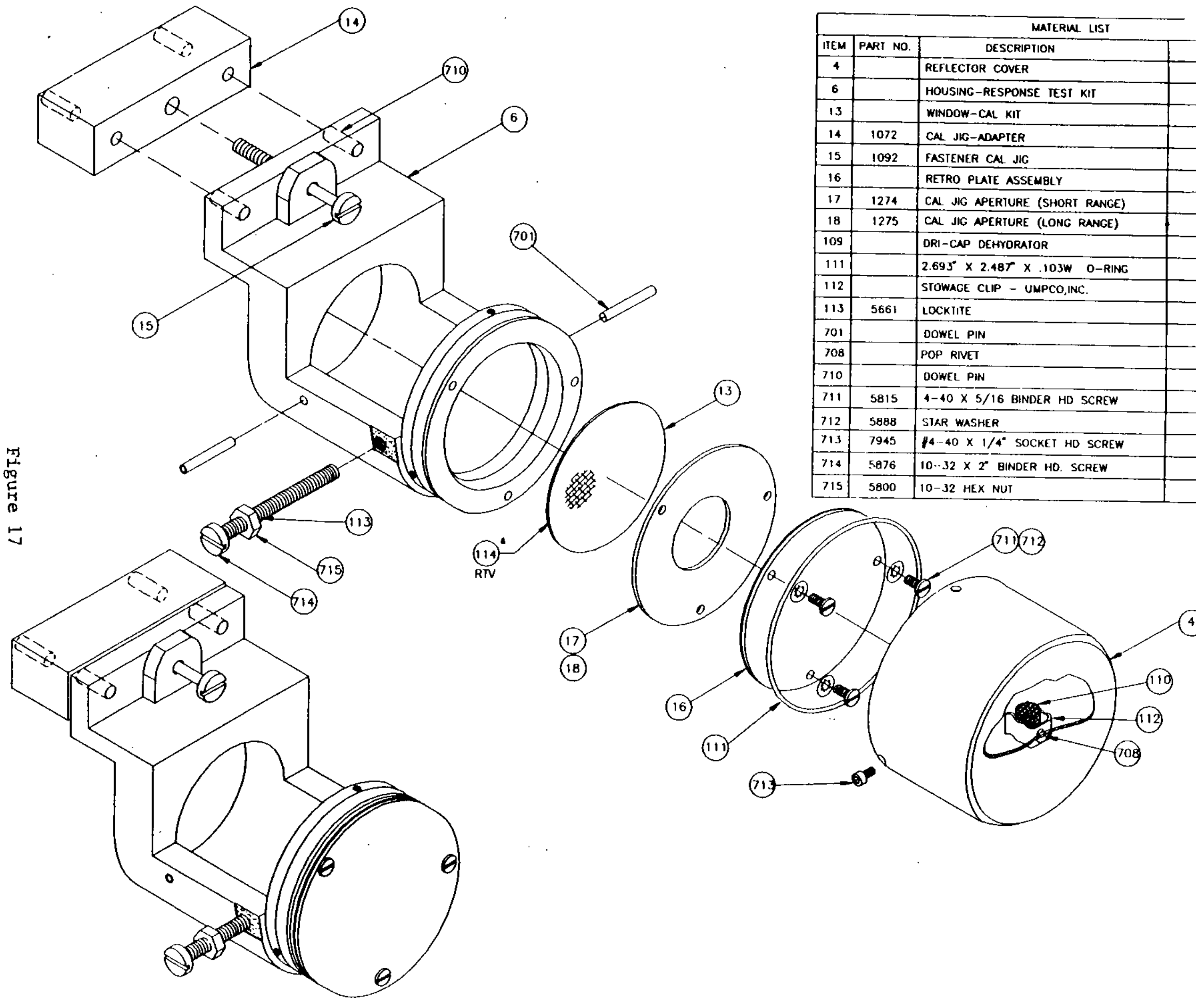
## 2.6 DATA CABLE

The data from the Transmissometer is terminated in a junction box attached to the blower plate assembly as shown in Figure 18. This wiring, done at the factory, uses 18 gauge shielded cable and a sealing technique to prevent moisture and dirt from contaminating the connector pins. The junction box with terminal boards provides the user with an easy method of continuing the cable to the control room. The junction box also allows the user to use heavier gauge wire for long conduit pulls.

It is recommended that the signal cable from the junction box be run through metal conduit to prevent adverse electrical noise from entering the signal cable. It also helps during electrical storms.

**CAUTION**

The factory should be consulted when cable runs greater than 5000 feet (1524 meters) are required.




| MATERIAL LIST | | | | |
|---|---|---|---|---|
| ITEM | PART NO. | DESCRIPTION | | QTY. |
| 4 | | REFLECTOR COVER | | 1 |
| 6 | | HOUSING-RESPONSE TEST KIT | | 1 |
| 13 | | WINDOW-CAL KIT | | 1 |
| 14 | 1072 | CAL JIG-ADAPTER | | 1 |
| 15 | 1092 | FASTENER CAL JIG | | 1 |
| 16 | | RETRO PLATE ASSEMBLY | | 1 |
| 17 | 1274 | CAL JIG APERTURE (SHORT RANGE) | | 1 |
| 18 | 1275 | CAL JIG APERTURE (LONG RANGE) | | 3 |
| 109 | | DRI-CAP DEHYDRATOR | | 1 |
| 111 | | 2.693" X 2.487" X .103W O-RING | | 1 |
| 112 | | STOWAGE CLIP - UMPCO,INC. | | 1 |
| 113 | 5661 | LOCKTITE | | A/R |
| 701 | | DOWEL PIN | | 2 |
| 708 | | POP RIVET | | 1 |
| 710 | | DOWEL PIN | | 2 |
| 711 | 5815 | 4-40 X 5/16 BINDER HD SCREW | | 3 |
| 712 | 5888 | STAR WASHER | | 3 |
| 713 | 7945 | #4-40 X 1/4" SOCKET HD SCREW | | 3 |
| 714 | 5876 | 10-32 X 2" BINDER HD. SCREW | | 1 |
| 715 | 5800 | 10-32 HEX NUT | | 1 |

Figure 17
Calibration Test Kit

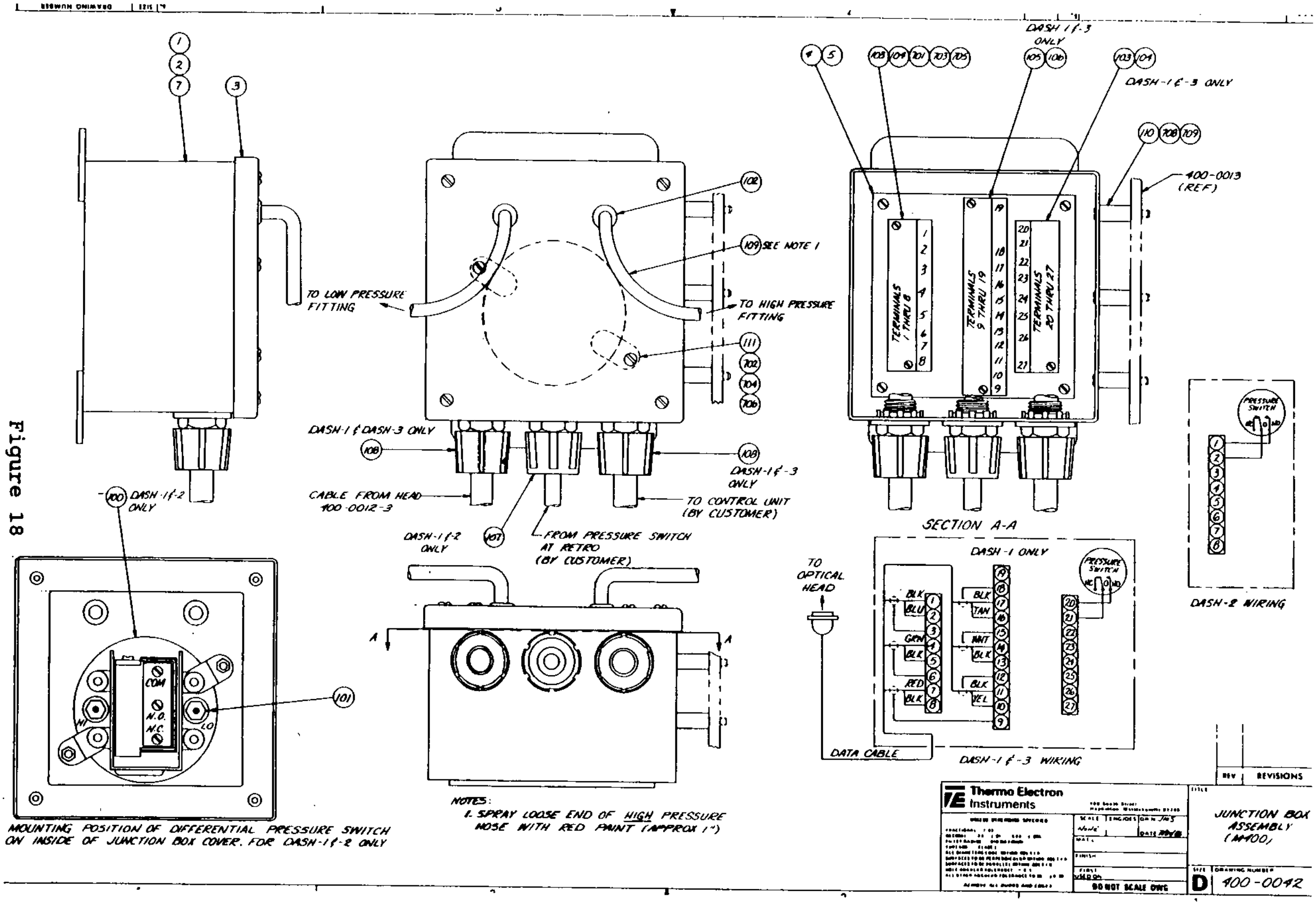



Figure 18 Cable Assembly and Wiring Diagram

## 2.7 RETRO ALIGNMENT TOOL

To reproduce the zero signal of the Transmissometer established during initial focussing and alignment, the Retro Assembly must be aligned on the stack with the plane of the Retroreflector perpendicular to the line of sight of the Transmissometer. The Retro Alignment Tool shown in Figure 19 is designed for this purpose and is easily used in the installation process. The unit consists of a small low-power telescope with a cross-hair reticle set in an adaptor block.

## 2.8 MAINTENANCE KIT

To properly maintain the Transmissometer system it is recommended that the proper items be on hand at the site. A spare parts and consumables list is provided in Section 6 of this manual. Optical lens cloths and solutions indicated in this section are the only ones recommended by the manufacturer.

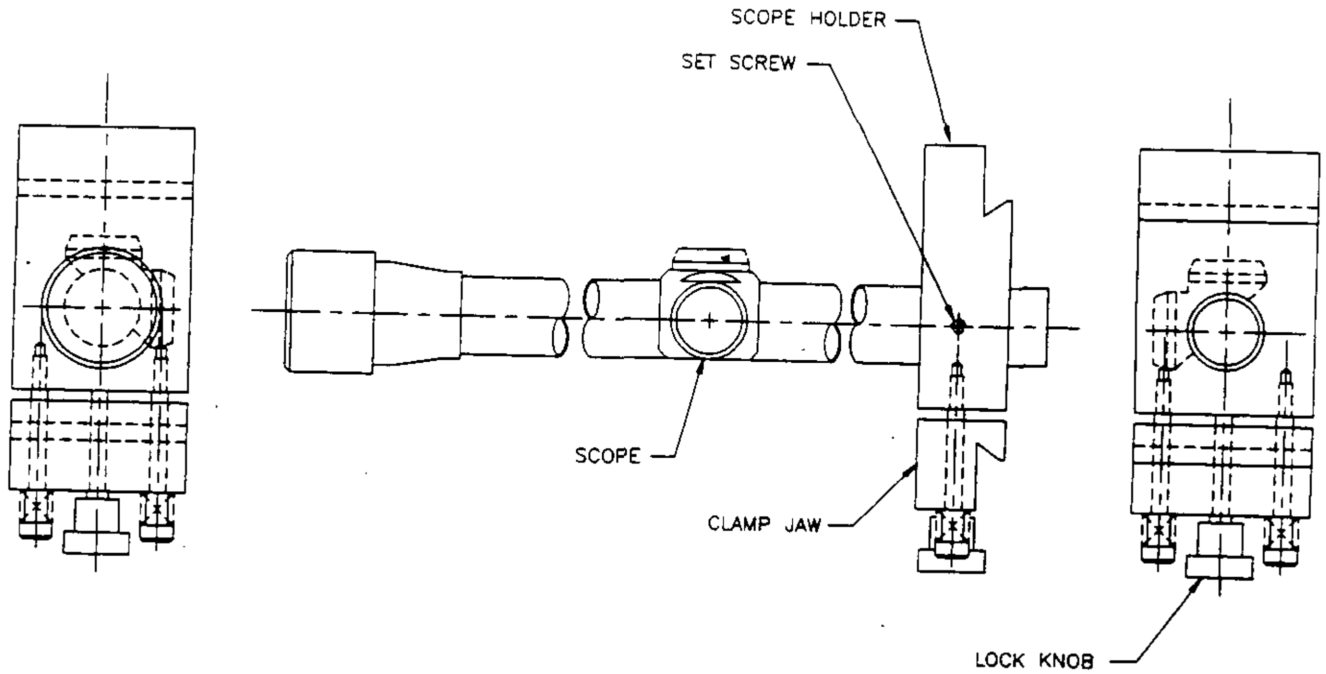



Figure 19

Retro Alignment Tool

## 2.9 RECORDER

The optional Remote Control Units can be supplied with either a single-pen or two-pen strip chart recorder to record the Transmissometer System output. The two-pen recorder may be used to record both the instantaneous and integrated stack information simultaneously. The recorders use a 10-cm wide Z-fold chart. The chart speed is selectable on the monitor front panel. On the low setting the chart speed is 3 cm/hr., while on the high setting the chart speed is 30 cm/hr. Chart speeds from 1.5 cm/hr. can be obtained if the factory is consulted prior to shipment.

The writing system uses a disposable cartridge pen which contains both the ink and stylus.

The recorder power requirement is 117 VAC, 50/60 Hz. 230 VAC, 50/60 Hz is optional but must normally be wired at the factory. The recorder is supplied with a complete operations manual. Optional scales are available in terms of nonlinear or linear opacity, and nonlinear or linear optical density.

## 3.0 BASIC TRANSMISSOMETER CALIBRATION AND CHECKOUT

Pre-installation calibration ensures precise operation of the Transmissometer when installed. This is normally done at the factory prior to shipment and when the true flange to flange mounting distance is known. It can also be performed on-site by the customer if a V.O.M. is available or by TEI Field Service personnel (see Section 7.3, Field Service). This calibration is conducted while duplicating the actual on stack conditions of instrument alignment and flange to flange separation for the Optical Head Assembly and the Retro Assembly. The flange to flange distance must be known accurately to within 1%. At this time the type of retroreflector, retroreflector aperture, and main field stop required for a given application are installed. The optical system is then focussed and the electronics adjusted to establish the zero opacity (clear stack) and upscale opacity points. The SPAN value, which is a function of the front chopper and the clear stack signal, is then determined and recorded.

**Note:** Clear stack conditions cannot be relied upon to give a true zero opacity value because of the presence of draft induced dirt and dust within the stack or duct.

## 3.1 INITIAL SETUP AND FOCUSING FOR RANGE

Mount the Optical Head Assembly and the Retro Assembly in any convenient supporting structure, or one such as shown in Figure 20, at a distance equal to the actual separation when mounted on the stack. Final system alignment hardware can be used for this purpose, as shown in Figures 21 through 24.

Threaded rods are firmly attached to the support with flat washers and hex nuts. The Optical Head Assembly and the Retro Assembly are then mounted on the rods with a pair of spherical washers on either side of the flanges for aiming and alignment adjustments. These adjustments are positively lockable.

Turn on the Optical Head Assembly to provide a bright target and coarsely aim the Retroreflector. Using the Retro Alignment Tool, as shown in Figure 25, sight through the alignment tool and adjust the Retroreflector mounting nuts and spherical washers to center the alignment tool cross-hair pattern onto the spot of light defined by the Optical Head Assembly aperture. Remove the Retro Alignment Tool.

Verify that the Retroreflector housing is equipped with the proper Retroreflector type and install the required aperture plate as defined in the system range schedule of Table 4. Be sure that the Retroreflector window is clean, then close the housing and secure the latch.

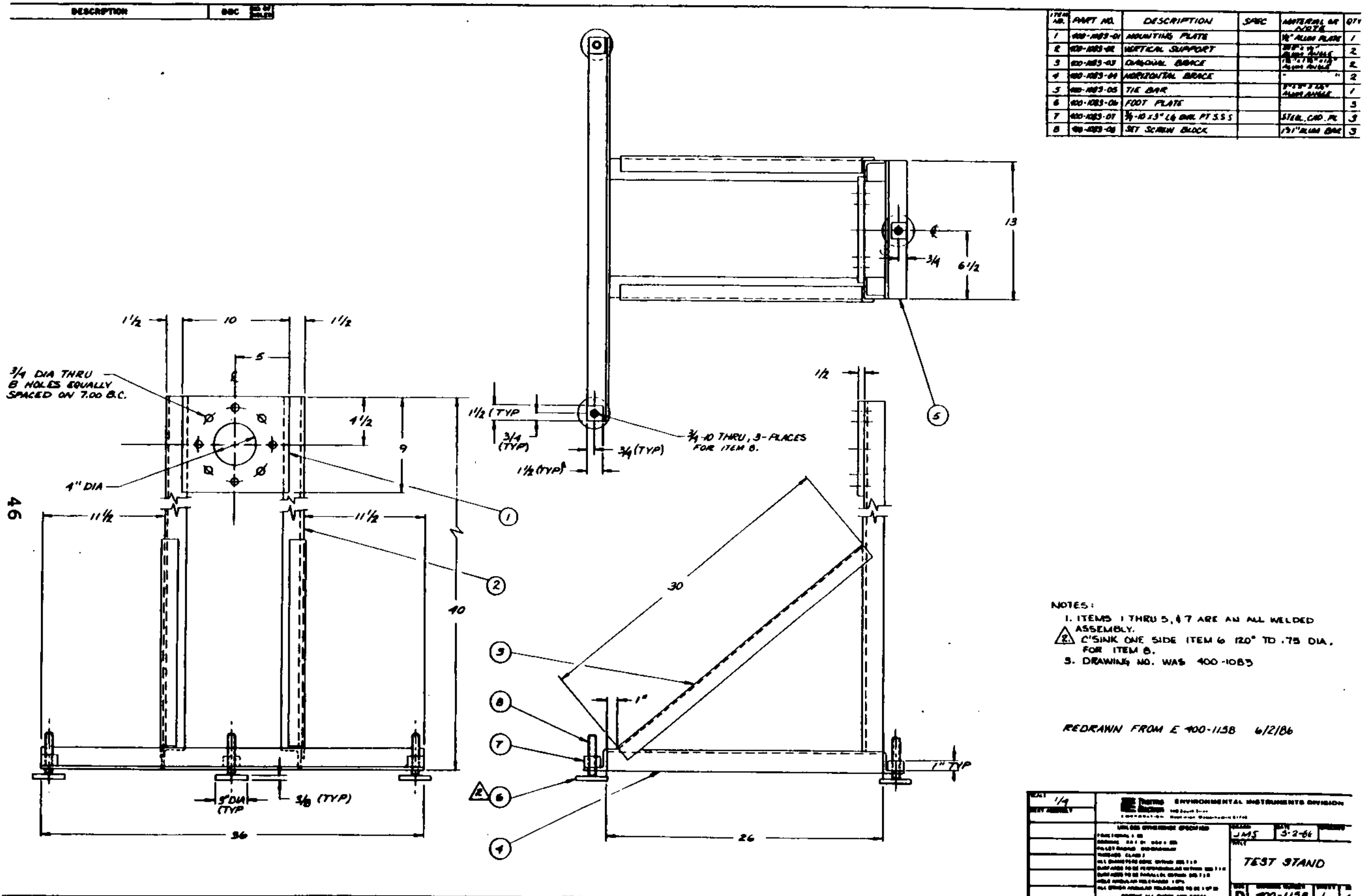



Figure 20. Te Stand

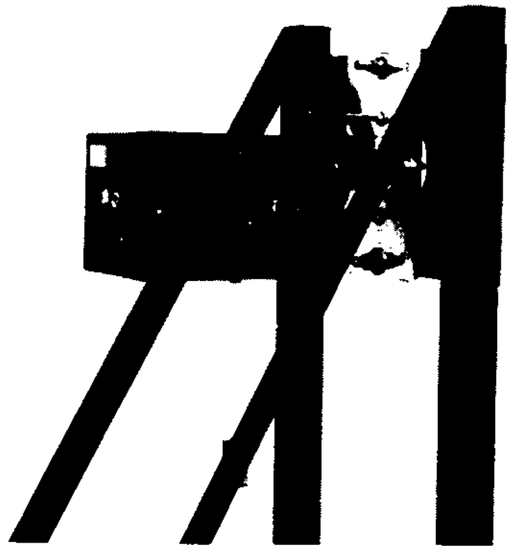


Figure 21. Optical Head Assembly in Test Stand

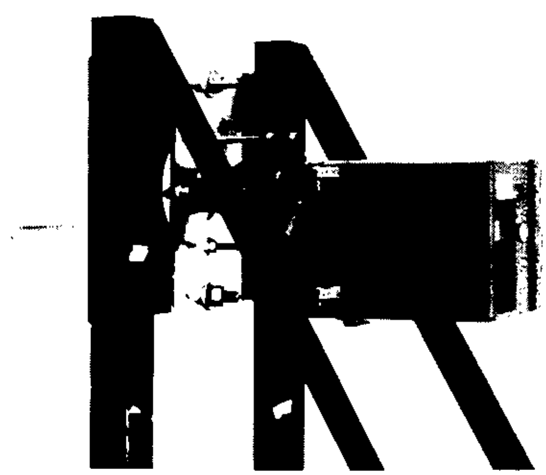


Figure 22. Optical Head Assembly in Test Stand

Figure 23. Retro Assembly in Test Stand

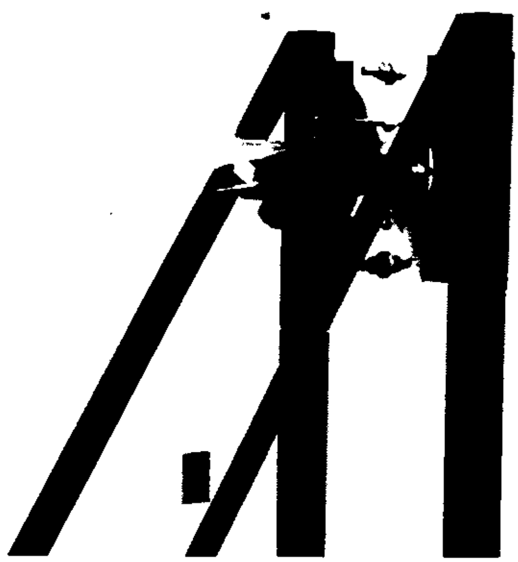


Figure 24. Retro Assembly in Test Stand

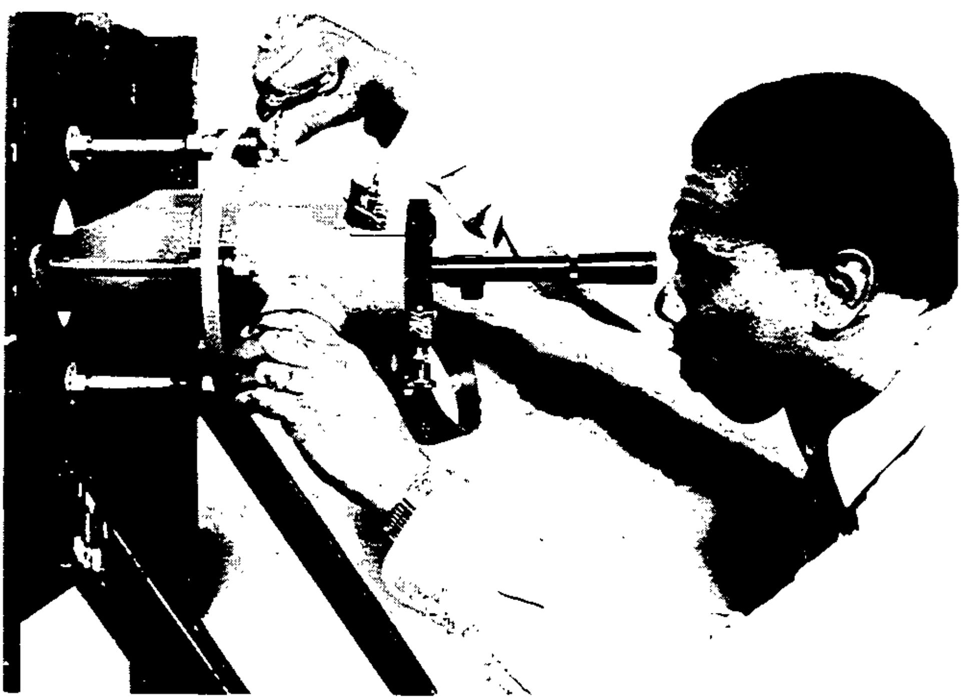


Figure 25

Using Alignment Tool

Table 4. SYSTEM RANGE SCHEDULE

| Stack Flange to Flange Distance | Retro Assembly | | Aperture Plate | |
|---|---|---|---|---|
| | Dash No. | Type | Dash No. | Size |
| 0–10" (0–25cm) | 03 | Scotch Lite | 01 | 3/8" (0.952cm) |
| 10"–20" (25cm–50cm) | 03 | Scotch Lite | 03 | 5/8" (1.59cm) |
| 20"–30" (50cm–70cm) | 03 | Scotch Lite | 04 | 7/8" (2.22cm) |
| 30"–40" (70cm–95cm) | 03 | Scotch Lite | 05 | 1–1/4" (3.18cm) |
| 40"–50" (95cm–1.3m) | 03 | Scotch Lite | -- | None Required |
| 50"–70" (1.3m–1.8m) | 01 | Plastic | 03 | 5/8" (1.59cm) |
| 70"–90" (1.8m–2.3m) | 01 | Plastic | 04 | 7/8" (2.22cm) |
| 90"–10' (2.3m–3.0m) | 01 | Plastic | 05 | 1–1/4" (3.18cm) |
| 10'–13' (3.0m–3.2m) | 01 | Plastic | -- | None Required |
| 13'–18' (3.2m–5.6m) | 01 | Plastic | 05 | 1–1/4" (3.18cm) |
| 18'–24' (5.6m–7.3m) | 01 | Plastic | -- | None Required |
| 24'–32' (7.3m–10.7m) | 02 | Glass Prism | 05 | 1–1/4" (3.18cm) |
| 32'–40' (10.7m–12.2m) | 02 | Glass Prism | -- | None Required |

50'(15.3m) operation range achieved with reduced projection angle.

Table 4

System Range Schedule

At the Optical Head Assembly, open the hinged section and ensure that the objective window is clean. (The chopper blade may be removed, if required, by loosening the hub clamp screw and drawing the chopper hub forward to clear the motor shaft.)

Remove the large cover over the optics section as shown in Figures 26 and 27. Loosen the main objective clamping set screw as shown in Figure 28.

Figure 26. Removing Screws for Main Cover Removal

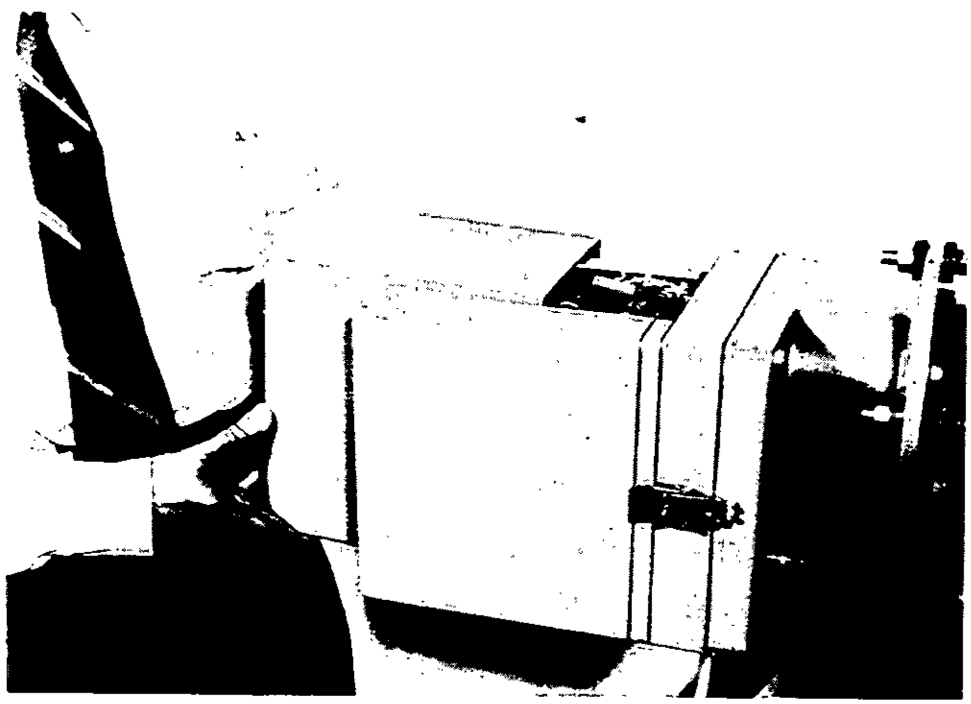


Figure 27. Removing Main Cover

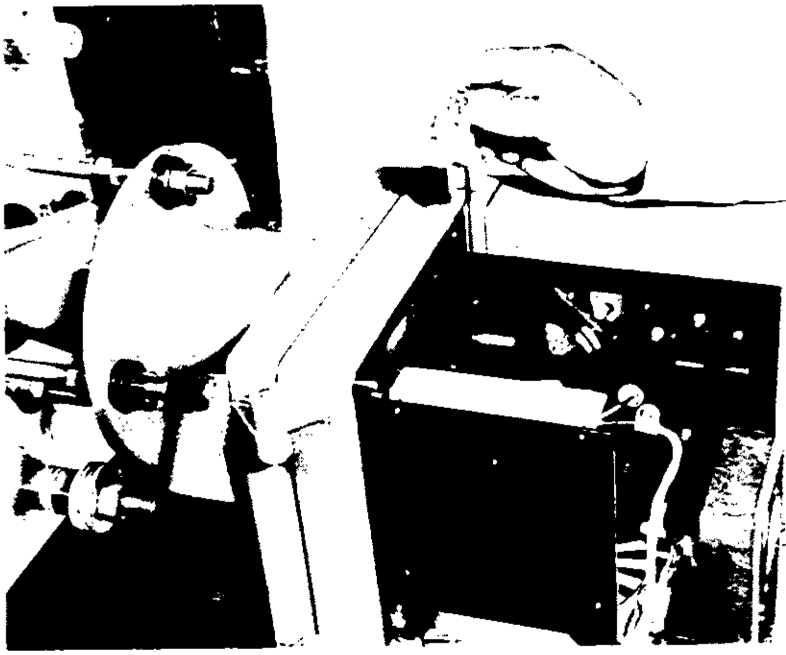
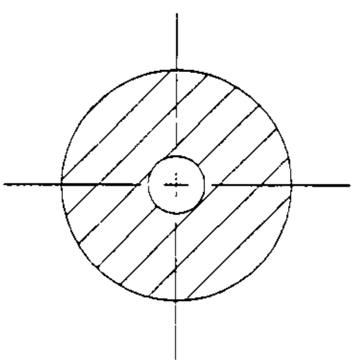


Figure 28.  Loosening Objective Lens Clamping Set Screw

Looking through the sighting eyepiece, a bright spot of light from the Retroreflector will be seen.  Using the eyepiece cross-hair pattern as a reference, focus the objective as shown in Figure 29 to obtain a sharply defined image of the Retroreflector spot.  Once optimum focus has been achieved, carefully tighten the objective set screw and replace the large cover.

**Note:** Do not over tighten the set screw; this could deform the lens cell.

The Transmissometer is now ready for electrical adjustments to set the 0% and 100% opacity points.



VIEW THROUGH MODEL 400
SIGHTING EYEPIECE

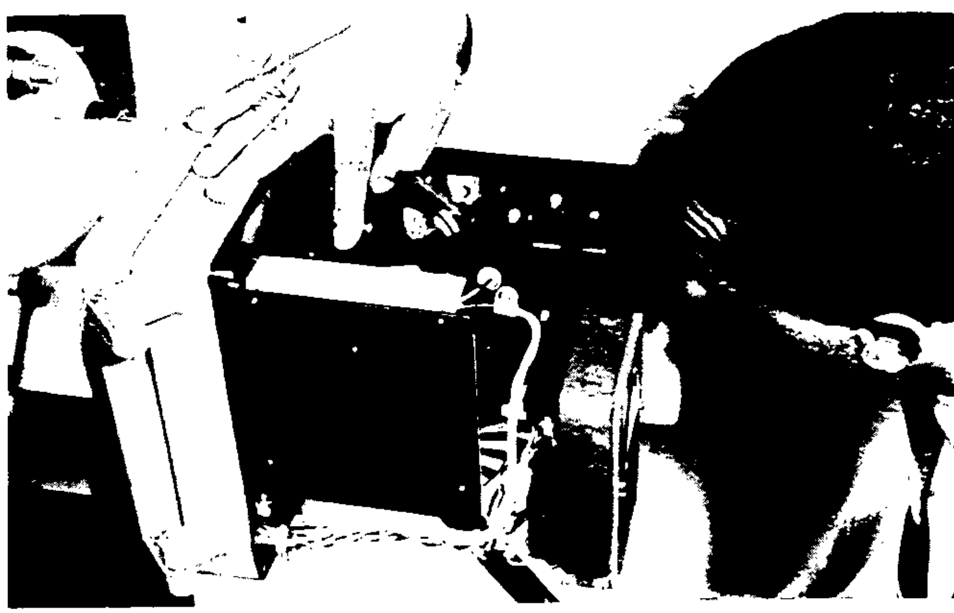


Figure 29.  Adjusting Objective Lens

## 3.2 SETTING 0% AND 100% OPACITY POINTS

With the proper aperture placed in the Retro Assembly, and the Optical Head Assembly focussed for the correct stack diameter and aligned, the following procedure is required to set the system electronics for 0 and 100% opacity. (Refer to Figure 12B for the component side of the main electronics board.)

1. After the unit has been turned on and allowed to run for about 30 minutes, remove the jumper plug that places +/-15 volts on one side of R37.

2. Place a voltmeter on TP12. (The voltage will be negative.)

3. Turn the MODE switch to the NORMAL position.

4. Be sure that there is a clear stack condition (no obscuration of the Retroreflector) and adjust R20 for 0% opacity as read on the panel meter.

5. Completely obscure the output light beam with an opaque flat black material, placed in the light beam at an angle of at least 15 degrees, so that no reflection is seen by the detection system. An alternative is to open the optical head assembly at the interface housing thus directing the light beam to a non-reflective target.

**Note:** The Calibration Test Kit may be used for clean stack simulation, if available.

6. Adjust R25 until the meter reads 100% opacity.

7. Remove the opaque material and check the meter for 0% opacity reading. Readjust R20 if necessary until the meter reads 0%.

8. Replace the opaque material in front of the light beam and recheck the 100% opacity reading. Re-adjust R25 if required.

9. Turn the MODE switch to the ZERO position.

10. If the meter reads 0 or below, then reconnect the red jumper plug that will place +15 volts on one side of R37. If the meter reads above 0, place the jumper so that -15 volts is placed on one side of R37.

11. Adjust R37 so that the meter reads 0% opacity.

12. The unit should be allowed to run an additional 30 minutes before it is given final check or any further readjustment.

## 3.3 CHECKING AUTOMATIC CALIBRATION CYCLE AND SPAN POINT

The unit should first be checked for proper operation in the manual ZERO and SPAN modes before the automatic calibration cycle is checked. The timing for the automatic calibration cycle is controlled by the time constant created by R8 and C5. (This circuitry is used when using the 400A Control Panel. When using the other panels the timer IC is replaced with a header plug and the calibration is controlled at the panel.)

To check the automatic cycle, place a V.O.M. probe on TP5. As factory set, the voltage at TP5 should climb slowly positive then step toward zero at a rate of approximately one step every 30 seconds. The presence of this stepping function indicates that the multivibrator section of the automatic cycle circuit is operating properly. The remaining portion of the automatic cycle must be checked by placing a recorder on the output of the unit. The ZERO and SPAN cycles should appear approximately every 2 hours, with the Zero and Span points maintaining their values within +/-3%.

The actual SPAN value is a function of the diameter of the two Scotchlite patterns on the Optical Head Assembly front chopper.

It is also a function of the actual clear stack signal level for the operating distance of the Transmissometer and the type of Retroreflector Unit used. Consequently, the SPAN value is a fixed reference between 30 and 70% opacity that should not change.

Following initial setup as outlined in Sections 3.1 and 3.2, set the control switch in the SPAN position, Figure 30. Carefully read the Span value on the meter and record on the title page of this manual.

## 3.6 CHECKING THE SYSTEM CALIBRATION

The calibration accuracy of the Transmissometer may be checked with any filter of known visual transmission, t, or opacity, 1-t. This can be conveniently done with the optional Calibration Test Kit, and the set of filters included in the Calibration Test Kit described in Section 2.5. With this kit the Optical Head Assembly opacity readings can be checked at any time the system is in operation as shown in Figures 31 and 32. The Calibration Test Kit has been adjusted to give a 0% opacity reading and locked to preserve the 0% opacity reading for on-stack field checks should clear stack conditions be unattainable. At this point any filter of known photopic opacity can be inserted into the beam and the instrument response, as read on the meter, should correspond to these values.

## 4.0 INSTALLATION

These procedures are to be followed in the installation of the Transmissometer System after selection of the measurement site.

## 4.1 SITE PREPARATION

Prior to installation, certain information must be known to assure proper calibration, focussing, adjustment, and electrical connection of the system. These are given in the following checklist.

The required information should be recorded in the checklist and should be provided to the factory so that proper installation drawings can be prepared. This is normally done in the early stages of ordering the Transmissometer.

# MODEL 400B TRANSMISSOMETER INSTALLATION CHECKLIST

1. Flange to flange distance, accurate to 1% (see Figure 4, Drawing no. 400-0000, Sht. 1) _____ ft.

2. Flange Mounting:
   Support rod hole center must be vertical (see Figure 14, Drawing no. 400-1108)
   _____ Yes
   _____ No

3. Mounting Clearances (see Figure 4, Drawing no. 400-0000, Sht. 2)
   _____ Yes
   _____ No

4. Electrical Power:
   (all power must be single phase)

   a. Transmissometer and Blower System - two 115 volt, 20 ampere circuits or two 230 volt, 10 ampere circuits. Factory must be notified if 230 volt power is to be used. _____ Volts

   b. Remote Monitor, 115 volt 15 W _____ Volts

5. Data Cable:

   a. Length _____ ft.

   b. Conduit Size (minimum 1" diameter) _____ in.

6. Stack Taper Ratio

   a. Stack inside diameter at Transmissometer location
      _____ ft.
      _____ in.

   b. Stack inside diameter at exit
      _____ ft.
      _____ in.

### 4.1.1 TRANSMISSOMETER SYSTEM ON-STACK POWER

Power to the Transmissometer Optical Head Assembly should terminate at a point within easy reach of the 6 foot (1.83 meter) long power cord supplied with the unit. Two 115 volt, single phase, 50/60 Hz, 20.0 ampere circuits are required to properly operate the Transmissometer and both Blower Assemblies with sufficient overload protection, one circuit for each side. The Optical Head and one blower are powered by one circuit; the retro blower is powered by the second circuit.

The Transmissometer and Blower Assemblies can also operate on 230 volt power; however, this requirement must be known at the time the Transmissometer System is ordered from the factory. For this configuration, two 230 volt, single phase, 50/60 Hz, 10.0 ampere circuits are required to properly operate the Transmissometer and Blower Assemblies with sufficient overload protection.

**CAUTION**

> Both sides must be hard wired or warranty will be voided. The Purge Blowers, when supplied as part of the system, must be installed and operating prior to mounting the Optical Head or Retro.

### 4.1.2 MOUNTING FLANGES

Two mounting flanges are required to mount the Blower Assemblies, Optical Head, and Retro Assemblies to the stack. No other mechanical connections or mounting points are required to place the Transmissometer System in operating position. The flange is a steel ring with an eight hole mounting bolt pattern as shown in Figure 13.

These flanges are welded to a 4 inch (10.16 cm) diameter section of Schedule 40 steel pipe, supplied by the customer, which is in turn welded or fixed to the stack wall. The flanges only need to be aligned visually so that there is an unobstructed view from either side.

Two basic mounting methods, one for a steel wall and one for a masonry wall, are shown in Figure 14. Larger diameter mounting pipe will be required whenever the distance between the stack inner wall and the Transmissometer flange exceeds one foot. This prevents reflections from the pipe walls from affecting the Transmissometer readings. Consult the factory for details.

### 4.1.3 FLANGE TO FLANGE DISTANCE

The stack outside diameter at the point of installation must be determined and the actual distance from the stack wall to the mounting surface of each flange measured. The sum of these three measurements is the flange to flange distance that must be known to properly select the Retroreflector type, the correct aperture size, and to focus the optical system for a given installation. (Refer to Figure 14 which illustrates typical mounting methods for metal stack and a masonry stack.)

### 4.1.4 STACK TAPER RATIO

If the stack is tapered and exit plume opacity is the governing parameter for regulatory compliance, the inside diameter of the stack at the point of measurement ($l_m$) and the inside diameter of the stack exit point ($l_e$) must be determined. The value of $l_e/l_m$ (stack taper ratio) must be known to develop the proper stack exit point opacity curve for manual data correction or to properly adjust the Remote Control Unit.

### 4.1.5 DATA CABLE LENGTH AND CONTROL CENTER POWER

The distance from the Transmissometer site to a control center, if the Remote Control Unit is to be used, must be determined to properly select the length of the optional Data Cable. Power for the Remote Control Unit must be 115 volt, single phase, 50/60 Hz, 10 watts (230 volt special order).

The minimum recommended conduit size for housing the Data Cable is 1 inch.

### 4.1.6 INSTALLATION TOOLS

No special equipment or tools are needed to install the Transmissometer System other than the Retro Assembly Alignment Tool described in Section 2.7. However, for the convenience of installation personnel, the following basic hand tools are recommended and are sufficient for all installation and/or maintenance functions described in this manual.

a. Two 3/4" Open End Wrenches
b. Two 9/16" Open End Wrenches
c. One 5/16" Open End Wrench
d. One Large Type Screwdriver
e. One Small Blade-Type Screwdriver
f. One Instrument-Size, Blade-Type Screwdriver (for adjustment of electronics, potentiometers)
g. One Large Phillips Screwdriver
h. One Small Phillips Screwdriver
i. A set of Allen Wrenches (ranging in size from 1/16" to 3/16")
j. Retro Alignment Tool
k. Calibration Test Kit (with filters)

## 4.2 BLOWER ASSEMBLY

After the mounting flanges have been installed, the Blower Assembly is bolted directly to the face of the mounting flange with four 1" bolts complete with flat washers, lock washers, and hex nuts, and **located at the 45 degree position holes.** Four 1/2" - 13 x 8" long threaded rods are inserted in the remaining four mounting holes and locked in place with washers and hex nuts. These threaded rods should extend out from the face of the blower mounting plate approximately 6 1/2 inches (16.51 cm). Two other 1/2" -12 threaded rods are inserted through the holes along the lower edges of the blower mounting plate and adjusted with washers and hex nuts to steady the assembly against the stack wall. The completed blower plate installation with the cover removed is shown in Figures 33 and 34. The installation for the Optical Head and Retro Assembly Blower Systems is identical and all hardware required is provide with the units.

**CAUTION**

The Purge Blowers, when supplied as part of the Transmissometer System, must be installed and operating prior to installing the Optical Head or Retro Assemblies. Failure to comply will void the warranty.

Figure 33. Installation Complete
(Retro Assembly without Cover)

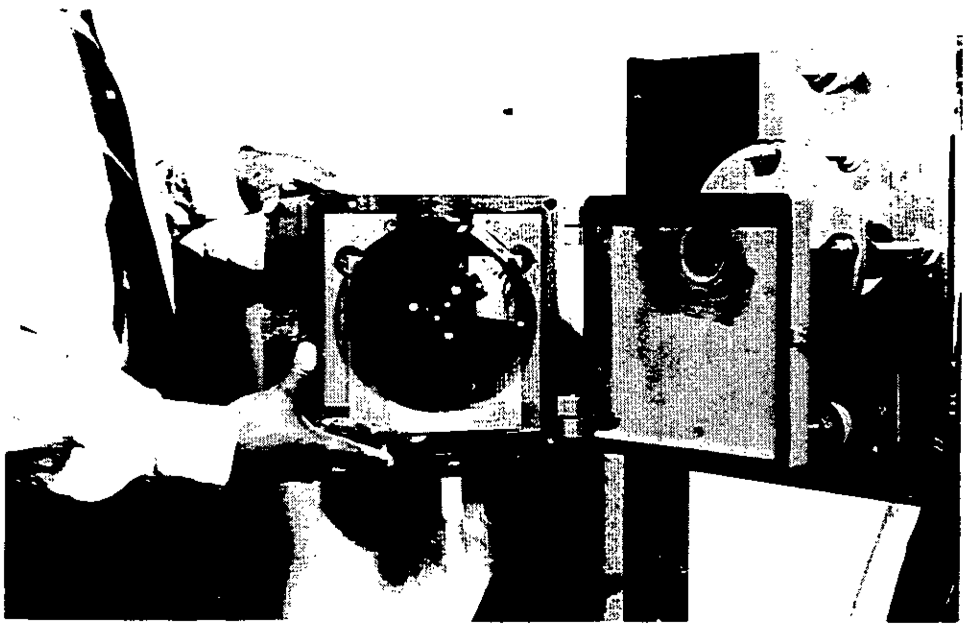


Figure 34. Installation Complete
(Optical Head Assembly without Cover)

## 4.3 AIR VALVE UNIT

The Air Valve Unit must be mounted to the flange of the Optical Head interface housing (Figure 35) and to the flange of the Retro Assembly housing (Figure 36) prior to installation of these units on the stack. The Air Valve Unit must be oriented with the bell shape of the housing upward to assure proper operation. All mounting hardware is provided with the unit. (If the unit is so equipped the purge fail hoses should be connected as color coded.)

Figure 35. Installation of Air Valve Unit on Interface Housing

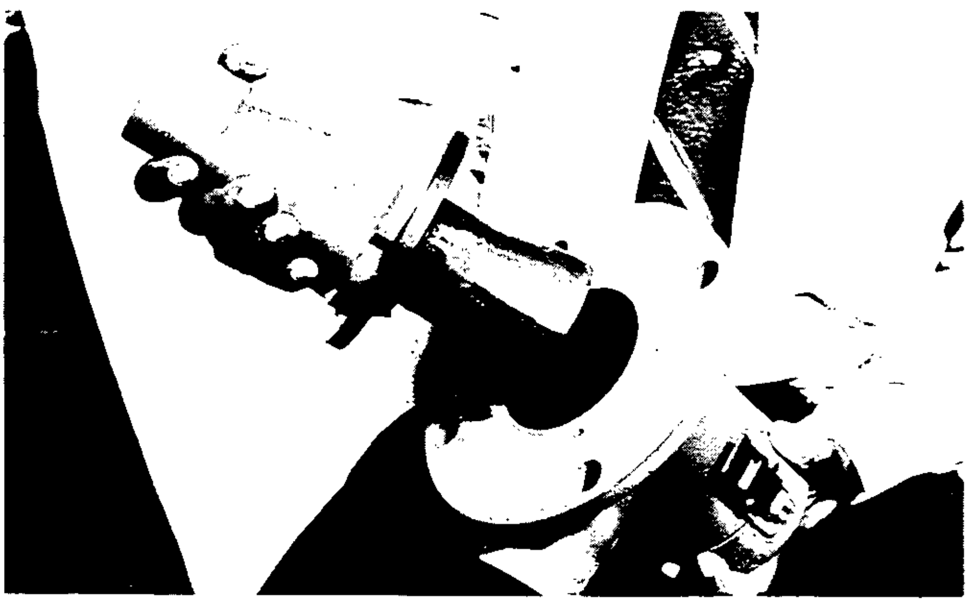


Figure 36. Installation of Air Valve Unit on Retro Housing

## 4.4 OPTICAL HEAD ASSEMBLY

The Optical Head Assembly is mounted to the stack in two stages. Loosen the hex screws that hold the gasket ring in place. Place a hex nut and one spherical washer set on each of the four threaded rods extending out from the blower mounting plate. Thread the nuts on far enough to allow the nozzle of the Air Valve Unit to be completely inserted into the gasket ring on the blower mounting plate and on the threaded rods as illustrated in Figure 37. Withdraw the Air Valve Interface Housing Assembly to set the interface housing flange 4 5/8" from the blower mounting plate. Place another spherical washer set and hex nut on each of the four threaded rods. Install the blower hose on the air inlet and tighten the hose clamp as shown in Figure 38.

**CAUTION**

At this point, power to the Blower Assemblies, when supplied as part of the Transmissometer System, must be turned on to assure air flow <u>before</u> the Optical Head main case is installed. Failure to comply will void the warranty.

The interface housing may now be coarse aligned by adjusting the hex nuts as shown in Figure 39. The opening on the far side of the stack must appear concentric with the opening through the interface housing.

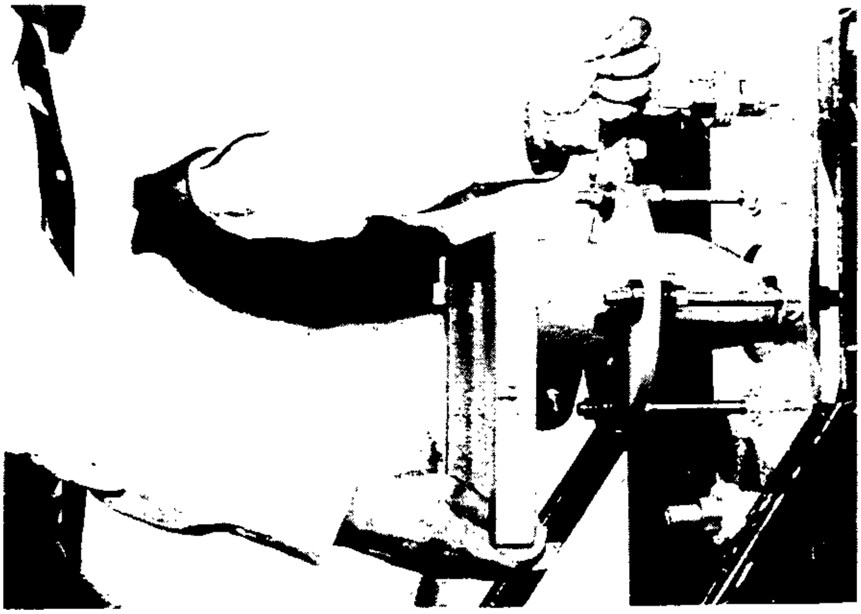


Figure 37. Inserting Air Valve Unit on Interface Housing

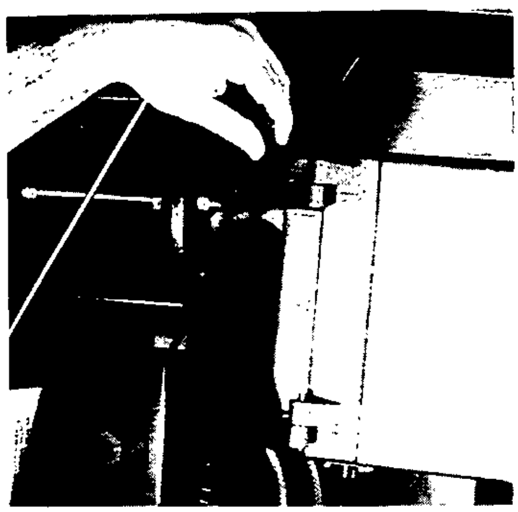


Figure 38

Tightening Hose Clamp

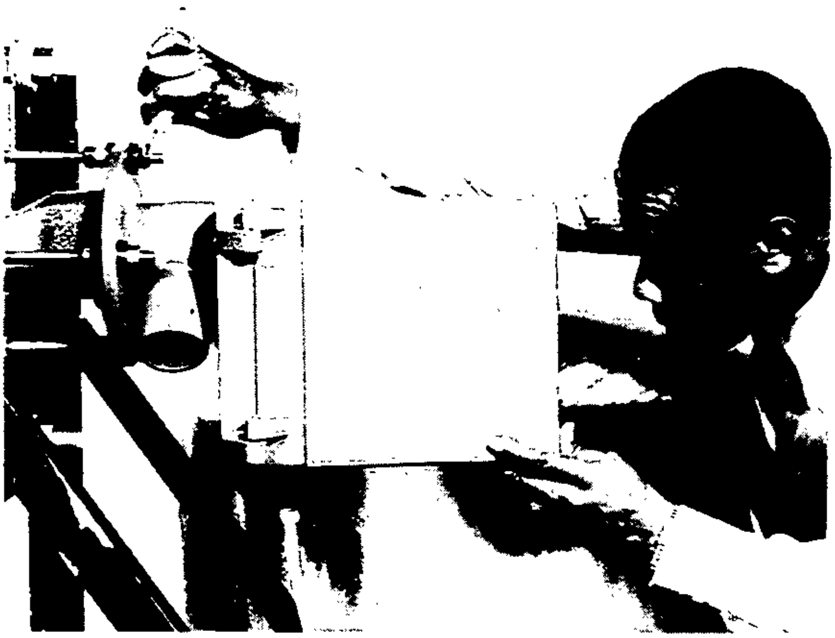


Figure 39

Adjusting Interface Housing

**CAUTION**

Be sure that the Optical Head Assembly power supply has been adjusted for the proper line voltage (see Section 2.1.4.1)

Place the Optical Head main case on the hinge pins of the interface housing as shown in Figure 40. Connect the Power and Data Cables to their respective connectors on the bottom of the main case, then close the unit and lock the fasteners. Open the access door on the back of the unit and turn on the POWER switch. The Optical Head is now installed but final alignment can only be carried out with the Retro Assembly in place.

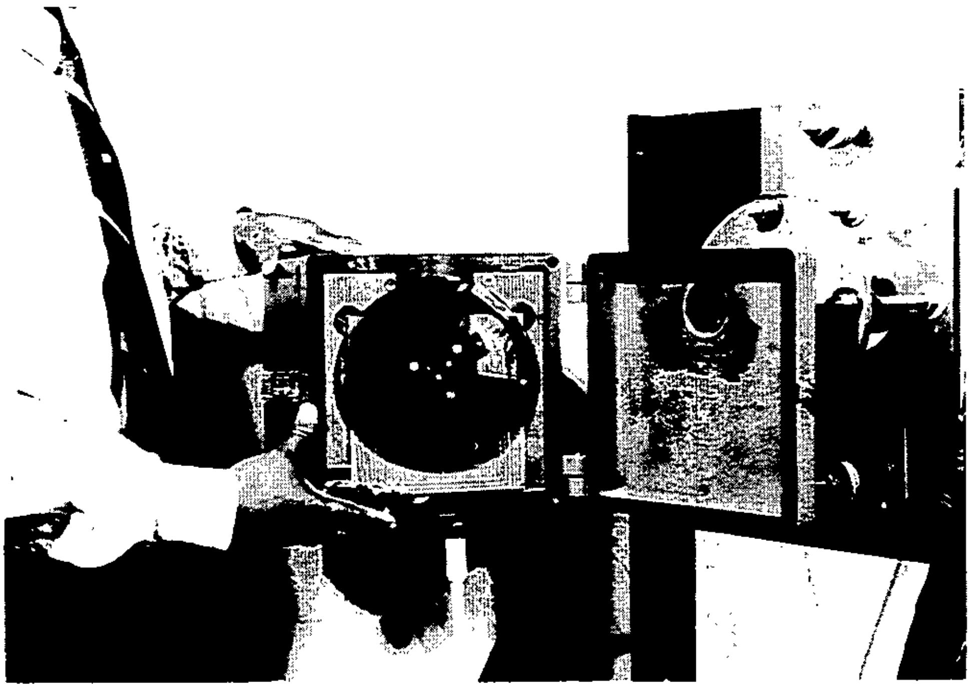


Figure 40. Optical Head Main Case on Hinges

## 4.5 RETRO ASSEMBLY FINAL ALIGNMENT

Place a hex nut and spherical washer set on each of the four threaded rods extending out from the blower mounting plate. Attach the blower hose to the inlet on the Retro Assembly housing and tighten the clamp in the same manner that it was done for the Optical Head interface housing.

**CAUTION**

At this point, power to the Blower Assemblies, when supplied as part of the Transmissometer System, must be turned on to assure air flow before the Retro Assembly is installed. Failure to comply will void the warranty.

Loosen the gasket ring hex head screws and insert the nozzle of the Air Valve Unit into the gasket ring with the flange on the threaded rods as shown in Figure 41. Withdraw the Air Valve Retro Housing Assembly to set the retro housing flange 4 5/8" from the blower mounting plate. Place another spherical washer set and hex nut on each of the four threaded rods finger-tight. Using the Alignment Tool as shown in Figure 42, adjust the hex nuts until the cross hair is centered on the bright objective lens aperture in the Optical Head Assembly across the stack. Tighten the nuts firmly for positive alignment. Tighten the gasket ring hex head screws, then attach the weather cover to the hinges on top of the blower mounting plate, close the cover, and fasten the latches.

Adjust the hex nuts on the Optical Head Assembly mounting flange as shown in Figure 43 until the cross hair in the eyepiece is centered on the bright image of the Retroreflector across the stack. Tighten the nuts firmly for positive alignment. Tighten the gasket ring hex head screws, then attach the weather cover to the hinges on top of the blower mounting plate, close the cover, and fasten the latches.

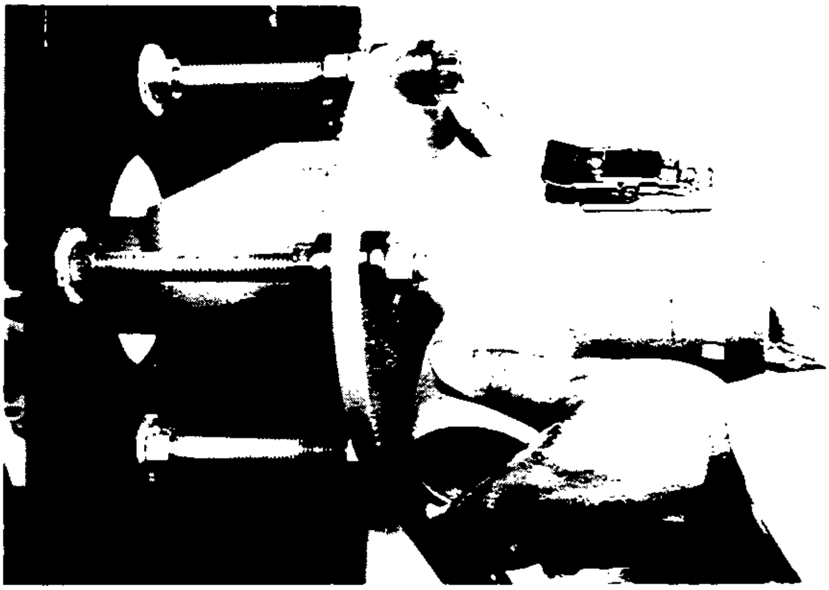


Figure 41

Mounting the Retro Assembly

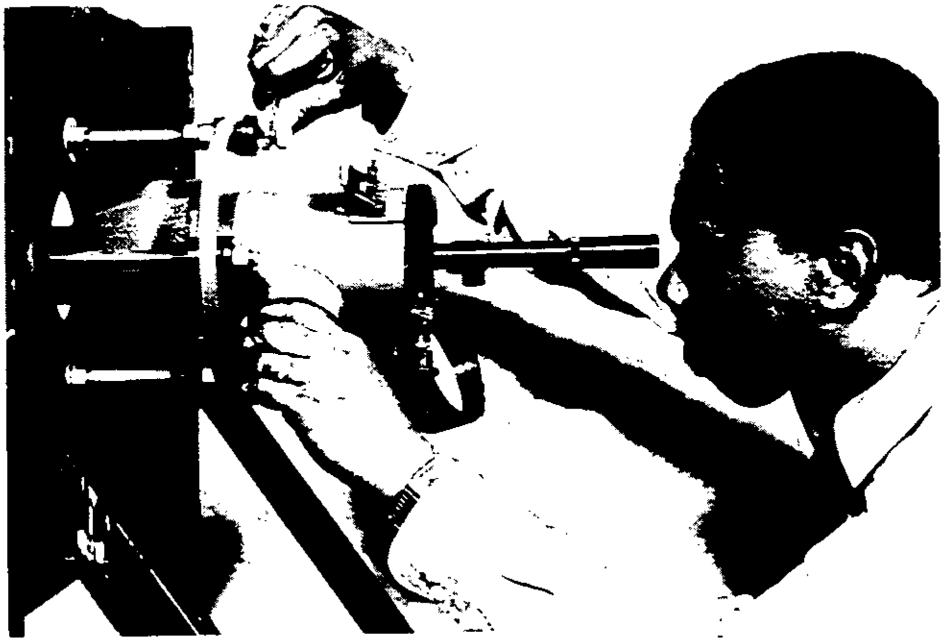


Figure 42

Using Alignment Tool

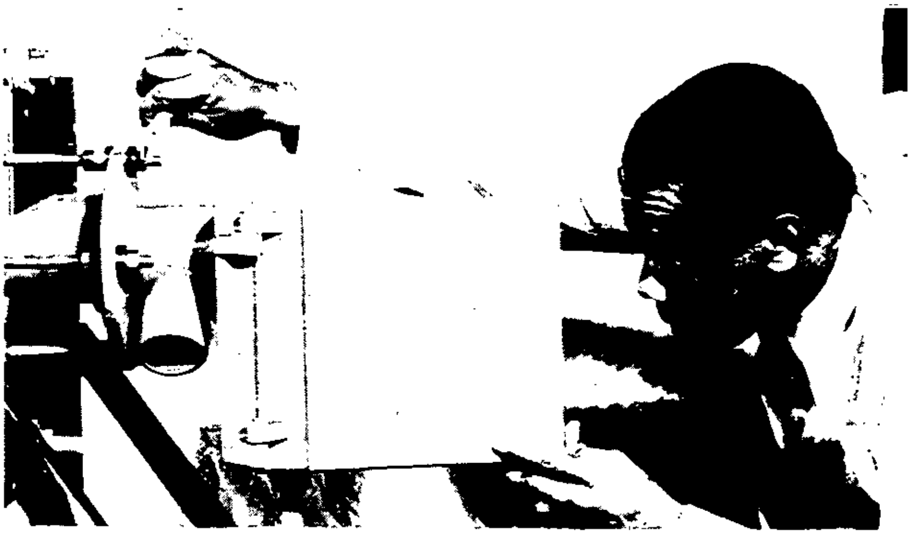


Figure 43

Final Adjustment of Optical Head Assembly

## 5.0 MAINTENANCE

The basic Transmissometer, with Air Valve Units and Blower Assemblies, is designed to operate unattended for extended periods. Very little maintenance is required although it is suggested that a routine inspection schedule be adopted to monitor the condition of the system since the physical environment will vary from one installation site to another. As part of the inspection schedule, the following items should be checked for cleanliness or serviceability. After initial installation, there should be no need for adjustments to the system unless the physical alignment or electronic settings have been disturbed. A factory representative should be consulted for equipment and component failures, warranty repairs, and field service.

There are four levels of maintenance for the Transmissometer System:

Level 1 - Routine Maintenance
Level 2 - Parts Replacement with no Adjustment
Level 3 - Parts Replacement with Adjustment or Recalibration
Level 4 - Factory Repair

**Level 1 - Routine Maintenance**

This involves cleaning the external optical windows and the chopper. Replacing the desiccator cartridges in the Optical Head and Retro Assemblies, air filters in the Blower Assemblies, and the fuse in the meter panel of the Optical Head Assembly. At this level of maintenance, the system response can also be checked using the Calibration Test Kit. This level of maintenance is preventative and diagnostic in nature and should be conducted on a regular schedule determined by environmental conditions at the instrument site. This maintenance, however, should be conducted at least quarterly.

**Level 2 - Parts Replacement With No Adjustment**

At this level of maintenance, certain basic parts and system components can be replaced without adjusting or recalibrating the system. These include the Power Supply Board, the meter and switches from the meter panel, the chopper motors and their capacitors, the blower motors, the air hose and clamps, and other external hardware items. This level of maintenance is just one step beyond Routine Maintenance, Level 1, and does not require system readjustment or recalibration.

**Level 3 - Parts Replacement With Adjustment or Recalibration**

At this level of maintenance, the entire Main Electronics Board, the lamp, Detector Assembly, optical pickups for the front chopper, and plug-in or solderable components from the Main Electronics Board may be replaced. This must be done using the instructions and/or schematics of this manual.

**Level 4 - Factory Repair**

This level of maintenance covers all other phases of maintenance or repair where internal optical alignment has been disturbed or severe physical damage has been sustained by the Transmissometer Optical Head Assembly. Under these conditions, factory tooling and adjustment systems should be used to properly effect the repairs.

In this section replacement of the most common routine maintenance items are discussed together with the replacement of the lamp, which is a Level 3 maintenance item.

## 5.1 OPTICS

At each inspection period, the protective windows over the Optical Head objective lens and the Retro Assembly Retroreflector should be cleaned. Turn off the power switch on the meter panel, open the optical case at the hinge plate, and stop the front chopper to gain access to the objective window. Open the back cover on the Retro Housing to gain access to the Retroreflector window. Clean the exposed optical surfaces with the cleaning fluid and lens tissue supplied with the Maintenance Kit. The lens tissue should be discarded after being used once to avoid scratching optical surfaces with any embedded grit picked up in the cleaning process. The reflective side of the chopper blade must also be cleaned at this time. Use common liquid dish soap and water to clean the chopper. The Calibration Test Kit and its neutral density filters should also be cleaned and free of fingerprints, oil smudges, dirt, and other contaminants before being used.

## 5.2 AIR FILTERS

During the routine inspection period these units should be checked for cleanliness. The elements can be partially cleaned with compressed air as a temporary measure, but once contaminated should be changed. The cartridges are replaced by removing the wing nut and hood of the filter unit as shown in Figures 44 and 45.

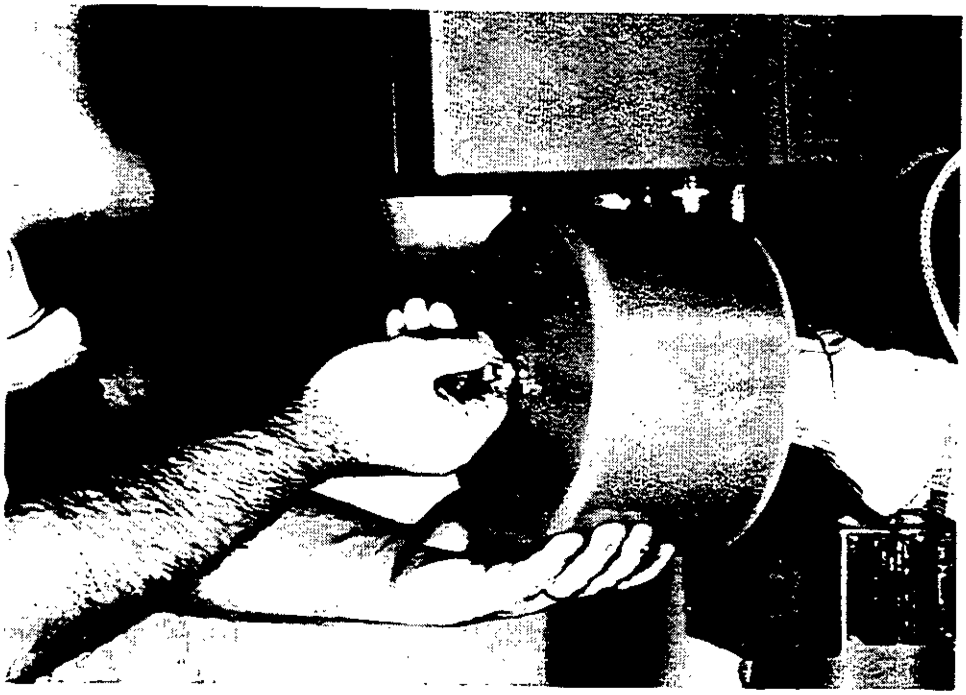


Figure 44. Loosening Filter Cover Wing Nut

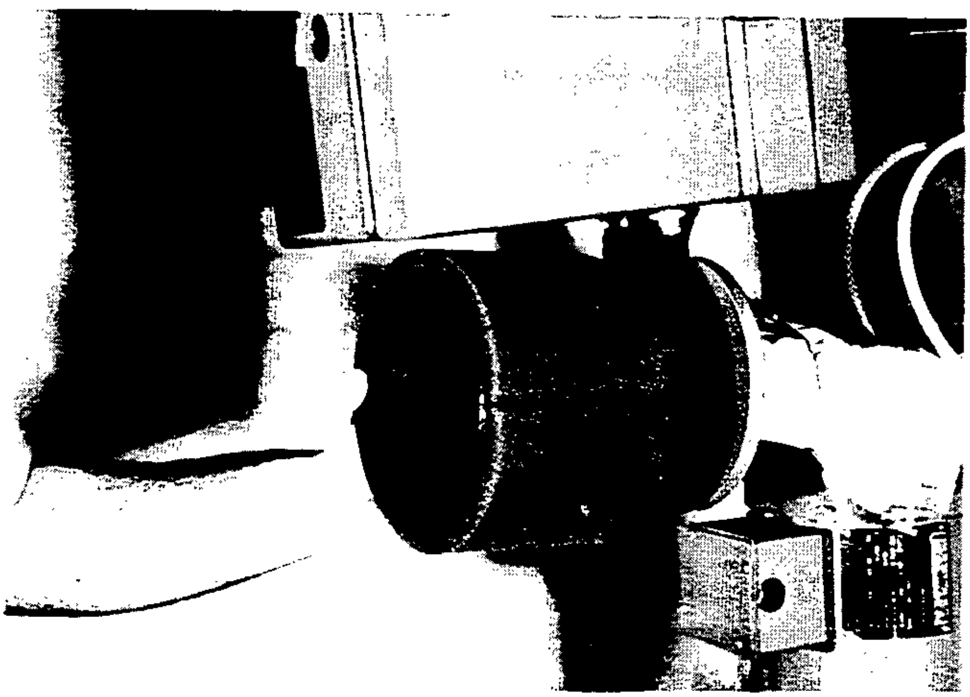


Figure 45. Removing Filter Cartridges

## 5.3 DESICCATORS

The desiccator unit located in the back surface of the cover plate of the Optical Head should be serviced when the indicating card is pink. The item should be removed from the cover, the end cap (opposite the indicator end) removed, and the desiccant cartridge replaced. The replaced desiccator material can be regenerated by drying with heat if desired.

The small desiccator cartridge in the Retro Assembly should be replaced when the material is pink in color. This cartridge and the silica gel can also be regenerated by heating if desired.

## 5.4 LAMP REPLACEMENT

A General Electric quartz-halogen lamp with a lifetime in excess of 30,000 hours is used as the light source in the Optical Head Assembly. Because of its long service life, the lamp should last about three years before replacement.

Replace the lamp as follows:

1. Remove the yellow power cord from the Optical Head.

2. Open the instrument at the hinge plate and remove the four 10-32 x 1 1/2" socket head cap screws as shown in Figure 26.

3. Remove the cover as shown in Figure 27.

4. Disconnect lamp power leads at the connector (Figure 26) and remove two 4-40 x 1/4" long socket head screws and washers (Figure 47).

5. Replace with new lamp and connector, ensuring that the leads are facing the front. Replace the 4-40 screws and washers and lightly tighten the two screws to seat the mounting pins, leaving an even exposure of the lamp base above its mounting structure.

6. Smoothly form the leads in the region adjacent to the meter support and reconnect the new lamp connector.

   **Note:** To avoid early lamp failure, clean the envelope of the new lamp with a methanol and water solution. This is required to remove fingerprints and other dirt before turning on the power.

7. Reconnect the instrument power.

Figure 46. Disconnecting Lamp Power Plug

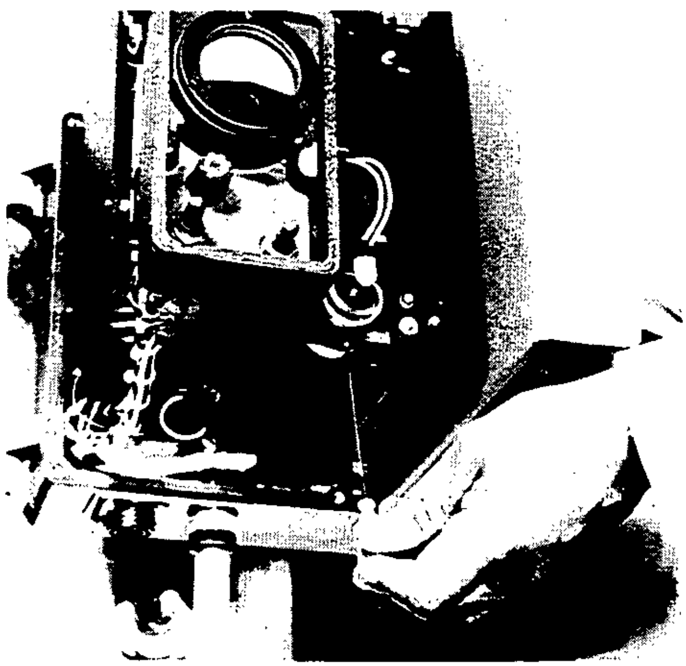


Figure 47. Removing the Lamp Screws

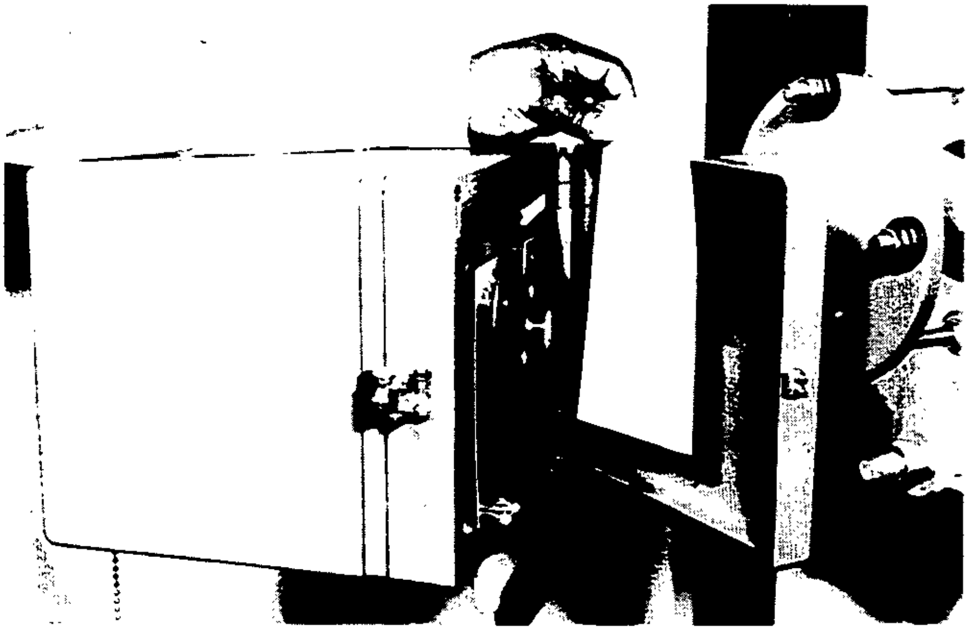


Figure 48. Centration of Filament Image

8. Place a small white card in front of the objective window as shown in Figure 48 and observe the image of the projected lamp. The lamp image must be centered both horizontally and vertically with respect to the objective aperture.

   **Note:** If the lamp image at the front of the objective is not centered, it will be necessary to adjust the position of the lamp holding bracket per Steps 9 and 10 below.

9. Slightly loosen the two socket head cap screws holding the lamp bracket (Figure 49). Should any of the screws be removed, they must be coated with Loctite Type 222 or its equivalent prior to their reinstallation.

10. Carefully move the lamp bracket to center the lamp image, then retighten the two screws lightly and alternately while preserving the centration of the lamp image. Continue to tighten in increasing amounts until the lamp bracket is firmly locked in position.

11. Recalibrate the Model 400 with the procedures described in this manual. Use the calibration appliance supplied with the instrument.

12. Replace the main cover, then close and secure the instrument for manual operation.

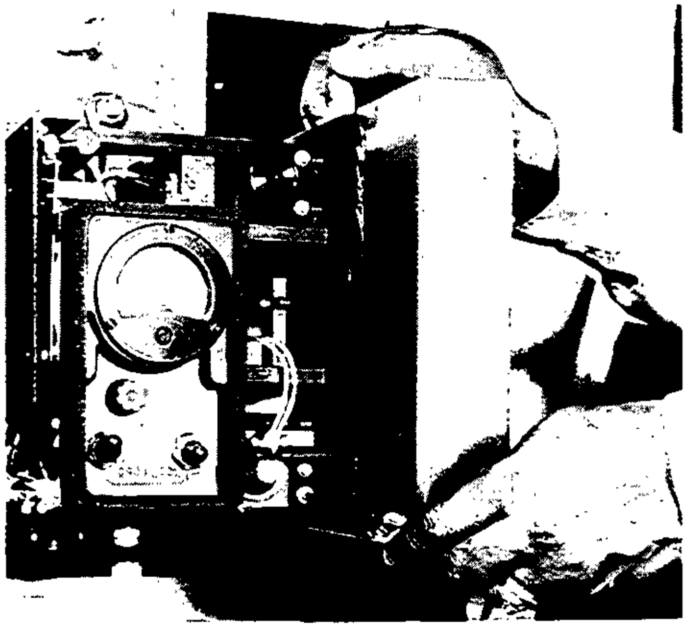


Figure 49. Loosening Lamp Bracket Screws

## 6.0 SPARE PARTS LIST

The following list, which is arranged by maintenance level category, covers major assemblies and parts that are normally replaced in accordance with routine maintenance procedures or in the case of equipment component failure. Field repairs by the customer should not be attempted without consulting a factory representative or the equipment warranty will be void. However, upon factory recommendation failed components should be immediately replaced, and the defective item, if salvageable, returned to the factory for repair or replacement.

**Note:** Items marked with an asterisk (*) are recommended spare parts which will probably require replacement during the normal course of equipment maintenance. The other items listed are recommended to minimize downtime in the event of unexpected component failure.

**Level 1 - Routine Maintenance**

| Part Number | Item |
|---|---|
| * 400-0015 (100) | Fuse, #313-3AG, 1/2 Amp Slow-Blow |
| * 400-0015 (101) | Dri Cap Dehydrator Retro Assembly |
| * 400-0015 (102) | Indicating Desiccator, Optical Head Assembly |
| * 400-0015 (103/104) | Lens Cleaning Solution |
| * 400-0015 (105) | Lens Tissue |
| * 400-0015 (106) | Air Filter Blower Unit |

**Level 2 - Parts Replacement With No Adjustment**

| Part Number | Item |
|---|---|
| 007-0178 | Power Supply Board |
| 400-0013 (100) | Blower Motor |

**Level 3 - Parts Replacement With Adjustment or Recalibration**

| Part Number | Item |
|---|---|
| 007-0524-1, -2 | Main Electronics Board |
| 400-0010 (114) | Lamp |

# 7.0 WARRANTY AND FIELD SERVICES

## 7.1 WARRANTY

All goods sold hereunder are warranted to be free from harmful defects in material and workmanship and to conform to the specifications, if any, agreed upon between the Purchaser and Thermo Environmental Instruments Inc. or in the absence of such specifications, to the cataloged description. This express warranty is in lieu of and excludes all other warranties, express or implied, by operation or law or otherwise. In no event shall Thermo Environmental Instruments Inc. be liable for consequential or special damages. Thermo Environmental Instruments Inc. agrees to rework or replace, at its option, any defective goods provided we are notified of such defects within ninety (90) days after receipt of the goods by the Purchaser or such other period as may be mutually agreed upon. Transportation charges on goods claimed to be defective will be allowed only in case defects are found by Thermo Environmental Instruments Inc. to exist, and not otherwise. All goods claimed to be defective should be returned to the point of manufacture unless otherwise advised.

## 7.2 FACTORY SERVICE

Defective equipment not covered by the warranty will be repaired at the factory on a time and material basis. Equipment received for repair will be inspected and the cost for all requested and/or necessary repairs will be quoted to the customer. No repair work will be initiated without the customer's written authorization to proceed. All shipping charges will be paid by the customer.

## 7.3 FIELD SERVICE

The costs of maintenance or repair of Thermo Environmental Instruments Inc. equipment not covered by the warranty and conducted on the customer's site will be charged on a time and material basis. The time charges will include travel time to and from the customer's facility and actual on-site service time. Premium labor rates will be charged for overtime and for Saturday and Sunday work. Material charges will include the cost of replacement parts not covered by the warranty and any additional parts or materials requested by the customer for that particular installation. Equipment not repairable on-site will be removed by Field Service personnel upon customer's authorization and returned to the factory for the required work. Repaired equipment will be returned to the customer for reinstallation. Assistance in reinstallation by Thermo Environmental Instruments Inc. Field Service personnel will be charged on a time and material basis. Additional on-site service of the repaired or replaced equipment within 30 days of the reinstallation will be provided at no extra charge, and will be considered as part of the original service call.

Calibration for a given installation is normally completed at the factory prior to shipment of the instrument. Should the instrument be required at a different location within the customer's facility, where the flange to flange distance is different than that at the initial installation, the instrument must be recalibrated. The instructions in Sections 3.0 and 4.0 of this manual are to be used to perform the calibration function and installation work. Assistance in this effort can be provided on a time and material basis. Two instrument support stands, as shown in Figure 20 are recommended as an aid in performing the calibration function. The mounting flanges, Thermo Environmental Instruments No. 400-1003 or equivalent, must be fixed in place by the customer prior to the arrival of Field Service personnel to avoid expending service time waiting for the completion of the flange installation. The site must also be wired for power. **FAILURE TO DO THIS WILL RESULT IN ADDITIONAL CHARGES.** Factory personnel should be consulted in the case of unusual installation requirements, such as stack or duct offsets greater than 1 foot each side, and Data Cable lengths longer than 5,000 feet.

## 7.4 MAINTENANCE SERVICE

A maintenance contract is also offered by Thermo Environmental Instruments Inc. for the inspection and service of installed Transmissometer equipment. Due to the individual nature of each installation, the maintenance contract cost is based on the amount, location, and type of equipment at each site and any local labor requirement conditions. The service includes periodic visits to the installation site to perform all routine maintenance required, to make any system adjustments considered necessary, and to replace or repair faulty or failed parts that are still under warranty. Equipment under warranty that <u>must</u> be returned to the factory will be repaired and failed parts replaced at no charge.

Equipment or parts failed or damaged that are not under warranty will be replaced with only a material charge to the customer, provided the repairs can be made on-site. Equipment that must be removed form the site and returned to the factory for repair will be subject to the normal factory service time and material charges. Reinstallation and any further service work on-site will be considered covered under the maintenance contract currently in force.

# Florida Department of
# Environmental Protection

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

Lawton Chiles
Governor

Virginia B. Wetherell
Secretary

October 7, 1993

Ms. Jewell Harper, Chief
Air Enforcement Branch
United States Environmental
Protection Agency
Region IV
345 Courtland Street, N.E.
Atlanta, Georgia 30065

Re: Amendment of Permit No. PSD-FL-151

Dear Ms. Harper:

Ogden Martin Systems, Inc. has requested that the referenced permit for the Lee County Solid Waste Energy Recovery Project be amended to authorize a higher air-to-cloth ratio for the ash handling building dust collection and ventilation system. The amendment will not allow an increase in permitted annual emissions of any air pollutant.

The Department finds their proposal acceptable and has drafted the enclosed amendment to permit No. PSD-FL-151. Because this facility is subject to Florida's Power Plant Certification regulations, we request EPA review and approval of the enclosed draft amendment.

Sincerely,

C. H. Fancy, P.E.
Chief
Bureau of Air Regulation

CHF/TH/bjb

Enclosure

cc: J. Heron
D. Knowles
J. Greshler

October 7, 1993

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

Mr. Joseph R. Treshler
Vice President
Ogden Martin Systems, Inc.
P. O. Box 709
Brandon, Florida 23509-0709

RE: Lee County Solid Waste Energy Recovery Facility
PSD-FL-151

Dear Mr. Treshler:

The review of your September 17, 1993 letter requesting an administrative change to the conditions of the Prevention of Significant Deterioration permit (PSD-FL-151) issued to Lee County Utilities on July 20, 1992, for the waste to energy recovery facility has been completed. You requested that Specific Conditions 4e. of the permit be revised to authorize a higher air-to-cloth ratio for the ash handling building dust collection and ventilation system.

The basis of your request is that the 0.010 grains/dscf is achievable using a standard industrial HVAC baghouse having an air-to-cloth ratio within the range of 8:1 to 10:1.

Based on the foregoing, it is determined that the proposed revision to the Specific Conditions 4e. of PSD-FL-151 is acceptable and will not result in an increase in permitted annual emissions of any pollutant subject to the PSD regulations. As an administrative change, this revision will not require additional public participation procedures.

Authority to construct a stationary source was granted for the Lee County Solid Waste Energy Recovery Facility project, subject to the conditions in the permit to construct on July 20, 1992. This administrative change to PSD-FL-151 does not alter the commence construction deadline for this facility. This authority to construct is based solely on the requirements of 40 CFR 52.21, the federal regulations governing significant deterioration of air quality, and in no way affects the approvals under other federal or State regulatory authorities. Please be advised that a violation of any condition issued as part of this approval, as well as any construction which proceeds in material variance with information submitted in your application, may subject Lee County Solid Waste Energy Recovery Facility project to an enforcement action.

Any questions concerning this administrative permit revision may be directed to Mr. Winston A. Smith, Director; Air, Pesticides, and Toxics Management Division at (404) 347-3043.

Sincerely,

Patrick M. Tobin
Acting Regional Administrator

Enclosure

cc: C. H. Fancy, FDEP

The Specific Conditions of federal permit PSD-FL-151 shall be modified as follows:

Specific Condition No. 4e

FROM:

4.e Baghouse Operations

All baghouses (except for lime silo dust collector) shall be equipped with pressure drop monitoring equipment. Baghouses shall have a maximum air to cloth ratio of 4:1. Extra bags shall be maintained at the site for emergency purposes.

TO:

4.e Baghouse Operations

**All baghouses (except for lime silo dust collector) shall be equipped with pressure drop monitoring equipment. Extra bags shall be maintained at the site for emergency purposes. Baghouse (combustion units) shall have a maximum to cloth ratio of 4:1. Baghouse (ash handling building dust collection system) shall have a maximum air-to-cloth ratio of 10:1.**

# OGDEN MARTIN SYSTEMS OF LEE, INC.

40 LANE ROAD
CN 2615
FAIRFIELD, NJ 07007-2615
(201) 882-9000

July 7, 1993

RECEIVED
JUL 13 1993
Division of Air
Resources Management

Bureau of Air Regulation
2600 Blair Stone Road
Tallahassee, FL 32399-2400

Attention: C. H. Fancy, P.E.

Florida Department of Environmental Regulation
South District Office
2295 Victoria Avenue
Suite 364
Ft. Myers, FL 33901

Attention: Philip Barbaccia

**Reference: Lee County Solid Waste Resource Recovery Facility
Ft. Myers, FL
Project C-1033**

**Subject: Information of the Continuous Emission Monitoring Devices
Power Plant Site Certification No. 90-3942 EPP (PPSC)
PSD Permit No. PSD-FL-151 (PSD)**

Gentlemen:

On behalf of Lee County, the permittee of the above reference PPSC and PSD, Ogden Martin Systems of Lee, Inc. has prepared and herewith submits to the Bureau of Air Regulation and to the South District Office of the Florida Department of Environmental Regulation four (4) copies of information covering the continuous emissions monitoring (CEM) devices for the Lee County Solid Waste Resource Recover Facility in accordance with the subject PPSC and PSD.

The Specific Conditions in the PPSC and the PSD that specifically require the submittal of the information provided herein are as follow:

PPSC: Sections XIV.A, XIV.A.2(b), and XIV.A.2(d)

PSD: Sections 3.b and 3.d

The information and plans provided herein are consistent with approved design concepts, regulations, and the Conditions of Certification.

This completes the submittals required to satisfy the above listed Sections of the PPSC and PSD.

Do not hesitate to call at (201) 882-7246 if you have any questions or further needs.

Very truly yours,

L Peter Young

L. Peter Young
Assistant Vice President
Project Management

LPY:rj
02LeeCo.Ltr

Encl.

cc: D. Cerrato - Malcolm Pirnie (w/1 set)
D. Markley - Malcolm Pirnie (w/1 set)
L. Sampson - Lee County (w/1 set)
J. Kowal - OMSL (w/1 set)
L. Ware - UE&C (w/1 set)
pf 5.1 FDER

G. Harper, EPA
B. Oven
D. Knowles

# OGDEN MARTIN SYSTEMS OF LEE, INC.

40 LANE ROAD, CN 2615
FAIRFIELD, NJ 07007-2615

TEL: (201) 882-9000
FAX: (201) 882-4199

AN OGDEN PROJECTS COMPANY


**VIA FIRST CLASS MAIL**

RECEIVED
JUN 17 1993
Division of Air Resources Management

June 15, 1993

Bureau of Air Regulation
2600 Blair Stone Road
Tallahassee, FL 32399-2400
Attention: C.H. Fancy, P.E.

Florida Department of Environmental Regulation
South District Office
2295 Victoria Avenue
Suite 364
Ft. Myers, Florida 33901
Attention: Philip Barbaccia

Reference: Lee County Solid Waste Resource Recovery Facility
Ft. Myers, Florida
Project C-1033, Our Ref. LE0709L

Subject: SAMPLING PORT LOCATIONS
POWER PLANT SITE CERTIFICATION NO. 90-3942 EPP (PPSC)
PSD PERMIT NO. PSD-FL-151 (PSD)

Gentlemen,

On behalf of Lee County, the Permittee of the above referenced PPSC and PSD, OMSL has had prepared and herewith submits to the Bureau of Air Regulation and to the South District Office of the Florida Department of Environmental Regulation four (4) prints of the Facility's stack general arrangement drawing No. 92-188-1 revision 1, dated 5/10/93 and the flue gas cleaning system general arrangement drawing no. 726-GA-02, revision 1, dated 5/10/93 in accordance with the subject PPSC and PSD.

pja/2901

The Specific Conditions in the PPSC and PSD that specifically require the submittal of the information provided herein are as follows:

| Specific Condition | | Subject |
|---|---|---|
| PPSC | PSD | |
| XIV.A (page 8) | 3.d (page 11) | Stack and air pollution control equipment outlet duct drawings showing sampling locations. |
| XIV.A.2.b &d (page 12) | 3.b (page 10) | Continuous emissions monitoring and test sampling port locations. |

The plan provided herein is consistent with approved design concepts, regulations, and the Conditions of Certification. Monitoring equipment specifications will be submitted shortly and the operation and maintenance manuals and calibration procedures shall be submitted prior to installation.

Do not hesitate to call at (201) 882-7246 if you have any questions or further needs.

Very truly yours,

L. Peter Young

L. Peter Young
Assistant Vice President -
Project Management

cc: L. Sampson - Lee County (w/1 set)
D. Cerrato - Malcolm Pirnie (w/1 set)
D. Markley - Malcolm Pirnie (w/1 set)
L. Ware - UE&C w/1 set)
D. Knowles, SF Dist
J. Harper, EPA
B. Oven

pja/2901

**OGDEN MARTIN SYSTEMS OF LEE, INC.**

40 LANE ROAD
P.O. BOX 2615
FAIRFIELD, NJ 07007-2615
(201) 882-9000

RECEIVED

MAR 12 1993

Bureau of Air Regulation

AN OGDEN PROJECTS COMPANY

REDISTRIBUTED 3-10-93 WITH ATTACHMENTS

**VIA FIRST CLASS MAIL**

March 4, 1993

Bureau of Air Regulation
2600 Blair Stone Road
Tallahassee, FL 32399-2400

Attention: C.H. Fancy, P.E.

Reference: Lee County Solid Waste Resource Recovery Facility
Ft. Myers, Florida
Project C-1033, Our Ref. LE0329L

Subject: AIR POLLUTION CONTROL SPECIFICATION
POWER PLANT SITE CERTIFICATION (PPSC) NO. 90-3942EPP

Dear Mr. Fancy,

On behalf of Lee County, the permittee, Ogden Martin Systems of Lee, Inc. hereby submits four (4) copies of complete specification information for the Air Pollution Control System for the referenced project. This information is being submitted pursuant to the Power Plant Site Certification for the Lee County Solid Waste Resource Recovery Facility, Case No. 90-3942EPP, Appendix A, Item XIV.A.

This specification titled "TECHNICAL SPECIFICATION FOR AIR POLLUTION CONTROL SYSTEM" SPEC NO. SM-105, ISSUE 006, DATE 12-06-91, REVISION 6, DATED 2/5/93" effectively provides the make and model number information as required.

pja/2709

Please contact me at (201) 882-7246 if you have any questions or require further information. Please note that the specification for the Municipal Waste Combusters was transmitted to your office on February 12, 1993 and the specification for continuous emissions monitoring system and stack drawings will be submitted at a later date.

Very truly yours,

L. Peter Young

L. Peter Young
Assist. V.P. - Project Management

cc: P. Barbaccia/D. Knowles (w/att.) - South District
L. Sampson (w/att.) - Lee County
D. Markley (w/att.) - Malcolm Pirnie
D. Cerrato (w/att.) - Malcolm Pirnie
L. Ware (w/att.) - UE&C
J. Kowal
J. Treshler (w/att.)
pf 5.1 FDER
J. Harper, EPA
D. Bunyak, NPS
B. Owen

pja/2709

# OGDEN MARTIN SYSTEMS OF LEE, INC.

40 LANE ROAD
P.O. BOX 2615
FAIRFIELD, NJ 07007-2615
(201) 882-9000

AN OGDEN PROJECTS COMPANY

RECEIVED

MAR 09 1993

Division of Air Resources Management

**VIA FIRST CLASS MAIL**

March 4, 1993

Bureau of Air Regulation
2600 Blair Stone Road
Tallahassee, FL 32399-2400

Attention: C.H. Fancy, P.E.

Reference: Lee County Solid Waste Resource Recovery Facility
Ft. Myers, Florida
Project C-1033, Our Ref. LE0329L

Subject: AIR POLLUTION CONTROL SPECIFICATION
POWER PLANT SITE CERTIFICATION (PPSC) NO. 90-3942EPP

Dear Mr. Fancy,

On behalf of Lee County, the permittee, Ogden Martin Systems of Lee, Inc. hereby submits four (4) copies of complete specification information for the Air Pollution Control System for the referenced project. This information is being submitted pursuant to the Power Plant Site Certification for the Lee County Solid Waste Resource Recovery Facility, Case No. 90-3942EPP, Appendix A, Item XIV.A.

This specification titled "TECHNICAL SPECIFICATION FOR AIR POLLUTION CONTROL SYSTEM" SPEC NO. SM-105, ISSUE 006, DATE 12-06-91, REVISION 6, DATED 2/5/93" effectively provides the make and model number information as required.

pja/2709

Please contact me at (201) 882-7246 if you have any questions or require further information. Please note that the specification for the Municipal Waste Combusters was transmitted to your office on February 12, 1993 and the specification for continuous emissions monitoring system and stack drawings will be submitted at a later date.

Very truly yours,

L. Peter Young

L. Peter Young
Assist. V.P. - Project Management

cc: P. Barbaccia/D. Knowles (w/att.) - South District
L. Sampson (w/att.) - Lee County
D. Markley (w/att.) - Malcolm Pirnie
D. Cerrato (w/att.) - Malcolm Pirnie
L. Ware (w/att.) - UE&C
J. Kowal
J. Treshler (w/att.)
pf 5.1 FDER

pja/2709

OGDEN MARTIN SYSTEMS
of LEE, Inc.

SPEC NO. SM-105
ISSUE 006
DATE 12/06/91

TECHNICAL SPECIFICATION

FOR

AIR POLLUTION CONTROL SYSTEM

Facility Name: LEE COUNTY RESOURCE RECOVERY FACILITY

Location: LEE COUNTY, FLORIDA

*****************************************************************************



*****************************************************************************

Specification Prepared By: Name: OGDEN MARTIN SYSTEMS

Address: FAIRFIELD, NJ

Telephone: 201-882-9000

Approved for Release:

| | Printed Name | Signature | Date |
|---|---|---|---|
| 1. | R. TERRAMOCCIA | | 1/23/91 |
| 2. | R. TERRAMOCCIA | | 11/15/91 |
| 3. | R. TERRAMOCCIA | R. Terramoccia | 1/16/92 |
| 4. | R. TERRAMOCCIA | | 9/3/92 |
| 5. | R. TERRAMOCCIA | | 11/9/92 |
| 6. | R. TERRAMOCCIA | | 11/20/92 |
| 7. | R. TERRAMOCCIA | R. Terramoccia | 2/25/93 |

## REVISIONS

| | | |
|---|---|---|
| 001 | Initial Issue .................................................. | 1/01/87 |
| 002 | Revision ........................................................ | 7/24/87 |
| 003 | Revision ........................................................ | 10/28/87 |
| 004 | Revision ........................................................ | 8/05/88 |
| 005 | Revision ........................................................ | 12/28/90 |
| 006 | Revision ........................................................ | 12/06/91 |

OGDEN PROJECTS INC.

TECHNICAL SPECIFICATION
FOR
AIR POLLUTION CONTROL SYSTEM

## TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

# TABLE OF CONTENTS

TABLE OF CONTENTS

## 1.0 GENERAL

This Specification details the technical requirements for the design, fabrication, shop testing, delivery, erection, field testing, start-up, and initial operation of the Air Pollution Control (APC) System for a municipal waste-to-energy facility. Where a conflict exists within this Document (this includes all the attachments listed in the Table of Contents, the more stringent requirement shall apply; if the conflict is not a case of more or less stringent, then the order of priority shall be 1) Air Permit (Attachment 9), 2) Service Agreement (Attachment 12), and 3) remainder of the Specification. All conflicts shall be brought to the attention of the Purchaser.

In general, the APC system shall include one or more trains of experience-proven equipment, complete with all ductwork and accessories. Each train shall be sized for the Design gas flow of one refuse fired boiler, reference Attachment 2. The equipment provided shall include a system complete in every detail except as specifically excluded herein.

System configuration shall be as indicated in Attachment 1. If multiple configurations are indicated in Attachment 1, separate proposals shall be provided for each required configuration.

It is the intent of this Specification that the Seller provide and install a complete "stand-alone" system. All Purchaser-supplied utilities, foundations, erection support, etc must be clearly defined by the Seller.

**NOTE THAT PROJECT SPECIFIC REQUIREMENTS ARE INCLUDED IN SECTION 4.4.**

### 1.1 Scope

The scope of Seller's supply for the Air Pollution Control equipment begins at the outlet flanges of the Purchaser's economizer and extends through the scrubber vessel (spray dryer), baghouse (or precipitator), and I.D. fans to the inlet flange at the stack. The scope of Seller's equipment supply for the reagent preparation system begins at the truck connection to the lime storage silo and extends to the dry scrubber. Lime will be delivered by trucks with pneumatic unloading systems.

### 1.2 Work to be Provided

The Seller shall furnish the following equipment, material, and services. The listing below is not intended to be complete. The Seller shall furnish all equipment, material, erection, and services required to provide a complete, readily maintained, and properly operating APC system, which satisfies the performance guarantees and requirements of this Specification.

1.2.1 Acid Gas Removal System

Scrubber complete with atomization equipment, gas distribution devices, external stiffeners, access door, and hopper.

Scrubber vessel atomizer/nozzle enclosure complete with heating and ventilation system, spare atomizer/motor assembly stand, an overhead monorail/trolley/hoist system for systems with removable components weighing in excess of 40 pounds, atomizer or nozzle maintenance area, hoist area, and eye wash facility.

All access platforms, stairs and/or ladders for the reagent preparation system, the scrubber vessel, the baghouse or precipitator and auxiliaries.

Truck unloading equipment including fill pipe and quick disconnect truck fittings.

Lime silo complete with prime/finish paint, relief valves, pneumatic filling connection, dust collection equipment, hopper(s), vibrators, isolation gate(s), level probes, hoist and caged ladder to roof (unless accessed from scrubber platform). Volumetric feeder(s) complete with automatic controls.

Slaker-classifier system including grit removal equipment, feed water preheaters for slaker start-up, if required, and vapor and dust venting and collection equipment. Vibrating screen to screen the slurry return from the atomizer, if required.

Lime slurry storage tank, and all other tanks required in the reagent preparation system. Slurry tanks shall be complete with baffles and top mounted agitators to prevent settling of solids. All slurry and water pumps required in the APC system.

Slurry piping and valves and all water, and air piping within the APC system (including thermal and anti-sweat insulation, heat tracing, pipe supports and hangers).

Water flushing system to clear all slurry piping, valves, pumps, tanks, atomizer and other equipment in the APC system which carries slurry.

Reagent preparation equipment enclosure complete with heating and ventilation system, and emergency shower and eye wash facilities.

Complete control system for scrubber, lime storage and slurry preparation system to control acid gas emissions, monitor slurry atomization, monitor and control lime preparation and interface with Purchasers controls.

1.2.2 Baghouse

Baghouse shall be either high ratio (pulse jet) or low ratio (reverse air) design consisting of multiple independent modules. Baghouses of the structural design (i.e., adjacent modules share a common wall) may be furnished for reverse air baghouses. The baghouse shall include steel plate pyramidal hoppers and a[illegible] necessary auxiliaries such as access platforms, doors and ladders, structural steel supports, flow distribution devices, flue gas bypass, all dampers with operators, bags, bag cages, etc. Reverse air or pulse-jet cleaning system including reverse gas fan, ductwork, dampers and controls.

Complete baghouse control system to monitor pressure drop, initiate and perform baghouse cleaning, interlock with Purchaser's controls, and bypass baghouse under emergency conditions.

### 1.2.3 Precipitator

Multiple (4 minimum) field electrostatic precipitator with appropriate gas distribution devices to provide a uniform flow across all flow passages. The precipitator shall include a pressurized walk-in penthouse including pressurization system, rigid discharge electrodes, impact type rapping system, steel plate troughed hoppers and key interlocked access doors.

Complete precipitator control system including automatic programmable controller system for optimum precipitator energization, independent rapper controls for each field, ground detection and interlocks with the purchaser's control system.

Portable grounding cables with insulated extension handles for use during internal inspection to ensure proper grounding of the high voltage system.

Transformer/rectifier power supplies with high-voltage bus and bus ducts between the transformer/rectifiers and discharge electrodes.

### 1.2.4 Ductwork

All ductwork from the Purchaser's economizer outlet flange to the absorber vessel, all ductwork from the scrubber vessel to the baghouse or precipitator, all baghouse or precipitator compartment inlet and outlet ductwork, all baghouse bypass ductwork, ductwork from the baghouse or precipitator outlet to the I.D. fan and ductwork from the I.D. fan to the stack. The ductwork shall be complete with external stiffeners, baffles, gas distribution plates, turning vanes and vane stiffeners for all turns, expansion joints, test ports, instrument connections, access doors and structural supports.

Particulate fallout hoppers with hopper heaters as required including those determined necessary by the model study, if required by paragraph 4.4.2.

### 1.2.5 Structural

All structural supporting steel from top of concrete foundations required to support the scrubber vessel, baghouse or precipitator, screw conveyors, and ductwork. All structural steel from top of foundations for equipment enclosures and the complete reagent preparation system including all steel required for the reagent preparation building and lime bin.

Platforms, walkways, grating, stairs, ladders/cages, safety chains, and handrails from top of foundations for access to all areas requiring maintenance, inspection, and cleanout: including the scrubber vessel penthouse, baghouse or precipitator roof, all access doors in the scrubber vessel, baghouse or precipitator, instrument connections and ductwork test ports, and all other required access locations. The Seller shall supply all platforms, walkways, grating, stairs, ladders/cages, safety chains and handrails for the complete reagent preparation system. Hopper access platforming is not required.

All framing and girts required for all enclosures. All architectural materials including floor forms, roof decks, roofing and accessories, wall panels, masonry walls, insulated siding and roofing, personnel and equipment access doors and door hardware, louvers, vent stacks, windows, flashing, seals, and weatherstripping. Exterior and interior architectural finishes.

1.2.6 Electrical

Electrical equipment to be supplied by Seller shall include but not necessarily be limited to 480 Volt power switchboards, 480 volt motor control centers, control panels, motors, above grade grounding system, cable tray and conduit, wire and cable, interior lighting system, 480V power receptacles and 120V convenience outlets, heat tracing. See Attachment No. 4 for typical power distribution.

1.2.7 Controls and Instrumentation

A complete control system for remote control and monitoring of the acid gas removal system, reagent preparation system, and baghouse or precipitator in accordance with Attachment 10.

All primary and final control devices required for the complete APC system including control valves, dampers, and drives. All local controls including transmitters, control panels necessary for the reagent preparation system and atomizer/nozzle assemblies. Hopper heater and vibrator controls, motor controls, and ductwork instrumentation.

1.2.8 ID Fans

The supply of ID Fans (if required in Paragraph 4.4.3) as specified in SM-104 and the complete erection of the fan including insulation and lagging, mounting all fan controls and instruments (damper drives, vibration and temperature instruments, etc.), instrument air, cooling water (if required) and connecting external ductwork.

1.2.9 Erection and Start Up

The complete erection and start up of the system.

1.2.10 Engineering

The complete design and specification of all components of the system. All specification and design data shall be provided to the purchaser.

1.2.11 Miscellaneous Services

Air compressors for slurry atomization including receivers.

Insulation and lagging for all surfaces subject to elevated temperatures.

All buildings to house the quoted equipment (i.e., lime slurry preparation/feed system, air compressors, MCC's, controls, etc.). Buildings to include heating, ventilation, lighting, 120V receptacle, siding to match facility, gutters/downspouts sized for a 25 yr/5 minute rainfall.

Site training program for Purchaser's personnel.

Emergency shower and eyewash stations.

Service air piping and hose stations throughout APC system.

Construction of optional flow model and performance of model studies if required in Paragraph 4.4.2.

Shop cleaning, surface preparation, and painting as described in attached Specification SA-550.

Shimming of all structural steel base plates and equipment.

All facilities and personnel necessary to perform all shop tests and inspections as specified herein.

Instrument connections for Purchaser's instruments on the scrubber and I.D. fan inlet ducts (see Section 2.6.1). Test ports on scrubber inlet and I.D. fan inlet and outlet ducts (see Section 2.6.1).

Installation, Start-up Operating and Maintenance Manuals covering the overall system as well as the individual components. Final record ("As-Built") drawings and reproducibles (Mylars), as required per attachment 13, showing all field changes and modifications.

1.3 Work by Others

The following work will be provided by others:

Foundations for structures and equipment, complete with anchor bolts.

Grouting of all structural steel base plates and equipment.

Ash removal system from scrubber/precipitator or baghouse hopper discharge flanges to disposal. However, Seller shall coordinate design with ash handling system for required conveyor rights-of-way, structural support, clearances and maintenance space.

Permanent outdoor area lighting on and about the installation.

Electrical power supply to Seller's switchgear/MCC as specified herein, and wiring from Seller's junction box to Seller's control panel in the control room (Ref. Attachment 10).

I.D. fan foundations, anchor bolts, power feed from Purchaser's MCC and instrument/control wiring.

Service, Instrument and pulse-jet air (if required) and water supplies to single terminal locations.

Underground electrical grounding loop for equipment.

APC system outlet and inlet (if required by air permit) flue gas monitors.

Touch-up and finish painting of uninsulated external ferritic steel.

## 2.0 TECHNICAL REQUIREMENTS

### 2.1 Basis of Design

#### 2.1.1 General

The APC system shall use lime reagent to remove $SO_2$, HCl and HF from the flue gas. The waste formed in the acid gas removal process shall be dry and be capable of being readily collected in the baghouse or precipitator.

Seller shall design the APC system in accordance with the following requirements. Establishment of Expected Operating and Design values in this specification does not relieve the Seller of its responsibility to design equipment that will meet or exceed all performance requirements. If the Seller's design dictates that these design parameters are insufficient to meet the specified performance required under all conditions of operation while providing a safe, reliable operating unit, it is the Seller's responsibility to use other design parameters, as approved by the Purchaser, required to meet the specified performance.

The APC system shall be capable of continuously producing a dry, free flowing waste product that will flow out of the scrubber vessel and baghouse or precipitator hoppers without plugging while meeting all of the requirements of the specification and the air permit (Attachment 9).

The APC system shall be capable of continuous boiler load following from minimum to maximum load while meeting all of the requirements of the Specification.

The structural design temperature range for the APC system including all ductwork, expansion joints, scrubber vessel, and baghouse or precipitator shall be 19°F to 600°F.

The structural design pressure range for the APC system including all ductwork, expansion joints, scrubber vessel and baghouse or precipitator shall be ±25 inches water.

Structural steel design for the APC system equipment shall be in accordance with SS-410, Structural Steel Specification. Stresses for normal operating temperatures, pressures, and ash loadings shall be considered in the design. Equipment transient pressures will be considered similar to wind in that a one-third increase in allowable stresses will be permitted and transient pressures will not be combined with the design wind or seismic loading. These transient pressures will, however, be combined with ash loading.

Except as allowed below, products which contain asbestos are prohibited. This prohibition includes items such as packings and gaskets even though the item is encapsulated or the asbestos fibers are impregnated with binder material. Asbestos products are acceptable only in exceptional cases where the Seller states in writing that no suitable substitute material exists, and, in addition, the Seller furnishes to the Purchaser a copy of U.S. Department of Labor "Material Safety Data Sheet" (Form No. OSHA 20) completed by the asbestos product manufacturer stating that the product is not an asbestos health hazard.

This Specification provides spare equipment with the intent of maximizing system availability. The Seller shall follow this philosophy in the detailed design of the equipment. The Seller's design shall incorporate features, both mechanically and electrically, such that a single component failure will not shut down more than one Air Pollution Control train.

The entire APC system shall be designed to allow ready operation and maintenance of all components. Sufficient area around all components shall be provided for operation and maintenance laydown (2'-6" clear as a minimum unless approved by the Purchaser) and clearly indicated on the Seller's drawings.

All equipment requiring filling, internal inspection, repair or removal of internals, and/or cleaning shall be furnished with hinged access doors, manholes with lids, or other suitable openings accessibly located and clear of all obstructions.

The APC system shall be designed to ensure that equipment which has been idled can be restarted without damage caused by solids settling or buildup. All equipment within the APC system shall be designed to eliminate solids buildup, erosion and corrosion at any point over the entire range of operating conditions. Selection of materials of construction is the responsibility of the Seller.

All ductwork and other equipment covered by this Specification shall be supported independently except that the support of scrubber inlet duct may be from boiler steel (first support only for bottom entering scrubbers).

The Seller shall design the system to fit within the boundaries shown on the attached general arrangement drawing(s), Attachment 8. It is the Seller's responsibility to provide a cost-effective system configuration that will allow Purchaser access for operation and maintenance. Where possible the Seller shall locate the gas cleaning trains close together to minimize platforming and area paving requirements.

The APC system is an extension of the major Facility building. The external lagging, siding and other finishes provided by the Seller shall match the color, form and texture of the main building. The Seller shall submit panel samples, color boards, paint chips, etc. to Ogden Martin Systems for their approval.

### 2.1.2 Codes and Standards

The Seller shall provide the APC system conforming with the applicable requirements of the latest edition (including addenda) in effect at the time of bidding of the following codes and standards. If there is, or seems to be, a conflict between this Specification and a referenced document, the matter shall be referred to the Purchaser.

AFBMA - American Friction Bearing Manufacturers Association

AGMA - American Gear Manufacturers Association

AISC - American Institute of Steel Construction

| | | |
|---|---|---|
| AMCA | - | Air Movement and Control Association |
| ANSI | - | American National Standards Institute |
| ASHRAE | - | American Society of Heating, Refrigerating and Air Conditioning Engineers |
| ASME | - | American Society of Mechanical Engineers |
| ASTM | - | American Society for Testing and Materials |
| AWS | - | American Welding Society |
| AWWA | - | American Water Works Association |
| HIS | - | Hydraulic Institute Standards |
| IEEE | - | Institute of Electrical and Electronic Engineers |
| IGCI | - | Industrial Gas Cleaning Institute, Inc. |
| IPCEA | - | Insulated Power Cable Engineers Association |
| ISA | - | Instrument Society of America |
| MGI | - | Metal Grating Institute |
| MPTA | - | Mechanical Power Transmission Association |
| NAAMM | - | National Association of Architectural Metal Manufacturers |
| NBFU | - | National Board of Fire Underwriters |
| NEC | - | National Electric Code |
| NEMA | - | National Electrical Manufacturers Association |
| NFPA | - | National Fire Protection Association |
| OSHA | - | Occupational Safety and Health Act |
| PFIS | - | Pipe Fabricator's Institute Standards |
| RMA | - | Rubber Manufacturers Association |
| SMACNA | - | Sheet Metal and Air Conditioning Manufacturers National Association |
| SSPC | - | Steel Structures Paint Council |
| UL | - | Underwriters Laboratories |

Further, the equipment and materials shall comply with all laws and regulations applicable in the state and locality of the refuse-to-energy facility installation.

### 2.1.3 Flue Gas Conditions

The range of flue gas conditions and flow rates at the economizer outlet, are specified in Attachment 2 and Figure 1 of Attachment 3. The entire APC system shall be capable of continuously cleaning 100 percent of the flue gas produced by the boiler for the entire range of operating conditions specified in Attachment 2 including Minimum operation (see note 2 of Att. 2). Acid gas constituents in the flue gas may be considerably lower than shown in Attachment 2. The Seller's equipment shall be capable of satisfactory operation, while meeting guarantee requirements with low acid gas concentrations.

### 2.1.4 Water Supplies

Scrubber/dilution water, slaking water, potable water and cooling water supply/return will be supplied by Purchaser at the terminal point identified in Section 2.1.7. Page A5-1 of Attachment 5 shows the expected water quality for the scrubber/dilution and slaking waters as well as the temperature, pressure and GPM available for the scrubber/dilution, slaking and potable waters.

The Seller shall recommend the most effective feed point(s) to use this water. The Seller shall also specifically state in his proposal any limitations or adverse operating conditions that may occur by using this water supply.

### 2.1.5 Lime

A commercial supply of pebble lime will be provided to the system. The Seller's equipment shall be designed to handle the full range of particle size distribution.

The following analysis is on a dry basis for lime normally available at the plant site.

3/4 in. Minus High Calcium Lime

Composition (percent by weight)

| | Range | Average |
|---|---|---|
| Available CaO | 85 - 94 | 90 |
| Total CaO | 87 - 98 | 91 |
| MgO | 1 - 5 | 2 |
| Inerts | 1 - 16 | 7 |

2.1.6 Compressed Air

Service air and instrument quality (-40°F dewpoint) air will be available at 80-120 psig. Purchaser supplied compressed air shall be used for pulse-jet and lime bin vent filter cleaning and for control purposes. Seller shall provide the complete process air system (if needed for atomization) for the APC system. The system should include air compressors, receiver, silencers, piping and controls required for the spray dryer nozzles, maintenance, and other uses. The air compressors shall include provisions to prevent the leakage and spillage of lubricating oil to grade or surrounding equipment. The Seller shall provide one standby compressor. This equipment shall be enclosed in a heated and ventilated building with filtered external air supply to the compressor intake.

2.1.7 Terminal Points

The interfaces between Seller's and Purchaser's equipment, material, and services are as specified below.

- Unless specified in Attachment 1, Seller to assume the outlet flange at each boiler economizer to be approximately 8 ft. inside the column line of the boiler building, and 25 to 35 ft. (center line) above grade and 4' high by the width of the stoker (see Attachment 1). Seller is responsible for matching the boiler economizer outlet flange dimensions and location.

- The stack breeching flange (approximately 1'-0" from stack shell and in the vertical plane). Duct to stack breeching flange to be at a 45 degree angle. Seller is responsible for matching stack breaching flange dimensions and location.

- Scrubber vessel hopper or delumper, baghouse or precipitator and ductwork hopper flanges, located 10 ft. above finished grade. Hopper flanges shall be fitted with studs tack-welded in place so as to allow insulation of the entire hopper.

- The Purchaser-supplied ash handling system will run beneath the hopper outlet along the axis of the scrubber/baghouse. The Seller shall maintain a clear, three foot wide, aisle along this axis and the hopper shall be capable of supporting Purchaser's screw conveyors and/or rotary or double dump valves hanging from the hopper flange and/or Seller's steel.

- All APC system equipment and materials structural supports at grade level on Purchaser's concrete foundations (6" above grade) and/or pedestals.

- Lime receiving system at the truck unloading station.

- All process drains at grade level at Purchasers U-drain or catch basin.

- Downspouts at grade level outside APC area perimeter

A single point of supply for the following utilities will be furnished by Purchaser to the APC system at the boiler house rear column line at grade. All of these utilities will be provided at a common supply location:

Service Air
Instrument/pulse-jet air
Water supplies, as applicable (scrubber/dilution water, slaking water, potable water, cooling water supply and return)

Seller to furnish instrument air piping to purchaser's CEM building(s).

One source of above grade 480V power per APC train will be supplied by the Purchaser and terminated at the Seller's switchgear/MCC. Control Wiring shall terminate at common junction box and/or control cabinet (Ref. Attachment 10) in Seller's electrical equipment building. Power wiring for the I.D. Fans will be terminated at the motor by the Purchaser. Control and instrument wiring for I.D. fans will be terminated at the fan by the Purchaser (fan to be provided with a common terminal box for these terminations).

## 2.2 Acid Gas Removal System

The Expected Continuous and Design lime consumption rates, mentioned in the sections that follow, shall be defined as the consumption of lime (as guaranteed in Section 3) required to achieve the guaranteed acid gas removal with the "Expected Continuous and Design" flue gas conditions (as specified in Section 2.1.3) present at the economizer outlet.

### 2.2.1 Scrubber Vessel

The scrubber vessel shall be of the "dry" scrubbing, spray dryer type. The metal thickness for the roof, walls, and hopper of the scrubber vessel shall be 1/4 in. minimum carbon steel (A-36) or other suitable material as recommended by Seller to withstand the flue gas conditions shown in Attachment 2. The scrubber vessel sections shall be gas-tight and seal welded internally and shall be structurally reinforced with external stiffeners, ribs and supports. No internal structural supports shall be allowed.

Bolted, hinged and gasketed access doors shall be provided where necessary to enable proper inspection, cleaning, and maintenance of the interior of the scrubber. Doors shall have two pinned connections at each hinge. As a minimum, an access door shall be provided in the side of the scrubber vessel and near the bottom of the scrubber vessel hopper.

No bypass of the scrubber shall be provided. However provisions shall be made for removal and cleaning of the spray atomizer(s) while flue gas flows through the scrubber.

Abrasion resistant gas distribution plates shall be provided at the flue gas inlet to the scrubber vessel, if required. The deflector plates shall be designed to give good gas and particulate distribution to the scrubber, to minimize abrasive impingement of the fly ash on the scrubber equipment, and to prevent short circuiting of the flue gas around the lime slurry spray across the operating range of the scrubber.

The scrubber vessel shall have a solids collection hopper with vibrator, high level switch to indicate abnormal solids build-up, two rod out ports, hinged access door and two strike plates. The high level switch should be located at an elevation equal to that of the bottom of the hopper access door. The valley angle of the hopper shall not be less than 55 degrees with the horizontal. The outlet of the hopper shall be fitted with a flanged transition piece which can easily be replaced by a delumper, if necessary. The outlet of the transition piece shall be a 12 inch square flanged connection 10 feet above finished grade for connection to the Purchaser's ash handling system. The hopper's ash outlet flange shall be capable of supporting 2000 lbs of Purchaser's ash handling equipment. The lower 1/3 of the hopper plus all transition pieces, flanges and other heat sinks shall be heated to eliminate any cold spots that may cause plugging. The Seller shall supply and install a lump breaker, if required to insure that plugging will not occur. If provided, the lump breaker outlet shall be a 12" square flanged connection 10 feet above finished grade for connection to Purchaser's Ash Handling System.

As a minimum, the scrubber vessel shall be designed to support the mass of the vessel if the vessel hopper becomes filled with solids to the point that the scrubber outlet is plugged, all other horizontal surfaces have 2.5 ft buildup and all vertical surfaces have a 6 inch building simultaneously with a density of 120 lb per cu. ft.

The ash/scrubber waste shall be assumed to weigh 45 lb per cu ft for capacity purposes and 120 lb per cu ft for structural design purposes. The Design lime consumption rate shall be used as a basis for calculating the maximum ash/scrubber waste collection rate.

### 2.2.2 Scrubber Vessel Atomizer/Nozzle Enclosure, Platforms and Stairways

A weather tight enclosure shall be furnished to enclose the scrubber vessel atomizer or dual-fluid nozzles and control valves, etc. located at the scrubber. Roof areas of weather enclosure and scrubber vessel roof (if different from weather enclosure roof) shall be sloped to drain to gutters and downspouts running to grade at a point just outside the APC area perimeter (but not near future train). Gutters & downspouts shall be sized to accommodate a 25 year/5 minute rainfall. The enclosure shall be insulated, heated and ventilated to allow maintenance throughout the year. Enclosure material, color (manufacturer's standard) and texture shall meet the aesthetic requirements the of project. Adequate area shall be provided within the enclosure for atomizer or nozzle maintenance and cleaning. The operating floor shall be checker plate with kickplate around perimeter or a Purchaser-approved alternate, sloped to a floor drain which is to be piped to grade with seals around perimeter and at penetrations (or six inch high curbs) to prevent lime or water from running down to lower elevations. Handrailing shall be supplied by Seller to prevent personnel from walking on areas not covered with plate or grating.

The seller shall provide water and compressed air in the enclosure for maintenance purposes. Liner panels of coated steel shall be provided to protect wall insulation from washdown water spray.

An overhead monorail/trolley/electric hoist system shall be provided for rotary atomizer designs capable of removing the complete atomizer assembly from its operational position and moving it to a spare atomizer stand and lowered to, and raised from, the Purchaser's maintenance trucks for maintenance or replacement.

The Seller shall provide one centrally located stairtower together with walkways to access all scrubber vessels as well as baghouses or precipitators. The scrubber vessel and its inlet and outlet duct access doors and instrumentation shall be accessible from these walkways.

For APC systems where slurry atomization takes place in the top of the scrubber vessel, the Seller shall provide one centrally located access walkway (including any stairs to accommodate any differences between the boiler and scrubber penthouse platform elevations) from the boiler building rear wall to the access walkway connecting the scrubber vessels. Subsequently, the above-mentioned stairtower need not extend to the scrubber penthouse; instead a ladder may be furnished from the top of the scrubber vessel to grade or to the top of the stairtower, thus providing the penthouse with two means of egress.

### 2.2.3 Rotary Atomizers or Dual-Fluid Nozzles

Slurry spraying equipment shall be designed to withstand all conditions occurring in the spray dryer. All spraying components within atomizers or nozzles shall be designed to avoid plugging, erosion, corrosion, slurry solid buildup, scaling, acid attack, vibration fatigue, chloride corrosion and cracking. The design and materials of construction choice shall be supported by successful commercial experience with the selected design and material in similar service.

Seller shall provide one complete spare rotary atomizer and/or dual fluid nozzle assembly. The spare rotary atomizer and drive system shall be complete with motor, gear, shaft, wheel, and other required components. The spare dual fluid nozzle assembly shall be complete with piping, valve, nozzle, instruments, and other required components. The Seller's design shall allow the removal and replacement of a complete atomizer or nozzle assembly within 30 minutes.

For dual-fluid nozzle designs, Seller to provide a low air flow alarm for each nozzle. For rotary atomizer designs, Seller to provide a fully automatic forced lubrication system with oil pump and a vibration and bearing temperature detection system for each atomizer. Low air flow, high bearing temperature (including motor bearings) and high vibration shall be alarmed in the main control room. The rotary atomizer shall also be fitted with an elapsed time meter in the main control room.

### 2.2.4 Reagent Preparation System

The reagent preparation system shall consist of a truck unloading station, lime storage silo, lime feeders, lime slaker-classifier system, slurry storage tank and pumps, dilutions tanks (if required), piping, valves and fittings to feed dilute lime slurry to the spray dryer atomizer. The Seller shall provide the arrangement and design of the complete system. The arrangement shall recognize that this is a high maintenance area subject to line plugging, lime spills and frequent maintenance of pumps, agitators and other equipment. Provisions shall be provided for washdown of operating levels. Such provisions shall include floors sloped to drains with cleanout provisions and liner panels of coated steel to protect wall insulation from water spray. Electrical equipment in these areas shall be suitable located and protected. Elevated floors shall be solid flooring sloped to downcomers extending to drains at grade and include seals at penetrations or six inch high curbs to prevent lime or water from running down to lower elevations. Access shall be provided for disassembly and normal maintenance of equipment without interfering with the operation of the system. If an elevated level in the lime silo is used to house the slakers, access to this area shall be by a stair tower and landing exterior to the silo and provisions shall be made for the removal and replacement of all major equipment enclosed in the silo. Pumps shall be located in a separate building along with the purchaser supplied grit bin. The building shall be heated and ventilated and fitted with a roll-up door for fork-lift access to the grit bin. Seller to furnish a preliminary arrangement of the equipment housed within the silo's skirted area with his proposal. Final detailed arrangement of this equipment must be approved by Purchaser.

The reagent preparation system shall accept delivery of lime from trucks and produce a slurry of a controlled density and solids content. This slurry shall be fed to the scrubber vessel at a controlled rate to meet the specified acid gas removal and outlet gas temperature. A common reagent preparation system with separate reagent injection pumps including an installed common spare pump or two 100% pumps, or three 50% pumps shall be provided.

The reagent preparation system shall be designed to handle the composition and size ranges of the Purchaser's lime as specified in Section 2.1.5. For any equipment which comes into contact with pebble lime, the lime shall be assumed to weigh 55 lb per cu ft for capacity purposes and 80 lb per cu. ft. for structural design purposes. The entire reagent preparation system shall be designed to prevent dusty, humid, and maintenance intensive conditions external to the equipment.

The lime storage and handling system shall be based on a mass flow design (first-in-first-out material flow) and shall be designed to minimize segregation problems.

2.2.4.1 Lime Silo

The lime bin shall have a minimum seven (7) days of storage capacity at the Expected Continuous lime consumption rate.

The Purchaser's lime will arrive on site in differential pressure, pneumatic truck trailers. Normal shipment size will be 20-32 tons of lime. The lime silo shall be designed such that the truck mounted blower shall be capable of unloading the lime directly into the lime silo by means of a positive pressure airstream in a fill pipe to the top of the silo. The conveying air will be exhausted from the bin through a silo vent type dust collector. Exhaust air shall have less than the smaller of 0.02 gr/DSCF of particulate or the requirements of the air permit (Ref. Attachment 9). Interlocks are required between the fill connection and vent filter.

Truck attachment fitting shall be a standard quick disconnect 4-in. female fitting. The fill pipe shall be schedule 80 seamless steel and conform to ASTM A53, Grade B. Bends and elbows shall be flanged Fuller 450 Iron, or purchaser approved equal. Long radius bends and elbows shall be used with a minimum centerline radius of 4 ft. The combined vertical and horizontal run of fill pipe shall not be greater than 150 ft. with the vertical rise limited to 100 ft. maximum. The run of fill pipe, from the truck fill connection, located at the truck access road to the silo, should be vertical first (with the inlet approximately 4 ft. above grade) followed by horizontal and arranged to minimize the bending of the flexible hose which will be attached to it.

The silo shall be designed to have a minimum freeboard of 4 ft. The design of the silo shall allow surges from the pneumatic unloading system and still provide a constant flow of lime to the volumetric feeder.

The lime silo shall be constructed of ASTM A36 steel plate and structural supports. The roof pitch shall be 1/4 in. per ft minimum. Minimum plate thicknesses shall be 1/4 in. The storage section of the silo shall be of all welded construction. As an option, Seller may offer a price deduct for a bolted silo. Bolted silos shall be leak tested using a high pressure water spray in accordance with the manufacturer's recommendations. The roof shall be constructed of checkered plate with an access manhole, pressure and vacuum relief valve, and necessary flanged piping connections for fill piping and level instrumentation (high, low and low-low). Handrail and curb plate shall be provided at the perimeter of the silo roof. A jib boom shall be mounted on the silo roof and located so that it can be used to repair or replace the fill pipe, the dust collector, bags, and any other roof mounted equipment. The hoist capacity shall be capable of lifting the heaviest piece of equipment mounted on the silo roof. Access to the top of the silo and any instrumentation mounted on the silo shall be by cage ladder and platforms complete with handrailing and toeboard meeting the requirements of OSHA.

All steel plates, supports, handrails, etc., shall be prime painted in accordance with Specification SA-550 attached hereto.

The silo shall be furnished with two vibrators or a vibrating bin activator at least 1/3 the diameter of the silo to maintain a free flow of lime without bridging or rat-holing. Provisions shall be included in the hopper to allow for emergency rodding and air blasting. The silo hopper shall be sloped a minimum of 60 degrees from horizontal. A manually operated isolation gate shall be provided between the hopper (or bin activator, if provided) and volumetric feeder.

Slurry preparation system equipment may be located in a skirted area below the lime silo provided that all arrangement, access and ventilation, etc. requirements of Section 2.2.4 and 2.2.4.10 are met. The skirt shall be mounted on Purchaser's foundation which will consist of a sloped and curbed concrete pad; seller's general arrangement drawings to reflect this.

2.2.4.2 Volumetric Feeder

The Volumetric feeder shall accept lime from the lime silo and feed it at a controlled rate to the slaker. The feeder shall be completely enclosed to provide dust-free operation including all connections to the lime silo and slaker. The feeder shall be constructed to prevent moisture from the slaker from entering the feeder. Access doors shall be provided such that inspection, maintenance or cleanout of all of the feeder components can be readily performed. The area underneath and around the feeder shall be checker plate. Each feeder shall be fitted with a rotation counter.

2.2.4.3 Lime Slaker-Classifier System

A redundant slaker system shall be provided. Each slaker will be designed for batch operation and sized for 100% of the Design lime consumption. The slaker-classifier shall produce a slurry containing solids with a maximum size as required by atomizer clearances. The vibrating screen classifier shall be fitted with heavy rubber boots at all discharge connections. The classifier screen shall have an open top and be made of stainless steel, resist tearing and be easily replaceable. Slurry recirculation from the scrubber shall not be directed to the classifier screen. The classifier shall remove the grits to a discharge 8 ft. above grade. Seller shall provide a rubber (or purchaser approved equal) chute from the classifier to the Purchaser's grit bin. The chute shall be suitably restrained and be a minimum of 60° from the horizontal. Suitable provisions, including adequate access, shall be furnished by the Seller to allow the Purchaser to access the grit bin with a fork lift truck. Seller shall provide a heated enclosure for the grit bin (grit bin is approximately a 6' cube) including a roll-up door. The slaker shall be provided with dust collection and ventilation equipment of the wet educator or wet scrubber type. The hot, humid, dusty air shall be vented from the discharge of the slaker and passed through the wet system. The clean side discharge shall be piped outside the reagent preparation building to a point sufficiently away from all personnel access platforms using a fan system designed for the humid conditions. The dirty side stream shall be returned to the slaker.

The slaker design shall include provisions to prevent explosive slaking. Minimum requirements shall include a high temperature switch and low water pressure switch which will alarm and provide an alternative source of water to the slaker.

The slaker shall be provided with manholes for inspection, maintenance, or cleanout as necessary. The area underneath and around the slaker shall be checker plate.

An in-line preheater shall be provided, if required, to preheat the slaking water during start-up of the lime slaker. The preheater shall be capable of heating water from 35°F to the required inlet temperature.

2.2.4.4 Slurry Tanks

A cylindrical lime slurry storage tank shall be provided for the storage of the slaked lime slurry. There shall be no pumps between the slaker-classifier and the lime slurry storage tank. The lime slurry storage tank shall be furnished with one or more top mounted agitators and baffles to achieve good mixing and a uniform slurry. As a minimum, the lime slurry storage tank shall have 3 baffles. Adequate provisions shall be included in the design of the lime slurry storage tank to allow representative sampling of the tank contents. Metal tanks shall be all welded construction and shall be constructed of ASTM A283, Grade C or ASTM A36. Structural support members shall be constructed of ASTM A36.

The lime slurry storage tank shall be provided with a net storage capacity of 6 hours at the Design conditions. The net storage capacity is the total volume of the tank less 2' freeboard and the volume below the low-low level pump trip. Two thirds of the net capacity shall be used as inventory between slaker operating cycles, one third shall provide time for operator action if there is a system outage. If the slurry storage tank low level switch is still activated after a suitable time delay, an alarm will be sent to the main control room.

Lime slurry mix/head tanks, shall be sized with minimum residence time, furnished with a top mounted agitator and shall be of the same material of construction as the lime slurry storage tank. The residence time shall be less than 5 minutes at 80% flue gas flow and the low end operating gas temperature.

Suitable instrumentation shall be provided to control level in each tank. As a minimum, this shall include a high-high alarm and low-low alarm/pump trip. Slurry tanks shall be designed so that the low level condition does not infringe upon the minimum required NPSH of the pumps. Each tank shall be totally enclosed with no internal supports.

Top and side (near bottom) entry access doors shall be provided in each tank for inspection, maintenance, and cleaning. Tank design shall comply with AWWA D100. These tanks shall be self-supporting and externally stiffened. A drain connection shall be provided at the base of each tank (as close to the bottom as possible) complete with isolation valve. An overflow port shall be provided near the top of each tank and piped to a trench. Each tank shall be vented.

Access to the top of the tank and instrumentation shall be by caged ladders and platforms with handrailing and toeboard plates which meet all OSHA requirements.

2.2.4.5 <u>Agitators</u>

Each slurry tank shall have at least one top mounted, electric motor driven agitator assembly. All elements of the drive train shall be directly connected; no drive belts or chains will be allowed. Each agitator shall be designed so that no solids settle on the bottom of the tank while the agitator is on. Each agitator shall be designed to restart without overstressing (by a two time stress margin) after the tank solids have settled completely after 24 hours. Side entry agitators shall not be used.

All agitators shall be coated with neoprene or Purchasers-approved equal or constructed of an abrasion-resistant alloy.

The largest diameter pitched-blade impeller required by the design load operating conditions that will provide satisfactory operation over the entire range of operating conditions shall be furnished. The motor and couplings shall be adequately protected from the slurry. Couplings shall be rated at no less than 120% of the motor horsepower.

Lubricating oil shall be prevented from leaking into the tanks. Lip seals shall prevent vapor escape to the atmosphere and foreign material entry to the tank.

Each gear drive unit shall have an AGMA Class I gear rating and service rating suitable for continuous duty and moderate shock loads. Each gear drive shall have a minimum overall service rating of 1.50. All gear drive shafting shall be mounted on antifriction bearings. The minimum AFBMA B-10 life of the output shaft bearings shall be 250,000 hours when subjected to the normal torque, thrust, gear separating forces, and maximum bending force. All other bearings shall have a minimum B-10 life of 50,000 hours.

### 2.2.4.6 Slurry and Water Pumps

#### 1. General

A completely installed and functional spare pump shall be provided in every service. This can be accomplished either with one pump per train with one common spare, two 100% pumps or three 50% pumps. All pumps, unless dedicated to a scrubber train, shall be hard piped and shall automatically start if the operating pump trips. Slurry pumps dedicated to a scrubber train may be furnished with hose connections such that the spare pump would be manually placed in service via rubber hoses, provided the hoses are fitted with quick disconnect couplings and isolation valves at the hose connection to avoid spillages during a transfer. Pumping systems shall be designed such that, at all conditions of operation, the available NPSH shall be no less than 1.25 times the required NPSH which results in 3 percent breakdown.

Pump suction and discharge lines shall be in accordance with the Hydraulic Institute Standards (HIS) and shall be designed for the maximum pressures and temperatures to which they will be subjected by the pump. Pump systems shall be isolateable to permit shutdown for maintenance. All hard piped pump connections shall be flanged and meet the standard ANSI requirements for size and configuration.

Direct coupled pumps and drives shall be mounted on the drip pan base and prealigned at the Seller's shop.

Centrifugal pumps selected shall be capable of continuous operation at any point on their curves from minimum to runout flow. Operation at shutoff for periods of up to 5 min shall be accommodated with no deleterious effect on seals, vibration, or wear. Pumps shall have constantly rising-to-shutoff characteristic curves.

To minimize operating costs and to provide nominal operating conditions, pumps selected shall be at or near their BEP flows.

Identical pumps shall be manufactured to have completely interchangeable parts. Where possible, a minimum number of pump designs and sizes shall be employed in all of the systems furnished under this specification to minimize parts inventory.

All pumps shall have the following maintenance provisions: lifting lugs or eye bolts as required for component replacement, removable casing cover plate, and removable shaft, impeller, and seal.

Bearings shall be antifriction type on all pumps and shall have a minimum B-10 life at maximum thrust of 50,000 hr. Pumps shall employ grease lubrication (which can be applied while on-line), with no cooling required.

2. Water Service

Water pumps shall be designed in accordance with the attached SM-121 (except for Sect. 1.3 items 1, 2 & 4) and shall be of suitable metallurgy for the service. Water pumps shall have a minimum of 1/8 in. corrosion allowance on areas exposed to the pumped liquid. Metal impellers shall not be greater than 90 percent full diameter.

Water pumps shall be direct drive. Couplings shall be non-lubed flexible disc-type. All couplings shall have coupling guards meeting OSHA requirements.

3. Lime Slurry Service

Slurry pumps may be of the horizontal centrifugal or positive displacement type. Horizontal centrifugal pumps may be rubber or abrasion resistant metal lined. Rubber lined pumps shall be V-belt driven and fitted with variable pitch sheaves so that speed may be increased if necessary to achieve design margins on flow and head. Metal lined pumps shall have a minimum Brinell hardness of 600 and shall include a minimum of 1/8" corrosion allowance. Metal lined pumps shall also include a replaceable suction liner. Metal impellers shall not be greater than 90% full diameter.

Each slurry pump shall be capable of delivering 110 percent of the flow rate required at the Design lime usage rate (at the maximum scrubber outlet temperature - ref. note 3 on pg. A2-2) and 121 percent of the corresponding head. Each slurry piping system capacity shall be at least 10 percent above the capacity required at the Design lime usage rate.

Positive Displacement Slurry Pumps

Positive displacement pumps shall have a relief valve to protect the pump/discharge piping in the event of discharge valve closure.

Progressive cavity positive displacement pumps shall not be used.

Diaphragm positive displacement pumps shall be of the hydraulically balanced diaphragm type as manufactured by Wanner Engineering (Hydra-cell). The pump speed shall be limited to 1/2 the rated speed. The material of construction shall be cast iron or stainless steel pump casing, ceramic valves and seats, Celcon retainers, Elgiloy valve springs, and BUNA-N Elastomers. The suction and discharge shall have reinforced hydraulic hose flexible connections rated at 1-1/2 times the discharge pressure; the suction size shall be one size larger than the pump inlet size.

Centrifugal Slurry Pumps

The design of horizontal centrifugal pumps shall employ adjustment features that permit axial movement to restore clearances without disassembly of the pump or motor.

Packing with lantern rings and injection water shall be used for shaft sealing on all pumps. Hardened surface replaceable shaft sleeves shall be employed under packing with a minimum Brinell Hardness of 600. Stuffing box/impeller designs employing expeller vanes or other features shall be used to reduce to a minimum the injection water requirement. The injection water's function shall be to keep the packing cool, lubricated and free from lime solids. The injection water line shall be fitted with both modulating and isolation valves capable of tight shut-off.

Pump casings shall be designed to accommodate maximum operating temperatures and pressures in all areas wetted by the pumpage from suction to discharge.

The slurry pump impeller tip speed shall not exceed 5,100 ft/min.

The horizontal centrifugal slurry pumps shall be capable of reverse rotation (during flushing) without adverse effects. Positive displacement slurry pumps shall be flushed by running the pump with flushing water in-lieu of slurry.

The entire slurry pump assembly, including base plate, shall be sized so that the first critical speed is above the running speed by at least 25 percent.

The slurry pump peak to peak amplitude of vibration at all flows, as measured on the bearing housings, shall not exceed the limits established by the HIS, Figure 66, for field taken vibration at the running speed of the pump, taken axially or radially. Shop vibration levels taken during shop testing shall not exceed half of the field allowable levels.

V-belt drives shall be in accordance with the Rubber Manufacturers Association (RMA) and the Mechanical Power Transmission Association (MPTA). V-belt drives shall be sized to permit at least the loss of one belt without loss of performance from the pump. They shall include a safety guard and adjustment between the motor and reducer.

2.2.4.7 Piping

Unless otherwise specified herein, all piping materials and fabrication shall comply fully with all applicable requirements of ANSI B31.1 and the Pipe Fabricator's Institute Standards. All carbon steel piping shall be A53 or A106 material.

Except for air piping, all piping 2 in. and smaller shall be minimum schedule 80 carbon steel; all piping 2 1/2 in. and larger shall be minimum schedule 40 carbon steel type. All air piping shall be schedule 40 galvanized steel. All Seller-supplied and designed piping shall be installed above ground and shall be designed for the maximum pressure that could be produced by the pumping systems.

All water and lime slurry piping shall either be enclosed or heat traced. No piping or valves shall be located across platforms, stairs or ladders so as to cause an operating hazard.

Slurry piping shall be carbon steel. Slurry piping shall be furnished with an adequate number of connections for proper flushing and drainage. Piping connections for all slurry services shall be flanged. The inside diameters of all slurry pipe mating connections to valves, fittings, and other pipe shall match. Slurry piping shall be designed so it can be taken apart easily for maintenance and cleaning. Cleanouts shall be provided at all tees, fittings, etc.

Slurry piping shall be arranged to prevent plugging and settling of solids in lines and valves. The slurry piping system shall be designed to maintain velocities of 4-8 ft. per second over the entire load range. Slurry piping shall be routed in straight lines wherever possible to eliminate unnecessary bends. Bends and elbows shall be flanged for easy replacement. Slurry piping shall be designed to be self-draining by gravity. Horizontal lines shall be adequately sloped to ensure drainage.

Seller shall furnish a duplex type basket strainer for each scrubber train accessibly located in the scrubber penthouse upstream of control valves. Strainer basket openings shall be 3/16" maximum. Each strainer shall be fitted with a local differential pressure gauge and a high differential pressure switch which is alarmed in the main control room.

Sample valves shall be included in the design of the slurry piping to allow easy, routine, and representative sampling of the slurry fed to the scrubber.

All piping not to receive insulation shall be primed per the requirements of Specification SA-550

2.2.4.8 Valves

All valves shall conform to the applicable requirements of ANSI B16.34 and all other applicable standards. All valves shall be shipped to the site with a metal tag identification.

The use of valves in slurry lines shall be minimized. Unless otherwise approved by the Purchaser, slurry isolation valves shall be full-port pinch valves, plug or knife gate valves. Pinch valves shall be flanged and designed with through bolts, shall have a totally enclosed cast iron body, and shall be provided with a neoprene sleeve and neoprene lined flange. Pinch valves shall not collapse under negative pressure conditions that may occur.

The use of check valves in slurry lines shall not be allowed.

Manually operated valves requiring manipulation during operation shall be located so that handwheels are not higher than 5 ft above a platform or grade. Valves which do not meet the above requirements shall be equipped with chain operators or extension stems complying with the above criteria. Valve stems shall not be oriented below horizontal centerline. Every effort should be made to locate valves for easy inspection, operation and maintenance.

Restriction orifices used in slurry service shall be of an abrasion resistant material (eg-ceramic); carbon or stainless steel are not permitted.

2.2.4.9 Slurry Flushing/Chemical Cleaning System

A complete manual flushing system shall be supplied including permanently installed piping, pipe hangers, connections, and valves for a complete water flushing system. The system shall include flushing of all slurry piping and equipment from the slurry storage tank to the atomizers. Rubber hoses/hose connections may be used in-lieu of permanently installed piping provided the flushing water piping is within 10 ft. of the slurry hose connection.

As a minimum, the slurry flushing system shall be capable of providing a complete four volume flush of the entire slurry system and be capable of providing flush water velocities of 4 ft/sec. Waste flush shall be directed to the freeboard in the slurry tank. Flushing of piping systems shall be downhill.

Flushing water connections shall be located on the top or side of slurry piping to avoid plugging.

The slurry piping system shall be designed to allow chemical cleaning of all the slurry piping. Sufficient piping connections and isolation valves shall be provided to allow recirculation of chemical from main slurry pumps to scrubber atomizer connection.

2.2.4.10 Reagent Preparation Building

Any equipment which cannot be conveniently located in the skirted area under the lime silo shall be located inside a heated, ventilated and insulated prefabricated building. The building will be constructed so as to leave space clear around all tanks, the volumetric feeder, slaker, classifiers, and pumps for routine inspection and maintenance as well as to allow equipment removal for overhaul or replacement. The building shall be tall enough to allow ready access to the top of the tallest tank and to allow easy removal of agitator assemblies. The building exterior shall match in color, form and texture with the balance of the overall facility. Steel within the building shall comply with the finishing requirements for ferrous metals stated herein and in Specification SA-550.

The ventilation system shall remove all dust from the building.

2.2.4.11 Shower and Eye Wash Stations

Shower and eyewash stations shall be provided in all lime handling areas to meet OSHA requirements. Minimum requirements are as follows:

- Combination shower/eyewash station
  - -Slaker area
  - -Slaker pump area
  - -Scrubber penthouse (one per unit unless combined penthouse with two trains is provided. In this case a common centrally located station is acceptable.

- Eyewash Station
  - -Lime unloading station
  - -Lime silo feeding area if separate from slaker area
  - -All other separate areas where lime is being pumped (valve stations, pumps etc.

All shower and eyewash stations shall be located adjacent to hazardous equipment with unobstructed access from expected operator inspection and maintenance areas. Shower and eyewash stations shall not have curbs or other obstructions. All stations shall be supplied from the facility potable water system unless specific approval is provided by Ogden Martin Systems Inc. Shower and eyewash stations shall be freeze protected.

Emergency shower/eyewash stations shall be per drawings RS-425 A through D (see Attachment 17).

2.2.5 Spray Atomization Compressors

The Seller shall furnish the complete system to supply atomizing air for the spray dryer dual-fluid nozzle, if offered. The Seller shall provide either one compressor per scrubber train with one installed spare, two 100% capacity compressors or three 50% capacity compressors. See Section 2.9.2, Induction Motors, for further sizing guidelines.

The compressors shall be the lubricated rotary screw type and shall be direct driven by an electric motor. Each compressor shall be a package unit complete with all controls, coolers (air coolers are not permitted), lube oil system, etc. Each compressor shall include:

High water temperature alarm switch.

Thermostatic water temperature control valve for each aftercooler.

Cooling water sight flow indicator.

Automatic drain traps for aftercooler moisture separator.

Magnetic water shutoff valve interlocked with compressor motor starter.

One receiver equipped with relief valve, pressure gauge, pressure switches, and automatic moisture trap with drain valve.

Integrally mounted control panel for each compressor.

Integrally mounted motor starter for each compressor.

Hour meter, selector switch (hand-off-auto) and motor starter for each compressor at control panel.

The compressor unit including motor shall be enclosed in a sectionalized steel sound-insulating canopy with doors to provide ready access for normal maintenance.

2.2.5.1 Compressor - Technical

1. General

The compressor shall be the lubricated rotary screw single stage type and shall meet the requirements of this specification. This compressor shall be direct driven by an electric motor (1800 RPM maximum). The compressor tip speed shall not exceed 35 meters per second.

The inlet air filter, cooling water system, control system and driver shall be included as part of the package. Also included shall be a common base-frame for the equipment and an enclosure for the compressor and driver.

All piping shall be in accordance with ANSI B31.1 latest edition.

2. Materials

All materials of construction shall be those proven by service in similar designs and suitable for the specified conditions of service, including atmospheric conditions of pressure, temperature, relative humidity and airborne contaminants. The metallurgy of all major components shall be clearly stated in the Seller's proposal.

Products which contain asbestos are prohibited. This prohibition includes items such as packings or gaskets, even though the item is encapsulated, or the asbestos fibers are impregnated with binder material.

The seller shall select suitable materials and fill in the required information on the data sheets. No changes to the materials so listed shall be permitted after the contract award, without the approval of the Purchaser.

Materials shall be identified by reference to appropriate ASTM Specification, AISI type number, etc. When no such appropriate designation is available, the manufacturer's code or trade name may be used. In such cases, the manufacturer shall be identified and the chemical composition and significant physical properties of the material shall be presented elsewhere in the proposal.

Castings shall be free from shrinkage cracks, hot tears, gas holes, blisters, or other similar injurious defects. Surfaces of castings shall be cleaned by sand or shot blasting, or other standard cleaning method. All mold parting fins and remains of gates and risers shall be removed and ground flush.

3. Stage

The compressor stage shall be a cast iron, one-piece casing that will house two precision-made screw-type rotors.

4. Rotor

Rotors shall be of one-piece steel or nodular iron construction. The rotors shall have a profile that keeps leakage losses at a minimum to insure a high efficiency. Rotors must be balanced dynamically to guarantee vibration-free operation. The shaft shall be the integral part of the rotor.

5. Bearings

Bearings shall be of the antifriction type. Radial loads shall be carried by roller bearings and axial loads by ball bearings. The axial load, resulting from compression, shall be divided on the main and auxiliary thrust bearings through a balancing arrangement.

6. Lubrication System

The lubrication system for each compressor shall include but not be limited to oil filter, high differential pressure switch, water cooled oil cooler, pressure gauge, thermometer, low oil pressure alarm and shutdown switch and oil level gauge.

Each compressor shall be furnished with an air/oil separator designed to produce air with an oil or hydrocarbon content not to exceed two (2) ppm under normal operating conditions.

7. Coolers

Aftercoolers shall be of the shell and tube type, and shall be ASME coded and stamped. Removable tube bundles are required for all coolers. Withdrawal distances for removing tube bundles or tubes from coolers shall be clearly indicated on outline drawings to be furnished by the Seller.

Flanges and gaskets in heads and at tube sheets shall be designed so that water can not leak into air spaces. Tubes shall be rolled into both tube sheets. U-tubes shall not be employed. Heads and water boxes shall be easily removed for cleaning without disturbing connecting piping, and when removed, the tubes shall be accessible for brushing through without removing the tube bundle.

A moisture separator with automatic drainage shall be provided as a part of the aftercooler to remove condensables from the cooled air. An automatic water temperature regulating valve shall also be provided.

8. Air Intake Filter

A suitably rated, dry type air intake filter as recommended by the manufacturer shall be provided with the compressor.

9. Regulating System

The regulating system shall provide compressor operation from full load (100%) to no load (0%), matching the compressor output to system air demand requirements. In addition, the auto start/timed stop control shall also be provided.

10. Unloading Control System

The control system shall be integral to the compressor package and is to consist of an electro-pneumatic regulator designed to provide manual and automatic running. The control system is to provide circuits for loading delay and starting idling delay at shutoff. The control system shall also provide for automatic shutoff of the compressor during periods of low demand and excessive idling to conserve energy. The control circuits shall be suitable for 120 volt, single phase, 60 Hz.

11. Control Panel and Motor Starter

The control panel shall be integrally mounted with each compressor in an enclosure. A selector switch with hand-off-auto position along with an alternator for lead/lag control shall be provided to manually select either compressor as run or as standby. In addition, in the period of unusual high demand by the system if one compressor fails to satisfy the system demand at the rated pressure, provision shall be made to start the standby compressor automatically. The control panel shall also have the following instruments, gauges and switches mounted on it.

Start/Stop switch with run indicating light
Selector switch for low demand mode and auto-start/timed-stop
Hour meter
Discharge air pressure gauge
Discharge air temperature gauge with sensing element at air compressor
Differential pressure gauge for air intake filter
Cooling water temperature outlet gauge
Power on indicating lights

Each compressor shall be provided with one form "C", dry contact for trouble alarm rated at 5 amps minimum at 120 VAC, wired to Seller's annunciator. Seller shall provide 480V, 3-phase, 3 wire power to each motor starter. Seller shall provide 480V to 120V dry type transformers, complete with both primary and secondary fuses to provide control power for the control panel. Seller shall provide lockable disconnects for each source of the control power. Control power shall be available regardless of which compressor is out of service.

Seller shall provide complete FVNR circuit breaker type combinations motor starters with manual reset thermal overload-relays, 120V AC operating coils, 480 to 120V dry type control transformers complete with both primary and secondary fuses, and a separate enclosures. Circuit breakers shall be capable of interrupting 25,000 amps without the use of fuses or current limiters and without considering the starters and overloads. A disconnecting means shall be provided on the front of the enclosure suitable for locking in the open position. Seller shall provide adequate space and the required terminals to terminate cables.

Enclosures shall be NEMA 12 for indoor applications and NEMA 4 for outdoor applications. Nameplates shall be provided for each device using Purchaser's identification. Each nameplate shall be made of laminated plastic and shall be fastened with stainless steel screws. The nameplate shall be white with black lettering.

12. Air Receiver

An ASME Code Air Receiver, for 150 psig design pressure, shall be furnished. The receiver shall be complete with pressure gauge, relief valve set at 125 psig, automatic moisture trap with drain valve, inspection opening, and base ring. The air receiver shall be large enough so that, in case of start-stop capacity control, the number of starts shall not exceed that acceptable for the electric motor, but not less than 13.5 cubic feet. In addition, the receiver shall contain a low pressure switch and a high pressure switch to cut-in (start) and cut-out (stop) on the compressor.

13. Noise

The maximum sound level from the equipment furnished under this specification should not exceed 87 dBA at 3 feet from any surface of the unit. Sound pressure levels shall be measured in decibels re: 0.0002 microbars using a sound level meter conforming to ANSI S1.4A tolerance limits. Measurements shall be performed in accordance with ANSI S1.13 (corrected to free field environment in accordance with IEEE 85).

14. Marking

The equipment shall be provided with a permanently attached nameplate located in a readable position. The nameplate material shall be compatible with the material to which it is attached to prevent galvanic corrosion. Nameplates shall not be attached to pressure retaining surfaces with mechanical fasteners.

The compressor nameplate shall be stamped with the following information:

- o Purchaser's mark number
- o Manufacturer's name, model, and serial number
- o Year manufactured
- o Design pressure and temperature
- o Rated capacity, acfm
- o Rated discharge pressure, psig
- o Rated speed, rpm

The intercooler, aftercooler, and moisture separator shall be code stamped and the nameplates shall be in accordance with ASME VIII (latest edition). The dryer name plate shall also include the Purchaser's mark number, manufacturer's name, model, serial number, year manufactured, design pressure and rated capacity.

15. Induction Motors

All motors shall be TEFC and conform to Purchaser's Induction Motor Specification SE-211. An Induction Motor Data Sheet (Attachment No. 1 to Specification SE-211) shall be completed and submitted to the Purchaser for each motor supplied.

16. Wiring

For skid mounted equipment furnished as a complete package, 600 volt cables shall be copper conductors with thermosetting insulation and jacketing material for cables between Seller furnished panels and motors.

PVC material shall not be used. Conduit furnished on skid mounted equipment shall be rigid galvanized steel for outdoor applications or intermediate metal conduit for indoor applications, minimum size of 1/2 inch. Suitable liquid tight flexible conduit shall be provided at each motor connection with grounding jumper.

Electronic instrumentation cable shall be 600V shielded single pair No. 16 AWG or multipair No. 20 AWG as required. PVC material shall not be used.

Control wiring shall be Type SIS No. 14 AWG minimum. PVC material shall not be used. All control wires shall be terminated with insulated ring tongue or locking spade compression type terminals. All wires shall be provided with wire markers.

Power cable between the motor starter and the motor shall have XLPE or EPR insulation and neoprene, hypalon or thermo setting chlorinated polyethylene (CPE) jacket. Cables shall be rated for a conductor temperature of 90°C in dry locations and 75°C in wet locations.

17. <u>Welding</u>

All welding, welding procedure qualifications, and welder qualifications shall be in accordance with the requirements of ANSI B31.1.

18. <u>Piping</u>

All interconnecting piping between equipment (compressor, aftercooler, receiver etc.) shall be 150 lb, carbon steel, threaded (2 in. and smaller) and butt welded (2 1/2 in. and larger).

19. <u>Valves</u>

All isolation valves shall be gate or ball valves that do not require disassembly for installation.

20. <u>Hydrostatic Tests</u>

Each compressor, cooler, filter, and other pressure vessels shall be hydrostatically tested at 1 1/2 times its design pressure. These tests shall be in accordance with code requirements where applicable.

Each component, subassembly or assembled system shall be hydrostatically tested at 1 1/2 times the system design pressure.

Components of the system subject to cooling water shall be hydrostatically tested at 1 1/2 times the cooling water system design pressure but not less than 115 psig.

Tests shall be maintained for a duration of at least 10 minutes to permit examination of parts under pressure.

The basis for acceptance shall be no leakage.

21. Performance Test

The Seller's standard shop mechanical running test shall be performed. As a minimum, this shall include a completely assembled compressor with all auxiliaries and controls. The test shall be run for a period of not less than one hour to ensure proper clearance, internal alignment, bearing operation, and general mechanical acceptability.

Test certificates shall be submitted to the Purchaser.

22. Inspection

The following are the mandatory hold points for which prior notification is required:

- o Major repairs
- o Performance testing (optional)
- o Shipping release

23. Shop Cleaning

Cleaning of surfaces which are not be painted or coated shall be done according to the Supplier's best recommended practice.

Parts or subassemblies that may have crevices or inaccessible surfaces after assembly shall be cleaned as well as practicable prior to assembly.

Welded stainless steel and nickel alloys which are not re-solution annealed, as well as hardened low or high alloy steels, shall not be acid pickled.

All cleaning operations shall be conducted so that stainless steel and nickel alloys are not contaminated with lead, copper, mercury, and/or other low melting point metals; chlorides, sulfur, and halogens, as well as ferritic steel materials.

24. Shop Painting

External noncorrosion-resistant metallic surfaces shall be primed and finished in accordance with the Seller's standards unless otherwise specified below.

25. Packaging

Packaging shall be adequate to prevent contamination, mechanical damage, or deterioration of the item supplied, as defined in the requirements listed below. These requirements are applicable immediately after manufacture.

All expendable materials, such as tapes, barriers, plugs, desiccants and desiccant bags, caps, inhibitors, etc., to be in contact with austenitic stainless steel or nickel alloys shall not contribute to corrosion during the storage period by, for example, rain or condensate leaching deleterious chemicals contained in the expendable material.

Items not immediately packaged after manufacture shall be protected from contamination.

Items shall be inspected for cleanliness immediately before packaging. Cleaning acceptance criteria are invoked as defined in this Specification. Any entrapped water shall be removed.

All openings into items shall be sealed or plugged. Weld-end preparations shall be protected against corrosion and physical damage.

Items shall be packaged in suitable containers, crates, or on skids.

The outermost covering shall be clearly marked with the complete vendor identification, which shall include weight.

The center of lifting points for large and heavy equipment shall also be identified.

All items subject to corrosion shall be suitably protected.

26. Shipping

The weight and lifting points, indicated on the crate, skid, or package shall be utilized for all handling procedures.

When shipping by open carrier, items shall be covered by fire-retardant materials, e.g., tarpaulins, to prevent contamination from road, dust, dirt, salt spray, and other forms of contaminants. Cover installation shall be made so that air circulates under the cover to prevent condensation.

Shipments made in closed carriers do not require tarpaulins.

27. Provision for Storage

It is expected that the equipment will be stored at the jobsite in an unheated building or outdoors with equivalent protection.

The Seller shall include his long-term storage and maintenance procedure(s) applicable to site storage with each shipment to which they apply.

## 2.3 Baghouse

Allowable baghouse design parameters shall be as follows:

| | | |
|---|---|---|
| Maximum "pulse jet" net gas to cloth ratio (ft/min) | = | 3.3 |
| Maximum "reverse air" net gas to cloth ratio (ft/min) | = | 2.0 |
| Minimum "reverse air" fan flow to cloth ratio (ft/min) | = | 1.5 |
| Minimum spacing between bags (in.) | = | 2.0 |
| Minimum number of baghouse compartments | = | 6 |

| | | |
|---|---|---|
| Minimum spacing between bags and internal walkways, walls and other internal structures (in.) | = | 3.0 |
| Particulate density for particulate hopper capacity design ($lb/ft^3$) | = | 30 |
| Particulate density for particulate hopper structural design ($lb/ft^3$) | = | 120 |

Maximum air to cloth ratios shall be based on the baghouse inlet flow corresponding to the economizer outlet flow for the process Design condition of Attachment 2 plus inleakage (as estimated by Seller but not less than 3%), atomizing air, quench water and baghouse operation with one module off-line for cleaning. Reverse air baghouse net air to cloth ratio shall include the effect of the reverse air flow. Both reverse air and pulse-jet bag cloth area used in calculating the above air to cloth ratios shall only include the effective bag area and shall not include fabric covered by thimbles, anti-collapse rings, caps, cuffs, seams, etc. Seller shall provide a bag dimensional drawing and the effective bag area calculation method with his proposal in order to verify that the air to cloth ratio has been correctly calculated.

2.3.1 Baghouse Structure

The baghouse shall consist of individual, isolatable modules constructed of structurally stiffened, self-supporting panels. The compartments shall be gas-tight, seal welded internally and structurally reinforced with external stiffeners, ribs, and supports. Baghouses of the structural design (i.e. - adjacent modules share a common wall) may be furnished for reverse air baghouses. No internal structural supports shall be allowed in the baghouse hoppers. Internal supports will be allowed in the compartment provided these supports do not interfere with normal access and maintenance. The roof shall be sloped 1/4 in. per ft or greater. The casing and roof shall be constructed of minimum 3/16 in. plate. Roof areas shall be sloped to drain to gutters and downspouts running to grade at a point just outside the APC area nearest the I.D. fans.

The baghouse shall have a walk-in plenum design to allow access to the bags and cellplate. Access door seals shall be designed to prevent air in-leakage.

Mechanisms such as dampers and damper operators which are exposed to the flue gas shall be designed, constructed, and supported so as to operate properly without any distortion or overstress due to thermal expansion or shock up to the baghouse structural design temperature. Damper bearing grease fittings shall be easily accessible.

The Seller's design shall include provisions to bypass 100 percent of the flue gas flow from the inlet to the outlet of the baghouse under emergency conditions. The bypass dampers and duct shall be designed so that the pressure drop across the baghouse bypass during 100 percent gas bypass will not exceed the pressure drop across the baghouse during the design conditions shown in Attachment 2 with one compartment off-line for cleaning. The bypass dampers shall be poppet type; any other type shall require approval of the Purchaser. Positive shutoff capability is required for these bypass dampers. Bypass dampers shall be fail open type.

The Seller shall supply all baghouse access platforms and stairways from the foundation level up. Reverse air baghouses shall include an internal walkway system to allow access to all bags. Walkways shall be located at the cellplate and bag hanging levels. Pulse jet baghouses shall have access to the cellplate.

Hinged access doors with latch shall be provided in each hopper and where necessary to enable proper inspection, cleaning, and maintenance of the interior of the baghouse including inlet and outlet ducts.

The cellplate shall be leaktight such that flue gas may pass only through the bags. The flue gas inlet to each module shall be located below the bags. Cellplate holes shall be mechanically punched (i.e. - no flame cutting is permitted); hole tolerance shall be ± 0.010".

The Seller shall arrange the baghouse to assure an even distribution of flue gas and particulate through the baghouse at all loads and insure no ash build-up in the ductwork. The Seller shall supply internal gas deflector plates at the gas inlet to each compartment if required. The use of perforated plates as a gas distributor is not permitted.

All exposed steel shall be painted in accordance with Specification SA-550.

2.3.2 Bags/Cages

Fiberglass bags with teflon and/or acid-resistant finish are preferred and shall be furnished in accordance with the requirements of section 2.3.2.1 and 2.3.2.2 for pulse-jet and reverse air bags, respectively. The Seller shall provide the type of bag required to meet the emission requirements of Section 3. The type of bags supplied shall have had prior experience in a similar temperature and environment and shall be subject to approval by the Purchaser. Maximum bag dimensions are 14 feet long by 6 inches in diameter and 24 ft. long by 8 inches in diameter for pulse-jet and reverse air type baghouses, respectively.

Bags and their configuration shall be so designed and constructed that replacement may be made without removing other bags (pulse-jet baghouse only) or causing misalignment of the bag supports. Installation and removal of bags shall be a simple process requiring a minimum of tools and time.

Bags for pulse jet air service shall be supported by internal cages in accordance with section 2.3.2.3. The Seller shall provide a bag to cellplate sealing system that will maintain a gas and dust tight seal under all operating conditions. The bag spacing and support shall be such that adjacent bags do not touch each other, baghouse walls or any internal struts during operation. The use of bag alignment grids is not permitted.

Bags for reverse air service shall be clamped to thimbles in the lower cellplate and suspended from a structural member with a spring or counter weight mechanism to maintain proper bag tension. The tensioning system shall include provision for tension adjustment. Snap bands sewn into the bag may also be used for bag to thimble attachment. The Seller shall provide spring tensioning devices for installation of the bags. Bag access at the lower tube sheet shall consist of walkways a minimum of 24 inches wide and arranged such that no more than three rows of bags shall be accessed from each side.

2.3.2.1 Pulse-Jet Filter Bag Specification

Seller to Adhere to the Following Requirements

1. Maximum Fabrication Tolerances for Woven Fiberglass Pulse-Jet Filter Bags (Nominal 6" Diameter by 14' Long)

   a. Filter Bag Diameter: Diameter +0.12", -0"
      Flat Width +3/16", -0"

   b. Filter Bag Length:

      Seam Side: ±3/8"
      Opposite Seam Side: Note to exceed seam length by more than 1/2"

Length shall be defined as the distance from the top edge of the bag to the top row of disc stitching; i.e., the effective inside length of the bag.

Refer to Section 4 for the Bag Construction Specification and to Attachment 14 for Fabric Specifications; Seller's exceptions to these requirements must be provided in detail.

2. Filter Bag Quality Control

Two reference filter bags shall be provided to Ogden Martin (Fairfield, NJ) as the baseline comparison with a quality control cage and tubesheet hole to be supplied by the Seller. Quality control filter bags must properly fit the cage and tubesheet and must comply with the dimensional tolerances specified in Section 1 above, with the construction details specified in Section 4 below, and with the fabric specification in Attachment 14. In addition, three bags shall be sent to the job site for field verification of cell plate fit per section 2.3.2.3 of this Specification. The Seller shall not proceed with bag manufacture until reference bags and fabric are approved by Ogden Martin.

3. Quality Inspection

   a. Shop Fabrication

   Ogden Martin reserves the right to have a representative visit the filter bag fabrication site and inspect the filter bags designated for delivery to the project site. Seller must notify Ogden Martin at least two weeks prior to filter bag fabrication. Notification should be to the Project Manager.

   Filter bags shall be measured for their critical dimensions at the fabrication site by the manufacture's inspector. If filter bag tolerances are greater than those specified in Section 1, they will be rejected and deemed unsatisfactory for use at the subject project or any other Ogden Martin Facility unless approved by Ogden Martin. Each rejected bag must be replaced at the Seller's expense with a substitute that complies with this Specification. Ogden Martin will not be responsible for replacement costs of the unacceptable filter bags.

b. Facility Installation

Filter bag quality may be inspected at the Facility after bags and cages have been installed in the baghouse. This quality control inspection will occur if there is visual evidence of poor fabrication as evidenced by crooked, puckered or tight seams; nonuniform bag length; inadequate bag/cage fit; inadequate sealing between the bag and tubesheet; or other associated reasons. The Seller will be contacted before any removal of bags, should this be required to facilitate such an inspection.

Any filter bags which are not in compliance with this specification will be rejected. Replacement components will be supplied by the Seller at the Seller's expense including materials, freight, removal of the rejected filter bags, and installation of the replacement bags, including labor and manpower.

4. Filter Bag Construction

a. Thread

PTFE-coated (Teflon-coated) fiberglass; type B-4 in the vertical seam stitching and type B-4 or B-6 in the circumferential stitching.

b. Seam

The vertical seam shall be "felled" with triple needle type 401 multithread chain stitching. The seam width shall be 1/2" to 5/8" with fabric edges fully interlocked as shown in attachment 15 . The seam shall be relatively flat and free of puckers. The filling yarn misalignment at the seam (seam registration) shall not exceed 3/4".

c. Top

The top of the bag shall be designed and constructed to provide a gas-tight seal when properly installed in the tubesheet according the Seller's instructions. The opening in the top of the bag shall have sufficient clearance to permit the cage to be inserted fully without binding. Baghouse OEMs utilize different bag sealing methods and thus different bag top designs. The most common type is the double-beaded snap band top, the construction of which is specified below. If the Seller uses an alternate design, a detailed description of the bag top construction must be provided.

<u>Double-Beaded Snap Band Type (Example):</u> The top cuff shall be made of a separate piece of woven glass fabric, self-material (same fabric as the bag) or approved alternate. The fabric shall be bias-cut for better conformity to the shape of the gasketed band.

It shall contain a 1.0 inch wide by 0.015 inch thick snap band to which a double-beaded fiberglass gasket has been attached with contact adhesive. The gasket shall be sized to fit around the full circumference of the band (no significant gap) without overlapping.

The snap band shall be constructed of a material which will provide resistance to corrosion (including stress corrosion cracking) in the incinerator/spray dryer flue gas, sufficient to preclude any adverse effect on bag function. The band shall have rounded edges and be free of burrs.

The cuff/band assembly shall be constructed so that it snaps into the tubesheet hole easily but snugly, providing a gas-tight seal. It shall be sewn to the top of the bag with double-needle type 301 lock stitching as shown in attachment 15. The top row of stitching shall be sufficiently close to the band (approximately 1/16") to minimize shifting of the band inside the cuff during installation. The cuff seam shall be positioned approximately 180° opposite the bag seam. The finished cuff length shall be nominally 3 inches long (on its externally facing surface).

d. Bottom

A separate, 3 inch long (minimum) reinforcement, made of self-material or an approved alternate fabric, shall be attached to the bottom of the bag with two rows of double-needle type 301 lock stitching. The reinforcement shall be sewn closed vertically to prevent dust buildup between it and the bag, and this seam shall be offset approximately 180° from the bag seam.

A disc shall be fabricated from two layers of self-material (or approved alternate fabric) sewn together with overcast stitching. This disc shall be sewn into the bottom of the bag using a lap seam with double-needle type 301 stitching. The disc and bottom of the reinforcement may be attached simultaneously.

e. General Sewing Quality

No raw fabric edges shall be exposed.

All circumferential stitching shall be relatively smooth and free of puckers and shall not result in any significant constriction of the bag at the cuff or reinforcement attachments.

On reworked bags, no needle holes (from which stitching has been removed shall be exposed.

f. Bag Dimension and Bag/Cage Fit Guidelines

Bag dimensions shall be governed by the actual fit of the bag on the Seller's cage. The bag "pinch" on the cage,, which is approximately equal to one-half the excess circumference of the bag vs. that of the cage, shall range from approximately 1/8" to 5/16', and the flat width of the bag shall be established to achieve this pinch.

When the bag is installed in the tubesheet with the cage fully inserted according to the Seller's instructions, the bottom of the cage shall be located from approximately 1/4" below the disc stitching to approximately 1/2" above the disc stitching at the bag seam. The bag length shall be established to achieve this configuration relative to the cage. Since bag length measurements are difficult to make accurately, with values obtained depending on measurement technique, a suitable bag length shall be determined by actual bag/cage fit, not by calculation. A properly fitting sample bag shall then be used as a prototype for bag production, and using proper fabrication techniques, a consistent bag/cage fit shall be obtained.

2.3.2.2 Reverse Air Filter Bag Specification

Seller to Adhere to the Following Requirements

1. Maximum Fabrication Tolerances for Conventional Woven Fiberglass Filter Bags.

   a. Filter Bag Diameter: Diameter ± 0.08"
      Flat Width ± 1/8"

   b. Filter Bag Length (under tension):

      Seam Side: ± 3/4"
      Opposite Seam Side: Seam Side Length + 3/4" maximum

   Length shall be defined as the overall length of the bag proper, excluding cap/bolt height, at the original bag installation tension which shall be specified by Seller.

   Refer to Section 4 for Bag Construction Specification and to Attachment 16 for Fabric Specification; Seller's exceptions to these requirements must be provided in detail.

2. Filter Bag Quality Control

   Two reference filter bags shall be provided to Ogden Martin as the baseline comparison with a quality control thimble and bag cap to be supplied by the Seller. Quality control filter bags must comply with the dimensional tolerances specified in Section 1 above, with the construction details specified in Section 4 below, and with the fabric specification in Attachment 16. The Seller shall not proceed with bag manufacture until reference bags and fabric are approved by Ogden Martin.

3. Quality Inspection

   a. Shop Fabrication - same as paragraph 2.3.2.1 (3a).

   b. Facility Installation

      Filter bag quality may be inspected at the Facility after bags have been installed and tensioned in the baghouse. This quality control inspection will occur if there is visual evidence of poor fabrication as evidenced by crooked, puckered or tight seams; nonuniform bag length; inadequate bag/thimble fit; excessive puckering of cuffs or ring covers; skewed ring covers; or other associated reasons. The Seller will be contacted before any removal of bags, should this be required to facilitate such an inspection.

Any filter bags which are not in compliance with this specification will be rejected. Replacement components will be supplied by the Seller at the Seller's expense including materials, freight, removal of the rejected filter bags, and installation of the replacement bags, including labor and manpower.

4. Filter Bag Construction

a. Thread

PTFE-coated (Teflon-coated) fiberglass; type B-4 in the vertical seam stitching and type B-6 in the circumferential stitching (cuffs and ring covers).

b. Seam

The vertical seam shall be "felled" with triple-needle type 401 multithread cnain stitching. The seam width shall be 1/2" to 5/8" with fabric edges fully interlocked as shown in Sketch No. 1 (Attachment 15). The seam shall be relatively flat and free of puckers. The filling yarn misalignment at the seam (seam registration) shall not exceed 3/4".

c. Top Cuff

The bag top shall have an integral cuff, nominally 2" long, enclosing a metal compression band sized to fit the Seller's shop-installed bag cap. The cuff shall be fabricated to provide two layers of fabric on each side of the band; either by use of a separate band cover or a "double turnback" construction. The cuff shall be sewn with two rows of double-needle type 301 lock stitching, and the row of stitching adjacent to the band shall be sufficiently close to the band to minimize its movement inside the cuff. The cuff shall be relatively smooth and free of puckers, especially around the band.

d. Bottom Cuff

The bag bottom shall have an integral cuff, nominally 3" long, sized to fit the Seller's thimble and constructed by one of two alternative methods, according to the type of thimble used:

<u>Compression Band Type</u>: This type cuff shall be fabricated according to the specifications for the top cuff in Section 4.c above. Bag/thimble fit is very critical for this design, and <u>the bottom cuff/band assembly should be sized to fit thimbles with diameters at both extremes of the tolerance</u>.

<u>Rope Type</u>: This type cuff, which requires a separate hose clamp connector for thimble attachment, shall consist of a simple hem enclosing a glass rope at the bag bottom. The cuff shall be sewn with two rows of double-needle type 301 lock stitching.

e. Cuff Band(s)

The compression band inserted in the top cuff (and bottom cuff, if applicable) shall be approximately 0.5" wide x 0.015" thick with a circumference sized to assure proper fit on the Seller's bag cap (and thimble, if applicable). It shall be constructed of a material which will provide resistance to corrosion (including stress corrosion cracking), in the incinerator/spray dryer flue gas, sufficient to preclude any adverse effect on bag function. The band shall have rounded edges and be free of burrs.

f. Anti-Collapse Rings

The bag shall be fabricated with a minimum of five (5) anti-collapse rings attached. The number and spacing of these rings along the length of the bag shall be specified by the Seller, but in no case shall the spacing between any two rings, or the distance from either "end" ring to its respective end of the bag, exceed four feet.

The rings shall be constructed of 1/8" diameter (minimum) mild steel, plated or coated if necessary to provide resistance to corrosion sufficient to preclude any adverse effect on bag function. **<u>Galvanized steel is not acceptable</u>**. Rings shall be butt-welded with a smooth weld free of burrs. They shall be round, and the ring diameter selected to minimize puckering of either the ring cover fabric or the bag fabric; i.e., the I.D. of the rings should be approximately equal to the O.D. of the inflated bag.

g. Ring Covers

Each ring shall be enclosed in, and attached to the outside of the bag with, a ring cover which shall be nominally 1-3/4" wide. The ring cover shall be fabricated from the same fabric as the bag, and it shall be constructed so that there are two layers of fabric on each side of the ring (in addition to the bag fabric).

The ring covers shall be sewn with two rows of double-needle stitching (type 301 or 401), one row on each side of the ring, and the row of stitching closest to each edge of the ring cover shall be at least 1/8" from that edge. The ring covers shall be sewn perpendicular to the vertical axis of the bag and shall be relatively free of puckers.

h. Bag Cap

A bag cap of the Seller's (or bag vendor's) standard design shall be furnished with each bag. The cap shall be constructed of 22 gauge (minimum) mild steel, plated or coated if necessary to provide resistance to corrosion sufficient to preclude any adverse effect on bag function. Each cap shall be fitted with an eyebolt or J-bolt (also corrosion-resistant) whose dimensions and method of attachment to the cap shall be specified by the Seller. The eyebolt shall remain firmly attached to the cap throughout the life of the bag.

The cap shall be installed by the vendor prior to bag shipment, and each cap shall be oriented so that the plane of the eyebolt is either aligned with, or rotated 90° from, the bag seam, as specified by the Seller. The eyebolt shall be covered with a snug fitting, but easily removable, protective device to prevent damage to the glass bag fabric during shipment.

2.3.2.3 Pulse Jet Cage Specification

1. Construction

   a. 20 vertical wires equally spaced.

   b. Horizontal rings spaced 6 inches apart.

   c. All wires of 11 gauge carbon steel construction unless otherwise specified. Wires may be electroplate galvanized at the Seller's discretion.

   d. All surfaces to be smooth to prevent damage to bag.

   e. Weld all points of contact on cage.

   f. Specified tolerances in item 2 apply throughout entire length of cage.

   g. Bottom pan shall be of 18 gauge carbon steel construction unless otherwise specified. A pan that creates a tapered bottom is not acceptable. Crimping of the pan around wires is not acceptable.

   h. Cage collar for interfacing with cellplate shall be fabricated of 18 gauge carbon steel and shall be level such that it would provide a seal with a level cellplate.

2. Fabrication Tolerances

   a. Diameter : Specified diameter +0/-1/16 of cages outside diameter.

   b. Length : Specified length +0/-1/4".

3. Fabrication Procedures

   a. Cellplate Fit

      Three test cages which meet these specifications shall be installed at the site to confirm that cage and cellplate sizing is correct. The test cages shall also be fitted with bags at the site to confirm cage - bag - cellplate sizing. The installation shall be witnessed by OMS.

   b. A test cage which meets these specifications shall be fit to a bag to confirm bag-to-cage fit before mass production commences. The test cage shall be fabricated on equipment that will be used for the production run.

2.3.3 Bag Cleaning System

A pulse jet or reverse gas cleaning system shall be designed and furnished for dislodging collected particulate adhering to the collecting bags, and to any other surfaces where accumulated particulate may impair baghouse performance. The bag cleaning system shall clean all bags equally. Pulse-jet baghouses shall be capable of cleaning using both on-line and off-line cleaning. Each pulse jet module valve header shall be isolateable from the compressed air system at the baghouse module.

The Seller shall incorporate, into the design of his bag cleaning system, mechanisms to prevent "bag popping" caused by the sudden rush of incoming flue gas into bags which have just been cleaned. The preferred mechanism is staging the opening of outlet isolation valves of the off-line compartment as it goes back on-line. The Seller may quote an alternative, subject to approval by the Purchaser.

The bag cleaning system shall automatically perform periodic cleaning of bags such that the guaranteed average draft loss through the APC system as stated in Section 7.1bi of Attachment 7 is not exceeded.

The cleaning system shall be designed to dislodge collected particulate into the particulate hoppers without allowing dislodged particulate to be released to the flue gas outlet from the baghouse to a degree that the guaranteed outlet particulate loading and stack opacity will be exceeded. The cleaning system will also be designed to produce a minimum amount of wear and tear on the filter bags consistent with removing a sufficient amount of collected particulate. The off-line cleaning cycle shall consist of the following steps: 1) compartment isolation, 2) bag cleaning by reverse air or pulse jet mechanism, 3) no flow period to allow suspended particulates to settle, and 4) return compartment to service. The on-line cleaning cycle shall include the simultaneous pulsing of the identical row in each of the baghouse modules. The cleaning shall proceed by pulsing alternate rows (i.e. 1, 3, 5...15, 2, 4, 6...14). Pulsing will be initiated at a high differential set point and stopped at a low set point. Both set points will be monitored by separate and independent switches. The next cleaning cycle shall start with the row at which the previous cleaning cycle stopped.

Pulse-jet: For baghouses utilizing the pulse-jet (high ratio) concept, -40°F dewpoint air will be supplied by Purchaser at the piping interface point. Seller to state quantity of air required assuming all trains are cleaning simultaneously. Seller shall provide one air receiver in accordance with Section 2.3.5.

Reverse Air: Baghouses utilizing the reverse air (low ratio) concept shall have one reverse air fan per train. The fan shall be located at grade next to the baghouse to minimize duct work. Reverse gas flow shall normally be taken from the outlet duct of the baghouse. The reverse air fan shall have backward-curved blades and shall not operate at speeds in excess of 1180 RPM. The Seller shall provide an option cost to provide an atmospheric fan inlet with isolation damper and air heater to heat air to flue gas temperature. This system shall be used when the baghouse is operating with high opacity.

Reverse air fans shall meet the technical requirements of SM-104.

2.3.4 Compartment Isolation and Ventilation Systems

Baghouses shall include a compartment isolation and ventilation system capable of providing total compartment isolation and ventilation such that personnel access for inspection/maintenance can be safely effected (i.e. - temperature shall not be greater than 110°F based on the Design Summer ambient temperature) in an isolated compartment within two (2) hours while the rest of the baghouse is on-line and that isolated compartments will comply with any State or OSHA regulations for the protection of personnel. A ventilation system utilizing one portable fan per row of modules and the necessary electrical outlets is acceptable. Each portable fan shall be provided with a weather enclosure for storage when not in use.

The compartment outlet and reverse/pulse air dampers for isolation shall be capable of being manually closed at the baghouse control panel. All baghouse designs shall include mechanical devices to lock dampers in a safe position. All outlet damper and bypass damper actuators shall be accessible from platforms.

The compartment isolation system shall be capable of isolating any individual compartment. Poppet type dampers shall be used for compartment inlet, outlet, and reverse gas dampers. Butterfly damper is acceptable for inlet to module. Any other type of damper will require approval by the Purchaser. The inlet damper shall be capable of being operated manually from grade.

2.3.5 Pulse-Jet Receiver

An ASME Code Air Receiver, for 125 psig design pressure, shall be furnished. The receiver shall be complete with pressure gauge, relief valve set at 125 psig, automatic moisture trap with drain valve, inspection opening, and base ring. The air receiver shall have a capacity of 400 gal. minimum. Portion(s) subject to freezing shall be heat traced and insulated.

2.4 Electrostatic Precipitator

Each ESP shall be sized and designed so that under all operating conditions the outlet dust loading will not exceed the particulate emission and opacity guarantees.

Baffling shall be provided to prevent gas bypassing either above, under, or around the collecting surface.

The precipitator shell shall be fabricated from a minimum of 3/16" plate with external columns and stiffeners. The precipitator shall be gastight.

The entire precipitator roof shall be externally insulated, waterproof, and suitable for foot traffic. Overlapping coating construction seals shall be provided around all protrusions through the roof. All quick-opening openings, through which personnel might come in contact with high voltage equipment, shall be interlocked to prevent opening before the precipitator electrical supply is deenergized. These doors shall have permanently attached warning signs marked "Danger-High Voltage." Multiple-bolted openings shall not require interlocks but must have permanently attached warning signs marked "Danger-High Voltage."

All portions of each precipitator proper shall be weatherproof. Roof areas shall drain to gutters and downspouts to grade at a point just outside the APC area perimeter boundary nearest the I.D. fans.

External accessories, such as extensions for access doors, inspection openings and other equipment, shall be designed to clear by 2 in. an insulation thickness of 3 in. for the shell sides and hoppers plus a ribbed lagging 1-1/2 in. in depth, all of which will be outside the shell and hopper stiffeners. A minimum 12 in. normal clearance shall be provided between the hopper side slope stiffeners and the supporting steel to provide access for installation of insulation and lagging.

Hinged access, inspection, and clean-out doors with gastight seals shall be provided in the hopper, and where necessary, to enable proper inspection, cleaning, and maintenance of the equipment.

Doors shall be capable of gastight sealing with repeated opening and closing and shall be completely equipped with safety interlocks. No sealing compound shall be used to obtain gastightness.

A walk-in penthouse shall be provided, and be equipped with a pressurization fan system. Penthouse shall be sided and roofed to meet requirements of 2.8.8.

The Seller shall design and provide all flow distribution devices to insure proper flow distribution. Stiffening and reinforcement shall be included as needed.

Precipitators shall be designed to accommodate the thermal shock of occasional sudden shutdown and startup, including temperature cycling between ambient and operating temperatures. Seller shall advise if his equipment has any limitations which cannot cope with such an occurrence.

As a minimum, structural design shall be based on a static flue gas pressure at the inlet flange ranging from plus 25 to minus 25 inches of water column.

The precipitator shall be conservatively sized and shall have a minimum of three (3) or more electrically and mechanically separated fields.

2.4.1 Collecting Plates

The collecting plates shall be:

1. Smooth sheet (except for stiffeners and baffles) of minimum 18 gage USSS&P thickness.

2. Designed, constructed, and supported to withstand, without mechanical distortion or overstress, the rapping energies required for proper dust removal.

3. The plate shall not deviate from the normal center line of plate by more than 1/4 in.

4. Constructed and supported to eliminate any distortion due to thermal expansion or shock up to the rated design temperature.

5. Completely shop assembled in individual curtains.

6. SCA shall not be less than 370 sq ft/1000 acfm.

All series fields shall be of the same length in direction of gas flow.

Minimum active aspect ratio to meet performance shall not be less than 1. Aspect ratio is defined as the ratio of total collecting curtain length to collecting curtain height. Active aspect ratio shall be calculated exclusive of spaces between the series fields.

2.4.2 Discharge Electrodes

Discharge electrodes shall be of the stiff or rigid design. Weighted wire electrodes will not be acceptable. Electrodes shall be stabilized against movement by means of a proven design without the use of insulators for attaching the lower frame to the hopper or precipitator sidewall. Each bus section shall be supported by means of alumina insulators. Electric resistance heaters with controls shall be provided for preheating insulators prior to startup and for supplemental heating during low load conditions.

All mechanical terminations and connections of discharge wires to support frames shall be provided with positive electrical contact to prevent spit-arcing, metal fatigue, and breakage, particularly those associated with rapping stresses. All mechanical terminations and connections shall be preferably of a welded nature.

Each discharge assembly shall be designed to remain plumb to ensure accurate electrode alignment throughout the service life of the precipitator. Each assembly shall hang within 1/4 in. of plumb center line.

2.4.3 Rapping Systems

Rapping systems shall be adequate to provide removal of collected particulate matter from both collecting curtain and discharge electrodes, to the extent that precipitator performance requirements and guarantees shall not be impaired by excessive particulate accumulations.

Puffs of particulate matter resulting from rapping shall not be visible under any conditions of precipitator operation. The collecting curtain rapper system shall be of the impact type, as distinguished from the forced vibration or vibrator type. The maximum installed and operating design levels of specific rapping energy expressed as foot pounds per pound of system rapped by an individual rapper shall be stated. A minimum of 50 G's acceleration shall be imparted to all parts of the collecting curtain.

There shall be maximum of 1,500 sq ft of collecting surface per individual rapper. The rapping system shall be completely flexible and adjustable as to rapping period, frequency, and rapping cycle. Rappers in any one series field shall be separately adjustable with relation to the rappers in any other series field. The rapping system shall be designed so that adjustments can be made on an individual rapping section, whether the precipitator is energized or not.

The rapper controls shall be of the maintained contact type, i.e., all controls shall restart without operator action upon energizing the entire precipitator system. A test shall be conducted on all rappers to demonstrate that rapping uniform and in accordance with design requirements. The details of the test procedure shall be submitted to the Purchaser in advance for approval.

### 2.4.4 Electrical

The precipitators shall be designed with the following electrical equipment:

1. Heavy-duty, high-voltage support insulators and bushings.

2. Main high-voltage silicone oil filled transformer and silicon diode rectifier sets and protective equipment, all totally enclosed in a self-contained tank, for outdoor service conforming to all applicable codes and regulations. Bus and bus duct to connect T/R to discharge system.

3. Each T/R shall contain primary voltage taps, terminals for wiring to a separate T/R control unit, insulating fluid high temperature and low liquid level alarm contacts, insulating fluid temperature and level indicators, and key interlocked position selector switch.

4. 460V, 3 phase, power distribution switchboard, circuit breaker type, each panel breaker; the necessary feeder breakers for distributing power to all transformer-rectifiers, rappers, vibrators, and all other equipment required for operation of the precipitators, and the necessary monitoring instruments.

5. Contactors, control relays, load sensing devices, and all necessary controls including rectifiers, control units, and reactors, completely wired.

6. Automatic programmable controller system for optimum precipitator energization under fluctuating boiler flue gas outlet conditions.

7. Indicators to monitor precipitator performance and detect grounds in addition to control cubicle instruments, failure indicators for electrode rappers, and provisions for adding remote indicators for each high voltage system.

8. Electrically-operated rapping systems with automatic controls.

9. Rapper control cabinet for collecting curtain and discharge electrode rappers, completely wired.

10. Alarm circuit system for rectifier and ventilating system.

11. Provisions to allow shutdown of any one of the precipitator sections with uninterrupted service of the remaining sections.

### 2.4.5 Platforms and Stairways

Platforms, access stairways, walkways and handrails shall be provided to all areas requiring equipment and valve access, maintenance and routine inspection. Caged ladder access to precipitator roof from grade shall be furnished.

## 2.5 Hoppers (Baghouse and Precipitator)

A minimum number of ash collecting hoppers consistent with good design shall be provided. Precipitators shall have troughed hoppers which terminate with a 12 inch wide flanged opening. Baghouses shall have one pyramidal hopper per module, which terminate in a 12" x 18" flanged opening (18" dimension shall be parallel to the baghouse collecting screw conveyor). Hoppers shall be constructed of minimum 1/4 inch plate. A Purchaser-supplied screw conveyor will run beneath the hopper outlets of each row of modules along the scrubber/baghouse (precipitator) axis. Each hopper flange shall be capable of supporting 200 lbs. per linear foot of conveyor located directly beneath each module or 2000 lbs., whichever is greater. In addition, each pyramidal hopper shall be provided with two hanger rod mounting lugs, each designed to support 1000 lbs. of Purchaser's equipment. Location of these lugs shall be coordinated with conveying equipment supplier through the Purchaser's Engineer.

Sufficient allowance in hopper dust capacity shall be made for unequal distribution of ash between the front and rear hopper sections. Adequate hopper capacity shall be furnished for minimum of 8 hour emergency fly ash storage at the Design conditions shown in Attachment 2.

Hoppers shall be located so as to eliminate the possibility of ash build-up in the immediate area of the gas distribution plates. The valley angle of all hoppers shall not be less than 55 degrees with the horizontal. The temperature of the hoppers shall be maintained at flue gas temperature by electrical heaters and insulation during normal operation.

Hoppers shall have no internal baffles. Each pyramidal hopper shall have a high level switch, two poke holes of 4 inch diameter pipe with caps, two connections (90 degrees apart) for a future air cannon, one 8 inch square strike plate, one electric vibrator with adjustable on/off cycle timer, and one flanged clean-out and hinged access door with safety chain and closure plate. The high level switch should be located at an elevation equal to that of the bottom of the hopper access door. Troughed hoppers shall have similar provisions but in numbers consistent with the hopper length. Hoppers shall be arranged to provide a minimum clearance of 10 feet to finish grade below hopper flanges for installation of Purchaser's ash removal system. Access to the hoppers may be from either side that is not obstructed by the ash conveyor. All poke holes, strike plates, level probes and the access door shall be on these sides of the hopper. The air cannon connections and vibrator may be located on the hopper sides above the ash conveyors. No conduit, piping or other obstructions shall be located to obstruct access to the access door, strike plates or poke holes, nor shall the strike plates and poke holes obstruct the access door.

## 2.6 Ductwork

### 2.6.1 General

Ductwork shall be designed so that the maximum gas velocity at the Design load gas flow rate specified in Attachment 2 shall be 3,600 feet per minute.

The maximum and minimum temperature of the flue gas (temperature gradient) at the baghouse or precipitator inlet shall not deviate by more than plus or minus 5°F from the bulk average gas temperature.

All ducts shall be gas-tight and seal welded internally and shall be structurally reinforced with external stiffeners, ribs, and supports. The use of internal supports shall be minimized.

Damper bearing grease fittings shall be easily accessible outside the gas stream for on-line greasing.

Rigid stiffener corners shall be designed to resist the moment and shear developed by the stiffeners. Plates, channel stiffeners, and supporting structures shall be designed using a minimum particulate load of 200 psf on the projected area of the bottom of the scrubber outlet duct; the minimum particulate load for all other ducts shall be 100 psf. Under the maximum design loading condition, the deflection of duct plate and duct plate stiffeners shall not exceed the lesser of 1/240 of the span or the plate thickness.

Access doors shall be provided and located on the sides or top of ducts and shall be located such that each duct section can be entered for inspection and maintenance. As a minimum, access doors shall be provided at the inlet of the spray dryer, inlet of the baghouse, outlet of baghouse and outlet of I.D. fan. Access doors must be hinged and be easily accessible from platforms and ladders.

Particulate fallout hoppers shall be provided as necessary including those determined necessary by model study. These hoppers shall be fitted with all the accessories a baghouse hopper is fitted with (e.g. hopper heater, vibrator, level switch, etc.) Hopper outlet shall be 12" square flanged and 10 ft. above finished grade.

The Seller shall design for proper flow distribution of flue gas and solids within the ductwork by providing adequate distributors or other devices as required. Scrubber and I.D. fan inlet ducts shall be horizontal or vertical only. In sharp turns or elbow sections, a suitable number and arrangement of curved deflector vanes shall be provided to avoid turbulence and minimize pressure loss. Vanes shall be adequately braced and stiffened. Suitable man access ways shall be provided to each vane assembly. Vanes shall be designed to minimize the build up of ash on their surface.

Seller to provide two 4" diameter, 150 lb. ANSI flanged instrument connections on the scrubber inlet duct for Purchaser's CEM analyzers. As part of the option requested in Section 4.4.5, Seller shall provide two 6" diameter (180 degrees apart and in the same plane) and two 4" diameter 150 lb. ANSI flanged instrument connections on the vertical portion of the I.D. fan inlet duct for the Purchaser's opacity and CEM analyzers, respectively. The opacity and CEM connections shall be located in accordance with CFR, Title 40, Part 60, Appendix B.

8" diameter, 150 lbs ANSI flanged test ports together with blind flange shall be provided both in the inlet duct of the scrubber vessel and, as part of the option requested in Section 4.4.5, the vertical portion of the I.D. fan inlet duct. These test ports shall be provided in accordance with the CFR, Title 40, Part 60 Appendix A, Method 1, but as a minimum, shall not be less than two equivalent duct diameters downstream and one half equivalent duct diameter upstream of ANY flow disturbance (expansion joints are to be considered a flow disturbance). The test ports shall have a clearance zone to accommodate the sample testing apparatus. This clearance zone (when facing the test port) should be at least

12" to the right/left and top/bottom of the port center line, respectively, and should extend at least one duct diameter (or duct width, if rectangular) plus 3 feet from face of flange. Also eye hooks shall be provided approximately 4 feet above the 8" diameter ports. 2" diameter threaded test ports with caps shall also be provided on the I.D. fan inlet and outlet ducts for the purpose of testing fan performance in accordance with AMCA.

A single sample extraction point shall be provided between the scrubber and particulate collector.

The 8" diameter test ports, opacity connections and CEM connections shall be in accordance with Attachment 18.

Instrument test and sample connections shall be welded to the duct in accordance with ANSI B31.1. All welding shall be done prior to insulation. All duct connections shall terminate 6 in. outside stiffeners, insulation and lagging, except as may be required by CFR, Title 40, Part 60, Appendix B, Specification 1 for the opacity ports.

2.6.2 Materials

The choice of ductwork material shall be supported by successful experience with the selected material in similar environments and shall be subject to approval by the Purchaser. The steel plate used in the duckwork shall not be less than 3/16 in. thickness. Continuous angle or bent plate shall be 1/4 in. minimum.

Ductwork material shall conform to the requirements of this specification and to all applicable ASTM and AWS specifications as listed below:

1. As a minimum, structural steel shapes and plates shall conform to ASTM A36 or high strength steel as selected by the Seller and approved by the Purchaser.

2. As a minimum, pipe stiffeners shall conform to ASTM A53, Grade A or B.

3. As a minimum, weld filler material for ASTM A36 steel shall conform to AWS A5.1, E70 series.

2.6.3 Expansion Joints

Expansion joint material shall be designed to withstand the acidic condensation, thermal expansion, high chloride, high fluorides and caustic concentration, hygroscopic ash, flyash and APC system waste abrasion, and other harsh environments. Expansion joints shall be designed for the design temperature that will be encountered with the scrubber out of service and the baghouse bypassed. Expansion joints shall be gas-tight and installed in all gas ducts as required so that the expansion and contraction of the ducts during operation, including torsion and misalignment, can be readily accommodated without damage, misalignment or excessive stress of support structural steel members or connected equipment. Expansion joints shall be installed such that half the stress exists in the cold position and half in the hot position to avoid extreme deflections. Seller shall coordinate with the Stack & Boiler suppliers, the movements of the stack breeching connection and the Economizer outlet connection.

Any ties across the joint shall be between structural elements on the duct rather than to portions of the joint. Every reasonable effort shall be made to avoid locating expansion joints in horizontal gas ducts.

Fabric expansion joint frames and backing bars shall be of the same material as the adjacent duct plate. All holes in the plate, including flange bolt holes, shall be drilled unless otherwise specified. Corners shall be molded with no splices. A backing bar shall also be provided with holes matching the flange bolting pattern.

The expansion joints will be designed and constructed so that, under any operating condition, no portion of the joint will extend beyond the inside surface of the connecting duct.

Expansion joints shall include a system of internal baffles or "pillow" to keep particulates from collecting.

Expansion joints shall be of "multi-layer" design with sufficient insulation layers to prevent the formation of cold spots.

2.6.4 Ductwork Access

Access platforms shall be provided for all areas requiring routine access and as a minimum shall include damper actuators, I.D. fan inlet guide vanes, duct access doors (except those which can be accessed from grade as with the hopper access doors), all sample connections and instruments as well as the instrument connections and test ports required for Section 2.6.1, except for the scrubber inlet duct test ports (except as required below) and the 2 inch diameter AMCA test ports.

Access to the scrubber inlet duct test/instrument port access platform is from the boiler building. This platform is cantilevered off boiler building steel and provided by the boiler vendor. However, if Seller locates these test/instrument ports in the horizontal duct run to the scrubber (assuming port locations are in accordance with CFR, Title 40, Part 60), then Seller shall furnish, support and provide access to this platform and, if any of the test ports are on the top of the duct, Seller to provide a monorail with a manual hoist supported from the penthouse roof with sufficient clearance for the test apparatus as described in Section 2.6.1.

For plants with more than two APC trains, a 10 foot high x 12 foot wide (minimum) clearance zone is to be provided between the baghouse (precipitator) and I.D. fan or the I.D. fan and the stack.

2.6.5 Transition Pieces

Seller shall provide all necessary transition pieces in the ductwork between the economizer gas outlet and the scrubber inlet, between the electrostatic precipitator or baghouse outlet and the I.D. Fan inlet connection, and between the I.D. Fan outlet connection and the stack inlet connection for each train. Economizer outlet transition shall have a maximum angle of divergence of 30 degrees. All transition pieces shall be fitted with turning vanes if required to ensure proper flue gas distribution. Seller to provide the gaskets and bolts/nuts for the economizer and stack duct connections.

## 2.7 General Mechanical Equipment Requirements

### 2.7.1 Pipe and Pipe Supports

The Seller shall engineer, design, detail, furnish, fabricate, and deliver all materials and components necessary for the complete and adequate support and restraint of all piping systems included in the scope of this specification.

Supports shall include, but not be limited to, hangers, springs, anchors, guides, sway braces, vibration eliminators, shock suppressors, pipe attachments, supplementary steel, masonry anchors, and all hardware and components necessary for the proper support of the piping systems.

Seller-supplied pipe supports shall be designed to avoid problems such as pipe breaking, cracking, joint separation, and shear loads due to valve weight. The design of support systems and the individual supports shall comply with all requirements of ANSI B31.1, except as specified herein.

Outside pipe supports shall include provisions for heat tracing and insulation, as required.

Minimum overhead clearances for the lowest projection of any support component shall be 7'-0" except where operation, maintenance, equipment removal, or other considerations require additional clearance. No supports, however, shall interfere with stairs, passageways, access door, or normal plant activities; nor shall any support component project through platforms, floors, stairs, or walls. Supports shall not utilize other piping systems for attachments or be attached to valve, flange, or equipment bolts. No supports shall be affixed to equipment or piping specialties.

### 2.7.2 Heating and Ventilation

The Seller shall design and supply the complete heating and ventilation systems for the scrubber vessel atomizer enclosure, reagent preparation building, compressor building and lime silo equipment areas. The design shall be in accordance with ASHRAE, NFPA 90 and SMACNA.

Each heating and ventilation system shall heat and ventilate the enclosures, maintain a uniform temperature throughout the enclosure, and allow all enclosed equipment to operate within normal operating temperature ranges without failure or adverse effects.

The ventilation systems shall be designed to minimize dusting in those areas of the APC system which are near equipment handling dust.

Electric heating shall be used throughout the enclosures and buildings. Electric heaters shall have electric heating elements with built-in thermostats. Heating coils shall be electrically operated. Electric heating equipment shall bear the UL approved label. Heater controls shall have NEMA 12 enclosures (minimum).

### 2.7.3 Thermal Insulation and Lagging

The Seller shall provide thermal insulation and lagging on all surfaces subject to elevated temperatures during operation, such as scrubber and baghouse (precipitator) shell, roof, hoppers, etc. and ductwork, and transitions. Hopper shall be insulated down to purchaser's ash removal equipment. In addition Seller shall provide thermal insulation and lagging for the reverse air fans and I.D. fans (if I.D. fans are in Seller's scope) and the stack breechings up to the stack shell. Fan inlet guide vanes shall be fitted with removable insulation for ease of maintenance. Insulation shall consist of fiberglass or mineral wool blocks of suitable thickness to assure that the cold face temperature does not exceed 120°F at the design summer ambient temperature. Minimum thickness shall be 3 inches.

Insulation shall be provided in spaces between adjoining walk-in plenums. Insulation is also required between adjacent modules of reverse air baghouses. Pulse-jet baghouses designs may insulate between modules or seal this space and provide draft stops at 2 feet intervals. For reverse air baghouses of the structural design, insulation shall be provided on at least one side of all common walls. Lagging connecting, the hoppers to the side walls shall be provided so as to avoid up drafts.

The thermal insulation for the system ductwork and equipment shall be designed to maintain the minimum stack entrance temperature (see Attachment 3) under all conditions as shown in Attachment 2. The temperature loss across the baghouse (precipitator) shall be limited to 10°F at minimum ambient conditions.

Lagging shall be suitable for outdoor installation, flush with insulation and consist of minimum 0.04" thick ribbed, aluminum, installed properly and fastened to provide a waterproof envelope for the insulation. Lagging color (manufacturer's standard), texture and profile shall be as specified by the Purchaser to match the facility building siding.

The entire system, from discharge of the economizer to and including the stack breeching inlet shall be considered as an outdoor application unless noted otherwise in Section 4.4.9; and shall be detailed, fabricated, and installed to be completely weatherproof in all respects. In addition, all panels shall be designed to accommodate thermal expansion and be readily removable for inspection and repair of the gas system without extensive dismantling of nonaffected areas.

Insulation material shall be Owens-Corning T.I.W. - Type II or equal with a nominal density of 3 1/2 lb./ft or semi-rigid bonded mineral wool block insulation with a nominal density of 10 lb./ft.

Proper drainage for all horizontal insulation surfaces exposed to the weather shall be provided. A minimum 1/4 in. per foot slope is required for the top of the baghouse or precipitator, outside roof areas of the absorber vessel, tops of rectangular or square ducts, and other flat areas exposed to the weather.

Insulation support steel and panels for the top of the baghouse or precipitator, scrubber vessel, and rectangular or square ducts shall be capable of supporting a 250 lb walking load without permanent deformation or crushing of insulation.

The Seller shall supply all access doors of the baghouse, or precipitator, hoppers, and scrubber vessel with hinged insulated panel doors fitted with bolt or snap latches and designed for frequent use. All other access doors, removable panels and other parts which must be infrequently opened or removed shall be insulated with removable insulation panels.

The Seller shall furnish and install insulation and lagging for piping or equipment for personnel protection when the piping or equipment is located within 8 ft above operating levels, and at or near platforms and walkways or where there exists the possibility of human contact. Cold lines such as cooling and process water will have anti-sweat insulation.

Personnel protection insulation shall be provided to limit temperature to 135°F maximum on outside surface of insulation at the design summer ambient temperature. The Seller shall also furnish and install insulation and lagging for all heat traced pipe and equipment.

2.7.4 Hopper Heaters

The Seller shall provide a hopper heating system for the scrubber and baghouse or precipitator hoppers that ensures a minimum temperature, equal to the flue gas temperature, maintained at the hopper walls.

The heaters shall be designed to supply a start-up temperature rise to 150°F above an ambient of 70°F in 8 hours. The design safety factor shall be 10 percent. The heaters shall be concentrated on the bottom third of the hopper height, heaters shall also be provided on any transition pieces or chutework beneath the hopper. For heat loss calculations, the entire hopper area shall be considered.

Strip heaters or tape shall be used on the bottom of scrubber and particulate removal hoppers to compensate for heat sink losses at the outlet (throat) poke holes, strike plate, etc. Each heater shall be supplied with high temperature insulated cold leads long enough to reach terminal boxes mounted on two opposite corners of the hoppers. All heater connections, both parallel and series, shall be made inside these terminal boxes.

The heaters for the hopper walls and other flat surfaces shall be of the metal-clad "Module" low watt density type to be mounted directly to the hopper wall between the stiffeners with a minimum of two weld studs. Modules shall be sized to cover the maximum area of the section being heated.

Hopper heating shall be individually controlled (per hopper). Two temperature sensors per hopper shall be supplied. One RTD shall be used as a spare with its leads brought out a minimum of 12 inches to a terminal box. Both temperature sensors shall be mounted on the hopper surface. The sensors shall be located in the lower section of the hopper approximately 12 inches from the throat.

The heaters and temperature sensors shall be resistant to natural and induced vibration plus shock loading that will be encountered in normal operation.

Open areas between the ends of adjacent stiffeners shall be closed off to prevent any vertical or "chimney" heat losses. Insulation shall not touch heaters except at "cold ends." The contactors, circuit protection, appropriate switches, and relays shall be supplied by the Seller.

## 2.8 Structural Requirements

### 2.8.1 General

The Seller shall furnish the Purchaser with a comprehensive load diagram for use in the design of all support foundations including I.D. fan, if furnished by Seller. The load diagram shall be stamped by Seller's Professional Engineer registered in state where work is performed and shall contain support loads for each load combination. The diagram shall also contain any special requirements that need to be accounted for in the foundation design, such as component weights and centers of gravity for each loading condition, clearance requirements, pier size restrictions, in addition to base plate sizes, anchor bolt diameters, locations, projections and all that is necessary to complete foundation design.

Seller shall supply design loads and other data as required for the inlet duct which may be supported off boiler building steel. Seller shall also provide the Purchaser with reasonable, allowable settlements of foundations and tolerances of alignments acceptable for the performance of Seller's equipment. OMS foundation design criteria is one inch total settlement and 3/4 inch differential settlement.

### 2.8.2 Design Loads

Design loads shall conform to Governing codes and regulations, as applicable, and the additional requirements herein. The APC system equipment shall be self-supporting above Purchaser's foundations and designed structurally for the following load conditions:

1. Dead Loads (DL)

   Dead load shall consist of the weight of all permanent construction including, but not limited to, fixed equipment (including Purchaser's ash conveying equipment), framing, piping, floors, walls, roofs, partitions, insulation, stairs, handrail, ductwork, siding, Purchaser's and Seller's cable trays, electrical raceways, enclosures/boxes, lighting fixtures and other structures.

2. Live Loads (LL)

   Live load shall be considered as loading not permanently fixed to the structure and occurring over areas not occupied by equipment. Actual equipment loads shall be used whenever they exceed the live load specified for that area.

   Equipment laydown loads shall be considered as live loads. However, no live load reduction will be permitted in areas where laydown loads are considered. Live load for ash buildup in the scrubber inlet ducts shall be 200 pounds per square foot; 100 pounds per square foot for all other ducts.

The following table is a guide to the minimum live loads required for the APC system and its related structures.

| Location | Live Load (psf) |
|---|---|
| Roofs and Casing | |
| Access Prevented | 30* |
| Access not Prevented | 100 |
| Access Floors | 125 |
| Stairs | 100** |
| Walkways & Misc Platforms | 100 |
| Heavy Storage Areas | 250 |

* or snow load (when applicable) which ever is higher.

** Fixed stairways shall be designed and constructed to carry a load of 5 times the normal live load anticipated but never of less strength than to carry safely a moving concentrated load of 1,000 pounds (OSHA 1910.25).

3. Wind Loads (WL)

Wind pressures and shape factors to be applied to all APC system components and exposed equipment and structures shall be determined in accordance with the applicable building code. Allowance shall not be made for the effect of shielding by other structures.

Ideally, the overturning moment calculated from wind pressure shall not exceed two-thirds of the dead load resisting moment. The uplift forces calculated from the wind pressure shall not exceed two-thirds of the resisting dead loads. However, for overall design economy, the dead load of foundations may be utilized (in whole or in part) provided the foundation system is not penalized. Vendor is to identify his requirements (with proposal) for OMS review and approval.

For determining stresses, all vertical design loads, except roof live loads and monorail loads (both vertical and horizontal), shall be considered to be acting simultaneously with the wind pressure. All allowable stresses shall be increased by one-third when wind or seismic loads are included.

4. Seismic Loads (SL)

All structures shall be designed for lateral and vertical forces for the applicable seismic zone in accordance with the requirements and procedures set forth in the applicable building code. The lateral load resisting system will be braced frames.

Individual pieces of mechanical equipment shall not require seismic design (except in Seismic Zones 3 and 4) other than their support and anchorages. The design of the structures, equipment anchorages, and supports shall be adequate to prevent overturning, displacement, and dislocation. Piping and ductwork shall be investigated to determine whether stops or other restraints are required for seismic design loading.

Earthquake forces shall be assumed to act at right angles to only one face of the structure at a time for rectangular structures.

5. Thermal and Shrinkage Loads (TL)

   The APC system shall be designed with due consideration to the loads forces and effects due to contraction or expansion resulting from temperature changes, shrinkage, moisture changes, creep in component materials, or combinations thereof.

6. Combination of Loads

   The design of the APC system shall consider the combination of loads listed in the applicable building code.

2.8.3 Structural Material Standards

Structural Steel shall conform to the requirements of the attached specification SS-410. Preparation and painting shall conform to the requirements of specification SA-550. Gasket material shall comply with ASTM F104.

2.8.4 Structural Steel

The Seller's work includes designing, furnishing, detailing, fabricating, shop priming, transporting, delivering, handling and erecting all the structural steel and platework required for the APC system ductwork, scrubber vessel, baghouse or precipitator, reagent preparation equipment, control room enclosure and other equipment.

The attached OMS Specification SS-410 and State/local building Codes, are hereby incorporated in this Specification and shall apply except as otherwise specified or required.

The Seller shall correct any errors caused by faulty fabrication or detailing at no cost to the Purchaser. The Purchaser and the Seller's Registered Professional Engineer will approve all methods employed to correct errors.

The structural steel includes:

1. The complete structural steel framing and bracing systems above the Purchaser's foundation level (which is approximately 6" above finished grade) to support Seller's equipment. Seller to coordinate bracing design to avoid Purchaser's screw conveyors.

2. Galvanized grating, complete with primed plate, angle curbs, railings, toe plate, banding, sleeves & stiffeners.

3. Stairways including stringers, stair treads, handrail, landings, hangers, and bracing. Treads with non-skid nosing & connecting cl[illegible]

angles. All stair treads and platform grating shall be serrated when located outdoors in northern climates where ice and snow accumulation can occur.

4. Structural steel for equipment, pipe supports and duct supports.

5. Ladders, safety cages, top hoops, guides, supports and self-closing safety gates.

6. All lifting beams attached to steel framing.

7. All miscellaneous steel framing, platforms, and pipe supports, including clips and angles for attachment to plates or embedded items.

8. Miscellaneous plates including raised pattern plates, flashing, and plates attached to or welded to structural steel framing.

9. All base plates for columns or posts and shim plates.

10. Bolts, washers, nuts, and direct tension indicators, where applicable, for all shop and field connections.

11. Shop weld.

12. Shop priming or galvanizing where required as indicated on drawings and specified herein.

13. Temporary steel that may be required for erection purposes.

14. Support brackets for Purchaser's cable trays and screw conveyors.

15. Pre-engineered enclosure for electrical and mechanical items.

Full provision shall be made so that each component can expand and contract under the operating cycle of temperatures without damage to itself or to any adjoining component, and without the leakage of any gas outward or of air inward. Expansion joints, guides, braces, stiffeners, etc., shall be provided as required so that this thermal movement can be accommodated in a conservative, properly engineered, trouble-free manner, without deleterious side effects.

All structural components shall be stiffened and braced in such a manner as to prevent detrimental distortion, deformation or an objectionable level of vibration. Stress analysis shall consider the most severe load combinations which could result from the above listed loadings acting with the loads imposed by all component equipment, platforms, ladders, and other attachments, including the loads and forces imposed thereon.

Arrangement of vertical bracing for precipitator or baghouse structure should allow passage under the structure. K-brace is preferred in lieu of X-brace. Bracing design shall accommodate purchaser's screw conveyors.

Structures, equipment, buildings, weather enclosures and the top surface of horizontal ducts shall be designed so that the surfaces are self-draining.

The noncumulative tolerances of linear dimensions for terminal flanges and load supports shall be as follows:

Dimensions 10 ft or less: 1/8 in.

Dimensions greater than 10 ft: 1/4 in.

All paint priming of structural steel shall follow the requirements of Specification SA-550.

2.8.5 Access Platforms, Ladders, and Stairways

The APC system design shall include adequate access to all equipment requiring maintenance and/or inspection.

Areas accessible by personnel shall be designed according to the applicable building code and OSHA standards.

2.8.6 Railing and Grating

All railing shall be constructed of 1 1/4" diameter schedule 40 pipe (OSHA approved). Handrail shall be designed in accordance with the applicable building code and OSHA standards (check codes for 2 or 3 rail system). Posts shall be spaced a maximum of 8 feet on center. It shall be the responsibility of the Seller to determine the required spacing of rails and point load requirements.

All pieces cut for piping or equipment shall be banded where the opening is more than 8 inches in diameter or more than 50 sq. inch in area. Banding strips shall project 4 inches above the top of the grating to form a curb and be at least the same thickness as the bearing bars to which they are welded.

Stair treads shall be the same construction as the floor grating. Standard treads shall not be less than 9-3/4 inches wide. The Seller shall provide special sized treads where they may occur, or otherwise be necessary due to interferences, notably at the top tread of certain runs.

Treads shall not have kick plates. Standard supporting clips shall be provided at each end of stair treads for mounting to the stair stringers with two 3/8 inch diameter bolts.

Cast 1-1/4 inch abrasive nosings shall be fastened to all stair treads and to grating at main floors or landings at the head of all descending stair runs.

2.8.7 Siding and Roofing

Siding will be furnished by the Seller. Siding shall be same as the lagging on the insulated baghouse or precipitator. The siding shall be insulated to provide a U-value not to exceed 0.14. The exterior metal panel shall match in color, pattern and texture with the balance of plant buildings. Coating shall be factory applied synthetic coating.

Roofing type shall be determined by Seller for best response to need. All roofing shall be by one manufacturer.

## 2.9 Electrical Requirements

### 2.9.1 General

The electrical system shall meet all applicable NEMA, IEEE and ANSI standards and shall be in full compliance with the latest issue of the National Electrical Code and the National Electric Safety Code.

The installed electrical system shall meet the requirements of Purchaser's technical specification for Electrical Installation, SE-213.

Equipment to be supplied by Seller shall include but not necessarily be limited to the following major items per flue gas train:

480 Volt Power Switchgear
480 Volt Motor Control Centers (including current limiting reactors)
Control Panels
Motors
Grounding System (above grade)
Cable Tray and Conduit
Wire and Cable
Interior Lighting System, 480V Power receptacles and 120V convenience outlets
Heat tracing

Seller shall provide clear access and working space around control panels, starters and disconnect switches in accordance with Article 110-16 of the NEC. In no case shall the minimum clear distance be less than 3 feet for 0-150 volt enclosed equipment and 3 1/2 feet for 151-600 volt enclosed equipment. The minimum width of the working space shall not be less than 30 inches. Electrical equipment, raceway, devices and support shall not block or obstruct access to screw conveyors, access doors, platforms, instrumentation, etc.

The Purchaser will furnish, install, and connect one 480 volt, 3 phase, 3 wire power feed per flue gas train to the Seller furnished equipment. The mechanical design philosophy is that no single equipment failure will shut down more than one APC train. The design of the electrical distribution system shall be consistent in that the loss of a single feeder shall not affect more than one APC train. Seller shall state in his proposal the maximum demand kW and KVA of each feeder. Purchaser will furnish, install and connect one 125V DC feeder for the annunciator. Seller shall state the demand kW of the DC feeder.

Seller's system must be capable of safe shutdown during a complete loss of AC power. If Seller proposes to use DC power to accomplish this, all loads must be clearly identified in the proposal. A typical one line is shown on Attachment 4. The information shown is typical for each train. Common equipment shall be capable of being manually transferred to an alternate source of power.

All control and instrumentation wires requiring remote connection to the control panel in the plant main control room shall be terminated by Seller at the Seller's junction box and/or control cabinet (Ref. Attachment 10) located in the APC system building (provided by Seller) at ground elevation.

### 2.9.2 Induction Motors

All motors shall conform to Purchaser's Induction Motor Specification SE-211. An Induction Motor Data Sheet (Attachment No. 1 to Specification SE-211) shall be completed and submitted to the Purchaser for each motor supplied. Motors 100 hp and above shall be supplied from a 480V power switchgear circuit breaker.

It is the Purchaser's strong preference that all motors be limited to 200 HP, 460V. If the Seller's equipment requires larger motors the Seller shall, prior to submitting the proposal, obtain guidance concerning allowable motor size, voltage level, and power feed from the Purchaser. All motors at voltages greater, than 460V must be 4000V and comply with the Purchaser's Specification SE-212, Squirrel Cage Induction Motors, 2000V and above.

### 2.9.3 480V Power Switchgear (if required)

Each low voltage switchgear section shall consist of one metal enclosed indoor switchgear assembly, drawout type, rated 600V AC and arranged for 480V three-phase, three wire as indicated in Attachment No. 4. It shall be designed, factory assembled, and tested in accordance with the latest applicable IEEE, NEMA, and ANSI Standards.

The switchgear shall consist of sufficient vertical dead front steel structures to house the required number of circuit breakers with a minimum number of empty spaces remaining. Each individual frame shall be divided into a front breaker compartment, a bus compartment and a rear cable compartment. The bus compartment shall be located between the front enclosure and a cable compartment. It shall contain main horizontal bus and bus supports. The bus compartment shall be completely isolated from the other two compartments by barriers. The cable compartment shall be completely isolated from the bus compartment and adjacent units by means of removable barriers.

Field adjustable cable supports shall be provided in the cable compartment for all power cables.

Access to breaker and auxiliary compartments shall be provided by hinged front doors of formed steel construction. Access to rear compartments shall be provided by removable bolted steel covers.

Main bus shall extend through all units of the switchgear with bus interconnections to the circuit breakers in each individual unit. The bus material shall be copper with tin or silver plated joints and of the same current rating as the main circuit breaker when a main breaker is required. It shall be braced to withstand the stresses resulting from the maximum short-circuit current available. The minimum bracing shall be 50,000 amperes symmetrical unless otherwise specified. The bus shall be complete and all hardware for joining shipping splits shall be furnished by the Seller, with assembly procedures and torque values to be used for tightening bolts.

A copper ground bus, minimum size 1/4 inch by 2 inches, shall be furnished over the full length of the switchgear, bolted or brazed to the framework of each vertical section. Compression type terminals shall be furnished at each end for 4/0 AWG copper grounding cable.

Each power circuit breaker shall be 600 volt Class, 3-pole, air break, draw-out type with stored energy operating mechanism. The power circuit breakers shall be manually or electrically operated and be furnished with solid state trip devices having trip elements as stated in Attachment No. 4. Trip indication lights or targets on solid state trip devices shall be furnished.

The draw out mechanism shall hold the circuit breaker rigidly in connected, test, disconnect, and fully withdrawn position. The draw out mechanism shall be operated externally by a removable handle. The removable handle shall engage the rack out mechanism through an opening in the breaker.

Electrically operated breakers, if required, shall be equipped with an electric motor to charge the stored energy mechanism and be provided with one pushbutton for tripping the breaker. After the circuit breaker is closed, the motor shall charge the closing springs for subsequent operation of breaker. It shall be possible to manually charge the stored energy mechanism in the event the control power is lost, and manually close and trip facilities shall be provided. The electrically operated breakers shall be suitable for operating from the Purchaser's control voltage source which can vary between 70-140V DC.

When the circuit breaker is in the test position, control circuits shall permit local operation of the breaker. Circuits for remote operation and indication of the breaker shall be disconnected when the breaker is in the test and disconnect position.

Manually operated breakers shall be spring charged and closed by the operation of an insulated handle and be furnished with a manual trip button for tripping the breaker.

The circuit breaker shall be furnished with mechanical indicators for:

1. Positive indication of breaker open or closed position.

2. Breaker closing spring charged or discharged status.

3. Positive indication of breaker position i.e. connected, test or disconnect.

Each breaker shall have provision for padlocking in disconnect position.

Each circuit breaker element shall be provided with a minimum of 4 normally open and 4 normally closed auxiliary switches for Purchaser use.

Electrically operated breakers used for motor feeders shall be provided with an Overcurrent Trip Switch (OTS). The OTS shall operate only when the breaker is tripped on an overcurrent or fault condition. A reset pushbutton on breaker face plate shall be provided. The OTS shall have two independent normally closed and two independent normally open contacts for breaker interlocking and alarm purposes wired to accessible terminal points.

Terminal blocks shall be barrier type with a marker strip down the center and shall be suitable for ring-tongue terminal lugs. All terminal blocks shall be readily accessible. At least 20% spare terminals shall be provided.

All switchgear assemblies shall be furnished completely wired. All alarm and control wiring shall terminate at terminal blocks.

All spare auxiliary switches shall be connected to terminal blocks.

All secondary control circuit wiring shall be not smaller than No. 14AWG. PT circuit wiring shall not be smaller than No. 12AWG and CT circuit wiring shall not be smaller than No. 10AWG. The control wire shall be flexible, stranded, tinned-copper, Type SIS, VW-1 rated, 600V rated.

All fuse blocks for secondary circuits shall be pullout block type. Trip and close circuits shall be fused separately in each compartment. Fuses shall be nonrenewable type and shall be furnished by the vendor. Fuse size shall be 30 Amp. minimum for trip circuit.

Connections between shipping sections shall be arranged to require a minimum of field wiring. Terminal blocks shall be provided on one side of a shipping break and coiled wires, property tagged, shall be provided on the other section to facilitate these connections.

Terminal lugs for the Purchaser's external power, and grounding cables shall be furnished by the Seller. The lugs shall be Burndy YA, two hole, compression type.

Wiring splices of any type will not be accepted. Both ends of all internal wires shall be identified by preprinted plastic sleeves. Wire leads shall be terminated using indent compression type ring-tongue lugs.

The following maintenance accessories shall be furnished:

1. One breaker levering crank for each switchgear.

2. One manual spring charging lever for each switchgear.

3. One solid state trip device test and calibration unit per purchase order. It shall be suitable for operation from a 120V AC 1 phase, 60 Hz power supply. Device shall be suitable for each type of breaker furnished.

4. One travelling type circuit breaker lifting device with rail mounted on top of switchgear.

Low voltage switchgear shall be tested in accordance with requirements and procedures of the applicable standards with any additional inspection and tests which may be required to insure that all devices are correctly wired and that all equipment are in satisfactory operating condition.

Each circuit shall be given a continuity test.

All power and control wiring shall be given a voltage test for one minute at a minimum of 1,500 volts.

After fabrication, all metal work shall be thoroughly cleaned, given a bonderizing or equivalent treatment, and immediately prime coated with a rust-resistant paint. The prime coated surfaces shall be given two finish coats of ANSI No. 61 gray paint for indoor equipment. Touch-up paint shall be furnished by the manufacturer and shipped with the low voltage switchgear.

Nameplates shall be provided for each circuit breaker. Each nameplate shall be laminated plastic 3/32 inch minimum thickness, 1 inch high and 3 inches wide. The plate shall be white with 3/16 inch high engraved black lettering. All four front edges shall have a 1/16 inches bevel. Each nameplate shall be fastened to the compartment door with two stainless steel self-tapping screws. Nameplate inscriptions will be specified by the Purchaser. In addition, a nameplate shall be provided for each unit substation of the same material and construction except that the lettering shall be 1/2 inch high.

Laminated plastic nameplates, legible from floor level, shall be provided for all enclosures and control items such as meters, relays, switches, fuses, etc.

2.9.4 Motor Control Centers

Motor control centers shall be totally enclosed, free-standing, cabinet-type structures with copper main and vertical buses, combination motor starters, circuit breaker switches and other equipment as required. The systems fault current shall be limited to 22,000 amp symmetrical. This shall be accomplished by incorporating current limiting reactors into the Motor Control Centers.

Base pricing shall include current limiting reactors. An optional deduct price for eliminating the reactors shall be listed in the proposal. Purchaser will decide at the time one line diagrams are submitted for approval if the reactor will be required.

The motor control centers shall comply with SE-205.

Note that motor circuit protectors are not acceptable. All 480V motors, including motors supplied with subvendor systems such as the lime handling equipment, shall be fed directly from a Motor Control Center in the Seller's electrical building.

2.9.5 Grounding

The Seller's grounding system shall consist of the above-ground connections to the Purchaser's below-grade ground loop that will provide a network to which all equipment and metallic structures shall be connected, either directly or by interconnecting cables.

Purchaser will provide pigtails from the below grade ground loop for connection to building steel at alternate structural columns. Seller shall connect these pigtails to building steel at grade elevation. Equipment ground conductors shall be in strict compliance with the NEC and OMS specification SE-213. All ground connectors shall be UL approved.

2.9.6 Cable Trays

Cable trays may be used for raceways where practical and consistent with the provisions herein and in compliance with the NEC. Cable tray materials and installation shall be in accordance with SE-213.

Where installed in trays, low voltage power cables, control cables and instrumentation cables shall be run in separate cable trays. Control cables may be run in the same tray as the low voltage power cables provided they are separated by a continuous barrier to prevent mixing.

Trays for cables of different voltage levels shall be stacked in descending order with the highest voltage at the top.

2.9.7 Conduit

Conduit shall be as specified in SE-213

2.9.8 Wire and Cable

All cable shall be in accordance with OMS specification SE-210, "Power, Control & Instrumentation Cable".

Power cables for 480 volt service shall be rated 600 volts with individual round stranded copper conductors and shall be three conductor for sizes smaller than 250 MCM, and single conductor for sizes 250 MCM and larger. Three conductor power cables shall include a ground conductor sized in accordance with the NEC.

Control cable shall be multi-conductor and rated 600 volts with individual round stranded copper conductors. Multi-conductor control cables shall be selected so as to result in as few conductor combination as practical.

Ampacities and conductor sizes shall be based on the following:

1. Ampacities shall be determined in accordance with the NEC.
2. Voltage drop in feeder cables between bus and load shall not exceed 3 percent of rated voltage during rated operation of auxiliaries.
3. Control cables shall be No. 14 AWG minimum. Larger sizes shall be used if required for voltage drop considerations.
4. Cables for CT runs shall be No. 10 AWG minimum.
5. The full load current for transformers shall be determined from the KVA corresponding to their highest allowable continuous temperature rise.

Acceptable cable manufacturers and installation requirements shall be in accordance with SE-213.

2.9.9 Heat Tracing

All equipment, piping and instrumentation that is subject to freezing shall be protected with electric heat tracing. Termination of heat tracing on pipes shall extend a minimum of two feet into the heated enclosure. Heat tracing, installation and material requirements shall be in accordance with SE-213 and SE-209. Information identified in SE-209 to be provided by Purchaser shall be developed by Seller & provided to the heat tracing sub-vendor.

2.9.10 Installation Design Drawings

Seller shall furnish design drawings for the entire electrical installation. As a minimum, the drawings shall include a one line diagram, selective coordination curves, logic diagrams, control wiring diagrams comprised of schematic, elementary, internal and interconnection wiring diagrams for all power, control and instrumentation devices (including heating and ventilation), all conduit and cable tray routing drawings, grounding drawings, lighting drawing, and cable and conduit schedules.

Diagrams shall be complete system oriented, making it a complete self-explanatory system. The interconnection diagrams shall show the wiring from panel to panel or from panel to each remote point and shall include cable and wire numbers, conductor color coding and connections to terminal blocks.

Drawings for installation design shall be at least a quarter inch to the foot. Dimensions or undimensioned details not to scale shall be clearly identified as such.

The drawings shall be of sufficient scope and detail to permit checking of design by Purchaser. The design shall provide accessibility for maintenance work and for future additions; and ease of field connections.

2.10 Controls and Instrumentation Requirements

2.10.1 General

The Seller shall be responsible for the design, specification, purchase, installation and start-up of a complete system capable of automatically controlling the APC system. The operation of the system shall be from the Purchaser's main control room in accordance with the configuration selected in Section 4.4.10.2 and as described throughout section 2.10.

If the Seller determines that local panels are also required to support remote operation and start-up of the APC system, they shall be provided as required. However, continued APC system operation shall not be dependent on operators manning these local panels.

All elements of the APC control system shall be suitable for the plant operating environment. Suitable vibration suppression mountings complete with all hardware and fastening devices shall be provided, if required, to ensure that the elements are substantially isolated and that normal operation and life expectancy of the elements will not be adversely affected by vibration. However, seismic integrity of the equipment shall not be compromised.

2.10.2 APC Control System Functional Requirements

The system shall function automatically over the entire range of the operating conditions specified in Attachment 2 including startup and shutdown of the scrubber module.

The boiler draft control system, furnished by others, will control the I.D. fan inlet vanes in order to maintain a constant draft in the boiler. The Seller's controls shall be capable of maintaining stable APC system operation under these potential gas flow variations.

The system shall include automatic control of the lime feeding and slaking system in order to provide the proper lime slurry concentration to the atomizers and maintain the acid gas removal setpoint. The lime slakers shall provide a slurry of fixed concentration and store it in a lime slurry storage tank. Lime slurry from this tank will be further diluted with water to meet the requirements of each scrubber. Systems utilizing mix/head tanks for dilution shall be sized for a minimum residence time (ref. sect. 2.2.4.4).

Automatic control of stack $SO_2$ and HCl concentrations at a given setpoint over all operating conditions listed in Attachment 2 and load changes shall be provided for each APC train. The lime feed rate shall be regulated in proportion to the acid gas loading at the stack using as feed forward signals flue gas flow and/or inlet $SO_2$ concentration, as required. The Purchaser shall provide 4-20 MA signals for the variables specified by the Seller in Section 7.2, Item M of Attachment 7. The inlet and outlet $SO_2$ signals will be as described in section 4.4.14. The $SO_2$ signals will be corrected to 7% $O_2$ (or 12% $CO_2$).

The measurement of temperature at the scrubber vessel inlet and outlet ductwork shall be accomplished by using a minimum of three thermocouples at each measurement point for averaging or median selection. The automatic temperature controls shall protect the baghouse during load changes and trips from high and low temperature excursions. The outlet temperature of the scrubber vessel shall be automatically controlled to within 5-F of the setpoint.

Reset windup on loss of slurry or water source shall be eliminated in order to prevent overshooting on restart of these sources.

Pressure and temperature before (same location as CEM and Test ports) and after the scrubber and at the I.D. fan inlet (i.e.-same location as the test ports requested in Section 4.4.5) and pressure drop across the baghouse shall be measured and continuously recorded in the main control room either on a strip chart recorder or accessible via a CRT, as applicable. Pressure drop across each baghouse module shall be locally indicated. Pump discharge pressure shall be locally indicated.

The baghouse controls shall automatically cycle the compartments and control damper operating speeds to allow for cleaning without sudden pressure changes to allow for smooth ID fan operation.

The baghouse controls should provide capability to vary both the cleaning sequence and the cleaning time for each compartment to account for: (1) other compartments out of service, (2) the possibility of some compartments collecting more particulate than others because of inlet duct/compartment arrangement, and (3) on line cleaning of pulse-jet units.

Bag cleaning controls for initiating and monitoring the cleaning cycle, shall be furnished as required (see Paragraph 2.3.3 for the cleaning cycle requirements). The cleaning time, reverse gas time, dwell, settle and stage time, the overall pressure drop required to initiate the cleaning cycle, and the time interval which initiates the cleaning cycle even if the necessary pressure drop has not been reached, shall all be adjustable inputs to the bag cleaning control scheme. It shall not be necessary to re-configure the PLC or the DCS in order to change any of these adjustable inputs. A manual initiator shall also be provided at the main control room which will allow actuating a cleaning cycle at any time.

The scrubber and baghouse (precipitator) ash hoppers shall be equipped with automatically controlled electric heaters. The vibrators on ash hoppers shall operate under an automatic on/off sequence; both on and off time intervals shall be field adjustable within 1 to 10 minutes. It shall not be required to re-configure the PLC in order to adjust the timers. The vibrator's operation on a hopper shall be interlocked with the downstream screw conveyor (or dump valve) running. Purchaser will provide one dry contact for this purpose.

Unless otherwise required by conditions of attachment 9 the baghouse shall automatically go into bypass mode, under a de-energized condition, on:

1. high baghouse inlet temperature
2. low baghouse inlet temperature
3. loss of scrubber slurry
4. high baghouse pressure drop
5. loss of power
6. loss of control air
7. I.D. fan trip (signal from purchaser)

All abnormal conditions shall be alarmed as they occur. The following types of alarm shall be provided:

1. Process alarms for process variables out of limits.
2. Trouble alarms for systems malfunction.
3. Equipment trip and/or failure to start alarms.

### 2.10.3 Control System

#### 2.10.3.1 Single Loop Controller for the Plant Control System

The analog control system shall consist of individual control loops utilizing two wires, 4-20 ma transmitters and dedicated control algorithms for each control loop programmed into a programmable logic controller (PLC). Shared algorithms are not acceptable. The digital control system shall use the same PLC used for the analog control loops. System capacity, in terms of I/O and memory, shall provide for 20% expansion capability at a future date. One PLC per APC train shall be provided. PLC's shall be mounted in Seller's control cubicles for installation in Seller's electrical room (not in Purchaser's main control room).

The operator's interface with the APC control system will be thru a CRT system provided by the Seller (ref. attachment A10-1.) The CRT system shall meet the following requirements:

1. CRT's shall be at least 19 inch diagonal, include at least 8 selectable colors and have a resolution of at least 648 by 480 pixels.

2. Operator's input device shall be a keyboard. Touch screen CRT's are also acceptable. Any operator action either for screen access or equipment operations shall be executed in a direct and simple manner (e.g., using function keys). Provision shall be made to prevent inadvertent operation through accidental keystroke.

3. Two sets of CRT's with electronics and key board, redundant to each other, shall be provided. Any CRT set shall be capable of total control of the system, although each CRT set may be dedicated for a particular function during normal operation. Failure of one CRT set shall not inhibit, in any way, operation from another.

4. CRT's shall display actual process information without significant delay (less than 2 sec.). Any operator action shall be executed in less than one second. Display background information shall come up rapidly (less than one second).

5. CRT's shall have the following display formats: overview, group (or faceplate), point detail, trend, and process graphic. Process graphics shall be interactive reflecting actual on-line conditions.

6. All variables which otherwise were recorded on pen or multipoint recorders shall be trended on the CRT. It shall be possible to select any multiple process points for simultaneous trending and comparison on the CRT.

7. CRT electronics shall be capable of performing historical data storage and retrieval. The historical data shall be downloaded on a removable magnetic media for long time storage. The operator shall be alerted when a downloading is needed, so that previously stored data is not lost. It shall be possible to recall and view data points presently being stored or to reload pre-recorded points and to similarly view them.

8. CRT shall perform the communicator function of alarm displaying and listing. Means of rapid access to the CRT display page showing details of the alarm shall be provided.

9. One high speed printer shall be provided. The operator shall have the capability to direct data to the printer from either of the two CRT consoles.

10. CRT, printer, and keyboard shall be provided mounted in a console. Console configuration and color shall match Purchaser's control room layout. Purchaser shall approve console design.

2.10.3.2 <u>Distributed Control for the Plant Control System</u>

Both analog and digital controls shall use a Bailey network 90 DCS unit. The analog control loops shall use two wires, 4-20MA transmitters. The configuration (programming) of the Bailey DCS unit will be the Seller's responsibility in cooperation with Bailey. The seller's DCS unit will then be integrated with the purchaser's balance of plant DCS system by becoming a "drop on the purchaser's data highway (ref. Attachment A10-2).

One Bailey DCS unit per APC train shall be provided, and each DCS unit shall have redundant multifunction controllers (MFC); the I/O supporting hardware need not be redundant. System capacity, in terms of I/O, memory and power supply, shall provide for 20% expansion capability at a future date.

Seller, in cooperation with Bailey, shall provide the CRT graphics required for total system control and monitoring from the plant DCS CRT stations (by purchaser). Graphics shall be in the form of files ready to run on the purchaser's operators console (Bailey's MCS).

Option:

If requested in section 4.4.10.3, Seller shall provide an option for a PLC based control system in-lieu of a Bailey DCS (ref. Attachment A10-3).

The analog control system shall consist of individual control loops utilizing two wires, 4-20 ma transmitters and dedicated control algorithms for each control loop programmed into a programmable logic controller (PLC). Shared algorithms are not acceptable. The digital control system shall use the same PLC used for the analog control loops. System capacity, in terms of I/O and memory, shall provide for 20% expansion capability at a future date. One PLC per APC train shall be provided. PLC's shall be mounted in Seller's control cubicles for installation in Seller's electrical room (not in Purchaser's main control room).

Operator's interface with the APC control system will be through the plant distributed control system (Ref. Attachment 10, Page A10-3). A serial RS232 interface and a modem shall be provided for each PLC. Only control action with status feedback and data acquisition functions will be exercised over this serial link. Seller shall provide means of testing and starting up his system (to the point where the APC system is turned over to the purchaser) without the DCS, on a temporary basis. Permanent operation of the APC system without the DCS is not required.

Seller shall also provide CRT graphics (in the form of sketches) needed to interface his control system through the DCS, and the I/O signal list (with addresses of read and write PLC registers) required to support their graphics.

2.10.3.3 Field Wiring

The field wiring shall not connect directly to the Programmable Controller (PC) terminals. The PC terminals shall be wired to terminal blocks capable of connecting 600V, 12 AWG wire with ring tongue connectors; provisions shall be made for adding future terminal points to wire the added I/O. All inputs and outputs shall be isolated from the external devices; suitable isolating devices shall be provided by Seller.

2.10.4 Local Control Panels

If required, the local control panel(s) shall be vertical, and fabricated of hot rolled steel. The panels shall be suitably reinforced to provide sturdy, freestanding, rigid units. The panel shall be arranged for floor mounting with bottom cable entry.

The panel shall be totally enclosed NEMA 4 if in process areas or outside buildings, NEMA 12 in all other areas.

Internal fluorescent lighting and 120V, 20 amp utility receptacles for full height enclosed panels shall be provided.

2.10.5 Annunciator

Solid state annunciator shall be furnished in conjunction with a main control panel to provide visual and audible alarms for abnormal process conditions as specified in Purchaser's Technical Specification SC-317 Annunciator.

2.10.6 Local Instrumentation and Controls

All local instruments shall be fitted with a 1" x 2" x 1/16" stainless steel tag with instrument tag number stamped on it.

2.10.6.1 Transmitters

Transmitters shall be a 4-20 ma DC, two wire, solid state type, with plug in circuit board, external zero and span adjustments, and a minimum accuracy of ±0.5% of range.

Transmitters utilized for measuring differential pressure, flow, and level shall be furnished with a preassembled five way valve manifold suitable for mounting directly on the transmitter. Each transmitter shall have an integral junction box with terminal strip, integral test jacks, and conduit connection, and shall be complete with all mounting accessories.

When transmitters are required to provide multiple outputs to recorders, indicators, etc, as well as providing an input to the control system, the circuit shall be arranged so that disconnecting an input to a recorder, indicator, etc, shall not cause an upset in the control system, or a change in transmitter calibration.

Thermocouple converters shall have a minimum input resistance of 1 MOHM, input/output isolation, reference junction compensation, and zero and span adjustments with span suppression and elevation. The phasing (direction) of the thermocouple open circuit response shall be selectable in the field and preset at the factory for the fail safe direction.

2.10.6.2 Control Valves

Generally, control valves for throttling service shall be globe type for air and clean water with pneumatic diaphragm actuator and current to pneumatic positioners. The use of throttling control valves in slurry lines is not desired and shall be minimized; if required, the Clarkson Series C (Iris pinch type) or Fujican shall be used.

Control valves for on/off service may be of the plug knife gate or pinch type for slurry service and shall have diaphragm or pneumatic piston actuators.

Throttling control valves in slurry service shall be designed for a maximum turndown of 5 to 1 and a maximum velocity of 20 feet per second.

The materials of construction, specifically the wetted parts shall be chosen to provide the least maintenance and maximum reliability. Nitriding treatment of an surface exposed to the working fluid is not acceptable.

Generally, all valves in non-slurry service shall have welded ends. Valves in slurry service shall be flanged. Seller must also meet the requirements of Section 2.2.4.8.

Pulse-jet air pressure regulating valves shall be furnished for each train.

2.10.6.3 Air-Operated Actuators and Devices

Devices requiring air supplies of less than 90 psi shall be supplied with a filter regulator air set mounted and tubed on the device. Air sets shall consist of a combination air filter, pressure regulator, and integral relief valve and output gage. Connections shall be 1/4 inch minimum or more if required for speed of response of the device being supplied. Oilers shall be supplied, if needed.

2.10.6.4 Thermocouples

Iron constantan grounded type "J" thermocouples with magnesium oxide stainless steel sheathing shall be used. Thermowells shall be provided in all fluid system applications in order to facilitate thermocouple maintenance.

Thermocouple limits of error shall conform to National Bureau of Standards. (Where such accuracy is not satisfactory for the process ungrounded 100 ohm platinum RTDs may be used.)

2.10.6.5 Local Temperature Indicators

Local temperature indication shall be bimetallic type with universal joint and 5 inch diameter dial. Each thermometer shall be supplied with a thermowell.

2.10.6.6 Local Pressure Indicators

Pressure indicators shall be bourdon type, accurate to within 1 percent of span. Dials shall be white with black markings and shall be 4 1/2 inch in diameter. Gage movements shall be stainless steel, geared type. Case shall have a blowout disc in the back. Bourdon tubes used in flue gas service shall not contain copper material. Diaphragm seals shall be provided for services other than clean and non-corrosive fluid applications.

2.10.6.7 Pressure Switches

Switches shall be snap acting type with NEMA 4 cases. All wetted parts shall be stainless steel. Pressure connections shall be 1/2 in FNPT. Alarm and shutdown switch settings shall not be adjustable from outside the housing.

Switch contacts shall have a dual form "C: configuration and shall be rated at 125V AC, 10A resistive, and 125V DC 0.5A resistive. Switch contacts shall be wired to separate terminals. Alarm switches shall open to alarm. Switches used for shutdown and control shall open to cause the desired action.

2.10.6.8 Vibration Monitoring Equipment

When utilized, the vibration monitoring system will house all monitoring channel modules in an enclosure designed for mounting in the Seller's local control panel.

The vibration monitor will include power supplies, relays, and inter- connecting cabling with the following functions:

1. Alarm Functions

   A sequence of two lights per point for warning and high vibration.

   A third light will be illuminated when the monitoring channel is inoperable.

   Warning lights shall have an amber lenses and danger lights red lenses.

   Each light shall be identified on the vibration alarm panel, according to the functions, the rotating equipment being monitored and an appropriate unique instrument tag number.

2. Meters

   The monitors shall be supplied with analog meters for indication of the level of the signals from the probes. One meter with a selector switch for all channels will be acceptable. The meter scale shall be in units of displacement.

3. Outputs

   A 4-20 ma analog output, equivalent to units of displacement, shall be provided for each channel for use as a computer input.

   Front of the panel auxiliary outputs shall be provided for each channel to allow monitoring with external equipment.

   Two auxiliary form C alarm contacts common to all channels shall be provided at the warning vibration level. All vibration alarms shall be displayed by the Seller in the main control room.

2.11 Welding

All welding, weld, welding procedures and qualifications, and welder qualifications shall be in accordance with AWS D1.1, ANSI B31.1, AWWA D100 (as applicable), and the additional requirements of this specification. Welding procedures and welder qualifications shall be kept on file by the Seller and shall be subject to Purchasers' review upon request.

Drawings which require fabrication by welding shall indicate with symbols the joints to be welded in accordance with AWS A2.4.

As a minimum, all welds shall be visually inspected in accordance with the appropriate fabrication code. Individuals performing nondestructive examinations shall be qualified in accordance with SNT-TC-1A.

## 2.12 Cleaning, Surface Preparation, and Painting

All cleaning, surface preparation, and painting shall be in accordance with SA-550 and completed in the manufacturer's shop before shipment to the maximum extent practical. All internal and external surfaces of the equipment shall be cleaned of all mill scale, loose metal particles, weld spatter, slag, dirt, grease, oil and other foreign matter.

All external ferritic steel surfaces shall be prepared and coated in accordance with this section and SA-550. Surfaces of corrosion resistant materials (i.e. stainless steel or aluminum) shall not be painted or coated with rust preventatives. Machined surfaces, flanges, and other surfaces where the application of a protective coating might interfere with the intended operation shall be coated with readily removable rust preventative such as Tectyl 506G as manufactured by the Ashland Chemical Co. of Ashland, KY, or Purchaser's approved equal.

Field touch-up and finish painting of all uninsulated ferritic steel surfaces is by others.

Surfaces which will be insulated shall not be primed but shall be suitably protected prior to insulation. Surfaces which will be in contact with flue gas shall not be coated. All other surfaces shall be given a single shop primer coat.

## 2.13 Noise

The design and operation of the APC system and equipment shall meet all local, state and federal OSHA regulations pertaining to the control of noise. The design shall minimize noise levels to safeguard personnel on the site and to prevent noise pollution to the surrounding neighborhood. Interior work areas including the lime preparation and pumping areas, air compressor rooms, electrical rooms and the scrubber penthouse shall be designed to meet the OSHA eight hour unprotected exposure level per paragraph 1910.95. The maximum allowable noise level radiated externally shall be 60 dBA at 50 feet from the APC system.

## 2.14 Erection Requirements

### 2.14.1 Scope of Erection

Seller shall install the equipment furnished in accordance with approved drawings and instructions and shall provide all of the materials, labor, supervision, tools and equipment necessary for such work.

Work shall include receiving, unloading, storage, protection, necessary moving from storage, rigging, drilling, doweling, setting, welding, assembly, aligning, cleaning, testing, and any other work necessary to prepare the equipment and accessories, for normal continuous service. The equipment shall be installed in the locations shown on Purchaser approved drawings.

It shall be understood and agreed to by Seller that the work herein described shall be complete in every detail even though every item involved is not specifically mentioned. The Seller shall furnish the necessary field labor and supervision to erect the equipment and material furnished hereunder.

All sections of the scrubber vessel, baghouse or precipitator, and ductwork shall have parallel horizontal mating surfaces and square vertical mating surfaces. All sections shall be square on the mating surfaces and shall not require shimming, jacking, or distortion. Each scrubber vessel mating section shall be shop assembled one to another, securely fastened, match marked, and, for flanged sections, match drilled or punched and dowelled to assure trouble free field assembly and erection. The sections shall then be disassembled and shipped. Shipping braces shall not be used during shop assembly. Field corrections to fabricated mating components that do not mate properly shall be performed by the erection contractor at the Seller's expense (material and labor).

The Seller shall make all connections to Purchaser's economizer outlet, I.D. fan inlet and outlet (if fan is furnished by purchaser), stack inlet and utility and electrical ties and shall coordinate its terminal connection activities with Purchaser's or others erection schedule.

The Seller shall furnish, as required for erection and timely completion of scheduled activities, all cranes, derricks, trucks, rigging, welding machines, stress relieving and preheating apparatus, general tools, hand tools, and special tools for erecting the apparatus specified hereunder. All erection equipment shall remain the property of the Seller, unless otherwise agreed upon, and shall be operated under the Seller's direction. Transportation charges for all erection equipment shall be the responsibility of the Seller.

The Seller shall furnish all consumable, expendable, and minor materials required for the complete erection including, but not limited to, nuts, bolts, welding rod, gaskets, scaffolding, planks, cribbing, slings, and primer.

All work performed shall be in accordance with the applicable requirements of the OSHA safety and health regulation for construction and other codes and standards specified herein.

Hoisting and handling equipment shall be operated and maintained in accordance with the requirements of ANSI B30.2.0, Safety Standard for Overhead and Gantry Cranes, ANSI B30.5, Safety Standard for Crawler, Locomotive and Truck Cranes, ANSI B30.6, Safety Standard for Derricks, and ANSI A10.5, Safety Requirements for Material Hoists.

An inspection program shall be established for equipment and rigging.

2.14.2 Mechanical Erection Requirements

Equipment installation manuals that are provided by manufacturers shall be available at the Jobsite and shall be followed unless directed otherwise by the Purchaser or by the Manufacturers (with the Purchaser's approval).

Prior to setting equipment, the surfaces of all foundations, anchor bolts, soleplates, equipment, etc., shall be inspected, cleaned, and prepared to ensure satisfactory setting of the equipment.

Products which contain asbestos are prohibited. This prohibition includes items such as packings and gaskets even though the item is encapsulated or the asbestos fibers are impregnated with binder material.

Tanks and vessels shall be erected in accordance with AWS D1.1 and AWWA D100. All couplings and other exposed rotating parts shall have Seller-supplied safety guards meeting OSHA requirements.

2.14.2.1 Initial Setting Requirements

Manufacturers' installation and operating manuals shall govern all installation and erection work. Equipment shall be handled and set by the Seller to the correct elevation, location, and levelness. Jacking and/or leveling bolts not provided by the manufacturer shall be furnished by the Seller. In all cases, a sufficient number of jacking or leveling bolts or other such provisions shall be furnished to properly set baseplates without sag or stress.

All separate bearing plates shall be set level and flat within prescribed tolerances and to an elevation 1/8 to 1/4 in. below that required for the surface of the machine base which it is to support. The difference shall be made up when the equipment is set with shims, properly secured against shifting, in accordance with Manufacturers' instructions, and having sufficient area to transmit all expected static and dynamic loading without distortion of the equipment.

In the cases of equipment having more than one component mounted on a common base and those that are set on separate bearing plates, the shims shall be so arranged and secured that subsequent doweling after run-in and final alignment check will penetrate the shims so that dowels are not subjected to supported bending.

Consideration shall be given in all phases of the Work for the operating requirements of the equipment and due allowances made for thermal expansion of all components, thrust loadings, shaft sag, etc.

Local chipping of concrete shall be performed and temporary and permanent jacking plates and wedge blocks required for setting of bearing plates and alignment of equipment shall be set in grout, where required. Machining and final fitting of fillers, attachments, and interference-fit fasteners or dowels and the installation of all bearing plates, shear pins, etc., required for anchorage and alignment of all equipment and accessories included in this specification shall be provided by the Seller.

Due allowance shall be made for differential thermal expansion and shaft sag of equipment components at this and later points in installation and the equipment so set that final alignment can be made without cutting into the base material or appreciably reducing the built-in adjustability of the components in the form of shim stacks, etc. The final step in preparation for grouting shall be the correct and even tensioning of the anchor bolts using calibrated torque wrenches or extensometers as required by the manufacturer's instructions and final check on shaft alignment.

2.14.2.2 Shimming and Grouting

Shims for concrete foundations shall be random size stainless steel or brass sheets, plates, or bars, for all permanent shims exposed to air or water. Carbon steel may be used for temporary shims and those fully surrounded by grout. Shims shall be located adjacent to all anchor bolts and at sufficient intermediate points to ensure adequate support of equipment. Shim packs used for fan bearings shall be a minimum of 90% contact with the concrete it rests on with no grout underneath shims. Shims for structural steel foundations shall be stainless steel sheets or plates cut to suit.

Seller shall comply with Equipment Manufacturers' recommendations. Baseplates or soleplates shall be leveled by means of a precision level. Shaft alignment shall be inspected and approved by OMS.

2.14.2.3 Alignment of Equipment

Alignment of equipment shall be in accordance with the instructions provided in the manufacturer's installation manual. Alignment checks affecting performance shall be made in accordance with manufacturer's instructions, witnessed by the Resident Construction Manager, if so requested, and recorded. As a minimum a 16 point face check and 14 point rim check or reverse dial procedure shall be used for final coupling alignments of all rotating equipment.

After all piping and/or ducts have been connected to the equipment and initial start-up is imminent, a check shall be made of the alignment by the Seller, and realignment made if necessary, prior to makeup of the coupling. Motor halves of couplings shall be safely secured prior to motor rotational check.

After final alignment and torquing of anchor bolts, locking or jam nuts shall be provided for all bolts and shall be drawn up tightly. All anchor bolts having a projection beyond the locking nut of more than one-half the bolt diameter shall be cut off and deburred.

2.14.2.4 Lubrication

Lubrication of journal and thrust bearings shall be maintained as recommended by the equipment manufacturer.

At the completion of erection and alignment, and prior to initial rolling of equipment on power, lubrication of equipment shall be accomplished as recommended by the manufacturer.

All lubricating and oil systems shall be free from dust, dirt, and other foreign materials prior to the charging of lubricants.

2.14.2.5 Doweling of Equipment

After the installed equipment has operated at its normal operating temperature for a period of time, alignment shall be rechecked at essentially operating temperature, and upon approval by OMS, dowel pins shall be installed in the designated equipment, drivers, and baseplates. Where doweling is required by the manufacturer in other than hot operating condition, the manufacturer's recommendations shall be followed.

Dowel pins used for final positioning of equipment on baseplates shall conform to the requirements of the Standard for Threaded Taper Pins of The American Society of Tool Engineers and shall be furnished with threaded tops and fitted with backing out nuts to facilitate pin removal.

The dowels shall be correctly located, and holes drilled and reamed, and dowe[illegible] inserted and seated in accordance with Manufacturers' instructions. The dowe[illegible] shall form a full bearing, interference fit with all parts connected and m[illegible] precisely match the size and taper of the holes. On certain equipment, some doweling is required during installation and must be performed in correct sequence in accordance with the Manufacturers' instructions.

2.14.2.6 Tools and Spare Parts

All erection tools and spare parts furnished with the equipment shall be turned over to OMS at the conclusion of erection. Any tools furnished with the equipment and used by the Contractor for erection purposes shall be replaced if lost or broken, and cleaned and reconditioned before being turned over to OMS.

2.14.2.7 Piping and Valve Erection

1. General

The Seller is responsible for the furnishing, fabrication, and installation of all piping systems for the Work.

All shop and/or field fabrication and installation Work and all materials furnished shall comply with all requirements of ANSI B31.1 Power Piping.

Extreme care must be taken to minimize contamination in cutting and fabricating pipe and fittings.

Cleanliness of piping is imperative, therefore, extra care shall be taken to insure that the inside of all pipe, fittings and valves are thoroughly cleaned before erection. All parts of the piping system shall be free of blisters, mill scale, rust, sand, dirt and foreign material after fabrication and before erection.

All temporary openings in this piping system during erection shall be covered to maintain cleanliness.

2. Fabrication and Installation Requirements

Only pipe made by the open hearth, electric furnace or basic-oxygen processes shall be supplied. Pipe made by the acid-bessener process is unacceptable. Piping 2 inch NPS and smaller shall be field fabricated.

Piping 2 1/2 inch NPS and larger may be either shop or field fabricated. Piping requiring heat treatment or other special preparation or use of special tools and equipment not normally available at the Jobsite shall be fabricated in the shop.

The Seller shall make allowance for gaskets and backing rings or weld shrinkage, where required for joints.

Shop fabricated piping shall include appropriate couplings, fittings or stubs. For smaller field fabricated branch connections 2 inch NPS and smaller, nipples shall not extend more than 12 inches from the outside of the header.

Attachments welded to piping shall be of the same P-number material group as the piping material. Attachments, such as supports, braces, lugs and T-bars shall be furnished by the Seller and installed in the field. (Except piping which is heat treated and thin walled)

Piping 2 1/2 inch NPS and larger shall be shown on Seller's orthographic drawings as well as diagrammatically on P&ID's. Piping 2 inch NPS and smaller is generally shown diagrammatically on P&ID's only. Actual routing of these pipe lines shall be the responsibility of the Seller in the field.

To minimize risk of personal injury, equipment damage, and construction delays, all piping shall be erected in its permanent hangers.

Prior to erecting fabricated assemblies, the Seller shall inspect all exterior surfaces and interior surfaces, where possible, for cleanliness, damage, welding, and coating. Unsatisfactory fabrication shall be cleaned or repaired prior to rigging to position to minimize erection delays.

Piping and valves shall be carefully rigged into permanent supports with a sufficient number and size of hoists to prevent injury to personnel or damage to material. For slurry hose, if used, the Seller shall hoist hose into position in accordance with manufacturer's instructions, e.g. bending allowance. All hoisting forces imposed on building or hanger steel shall be reviewed by the Seller prior to making a lift to assure the adequacy of the supporting supply member; however, any subsequent damage to the structure or equipment caused by errors or omissions by the Seller shall be the Seller's responsibility to repair or replace.

After rigging and prior to welding or attaching in place, piping locations shall be checked for conformity to design dimensions, equipment location, and weld or gasket gaps. Welding procedures, as indicated in Section 2.11, and qualified welders shall be employed for all welding operations.

Piping shall be routed for adequate flexibility to permit expansion without imposing excessive forces and moments on connected equipment. Piping shall not be installed in passageways or in areas reserved for equipment removal. Piping shall be routed above required headroom clearances and parallel and close to walls and columns.

After connection of all piping to equipment, all flanged joints shall be disconnected and the alignment of the flanges at equipment shall be checked. Any misalignment shall be corrected by resetting or reworking the piping and/or pipe supports to prevent distortion of the equipment. Springing, bending, or localized heating to align the connection will not be permitted.

Piping shall not be routed through Electrical rooms or above electrical equipment.

During erection operations, pipe openings shall be temporarily covered to prevent the entry of dirt and foreign objects. Prior to ceasing daily work, open ends of erected piping shall be closed with covers of sufficient strength to suit conditions.

Piping, valves, and fittings shall be kept a sufficient distance from other work to permit not less than 1/2-in. clearance after allowance for insulation, if required. Care shall be taken in the installation of pipeline runs where drainage is required so that the pipeline will slope down toward the point of drain. All slurry pipe shall be sloped 1/4 inch per foot minimum for drainage.

For piping 2 1/2 inches and larger, the Seller's piping orthographic drawings shall indicate all valve handle extensions, chain operators, or other specialties which are required for adequate valve operation.

Valves shall be thoroughly inspected by the Seller and identified prior to erection. Operation and handwheel orientation shall be confirmed, and all components shall be checked for installed clearances and suitability for operation. Flange faces, weld end preparation, and body material shall be checked to assure proper alignment, bolting, and welding. Welding end valves, other than check valves, shall be one-half opened prior to welding and stress relieving. After erection, valve packings shall be adjusted, bonnet bolting checked, and operators lubricated and protected against freezing, rusting, or other damage.

Manually operated valves requiring manipulation during operation shall be located so that handwheels are not higher than 5 ft above a platform or grade. Valves which do not meet the above requirements shall be equipped with chain operators or extension stems. Valves shall be located or have stems turned so that handwheels or chains do not hang in passageways or over moving equipment. Valve stems shall not be orientated below horizontal centerline. Motor-operated and air-operated valves shall be located to allow easy access for maintenance.

For welded carbon steel pipelines, all items such as Saunders type diaphragm valves which contain materials subject to damage by heat, stressing, etc, during normal erection, welding, and testing shall be disassembled, and those materials shall be removed, tagged, and stored until the proper time for reinsertion in the body of the equipment.

High point vents and low point drains, including 3/4 in. valves of comparable material and pressure/temperature rating to the piping system on which they are used, shall be furnished and installed by the Seller. Vents, drains, and utility connections shall be arranged to prevent unintentional or undetected leakage.

Vent piping outlets shall be located so as not to be hazardous to personnel.

3. Clearance

In general, minimum headroom clearance under all piping, covering, and appurtenances shall be as follows:

6 ft-8 in. within structures
10 ft-0 in. within yard areas
16 ft-0 in. over secondary unit roads
22 ft-0 in. over railroads and main plant roads

No field run piping shall be located on floors or walkways or located in such a way as to cause tripping or "head knocker" hazards.

4. Instrument and Branch Connections

All instrumentation shall be furnished as specified in Specification SC-318, Technical Specification for Instrument Installation. The Seller will install connections for this equipment in accordance with the below listed requirements:

All in-line devices will be the same size as the pipe in which they are installed. All flow measuring instruments shall be installed with proper upstream and downstream straight pipe runs in accordance with ANSI/API-2530 (AGA Report No. 3) Orifice Metering of Natural Gas and Other Related Hydrocarbon Fluids. Meter runs shall be determined at a Beta ratio of 0.7. Use of actual Beta ratio and/or straightening vanes may be considered to shorten meter runs, with approval of the Purchaser.

For all other instruments, a 3/4 inch NPS pipe with root valve (shut off valve) and flange, where required, shall be provided by the Seller.

Piping branch connections to the first shutoff valve including instrument sampling takeoffs, flow, and pressure connections, shall conform to the applicable piping class and shall be not less than 3/4 inch NPS.

Root valves shall be of a standard globe pattern (diaphragm for slurries), mounted with stem upright or horizontal, unless otherwise specified.

Root connections on horizontal or sloping lines shall not be located below the center of the line. The following rules shall be observed:

a. Root connections for service on flue gas, shall be taken from the top or side of the duct, or from any point between the top and the side.

b. Root connections for service on liquids shall be taken only from the side of the pipe, with the root nipple horizontal.

All root nipples shall be as short as possible, in standard lengths. Room shall be allowed for free manual operation of the valve without the hand or fingers coming into contact with the surface of the pipe/duct or its insulation. Root nipples longer than 6 inch end-to-end shall not be used.

Stainless steel thermowells shall be installed in accordance with the Manufacturer's instructions.

All drain connections shall be valved; all hydrostatic vents shall be plugged.

All threaded pipe connections shall conform to American Standard Taper pipe threads per ANSI B1.20.1. All threads shall be full and clean-cut, ends shall be reamed after cutting to remove all burrs. Thread engagement shall be sufficient to make a tight joint. All threaded joints shall be made up with the use of a thread sealant on the male end.

Permissible sealants are:

Cajon - SWAK anaerobic pipe thread sealant (temperatures less than 350°F)
Federal Process Co - Antisieze Thread Guard with teflon tape (temperatures greater than 350°F)

Threaded joints in main steam, fuel gas and ammonia service shall be seal welded where feasible. Seal welded joints shall be made up without any sealant.

Pipe shall normally be supplied in double random lengths, except where price, availability, or special requirements dictate otherwise.

Steel pipe for butt weld construction shall be furnished with ends cut square for wall thickness 1/8 inch or less; wall thickness in excess of 1/8 inch shall be supplied beveled @ 37.5° ± 2.5° with 1/16 inch land.

Flanges and flanged fittings shall be in accordance with ANSI B16.5 Standard. 150 lb ANSI Steel flange faces shall have a serrated finish per paragraph 6.3.4 of ANSI B16.5 unless otherwise noted.

Welding neck flanges shall be specified in general, but slip-on flanges may be used where necessary to satisfy space requirements. The maximum allowable pressure rating for slip-on flanges, 300 lb ANSI.

Forged steel socket weld fittings shall conform to ANSI B16.11.

The use of short pieces of pipe (jointers) to make up straight lengths less than 20 ft long shall not be permitted.

Cast iron plugs in steel orifice flanges or elsewhere in steel piping, valves, equipment or fittings shall be replaced with solid steel plugs.

When bolting steel flanges to flat-faced cast iron flanges, the steel flanges shall be flat faced.

Nonmetallic gaskets for flanged pipe joints shall conform to ANSI B16.21.

Nuts for bolts and studs shall be the American Standard Hexagon Heavy Series. All bolts and capscrews shall be carbon steel. Nuts shall be cadmium plated.

5. Bends

Where not shown otherwise, the centerline radius of bends shall be five nominal pipe diameters. Final wall thickness of bends shall not be less than 87.5% of nominal thickness. Flattening shall not exceed 5% of nominal pipe diameter.

Bends shall be fabricated in accordance with the requirements of ANSI B31.1 and PFI.ES24.

6. Tolerances

Fabrication tolerances and minimum bending radii shall comply with the requirements of PFI Standards ES-3 and ES-24. Maximum allowable dishing of flange facing shall be 1/64 of an inch.

All bolt holes shall straddle horizontal and vertical centerlines of flanges unless otherwise noted. Bolt holes shall be aligned within a tolerance of 1/16 inch of the centerline of the piping.

The Seller shall check the internal alignment of pipe and fitting end preparation for makeup of weld joints. The total parallel misalignment of the inside of the root pass end preparation shall be no greater than 1/16 of an inch at any point on the circumference of the joint. Where misalignment is in excess of 1/16 of an inch the pipe of fitting ends shall be machined or ground until internal misalignment is within the 1/16 inch tolerance. Where necessary, the piping or fitting shall be built up by welding and machined or ground to suit this requirement. In no case shall machining or grinding reduce the thickness below the minimum wall thickness required by the applicable code plus 1/32 of an inch.

7. Joint Assembly

All piping connections shall be accurately aligned before bolting up to avo distortion and to prevent misalignment of equipment.

All flanged connections shall be tightened evenly to assure uniform bolt tens and pressure distribution on the gasket face. New gaskets shall be used for ea assembly operation, unless such assembly operation is intended solely for fit-

No reused gaskets shall be installed in the final assembly.

8. End Preparation and Backing Rings

Butt weld ends on piping and components will have end preparations dimensioned in accordance with ANSI B31.1.

The use of backing rings shall be in accordance with ANSI B31.1.

Permanent backing rings shall not be used for joints in raw water piping, steam lines or any piping which contains corrosive fluids or operate at pressures above 150 psig.

9. Welded Attachments

Integral attachments welded to piping shall be of the same P-number material group as their piping material.

10. Welding Inspection (Per requirements of ANSI B31.1)

The Seller shall perform visual inspection of welding operations including examination for internal alignment and groove details prior to welding, examination for surface holes, cracks, and other defects during welding, and

examination for surface defects, undercuts and reinforcement heights after welding. Visual examination shall be performed after any required repair welding.

11. Welding

All welding, welding procedures, including welding procedures qualifications and welder qualifications shall be in accordance with ANSI B31.1 and additional requirements of this specification. The Seller shall submit for Purchaser's approval his proposed welding procedures. All welding procedures and qualification test reports shall be maintained in the Seller's files. One copy of approved welding procedures shall be submitted to the OMS field office. Further, the Seller shall maintain full documentation of welds and weld repairs, including welder, metals, systems, test, etc.

Welding shall not be performed on materials that are below a minimum temperature of 55°F and surfaces to be welded shall be free of moisture prior to welding. All welds shall be full penetration, except fillet, socket and seal welds. Limitations in the code for pressure piping on weld reinforcement shall apply to internal surfaces as well to external. Welds shall be free from projections beyond permitted reinforcement. Welding shall not be performed if the ambient temperature is below 10°F.

Only low-hydrogen type electrodes shall be used to weld steels when the shielded metal arc welding (SMAW) process is selected for production.

12. Weld Filler Metals

Weld filler metals shall meet all requirements of the applicable ASME II, Part C, Specifications.

All welding materials shall be stored in a controlled access, clean, dry area that is weathertight and is maintained at a temperature between 40°F and 140°F. Low hydrogen electrodes shall be stored in their sealed shipping containers.

Welding rod shall only be issued to welders for a maximum of a 2-hour period if not heated at the location of the Work.

If the seal is damaged during shipment or storage, the covered electrodes in that container shall be rebaked prior to issuance. If a container is damaged in storage, and the damage is witnessed, the electrodes from that container shall be immediately placed in a storage oven. When a container of covered electrodes is opened and only a portion of the content is issued, the remaining portion shall be immediately placed in a storage oven. Electrodes shall be issued from the storage oven on a first-in, first-out basis. Covered electrode storage ovens shall be maintained at the following temperatures:

| | |
|---|---|
| EXX 15, 16, 18<br>EXXX 15, 16, 18 | 300 F, ±50°F |
| All other covered electrodes requiring oven storage | 180 F, ±25°F |

These storage ovens shall only be used for the holding of the aforementioned types of covered electrodes.

Materials which are damaged shall be discarded. All covered electrodes which are oil or water soaked, dirty, or the flux has separated from the wire, shall be discarded. Bare carbon steel wire shall be discarded if a bloom of rust develops on it and cannot be removed by light sanding. All flux cored wire shall be discarded if it becomes oil or water soaked. Bare and flux cored wire that becomes dirty can be used if it is cleaned prior to use.

13. Weld Repair

The repair of any unacceptable defect disclosed by visual, or other inspection means shall be made by removing (per Code) the material in the defective area until free of the defect, then rewelding and reinspecting, observing all of the requirements of this specification for each operation performed. Repair work shall be performed only after review by Resident Construction Manager. Inspection of repairs shall be performed by the same method and to the same acceptance standards as the method which disclosed the defect. Peening of weld deposits is prohibited.

14. Brazing

All brazing shall be in accordance with ANSI B31.1.

Brazing filler metals shall meet the requirements of the applicable ASME II, Part C, Filler Metal Specification.

15. Leak Testing

All piping shall be leak tested in accordance with ANSI B31.1, Chapter paragraph 137. Hydrostatic testing is the preferred method and shall be used to the greatest extent practical. An initial service leak test may be used systems similar to those described in Chapter VI, paragraph 137.6. Leak tests shall be performed on completed piping systems or completed portions of systems whichever is more convenient; however, all piping shall be leak tested as required by the Code. All leak tests shall be witnessed by OMS. The Seller shall notify the Resident Construction Manager at least three (3) working days in advance of any scheduled leak testing.

16. Valves

The Seller shall be responsible for installing all valves in accessible locations. Where valves are unable to be located adjacent to platforming, chain operators shall be provided to allow operation from below. The maximum allowable valve height with relation to grade or platform shall be 6 feet-3 inches to the handwheel with the valve stem in an upright vertical position. The maximum allowable horizontal distance from a platform to the center line of the handwheel (i.e., vale stem) shall be 2 feet, with the handwheel at a maximum height of 5 feet-3 inches above the platform.

Valve stems shall be installed in the vertical position whenever possible. Under no circumstances shall valve stems be installed below a horizontal position.

17. Pipe Hangers and Supports

The Contractor shall be responsible for the engineering, design/ arrangement, furnishing, delivery, and installation of all pipe hangers and supports.

a. Materials

Materials used for pipe supports shall conform to the requirements in Paragraph 121 of ANSI B31.1 and in MSS SP-58 as applicable.

Unless otherwise specified, structural shapes shall be ASTM A36 and structural tubing shall be ASTM A501 or A500 Grade B.

Welded attachments to piping shall be of the same P-number material group as the piping.

b. Pipe Support Design

All hanger components and pipe supports shall be designed by the Seller to meet the requirements of Paragraphs 120 and 121 of ANSI B31.1, and shall conform to the requirements of the Manufacturer's Standardization Society Standard Practices SP-58 and SP-69.

c. General Requirements

All hanger components shall support the pipe in the normal operating position and during hydrostatic test and shall allow for the expected expansion or contraction except where anchored and guided, and shall not cause excessive stresses in the piping or loads on the connected equipment or structural component.

The Seller shall be held responsible for damage caused by pipe movement due to improper support to attachments, connecting equipment, insulation, etc. All piping attached to pumps shall be reviewed for flexibility and to ensure that pump nozzle loads are within pump allowances.

Standard stock or production parts shall be used where possible, but the recommended load ratings and limitations in hanger catalogs shall not be exceeded.

No support shall utilize other piping systems for attachment. Hangers shall not be attached to flanges, valves or equipment bolts, or to equipment.

No support shall be located where there is a piping weld.

Supports made of structural steel shall be designed to be shipped in one piece where practical.

All piping shall be adequately flexible for differential settlement of 3/4 inch and total settlement of 1 inch.

Miscellaneous structural steel shall be fabricated in accordance with AISC.

Piping systems, in addition to being properly supported, shall be restrained where applicable for horizontal stability against dynamic effects such as wind, seismic vibrations, excessive movement, etc.

Vertical pipe should be supported directly with riser type hangers rather than having the weight of the riser supported by adjoining horizontal pipe. When a riser support employs two hanger assemblies, each shall be designed to support total design loads. When riser clamps are used to support vertical piping, the Seller shall design and furnish suitable stops or lugs for attachment to the pipe. Friction clamps alone are not acceptable.

A minimum of 6 inches shall be maintained between pipe supports and any obstructions.

All supports for FRP or Mastic piping shall be designed and located using recommended practice established by reputable manufacturers (i.e., Fibercast, A. O. Smith, etc.)

When the pipe is covered with insulation and is to rest on the support, protection saddles or shoes shall be used. Protection saddles shall be tack-welded to carbon steel piping. The saddle material shall be of the same P-number group as the piping material.

All hangers, riser clamps and anchors, saddles and floor flanges shall be galvanized or cadmium plated for outdoor services only. Threaded rods and nuts shall be cadmium plated. Use painted carbon steel for indoor services.

Galvanizing coating shall conform to ASTM Specification A123.

d. Support Loads on Structures

Pipe support loads shall not overload building structure members.

Channels, stair stringers, braces, and intermediate walkway members shall not be used for piping loads.

Accurate weight balance calculations shall be made to determine the required supporting force of each hanger and the limits imposed upon each equipment connection. The weight balance for all hangers shall include the weight of the pipe, fittings, valves and specialties, the medium transported, the insulation used, and the suspended portion of hanger assemblies and pipe attachments.

Should individual or accumulated loads exceed supporting structure design limits, or should there be any question of the adequacy of the supporting member, or the support point is located between structural members, the Seller shall provide supplementary supporting steel. Supplementary steel shall be properly framed to

columns or beams of sufficient capacity to support the load within the allowable stress and deflections specified by the applicable sections of the AISC specification for the Design, Fabrication, and Erection of Steel Buildings.

Pipe support rods shall not pass through cable trays, and pipe shall not be hung from cable trays or cable tray hangers.

Structural steel for pipe supports shall not be cantilevered from building structural beams, or channels, etc., except when specifically reviewed and accepted by the Purchaser.

Pipe support attachments shall not impose torsion on structural steel members.

Where it is necessary to weld to existing structural steel members to carry pipe supports, anchors, etc., the welds for securing plates to the structural members shall in all cases be parallel to the length and located at the web of the structural member. Welding across the flange of existing structural steel members is not permitted.

e. Attachments to Piping

Integral attachments shall be used only where nonintegral attachments are impractical.

Nonintegral attachments to piping shall be of materials compatible with the pipe material and operating temperature of the piping system. Pipe attachments shall be suitably coated or isolated from the pipe where required to assure the expected life of the piping and the hanger. Attachments to the piping shall be of sufficient area to prevent stress concentrations in the piping and shall have sufficient rigidity to prevent distortion of the pipe by the suspended load. Double bolt pipe clamps shall be utilized when possible to ensure that rods are connected outside of insulation.

f. Attachments to Structures

Structural attachments to steel shall be designed to support the maximum calculated loads. Welded attachments to beam flanged in tension shall require all welding to be parallel to the web of the members.

g. Anchors, Restraints, and Sliding Supports

All anchors, guides, and restraints shall be capable of supporting the pipe and resisting any expansion or contraction thrusts, water hammer, that may be imposed by the piping.

Sliding supports and guides shall be designed to withstand the induced friction force in addition to other loads on the support.

Corners and edges of metal slides and guides in sliding supports shall be rounded or chamfered and guide parts shall be designed with sufficient length so that binding within the necessary clearance will not occur.

h. Hangers

Screw adjustments shall be accessible and workable when fully loaded. Nuts, clevises, sleeves, turnbuckles, etc. shall have their full length of thread in complete service while in use and the amount of male thread available for adjustment plainly visible. Sight holes shall be provided for visibility in parts where necessary.

Full locknuts or other suitable locking devices shall be furnished where necessary. Upset threads shall not be used as a locking method for threaded parts which require disassembly.

i. Hanger Rods

Hanger rods shall be designed in accordance with paragraph 121.2.2 of ANSI B31.1. Rods shall be compatible with the other component parts of the hanger assembly and shall be subjected to tension loads only. Where horizontal movement is anticipated, the rod shall be fitted with welded eye rods, links, or swivels to permit unrestrained swinging of the rod. Where lateral or axial movements exceed 4 deg, all hanger assemblies shall be offset in the cold position to ensure vertical alignment when the piping system is in operation. Hanger rod lengths shall be calculated to provide for at least plus or minus 2 inches of rod adjustment subsequent to hanger erection. Maximum length (pin-to-pin) of rods shall be 20 ft unless otherwise specifically approved by the Purchaser. Minimum rod length (pin-to-pin) shall be 12 inches for each half inch of horizontal movement using rod and clevis or rod and clamp type support. If space does not permit adequate rod length, a trapeze tube support shall be used.

j. Components

Bolt heads and nuts shall be heavy hex and shall conform to the dimensions and tolerances of ANSI Standard B18.2.1 and B18.2.2.

Material for bolts and nuts shall conform to ASTM A307 and ASTM A325. Material for anchor bolts, hanger rods, U-Bolts, etc., shall conform to ASTM A36.

2.14.2.8 Insulation Erection

All insulation and insulation supports shall be furnished and installed by the Seller.

Insulation for equipment requiring normal maintenance or periodic inspection shall be of the boxed construction type and design, which is easily removable and replaceable without damage to the insulation or associated equipment.

Insulation shall be placed behind the identification plates on vessels and equipment, sealed with mortar, and flashed with aluminum against the entrance of water. Nameplates shall remain visible on all insulated components.

2.14.2.9 Scrubber Vessel, Baghouse or Precipitator and Ductwork Insulation

The Seller shall apply panel insulation to all exposed steel surfaces of the scrubber vessel, baghouse or precipitator, ductwork and hoppers.

The entire insulation system shall be designed, fabricated, installed, flashed, and sealed to provide complete weatherproof integrity under the full range of interior and exterior temperature conditions.

All joints and trim shall be of good workmanship, clean and neat in appearance. Corrugations must nest neatly and properly on all overlappings.

All expansion joints shall be covered with insulation only up to and inclusive of the metal flanges.

2.14.3 Structural Erection Requirements

All structural and miscellaneous steel and associated items shall be erected in accordance with the AISC Manual of Steel Construction and SS-410.

Welding

All welding requirements shall be as specified in Section 2.11.

2.14.4 Controls and Instrumentation Erection Requirements

The Seller shall furnish all labor, materials, and supervision required to complete the work. All flushing, purging, testing, precalibration inspection and loop checking, calibration and calibrated loop checking of installed instrumentation shall be performed by the Seller. For detailed requirements refer to Purchaser's Specification for Instrument Installation No. SC-318.

## 3.0 GUARANTEED PERFORMANCE, TESTS, MODEL STUDY AND FILTER BAG WARRANTY

### 3.1 Required Performance Guarantees

The Seller shall guarantee that the minimum particulate, sulfur dioxide, hydrogen chloride, hydrogen fluoride and sulfuric acid removal efficiencies and maximum concentration and opacity in the flue gas exiting the baghouse or precipitator will be as shown in Attachment 3 based on test procedures outlined in Section 3.2.1.1.

Additional required performance guarantees are shown in Attachment 3. The Seller shall also guarantee that there will be no buildup of solid material on or in the scrubber vessel, baghouse or precipitator, ductwork, hopper sides, horizontal shelves, vanes, or any other equipment which would be detrimental to the APC system and/or to its continuous operation.

The APC system shall meet these guarantees while the following conditions (which may or may not occur simultaneously) are imposed:

1. The boiler operating under any condition of normal operation, including periods when boiler tube soot blowing or rapping is taking place.
2. Any plant operating conditions including any flue gas conditions entering the APC system within the Expected Continuous and Design ranges specified in Attachment 2 and Figure 1 of Attachment 3.
3. Removing particulate from the scrubber vessel and baghouse or precipitator hoppers.
4. Normal operation, with any one of the baghouse compartments isolated for cleaning, except for the average system pressure drop guarantees.

#### 3.1.1 Performance Guarantee Curves

In its bid, the Seller shall furnish the following performance guarantee curves. These curves will be used to correct from actual test conditions to guarantee conditions to determine if the Seller's APC system actually meets the Performance Guarantees during the Purchaser's Acceptance Tests.

These curves shall be drawn on graph paper of sufficient divisions to allow the determination of the parameters to three significant figures.

1. The Seller shall provide a set of curves or equations to adjust the lime consumption guarantee to actual flue gas test conditions. The adjustment shall include all possible flue gas variations that the vendor expects will affect performance, such as HCl, $SO_2$ and [illegible] content, inlet and outlet temperatures, and ratio of [illegible] concentration and HF to $SO_2$. The range of $SO_2$ and HCl concentrat[illegible] shall be from 50% of Expected Continuous Operation to Des[illegible]

conditions, the range of inlet temperature shall be from 50° less than Expected Continuous Operation to Design Operation Condition as shown in Attachment 2.

2. Guaranteed APC system static pressure drop vs. the total flue gas flow rate (in ACFM) exiting the economizer for maximum and average guarantees.

3. Guaranteed precipitator collection efficiency vs. gas volume.

4. ESP correction curve factors vs. temperature, moisture and resistivity.

Additionally, in its bid, the Seller shall address any other operating parameters, if any, which may affect the test verification of compliance with the Performance Guarantees.

3.2 Tests

Seller shall make provision in the design of the equipment for installation of all the required test instruments. As a minimum, this shall include the required test ports and access.

3.2.1 Performance Tests

System performance testing for verification of guarantees shall be performed by the Purchaser. The Seller shall provide a technical representative to participate in the development of testing procedures and provide technical direction for the tests. Deficiences, or fault conditions determined during these tests shall be promptly corrected by the Seller.

3.2.1.1 Performance Test Procedures

The system performance tests for verification of Seller's acid gas removal, particulate removal, opacity, lime consumption, system delta P and power consumption guarantees shall be performed simultaneously and be based on the following:

1. Particulates: Test Method 5 as published in the most recent edition of Title 40, CFR part 60, Appendix A or the results from a combined test method 5/12/101A.

2. PM-10: Test method 201A as published in the most recent edition of Title 40, CFR part 60, Appendix A.

3. Sulfur Dioxide: Test Method 6C as published in the most recent edition of Title 40, CFR Part 60 Appendix A.

4. Hydrogen Florides: Test Method 13B as published in the most recent edition of Title 40, CFR Part 60, Appendix A. Test to include analytical finish from Standard Methods for the Examination of Water and Wastewater.

5. Hydrogen Chlorides: Test Method 26 as published in the NSPS with analysis of the impinger catch by ION chromatography.

6. Opacity: Test Method 9 as published in the most recent edition of Title 40, CFR Part 60, Appendix A or by an EPA approved opacity monitor.

7. Sulfuric Acid: Test Method 8 as published in the most recent edition of Title 40, CFR Part 60, Appendix A.

8. Lime consumption, system pressure drop, and power consumption: test methods as mutually agreed to by Purchaser and Seller.

The above tests shall also include all other referenced test methods as published in the Federal Register.

Acceptance shall be based upon the average test value of three consecutive tests.

3.2.2 Shop Tests

Purchaser shall be given 10 days prior notice of all shop tests.

The Seller shall perform shop performance tests on all equipment specified herein to demonstrate proper operation and to verify performance. These tests shall be conducted in the Seller's shops prior to shipment.

All tests shall comply with and be conducted in accordance with the applicable governing codes and regulations. Subsupplier-furnished equipment shall be tested and certified by the respective manufacturers.

Rotating atomizers shall be shop tested for dynamic and static balance. The nozzles shall be shop tested for slurry flow and droplet size distribution.

All pressure sealing baghouse (precipitator) welds including the cellplate shall be dye penetrant tested.

For each precipitator rapper, Seller shall demonstrate that rapping is uniform and in accordance with design requirements. The details of the test procedure shall be submitted to the Purchaser in advance for approval.

All transformers shall be subjected to routine tests as required by NEMA Standard ST-1 and ST-20. Values measured during transformer tests must agree with guaranteed values within ANSI standard tolerances.

Each load center assembly and each breaker removable element shall be given the full series of production tests described in ANSI C37.20. Where test jigs are used to adjust and verify mechanical alignment as a substitute for aligning breakers in cubicles, the machanical operation tests, ANSI C37.20 Section 20-5.3.2, of all assemblies and all removable elements shall demonstrate correct operation of the secondary contact subassemblies by means of electrical continuity checks.

Each instrument transformer shall be given routine tests described --

ANSI C57.13. In addition, each potential transformer shall be given an induced potential test in accordance with ANSI C57.13.

Each protective relay shall be given a dielectric test in accordance with ANSI C37.1. The test shall include coil and contact circuits and shall be made either at the point of relay manufacture or as a part of the dielectric test of the switchgear assembly.

Each motor control center shall be subject to the following: dielectric tests listed in NEMA ICS-1 and ANSI C37.90, as applicable; continuity tests on secondary wiring, instrument wiring and grounding of noncurrent carrying parts. Shop tests shall be performed to demonstrate the proper operation of the control systems and provide the systems with an initial calibration. Calibration data on test instruments shall be furnished to the Purchaser, and shipped to the jobsite with respective instruments.

3.2.3 Component and Subsystem Field Tests (By Seller)

After the APC system has been erected, the Seller shall inspect the unit to ensure that it has been erected in accordance with the Seller's drawings and this Specification. Any erection errors or deficiencies shall be corrected by the Seller at its expense. Upon correction of any deficiencies in erection, the Seller shall notify the Purchaser in writing that the unit has been erected in accordance with the Seller's drawings and specifications. The Seller shall continue to be responsible for the maintenance and condition of the equipment and material until it is turned over to the Purchaser.

The Seller shall furnish all equipment, materials, labor and supervision personnel including service representatives from the Seller's subsuppliers to perform component and subsystem field tests as outlined below. All tests shall be sequenced properly to avoid schedule delaying repairs if the tests indicate inadequate design or performance. All energization of motors and electrical equipment shall be performed by the Purchaser's personnel with the concurrence of the Seller. All other work associated with these tests shall be performed by the Seller. The Seller shall also furnish all equipment, material, and personnel to prepare the unit for these tests including furnishing and installing start-up strainers, installation of packings, aligning and lubricating couplings, removing loose materials from vessels and compartments, checking rotation of motors and rotating equipment, filling instruments with necessary fluid, and checking level of lubricating and seal oil in rotating equipment and drivers.

During the component and subsystem field tests, if the Seller finds installed equipment which does not operate as required, the Seller shall immediately advise the Purchaser of the existence and nature of the problem. Any equipment which does not operate as required shall be repaired or replaced by the Seller at the Seller's expense. Additional tests required to show that the repaired or replaced equipment operates as required shall be performed at the expense of the Seller.

The Purchaser may witness and/or participate in the component and subsystem field tests. The following component and subsystem field tests shall be carried out

1. Piping Systems

All piping shall be field tested in accordance with ANSI B31.1.

2. Electrical Tests

The following electrical tests and checks shall be performed:

a. Megger and record reading for all circuits and equipment except instrumentation and control panels which could be damaged by this test.

b. Megger and record reading for all motors when received, including those shipped with the driven equipment.

c. Check out and test of all systems to make certain that operation of these systems conform to the design drawings.

d. Phase rotation and voltage of power interconnections.

e. All fuse and circuit breaker ratings correct as specified or shown on drawings.

f. Control switchboards and switchgear in operating condition, clean, adjusted and tested, all circuit breakers aligned and checked for proper operation. All relay shipping blocks removed. Protective relays properly set and adjusted.

g. All equipment properly grounded. All metal raceway electrically continuous and correctly grounded.

h. All motors checked for rotation, properly lubricated, tested, clean, and ready for operation, with driven equipment connected or positively and safely disconnected as may be required. Thermal overload relays in motor starters of correct ratings and properly installed.

i. Valve and damper operator and other limit switches correctly connected and adjusted.

3. Instruments and Controls Calibration and Loop Check

All instrument loop check and calibration work shall be performed by qualified calibrating technicians under the supervision of a Seller supplied qualified calibration engineer. When the instrument loop has been tested and calibrated, the event shall be recorded on a document bearing the date of verification, and the signature(s) of the responsible supervisor(s) who performed the inspection.

Inspection and preparation of instrument loops for release for calibration shall include the following (see also Purchaser's Specification for Instrument Installation No. SC-118):

a. All loop hardware shall have been inspected for conformity to drawings and specifications and for integrity of workmanship.

b. All electrical circuits pertinent to the loop shall be energized, preferably from their permanent power sources with fuses and protective devices in place and functional.

c. Functionally closed loops should be checked by manipulating the primary sensing device(s) and observing response of the final control element(s).

d. Digital inputs from switching devices to electrical systems, such as logic matrices and motor control circuits, shall be checked by verifying that it actuates the correct relay in the correct direction.

e. Alarm circuits shall be checked by manipulating the switching device to sound the alarm and light up the correct display window.

f. Analog or on-off inputs from, or outputs to, other loops shall be cheked by verifying correct action at the receiving device, preferably while operating all loop components in concert.

g. All fluids introduced to instrument bodies and attached piping for purpose of calibration, or for any other purpose, shall be compatible with the fluid with which the instrument and piping will be filled during normal operation, and shall be free of system contaminants.

h. All analog devices shall be adjusted for zero, linearity, and span across the full range and their smooth performance shall be verified by repeated cycling across the full range. All instruments shall be adjusted to their full design accuracy.

i. Every instrument shall be individually calibrated by applying measured inputs and measuring the outputs. In no case shall two or more instruments be gang calibrated, as, for example, by feeding measured pressure into a transmitter and then adjusting the receiver gage to agree.

4. <u>Inspection of Baghouse Tubesheet Welds</u>

A complete visual inspection of the tubesheet shall be made to check the welds around the thimbles and the welds between sections of tubesheet. In addition, for field fabricated tubesheets, a dye penetrant test shall be made of all tubesheet welds. All leaks shall be repaired by the Seller to the satisfaction of the Purchaser.

5. <u>Absorber Vessel, Baghouse, or Precipitator and Ductwork Weld Tests</u>

After the absorber vessel, baghouse or precipitator, and ductwork are erected, and preferably with a minimum of insulation in place, the absorber vessel, baghouse or precipitator, and ductwork shall be tested for leaks. 10% of the welds shall be tested using a dye penetrant test. OPI field personnel to approve Seller's selection of welds to be tested. If more than 10% of the tested welds fail, Seller shall test all welds. All discernible leaks shall be repaired by the Seller to the satisfaction of the Purchaser.

6. Tanks, Bins, and Vessels

Tanks, bins, and vessels (except the absorber vessel) shall be tested in accordance with AWWA D100 or AWS D1.1, whichever is applicable.

7. Other Component and Subsystem Field Tests

Running tests of all other equipment shall be conducted for a general operational check including vibration, noise, clearances, tightness, lubrication system, and performance at design point. These tests shall be performed in accordance with manufacturers' recommendations and all applicable codes and standards.

### 3.2.4 Model Study

If required by Section 4.4.2, the Seller shall be responsible for the construction and performance testing of a three-dimensional model of the APC system including, but not limited to, ductwork from the economizer to the scrubber vessel, the scrubber vessel, the ductwork from the absorber vessel to the baghouse or precipitator, the baghouse or precipitator, and the ductwork from the baghouse or precipitator through the ID fans to the stack inlet. If I.D. fans are furnished by Purchaser, Seller shall model the ductwork from the baghouse or precipitator to the ID fans based upon the Purchasers' design. Tests are to be conducted that will establish the proper arrangement of the APC system equipment with regard to adequate and correct gas flow, temperature, and particulate distribution throughout the gas flow rates specified in this specification. The three-dimensional model shall not be smaller than 1/12 scale and shall be constructed of transparent plastic to the greatest extent possible so that visual inspection may be made of all areas.

Dimensionless similarity parameters shall be maintained at the same value as in the actual design. Where this is physically impossible, the Seller shall include, in the test result report, a list of the variations from model to actual values and the correction factors used for these variations.

The APC system model shall be built and tests shall be performed by a firm approved by the Purchaser or, Seller may use its own in-house laboratory and test facilities to model the APC system if approved by the Purchaser.

Induced draft fans shall be used to draw air through the APC system model. The model shall be constructed with sufficient detail to incorporate any structural or mechanical members including, but not limited to, gas distribution vanes, duct supports, stiffeners, dampers, and other flow control devices, particulate filter media, tubesheet, internal compartment braces and any other equipment located internally to the APC system. Internal members shall be physically modeled, mathematical models of internal members are not acceptable.

Tests shall be performed at flue gas flow conditions which simulate the Minimum, Expected Continuous operation and Design flue gas flow as specified in Attachment 2 with different combinations of baghouse compartments isolated.

Test results and Seller's conclusions shall be submitted to the Purchaser for review and comment prior to fabrication of the APC system equipment and ductwork components.

All changes, modifications or adjustments to the Seller's APC system, which are shown by the model studies to be necessary to meet Seller's guarantees and/or the performance requirements of this specification, shall be made by the Seller at no additional cost to the Purchaser, and a modified flow model system shall be retested to verify that all guarantees and requirements of this specification are being met.

Seller shall maintain the APC system model until after completion of the Purchaser's Acceptance Tests. Upon successful completion of the Purchaser's Acceptance Tests, the APC system model shall be destroyed or shipped to the Purchaser whichever the Purchaser selects.

### 3.3 Filter Bag Warranty

The Seller shall guarantee baghouse pulse-jet/reverse air filter bags for a period of two/three years from the date of first refuse fire. The filter bag warranty shall be valid for on-line or off-line cleaning or a combination of both over time. During the guarantee period the Seller shall provide replacement bags for all failed bags, as well as all failed replacement bags, at no cost to the Purchaser. Replacement bags shall be of equal or superior quality to the original bags. If it is shown that the bags are not adequate for the service described in this specification or if greater than 20% of the installed bags have failed, the Seller shall execute a test program to determine the correct bag material or design, and shall re-fit each baghouse at no cost to the Purchaser. This test program shall be executed with all reasonable efforts to minimize its affect on the operation of the resource recovery facility.

## 4.0 SUPPLEMENTAL REQUIREMENTS

### 4.1 Conditions

No deviation or nonconformance from this specification or applicable codes and standards invoked by this specification shall be accepted until approved by the Purchaser. Deviations are considered departures from any requirement of this specification. Uncorrectable nonconformances are considered to be conditions which cannot be corrected within the specification requirements by rework or replacement.

The Seller shall promptly document and notify the Purchaser of all deviations and nonconformances from the specification such as deviations from applicable codes and/or drawings. Further engineering and fabrication after detection of any deviation or nonconformance prior to the Purchasers' approval shall be at the Seller's risk. No departure from the specification shall be binding on any party until an addendum or revision to the specification has been issued by the Purchaser.

### 4.2 Proposal Data and Drawings

The Seller shall indicate his understanding of and compliance with this specification by completing and submitting information requested in Attachment 6 of this specification with the proposal. Seller's proposal shall indicate in detail, in separate section, any exceptions taken to this specification, explaining the inability to comply and any alternatives offered. Blanket or general exceptions will not be accepted, each exception shall include the specific paragraph to which the exception refers, the Seller's alternate equipment or system and the cost impact of this change.

Detailed information concerning all components and accessories shall be furnished in the form of an equipment data list. Erection weights shall be included. Deviations from such information will not be permitted subsequent to issuance of a purchase order.

Seller shall include with the proposal, a priced list of all recommended spare parts and special tools.

Seller shall fill in completely all data required in Attachment 7. The data that do not apply to the Seller's equipment shall be answered with "N/A" (Not Applicable). The data contained in Attachment 7 shall be a firm contractual commitment of what the Seller will furnish. Changes to the data shall be submitted in writing and shall be subject to Purchaser's approval.

### 4.3 Approved List of Subsuppliers

Seller shall purchase equipment, material, or services from the suppliers included in the list below or from Purchaser's approved equal.

| Equipment | Manufacturer |
|---|---|
| Compressors | 1. Gardner-Denver<br>2. Sullair<br>3. Ingersoll-Rand<br>4. Atlas Copco<br>5. Joy Manufacturing<br>6. Dresser Industries |
| Fans | 1. Buffalo Forge<br>2. Howden<br>3. TLT Babcock<br>4. Garden City |
| Valves | 1. Rockwell Edward<br>2. Powell<br>3. Dezurick<br>4. Clarkson<br>5. Jamesbury<br>6. Fisher (all control valves for water, air...)<br>7. Fujican |
| Valve Operators (motorized) | 1. Limitorque<br>2. Rotork |
| Water Pumps | 1. Ingersoll-Rand<br>2. Lawrence Pump, Inc.<br>3. Gould Pumps |
| Slurry Pumps | 1. Warman International Inc.<br>2. Robins Myers<br>3. Lawrence Pumps, Inc.<br>4. Goulds (Morris)<br>5. Wanner (Hydra-Cell) |
| Agitators | 1. Chemineer<br>2. Philadelphia Gear<br>3. Cleveland Mixer<br>4. Lightning |
| Filter Bags | 1. BHA<br>2. Midwesco<br>3. Menardi |
| Hopper Heaters | 1. Edwin L. Wiegard Division of Emerson Electric Co.<br>2. Bylin Heating System<br>3. Hotfoil |
| Slakers | 1. Wallace & Tiernan<br>2. Kennedy Van Saun<br>3. Portec<br>4. WHM<br>5. BIF |

| Equipment | Manufacturer |
| --- | --- |
| Small Dust Collectors (Not baghouse) | 1. Zurn<br>2. Mikropul<br>3. American Air Filter<br>4. Flex-kleen |
| Volumetric Feeders | 1. Wallace & Tiernan<br>2. Ramsey<br>3. Merrick |
| Bin Activators | 1. Vibranetics<br>2. Kinergy Corp.<br>3. Vibra Screw |
| Expansion Joints | 1. Pathway Bellows Inc.<br>2. Raybestos Manhattan<br>3. Papco<br>4. Dynex |
| 480V Power Switchgear | 1. Westinghouse Type DS<br>2. Powell<br>3. ABB<br>4. General Electric |
| Motor Control Centers | 1. Westinghouse (Series 2100)<br>2. Siemens-Allis<br>3. ~~Telemecanique~~ Square D |
| Programmable Logic Controller | 1. Modicon<br>2. Allen Bradley<br>3. Westinghouse<br>4. GE |
| Low Voltage Power Cable and Lighting Wires | See SE-213 |
| Control Cables | See SE-213 |
| Instrumentation Cables and Thermocouple Extension Wires | See SE-213 |

4.4 Project Specific Requirements

The attached Project Specific Requirements, if any, are clarifications additions, deletions, and/or revisions to the preceding Specification requirements and shall be considered as part of this Specification.

4.4.1 Number of Trains 2

4.4.2 Model Study (yes/no) NO

4.4.3 ID Fans (yes/no) YES

4.4.4 The following economic factors shall be used in evaluating the vendors proposals:

1. Lime ($/LB/HR of 90% CaO): 3700
2. Power Consumption ($/KW): 2600
3. Pressure Drop ($/In. w.g./train): 55000

4.4.5 Seller to provide an option price to have test ports and instrument connections for Purchaser's opacity and CEM instruments located on the I.D. fan inlet duct (Ref. Section 2.6.1) plus associated access platforms (Yes/No) OPTION IS NOT SELECTED YES 5

4.4.6 Design summer/winter ambient temperature (°F) 110 / 35

4.4.7 Structural Design Criteria

- Governing Code SBCCI Year LATEST EDITION
- Wind Speed 100 MPH C Exposure
- Earthquake Seismic Risk Zone 0
- Ground Snow Load (Minimum) 0 psf

4.4.8 Boiler auxiliary fuel (fuel oil, natural gas, propane PROPANE

4.4.9 APC area to be enclosed (Yes[redacted] YES

4.4.10 Control System

4.4.10.1 The balance of the plant control system is:

- [ ] Single Loop Control System
- [x] Distributed Control System; Manuf./Model BAILEY NETWORK 90

4.4.10.2 Seller to provide the Control System interface in accordance with page:

- [ ] A10-1
- [x] A10-2

4.4.10.3 Seller to provide option for a PLC based control system (ref. Att. A10-3) in-lieu of a DCS based system (yes/no) OPTION IS NOT SELECTED YES 5

4.4.11 Boiler will have ammonia injection for reduction of $NO_x$ (Yes[redacted] YES

4.4.12 Additional economizer outlet particulate loading (Above those shown in attachment 2) due to purchaser's furnace dry lime injection system, gr/scf dry (Expected Continuous/Design) N/A / N/A

4.4.13 Cooling Water Pressure at interface point, psig

1. Supply avaialable LATER
2. Return required LATER

4.4.14 The Purchaser's CEM system shall provide the following $SO_2$ control signal

1. Inlet to scrubber (yes[redacted] YES
2. Outlet to stack (yes[redacted] YES
3. "Sample and Hold"/Dedicated DEDICATED
4. Continous Signal time (minutes) N/A
5. "Hold"/Calibration time (minutes) 15

REFER TO PAGES 101 - 106
FOR ADDITIONAL REQUIREMENTS

6

## Project Specific Requirements

4.4.15 All equipment including scrubbers, fans, breaching, ducts and baghouses shall be insulated to maintain a maximum 10°F temperature drop through the entire unit. As a minimum, 4 inches of fiberglass batt insulation over external stiffeners shall be installed complete with cladding.

4.4.16 All expansion joints handling gases above ambient temperatures shall be insulated to prevent condensation at the joint.

4.4.17 All expansion joints shall be flanged with air tight sealing gaskets made of non-hazardous materials.

4.4.18 The APC equipment and ID fans shall be completely enclosed. Therefore, weather enclosures or penthouses are not required. Walk-in plenum baghouses are still required.

4.4.19 Heat tracing provided only for freeze protection is not required. Heat tracing required for the process, if applicable, shall be provided. 7

4.4.20 The maximum available clearance at the scrubber area is 95 feet. The maximum available clearance at the baghouse area is 51 feet. The APC system, including the 12 foot by 25 foot CEM enclosure, ID fans and all required access and maintenance areas shall fit within the 135 foot long 94 foot wide area shown on Attachment 8. Access provision within the APC area shall include a path capable of accommodating fork lift truck access to all areas. An 8'-0" minimum clearance shall be provided between the lime silo and all support column piers, and a 7'-0" minimum clearance shall be provided between the ID fans and the baghouse support column piers. 7

4.4.21 The lime silo vent baghouse shall have a maximum air to cloth ratio of 4:1 and shall be designed to have a particulate removal efficiency of 99% of particles larger than 1 micron.

4.4.22 All rooms or enclosures (i.e., Lime Slurry prep., MCC's, control room etc.) located within the enclosed APC area shall be provided with lighting, convenience receptacles and appropriate HVAC systems. Emergency battery packs shall be provided and shall meet the requirements specified herein and NFPA 101 Section 5-9.

4.4.23 A complete set of aperture cards and a complete set of all CADD files shall be provided for all as-built drawings associated with this contract. The aperture card requirements shall be consistent with Attachment 19.

4.4.24 Seller shall provide a complete Mercury Control System. The system shall be designed for the following conditions:

- Unabated Hg @ economizer outlet = 500-1500 micrograms/$DNM^3$ @ 7% $O_2$

- Required stack concentration of Hg =

  100 Micrograms per $DNM^3$ @ 7% $O_2$ or
  80% removal, whichever is less stringent
  Hg emissions shall not exceed 0.0379 lb/hr per unit

- Flue gas at economizer outlet shall have volumetric flow and composition shown on specification SM-105 data sheets for the design case.

- Powdered activated carbon consumption shall not exceed 1 lb/ton of MSW burned and the use rate shall be continuously monitored and recorded.

- Carbon handling shall accommodate "supersaks" which are loaded to the system at grade.

- System shall be redundant in that a single component failure shall not impact operation of both boiler trains.

4.4.25 The monorail to hoist the atomizers shall be supported by the Seller and shall be completely independent of Purchaser's enclosure. Seller shall not rely on Purchaser building steel for support. Further, the hoist mechanism shall be electrically driven in both directions, with provision for manual override and operation.

4.4.26 Page iv, Table of Contents:

Attachments 11.2, 11.3, 11.4, 11.6, 11.9, 12, 16 and 18 are not applicable to this project and are deleted from the specification. Attachment 19, Aperture Card Requirements, is added to the specification requirements.

4.4.27 Page 1, Section 1.2:

520 hours of start-up and check-out supervision and 40 hours of operator training shall be provided.

4.4.28 Page 7, Section 2.1.1 third paragraph:

Purchaser's ash removal equipment will be designed for continuous ash removal to prevent hopper build-up. Purchaser will supply an air-lock mechanism below each scrubber hopper flange.

4.4.29 Page 8, Section 2.1.1 twelfth paragraph:

Idled equipment will be flushed and drained to avoid solids settling if downtime is greater than 4 hours.

4.4.30 Page 11, Section 2.1.6:

Compressed air supplied by Purchaser to a single interface point will not be dry. Seller shall provide a dual 100% electric heat regenerative air dryer for -40 F dewpoint and distribution piping for compressed air.

4.4.31 Page 13, Section 2.2.1, Second paragraph:

Provisions need not be provided for a future delumper at the scrubber outlet hopper.

4.4.32 Page 14, Section 2.2.3:

Each scrubber vessel shall be provided with a single rotary atomizer of the Combustion Engineering design.

4.4.33 Page 17, Section 2.2.4.2:

Provisions shall be included to allow for grab sampling of lime from the lime storage silo.

4.4.34 Page 17, Section 2.2.4.3:

Each slaker shall be located at a different floor level within the lime silo enclosure to maximize access. Independent grit screens must be maintained. In addition, the lime preparation control panel shall be located external to the enclosure, to prevent damage from the lime preparation area environment.

4.4.35 Page 18, Section 2.2.4.4, fourth paragraph:

Ultrasonic type level probe shall be provided for the lime slurry storage tank.

4.4.36 Page 19, Section 2.2.4.5, second paragraph:

The life of the output shaft bearings shall be 50,000 hours, as opposed to 250,000 hours.

4.4.37 Page 21, Sections 2.2.4.6 and 2.2.4.7:

Concentrated lime slurry flow rate to each scrubber head tank shall be measured and recorded utilizing Controllotron ultrasonic flow meters.

Dedicated lime slurry and dilution water pumps shall be provided for each unit, each with independent and separate ring headers to feed the scrubber head tanks. A back-up slurry and back-up water pump shall be provided to supply either unit. Low slurry pressure alarms shall be provided for each ring header at the inlet to slurry control valves. Fujikin control valves shall be provided to: 1) regulate flow to the head tanks to the feed tanks and 2) regulate flow from the feed tanks to the atomizers. Gravity return headers shall be provided on slurry and water supplies to the head tank and arranged so that constant pressure is maintained at the inlet to regulating valves. 6 7 6

4.4.38 Page 21, Section 2.2.4.7, second and fourth paragraphs:

Cleanouts will be provided at all tees and 90° elbows, but not necessarily at all fittings such as valves etc. 7

4.4.39 Page 22, Section 2.2.4.8, first paragraph:

All slurry valves will conform to ANSI B16.34. Water or air valves may require the use of screwed connections on some supplied valves.



pja/2335

4.4.40 Page 23, Section 2.2.4.9, second paragraph:

Reject water from the flushing process will not be directed back to the slurry storage tank. Valving and connections shall be provided to recycle flush water or discharge to floor trenches.

6

4.4.41 Page 33, Section 2.3.2:

Bag cages of split design shall be allowed to reduce overall height requirements. However, all aspects of cage construction must meet specification requirements.

4.4.42 Page 33, Section 2.3.2 third paragraph:

The bag suspension system is designed to avoid contact between adjacent bags. During installation and operation some bags may touch, however, these shall not exceed 5% of the bags in any one module. No bags shall touch the side walls.

7

4.4.43 Page 46, Section 2.5, fourth paragraph:

Delete "and closure plate" from the end of the first sentence.

4.4.44 Page 47, Section 2.6.1, fifth paragraph:

Ductwork plate deflection shall not exceed 1.5 times the plate thickness. Ductwork stiffener deflections shall not exceed L/240.

4.4.45 Page 47, Section 2.6.1, eighth paragraph:

Test ports at scrubber inlet ductwork shall also comply with the requirements of the Florida Administrative Code Section 17-2.700.

4.4.46 Page 50, Section 2.7.2:

The lime silo vent and carbon use bins shall be vented to the outdoors (external to APC enclosure by Purchaser). Slakers shall be vented from the slaking area.

7

4.4.47 Page 51, Section 2.7.3, fourth paragraph:

Lagging on outdoor equipment and ductwork (i.e. ductwork to chimney) shall be identical to lagging utilized by Purchaser for balance of Facility.

4.4.48 Page 52, Section 2.7.4, fifth paragraph:

Hopper heaters shall be controlled by thermostats in lieu of RTDs. A single, dual setpoint thermostat shall be provided for each hopper. One setpoint shall be for control, while the other shall be for low temperature alarm. The loss of a single controller shall not affect the operation of other heaters.

4.4.49 Page 53, Section 2.8.1, second paragraph:

The 3/4" differential criteria is between supports of different equipment. A 3/16" differential between supports of the same equipment will be utilized. 7

4.4.50 Page 53, Section 2.8.2

Building code safety factors will be followed for local combinations addressed by the Building Code. For load combinations not addressed by Building Codes, standard procedures will be used.

4.4.51 Page 56, Section 2.8.4, item 14:

Support brackets for Purchaser supplied cable trays shall be by Purchaser. Seller shall include provisions for accepting associated loading on Seller supplied steel.

4.4.52 Page 62, Section 2.9.4, fourth paragraph: 6

Westinghouse Series "C", or purchaser approval equal, motor circuit protectors may be provided in the supplied combination motor starters.

4.4.53 Page 65, Section 2.10.2, second paragraph:

Feed forward correction of $SO_2$ set point shall be utilized.

4.4.54 Page 65, Section 2.10.2, seventh paragraph:

Baghouse controls shall accommodate simultaneous cleaning of a minimum of four baghouse modules when in on-line cleaning mode.

All baghouse outlet dampers shall fail open on loss of air or loss of power. 6

Baghouse bypass damper(s) shall fail closed on loss of power. An air cylinder with trip valve(s) shall be provided to allow manual opening of the damper(s) from the control room on loss of air, or locally on loss of power.

4.4.55 Page 66, Section 2.10.2, second paragraph:

Change the words "the baghouse shall automatically go into bypass mode, under de-energized condition" to "the control system shall alarm".

4.4.56 Page 73, Section 2.14.1, first paragraph: 6

The absorber vessel, baghouse and ductwork need not be shop assembled and disassembled prior to delivery. Match marking, punching or doweling of absorber vessels is not required. 7

4.4.57 Page 97, Section 4.3:

Add Chemco as an approved slaker supplier.

4.4.58 Attachment 2, page A2-2: 6

Add to Note 2 that the baghouses will remain on-line during start-up and shut-down of the boiler units.

4.4.59 Attachment 4:

The power distribution system shall be similar to the alternate scheme presented. The 150 hp atomizer motor starters are not local combination starters, but shall be installed in the MCC prior to the current limiting reactors.

(((( END OF PROJECT SPECIFIC REQUIREMENTS ))))

# ATTACHMENT 1
## SYSTEM CONFIGURATION

Proposals shall be provided for the following system configurations:

- Electrostatic Precipitator Only ____ Yes __X__ No
- Scrubber/Electrostatic Precipitator ____ Yes __X__ No
- Scrubber/Baghouse __X__ Yes ____ No

General Arrangement Drawings (See Attachment 8)

Economizer Outlet Connection (Approximate Ref. Section 2.1.7)

- Centerline Height above grade __32'-6"__
- Height/Width (ft.) __3'-10", 30'-8"__
- Distance inside Boiler Building Column [redacted] (ft.) CENTERLINE __1 FOOT__ LS
- Stoker Width (ft.) __29'-6"__

Stack Interface (approximate)

- Maximum Breeching Width/Height (ft.) __4'-5", LATER__
- Stack Shell Outside Dimensions (ft.) __LATER__
- Stack Foundation Dimensions (ft.) __LATER__

## ATTACHMENT 2
## ECONOMIZER OUTLET OPERATING CONDITIONS(1)

| | | Expected Continuous(2) | Design(3) |
|---|---|---|---|
| Gas Quantity (wet) | lb/hr | 382,910 | 440,000 |
| Gas Quantity (dry) | lb/hr | 350,890 | 406,000 |
| Gas Volume (wet) | SCFM (@68°F) | 86,080 | 99,000 |
| Gas Temperature | °F | 425-500 | 425-500 |
| Gas Pressure | IWC | approx.-1.5 | approx. -3 |
| **Gas Composition (Wet)** | | | |
| $CO_2$ | vol. % | 8.57 | 8.30 |
| $O_2$ | " | 9.16 | 9.75 |
| $N_2$ + Ar | " | 68.98 | 70.09 |
| $H_2O$ | " | 13.24 | 11.72 |
| $SO_2$ | " | 0.0116 | 0.0530 |
| HCl | " | 0.0420 | 0.0883 |
| HF | " | 0.0 | 0.0044 |
| Total | | 100.00 | 100.00 (ROUNDED) |
| **Gas Composition (Dry)** | | | |
| $CO_2$ | vol. % | 9.88 | 9.40 |
| $O_2$ | " | 10.56 | 11.04 |
| $N_2$ + Ar | " | 79.50 | 79.40 |
| $H_2O$ | " | 0.0 | 0.0 |
| $SO_2$ | " | 0.0134 | 0.0600 |
| HCl | " | 0.0484 | 0.1000 |
| HF | " | 0.0 | 0.0050 |
| Total | | 100.00 | 100.00 (ROUNDED) |

| | | Expected Continous (2) | Design(3) |
|---|---|---|---|
| Acid Gases (Dry Gas) | | | |
| $SO_2$ | Lbs/hr | 100 | 531 |
| $SO_2$ | PPMDV | 134 | 600 |
| HCl | Lbs/hr | 206 | 494 |
| HCl | PPMDV | 484 | 1000 |
| HF | Lbs/hr | 0 | 14 |
| HF | PPMDV | 0 | 50 |
| $H_2SO_4$ | PPMDV at 7% $O_2$(4) | 14 | 45 |
| Particulates (Wet Gas) (5,6) | | | |
| gr/scf (68°F) | | 2.2 | 2.5 |
| lbs/hr | | 1623 | 2121 |

NOTES

1. All data are for one (1) unit and are based on combustion calculations and not the "pitot tube" conditions. The Seller shall provide allowance for in-leakage (3% minimum); this shall be included in Seller's mass balances (assume inleakage occurrs half in scrubber & half in baghouse). In addition, the boiler may be fired on Auxiliary fuel (see section 4.4.8), refuse, or a combination of both.

2. Minimum operation will be at 70% of flow based on Expected Continuous operation. During initial start-up of the boiler, economizer outlet flue gas temperatures will be about 330°F. As the boiler fouls the outlet temperature will increase to the temperature shown. This initial operation will last approximately 4 to 6 weeks. Similar, less severe, conditions may also occur after major boiler overhauls. The scrubber vessel and auxiliaries shall be designed such that acid gas scrubbing can begin at 330°F and 70% of "Expected Continuous" gas flow and flue gas can be passed through the baghouse modules. Lime consumption and acid gas removal efficiency guarantees are not required for this operation. The Seller shall state the estimated acid gas removal efficiency at this operating point. The Seller shall also list any other system start-up limitations that would affect operation under the above conditions.

3. Seller shall provide mass balance for the Design Condition at the normal operating, high $O_2$ and high $H_2O$ points shown in figure 1 of attachment 3. For the high $O_2$ and $H_2O$ cases, the lbs/hr of flue gas and acid gases are the same as shown above. The gas compositions for the High $O_2$ and High $H_2O$ cases are shown below. Seller shall also provide Mass Balance for the Design Condition based on the highest scrubber outlet temperature shown in note 2 of attachment 3 using the most stringent combination of $O_2/H_2O$ (Ref. figure 1 of Attachment 3) with respect to consumption of lime.

Gas Composition (Vol. % Wet)

| | High $O_2$ Case | High $H_2O$ Case |
|---|---|---|
| $CO_2$ | 7.06 | 8.70 |
| $O_2$ | 11.16 | 8.36 |
| $N_2$ & Ar | 70.49 | 66.50 |
| $H_2O$ | 11.23 | 16.38 |

4. $H_2SO_4$ concentrations are shown at an $O_2$ concentration of 7%. The APC system shall be designed to accomodate the range of $O_2$ concentrations shown in figure 1 of Attachment 3.

5. Minimum particulate loading is 0.25 gr/dscf.

6. Seller's design shall also include the additional particulate loading shown in section 4.4.12.

ATTACHMENT 3

REQUIRED GUARANTEES

3.1. Emission Guarantees (1)**

| | |
|---|---|
| Particulates: | 0.010 gr/dscf corrected to 7% $O_2$. |
| PM-10 | 0.010 gr/dscf corrected to 7% $O_2$. |
| Sulfur Dioxide: | 85 % min. removal rate or 30 ppmv (dry)(max) corrected to 7% $O_2$, whichever is less stringent. |
| Hydrogen Chlorides: | 95 % min. removal rate or 25 ppmv (dry) (max) corrected to 7% $O_2$, whichever is less stringent. |
| Hydrogen Fluoride: | 95 % min. removal rate or 1 ppmv (dry) (max) corrected to 7% $O_2$, whichever is less stringent. |
| Sulfuric Acid: | * % min. removal rate or * ppmv (dry) (max) corrected to *, whichever is less stringent. |
| Opacity: | less than 10 % under all operating conditions and based on a 6-minute rolling average |

Averaging Time: The above guarantees shall be verified by the test methods in Section 3.2.1.1 Acid gases that are monitored with CEM analyzers and subject to averaging times will be monitored for a 72 hours period to confirm that system response time is sufficient to maintain compliance. Averageing times are as follows: (REFER TO ATTACHMENT 9)

3.2 Overall System Static Pressure Drop (1)

Seller shall provide overall maximum and average APC system static pressure drop guarantees based on the flows and temperatures at the Economizer outlet. The Maximum pressure drop shall be with one baghouse compartment isolated at the start of a cleaning cycle. The Average pressure drop shall be the average between the baghouse cleaning and non-cleaning modes. Correction curves shall be provided as specified in Section 3.1.1. These guarantees shall be provided for the following operating conditions:

a. Expected Continuous Operation - Maximum and Average

b. Design Condition - Maximum and Average

c. 0.91 x flow at the Design Condition - Maximum only (for use in I.D. fan Test Block Pressure determination)

* - $H_2SO_4$ EMISSIONS SHALL NOT EXCEED 8.95 LB/HR



** - REFER ALSO TO ATTACHMENT 9

3.3. <u>Total System Power Consumption</u>

a. Vendor to supply this data for Expected Continuous Operation and Design Conditions. Guarantee values shall be 24 hour average values and shall include <u>all</u> equipment (except the I.D. fan) supplied by Seller.

b. Guaranteed maximum power demand.

3.4 <u>Total System Water usage</u>

Seller to supply this data for Expected Continuous Operation and Design Conditions.

3.5 <u>Instrument/Pulse-Jet Air Consumption</u>

3.6 <u>Total Reagent Consumption</u> (as 90% CaO) (1)

Vendor to supply this data for Expected Continuous Operation and Design Conditions and correction curves as specified in Section 3.1.1.

3.7 <u>Bag Life</u> - 2[redacted] years (minimum) for Pulse-Jet[redacted] Bags

3.8 In addition to the above, Seller shall guarantee that the APC system being furnished will meet all sections of the regulations of applicable regulatory agencies and permits that apply to acid gas removal and particulate removal requirements including test methods, reporting criteria, etc. Copies of which are attached hereto and form an integral part of this Specification (Attachment 9).

3.9 <u>Gas Temperatures for Above Guarantees</u>

a. Scrubber Exit (2)

<u>285</u> °F

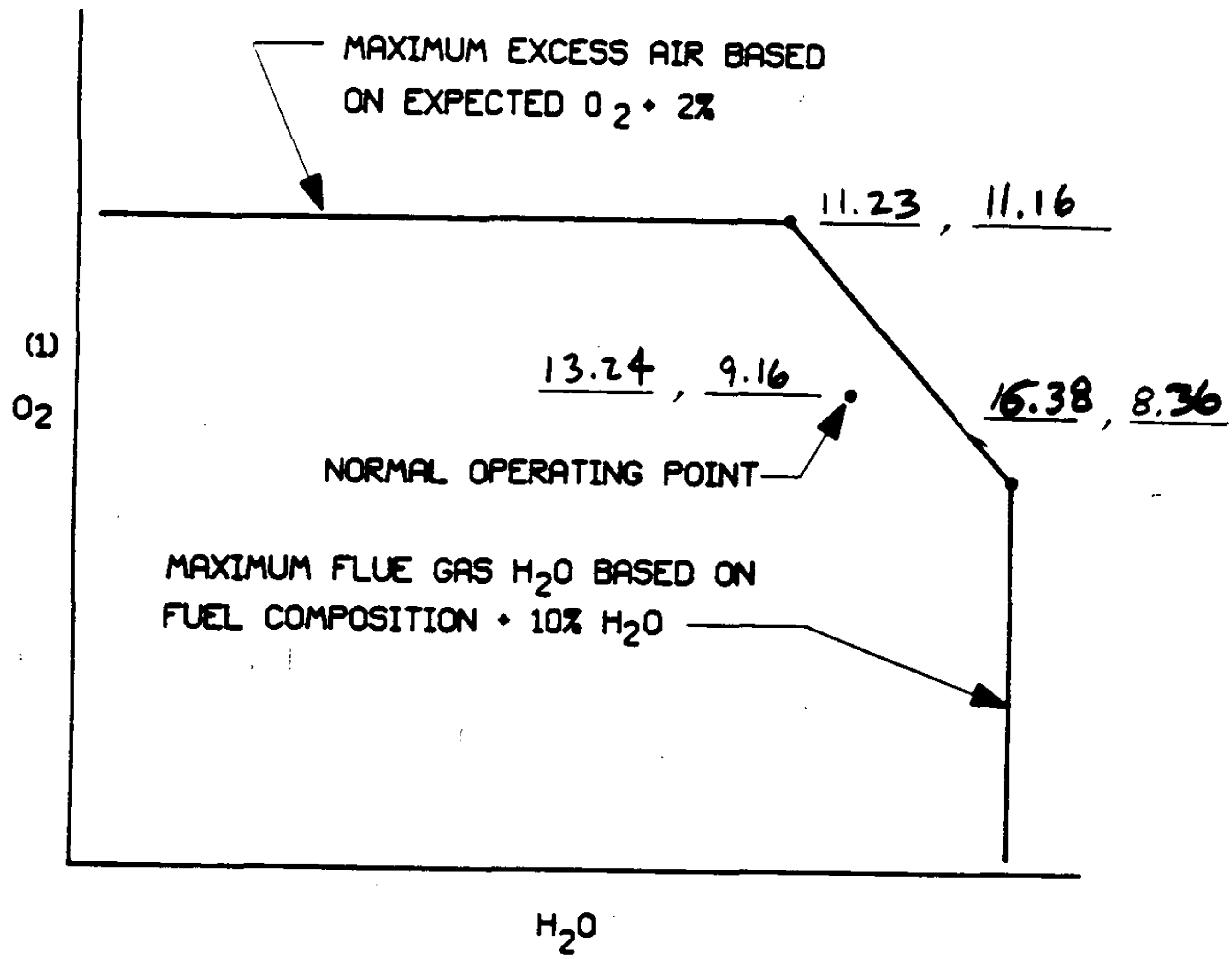
b. Stack Inlet

maximum 10°F drop from Scrubber outlet

NOTES:

1. These guarentees shall be met for each individual combustion train. The methods of Section 3.2.1.1 and compliance with averageing times as verified with facility CEM equipment shall be used.

2. Emission guarantees shall also be met for scrubber outlet temperatures ranging from <u>270</u> °F to <u>300</u> °F.




(1) $O_2$ IS BASED ON HIGH EXCESS AIR OPERATION.
ADDITIONAL AIR FLOW SHALL BE CONSIDERED.



AN OGDEN COMPANY

FIGURE 1

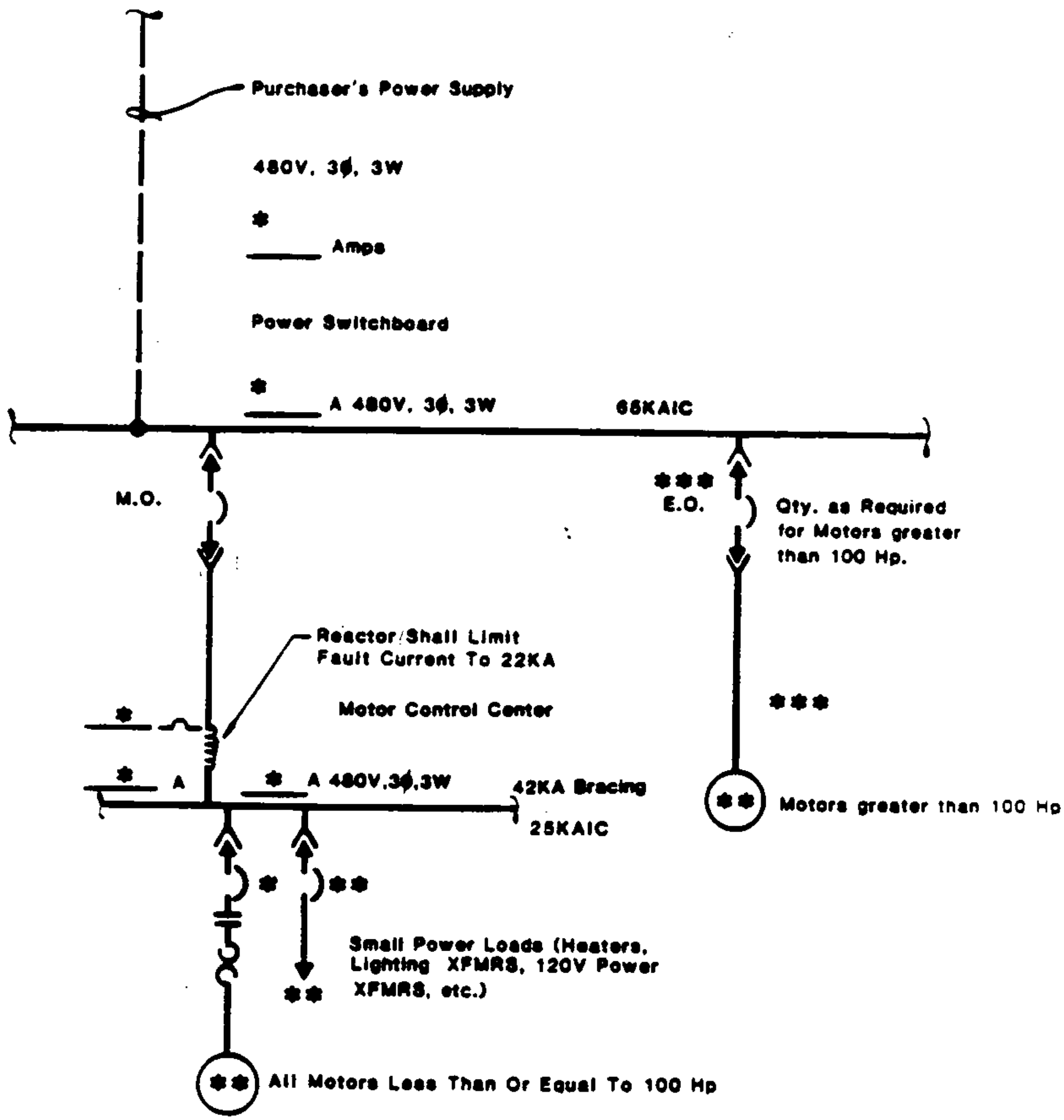
EMISSIONS GUARANTEE CURVE

| OGDEN PROJECTS, INC | |
|---|---|
| APPROVED: | DATE: |
| DWG. No. SM-105 | REV. |

ATTACHMENT - 4 (2 Pages)

SUBJECT Typical Flue Gas Cleaning Oneline - Base

SPECIFICATION SM - 105

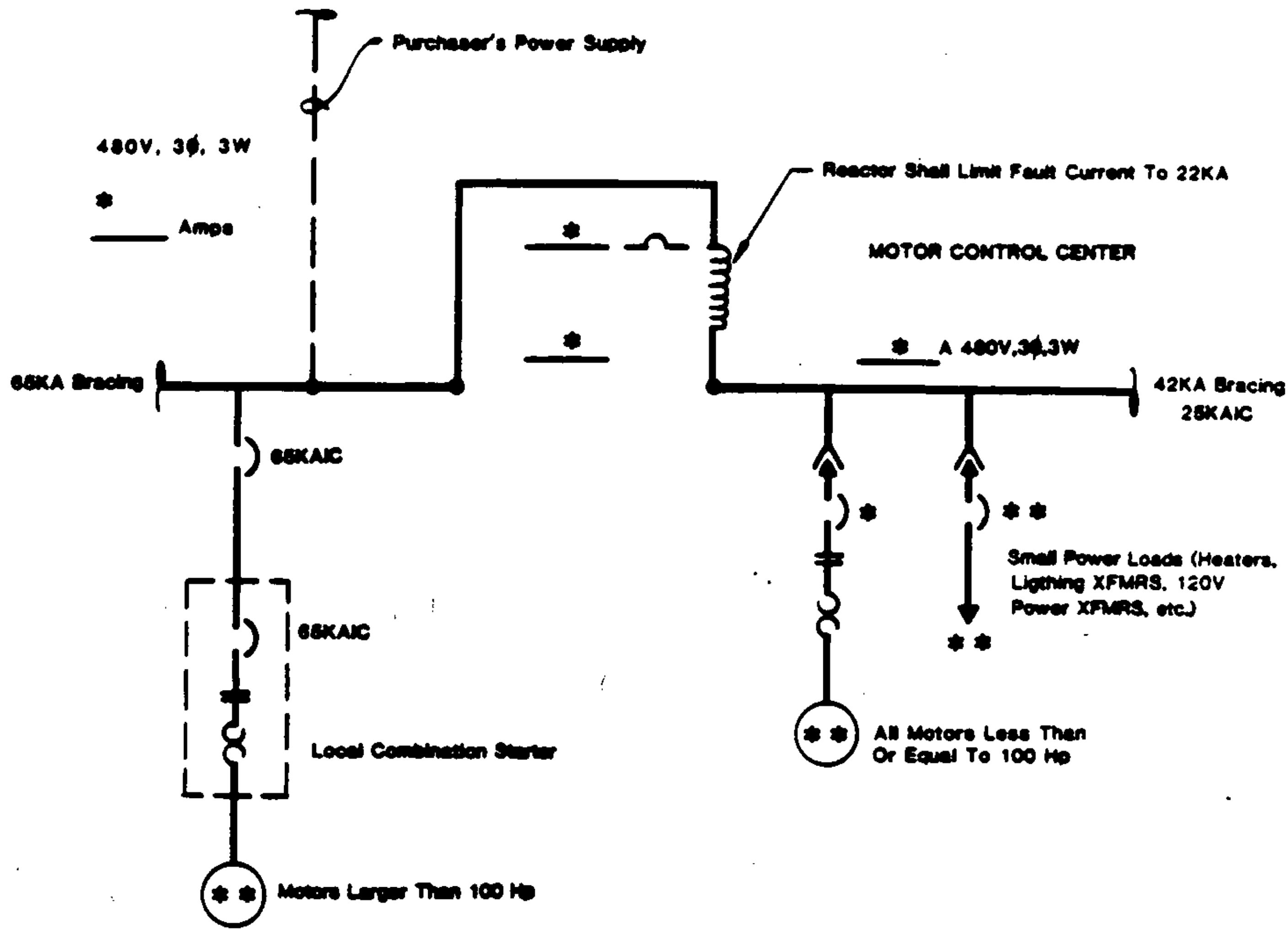



* Ratings to be determined by Vendor.
** Quantity to be determined by Vendor.
*** Breakers can be manually operated if Local Combination starter is provided.
Equipment shown is typical for each combustion train.

# ATTACHMENT - 4

**SUBJECT:** Typical Flue Gas Cleaning Outline - Alternate

**SPECIFICATION SM - 105**




* Rating to be determined by Vendor.

* * Quantity to be determined by Vendor.

ATTACHMENT 5
## SERVICE WATER ANALYSIS

Millgrams Per Liter
(Except Where Units Are Indicated)

| | Slaking Water | Scrubber/ Dilution Water |
|---|---|---|
| METHYL ORANGE [redacted] Alkalinity ($CaCO_3$) | 50 | 300 |
| Phenol Alkalinity ($CaCO_3$) | | |
| Noncarbonate Hardness ($CaCO_3$) | | |
| Total Hardness ($CaCO_3$) | 100 | 800 |
| Calcium (Ca) | 50 | 400 |
| Magnesium (Mg) | 50 | 400 |
| Sodium (Na) | 720 | 15,000 |
| Chloride (Cl) | 300 | 10,600 |
| Fluoride (F) | 10 | 100 |
| Nitrate (N) | 5 | 50 |
| Total Phosphate (P) | 5 | 50 |
| Sulfate ($SO_2$) | 500 | 5,000 |
| Total Cations (meq/l) | 820 | 15,800 |
| Total Anions (meq/l) | 820 | 15,800 |
| Total Dissolved Solids | | |
| Turbidity (NTU) | - | - |
| Silica (SiO ) | 15 | 100 |
| Color (Pt-Co Color Units) | 5 | 5 |
| Conductivity (umhos/cm) | | |
| pH Value (pH Units) | 5-7 | 6-9 |
| Total THM's (ug/l) | | |
| Free Chlorine | | |
| Gpm available | | |
| Pressure/Temperature (psig/°F) (at supply point) | / | / |

Potable water is available at the supply point at ______/______/______ GPM/psig/°F.

ATTACHMENT 5 (Cont'd)
TYPICAL SCRUBBER/DILUTION WATER ANALYSIS

| Component | Range in ppm as $CaCO_3$ | |
|---|---|---|
| Ca | 100-1000 | ppm as $CaCO_3$ |
| Mg | 50-400 | ppm as $CaCO_3$ |
| Na | 1000-4000 | ppm as $CaCO_3$ |
| $SO_4$ | 2000 | ppm as $CaCO_3$ |
| Cl | 2500 | ppm as $CaCO_3$ |
| $NO_3$ | 25-100 | ppm as $CaCO_3$ |
| $HCO_3$ | 300 | ppm as $CaCO_3$ |
| $SiO_2$ | 200 | mg/l |
| pH | 6.5-8.5 | |
| TDS | 4000 | |
| TSS | < 200 | |
| Temperature | 45-120 | °F |
| Gpm available | ________ | gpm |
| Pressure Available | ________ | psig |

Note: The above are based on using cooling tower blowdown from a zero discharge facility.

--

ATTACHMENT 6

INFORMATION REQUIRED WITH BID

Seller shall submit all equipment data and descriptive details which will facilitate evaluation of this proposal, and should include:

6.1 System heat and material balances for Expected Continuous operation and Design conditions (ref. note 3 page A2-2), including a schematic diagram clearly labeling each stream. Also provide mass balance [redacted]

6.2 General arrangement and elevation drawings(s)

6.3 Lime preparation equipment arrangement.

6.4 Complete description of proposed equipment including electrical equipment.

6.5 Complete description of proposed control system operation and hardware including P&IDs of all systems.

6.6 Foundation loading diagrams including I.D. fan and scrubber inlet duct at Boiler Building interface ("not to exceed") and column location plan. Also Seller to identify his requirements regarding use of Purhaser's foundations to resist overturning moments and uplift forces (Ref. section 2.8.2 item 4).

6.7 Motor list and electrical load summary, and ID, RA & Compressor motor data sheets.

6.8 Performance data including guarantee correction curves and listing of specific guarantees.

6.9 Estimated performance at 330°F and 70% of "Expected Continuous Operation" gas flow, including any operating constraints (see Page A2-2).

6.10 Completed Data Sheets in Attachment 7.

6.11 Detailed explanation of electrical distribution system including one line diagram, description of protective relaying scheme, system flexibility, interlocks, demand kW and KVA of each power feed, and essential power requirements.

6.12 Construction sequencing schedule including crane location and laydown area.

6.13 Priced list of all recommended spare parts and tools.

6.14 Statement of full compliance with this Specification with all exceptions listed in a dedicated section of Seller's proposal; listed exceptions shall include a detailed explanation as to why the exception was taken.

INFORMATION REQUIRED WITH BID

6.15 Complete pricing data including the following options (if offered).

a. Deletion of current limiting reactors in MCC's (see Section 2.9.4)

b. Reverse air fan atmospheric inlet (see Section 2.3.3)

c. Bolted lime silo (see Section 2.2.4.1)

d. I.D. fans (see Section 4.4.3); Provide Break-out price

e. Test/instrument ports and access platform at I.D. fan inlet duct (see Section 4.4.5)

f. Option price for Seller's standard control system as shown in Attachment A10-3.

6.16 Bag dimentional drawing including calculation method of bag effective area.

5

## ATTACHMENT 7

## FLUE GAS CLEANING SYSTEM DATA SHEETS (18 Pages)

| 7.1 Guarantees (1) | | Expected Continuous Operation (2) | Design Conditions (2) |
|---|---|---|---|
| **a. Emission Guarantees** | | | |
| i - | Particulate | 0.010 gr/dscf at 7% $O_2$ | 0.010 gr/dscf at 7% $O_2$ |
| ii - | PM-10 | 0.010 gr/dscf at 7% $O_2$ | 0.010 gr/dscf at 7% $O_2$ |
| iii - | $SO_2$ | 85% Removal or 30 ppmd @ 7% $O_2$ | 85% Removal or 30 ppmd @ 7% $O_2$ |
| iv - | HCl | 95% Removal or 25 ppmd @ 7% $O_2$ | 95% Removal or 25 ppmd @ 7% $O_2$ |
| v - | HF | 95% Removal or 1 ppmd @ 7% $O_2$ | 95% Removal or 1 ppmd @ 7% $O_2$ |
| vi - | Opacity | 10% | 10% |
| vii - | Sulfuric Acid | ≤ 8.95 lb/hr | ≤ 8.95 lb/hr |
| **b. Performance Guarantees** | | | |
| i - | Static pressure drop from economizer outlet flange to Stack inlet, IWC (max/avg) | 11.0/ 9.9 | 11.8/ 10.7 |
| ii - | Static pressure drop from economizer outlet flange to stack inlet, IWC (maximum) | 10.7 | (3) |
| iii | Stack Inlet, temp., °F | 275 | 275 |
| iv - | Bag life, years | 2 | 2 |
| **c. Utilities Guarantees (total for all trains)** | | | |
| i - | * Power consumption, kW | 148 | 171 |
| ii - | ** Maximum power demand, kW | 444 | 444 |
| iii - | Reagent consumption, lbs/hr | 768 | 2,811 |
| | lbs/hr CaO | 691 | 2,530 |



* Consumption exclusive of HVAC, lighting, hopper heat, or I.D. [illegible]ns. Valves are based on 425 °F SDA inlet temperature.

** Connectedmaximum power exclusive of HVAC, lighting, hopper [illegible] or I.D. Fans.

| | | | |
|---|---|---|---|
| iv - | Water consumption, gpm: | | |
| | - Scrubber/Dilution | 82 | 76 |
| | - Slaking | 9 | 31 |
| | - Potable | | |
| v - | Instrument/pulse-jet air | 90 | 90 |

Notes:

(1) As per the requirements in Attachment 3 and Section 3.0.

(2) Based on an APC System in-leakage of 3 % of the economizer outlet flow.

(3) Reference section 3.2c of Attachment 3

7.2 Scrubber Vessel (Data per train)

| | | |
|---|---|---|
| a) | Manufacturer | ABB ES |
| b) | Type (rotary atomizer, dual fluid nozzle) | Rotary Atomizer |
| c) | Gas residence time (Expected/Design) | 17. 43 / 15.23 |
| d) | Stociometric ratio (Expected/Design) | 1.28 / 1.33 |
| e) | Reagent flow rate, gpm (Expected/Design) | 41.3 / 47.9 |
| f) | Percent solids in slurry (Expected/Design) | 2.0 / 6.2 |
| g) | Minimum flue gas flow to meet guarantees, SCFM | 70% of Expected |
| h) | Minimum total flue gas enthalpy to meet guarantees, Btu | 70% of Expected |
| i) | Minimum flue gas flow and enthalpy required to start-up scrubber | 70% of Expected |
| j) | Slurry droplet size, (microns) | 121 |
| k) | Maximum possible $Ca(OH)_2$ injection (lb/hr) | 1,519 |
| l) | Estimated system response time to a step change in $SO_2$ content of flue gas | 2 min. @ Expected Cond. |

| | | |
|---|---|---|
| m) | $SO_2$ control signal requirments | |
| | i. Inlet $SO_2$ signal (Yes/No) | Yes |
| | ii. Outlet $SO_2$ signal (Yes/No) | Yes |
| | iii. Flue gas flow feed forward (Yes/No) (expressed as steam flow or scrubber delta P) | No |
| | iv. Time between $SO_2$ signal updates | 5 min. |
| n) | Vessel diameter, Ft. | 36 |
| o) | Vessel straight side height, Ft. | 28 |
| p) | Vessel design pressure, IWC/temperature, °F | ± 25 / 600 |
| q) | Vessel wall material / thickness, in. | A-36 / 1/4 |
| r) | Vessel insulation material / thickness | Fiberglass / 4" |
| s) | Insulation lagging material/thickness, in./ finish | Al. / .04 / Vendor Std. |
| t) | Penthouse | |
| | - Siding material / finish | n/a / |
| | - Insulation material / thickness | n/a / |
| | - Length / width / height, Ft. | n/a / / |
| | - Heating, kW | n/a |
| | - Type of crane / crane capacity | Electric Hoist / 3 ton |
| u) | Wall cleaner (if included, provide separate description) | n/a |
| v) | Scrubber outlet delumper included? | No |
| | - tons/hr. | n/a |
| | - hp | n/a |
| w) | Ash and spent lime to ash system, lbs./hr. (Expected/Design) | 353 / 682 |
| x) | Hoppers | |
| | i - Net operating capacity, cu. ft | Continuous Evac. |
| | ii - Net operating capacity, hrs. | Continuous Evac. |

| | | |
|---|---|---|
| iii - | Heaters (Kw, manuf., type) | 6.5 /later/ blanket |
| iv - | Poke holes (quantity, size) | 2 / 4 |
| v - | Level switch (manufacturer, type) | later / capacitance |
| vi - | Reinforced strike plates, quantity | 2 |
| vii - | Valley angle | 60 |
| viii - | Flange size | 12" x 12" |
| ix - | Clearance below hopper flange | 10' |
| x - | Hopper lower 1/3 portion temp. min./max., °F | Min. - 150oF above minimum ambiet (w/o flue Gas) Maximum - 285oF |
| xi - | Access doors (quantity, size) | 1 / 24" x 24" |
| xii - | Vibrator (quantity, manuf. type) | 1 /later/ |

y) Compressor(s)

| | | |
|---|---|---|
| i - | Manufacturer and Model No. | n/a |
| ii - | Quantity / train | n/a |
| iii - | Quantity, total | n/a |
| iv - | Type | n/a |
| v - | Flow each, cfm | n/a |
| vi - | Pressure, psig | n/a |
| vii - | Brake hp/rpm | n/a / |
| viii - | Motor hp/rpm | n/a / |
| ix - | Cooling water each, GPM | n/a |
| x - | Cooling water supply pressure required at interface, psig | n/a |
| xi - | Cooling water return pressure available at interface, psig | n/a |

z) Structural support steel surface prep. and finish — SP6/1 coat primer

aa Instrumentation and controls description — please provide as an attachment

| | | |
|---|---|---|
| bb | Required scrubber water pressure at grade, psig | 60 |
| cc | Required slaking water pressure at grade, psig | 40 |
| dd | Required dilution water pressure, at grade, psig | 40 |
| ee | Required instrument air pressure, psig | 80 |
| ff | Centerline distance between two trains, ft. | 53'-8" |
| gg | Distance from economizer outlet to stack centerline, ft. | 177'-6" |

7.2.1 Rotary Atomizer Design

| | | |
|---|---|---|
| 1. | No. of atomizers per vessel | 1 |
| 2. | Reagent Flow to Atomizer, gpm | 41.3 (exp.) |
| 3. | Maximum possible Reagent flow to Atomizer, gpm | 47.9 (design) |
| 4. | Atomizer manufacturer | Combustion Engineering |
| 5. | Atomizer diameter | 10" wheel |
| 6. | Atomizer RPM | 11,295 |
| 7. | Atomizer Hp | 150 |
| 8. | Gear box manufacturer | Sundstrand |
| 9. | Gear box: ratio / type | 3.18 / 2-stage spur |
| | No bearings | 6 |
| | Bearing type | ball (4), journal (2) |
| | Lubrication system | Forced Oil Lubrication |
| 10. | Drive motor manufacturer | later |
| 11. | Drive motor: RPM / type | 3550 / TEFC |
| | Voltage | 480 |
| | hp | 150 |
| | Heaters | no |
| | Bearings (type/lubrication) | / |

| | | |
|---|---|---|
| 12. | Can assembly be removed for inspection/repair without shutdown of the boiler | Yes |
| 13. | Expected life of atomizer wheel | Body components -10 yr Wear components -3 yrs. |
| 14. | Attach description of atomizer design including: | |
| | -Outline sketch with dimensions and weight | Wheel - 10" dia. x 4", 41 lbs. |
| | -Vibration monitoring instrumentation | Eddy current proximity Probe |
| | -Atomizer wheel design features to minimize erosion, vibration, plugging | Hardened tool steel & silicon carbide wear components |
| | -Lubrication system | Internal and External lube oil pumps |
| | -Nozzle Material | Hardened tool steel & silicon carbide wear components |
| 15. | Cooling water user flow, GPM | n/a |
| 16. | Cooling water supply pressure required at interface point, psig | n/a |
| 17. | Cooling water return pressure available at interface, psig | n/a |
| 18. | Minimum Nozzle clearance for slurry flow | n/a |

7.2.2 Dual Fluid Nozzle Design

| | | |
|---|---|---|
| 1. | Number of nozzles | n/a |
| 2. | Nozzle material | n/a |
| 3. | Minimum nozzle flow clearance for lime slurry | n/a |
| 4. | Expected nozzle life | n/a |
| 5. | Can nozzles be removed for inspection / replacement without shutdown of the boiler | n/a |
| 6. | Number of inlet gas distributors / nozzle assemblies | n/a |
| 7. | Number of spare nozzles provided | n/a |
| 8. | Shield air blower, CFM | n/a |

| | | |
|---|---|---|
| 9. | Shield air blower, Hp/Rpm | n/a / |
| 10. | Shield air blower delta P, in. $H_2O$ | n/a |
| 11. | No. of shield air blowers | n/a |
| 12. | Compressed air requirement (Expected/Design) | n/a / |

7.3 Reagent Preparation System (common) (Data for all trains)

a. Lime storage silo(s)

| | | |
|---|---|---|
| i - | Diameter, ft. | 13 |
| ii - | Height(straight side/hopper), ft. | 18' / 10' |
| iii - | Capacity, tons gross/net | 78 / 62 |
| iv - | Capacity, days @ Expected conditions | 7.7 |
| v - | Skirted silo (yes/no) | Yes |
| vi - | Equipment located inside skirted silo | Yes |
| vii - | Access doors size/no. | Vendor / Standard |
| viii - | Bin activator or vibrator, manuf./type | Later / Bin activator |
| ix - | Screw feeder, manuf./capacity | Later / 3,000 lb.hr (CaO) |
| xi - | Weigh feeder, manuf./capacity | n/a / |

b. Lime silo accessories

| | | |
|---|---|---|
| i - | Dust collector, manuf./type | Later / Shaker |
| ii - | Level indicator, manuf./type | Later / Capacitance |
| iii - | Truck unloading equipment | sched. 40 fill pipe and control panel |

c. Slaker(s)

| | | |
|---|---|---|
| i - | Manufacturer | Portec, Chem[illegible], or equal |
| ii - | Quantity | 2 |
| iii - | Capacity, lbs/hr (each) | 3,000 (CaO) |
| iv - | Motor hp | 2 |

| | | |
|---|---|---|
| d. | Grit removal system, manuf./type<br>no. screens/mesh | Sweco or equal / Vibrating Screening<br>2 / 40 |
| e. | Grit discharge chute to 3 ft. above outdoor grade level provided (Yes/No) | Yes |
| f. | Reagent storage tanks(s) | |
| i - | Quantity | 1 |
| ii - | Net flow leaving tank, gpm (without slakers operating) | 7.7 (Expected) |
| iii - | Capacity, gallons gross/net* | 11,914 / 8,936 |
| iv - | Capacity (Design), hours-net | 8 |
| v - | Diameter/height, ft | 13 / 12 |
| vi - | Material/thickness | C.S / 1/4" |
| vii - | Agitator (Quantity, manuf., type, hp) | 1 / later / 5.0 |

* Net capacity shall not include the 2' freeboard and the volume below the low-low level switch.

| | | |
|---|---|---|
| g. | Reagent Mix/Head tank(s) | |
| i - | Quantity | 2 |
| ii - | Capacity, gal. (gross/net) | 70 / 47 |
| iii - | Residence time (Expected Continuous), minutes | 1 |
| iv - | Diameter/height, ft | 2 / 3 |
| v - | Material/thickness | C.S. / 1/4" |
| vi - | Agitator (Quantity, manuf., type, hp | 2 / later / 1 |
| h. | Reagent Transfer Pumps | |
| i - | Type | Centrifugal |
| ii - | Quantity | 3 |
| iii - | Capacity, gpm | [redacted] 42 RLT |

| | | | |
|---|---|---|---|
| | iv - | TDH, Ft. | [redacted] 137 -RLT |
| | v - | RPM | [redacted] 1320 -RLT |
| | vi - | Type of gland (mech. or pressurized) | Pressurized |
| | vii - | Material, - casing | Cast |
| | | - impeller | Metal Lined See Cut Sheets |
| | viii - | Motor hp | [redacted] 15 -RLT |
| | ix - | Brake, hp | [redacted] 11.2 -RLT |
| | x - | Manufacturer and Model No. | Goulds/1-1/2 x 2-14 |
| i. | Reagent feed pumps | | |
| | i - | Type | n/a |
| | ii - | Quantity | n/a |
| | iii - | Capacity, gpm | n/a |
| | iv - | TDH, Ft. | n/a |
| | v - | RPM | n/a |
| | vi - | Type of gland (mech/pressurized) | n/a |
| | vii - | Material, - casing | n/a |
| | | - impeller | n/a |
| | viii - | Motor, hp | n/a |
| | ix - | Brake, hp | n/a |
| | x - | Manufacturer and model no. | n/a |
| j. | Water pumps | | |
| | i - | Type | Centrifugal |
| | ii - | Quantity | 3 |
| | iii - | Capacity, gpm | 75 [redacted] -RLT |
| | iv - | TDH, Ft | 130 [redacted] -RLT |

| | | |
|---|---|---|
| v - | RPM | Later |
| vi - | Material | Cast |
| vii - | Motor hp | 7.5, RLT |
| viii - | Brake, hp | 4.1, RLT |
| ix - | Manufacturer and Model No. | Goulds/3196 |

| | | |
|---|---|---|
| k. | Describe building (include Bldg. Manuf.) | Skirted Silo |
| l. | Describe if additional tanks and pumps are provided | Yes - 1 dilution water tank |
| m. | Lime slurry recirculation system (yes/no) | Yes |
| | i - orifice plate material | n/a |
| n. | Lime slurry Strainer | Yes |
| | i - Type | Duplex |
| | ii - location | Feed tanks |
| | iii - Basket Mesh | Later |

7.4 Fabric Filter Option (Data per train)

| | | |
|---|---|---|
| a. | Manufacturer | ABB ES |
| b. | Type (pulse-jet/reverse air) | Pulse Jet |
| c. | Overall size | 60' x 33' |
| d. | Structural design temp., °F | 600 |
| e. | Structural design pressure, IWC | + - 25 |
| f. | Gas volume, ACFM/Temp. °F (including in-leakage-3% min.) | |
| | i - Inlet at Expected Continuous * | 139,769 / 285 |
| | ii - Inlet at Design condition * | 160,147 / 285 |
| | iii - Outlet at Expected Continous | 138,024/ 275.7 |

*Use B.H. outlet flow from mass balance corrected to B.H. inlet temperature.

| | | |
|---|---|---|
| g. | Outlet gas volume (design), ACFM/Temp. °F (without in-leakage) | 156,081 / 275.8 |
| h. | Casing material/thickness | A-36 / 3/16" |
| i. | Exterior surface prep. and finish | No / Paint |
| | Interior surface prep. and finish | No paint |
| j. | Access doors (quantity per module, size) | 1 / 2' x 7' |
| k. | Insulation, material/thickness | Fiberglass / 4" |
| | Lagging, material/thickness/finish | Al / 0.040 / Vendor St |
| l. | Bags/Cages | |
| | i - Bag Material, finish and manuf. | Burlington / / 625-I |
| | ii - Bag Diameter/length (actual, not nominal) | 6" / 14'-1-3/4" |
| | iii - Cage Material, finish and manuf. | c.s / n/a / later |
| | iv - No. and gage of cage wires | 20 / 12 |
| | iv - No./guage/mat'l of rings | n/a / / |
| | v - Effective cleaning area per bag as specified in Section 2.3. | 21.6941 |
| | vi - Bag to tubesheet sealing method | snap-ring |
| m. | Number of bags per module | 320 |
| n. | Number of modules per baghouse | 8 |
| o. | Effective cleaning area per baghouse | 55,537 $ft^2$ |
| p. | Air to cloth ratio (Expected/Design) | |
| | i - With all modules in service | 2.517 / 2.884 |
| | ii - With one module out of service | 2.876 / 3.296 |
| q. | Max. continuous operating temp. for bags, °F | 500 |
| r. | Excursion temp. for bags for 30 minutes, °F | 500 |
| s. | Bypass duct size | 50" dia. |

t. Bypass dampers

i - Quantity: *2 per FF*

ii - Type and manufacturer: *poppet / later*

iii - Size: *50" dia.*

iv - Type of operator: *pneumatic*

u. Inlet damper

i - Quantity: *1 per module*

ii - Type and manufacturer: *betterfly/ later*

iii - Size: *later*

iv - Type of operator: *manual chain*

v. Outlet dampers

i - Quantity: *1 per module*

ii - Type and manufacturer: *poppet / later*

iii - Size: *later*

iv - Type of operator: *pneumatic*

w. Reverse gas fan

i - Manufacturer and Model No.: *n/a*

ii - Quantity: *n/a*

iii - Capacity, ACFM/static head, inches: *n/a /*

x. Ventilation fan

i - Manufacturer and Model No.: *n/a*

ii - Quantity, per train/total: *n/a /*

iii - Capacity each, CFM: *n/a*

y. Penthouse heating, ventilating and lighting: *n/a*

z. Hoppers

i - Type: Pyramidal

| | | |
|---|---|---|
| ii - | Net operating capacity each, $F^3$ | *continuous evacuatic* |
| iii - | Net operating capacity each, (Design), hrs. | *cont. evacuation* |
| iv - | Heaters (total kW, manuf., type) | *6 / Bylin or equal / blanket* |
| v - | Vibrator (quantity, manuf., type) | *1 / later / pneumatic* |
| vi - | Poke holes (quantity, size) | *2 / 4"* |
| vii - | Level switch, type and manuf. | *capacitance / later* |
| viii - | Reinforced strike plates, quantity | *1* |
| ix - | Valley angle | *55* |
| x - | Flange size | *12" x 18"* |
| xi - | Clearance below hopper flange | *10'* |
| xii - | Hopper lower 1/3 portion temp. min./max, °F | Min - 150°F above minimum ambient (w/o Flue Gas) Max. - 285°F |
| xiii - | Access doors (quantity, size) | *1 / 24" x 24"* |

aa. Ash and spent lime to disposal, lbs/hr *per FF*

| | | |
|---|---|---|
| i - | Expected Continuous Operation | *2,035* |
| ii - | Design condition | *4,063* |

| | | |
|---|---|---|
| bb. | Monorail (quantity, manuf., type) | n/a / / |
| cc. | Hoist (quantity, manuf., capacity) | n/a / / |
| dd. | Structural support steel surface prep. and finish | *SP6* / 1 coat primer |
| ee. | Instrumentation and controls description | Please provide as an attachment |

7.5 Electrostatic Precipitator Option (Data per train)

| | | |
|---|---|---|
| a. | Manufacturer | *n/a* |
| b. | Volume, ACFM @ Expected Continuous | *n/a* |

| | | |
|---|---|---|
| | @ Design condition | n/a |
| c. | Temperature, °F @ Expected Continuous | n/a |
| | @ Design condition | n/a |
| e. | Dust bulk density, lb/cu ft | n/a |
| f. | Actual Pressure drop across precipitator including gas distribution devices, IWC | |
| | - Expected Continuous | n/a |
| | - Design | n/a |
| g. | Gas velocity, ft/sec (Expected/Design) | n/a / |
| h. | Residence time, seconds (Expected/Design) | n/a / |
| i. | Chambers, quantity | n/a |
| j. | Fields, quantity and aspect ratio | n/a / |
| k. | Cells, quantity | n/a |
| l. | Casing material and thickness, inches | n/a |
| m. | Casing design pressure, IWC | n/a |
| n. | Hoppers | |
| | i - Type | n/a |
| | ii - Quantity | n/a |
| | iii - Net operating capacity each, $ft^3$ | n/a |
| | iv - Net operating capacity each, hrs. (Design) | n/a |
| | v - Heaters (type/manuf., kw per hopper) | / n/a / |
| | vi - Vibrators (quantity, manuf., type) | / n/a / |
| | vii - Poke holes (quantity, type) | n/a / |
| | viii - Level switch, manuf. and type | n/a / |
| | ix - Reinforced strike plates, quantity | n/a |
| | x - Valley angle | n/a |
| | xi - Ash outlet Flange size | n/a |
| | xii - Clearance below hopper flange | n/a |

| | | |
|---|---|---|
| xiii - Hopper lower 1/3 portion temp. min./max, °F | | n/a / |
| xiv - Access doors (no., size) | | n/a |
| xv - Access door safety interlock | | n/a |
| o. | Ash and spent lime to disposal, lbs./hr. | |
| | i - Expected Continuous Operation | n/a |
| | ii - Design Condition | n/a |
| p. | Insulator compartment material and thickness, inches | n/a |
| q. | Number of insulator compartments | n/a |
| r. | Precipitator internal gas distr. devices | |
| | i - Types/location | n/a |
| | | n/a |
| | | n/a |
| s. | Access Doors (Quantity, type and size) | |
| | i - Roof | / n/a / |
| | ii - Shell | / n/a / |
| | iii - Insulator compartments | / n/a / |
| | iv - Other | / n/a / |
| t. | Collecting System | |
| | i - Number of gas passages | n/a |
| | ii - Spacing of gas passages, Inches | n/a |
| | iii - Collecting surface material and thickness | n/a / |
| | iv - Collecting surface effective length, feet | n/a |
| | v - Collecting surface effective height, feet | n/a |
| | vi - Total collecting effective surface area, sq. ft. | n/a |

| | |
|---|---|
| vii - Maximum collecting surface area rapped at any instant, sq. ft. | n/a |
| viii - Collecting surface rappers, type | n/a |
| | n/a |
| ix - Number of collecting surface rappers | n/a |
| x - Specific rapping energy (ft./lbs) per lb. of system rapped per rapper maximum installed | n/a |
| operating design | n/a |

u. Discharge Electrode

| | |
|---|---|
| i - Type/material/thickness | /n/a / |
| ii - Type discharge electrode rappers | n/a |
| iii - Total number of discharge electrode rappers per field | n/a |

v. High Voltage Electrical Set

| | |
|---|---|
| i - Type transformer-rectifier | n/a |
| ii - Number transformer-rectifiers | n/a |
| iii - Size transformer-rectifier | n/a |
| - Voltage rating KV (DC) avg. (For pure resistive loads) | n/a |
| - Current rating mulliamps (DC) Avg. (For pure resistive loads) | n/a |
| iv - Number of transformer-rectifier control cabinets | n/a |
| v - Construction of transformer-rectifier control cabinets | n/a |
| vi - Transformer-rectifier insulation fluid | n/a |
| vii - Wave form of high voltage | n/a |
| viii - Number and type high voltage switches | n/a |
| | n/a |

ix - Key interlocks

| | |
|---|---|
| Control cabinets | n/a |
| Transformer-rectifiers | n/a |
| Access doors | n/a |

x - Type transformer-rectifier controls n/a

n/a

n/a

xi - Maximum ambient temperature for transformer-rectifier, °F n/a

xii - Maximum ambient temperature for transformer-rectifier control cabinets, °F n/a

w. Power Consumption, KVA

| | |
|---|---|
| i - Transformer-rectifier | n/a |
| ii - Rappers | n/a |
| iii - Insulator heaters and blowers | n/a |
| iv - Other | n/a |
| v - Total | n/a |

x. Total connected load, KVA n/a

y. Power distribution

i - Individual breakers each control cabinet n/a

ii - Central distribution panel n/a

z. Heat insulation, type, thickness, and lagging n/a

aa. Weather enclosure, material and thickness n/a

bb. Weather enclosure heating, ventilating and lighting n/a

cc. Insulator compartment blower system n/a

dd. Model study n/a

7.6 Auxiliaries (Data per train)

a. Ductwork

| | | |
|---|---|---|
| i - | Material and thickness | A-36 / 3/16" |
| ii - | Insulation type/thickness | Fiberglass / 4" |
| | Lagging type/thickness | Al / .040 |
| iii - | Access doors (quantity size, location) | 24" X 24" See GAs |
| iv - | Support steel | A-36 |
| v - | Expansion joints | |
| | Quantity | See GAs |
| | Manufacturer and model | RM type III or equal |
| | Material | Viton |
| | Maximum continuous operating temperature, °F | 500 |

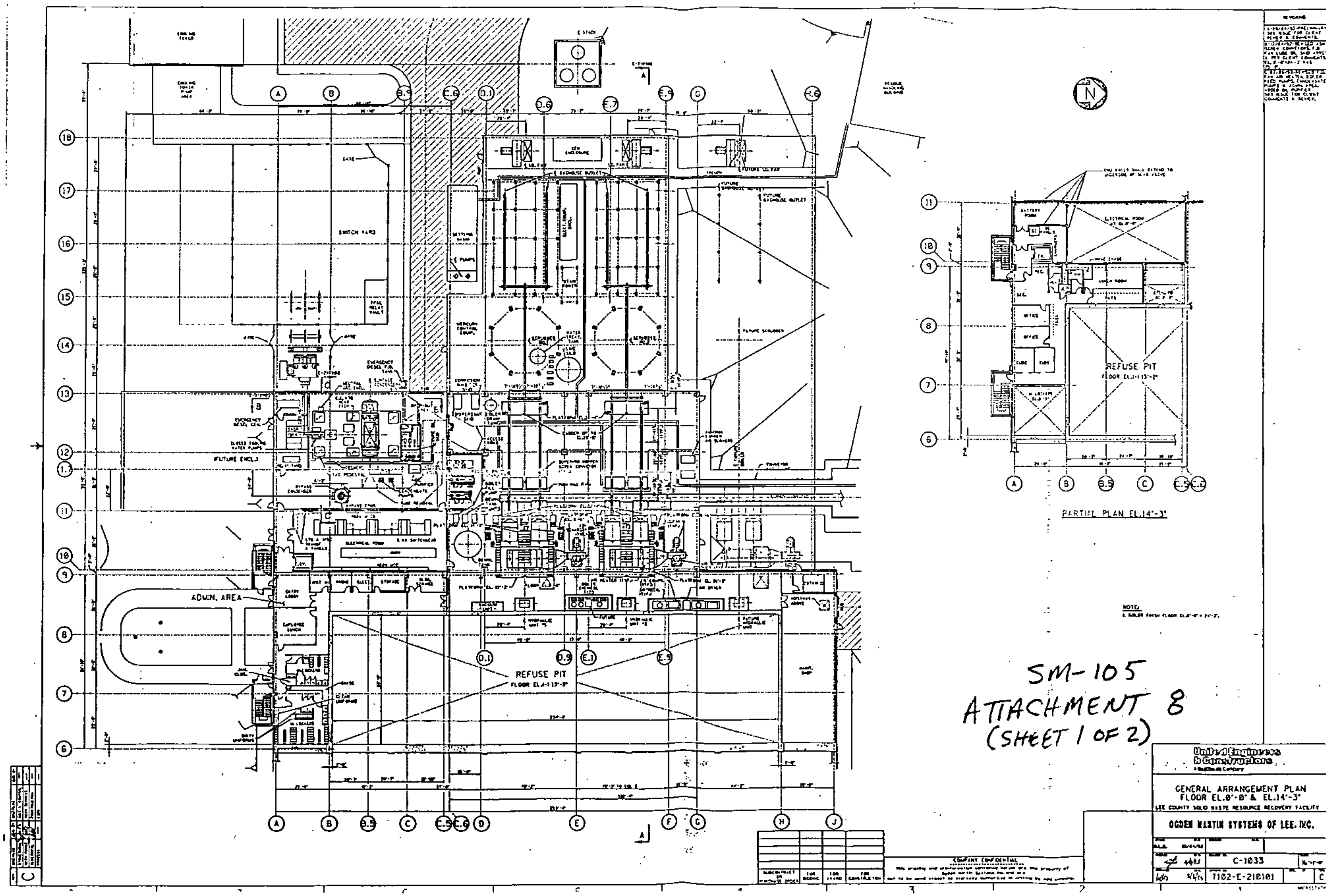
b. Test ports

| | | |
|---|---|---|
| i - | Quantity | as required |
| ii - | Size | 4" |
| iii - | Location | Econ. outlet & FF outlet |

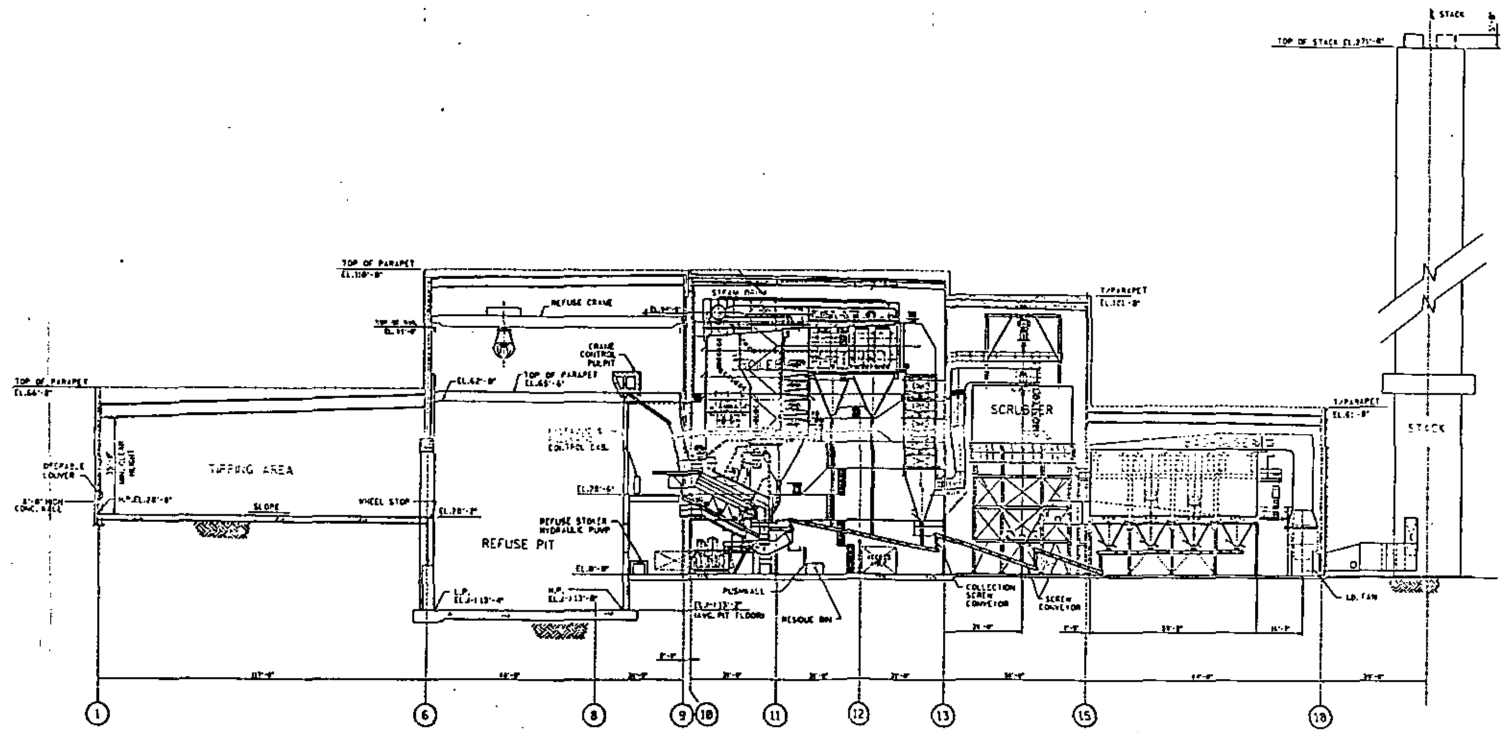
c. Piping material

| | | |
|---|---|---|
| - | Lime slurry | C.S. |
| - | Other | C.S. |

| | | |
|---|---|---|
| d. | Piping heat tracing | not required |
| e. | Piping insulation type/thickness | later / |
| | Lagging type/thickness | later / |
| f. | Describe Slurry Flushing System | manual |




SM-105
ATTACHMENT 8
(SHEET 1 OF 2)




SECTION A-A

SM-105
ATTACHMENT 8
(SHEET 2 of 2)

United Engineers & Constructors

GENERAL ARRANGEMENT
SECTION A-A

LEE COUNTY SOLID WASTE RESOURCE RECOVERY FACILITY

OGDEN MARTIN SYSTEMS OF LEE, INC.

C-1833

7182-E-218901

C

COMPANY CONFIDENTIAL

ATTACHMENT 9

# Florida Department of Environmental Regulation

Twin Towers Office Bldg. ● 2600 Blair Stone Road ● Tallahassee, Florida 32399-2400

Lawton Chiles, Governor

Carol M. Browner, Secretary

PERMITTEE:
Lee County Utilities
2178 McGregor Blvd.
Ft. Myers, FL 33902

Permit Number: PSD-FL-151

County: Lee
Latitude/Longitude: 26°37'54"N
81°45'41"W
Project: Lee County Waste to Energy Recovery Facility Units 1 and 2

This permit is issued under the provisions of Chapter 403, Florida Statutes, and Florida Administrative Code Chapters 17-2 and 17-4. The above named permittee is hereby authorized to perform the work or operate the facility shown on the application and approved drawings, plans, and other documents attached hereto or on file with the Department and made a part hereof and specifically described as follows:

For the construction of the Lee County Solid Waste Energy Recovery Facility located at Buckingham Road and State Road 82, in Fort Myers, Florida consisting of two mass-burn Municipal Waste Combustors (MWC) with two units to be constructed initially and the third unit to be installed in the future. These mass-burn units shall have a maximum permitted capacity of 660 tons/day, each unit, for a total capacity for both units not to exceed 1320 tons/day; and a maximum heat input of 275 MMBtu/hr, per unit, for a total heat input for both units not to exceed 550 MMBtu/hr, based on a municipal solid waste average heating value of 5000 Btu/lb.

Each combustor unit shall be of Stoker Waterwall design (or equivalent) capable of generating 20 MW for a total of 40 MW from both units. Each unit shall be allowed to produce a maximum of 186,200 lbs of steam per hour at 865 psig and 830°F. Each combustor unit shall be equipped with auxiliary burners to be fired by only propane gas. Emissions from each combustor shall be controlled by a slaked lime scrubber followed by a baghouse. $NO_x$ emissions shall be controlled by a SNCR System. Mercury emissions shall be controlled by injecting activated carbon.

The permittee must submit four copies of complete information prior to purchase and installation of any combustor and related equipment. Such information shall include the following: make and model numbers of each MWC and all pollution control and continuous emissions monitoring devices and related equipment.

The power plant site certification number for this facility is PA90-30.

This source shall be constructed in accordance with the permit application; plans, documents, amendments and drawings, except as otherwise noted in the General and Specific Conditions:

Attachments are as follows:

Power Plant Site Certification package filed on June 29, 1990 and related correspondence.

**GENERAL CONDITIONS:**

1. The terms, conditions, requirements, limitations, and restrictions set forth in this permit are "Permit Conditions" and are binding and enforceable pursuant to Sections 403.161, 403.727, or 403.859 through 403.861, Florida Statutes. The permittee is placed on notice that the Department will review this permit periodically and may initiate enforcement action for any violation of these conditions.

2. This permit is valid only for the specific processes and operations applied for and indicated in the approved drawings or exhibits. Any unauthorized deviation from the approved drawings, exhibits, specifications, or conditions of this permit may constitute grounds for revocation and enforcement action by the Department.

3. As provided in Subsections 403.087(6) and 403.722(5), Florida Statutes, the issuance of this permit does not convey any vested rights or any exclusive privileges. Neither does it authorize any injury to public or private property or any invasion of personal rights, nor any infringement of federal, state or local laws or regulations. This permit is not a waiver of or approval of any other Department permit that may be required for other aspects of the total project which are not addressed in the permit.

4. This permit conveys no title to land or water, does not constitute State recognition or acknowledgement of title, and does not constitute authority for the use of submerged lands unless herein provided and the necessary title or leasehold interests have been obtained from the State. Only the Trustees of the Internal Improvement Trust Fund may express State opinion as to title.

5. This permit does not relieve the permittee from liability for harm or injury to human health or welfare, animal, or plant life, or property caused by the construction or operation of this permitted source, or from penalties therefore; nor does it allo-

**GENERAL CONDITIONS:**

the permittee to cause pollution in contravention of Florida Statutes and Department rules, unless specifically authorized by an order from the Department.

6. The permittee shall properly operate and maintain the facility and systems of treatment and control (and related appurtenances) that are installed or used by the permittee to achieve compliance with the conditions of this permit, as required by Department rules. This provision includes the operation of backup or auxiliary facilities or similar systems when necessary to achieve compliance with the conditions of the permit and when required by Department rules.

7. The permittee, by accepting this permit, specifically agrees to allow authorized Department personnel, upon presentation of credentials or other documents as may be required by law and at a reasonable time, access to the premises, where the permitted activity is located or conducted to:

a. Have access to and copy any records that must be kept under the conditions of the permit;

b. Inspect the facility, equipment, practices, or operations regulated or required under this permit; and

c. Sample or monitor any substances or parameters at any location reasonably necessary to assure compliance with this permit or Department rules.

Reasonable time may depend on the nature of the concern being investigated.

8. If, for any reason, the permittee does not comply with or will be unable to comply with any condition or limitation specified in this permit, the permittee shall immediately provide the Department with the following information:

a. a description of and cause of non-compliance; and

b. the period of noncompliance, including dates and times; or, if not corrected, the anticipated time the non-compliance is expected to continue, and steps being taken to reduce, eliminate, and prevent recurrence of the non-compliance.

**GENERAL CONDITIONS:**

The permittee shall be responsible for any and all damages which may result and may be subject to enforcement action by the Department for penalties or for revocation of this permit.

9. In accepting this permit, the permittee understands and agrees that all records, notes, monitoring data and other information relating to the construction or operation of this permitted source which are submitted to the Department may be used by the Department as evidence in any enforcement case involving the permitted source arising under the Florida Statutes or Department rules, except where such use is prescribed by Sections 403.73 and 403.111, Florida Statutes. Such evidence shall only be used to the extent it is consistent with the Florida Rules of Civil Procedure and appropriate evidentiary rules.

10. The permittee agrees to comply with changes in Department rules and Florida Statutes after a reasonable time for compliance, provided, however, the permittee does not waive any other rights granted by Florida Statutes or Department rules.

11. This permit is transferable only upon Department approval in accordance with Florida Administrative Code Rules 17-4.120 and 17-30.300, F.A.C., as applicable. The permittee shall be liable for any non-compliance of the permitted activity until the transfer is approved by the Department.

12. This permit or a copy thereof shall be kept at the work site of the permitted activity.

13. This permit also constitutes:

   (x) Determination of Best Available Control Technology (BACT)
   (x) Determination of Prevention of Significant Deterioration (PSD)
   (x) Compliance with New Source Performance Standards (NSPS)

14. The permittee shall comply with the following:

   a. Upon request, the permittee shall furnish all records and plans required under Department rules. During enforcement actions, the retention period for all records will be extended automatically unless otherwise stipulated by the Department.

**GENERAL CONDITIONS:**

b. The permittee shall hold at the facility or other location designated by this permit records of all monitoring information (including all calibration and maintenance records and all original strip chart recordings for continuous monitoring instrumentation) required by the permit, copies of all reports required by this permit, and records of all data used to complete the application for this permit. These materials shall be retained at least three years from the date of the sample, measurement, repor or application unless otherwise specified by Department rule.

c. Records of monitoring information shall include:

- the date, exact place, and time of sampling or measurements;
- the person responsible for performing the sampling or measurements;
- the dates analyses were performed;
- the person responsible for performing the analyses;
- the analytical techniques or methods used; and
- the results of such analyses.

15. When requested by the Department, the permittee shall within a reasonable time furnish any information required by law which is needed to determine compliance with the permit. If the permittee becomes aware that relevant facts were not submitted or were incorrect in the permit application or in any report to the Department, such facts or information shall be corrected promptly.

**SPECIFIC CONDITIONS:**

1. This facility shall be allowed to operate continuously (i.e. 8760 hours/year).

2. Emission Standards

Based on the permitted capacities mentioned in the project description the stack emissions from each unit shall not exceed any of the following limitations:

a. Particulate matter: Particulate emissions from the baghouse shall not exceed 0.010 grains/dry standard cubic

**SPECIFIC CONDITIONS:**

foot, corrected to 7% $O_2$; 5.34 lbs/hr per unit; and 21.3 tons/year per unit.

b. $PM_{10}$: In no case shall $PM_{10}$ emissions exceed 0.010 gr/dry cubic standard foot, corrected to 7% $O_2$ for the fraction of particles less than 10 microns in diameter; 5.34 lbs/hr per unit; and 21.3 tons/year per unit.

c. *<u>Opacity</u>: In no case shall visible emissions from each baghouse exhaust exceed 10% opacity (six minute average).

d. *$SO_2$: 30 ppmdv corrected to 7% $O_2$, 24 hour daily geometric average or at least 80% removal efficiency, whichever is least restrictive. In no case shall $SO_2$ emissions <u>exceed</u> 0.150 lbs/MMBtu per unit, 41 lbs/hr/unit, and 163.3 tons/year, per unit.

e. *$NO_x$: 180 ppmdv corrected to 7% $O_2$, 24 hour daily block average (midnight to midnight). In no case shall $NO_x$ emissions <u>exceed</u> 0.290 lb/MMBtu, 80 lbs/hr per unit, and 320 tons/year, per unit.

f. *Carbon Monoxide: 100 ppmdv at 7% $O_2$, 4-hour block average beginning at midnight. In no case shall CO emissions <u>exceed</u> .10 lb/MMBtu, 27.2 lbs/hr/unit, and 108 tons/year, per unit.

g. *VOC (Hydrocarbons): 37 ppmdv at 7% $O_2$. In no case shall VOC emissions <u>exceed</u> 0.021 lb/MMBtu, 5.80 lbs/hr/unit and 23 tons/year, per unit.

h. HCl: 25 ppmdv at 7% $O_2$, or at least 95% removal efficiency, which ever is least restrictive. In no case shall HCl emissions <u>exceed</u> 0.064 lb/MMBtu, 17.70 lbs/hr/unit, and 70.70 tons/year, per unit.

i. $H_2SO_4$ (sulfuric acid mist): In no case shall $H_2SO_4$ emissions <u>exceed</u> 0.036 lb/MMBtu, 9.85 lbs/hr/unit and 39.3 tons/year per unit.

j. *F (fluoride): 5.0 ppmdv at 7% $O_2$. In no case shall F emissions <u>exceed</u> 0.0035 lb/MMBtu, 0.96 lbs/hr/unit, and 3.8 tons/year, per unit.

**SPECIFIC CONDITIONS:**

k. *Pb (lead): In no case shall lead emissions <u>exceed</u> 0.00060 lbs/MBtu, 0.165 lbs/hr/unit and 0.66 tons/yr., per unit.

l. *Be (Beryllium): In no case shall Be emissions <u>exceed</u> $1.35 \times 10^{-7}$ lbs/MMBtu, $3.70 \times 10^{-5}$ lbs/hr/unit, and $1.47 \times 10^{-4}$ tons/year, per unit.

m. *Hg (Mercury): In no case shall mercury emissions <u>exceed</u> 0.000138 lbs/MMBtu, 0.0379 lbs/hr/unit, and 0.166 tons/yr per unit at 140 ug/dscm at 7% $O_2$ or at least 70 percent removal efficiency by weight.

n. As (Arsenic): In no case shall arsenic emissions <u>exceed</u> $9.10 \times 10^{-6}$ lbs/MMBtu, $2.50 \times 10^{-3}$ lbs/hr/unit, and 0.01 tons/year, per unit.

o. *Dioxins/Furans: In no case shall emissions of total (tetra thru octa-chlorinated dibenzo-p dioxins and dibenzofurans) <u>exceed</u> 30 ng/dscm @ 7% $O_2$, $2.54 \times 10^{-8}$ lbs/MMBtu, $7.0 \times 10^{-6}$ lbs/hr/unit, and $2.80 \times 10^{-5}$ tons/year, per unit.

p. *$NH_3$: In no case shall ammonia slip from exhaust gases <u>exceed</u> 50 ppmv.

q. There shall be no visible emissions (less than 5% opacity) during the operations of the lime silo.

r. In no case shall emissions from the ash handling building baghouse <u>exceed</u> a particulate limit of 0.010 grains/dscf and visible emissions of 5% opacity.

* Pursuant to Rule 17-4.080 F.A.C., for good cause shown and after notice and an administrative hearing, if requested, the Department may require the permittee to conform to new or additional conditions for the pollutants CO, VOC, F, $NH_3$ $SO_2$, NOx, Pb, Be, Hg, dioxins and furans,and visible emissions. The Department shall allow the permittee a reasonable time to conform to the new or additional conditions, and on application of the permittee, the Department may grant additional time.

**SPECIFIC CONDITIONS:**

3. Test Methods/Continuous Emissions Monitoring System (CEMS)/Testing Frequency/Sampling Ports/Record Keeping/Reporting of Excess Emissions and Malfunctions.

   a. Test Methods

   Compliance with emission limiting standards mentioned in Specific Condition No. 2 shall be demonstrated using EPA Methods, as contained in 40 CFR Part 60 (Standards of Performance for New Stationary Sources), or 40 CFR Part 61 (National Emission Standards for Hazardous Air Pollutants), or any other method as approved by the Department, in accordance with F.A.C. Rule 17-2.700(3). A test protocol shall be submitted for approval to the South Florida District and to the Bureau of Air Regulation at least 90 days prior to testing. This protocol shall include details on how the weight percentage of used tires in the MSW stream will be accounted for during the compliance testing.

| EPA Method | For Determination of |
|---|---|
| 1 | Selection of sample site and velocity traverses. |
| 2 | Stack gas flow rate when converting concentrations to or from mass emission limits. |
| 3 or 3A | Gas analysis when needed for calculation of molecular weight or percent $O_2$. |
| 4 | Moisture content when converting stack velocity to dry volumetric flow rate for use in converting concentrations in dry gases to or from mass emission limits. |
| 5 | Particulate matter concentration and mass emissions. |
| 201 or 201A | $PM_{10}$ emissions. |
| 6, 6C, or 19 | Sulfur dioxide emissions from stationary sources. |
| 7, 7C, or 19 | Nitrogen oxide emissions from stationary sources. |

SPECIFIC CONDITIONS:

| | |
|---|---|
| 9 | Visible emission determination of opacity.<br>- At least three one hour runs to be conducted simultaneously with particulate testing for the emissions from dry scrubber/baghouse, and ash handling building baghouse.<br>- At least one lime truck unloading into the lime silo (start to finish). |
| 10 | Carbon monoxide emissions from stationary sources. |
| 12 | Lead concentration from stationary sources. |
| 13A or 13B | Fluoride emissions from stationary sources. |
| 23 | Dioxin/furan concentration. |
| 18 <u>or</u> 25 | Volatile organic compounds concentration. |
| 26, 26a | HCl emissions or other methods approved by DER. |
| 101A | Mercury emissions based on an average of three runs. |
| 29 | Antimony, Cadmium |
| 104 | Beryllium emission rate and associated moisture content. |
| 108 | Arsenic |

Note: The weight of MSW being fed to each combustor during the stack test shall be continuously monitored and recorded by a weighing device which is properly calibrated. Stack tests shall be conducted upstream and downstream of the applicable control device for $SO_2$, Hg and HCl. Soot blowers shall be operated in a mode consistent with the normal cleaning requirements of the system during the compliance testing.

b. <u>Continuous Emissions Monitoring System (CEMS)</u>

Continuous emission monitors with recorders shall be installed, calibrated, maintained and operated subject to approval by the Department for the following:

**SPECIFIC CONDITIONS:**

Carbon Monoxide, Oxygen, Nitrogen Oxide, Opacity, and Sulfur Dioxide (for $SO_2$ one monitor shall be located upstream of the scrubber and one shall be located downstream of the baghouse), as specified in 40 CFR 60, Appendix B; total steam production (lbs/hr, pressure, and temperature) and power generation (MW) for each unit; ammonia injection rate; slaked lime; activated carbon injection or usage rates; and thermocouple to measure temperature of combustion zone (to be specified by the vendor). The monitoring devices shall meet the applicable requirements of Chapter 17-2, Section 17-2.710, F.A.C. and 40 CFR 60.45, and 40 CFR 60.13, including certification of each device in accordance with 40 CFR 60, Appendix B, Performance Specifications and 40 CFR 60.7 (a)(5). Data on monitoring equipment specifications, manufacturer, type, calibration and maintenance needs, and its proposed location after the economizer or in the air pollution control equipment outlet duct shall be provided to the South District Office for review prior to installation together with and subject to the same provisions as submittal of air pollution control equipment as mentioned earlier.

c. Testing Frequency

Compliance with emission standards contained in Specific Condition 2 shall be determined by conducting stack tests within 120 days of completion of construction and initial operation and annually thereafter. In addition to the three test runs conducted under normal operation, three compliance test runs shall be conducted annually under soot blowing conditions for particulate and VE. Each soot blowing test run shall be a representative of normal soot blowing operation. The compliance tests may be staggered throughout the year with the approval of the Bureau of Air Regulation. Pursuant to Rule 17-2.700(2)(b), when the Department, after investigation, has good reason (such as complaints, increased visible emissions or questionable maintenance of control equipment) to believe that any applicable emission standard contained in this permit is being violated, it may require the owner or operator of the source to conduct compliance tests which identify the nature and quantity of pollutant emissions from the source and to provide a report on the results of said tests to the Department. Compliance testing for the flyash handling building (baghouse) and the lime silo loading operation (V.E. test) shall be conducted within 120 days of completion of

**SPECIFIC CONDITIONS:**

construction and initial operation and annually thereafter. All notification requirements of 40 CFR parts 60 and 61 shall be complied with by the owner/operator of the SWERF.

d. Sampling Ports

The Permittee shall provide sampling ports in the air pollution control equipment outlet duct or stack and shall provide access to the sampling ports in accordance with Section 17-2.700, F.A.C. Drawings of testing facilities including sampling port locations as required by Section 17-2.700 shall be submitted to the South District Office for approval at least 60 days prior to construction of the sampling ports and stack.

e. Record Keeping

Lee County Solid Waste Energy Recovery Facility shall maintain a central file containing all measurements, records, and other data that are required to be collected pursuant to the various specific conditions of this permit. This file shall include but not be limited to:

(i) the data collected from in-stack monitoring instruments,

(ii) the records on MSW input rate,

(iii) the amount of propane gas burned per unit,

(iv) the results of all source tests or performance tests,

(v) the amount of ammonia, activated carbon, or other chemicals used for NOx and mercury control,

(vi) calibration logs for all instruments,

(vii) maintenance/repair logs for any work performed which is subject to this permit.

All measurements, records, and other data required to be maintained by SWERF shall be retained for at least two years following the date on which such measurements, records, or data are recorded and made available to the Department upon request. The permittee shall keep accurate records of MSW being fired to each combustor along with the weight percent of used tires in the waste stream being combusted on an estimated weekly basis

**SPECIFIC CONDITIONS:**

for the entire life of this facility. The South District office of the Department and the Bureau of Air Regulation shall be notified in writing at least 30 days prior to any compliance testing.

f. Reporting of Excess Emissions and Malfunctions

(i) A malfunction means any sudden and unavoidable failure of air pollution control equipment or process equipment to operate in a normal or usual manner. Failures that are caused entirely or in part by poor maintenance, careless operation, any other preventable upset condition, or preventable equipment breakdown shall not be considered malfunctions.

(ii) Excess emissions resulting from startup, shutdown or malfunction of any source shall be permitted providing (1) best operational practices to minimize emissions are adhered to and (2) the duration of excess emissions shall be minimized but in no case exceed two hours in 24 hour period unless specifically authorized by the Department for longer duration (Rule 17-2.250(1), F.A.C.).

(iii) Excess emissions which are caused entirely or in part by poor maintenance, poor operation, or any other equipment or process failure which may reasonable be prevented during startup, shutdown, or malfunction shall be prohibited (Rule 17-2.250(4), F.A.C.).

(iv) In case of excess emissions resulting from malfunctions, each source shall notify the Department or the appropriate Local Program in accordance with Section 17-4.130, Florida Administrative Code. A full written report on the malfunctions shall be submitted in a quarterly report (Rule 17-2.250(6), F.A.C.).

(v) The owner or operator shall submit excess emission reports for any calendar quarter during which there are excess emissions from the facility. If there are no excess emissions during the calendar quarter, the owner or operator shall submit a report quarterly stating that no excess emissions occurred during the quarterly reporting period. The report shall include the following:

(A) The magnitude of excess emissions computed in accordance with 40 CFR 60.13(h), any conversion factors used, and the

SPECIFIC CONDITIONS:

date and time of commencement and completion of each period of excess emissions [40 CFR60.7(c)(1)].

(B) Specific identification of each period of excess emissions that occurs during startups, shutdowns, and malfunctions of the furnace boiler system. The nature and cause of any malfunction (if known) and the corrective action taken or preventive measured adopted [40CFR60.7(c)(2)].

(C) The date and time identifying each period during which the continuous monitoring system was inoperative except for zero and span checks, and the nature of the system repairs of adjustments [40CFR60.7(c)(3)].

(D) When no excess emissions have occurred or the continuous monitoring system has not been inoperative, repaired, or adjusted, such information shall be stated in the report [40CFR60.7(c)(4)].

(E) The owner or operator shall maintain a file of all measurements, including continuous monitoring systems performance evaluations; monitoring systems or monitoring device calibration; checks; adjustments and maintenance performed on these systems or devices; and all other information required by this permit recorded in a permanent form suitable for inspection [40CFR60.7(d)].

4. <u>Miscellaneous Requirements</u>

a. <u>Start-up and Shut-down Procedures</u>

During start-up procedures, propane gas shall be used to preheat the combustion zone to achieve a furnace roof temperature of 1270°F and a minimum temperature of 1800°F above the grate (at a height to be specified by the vendor) prior to the ignition of MSW.

During all shut-down procedures, propane gas shall be used to ensure that the temperature above the grate, as specified above, does not drop below 1800°F and the furnace roof temperature is maintained above 1270° while any MSW is still burning.

SPECIFIC CONDITIONS:

b. Operating Procedures

Operating procedures shall include good combustion practices and proper training and certification of all operators. The good combustion practices shall meet the guidelines established in 40 CFR 60, Subpart Ea and procedures as established by the equipment manufacturers. All operators (including supervisors) of air pollution control devices shall be properly trained and certified in accordance with the manufacturers guidelines. A list of all such certified personnel shall be submitted to the South District Office. The Permittee/Operator shall inform the District office of any planned training sessions so that Department staff may attend any such training sessions related to operation and maintenance of air pollution control devices.

The emission standards for this facility shall apply at all times, except during periods of start-up, shut-down, or malfunctions, provided that the duration of start-up, shut-down, or malfunction shall not exceed 2 hours within 24 hour period. The start-up period commences when the affected facility begins the continuous burning of MSW and does not include any warm-up period when the affected facility is combusting only propane gas and no MSW is being combusted. During all startups, shutdowns and malfunctions the owner/operator shall use best operational practices to minimize air pollutant emissions. Within 90 days prior to commencing commercial operations of this facility, the permittee shall submit to the South District Office for approval a operational procedures manual that identifies and describes best operational practices that will be used during startup, shutdown, and malfunctions of this facility.

c. Odor Control

No objectionable odors are allowed from this facility pursuant to F.A.C. Rule 17-2.620. The truck access doors to the facility shall remain closed except during normal working shifts when MSW is being received near the storage pit area to allow vehicle passage. To minimize odors at the facility, a negative pressure shall be maintained on the tipping floor and air from within the building will be used as combustion air.

SPECIFIC CONDITIONS:

d. Auxiliary Burners

Auxiliary burners for each unit shall be fired only by propane gas and shall not exceed the 10% capacity factor as determined by 40 CFR 60.44b(d).

e. Baghouse Operations

All baghouses (except for lime silo dust collector) shall be equipped with pressure drop monitoring equipment. Baghouses shall have a maximum air to cloth ratio of 4:1. Extra bags shall be maintained at the site for emergency purposes.

f. Restriction for Type of Wastes Combusted

No biological waste, medical waste, bio-hazardous waste, sewage sludge or hazardous or unauthorized wastes shall be received or combusted at this facility without obtaining proper modification to the power plant site certification and this permit. The Permittee may combust up to 3% (by weight) of used tires along with the MSW. If the applicant wishes to combust used tires in excess of 3% (by weight) a modification to the construction permit will be required prior to increasing the feed rate of the tires. The County shall establish a household battery collection program to be specified by the applicant prior to start of construction, to further minimize mercury emissions. Chromium compounds shall not be used as an additive in the cooling tower water.

g. Fugitive (Unconfined) Emissions

Fugitive emissions at this facility shall be adequately controlled at all times. All roads shall be adequately paved and vacuum swept if appropriate, to keep free of visible dust. Speed limit signs shall be posted. Residue from the grates, grate siftings, and ash from the combustor/boiler and fabric filter hoppers during normal operations shall be discharged into the ash quenching system so as to minimize visible dust. The ash/residue in the ash handling building shall remain sufficiently moist to prevent dust during storage and handling operations.

SPECIFIC CONDITIONS:

h. The height of the boiler exhaust stack shall not be less than 275 feet above grade or the height determined to be Good Engineering Practice.

i. The SWERF's boilers shall not be loaded in excess of their permitted capacity of 55,000 lb/hr. of MSW per unit, and 275 x $10^6$ Btu per hour, each unit, and 186,200 lb/hour of steam, based on heating value of 5000 Btu/lb of MSW.

j. The combustor boilers shall have a metal name plate affixed in a conspicuous place on the shell showing manufacturer, model number, type waste, and rated capacity.

k. Combustion efficiency shall be calculated by: %CE =(1/(1+($CO/CO_2$))) x 100, and shall be at least 99.5% for an 8 hour average.

5. Emission Control Equipment

a. The combustor's particulate control baghouse shall be designed, constructed and operated to achieve a maximum emission rate of 0.010 grains per dscf corrected to 7% $O_2$.

b. The facility shall be equipped with dry scrubbers which are designed, constructed and operated to remove $SO_2$ at an efficiency of 80% by weight or to achieve an emission rate of 30 ppmdv at 7% $O_2$, 24 hour daily geometric average, which ever is less stringent and to cool the flue gases to an average temperature not to exceed 300°F (3-hour rolling average).

c. The Permittee shall submit to the South Florida District and to the Bureau of Air Regulation within thirty (30) days after it becomes available, copies of technical data pertaining to the selected emissions control systems. These data should include, but not be limited to, guaranteed efficiency and emission rates, and major design parameters.

6. Stack Test Reports

a. Two copies of the results of the emissions tests for the pollutants listed in Specific Condition No. 2 shall be submitted within forty-five days of the last sampling run

**SPECIFIC CONDITIONS:**

to the South District Office, and one copy of the test results shall be submitted to the Bureau of Air Regulation in Tallahassee.

b. Emissions monitoring shall be reported to the South District Office on a quarterly basis in accordance with Section 17-2.710, F.A.C., 40 CFR, part 60, Subsection 60.7 or 40 CFR part 61 as appropriate.

c. Notice of anticipated and actual start-up dates of each waste combustor boiler shall be submitted to the DER South District Office and the Bureau of Air Regulation.

7. Pursuant to Recommended Order on Remand (DOAH Case No. 90-3942 EPP), Appendix B, Exhibit 96, dated May 21, 1992, evaluation test methodology for the mercury control process at this facility shall be subject to the following:

A. The permittee must operate the pollution control equipment at the facility under procedures designed to minimize emissions of mercury and maximize the removal of mercury from the flue gas of the facility. An activated carbon injection system for mercury control approved by the Department in accordance with Specific Condition No. 2 shall be operated continuously whenever MSW is burned at the facility. The emissions of mercury from the facility shall not exceed the standard established in Specific Condition No. 2(m).

B. The permittee shall determine through Department-approved operational testing the feed rate for activated carbon injection which provides the most effective mercury removal over the normal operating regime for the facility while achieving the levels stated hereafter. Following determination of this feed rate, the permittee shall not reduce it without specific written permission from the Department.

C. The permittee acknowledges and agrees that the 140 ug/dscm mercury emission standard established by Specific Condition No. 2(m) may be reduced to a level no lower than 70 ug/dscm at 7% $O_2$ or its equivalent upon written notice to the permittee that Departmental review of at least four operational test results (specified according to protocol) from the facility shows that a reduction of the 140 ug/dscm

**SPECIFIC CONDITIONS:**

standard is statistically achievable as determined by the student T-test at the 99 percent confidence limit and is in the public interest. If the Department elects to proceed under this provision, the procedures of Section 403.516(1), Florida Statutes, shall not apply unless the permittee disputes the factual basis for the Department's determination.

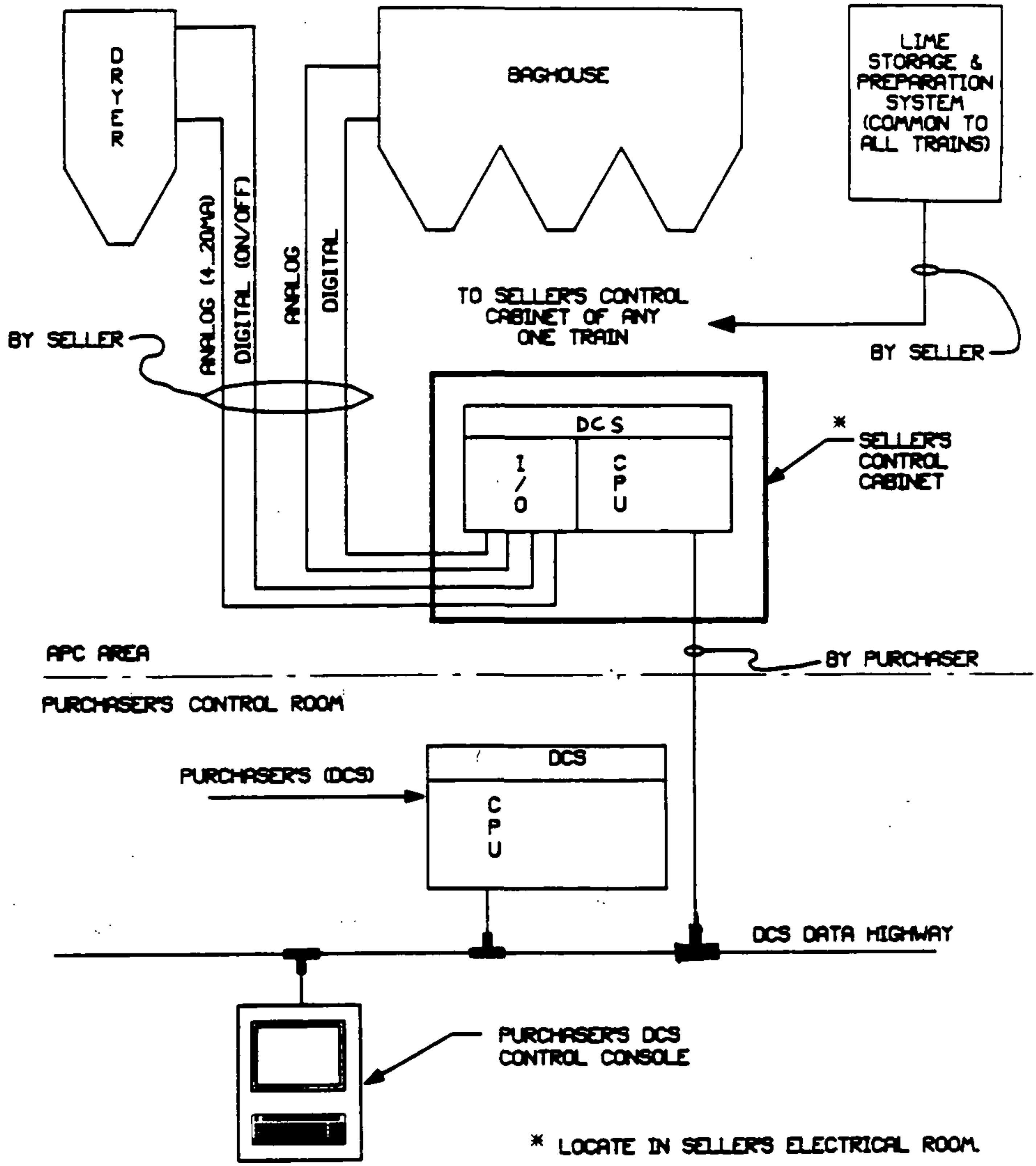
D. If the Department proposes to reduce the 140 ug/dscm mercury emission standard for the facility to a level below 70 ug/dscm at 7% $O_2$ or its equivalent, it shall proceed in accordance with the provisions of Section 403.516(1), Florida Statutes.

Issued this 20th day
of July, 1992

**STATE OF FLORIDA DEPARTMENT OF ENVIRONMENTAL REGULATION**

Carol M. Browner

Carol M. Browner, Secretary




A10-2

AN OGDEN COMPANY

ATTACHMENT 10

TYP. INTERFACE WITH PLANT CONTROL SYSTEM (DISTRIBUTED CONTROL SYSTEM)

| OGDEN PROJECTS, INC. | |
|---|---|
| APPROVED: | DATE: |
| DWG. No. SM-105 | REV. |

5

ATTACHMENT 11.1

OGDEN MARTIN SYSTEMS
of LEE, Inc.

SPEC NO. SA-550
ISSUE 002
DATE 08/15/90

TECHNICAL SPECIFICATION

FOR

PAINTING FERROUS METALS
INCLUDED IN SUBCONTRACTOR'S WORK

Facility Name: LEE COUNTY RESOURCE RECOVERY FACILITY

Location: LEE COUNTY, FLORIDA

**************************************************************************



**************************************************************************

Specification Prepared By: A/E Name: OMSL

Address: FAIRFIELD, NJ

Telephone: 201-882-9000

A/E Approved for Release:

| | Printed Name | Signature | Date |
|---|---|---|---|
| 1. | K. WALLS | | |
| 2. | | | |
| 3. | | | |
| 4. | | | |
| 5. | | | |

## REVISIONS

| | | |
|---|---|---|
| 001 | Initial Issue | 08/16/89 |
| 002 | Revision | 08/15/90 |

TECHNICAL SPECIFICATION
FOR
PAINTING FERROUS METALS
INCLUDED IN SUBCONTRACTOR'S WORK

TABLE OF CONTENTS

## 1.0 General

### 1.1 Scope

This Specification establishes the minimum requirements for the furnishing of all labor, materials, tools and equipment, the coordination of work with that of other trades, and the performing of services for the coating of ferrous metals as shown on the plans and specified herein, including both shop and field applied systems. This Specification shall be worked with Specification SA-502, Painting. Reference to other industry standards for compliance shall be interpreted as an integral part of this Specification.

#### 1.1.1 Work Included

Work shall include but is not limited to the surface preparation and application of prime and finish coats and touch-up of paint systems on ferrous metals. Items receiving coatings shall include but are not limited to:

- Structural Steel
- Miscellaneous steel angles, channel, plates, braces, brackets, embedments, etc.
- Equipment Supports
- Ducts as required
- Pipes
- Stair stringers and pans
- Handrails and Guardrails
- Hollow metal doors and frames, and industrial doors
- Electrical cabinets
- Louvers
- Equipment furnished without shop finish

### 1.2 Related Work

Items of work related to work of this Specification, but not included within its scope shall be furnished or performed under the General Contractor's responsibilities. These items include, but are not limited to:

- Shop finished equipment
- Removal and reinstallation of fixtures, equipment and systems by others when required

Other specifications related to work in this Specification include but are not limited to the following:

SA-502 Painting

## 1.3 References

### 1.3.1 Abbreviations

Abbreviations listed below, when used in this Specification, shall have the following meanings:

| | |
|---|---|
| ANSI | American National Standards Institute |
| CFR | Code of Federal Regulations |
| SSPC | Steel Structures Painting Council |

### 1.3.2 Codes and Standards

Work under this specification shall be performed in accordance with applicable sections of the following codes, standards, publications and practices, and to the extect referenced, form a part of this specification. Date of issue in effect at the time of Notice to Proceed shall apply.

| | |
|---|---|
| ANSI A13.1 | Scheme for the identification of piping systems |
| 29 CFR 1910 & 1926 | Occupational Safety and Health Act (OSHA) |
| SSPC-SP-1 | Solvent Cleaning |
| SSPC-SP-3 | Power Tool Cleaning |
| SSPC-SP-6 | Commercial Blast Cleaning |

## 1.4 Quality Assurance

All stages of work including surface preparation, priming and finish coating of surfaces, materials, equipment, workmanship, and touch-up shall be subject to inspection by a representative of Purchaser for conformance to the applicable SSPC specifications, the manufacturer's instructions, and this specification.

All components of each paint system, specified herein, shall be by one manufacturer. The paints of one manufacturer shall not be used over the paint of another and shall not be intermixed with each other unless approved by OMS.

## 1.5 Submittals

In compliance with all provisions and conditions of the Contract, the following items and documents shall be submitted per the document submittal schedule in Attachment 1.

### 1.5.1 Engineering Documents

- Technical data sheets on each product to be used.
- A paint schedule indicating the total system (material, thickness, etc) to be applied including surface preparation for each substrate type.

- Color selection charts with the full range of manufacturer's standard colors for selection by Purchaser.

- Material Safety Data Sheets for coatings, solvents, etc.

- Manufacturer's instructions for mixing, thinning, application and storage of the coating materials

1.5.2 Verification Documents

Written Certification that all coatings comply with the provisions of this specification. Alternate manufacturer's will only be considered upon submittal of complete technical and company data and approval by Purchaser.

1.6 Product Shipping, Handling and Storage

All coating materials shall be delivered to the job site in original, sealed and unopend containers bearing the Manufacturer's name, paint type designation, batch number, color and shelf life.

Coatings shall be stored in an area that is well ventilated and free from excessive heat, sparks, flame or the direct rays of the sun. Ambient temperature of stroage areas shall be maintained within the range specified in the coating manufacturer's printed instructions unless otherwise specified.

1.7 Scheduling

It shall be the responsibility of the contractor to provide schedules for the painting of surfaces and to coordinate the coating work with the work of all other trades.

1.8 Safety

The Contractor shall observe all OSHA, state and local laws, ordinances and regulations pertaining to health and safety. The precautions indicated on the paint containers with regard to fire and safety, as well as the laws of the state in which the project is located, shall be oberved.

2.0 Products

2.1 Acceptable Manufacturers

Subject to compliance with this specification and the painting schedule herein, the following coating manufcaturers are acceptable to provide the materials for the work:

a) Carboline Company
b) Cook Paint and Varnish
c) Glidden
d) Hampel's Industrial Coatings
e) Keeler and Long
f) Pratt and Lambert
g) Sherwin/Williams Company
h) Tnemec

The above manufacturer's provide the quality of paint, and are of the stature to provide the specified coatings for this project. The brand names and designations used in the specified Paint systems indicate the required type and quality of the coatings to be furnished.

## 2.2 Materials

Materials supplied shall be per the Paint Systems as listed in section 3.12. When required, all coatings shall be mixed in strict accordnace with the manufacturer's written instructions, and thinning shall not be permitted unless specified in those instructions. Thickness of coatings shall comply with manufacturer's recommendations. Where a range of thickness is presented in the technical data, the thicker coat shall be applied.

All tools and equipment necessary for surface preparation and application of coatings such as compressors, spray equipment, sandblaster, power tools, brushes, etc., shall be maintained in good working order.

Any false work (scaffolding, ladders, etc.) required for surface preparation and/or painting shall be designed by the Contractor for loads not less than those established by the state or local building codes and (OSHA) 29 CFR 1910 and 29 CFR 1926. The cable trays, conduit, piping, etc, shall not be used for support or access unless prior approval is obtained from OMS.

## 3.0 Execution

## 3.1 Coordination

It shall be the responsibility of the Contractor to coordinate with all material and equipment suppliers furnishing items that are to be shop primed and field finshed in order to ensure compatibility of the prime and finish coats. It is imperative that the paint systems specified herein be followed.

## 3.2 Job Conditions

### 3.2.1 Atmospheric Conditions

Paint shall not be applied when the surfaces are at a temperature of over 120°F unless the paint is specifically formulated for application at elevated temperatures. When painting in hot weather, precautions shall be taken to assure that the specified dry film thickness (DFT) of paint is obtained.

Paint shall not be applied in rain, snow, fog or mist, or when the relative humidity is such as to cause condensation on surfaces. All surfaces shall be completely dry before, and while being painted.

Forced ventilation shall be provided to keep fume levels at safe levels and shall be exhausted outdoors. Spark producing motors or implements shall not be used in areas when fume concentrations may occur.

### 3.2.2 Fire Protection

Oily rags and other waste which may constitute a fire hazard, shall be removed daily or stored in U.L. labeled metal containers with automatic closing covers.

The Contractor shall provide portable fire extinguishers of suitable type and sufficient number to permit placing at least one (1) extinguisher in any area where coating with fume-creating or flammable products is in progress, and where coatings are stored and mixed. No smoking shall be permitted in these areas and the Contractor shall be responsible for policing the work.

## 3.3 Color Selection

With the exception of standard colors for pipe identification or designated safety hazards, the colors will be selected specifically for this project and shall be presented separately in a color schedule.

Regardless of the source utilized in the selection of colors for the Project, the Contractor shall be responsible for assuring that all finish paints match the specified colors. If required, the Contractor shall submit samples of the specified color and the color selected by the Contractor to the Purchaser for color match analysis.

## 3.4 Protection of Adjacent Surfaces

All hardware, hardware accessories, machined surfaces, nameplates, lighting fixtures and similar items on or in contact with surfaces to be painted shall be removed, masked or otherwise protected prior to surface preparation and painting operations. All protective covers shall be removed upon completion of paint application.

### 3.5 Surface Preparation

Surfaces shall be prepared for coating in accordance with SSPC specifications and preparation technique for each surface shall be indicated in the painting schedule by the Contractor.

The anchor profile provided on steel shall be not less than that specificed by SSPC-SP-6.

After blast cleaning, dust, loose particles and spent abrasives shall be removed from the prepared surfaces by compressed air or vacuum cleaning, and the cleaned surfaces shall be primed as soon as possible after blasting and always before surface starts to rust. Cleaned surfaces shall not be allowed to stand overnight before coating.

Where applicable, dirt, dust, oil, grease and similar contaminants shall be removed by solvent cleaning in accordance with SSPC-SP-1.

### 3.6 Mixing

All ingredients shall be thoroughly mixed before use and agitated frequently during application to keep the paint in suspension. Mechanical mixers and agitated pressure pots shall be used as required.

Paints shall be thinned only when necessary for good application properties, and only with the recommended thinner, in amounts recommended by the paint manufacturer.

Catalysts or other types of multipackaged paints shall be mixed in strict accordance with manufacturer's recommendations and instructions.

### 3.7 Application

In general, the Manufacturer's specifications regarding the mixing, thinning, application, drying and general handling of the various materials shall be followed as being supplementary to this Specification.

Spray application may be used at the Contractor's option in non-enclosed areas when the spraying can be closely controlled to prevent spattering any other property.

Effective oil and water separators shall be used in all compressed air lines to remove oil or moisture from the air before it is used. Separators shall be placed as close as practical to the equipment. The effectiveness of the separators shall be tested by means of the "white blotter test." The test shall be performed prior to blasting or spray coating, and at intervals of four (4) hours during the work. Tests shall be at full operating pressure and velocity.

Nozzle sizes and pressure settings for spray equipment shall comply with the manufacturer's recommendations.

When coatings are applied by spraying, each coat shall be sprayed in two directions at right angles to each other, to obtain complete coverage. Care shall be exercised during spraying to avoid excessive evaporation of the volatile constituents, loss of material into the air, and the bridging over of crevices and corners.

Areas inaccessible to the spray gun shall be coated by brush and if not accessible by brush, daubers or sheepskins. Brushes shall be used to work coatings into cracks, crevices, and blind spots which cannot be adequately coated by spray.

When coatings are applied by brush or roller, the surface shall be cross-brushed or cross-rolled to secure uniformity of surface and the specified paint film thickness.

Film thickness of the coating being applied shall be periodically checked using a wet film thickness gauge. Dry film thickness shall be calculated from wet film thickness and volume solids and as recommended by the Coating Manufacturer. In addition, each coat shall be visually inspected for holidays and thin spots before the next coat is applied.

Steel which has been coated shall not be handled, worked on, or otherwise disturbed until the coating is completely set. Sufficient time shall elapse between coats to permit them to dry hard. All coats of coated surfaces shall be unscarred and completely integral at the time of application of all succeeding coats.

Prior to application of the finish coat, all visible rust resulting from construction damage, or other coating or surface defects, shall be removed and the surface prepared to the requirements of SSPC-SP3 Power Tool Cleaning and the prepared surface re-primed per Purchaser approved repair procedure.

## 3.8 Testing of Materials

The dry film thickness (dft) of non-metallic paints applied to magnetic surfaces shall be measured nondestructively using the "Elcometer" thickness gauge, as marketed by Gardmer Laboratories, or similar magetically operated testers. Non-metallic paints applied to nonmagnetic surfaces shall be measured using a battery powred, pentrating - needle type thickness gauge such as the "Gardner Thickness Gauge", also marketed by Gardner Laboratories.

## 3.9 Inspection

All work performed under this Contract shall be subject to inspection by Purchaser.

All definiencies, defects and damage revealed by the inspection and cased by test methods used shall be propmtly reparied or corrects, using the applicable type, grade and color of finish coat material, and preparation methods.

Any part of the paint system which is defective shall be corrected. The method of repairing damaged areas shall be in accordance with the requirements listed for the original system. Damage to adjacent systems painted by other shall be corrected in the same manner. Field touch-up of shop primer shall be with the same paint as the original primer.

3.10 Touch-Up

All shop-primed and shop-topcoated steel shall be touched up in the field as required, prior to final field, topcoating. Touch-up shall include any damaged or masked areas.

Field touchup shall be done after final erection or assembly, unless otherwise specified.

3.11 Clean-Up

All surfaces not coated under this specification, or those previously coated, shall be carefully protected during coating work.

Any unspecified coatings which are found during inspection shall be thoroughly cleaned and the original finish restored at the Contractor's expense.

Name and data plates on equipment shall not be painted and shall be left clean and legible upon completion of the project.

3.12 Paint System

The paint system descriptions provided herewith outline the generic paint system names. The paint system numbers are then utilized in the approved coating Manufacturer's system schedule and the Application Schedule to dictate the coating system for each type of substrate.

| | | |
|---|---|---|
| Ferrous Metal: | Prep: | SSPC-SP-6 |
| | Prime: | Recoatable Polyamide Epoxy |
| | Topcoat: | 100% Acrylic Gloss |
| Examples of Approved | System: | Mfgr. - Sherwin Williams |
| | Prime: | B67H5/B67V5 |
| | Topcoat: | B66 Series DTM Acrylic Gloss |

3.13 Project-Specific Requirements

The attached Project Specific Requirements, if any, are additions, deletions and/or revisions to the requirements of this Specification and shall be considered a part of this Specification.

ATTACHMENT 1

DOCUMENTS SUBMITTAL SCHEDULE

| Documents for Approval | Engineering Need Date For Vendor Data* | Schedule Date For Certified Vendor Submittal** |
|---|---|---|
| A. | | |
| Technical Data Sheets | 30 | |
| Color Charts | 30 | |
| Paint Schedule | 30 | |
| Mixing/Application Instructions | 30 | |
| | | |
| | | |
| | | |
| B. Documents for Information | | |
| Certificate of Compliance | 45 | |
| Material Safety Data Sheets | 30 | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

* Calendar days after award

** To be completed by seller and finalized prior to award

# ATTACHMENT 11.Z

(NOT UTILIZED)

ATTACHMENT 11.3

(NOT UTILIZED)

ATTACHMENT 11.4

(NOT UTILIZED)

ATTACHMENT 11.5

OGDEN MARTIN SYSTEM
of LEE, Inc.

SPEC NO. SC-315
ISSUE 004
DATE 09/24/91

TECHNICAL SPECIFICATION

FOR

CONTROL PANELS

Facility Name: LEE COUNTY RESOURCE RECOVERY FACILITY

Location: LEE COUNTY, FLORIDA

**************************************************************************



**************************************************************************

Specification Prepared By:

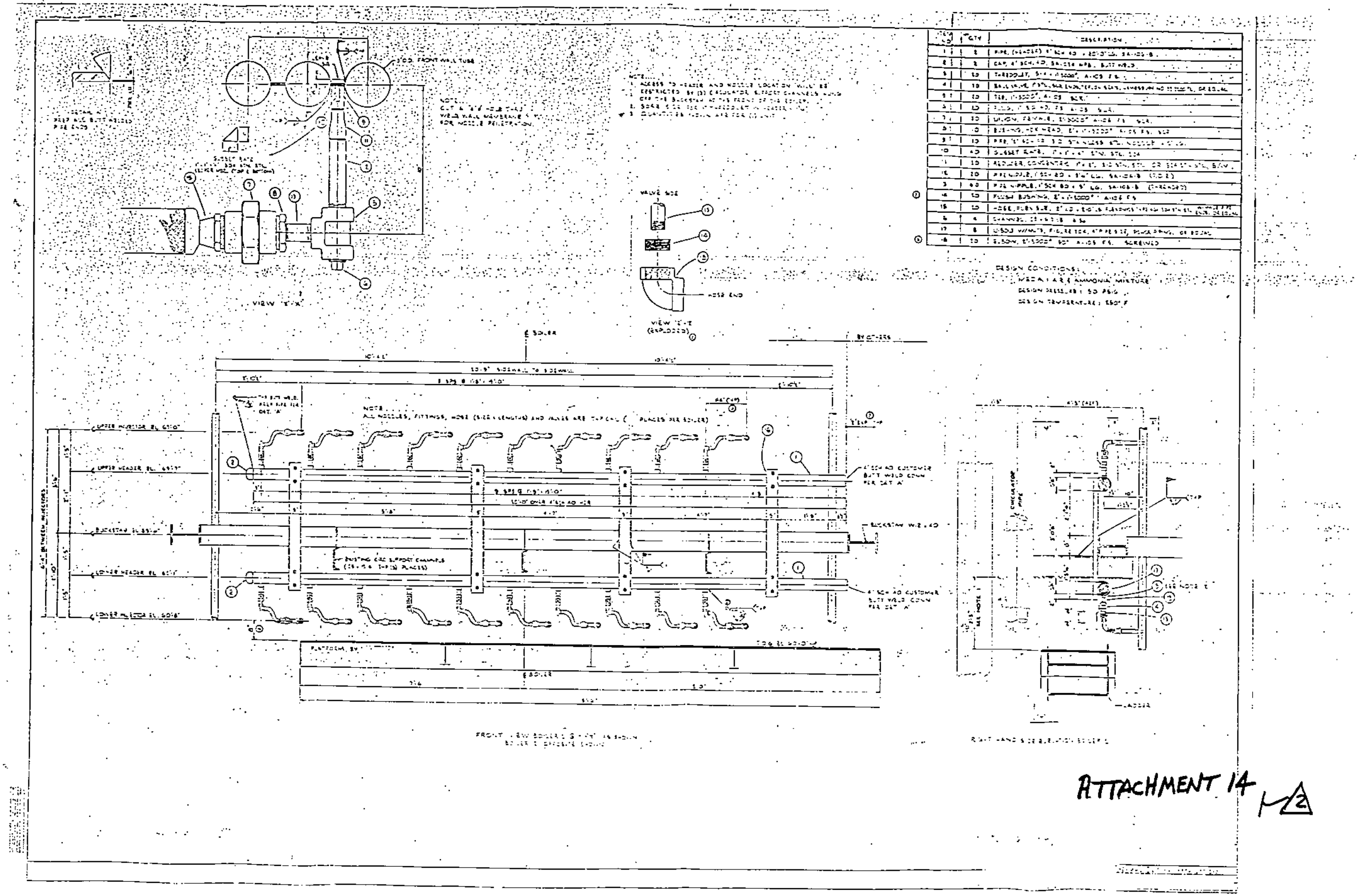
A/E Name: OMSL

Address: FAIRFIELD, NJ

Telephone: 201-882-7071

A/E Approved for Release:

| | Printed Name | Signature | Date |
|---|---|---|---|
| 1. | | | |
| 2. | R. TERRAMOCCIA | R. Terramoccia | 11/19/91 |
| 3. | | | |
| 4. | | | |
| 5. | | | |




| ITEM NO. | QTY | DESCRIPTION |
|---|---|---|
| 1 | 2 | PIPE, (HEADER) 4" SCH 40 x 20'-0" LG, SA-106-B |
| 2 | 2 | CAP, 4" SCH. 40, SA-234 WPB, BUTT WELD |
| 3 | 20 | THREDOLET, 3/4" x 3000#, A-105 F.S. |
| 4 | 10 | BALL VALVE, [illegible], OR EQUAL |
| 5 | 20 | TEE, 3000#, A-105 SCR. |
| 6 | 20 | PLUG, SCH 40, FS A-105 SCR. |
| 7 | 20 | UNION, FEMALE, 3000# A-105 FS SCR. |
| 8 | 10 | BUSHING, HEX HEAD, [illegible] 3000# A-105 FS SCR |
| 9 | 10 | PIPE, [illegible] STAINLESS STL NOZZLE [illegible] |
| 10 | 40 | GUSSET PLATE, [illegible] STN. STL. 304 |
| 11 | 10 | REDUCER, CONCENTRIC, [illegible] OR [illegible], B.W. |
| 12 | 20 | PIPE NIPPLE, SCH 80 x [illegible] LG, SA-106-B (T.O.E.) |
| 13 | 40 | PIPE NIPPLE, SCH 80 x [illegible] LG, SA-106-B (THREADED) |
| 14 | 20 | FLUSH BUSHING, [illegible] 3000# A-105 FS |
| 15 | 20 | HOSE, FLEX [illegible] OR EQUAL |
| 16 | 4 | CHANNEL, [illegible] A36 |
| 17 | 8 | U-BOLT W/NUTS, [illegible] OR EQUAL |
| 18 | 20 | ELBOW, 3000# 90° A-105 FS SCREWED |

ATTACHMENT 14

2

**OGDEN MARTIN SYSTEMS OF LEE, INC.**

40 LANE ROAD
P.O. BOX 2615
FAIRFIELD, NJ 07007-2615
(201) 882-9000

AN OGDEN PROJECTS COMPANY

RECEIVED

FEB 22 1993

Division of Air Resources Management

VIA FIRST CLASS MAIL

February 12, 1993

Bureau of Air Regulation
2600 Blair Stone Road
Tallahassee, FL 32399-2400

Attention: C.H. Fancy, P.E.

Reference: Lee County Solid Waste Resource Recovery Facility
Ft. Myers, Florida
Project C-1033, Our Ref. LE0300L

Subject: MUNICIPAL WASTE COMBUSTERS SPECIFICATION
POWER PLANT SITE CERTIFICATION (PPSC) NO. 90-3942EPP

Dear Mr. Fancy,

On behalf of Lee County, the permittee, Ogden Martin Systems of Lee, Inc. hereby submits four (4) copies of complete specification information for the Municipal Waste Combusters. This information is being submitted pursuant to the Power Plant Site Certification for the Lee County Solid Waste Resource Recovery Facility, Case No. 90-3942EPP, Appendix A, Item XIV.A.

This specification titled "TECHNICAL SPECIFICATION FOR MUNICIPAL SOLID WASTE STEAM GENERATORS SPEC NO. SM-101, ISSUE 011, DATE 10-31-91, REVISION 3, DATED 2/5/93" effectively provides the make and model number information as required.

pja/2666

Please contact me at (201) 882-7246 if you have any questions or require further information. Please note that the specification for the air pollution control equipment shall follow shortly. Specifications for continuous emissions monitoring and stack drawings will be submitted at a later date.

Very truly yours,

L. Peter Young

L. Peter Young
Assist. V.P. - Project Management

cc: P. Barbaccia/D. Knowles (w/att.) - South District
L. Sampson (w/att.) - Lee County
D. Markley (w/att.) - Malcolm Pirnie
D. Cerrato (w/att.) - Malcolm Pirnie
L. Ware (w/att.) - UE&C
J. Kowal
J. Treshler (w/att.)
pf 5.1 FDER

B. Owen,
J. Harper, EPA
J. Bunyak, NPS

pja/2666

F. Rivers/Air


CARLTON, FIELDS, WARD, EMMANUEL, SMITH & CUTLER, P. A.

ATTORNEYS AT LAW

ONE HARBOUR PLACE
P.O. BOX 3239
TAMPA, FLORIDA 33601
(813) 223-7000
FAX (813) 229-4133

FIRSTATE TOWER
P.O. BOX 1171
ORLANDO, FLORIDA 32802
(407) 849-0300
FAX (407) 648-9099

HARBOURVIEW BUILDING
P.O. BOX 12426
PENSACOLA, FLORIDA 32582
(904) 434-0142
FAX (904) 434-5366

FIRST FLORIDA BANK BUILDING
P.O. DRAWER 190
TALLAHASSEE, FLORIDA 32302
(904) 224-1585
FAX (904) 222-0398

ESPERANTE
P.O. BOX 150
WEST PALM BEACH, FLORIDA 33402
(407) 659-7070
FAX (407) 659-7368

BARNETT TOWER
P.O. BOX 2861
ST. PETERSBURG, FLORIDA 33731
(813) 821-7000
FAX (813) 822-3768

PLEASE REPLY TO:
Tallahassee




August 4, 1992

Honorable Lawton Chiles
Governor
The Capitol
Tallahassee, Florida 32399

RE: Lee County Resource Recovery Facility

Dear Governor Chiles:

Enclosed for your review is a letter dated July 31, 1992, from the United States Department of the Interior, Fish and Wildlife Service (Wildlife Service), concerning Lee County's resource recovery facility (Facility). In its letter, the Wildlife Service states that it has reviewed the environmental impacts of the County's Facility and concluded that "the operation of this Facility is <u>not</u> likely to adversely affect the Florida panther or other listed [threatened or endangered] species." The Wildlife Service has determined that the United States Environmental Protection Agency (EPA) and the Wildlife Service do not need to conduct a formal consultation under Section 7 of the Endangered Species Act (Act) for this project.

The Wildlife Service rejects the allegations that were made recently by Save The Panther, Inc., which contended a formal consultation under Section 7 of the Act is required. Save the Panther, Inc., also alleged that the Facility would adversely affect various threatened and endangered species.

You also may be interested in the Wildlife Service's determination that:

> "Incineration appears to be the best alternative, even when considering composting, for the disposal of solid wastes generated by the residents of Lee and Hendry Counties. This is the one that will result in the least overall impact on Service trust resources."

Honorable Lawton Chiles
August 4, 1992
Page Two

Please call me if you have any questions.

Sincerely,

David S. Dee

DSD:db

cc: Honorable Jim Smith
Honorable Bob Butterworth
Honorable Gerald Lewis
Honorable Tom Gallagher
Honorable Bob Crawford
Honorable Betty Castor
Carol Browner
James Yaeger
James Antista
Richard Donelan
M. B. Adelson
Hamilton Oven
D. Knowles, s Dist
D. Atkeson "

# United States Department of the Interior

FISH AND WILDLIFE SERVICE
75 SPRING STREET, S.W.
ATLANTA, GEORGIA
30303

TAKE PRIDE IN AMERICA

July 31, 1992

Mr. Greer C. Tidwell
Regional Administrator
Environmental Protection Agency
345 Courtland St., NE.
Atlanta, Georgia 30365

Dear Mr. Tidwell:

Several significant events regarding the Lee County, Florida Resource Recovery Facility (Facility) have occurred since you were notified by letter dated February 7, 1992, that the Fish and Wildlife Service (Service) was suspending consultation under Section 7 of the Endangered Species Act (Act). This letter is to apprise you of the current position of the Service regarding the need for consultation on this Facility.

Originally, the environmental analysis and ecological risk assessment provided by Lee County was based on annual mercury emissions in excess of 3,900 pounds. The Service held the opinion that this additional amount of mercury would cause a measurable impact on the environment of south Florida and could result in a may affect situation for the endangered Florida panther. This position was strengthened by the 1992 report of the Florida Panther Interagency Committee which linked mercury levels in the panther with consumption of raccoons and alligators from mercury contaminated areas. This was the primary reason for our request that formal consultation under Section 7 be initiated.

Since our last correspondence:

- Lee County has stated that an activated carbon injection system will be installed in each unit for the removal of mercury from flue gasses and the carbon feed rates will be monitored on a continuous basis to assure optimal conditions for mercury removal from the flue gases;

- Lee County has requested that the Florida Department of Environmental Regulation (DER) reduce the Facility's mercury emission limit by approximately 80 percent, from 700 ug/dscm (approximately 1,600 pounds/unit/year) to 140 ug/dscm or 70 percent removal, whichever is less restrictive. The Governor's order approving site certification (dated June 17, 1992) showed a change in wording; i.e., "mercury emissions shall not exceed 0.000138 pounds/MMBtu, 0.0379 pounds/hour/unit, and 0.166 tons/year/unit at 140 ug/dscm at 7 percent $O_2$ or at least 70 percent removal efficiency by weight." Further, DER may reduce the emission limit by up to 50 percent (i.e., down to 70 ug/dscm and 0.083 tons/year/unit), based upon test results;

- o Lee County has provided modeling data which indicates that actual emissions should be below 70 ug/dscm (330 pounds/year);

- o Lee County has provided data indicating that mercury in the fly ash and mercury trapped by the activated carbon injection unit, will not be subject to leaching action or to volatilization, even at temperatures well beyond those that might be expected in a normal landfill;

- o Lee County is required to conduct a biomonitoring program to measure mercury content in the aquatic food chain for up to 2 years before and 5 years after the beginning of operations, with the stipulation that permit limits may be decreased by the DER (for good cause shown and after notice and an administrative hearing), if warranted;

- o Lee County has agreed to comply with the new mercury emission limits to be established by the State of Florida (the Florida House of Representatives adopted a moratorium on new incinerator construction until the mercury problem can be studied and more stringent emission limits established) and the Environmental Protection Agency (EPA), when adopted;

- o Lee County has implemented a mercury collection program designed to reduce mercury content in the preincineration waste stream by more than 88 percent;

- o The Service has determined that mercury use in the manufacture of dry cell batteries, the major source of mercury in solid waste streams, will be discontinued prior to the time that the Lee County Facility begins operations; and

- o The Service has determined that this is not a new source of mercury (i.e., solid wastes from Lee and Henry Counties are currently being disposed of by landfill; with the result that at least 70 percent more mercury is currently being emitted into the atmosphere than will be emitted from the incinerator). Incineration appears to be the best alternative, even when considering composting, for the disposal of solid wastes generated by the residents of Lee and Henry Counties. This is the one that will result in the least overall impact on Service trust resources.

The Service does have concerns about the cumulative effects of mercury on the south Florida ecosystem. To begin addressing this concern, the Service plans to continue monitoring raccoons in south Florida, to initiate a monitoring program for mercury deposition in Lee County prior to operation of the Facility, and to work with the EPA and DER to begin a monitoring program throughout the State. We believe this type of effort is necessary to begin to address this issue in a successful manner. Therefore, we continue to request your assistance and support in this area. Considering the above, it is the position of the Service that the operation of this Facility is not likely to adversely affect the Florida panther or other listed species.

Although there continues to be a difference of opinion on the issue of the applicability of Section 7 of the Act to State issued PSD permits, this issue does not need to be resolved at present. Lee County has fully cooperated with the Service in its attempt to assess the effect of the project on threatened and endangered species and to find means to mitigate the impact of the project. During the past 10 months, the Service has analyzed information obtained from the EPA, the applicant, published literature, symposia, and a number of other sources. The Service has made a number of recommendations, including biomonitoring, which the applicant has adopted and has been incorporated in the DER PSD permit. The Service is, therefore, withdrawing its request for initiation of Section 7 consultation with the EPA on this particular permit.

Sincerely yours,

W. T. Olds Jr.

Warren T. Olds, Jr., C.W.B.
Assistant Regional Director

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION IV

345 COURTLAND STREET, N.E.
ATLANTA, GEORGIA 30365

4APT-AEB

JUL 17 1992

RECEIVED

JUL 20 1992

Bureau of
Air Regulation

Mr. Clair H. Fancy, P.E., Chief
Bureau of Air Regulation
Florida Department of Environmental
Regulation
Twin Towers Office Building
2600 Blair Stone Road
Tallahassee, Florida 32399-2400

RE: Lee County Solid Waste Energy Recovery Facility (PSD-FL-151)

Dear Mr. Fancy:

This is to acknowledge receipt of the draft of the final Prevention of Significant Deterioration (PSD) permit for the above referenced facility, received in our office on July 8, 1992. The proposed facility will consist of three stoker waterwall combustion/steam generation units permitted to operate at a capacity of 660 tons per day (tpd) each, for a total facility capacity not to exceed 1980 tpd. Two units will be constructed initially, with the third unit being installed in the future. Each unit is capable of generating approximately 15 megawatts (MW), for a total of 45 MW net.

The permit provides for the use of a hydrated lime scrubber followed by a baghouse for the control of particulates, acid gases, and metals. $NO_x$ emissions will be controlled by a Thermal de-$NO_x$ (selective noncatalytic reduction) system. Mercury emissions will be controlled by injecting activated carbon into the flue gas prior to the scrubber and baghouse. In addition, the County will establish a household battery collection program to further minimize mercury emissions. VOC, CO, and dioxin/furan emissions will be controlled through proper combustion practices and combustion control techniques.

We have reviewed the draft permit as submitted and have the following comments. As discussed during a telephone conversation on July 9, 1992, between Mr. Mirza Baig of your staff and Mr. Scott Davis of my staff, we are recommending the following changes to the Test Methods portion of the Specific Conditions (reference page 9):

1. Delete Method 101A as an EPA test method for lead. The permit should read:

   [Method] 12 Lead concentration from stationary sources

2. Delete the "0" in the EPA method "26, 26A0" for HCl emissions. The permit should read:

   [Method] 26, 26A HCl emissions

3. Substitute these specific EPA methods for mercury, antimony, arsenic, and cadmium emissions. The permit should read:

   [Method] 29 Antimony and Cadmium emissions based on an average of three runs.

   [Method] 101A Mercury emissions based on an average of three runs.

   [Method] 108 Arsenic emissions based on an average of three runs.

Thank you for the opportunity to review and comment on this permit. If you have any questions or comments, please contact Mr. Scott Davis at (404) 347-5014.

Sincerely yours,

Reginald S. Barnes / for

Jewell A. Harper, Chief
Air Enforcement Branch
Air, Pesticides, and Toxics
Management Division

Patty

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION IV

345 COURTLAND STREET
ATLANTA, GEORGIA 30365

SOURCE EVALUATION UNIT
AIR ENFORCEMENT BRANCH
FACSIMILE TRANSMISSION SHEET
Fax Number: FTS 257-5207 or 404/347-5207

DATE: 7/17/93 NUMBER OF PAGES (Including this sheet) ______

TO: Alan Farney PHONE: 904 488-1344

ADDRESS: FDER FAX NUMBER: 904 922-6979

FROM: Brian L. Beals PHONE: (404) 347-5014

If the following pages are received poorly, please call Angela at FTS 257-5014 or 404/347-5014.

SPECIAL INSTRUCTIONS FOR RECEIVER: ______