Mercury System Manual

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About This Manual

This manual provides information about installing, maintaining, and servicing the Mercury System. It also contains important alerts to ensure safe operation and prevent equipment damage. The manual is organized into the following chapters and appendices to provide direct access to specific operation and service information.

- Chapter 1 “Introduction” provides an overview of Mercury System instruments and describes associated Mercury System components.
- Chapter 2 “System Installation, Set Up and Shut Down” describes how to setup, start up, and shut down the instrument. It also provides the recommended initial parameter settings.
- Chapter 3 “Calibration” provides the manual system calibration procedure, the auto system calibration procedure, and the calibration check procedure.
- Chapter 4 “Troubleshooting” presents guidelines for diagnosing instrument failures, isolating faults, and includes recommended actions for restoring proper operation.
- Chapter 5 “Preventive Maintenance” describes the periodic maintenance procedures that should be performed on the system instruments and components to ensure proper operation.
- Chapter 6 “Optional Equipment” describes the optional equipment that can be used with the Mercury System.
- Appendix A “Warranty” is a copy of the warranty statement.
- Appendix B “System Reference Drawings” provides the plumbing and electrical drawings for the Mercury System instruments and associated components.
- Appendix C “Flowcharts of Menu-Driven Firmware” presents detailed flowcharts for the 80*i* and the 81*i* menu-driven firmware. They are provided here for convenience in navigating the Mercury System menus and screens.

Safety and Equipment Damage Alerts

This manual contains important information to alert you to potential safety hazards and risks of equipment damage. Refer to the following types of alerts you may see in this manual.

Safety and Equipment Damage Alert Descriptions

Alert	Description
DANGER	A hazard is present that will result in death or serious personal injury if the warning is ignored. ▲
WARNING	A hazard is present or an unsafe practice can result in serious personal injury if the warning is ignored. ▲
CAUTION	The hazard or unsafe practice could result in minor to moderate personal injury if the warning is ignored. ▲
Equipment Damage	The hazard or unsafe practice could result in property damage if the warning is ignored. ▲

Safety and Equipment Damage Alerts in this Manual and in the individual Mercury instruction manuals.

Alert	Description
WARNING	If the equipment is operated in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired. ▲
	The service procedures in this manual are restricted to qualified service personnel only. ▲
	This product is supplied with a three-wire grounding cord. Under no circumstances should this grounding system be defeated. ▲
Equipment Damage	Do not attempt to lift the instrument by the cover or other external fittings. ▲
	To prevent damaging the probe transducer, read the cable labels carefully and DO NOT connect the C or D cable to the wrong connector on the 82*i* rear panel.
	Some internal components can be damaged by small amounts of static electricity. A properly ground antistatic wrist strap must be worn while handling any internal component. If an antistatic wrist strap is not available, be sure to touch the instrument chassis before touching any internal components. When the instrument is unplugged, the chassis is not at earth ground. ▲
	Handle all printed circuit boards by the edges only. ▲
	Do not remove the panel or frame from the LCD module.

Alert	Description
	▲
	The LCD module polarizing plate is very fragile, handle it carefully. ▲
	Do not wipe the LCD module polarizing plate with a dry cloth, it may easily scratch the plate. ▲
	Do not use Ketonics solvent or aromatic solvent to clean the LCD module, use a soft cloth moistened with a naphtha cleaning solvent. ▲
	Do not place the LCD module near organic solvents or corrosive gases. ▲
	Do not shake or jolt the LCD module. ▲

Where to Get Help

Service is available from exclusive distributors worldwide. Contact one of the phone numbers below for product support and technical information or visit us on the web at www.thermo.com/aqi.

1-866-282-0430 Toll Free

1-508-520-0430 International

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Chapter 1
Introduction

System Overview

Note This manual is for use with the Mercury Freedom™ System integrated by Thermo Fisher Scientific. Systems integrated by others will vary from the information provided in this document. ▲

Model 80*i*

The Model 80*i* is normally configured as one component of an integrated Hg Continuous Emission Monitoring System (CEMS). The Thermo Scientific Mercury Freedom™ System is comprised of a Hg analyzer (Model 80*i*), a Hg calibrator (Model 81*i*), a Hg probe controller (Model 82*i*), and a Hg probe (Model 83*i*) along with additional peripheral components, such as a zero air supply, umbilical, and instrument rack. However, the Model 80*i* is also available as a stand-alone instrument.

The Model 80*i* Analyzer is based on the principle that Hg atoms absorb ultraviolet (UV) light at 254 nm, become excited, then decay back to the ground energy state, emitting (fluorescing) UV light at the same wavelength. Specifically,

$$Hg + h\nu(254nm) \rightarrow Hg^* \rightarrow Hg + h\nu(254nm)$$

The sample from the Hg probe (Model 83*i*) is introduced to the rear panel of the instrument as either Total Hg or Elemental Hg from the appropriate probe umbilical connection (see **Figure 1–1**). When the Model 80*i* is sampling Total Hg, the total sample is routed into the fluorescence chamber via Solenoids S1 (NO state) and S3 (NO state). During this time, the Elemental Hg sample bypasses the chamber via Solenoid S2 (NO state).

When the Model 80*i* is sampling Elemental Hg, the elemental sample is routed via Solenoids S2 (normally closed (NC) state) and S3 (normally open (NO) state) into the fluorescence chamber. During this time, the Total Hg sample bypasses the chamber via Solenoid S1 (NC state). As the monitored sample (Total or Elemental) leaves the optical chamber, it passes through a flow sensor, then to an external pump. The external pump is used to draw the sample through the instrument and to create the instrument vacuum which is measured with the pressure transducer.

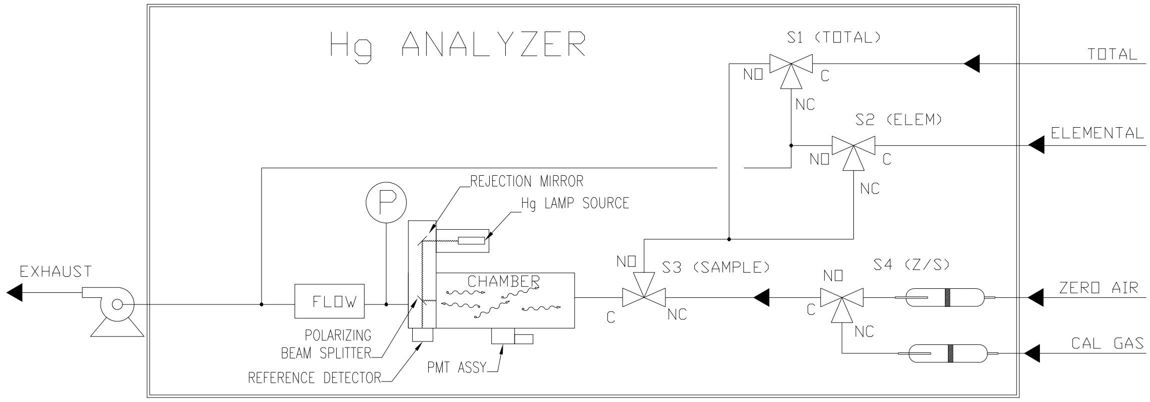

Figure 1–1. Model 80*i* Flow Diagram

Either the Total or Elemental sample is introduced into the fluorescence chamber, where UV light from a high energy Hg line source lamp excites the Hg atoms. The UV light is directed to the fluorescence chamber by a rejection mirror/beam splitter combination. A reference detector monitors the lamp intensity by viewing the transmitted light from the beam splitter.

As the excited Hg atoms decay back to the ground energy state, they emit UV light that is proportional to the Hg concentration. The Hg fluorescence is monitored by a solar blind photomultiplier tube (PMT) placed at a right angle to the exciting radiation. The PMT detects the UV light emission from the decaying Hg atoms.

Calibration gas from the Hg calibrator (Model 81*i*) is plumbed to the zero air and cal gas bulkheads on the rear panel of the Model 80*i*. The zero or span gas is routed through an internal critical orifice, through either the NO or NC port of Solenoid S4, through the NC port of Solenoid S3 and into the fluorescence chamber. During this time, both Total and Elemental Hg samples bypass the chamber and are sent to the external pump exhaust.

The Model 80*i* outputs the Total Hg or Elemental Hg concentration to the front panel display, the analog outputs, and also makes the data available over the serial or Ethernet connection.

Model 81*i*

The Model 81*i* Mercury (Hg) Calibrator generates known concentrations of gas phase elemental Hg by combining the output flow of a temperature controlled, saturated Hg vapor source with a flow of Hg-free dilution air or nitrogen. The Model 81*i* is normally configured as one component of an integrated Hg Continuous Emission Monitoring System (CEMS). The Thermo Scientific Mercury Freedom™ System is comprised of a Hg analyzer (Model 80*i*), a Hg calibrator (Model 81*i*), a Hg probe controller

(Model 82*i*), and a Hg probe (Model 83*i*), along with additional peripheral components, such as a zero air supply, umbilical, and instrument rack. However, the Model 81*i* is also available as a stand-alone calibrator.

Table 1–1 shows the Model 81*i* solenoid valve status for the different calibrator modes. Use this table along with **Figure 1–2** when reading the principle of operation description that follows. Note that a valve status shown as ON describes a valve that is energized, or in the Normally Closed (NC) state. A valve status shown as OFF describes a valve that is de-energized, or in the Normally Open (NO) state.

Table 1–1. Model 81*i* Valve Mode Status

Solenoid ID	Standby	Instrument Zero	Instrument Cal	Orifice Zero	Orifice Cal	System Zero	System Cal
Valve 1	ON	ON	ON	ON	ON	ON	ON
Valve 2	OFF	OFF	ON	OFF	ON	OFF	ON
Valve 3	OFF	OFF	ON	OFF	ON	OFF	ON
Valve 4	OFF	OFF	OFF	ON	OFF	ON	OFF
Valve 5	OFF	OFF	ON	ON	OFF	ON	OFF
Orifice Valve	OFF	OFF	OFF	ON	ON	OFF	OFF
Spike Valve	OFF	OFF	OFF	OFF	OFF	ON	ON

Clean, dry, Hg-free pressurized air/nitrogen (30-40 psig) feeds both a high flow (0-20 slpm) dilution air mass flow controller (MFC) and a low flow (0-50 sccm) Hg source MFC (**Figure 1–2**).

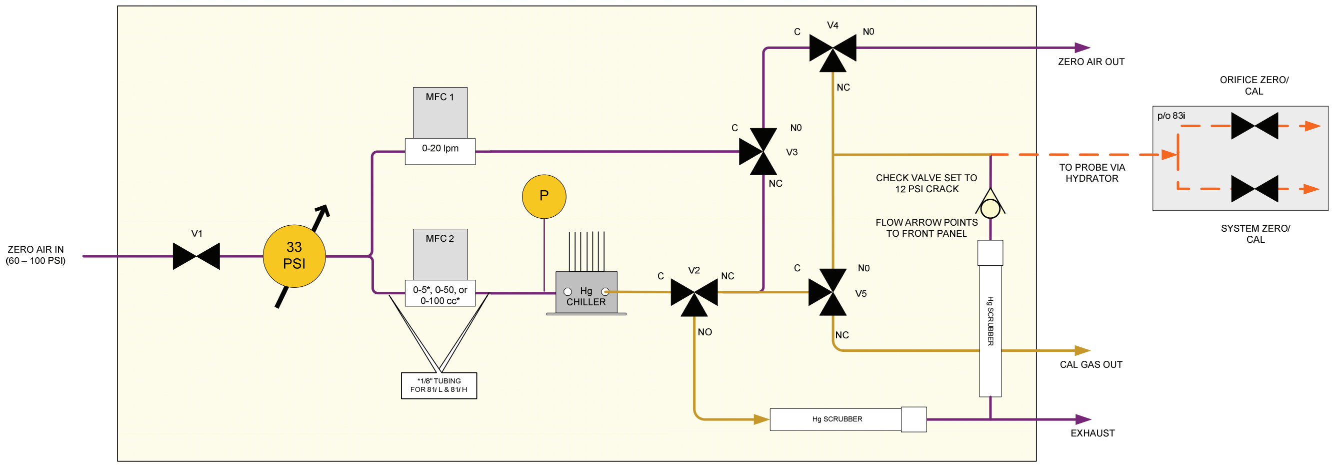

Figure 1–2. Model 81*i* Flow Diagram

The output of the low flow MFC is passed through a coiled, Teflon® tube encapsulated Hg source, which is maintained at a precisely known temperature and pressure. The Hg saturated flow is directed by Valve V2 (NC) to combine with dilution flow from Valve V3 (NC) providing calibration gas to either:

- A Hg analyzer via Valve V5 (NC)
- Or the Hg probe via Valve V5 (NO)

Calibration gas to the probe is sent directly to the critical orifice or to the spike port (for filter flooding) by switching the appropriate probe valve (orifice or spike).

The check valve is used to keep the orifice (located in the probe) from being over pressurized during an orifice zero or calibration.

Excess flow (atmospheric dump) during a probe calibration is routed through an internal Hg scrubber prior to being sent to exhaust. Also during any zero air mode (instrument, orifice, or system), the Hg saturated flow is directed via V2 (NO) through a Hg scrubber prior to being sent to exhaust.

Model 82*i*

The Model 82*i* Mercury (Hg) Probe Controller is configured as one component of the Thermo Scientific integrated Hg Continuous Emission Monitoring System (CEMS). The Model 82*i* is not available as a stand-alone instrument.

Pneumatics

Clean, dry, pressurized (~85 psig) air feeds two electo/pneumatic pressure transducers which adjust and maintain output pressure to the Model 83*i* probe eductor and blowback pneumatics (**Figure 1–3**).

Pressurized (~85 psig) Hg-free zero air or nitrogen feeds a third electo/pneumatic pressure transducer which adjusts and maintains dilution gas pressure to the Model 83*i* probe dilution module.

Three electronic pressure transducers (**Figure 1–3**) associated with the individual regulators are also contained within the Model 82*i*, as well as an electronic vacuum transducer monitoring the dilution module vacuum in the Model 83*i*.

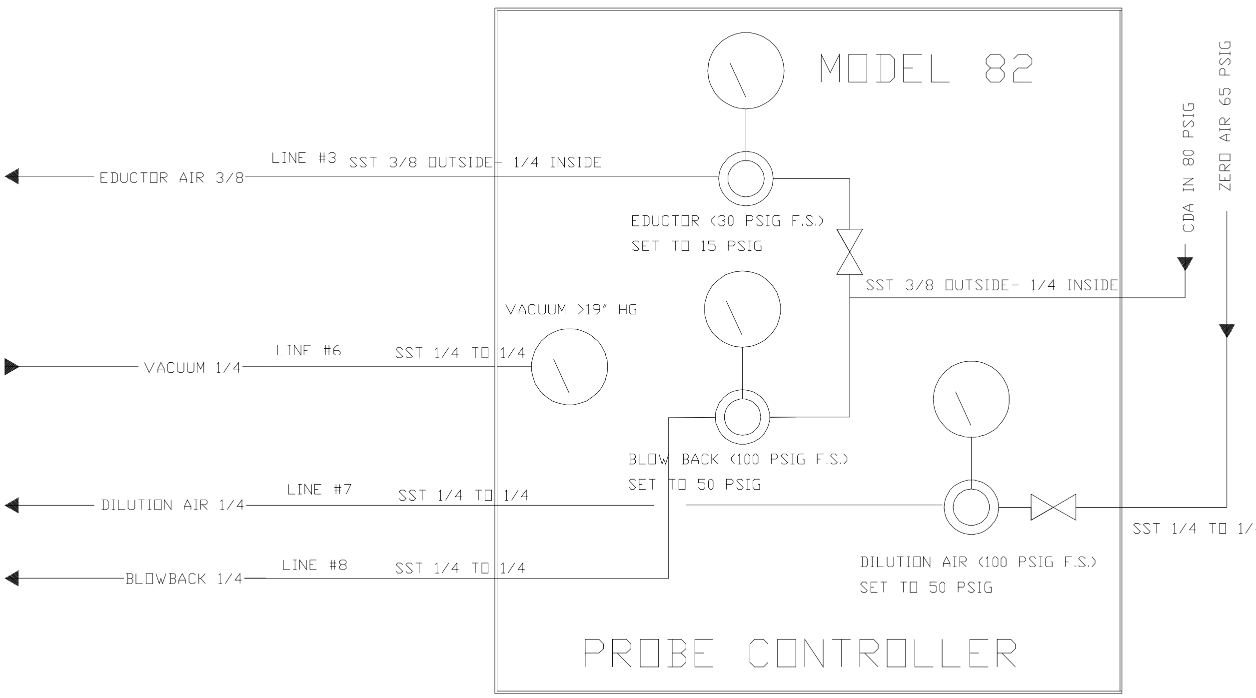

Figure 1–3. Model 82*i* Probe Controller Flow Diagram

Electronics

The Model 82*i* communicates with the Model 80*i* via a RS-485 link. The Model 80*i* acts as the master component in the Mercury Freedom™ System with both the Models 81*i* and 82*i* slaved to the analyzer. All commands are initiated by the Model 80*i*. The Model 82*i* receives commands and sends information to the analyzer.

The Model 82*i* also receives two 4-20 mA signals from the probe critical orifice pressure transducer and the fast loop venturi pressure transducer.

The Model 82*i* controls the temperatures of the probe, the heated umbilical line, and converter (located within the probe). These temperatures are set and recorded via the Model 80*i*.

Electrical Power

The Model 82*i* provides both 220 and 110 AC voltage to the Model 83*i* Probe. The 220 VAC powers the probe's stinger heater and filter/eductor heater. The 110 VAC powers the Total Hg converter as well as 4 to 6 probe solenoid valves for cal/zero gas, stinger blowback, filter blowback, and Hg spike.

The Model 82*i* has a dedicated 220 VAC feed to power the heated umbilical line.

Model 83*i*

The Model 83*i* Mercury (Hg) Extraction Probe is configured as one component of the Thermo Scientific integrated Hg Continuous Emission Monitoring System (CEMS). The Thermo Scientific Mercury Freedom™ System is comprised of a Hg analyzer (Model 80*i*), a Hg Calibrator (Model 81*i*), a Hg Probe Controller (Model 82*i*), and a Mercury Extraction Probe (Model 83*i*) along with additional peripheral components, such as a zero air supply, umbilical, and instrument rack. The Model 83*i* with built-in diluting probe has been designed specifically to monitor gaseous Hg emissions from coal-fired power plants.

The system is housed in a stainless steel enclosure and is designed to meet NEMA 4X specifications. To prevent sample condensation, all key elements (filter, diluting probe and sample eductor) have been mounted between heated aluminum blocks that can be maintained at temperatures as high as 250 °C.

The enclosure also houses an accumulator tank for back purging of the filter tube (blowback). External to the enclosure is a section with the electrical connections, solenoids for filter and stinger blowback, cal gas, an Hg spike, a differential pressure transducer, and an additional pressure transducer for the pressure at the critical orifice.

A special four-inch adapted mounting flange has been supplied for installation onto the port of the stack or duct.

Clean dry pressurized (~85 psig) air/nitrogen feeds two electronic pressure regulators in the Model 82*i*, which adjust and maintain output pressure to the Model 83*i* probe eductor and blowback pneumatics (**Figure 1–4**). Pressurized (~65 psig) Hg-free zero air feeds a third electronic regulator in the Model 82*i*, which adjusts and maintains dilution air pressure to the Model 83*i* probe dilution Module. Also contained within the Model 82*i* are three electronic pressure transducers associated with the individual regulators, as well as an electronic vacuum transducer monitoring the dilution module vacuum in the Model 83*i*.

The Model 83*i* extraction probe includes an filter with a built in dilution module and high temperature thermal converter for reducing oxidized Hg to elemental for subsequent analysis by the Model 80*i*.

The Model 82*i* provides both 220 and 110 AC voltage to the Model 83*i*. 220 VAC powers the probe's stinger heater and filter/eductor heater. 110 VAC powers the Total Hg converter as well as four (4) probe solenoid valves for cal/zero gas, stinger blowback, filter blowback, and Hg spike. The Model 82*i* also receives two (2) 4-20 ma signals from the probe critical orifice pressure transducer and the fast loop venturi pressure transducer.

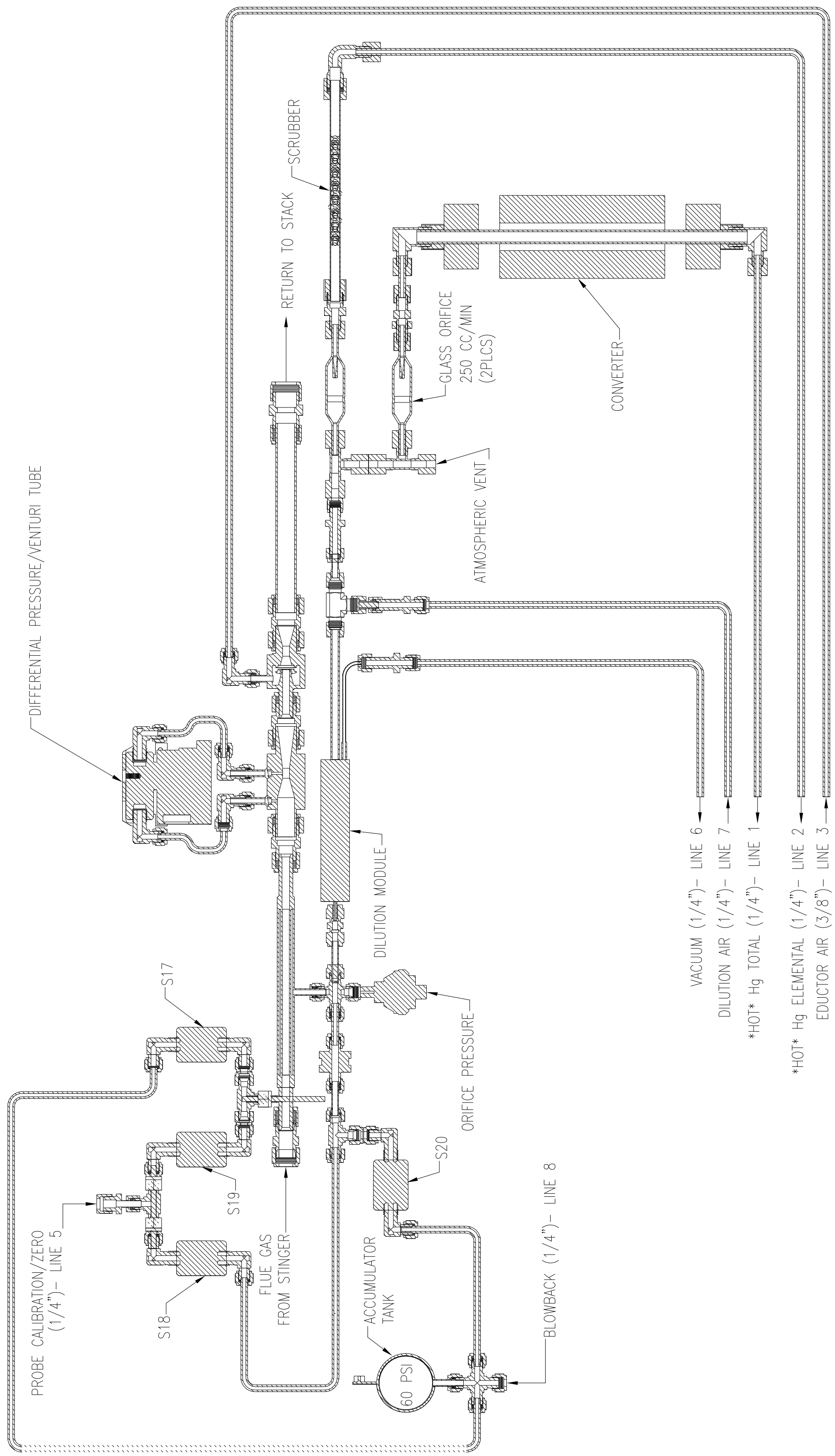

Figure 1–4. Model 83*i* Probe Flow Diagram

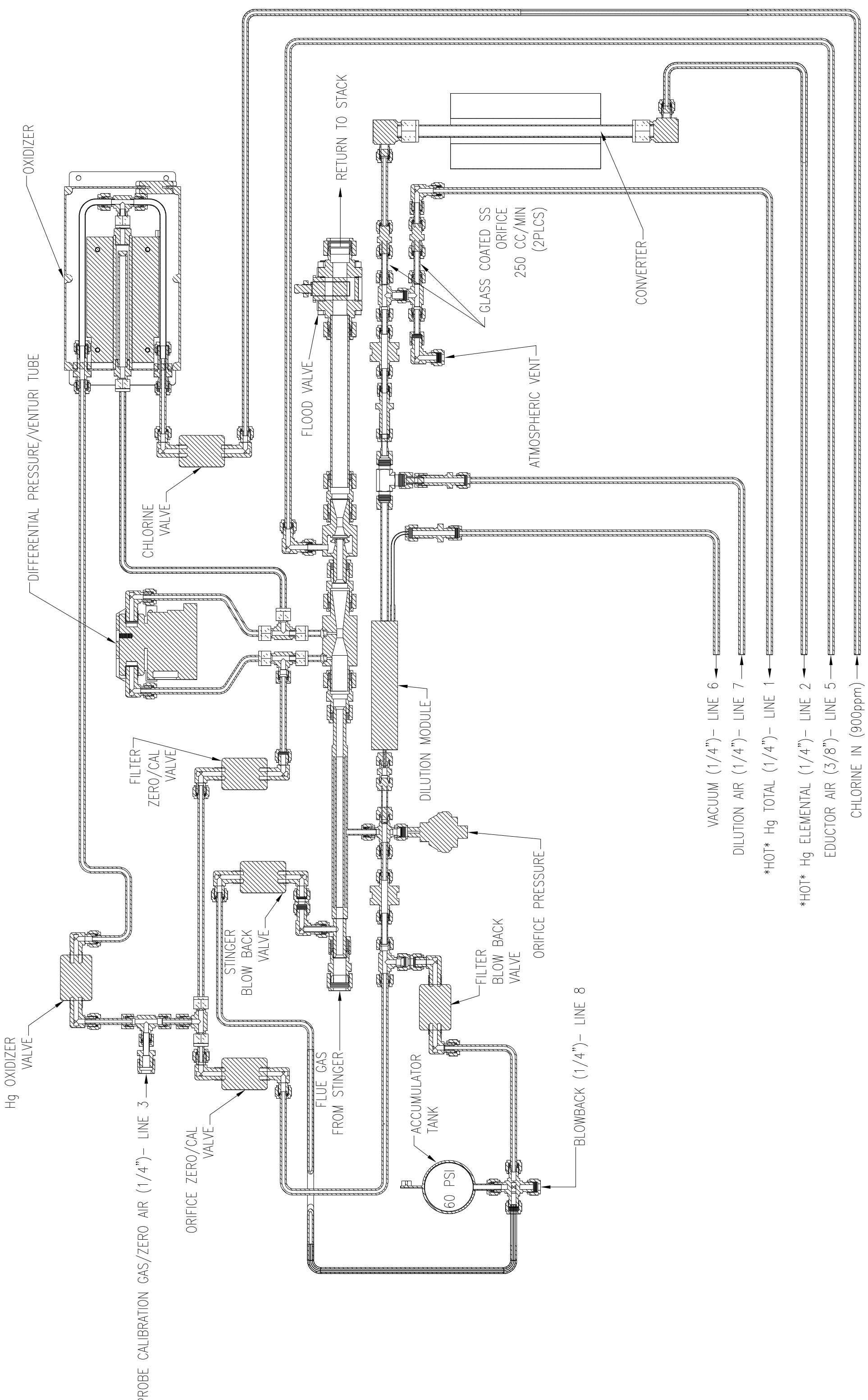

Figure 1–5. Model 83*i* Probe Flow Diagram with Oxidizer

Model 83*i* GC

The high temperature, dilution-based Model 83*i* GC Hg Non-Inertial Dilution Probe is compact, light weight, and modular in design for ease of both serviceability and manufacturability. The Model 83*i* GC consists of the following four functional sections:

- Heated Probe Barrel Assembly
- Heated Filter Probe Assembly
- Gas Conditioning Tray Assembly
- Electro-Pneumatic Tray Assembly

The heated filter probe, gas conditioning tray, and electro-pneumatic tray are housed in an enclosure assembly consisting of a stainless steel chassis that is shielded by a one-piece, epoxy-painted aluminum cover. In order to prevent sample condensation, all key elements (particulate filter block assembly, dilution eductor assembly, bypass eductor assembly, and sample flow orifice assembly) are heated and controlled to temperatures as high as 260 °C (500 °F). The sample stinger tube is also heated to a temperature exceeding 500 °F in order to prevent sample condensation and mercury adsorption prior to entering the filter block assembly.

The standard heated probe barrel assembly consists of a six-foot long by 1/2-inch OD Hastelloy C sample stinger tube that is encased by a one-inch OD, schedule 40, 316SS welded pipe/flange assembly. A five-foot long, 240 VAC/600 W coiled, cable heater envelops the 1/2-inch OD sample stinger tube within the annular space formed inside the one-inch OD pipe housing. The sample inlet temperature is maximized by operating the heater with continuous full power, which prevents sample condensation and minimizes mercury adsorption on to the stinger tube. The tip of the sample stinger, which contacts the stack or process gas, is shielded by a Hastelloy C shroud assembly in order to minimize the entry of sample particulates and mist into the system. The heated probe barrel assembly is supported by one-foot long, 1 1/2-inch OD, schedule 40, 316SS welded pipe/flange assembly attached to the enclosure chassis. The probe barrel assembly is fully retractable without removing the probe enclosure as it attaches and seals to the probe support assembly flange from inside the enclosure chassis.

Mercuric Chloride Generator

The TFS Mercuric Chloride Generator (Oxidizer) uses a patented process by which chlorine gas is mixed with elemental mercury (**Figure 1–6**). This mixing is done a short distance from the probe injection point to help minimize contact of mercuric chloride with cold spots. Mercuric chloride ($HgCl_2$) will adsorb or react on any "cool" surface (below 190 °C). The chlorine is supplied by a small cylinder (900 ppm Cl_2 in N_2 Balance), and the elemental mercury is supplied by the Model 81*i* elemental Hg generator

An oxidized mercury source is required in order to comply with 40 CFR Part 75 which states that a system integrity test needs to be performed once a week.

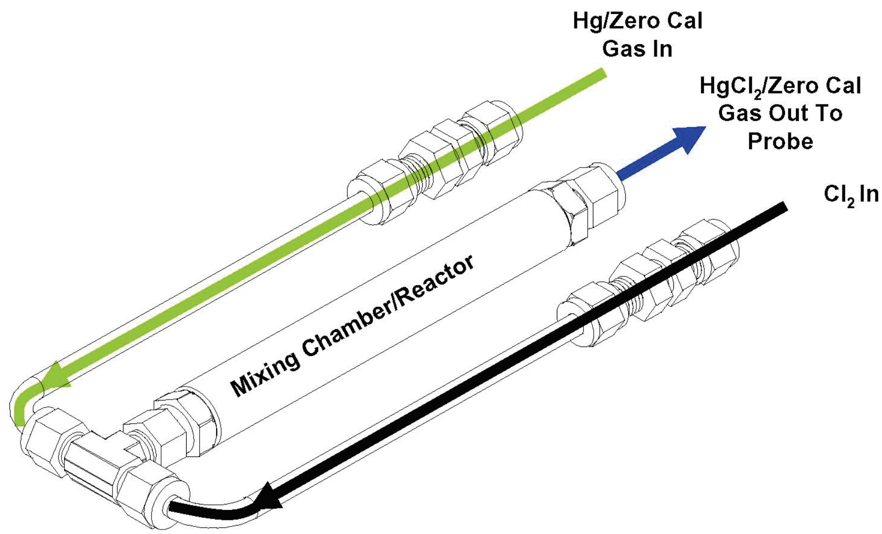

Figure 1–6. Oxidizer Flow Diagram

Component Description

Refer to **Figure 1–7** to identify and locate the oxidizer components.

Oxidizer Weldment

The oxidizer weldment acts as the reaction chamber where the generation of mercuric chloride occurs.

Heater

The heater is a 240V, 300W firerod-style heater that heats the heater block and oxidizer weldment to approximately 400 °C to facilitate the oxidation reaction.

Heater Block

The heater block encloses the oxidizer weldment for even heating.

Thermocouple

The Type K thermocouple is used to measure the oxidizer temperature.

Insulation

The insulation surrounding the heater block helps maintain a uniform and constant temperature.

Oxidizer Enclosure

The oxidizer enclosure is an aluminum box that contains the oxidizer components.

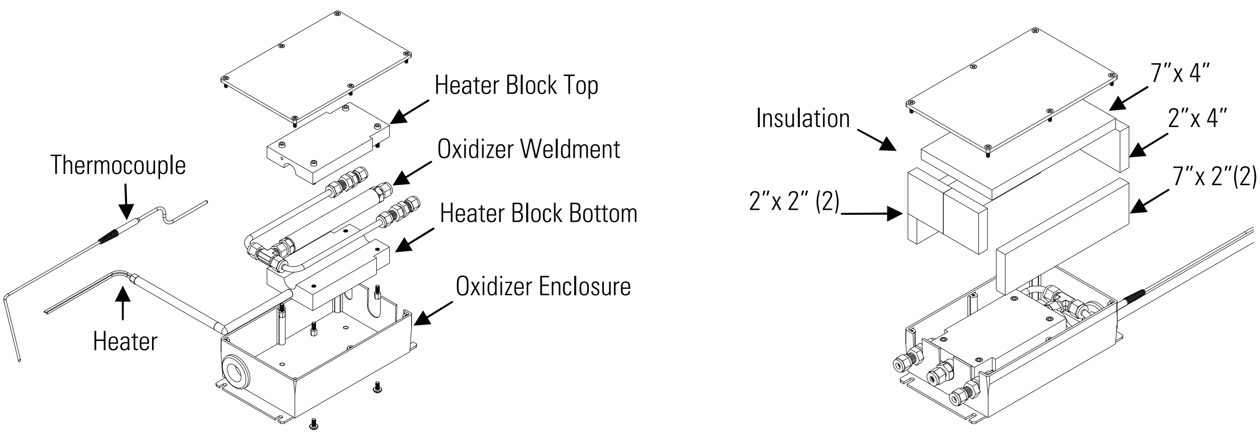

Figure 1–7. Oxidizer Components

Heated Hovacal Line

The E.U. version of the Model 83*i* comes equipped with a heated line for the Hovacal, in place of the oxidizer assembly. This glass coated S.S. line is used during Hovacal audits. It should be kept at at a constant temperature of 250 °C even when not being used in order to reduce cold spots. It should be capped when not in use.

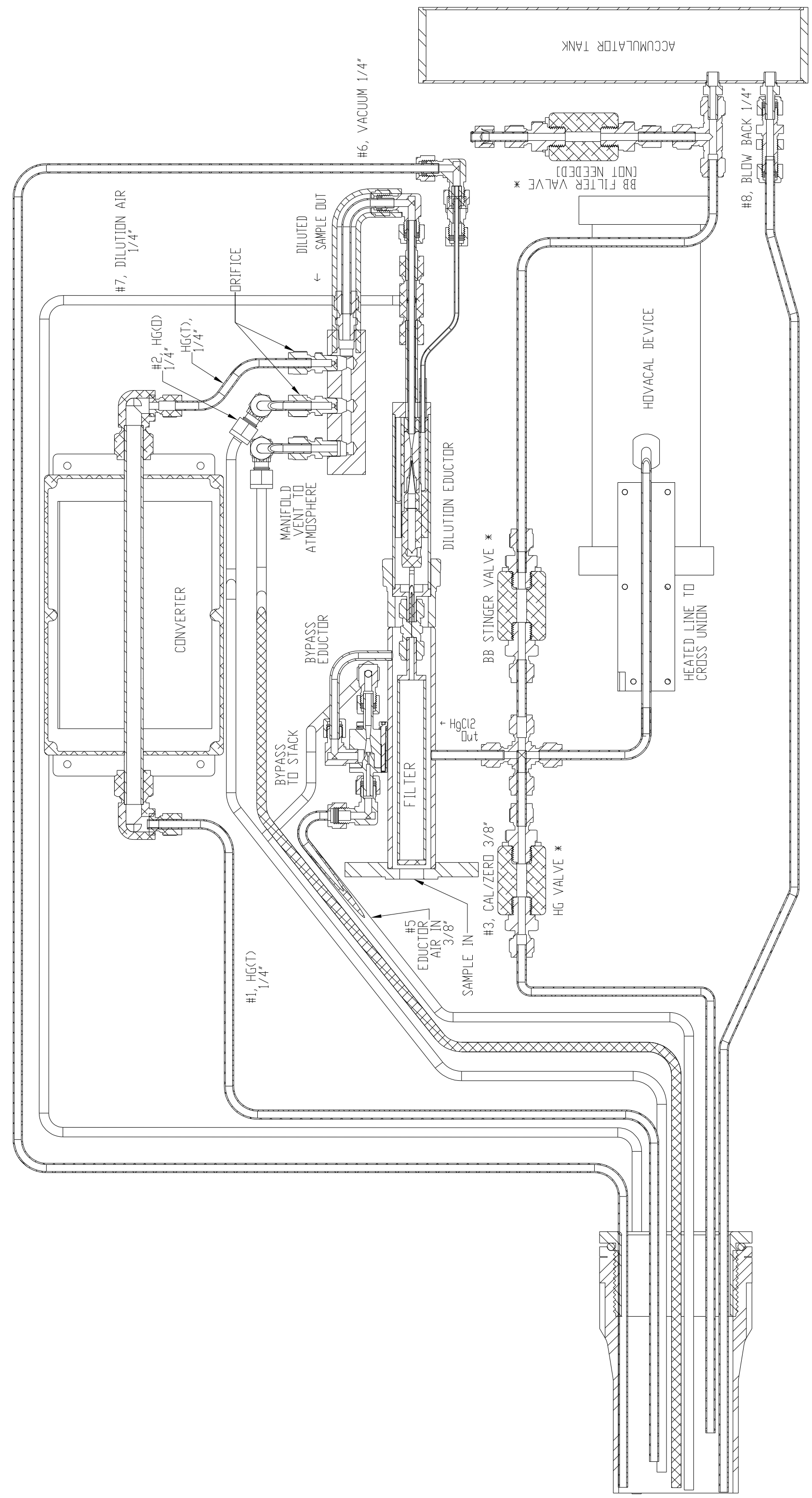

Figure 1–8. Model 83*i* Probe Flow Diagram with Hovacal Line

Hydrator

The Hydrator humidifies calibration gas, improves system response, and enables more complete Hg recovery. See **Figure 1–9** and **Figure 1–10**.

Figure 1–9. Hydrator System Mount and Close-up View

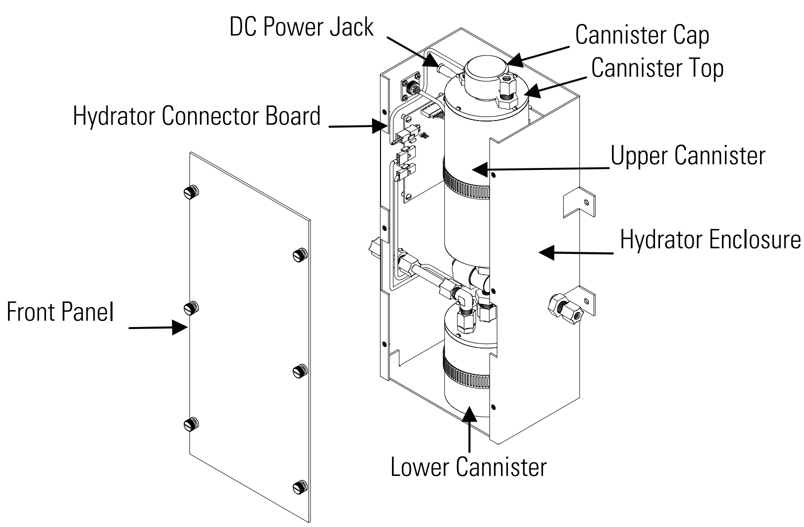

Figure 1–10. Hydrator Components

Nitrogen Generator

The MaxSense™ Nitrogen Generation Package (Nitrogen Generator) creates clean, dry compressed nitrogen gas from compressed air (**Figure 1–11**). The performance specifications are 99% nitrogen (N_2) gas at 60 scfh given 100 psig compressed air pressure. The complete system includes three-stage compressed air filtration designed to protect the Nitrogen Generator for constant performance with support to the Model 80*i*. Refer to the "Optional Equipment" chapter for more information.

Figure 1–11. Zero Air Panel System with Nitrogen

Zero Air Supply

The Zero Air Supply has been designed to provide oil-free and particulate-free, dry air from plant air. Zero Air Supply components include an oil mist coalessor, water coalessor with auto drain, particulate filter, accumulator tank, heatless air dryer, and regulator (**Figure 1–11**).

Scrubber Assembly

The three-stage scrubber assembly removes trace levels of mercury and interference compounds (**Figure 1–12**). It includes the following components:

- Silica Gel (Dryrite™) – Additional to a heatless or permeation air dryer
- Molecular Sieve (Purafil™) – Additional hydrocarbon and interference removal
- Activated Charcoal – Hydrocarbons and O_3, SO_2, Hg(0) removal

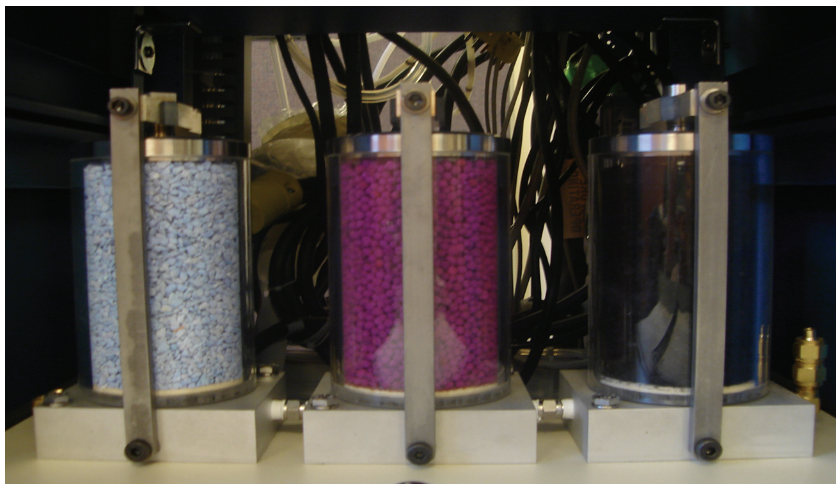

Figure 1–12. Scrubber Assembly

Stack Mounting Flange

The stack mounting flange (**Figure 1–13**):

- Provides the mounting interface for the Model 83*i* probe enclosure to the stack
- Mounts to a standard 8-hole, 150 #, four-inch flange on the stack

Note The special four-inch adapted mounting flange for installing onto the port supports the orientation of the stack flange in both single-hole top center and two-hole level. ▲

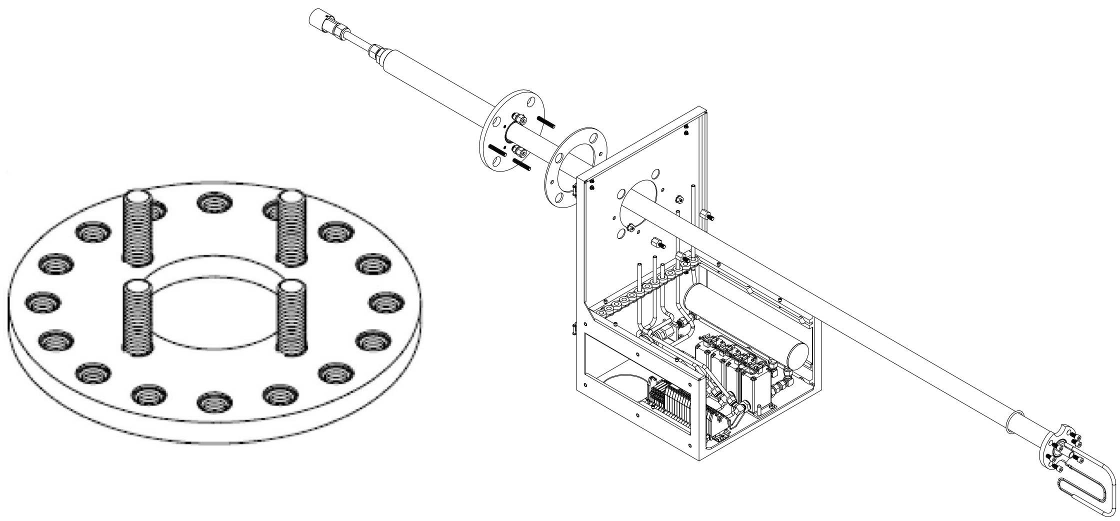

Figure 1–13. Stack Mounting Flange

Umbilical Cable

The umbilical cable is used to connect the rack system (in the CEMS shelter) with the extraction probe. The umbilical cable includes high-temperature, corrosive-resistant wiring, and chemically inert tubing with select adsorbtion characteristics. Refer to the electrical/pneumatic connection drawings in the System Reference Drawings appendix.

Mercury System Instruction Manuals

The following instruction manuals are currently available for the Mercury instruments:

- *Model 80i Hg Analyzer Instruction Manual* 103194-00
- *Model 81i Hg Calibrator Instruction Manual* 103068-00
- *Model 82i Hg Probe Controller Instruction Manual* 103519-00
- *Model 82X Fiber Optic Probe Controller Instruction Manual* 105464-00
- *Model 83i Extraction Probe Instruction Manual* 101187-00
- *Model 83i GC Hg Non-Inertial Dilution Probe Instruction Manual* 101187-00
- *Mercuric Chloride Generator Instruction Manual* 105648-00
- *Mercury System Manual* 105933-00

Chapter 2
System Installation, Set Up and Shut Down

This chapter provides the recommended procedures and settings for installing a Mercury System.

Lifting

When lifting an instrument, use a procedure appropriate to lifting a heavy object, such as bending at the knees while keeping your back straight and upright. Grasp the instrument at the bottom in the front and at the rear of the unit. It is recommended to have two persons lifting, one by grasping the bottom in the front and the other by grasping the bottom in the rear.

Equipment Damage Do not attempt to lift the instrument by the cover or other external fittings. ▲

Hg CEMS Requirements

- 120 VAC, 15 amps for 80*i*, 81*i*, pump and support
- 208/240 VAC 20 amps for 82*i* / Probe
- 208/240 VAC, 30 amps per 200 feet of heated umbilical (~0.13 amp/ft) – two zones maximum
- All power is needed at instrument end – power for probe sent via umbilical in a standard system.
- System with an 82X:

  No umbilical power: 208/240 VAC @ 50/60 Hz, 20 Amp service

  Umbilical power: 208/240 VAC @ 50/60 Hz, 30 Amp service line per 250 feet of hot wire up to 500 feet
- Air Flow requirements – Four CFM @ 85 psig (oil free)
- Estimated heat dissipation 1200 Watts
- Estimated power consumption 15 KW

Plumbing and Electrical Hookup

Refer to the "System Reference Drawings" in Appendix B for the system plumbing and electrical hookup connections.

Equipment Damage To prevent damaging the probe transducer, read the cable labels carefully and DO NOT connect the C or D cable to the wrong connector on the 82*i* rear panel. ▲

Set Temperature Defaults

Refer to **Table 2–1** for setting the default temperatures (or per site requirements). At the 80*i* Main Menu, select > Service > **Set Temperatures**:

Table 2–1. Default Temperatures

Parameter	Default Temperature Setting
Bench Temp	45 °C
Probe Temp	220 °C
Umbilical Temp	120 °C
Converter Temp	760 °C
Failsafe Valve Temp	200 °C
Oxidizer Temp	400 °C/250 °C Heated Hovacal Line

Mercury CEMS Power-Up Sequence

Use the following procedure to power up the Mercury CEMS.

Note If the 81*i* is in Service Mode, it will ignore 80*i* commands. ▲

1. Apply Power to the CEMS, turn power switches ON in the following order:

   Model 82*i*

   Model 81*i*

2. After the Model 81*i* initializes and the Run screen is displayed, power the Model 80*i*.

3. To test communication from the 80*i* to the 81*i*:

   a. Using the Model 80*i*, change the Gas Mode to one of the following: Instrument Zero, Instrument Cal, System Zero, or System Cal.

Example: From the Main Menu, select > Instrument Controls > Gas Mode > **Instrument Zero**.

b. Verify that the 81*i* changes to that mode.

4. To test communication from the 80*i* to the 82*i*:

   View Diagnostics from the 83*i*, such as Voltages > Interface Board 82*i* > Temperatures > Probe, or Pressure > Probe.

   Verify that readings are not zero. Also, unplug one of the 83*i* thermocouples and verify that the change is indicated on the 80*i*.

Start-Up

Use the following procedure to power up the Mercury CEMS.

1. Place the System in System Zero Mode to flush the system.

2. Turn OFF flow related components:

   Power OFF the sample pump

   Component Power > Eductor Power

   Service > Probe Set Temp Failsafe > Set To (250 °C)

3. Heat components to temperatures:

   Component Power > Umbilical 1 Power

   Component Power > Umbilical 2 Power

   Component Power > Converter Power

   Component Power > Stinger Power

   Component Power > Probe Power

   Component Power > Oxidizer

4. Restart flow related items:

   Service > Probe Set Temp Failsafe > Set To (normal Set-Point)

   Component Power > Eductor Power

   Power ON the sample pump

5. Place the system in Sample Mode.

System Checkout

Check that the 81*i* gas mode display mirrors what is shown on the 80*i* gas mode display as follows: 80*i* Gas Mode > Instrument Controls > Gas Modes > **Analyzer Zero**. Refer to the individual Mercury instruction manual if displays do not match and units are not communicating.

1. Inside the 82*i*, ensure that both circuit breakers are **ON**.

2. At the 80*i* Main Menu, select > Instrument Controls > Component Power > **Umbilical 1 Power**, turn umbilical 1 heater **ON**, and Umbilical 2 Power, if applicable.

3. At the 80*i* Main Menu, select > Diagnostics > Temperatures > Probe > **Umbilical**, and observe temperature rise to 120 °C. Verify the temperature control is within 10 °C of set point.

4. At the 80*i* Main Menu, select > Instrument Controls > Component Power > **Converter Power**, and turn the converter **ON**.

5. At the 80*i* Main Menu, select > Diagnostics > Temperatures > Probe > **Converter**, observe the converter temperature rise and control to 760 °C. Verify the temperature control is within 10 °C of set point.

6. At the 80*i* Main Menu, select > Instrument Controls > Component Power > **Probe Power**, and turn probe power **ON**.

7. At the 80*i*, select > Diagnostics > Temperatures > **Probe** and observe temperature rise to 220 °C. Verify temperature control is within 10 °C of set point.

8. At the 80*i* Main Menu, select > Service > **Set Pressures**, and set the following parameters to the value indicated:

   Blowback Pressure 60 psig

   Eductor Pressure 15 psig for dry stack 83*i* applications, 5 psig for wet stack applications, 15 psig for 83*i* GC

   Dilution Pressure 55 psig for 83*i*, 35 psig for 83*i* GC

9. While in Sample mode, at the 80*i* Main Menu, select > Instrument Controls > **Auto/Manual Mode**, and switch to **Manual Hg(t)**.

10. At the 80*i* Main Menu, select > Diagnostics > Pressure > **Analyzer**, and record the chamber pressure (typically < 70 mm Hg).

11. At the 80*i* Main Menu, select > Instrument Controls > **Auto/Manual**, and switch to **Manual Hg(0)**.

12. At the 80i Main Menu, select > Diagnostics > Pressure > **Analyzer**, and record the chamber pressure. There should be no more than four mm Hg difference between this pressure and the pressure recorded in Hg(t) mode. If the pressure difference is > four mm Hg, check the system for leaks.

13. At the 80*i* Main Menu, select > Diagnostics > Pressure > **Probe**, and verify vacuum pressure is > 20 inches Hg at 55 psig for 83*i*, >17.5 inches Hg at 35 psig for 83*i* GC.

14. Model 83*i* only - At the 80*i* Main Menu, select > Diagnostics > Pressure > **Probe**, and note venturi pressure.

15. At the 80*i* Main Menu, select > Instrument Controls > **Component Power**, and turn Eductor Valve Power **ON**.

16. At the 80*i* Menu > Diagnostics > Pressure > **Probe**, note venturi pressure. It should be at least 1.5 inches H_2O greater than the value while the eductor is OFF.

17. Wait 4-6 hours, then perform a system calibration. Refer to the "Calibration" chapter in this manual.

18. Allow the system to stabilize overnight, then perform a zero and span check. Refer to "Zero and Span Check" in the "Model 80*i* Instruction Manual" Calibration chapter. If the system passes the zero and span check, it is ready to run sample. If the system does not pass the zero and span check, recalibrate.

Recommended Initial Parameter Settings

This section provides recommendations for initial parameter settings.

Initial Service Settings

Table 2–2 lists the initial service settings.

Table 2–2. Initial Service Settings

Parameter	Typical Range
PMT Voltage	500 – 1000 V
Lamp Intensity	50k – 150k Hz
Cooler Temperature	10 – 15 °C
Bench Temperature	45 – 50 °C
Probe Temperature	190 – 220 °C
Valve Failsafe Temperature	190 °C
Umbilical Temperature	120 °C
Converter Temperature	760 °C
Blowback Pressure	40 – 65 psig
Eductor Pressure	5 – 20 psig
Dilution Pressure	30 – 65 psig
Oxidizer Temperature	400 °C/250 °C Heated Hovacal Line

Set-up Blowback Schedule

Table 2–3. Set-up Blowback Schedule

Parameter	Range	Default
Period	0 - 24 Hours	12 Hours
Filter Duration	0 - 60 Seconds	10 Seconds
Stinger Duration	0 – 60 Seconds	10 Seconds

80*i* Alarms Settings

Table 2–4. 80*i* Alarms Settings

Parameter	Range	Typical Value
Internal Temperature	15 – 45 °C	32 °C
Chamber Temperature	40 – 50 °C	45 °C
Cooler Temperature	10 – 15 °C	14 °C
Pressure	25 – 75 mmHg	50 mmHg
Flow	0.000 – 1.000 LPM	0.30 LPM
Intensity	10,000 – 150,000 Hz	80,000 Hz
Zero Check (Analyzer Max Offset)	0 – 600 µg	2.0 µg
Span Check (Analyzer Max Offset)	0 – 600 µg	4.0 µg
Zero AutoCal (Probe Max Offset)	0 – 600 µg	2.0 µg
Span AutoCal (Probe Max Offset)	0 – 600 µg	4.0 µg
Probe Dilution Factor	1 – 100	30
Hg(0) Concentration	0 – 600 µg	600 µg
Hg(2+) Concentration	0 – 600 µg	600 µg
Hg(t) Concentration	0 – 600 µg	600 µg
Mother Board Status		OK
Interface Board Status		OK

Probe Alarms Settings

Table 2–5. Probe Alarms Settings

Parameter	Range	Typical Value
Umbilical Temperature	100 – 200 °C	120 °C
Probe Temperature	190 – 250 °C	220 °C
Converter Temperature	700 – 900 °C	760 °C
Oxidizer Temperature	360 – 440 °C	400 °C
Heated Hovacal Line	240 – 260 °C	250 °C
Orifice Pressure	0.0 – 3.0 psig	0.5 psig
Dilution Pressure	0.0 – 70.0 psig	50 psig 83*i*, 35 psig 83*i* GC
Blowback Pressure	0.0 – 70.0 psig	60 psig
Eductor Pressure	0.0 – 30.0 psig	10 psig
Vacuum Pressure	0.0 – 29.0 inHg	21.0 inHg 83i, 18 inHg 83*i* GC

Normal Operational Parameters (with 83*i*)

Table 2–6 lists the 83*i* normal operational parameters.

Note Table 2–6 is a guideline. All values based on 10 μg/m³ at ~9 LPM. Eductor pressure is set to 5 psig for wet stack and 15 psig during dry stack application. If the orifice pressure is greater than 1.0 psig during a filter zero or span, it is possible that the probe inlet is clogged (because the outlet isolation valve is closed, and if the inlet stinger is clogged, the cal gas pressurizes the fastloop and pressurizes the orifice). ▲

Table 2–6. Normal Operational Parameters - 83*i*

Mode	Fastloop Actuator	Typ. Venturi Press (inH_2O	Typ. Orifice Press (psig)	81i Press (mmHg)	Eductor Press (psig)	83i Probe Cal/Zero Valve	83i Probe Spike Valve	83i Probe Stinger Blowback	83i Probe Filter Blowback
Sample	Open	0-4	0-1	~760	5 - 15	OFF	OFF	OFF	OFF
Analyzer Zero	Open	0-4	0-1	~760	5 - 15	OFF	OFF	OFF	OFF
Analyzer Span	Open	0-4	0-1	>800	5 - 15	OFF	OFF	OFF	OFF
Orifice Zero	Open	0-4	>2	~760	5 - 15	ON	OFF	OFF	OFF
Orifice Span	Open	0-4	>2	>900	5 - 15	ON	OFF	OFF	OFF
System Zero	Closed	>15	0-1	~760	0-1	OFF	ON	OFF	OFF
System Span	Closed	>10	0-1	850-1150	0-1	OFF	ON	OFF	OFF
Oxidizer	Closed			850-1150	0-1	OFF	OFF	OFF	OFF
Stinger Blowback	Open	0-4	>1	~760	5 - 15	OFF	OFF	ON	OFF
Filter Blowback	Open	0-4	>5	~760	5 - 15	OFF	OFF	OFF	ON

Normal Operational Parameters (with 83*i* GC)

Table 2–7 lists the normal operational parameters for the 83*i* GC.

Note Table 2–7 is a guideline. All values based on 10 µg/m³ at ~9 LPM. ▲

Table 2–7. Normal Operational Parameters - 83*i* GC

MODE	Typical Orifice Pressure (psig)	81*i* Pressure (mmHg)	Eductor Pressure (psig)	83*i* GC Cal/Zero Valve	83*i* Probe Spike Valve	83*i* Probe Stinger Blowback	83*i* Probe Filter Blowback
Sample	0-1	~760	5 thru 15	OFF	OFF	OFF	OFF
Analyzer Zero	0-1	~760	5 thru 15	OFF	OFF	OFF	OFF
Analyzer Span	0-1	>800	5 thru 15	OFF	OFF	OFF	OFF
System Zero	0-1	~760	0-1	OFF	ON	OFF	OFF
System Span	0-1	850-1150	0-1	OFF	ON	OFF	OFF
Oxidizer	0-1	850-1150	0-1	OFF	OFF	OFF	OFF
Stinger Blowback	>1	~760	5 thru 15	OFF	OFF	ON	OFF
Filter Blowback	>5	~760	5 thru 15	OFF	OFF	OFF	ON

Nitrogen Generator Venting

Because the exhaust is oxygen rich, proper precautions should be taken when venting. Any back pressure on the Nitrogen Generator exhaust will affect nitrogen purity. Vent the nitrogen exhaust via a 3/8-inch or larger tube.

Shut Down the System (prior to removal)

Use the following procedure for powering down the system before removal. The probe should be removed within two hours, otherwise stack gas and moisture will condense inside the probe and cause contamination.

Use the following procedure to shut down the system.

1. Turn the system air supply **OFF**.

2. At the 80*i* Main Menu, select > Mode > **FILTER ZERO**.

3. At the 80*i*, 81*i*, and 82*i* front panels, turn the power switches **OFF**.

4. At the 82*i* rear panel, disconnect the 120 VAC plug from the UPS connector, and disconnect the 208/220 VAC from the rear connectors.

5. Turn the sample pump **OFF**.

6. Inside the 82*i*, turn the two hot line power breakers **OFF**.

Updating Firmware

The firmware can be updated by the user in the field via the serial port or over the Ethernet. This includes both the main processor firmware and the firmware in all low-level processors. Refer to the *iPort* manual for the firmware update procedure.

Chapter 3
Calibration

Manual System Calibration

Use the following procedure to manually calibrate the Mercury System.

1. From the Model 80*i* Main Menu, select Instrument Controls > Auto/Manual Mode > **Hg(0)**.

2. From the Main Menu, select **Averaging Time**.

3. Set the averaging time to 60 seconds.

4. From the Main Menu, select Instrument Controls > Gas Mode > **Instrument Zero**.

5. Allow approximately four minutes for the instrument to stabilize.

6. From the Main Menu, select Calibration > **Calibrate Hg(0) Background**, and press ↵.

7. From the Main Menu, select Instrument Controls > Gas Mode > **Instrument Span Mode**.

8. From the Main Menu, select Calibration > Auto Zero/Span Check > **Inst Hg Span Conc**, select any target value between Span 1 and 6, then press ↵.

9. Allow approximately four minutes for the instrument to stabilize.

10. From the Main Menu, select Calibration > **Calibrate Hg(0) Coefficient**.

11. Enter the 81*i* output concentration, and press ↵.

12. From the Main Menu, select Instrument Controls > Auto/Manual Mode > **Hg(t)**.

13. Repeat Steps 4 through 11 for Hg(t) mode.

14. From the Main Menu, select Instrument Controls > Auto/Manual Mode > **Hg(0)/Hg(t)**.

15. Set Average Time to 120 seconds.

16. From the Main Menu, select Instrument Controls > Gas Mode > **System Zero**.

17. Wait approximately 15 minutes for the instrument to stabilize.

18. From the Main Menu, select Calibration > **Cal Hg(0) Background**, and press ↵.

19. From the Main Menu, select Calibration > **Cal Hg(t) Background**, and press ↵.

20. From the Main Menu, select Calibration > Auto Zero/Span Check > **Sys Hg Span Conc**, and choose the target concentration (Span 1 through 6).

Note The Sys Hg Span Conc screen is available only while in Hg(0) or Hg(t) Manual mode. ▲

21. From the Main Menu, select Instrument Controls > Gas Mode > **System Span**.

22. Wait approximately 15 minutes for the instrument to stabilize.

23. From the Main Menu, select Calibration > **Calibrate Hg(0) Coefficient,** and enter the 81*i* output concentration pressure.

24. Repeat for Hg(t) Coefficient.

25. Verify the 80*i* concentration reads similar to the 81*i* output concentration value.

26. Record the following values:

    Hg(0) Coefficient ____________________

    Hg(t) Coefficient ____________________

Auto System Calibration

Use the following procedure to perform an auto calibration.

1. From the Main Menu, select Instrument Controls > **Service Mode**.

2. Verify Service mode is **OFF**.

3. From the Main Menu, select Calibration > **Auto Zero/Span Check**.

4. Set the parameters shown in **Table 3–1**. Individual user requirements may vary from the values shown in **Table 3–1**.

Table 3–1. Example of Parameter Settings

Parameter	Setting
next time	As Required
period hour	24 hours
inst zero durat min	10
inst span durat min	10
inst zero cal reset	ON
inst span cal reset	ON
inst hg span conc	Span 3
sys zero durat min	15
sys span durat min	15
sys zero cal reset	ON
sys span cal reset	ON
sys hg span conc	Span 3
purge duration min	0
zero/span avg sec	120

Calibration Check Procedures

The system calibration check requires the calibration gas to go through all system components. The calibration check must be done daily with either Hg^0 or $HgCl_2$. Since the system uses a converter, if elemental Hg is used, you must do weekly system integrity checks.

The 80*i* automatic calibration check requires the following pre-conditions:

Analyzer Service Mode must be OFF.

Analyzer **must** control the Calibrator.

Zero / Span Check Set-up

Refer to **Table 3–2** for setting up the Zero/Span Check (from the Main Menu, select Calibration > **Auto Zero/Span Check**).

Table 3–2. Zero/Span Check Set Up

Parameter	Setting
Instrument Zero Duration Min	Duration of Analyzer Zero - typically 5 to 6 minutes
Instrument Span Duration Min	Duration of Analyzer Span - typically 5 to 6 minutes
Instrument Zero Cal Reset	Automatically update the Analyzer Background factor at the end of Zero Duration step
Instrument Span Cal Reset	Automatically update the Analyzer Coefficient at the end of Span Duration step
Instrument Hg Span Conc	Target value for Instrument Span. Update this value for Linearity Check.
Sys Zero Durat Min	Duration of Sys Zero - typically 10 to 15 minutes
Sys Span Durat Min	Duration of Sys Span - typically 10 to 15 minutes
Sys Zero Cal Reset	Automatically update the Sys Background factor
Sys Span Cal Reset	Automatically update the System Hg(0) / Hg(t) coeff
Sys Span Conc	Target value for Sys Span. Update this value for Linearity Check.

Chapter 4
Troubleshooting

The Mercury Freedom™ System has been designed to achieve a high level of reliability. In the event of problems or failure, the troubleshooting guidelines and system reference diagrams presented in this manual should be helpful in identifying and isolating problems.

The Technical Support Department at Thermo Fisher Scientific can also be consulted in the event of problems. See "Service Locations" at the end of this chapter for contact information. In any correspondence with the factory, please note both the serial program number(s) of the various instruments.

This chapter provides the following troubleshooting and service support information:

Safety Precautions

Read the safety precautions at the front of this manual before performing any actions described in this chapter.

System Troubleshooting Guides

The troubleshooting guides presented in this chapter are designed to help identify and isolate system-level problems.

These guides provide general troubleshooting information, indicate the checks that you should perform if you experience a Mercury System problem, list all the alarm messages you may see on the display, and provide recommendations about how to resolve the problem.

Note Refer to the individual Mercury instrument manuals for instrument-level troubleshooting information. ▲

Before Calling for Service Support

Before calling for service support, follow the recommended fault identification and isolation troubleshooting procedures in this chapter. Start with the "Most Common Service Calls" section that follows.

Next check the appropriate troubleshooting guides in the following sections:

- "Power-Up Failures" on page 4-3
- "Alarm Messages" on page 4-4
- "Firmware and Communications Troubleshooting" on page 4-12
- "System Zero and Calibration Troubleshooting" on page 4-12
- "Troubleshooting Interface Board Voltages" on page 4-15
- "Probe Troubleshooting with 82*i* LEDs" on page 4-15
- "Oxidizer Troubleshooting" on page 4-16
- "Heated Hovacal Line Troubleshooting" on page 4-18
- "Troubleshooting - Miscellaneous" on page 4-19

Note The Service mode includes parameters and functions that are useful when making adjustments or diagnosing problems. ▲

Most Common Service Calls

Table 4–1 lists the most common calls to the service support center. You should check this list and the corresponding recommended resolutions first before calling for service support.

Table 4–1. Troubleshooting – Most Common Service Calls

Malfunction	Possible Cause	Action
80*i* or 81*i* screen disappears on laptop	*i*Port failure	Close any open windows and restart *i*Port.
Filter/System span will not reach 81*i* value	Hydrator empty or liquid/gas leak	Ensure top reservoir is filled and the fill logic is correct.
Eductor pressure near 0 in sample mode	82*i* Pressure regulator failed	Tap regulator with screwdriver, replace if necessary.
Venturi reading near 0 while eductor reads 'good'	Probe pressure transducer failed	Replace transducer – 83*i* only.
Venturi reading abnormally high or low	Venturi ports partially or completely obstructed	Try cleaning venturi, but replacement is likely.
Filter span will not reach 81*i* value	Occluded filter or occluded critical orifice	Try cleaning filter or orifice, but replacement is likely.
80*i* flow too high	Broken/leaky critical orifice (pre-convertor/scrubber)	Inspect probe for break or plumbing leak.

Malfunction	Possible Cause	Action
83*i* ONLY - Venturi pressure “bad”, eductor pressure “good”	Isolation valve not rotating	Inspect visually and check wiring at probe.
Probe does not heat	Heater cartridge slipped out because of vertical probe mounting	Use tie wrap to secure heater.
	Component power OFF	Turn component power ON.
	Blown fuse in 82*i* power distribution board	Replace fuse.
Alarm bell symbol for Hg alarm	Hg(0) or Hg(2+) giving negative number / ceiling value substituted for floor	Calibrate / change ceiling value back to floor.
80*i* will not accept value < 3 $\mu g/m^3$ for calibration	80*i* and 81*i* firmware are not the same	Use 81*i* for setting calibration value.
Vacuum leaks in 83*i* GC	O-rings have melted or partially combusted/probe temperature runaway	Find cause of temp runaway. Replace O-rings.
Vacuum leak in 83*i* GC during Hg(T) analysis	Melted Teflon at convertor tube when probe enclosed	Install stainless fittings with Teflon ferrules at each end of convertor.
Convertor temp too low	Relay in 82*i* failed or heater burned out	Replace relay or heater.
Convertor temp too high	Relay in 82*i* failed and heater has not burned out yet	Replace relay.
High chamber pressure, noisy vacuum pump	Vacuum pump failed or is about to fail	Replace or rebuild pump.
Hydrator not filling or Hydrator bubbling	Hydrator valve not opening at proper time	I/O Configuration not set correctly. See “Hydrator” on page 6-1.

Power-Up Failures

Table 4–2 describes possible power-up failures and provides the recommended action to take to restore the system to normal operation.

Table 4–2. Troubleshooting – Power-Up Failures

Malfunction	Possible Cause	Action
Does not start - the light on power switch does not come on.	No power or wrong power configuration	Check the line to confirm that power is available and that it matches the voltage and frequency configuration of the instrument.
	Main fuse is blown or missing.	Unplug the power cord, open the fuse drawer on the back panel, and check the fuses visually or with a multimeter.

Malfunction	Possible Cause	Action
	Bad switch or wiring connection	Unplug the power cord, disconnect the switch and check operation with a multimeter.
Display does not come on - light on power switch does come on.	DC power supply failure	Check the green LED on the back edge of the power supply. If the LED is off, the power supply failed.
	DC power distribution failure	Check surface mount LEDs labeled “24V PWR” on the motherboard and the interface board. If lit, power is OK.
	Display failure	If possible, check instrument function through RS-232 or Ethernet.
		Reboot instrument.
		Contact Thermo Fisher Scientific Service Department.

Alarm Messages

Table 4–3 describes the alarm messages for the 80*i* and the 81*i*. The 81*i* alarms are indicated with “Alarm 81*i*” in the Alarm Message description. When a reference to a manual is included in the Action description, go to the associated manual, such as the 80*i* or 81*i*, not this “Mercury System Manual.”

Table 4–3. Troubleshooting – Alarm Messages

Alarm Message	Possible Cause	Action
Alarm 81*i* - Ambient Temp	Instrument overheating	Replace fan if not operating properly.
		Clean or replace foam filter, refer to the “Preventive Maintenance” chapter in the manual.
Alarm - Blowback Pressure	Low pressure - leak	Perform a leak test.
	High pressure	Check blowback pressure set point.
Alarm - Chamber Temp	Chamber temperature below set point	Check 10K thermistor, replace if bad.
	Heaters failed	Check connector pins for continuity.
Alarm - Converter Temp	Low or at ambient temp	Check voltages and continuity. Check component power status.
	High temp	Check set point.
Alarm 81*i* – Cooler Temp	Cooler temp does not match setting	Check Cooler fan/clean filter.
Alarm - Dilution	Low pressure - leak	Perform a leak test.

Alarm Message	Possible Cause	Action
Pressure		
	High pressure	Check dilution pressure set point.
Alarm - Eductor Pressure	Low pressure - leak	Perform a leak test.
		Check component power status.
	High pressure	Check eductor pressure set point.
Alarm - Flow	Flow low	Check 80*i* and 83*i* critical orifices.
		Make sure the sample particulate filter in the 83*i* is not blocked. Disconnect lines from the sample bulkheads, if flow increases, replace the filter.
Alarm - Intensity	Low - lamp is failing	Replace lamp.
Alarm - Internal Temp	Instrument overheating	Replace fan if not operating properly.
		Clean or replace foam filter.
	Ambient temperature resistor open or shorted	Check ambient temperature resistor.
	Bad interface board	Check interface board.
83*i* ONLY Alarm - Orifice Pressure	Low pressure – system leak	Perform a leak test.
	High pressure – blocked orifice	Check orifice.
Alarm - Pressure	High pressure indication	Remove line from pressure transducer. The pressure reading should go to ambient. Calibrate the pressure transducer, if necessary.
		Check input of external pump with vacuum gauge and repair or replace pump as necessary. Deadheaded vacuum should be approx. 12 mmHg. For pump repair, refer to the pump manual.
		Check flow system for leaks.
Alarm - Probe Dilut Factor	Refer to the "Troubleshooting" chapter in the "Model 83*i* Instruction Manual."	
Alarm - Probe Temp	Low or at ambient temp	Check set point.
	High temp	Check set point.
	Component power is OFF	Check that component power is ON.
		Check that temperature is set to 220 °C.
		Check AC voltage to probe.
		Check communication between 80*i*/81*i*/82*i*.
		Check cabling in back of instruments.

Alarm Message	Possible Cause	Action
		Measure ohms of thermocouple and heater. Check fuse on 82*i* power distribution board.
Alarm – Span Autocal		Check coefficients.
Alarm – Span Check		Check coefficients.
Alarm - Umbilical Temp	Low or at ambient temp	Check voltages and continuity. Check breakers in 82*i*.
	High temp	Check set point.
	Component power is OFF	Check that component power is ON.
	Temperature is not set to 120 °C	Check that temperature is set to 120 °C.
	No AC voltage to probe	Check that AC voltage is applied to probe.
	Faulty communication between 80*i*/81*i*/82*i*	Check communication between 80*i*/81*i*/82*i*.
	Cabling problem to instruments	Check cabling in back of instruments. Measure ohms of heater.
Alarm - Vacuum Pressure	Low pressure - leak	Perform a leak test. Ensure dilution air pressure is ON: ~35 psig for 83*i* GC, ~ 45 psig for 83*i*.
	High pressure - blockage	Check system for blockage.
Alarm - Venturi Pressure	Low pressure - leak	Check eductor.
Alarm - Zero Autocal		Check coefficients.
Alarm - Zero Check		Check coefficients.
The following board related alarms only occur during power up or reboot.		
Alarm - Interface Status Alarm - I/O Exp Status Alarm - Motherboard Status	Internal cables not connected properly Defective board	Check that all internal cables are connected properly. Cycle AC power to instrument. If still alarming, change board.

System Zero and Calibration Troubleshooting

Table 4–4 describes possible zero and calibration malfunctions and provides the recommended action to take to restore the system to normal operation.

Table 4–4. Troubleshooting – System Zero and Calibration

Malfunction	Possible Cause	Action
Cannot zero instrument or there is a high background signal when sampling zero air (zero air should produce a reading equivalent to less than 1 µg/m^3 multiplied by the dilution factor).	Zero air system is faulty, needs new scrubbers or requires maintenance	Test against an ultra-zero cylinder from a reputable scientific gas supplier or check effect of a new chromatography grade activated charcoal scrubber installed at the instrument inlet.
	Zero air flow rate is inadequate	Verify that the zero air system is providing adequate flow.
	Instrument is not drawing in zero or span gas	Check sample flow and pressure readings (Diagnostics menu).
		Ensure that zero/span valves are functioning.
		Use an independent flow meter to check flows at the zero inlet and exhaust bulkheads (they should match).
		Perform a leak test.
	Internal or external lines, filters, and other sample handling equipment are contaminated or dirty	Replace inlet filter (if installed) and as much of the tubing as possible with clean Teflon only.
	High scattered light	Go to Instrument Controls, select Lamp Compensation and toggle to OFF. If the previously high signal drops to zero or less when the lamp is OFF, the problem may be caused by scattered light from dust in the optical bench.
	Input board failure	Disconnect the input board from the interface board by unplugging ribbon cable labeled “INPUT.” The instrument reading should drop to zero or to a negative value.

Malfunction	Possible Cause	Action
	Critical orifice blocked	Check/clean orifice.
	External pump failure	Replace the external pump.
Instrument or system appears to zero, but there is weak or no response to span gas.	Insufficient air to 81*i*	Check the source pressure to the 81*i*. The pressure should be 30 psig.
	Calibration system failure	Check solenoids or other hardware to be sure that span gas is being delivered to the correct spot.
	Flow rate of the diluted span mix is inadequate	Verify that the zero air system is providing adequate flow.
	Critical orifice blocked	Check/clean orifice.
	Instrument is not drawing in span gas	Check sample flow and pressure readings (Diagnostics menu).
		Use an independent flow meter to check flows at the span inlet and exhaust bulkheads (they should match).
		Perform a leak test.
	Hg is being absorbed by tubing, filters, or dirt in the calibration system	Replace any lines made of vinyl or other plastics with fresh Teflon.
		Replace Teflon filter membranes that look dirty. Remove any filters that are not Teflon membranes.
	Lamp failed	Check the lamp intensity (Diagnostics menu) and voltage.
	81*i* output problem	Check 81*i* to verify output concentration.
	PMT or input board has failed	With previous coefficients and PMT voltage known, introduce a known concentration of span gas.
	Hydrator gas leak or no water	Check to see if bottom reservoir has water. Locate gas leak and repair.
Zero or Span will not stabilize	Flow rate of either zero of span gas is inadequate	Verify that the zero air system is providing adequate flow.
	Instrument is not drawing in span gas	Check sample flow and pressure readings (Diagnostics menu).
		Use an independent flow meter to check flows at the span inlet and exhaust bulkheads (they should match).

Malfunction	Possible Cause	Action
		Perform a leak test.
	Hg is being absorbed or released by dirt in the tubing or filters of the calibration system, or contamination inside the instrument	Replace any lines made of vinyl or other plastics with fresh Teflon. Replace Teflon filter membranes that look dirty. Remove any filters that are not Teflon membranes.
	Hydrator gas leak or no water	Check to see if bottom reservoir has water. Locate gas leak and repair.
	External pump failure	Replace the external pump.
	Averaging time is not set correctly.	Check the Averaging Time (Main Menu). If too high, the unit will be slow to stabilize. If too low, the signal may appear noisy. Set Averaging Time to one minute.
	Hot line temperature failure	Ensure hot line has power.
Reduced response or no response to sample gas with alarm(s) indicated	Undefined electronic failure or external pump failure	Check alarm screens and the diagnostic voltage screen to localize fault.
	Instrument is not drawing in sample as expected.	Check sample flow and pressure readings (Diagnostics menu).
		Check pump.
		Use an independent flow meter to check flows at the Hg(0) or Hg(t) inlet and exhaust bulkheads (they should match). Instrument should be in Manual mode with either Hg(0) or Hg(t) selected.
		Perform a leak test.
		Check the external plumbing for leaks or other problems.
		Check all external plumbing and the source of the sample to verify that the Hg is not being adsorbed by the sampling system. Lines carrying Hg must be made from clean Teflon.
	Instrument is not properly calibrated	Go to the Calibration Factors menu and verify that the Hg(t) Background and Hg(t) Coefficient are set appropriately.
	Input board malfunction	Go to Service menu and select Input Board Calibration > Input Frequency Display (ignore warning), and press Enter (leave Test off).

Malfunction	Possible Cause	Action
		At Gain = 1; Frequency = approx. 12 kHz.
		At Gain = 10; Frequency = approx. 80 kHz.
		At Gain = 100; Frequency = approx. 400 kHz.
	Signal cable failure	Go to Service menu and select Input Board Calibration > Input Frequency Display (ignore warning), and press Enter (leave Test off).
		Change Gain to 100. Frequency should be approx. 400 kHz. Unplug PMT signal cable. Frequency should drop to approx. 6 kHz.
	PMT failure	Check that the PMT voltage is approx. 750V (Service menu or Diagnostics menu).
	Lamp assembly failure	Check that the lamp intensity is approx. 80 kHz (Diagnostics menu).
Poor linearity	Nitrogen Generator feed air is not stable	Ensure air flow to Nitrogen Generator is regulated.
	Insufficient air of nitrogen flow to 81*i*	Check flows under Diagnostics menu in 81*i*.

Before the Mercury System leaves the factory, all instrument are configured and tested for proper intercommunication functionality. The following Steps are required only if there is a problem or when a system is configured in the field.

Use the following procedure to establish communication between the instruments in the Mercury System.

Establishing Communication Between Instruments in the Mercury System

Configure *i*Port as appropriate for your particular type of connection. Refer to *iPort Instruction Manual* for additional firmware communications and connection information.

Note If 81*i* is in Service mode, it will ignore 80*i* commands. ▲

1. After the 81*i* initializes, from the 81*i* Main Menu, select Instrument Controls > Communication Settings > **TCP IP Settings**, and set as follows:
   a. Set TCP/IP DHCP to **OFF**
   b. Set IP address to **192.168.1.201** (left justify)
2. From the 80*i* Main Menu, select Instrument Controls > Communication Settings > **TCP IP Settings**, and set DHCP to **OFF**.

   Ensure IP address differs from but is close to the 81*i* IP address, such as 192.168.1.200.
3. Under Main Menu, select Instrument Controls > **Service Mode**, and turn Service mode **ON**.

   The Service mode must be ON in order to change Cal Enable.
4. Return to Main Menu, select Diagnostics > **System Configuration**, and set the 81*i* Cal Enable to **YES**.
5. Return to System Configuration, enter the 81*i* TCP/IP address as displayed on the 81*i* (left justify).
6. Repeat the power-up sequence and ensure the 80*i*/81*i*/82*i* are communicating.

Cabling Instruments in the Mercury System

If the instruments in the Mercury System are not communicating as expected, check that the correct cables are being used and that they are connected properly.

Direct Connection

When connecting instruments within the Mercury System directly, use a crossover cable.

Hub/Router Connection

When connecting instruments within the Mercury System or connecting a local PC to the Mercury System via a hub or router, use straight cables. Do not use the UPLINK port unless you are connecting to a network or another hub.

Hub/Router Connection with UPLINK

When connecting instruments within the Mercury System or connecting a local PC to the Mercury System via a hub or router with an UPLINK port, use a crossover cable on the UPLINK port connection and a straight cable on the other port connections.

Firmware and Communications Troubleshooting

Table 4–5 describes possible firmware and communications malfunctions and provides the recommended action to take to restore the system to normal operation.

Table 4–5. Troubleshooting – Firmware and Communications

Malfunction	Possible Cause	Action
80*i* does not communicate with 81*i* or 82*i*	80*i* was powered up before 81*i*/82*i* were powered up	Shut down the three instruments. Power up 81*i* and 82*i*, wait 60 seconds, then power up the 80*i*.
	Units are not connected via secure cables	Check cable connections.
80*i* does not communicate with 81*i*	81*i* is in Service mode	Verify 81*i* is not in Service mode, set to OFF, if necessary.
81*i* will not respond to Gas mode commands from the 80*i*	80*i* configured improperly	Check 81*i* IP address under Diagnostics > System Configuration and ensure it reflects actual 81*i* IP address, left justified.
	81*i* in Service mode	Verify 81*i* is not in Service mode, set to OFF, if necessary.
	Incorrect Ethernet cables used	When attempting to communicate directly between instruments, a crossover cable is required. If using an Ethernet hub/switch port (other than UPLINK), straight cables are required.

Malfunction	Possible Cause	Action
	Ethernet cables disconnected or malfunctioning	Verify cable functionality, replace if necessary.
	Ethernet hub malfunction	Verify hub LEDs are lit. Troubleshoot/replace if necessary
Local PC will not connect via *i*Port	Incorrect Ethernet cables used	When attempting to communicate directly between the PC and instrument, a crossover cable is required. If using an Ethernet hub/switch port (other than the UPLINK port), straight cables are required.
	Ethernet hub malfunction	Verify hub performance, replace if necessary.
	*i*Port configured improperly	Open *i*Port, under File > Preferences, ensure proper selections are made.
		Under Instrument > TCP Connect, IP Addresses, ensure instrument IP addresses are listed correctly with a space between them.
	Local PC configured improperly	Under Network Connections, ensure the Internet Protocol (TCP/IP) Properties are set to reflect an IP address similar to those of the instrument(s). Also ensure the Subnet mask is 255.255.255.000.
82*i* diagnostic readings read zero (temp/pres)	RS-485 link down between 80*i* and 82*i*	Verify 15-pin RS-485 cable is connected between 80*i* and 82*i*.
		Verify DIP switch on 82*i* Interface Board is set to "00" (both switches in DOWN position).
		Verify RS-485 cable performance, replace if necessary.

Troubleshooting Interface Board Voltages

If a board has a voltage problem, the instrument generates an alarm for that board. Use the Voltages menu to access the particular board and to display the current diagnostic voltage readings.

- In the Main Menu, select Diagnostics > **Voltages**, and select the board.

```
VOLTAGES:
>MOTHERBOARD
 INTERFACE BOARD 80i
 INTERFACE BOARD 82i
 I/O BOARD




 RANGE   AVG   DIAGS ALARM
```

```
INTERFACE BRD80 VOLTAGES:
>   PMT SUPPLY      600.0 V
    3.3 SUPPLY        3.3 V
    5.0 SUPPLY        5.0 V
   15.0 SUPPLY       15.0 V
  P15.0 SUPPLY       15.0 V
   24.0 SUPPLY       24.0 V
  -15.0 SUPPLY      -15.0 V

 RANGE   AVG   DIAGS ALARM
```

Model 80*i* interface board voltages screen

When a voltage reading displayed on the Interface Board Voltages screen is different than the normal value, check the actual voltage reading on the interface board with a voltmeter. You can also use a voltmeter to check interface board voltages when the voltage readings are normal but you suspect there is a board problem.

Note If the interface board voltages all read 0.0 V, check that the 24 V LED is ON (**Figure 4–1**). If it is not ON, 24 V power is not being applied to the interface board. ▲

The interface board provides voltage check points for verifying board voltages. Refer to **Figure 4–1** for the interface test point locations on the interface board.

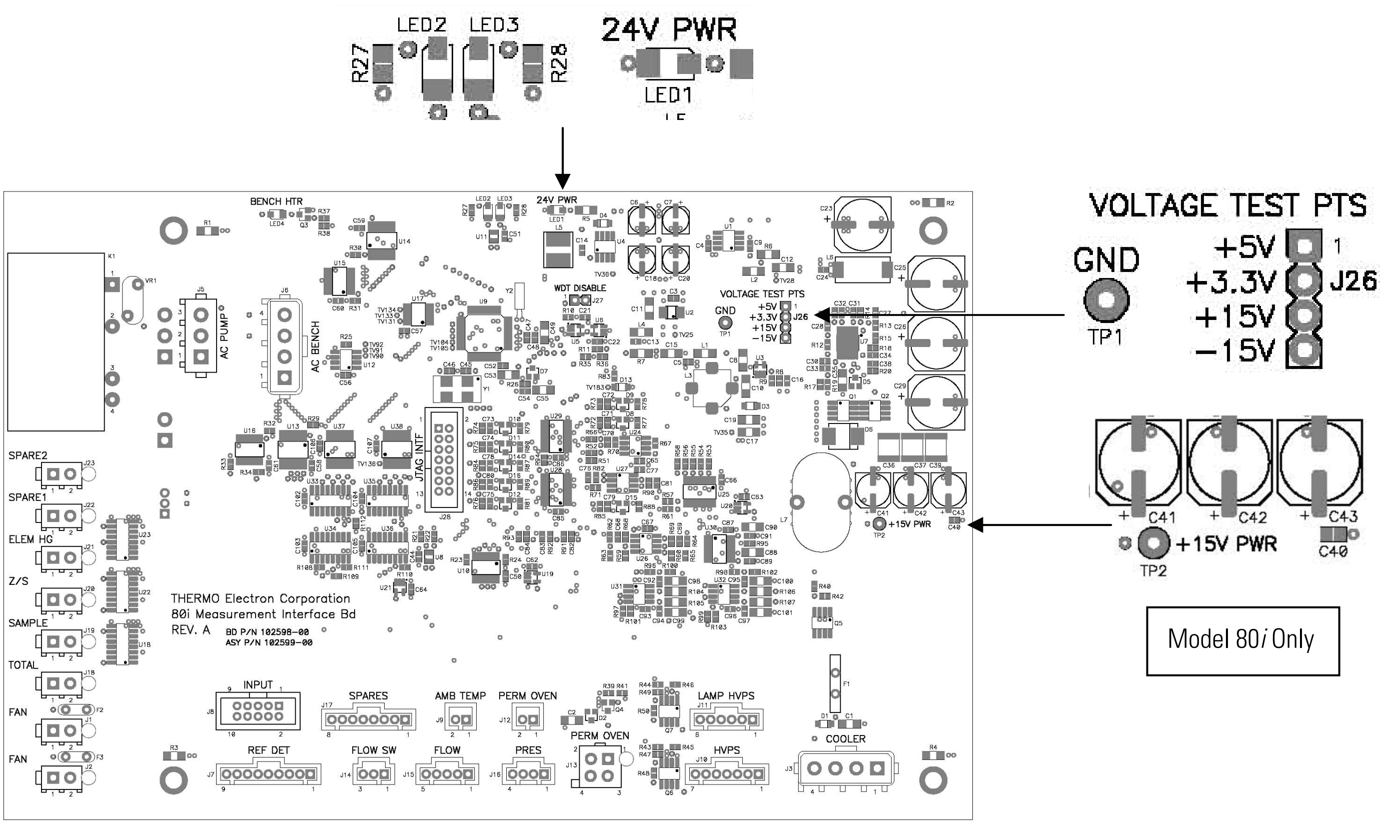

Figure 4–1. Example of Model 80*i* Interface Board Voltage Test Point Locations

Probe Troubleshooting with 82*i* LEDs

LEDs on the 82*i* measurement interface board are used to troubleshoot the 82*i* and the 83*i*. Each LED represents a valve in either the 82*i* or 83*i*. When an LED is ON, the associated valve is ON. Refer to **Table 4–6** for a recommended troubleshooting action to perform. In most cases, the problem will involve wiring and/or plumbing.

Table 4–6. Probe Troubleshooting – 82*i* Measurement Interface Board LEDs

LED No.	Description	Action
4	Blowback stinger (83*i*)	Check air supply and pressures via diagnostics. Check air at the probe.
5	Blowback filter (83*i*)	
6	Cal zero (83*i*)	Verify that the 81*i* is outputting cal gas, diagnostics, flows. Check at probe also.
7	Hg spike (83*i*)	
8	Eductor (82*i*)	Check failsafe temperature.
9	Dilution (82*i*)	Check air supply and pressures via diagnostics. Check air at the probe.

LED No.	Description	Action
10	Mercury valve (83*i*)	Verify that the 81*i* is outputting cal gas, diagnostics, flows. Check at probe also.
11	Chlorine valve (83*i*)	Check tank and shutoff valve.

Troubleshooting 82*i* Interface Board LEDs

LEDs at the top of the 82*i* interface board can be used to troubleshoot communication and 24 V problems (**Table 4–7**). LED2 normally blinks brightly and LED3 blinks dimly.

Table 4–7. Communication and 24 V Troubleshooting – 82*i* Interface Board LEDs

LED	Status	Malfunction	Action
LED1	OFF	24 V power not applied to interface board	Check cable.
LED2 LED3	OFF	Bad RS-485 connection	Check RS-485 connection.

Oxidizer Troubleshooting

Table 4–8 describes possible oxidizer malfunctions and provides the recommended action to take to restore the system to normal operation.

Table 4–8. Troubleshooting – Oxidizer

Malfunction	Possible Cause	Action
Low total mercury reading during oxidizer test	Hydrator is leaking	Leak test the hydrator to ensure there are no gas leaks. Use a hand vacuum pump and gauge assembly, or pressurize to 10 psig and use Snoop® leak test solution.
	Hydrator is dry	Bottom cylinder is empty because the I/O is not properly configured. The top cylinder is out of water.
	Cold spots in the probe (low Hg(t) readings)	The probe cover is off or not on tightly. Insulation is missing from internal tube assemblies.
	Poor recovery after an oxidizer test without flue gas	If oxidizer tests are being conducted (anywhere without flue gas), adding humidity when in Sample mode will "condition" the probe quicker between oxidizer runs. The added moisture will remove excess Cl_2 and $HgCl_2$.
	O-ring seal on filter access disk	Remove the filter access disk, and ensure that the face seal O-ring is not scored or otherwise

Malfunction	Possible Cause	Action
		compromised. Replace as required.
	Contaminated filter	If the probe has been running in a stack for more that 6 months without any preventive maintenance, remove and clean the filter in an ultrasonic bath or replace it.
	Calibration gas not transported by heated line	The elemental mercury calibration gas generated by the Model 81*i*, should be transported to the probe using a 3/8-inch heated PFA line (line #3 in the supplied umbilicals).
Poor oxidation, low total mercury reading during oxidizer test	Cl_2 valve or Hg valve not opening	Check the wiring of the umbilical to the probe (check valve grounding). Using an appropriate flowmeter, check the flow of both Hg and Cl_2 to the inlet of the oxidizer while in oxidizer mode (note that the Cl_2 valve has a 15 minute delay). For s/w versions 01.00.21.231 or later, this delay can be adjusted. Ensure that the 82*i* is communicating with the 80*i* and opening the valves when required. On the 82*i* interface board, the left most LED indicates that power is being sent to the Hg valve. The 2nd left most LED indicates that power is being sent to the Cl_2 valve.
	Leak in the Hg or Cl_2 valve to the oxidizer (in probe)	Ensure that the tubing and fittings on both the inlet and outlet of the Hg valve are leak tight. (Specifically check the 2-inch piece of Teflon tubing that connects valve 4 to valve 6.)
Slow total channel recovery after Cl_2 valve is ON	Quartz wool in either the inlet or exit fitting of the converter tube (affects total efficiency)	Shut the sample pump OFF, remove both the inlet and outlet fittings from the converter tube, and ensure there is no quartz wool in the fittings or tubing. If there is, clean and replace.
Poor oxidation, elemental mercury reading stays high	Cl_2 orifice plugged	Using a flowmeter (with appropriate Cl_2 compatible material), measure the flowrate of the Cl_2 after the regulator and orifice assembly. If there is low flow or no flow, clean orifice in an ultrasonic bath or by pressurizing orifice with water.
Low total efficiency	Mercuric chloride is being lost on cold spots	Check probe insulation and repair as necessary.

Malfunction	Possible Cause	Action
Prior to System Integrity test, baseline Hg reading is not flat	oxidizer not fully purged from previous test	Increase Post Condition duration.
High 80*i* pressure	Leaks in tubing	Check probe tubing for leaks and repair as necessary.

Heated Hovacal Line Troubleshooting

Table 4–9 describes possible heated Hovacal line malfunctions and provides the recommended action to take to restore the system to normal operation.

Table 4–9. Troubleshooting – Heated Hovacal Line

Malfunction	Possible Cause	Action
Low total mercury reading during ionic mercury (Hg) calibration	Hydrator is leaking	Leak test the hydrator to ensure there are no gas leaks. Use a hand vacuum pump and gauge assembly, or pressurize to 10 psig and use Snoop® leak test solution.
	Hydrator is dry	Bottom cylinder is empty because the I/O is not properly configured. The top cylinder is out of water.
	Cold spots in the probe (low Hg(t) readings)	The probe cover is off or not on tightly. Insulation is missing from internal tube assemblies.
	Poor recovery after an ionic mercury (Hg) calibration without flue gas	If ionic mercury (Hg) calibration tests are being conducted (anywhere without flue gas), adding humidity when in Sample mode will "condition" the probe quicker between oxidizer runs. The added moisture will remove excess Cl_2 and $HgCl_2$.
	Calibration gas not transported by heated line	The elemental mercury calibration gas generated by the Model 81*i*, should be transported to the probe using a 3/8-inch heated PFA line (line #3 in the supplied umbilicals).
Poor ionic calibration, low total mercury reading during ionic test	Leak in the Hovacal line to the heated blocks (in probe)	Ensure that the tubing and fittings on both the inlet and outlet of the heated blocks are leak tight.
Slow total channel recovery after Hovacal is ON	Quartz wool in either the inlet or exit fitting of the	Shut the sample pump OFF, remove both the inlet and outlet

Malfunction	Possible Cause	Action
	converter tube (affects total efficiency)	fittings from the converter tube, and ensure there is no quartz wool in the fittings or tubing. If there is, clean and replace.
Poor ionic calibration, elemental mercury reading stays high	No flow	Using a flowmeter, measure the flowrate of the Hovacal input.
Low total efficiency	Mercuric chloride is being lost on cold spots	Check probe insulation and repair as necessary.
High 80*i* pressure	Leaks in tubing	Check probe tubing for leaks and repair as necessary.

Troubleshooting - Miscellaneous

Table 4–10 describes possible malfunctions and provides the recommended action to take to restore the system to normal operation. When a reference to a manual is included in the Action description, go to the associated manual, such as the 80*i* or 81*i*, not this "Mercury System Manual."

Table 4–10. Troubleshooting – Miscellaneous

Malfunction	Possible Cause	Action
Excessive noise or spikes on analog outputs	Defective or low sensitivity PMT	With previous coefficients and PMT voltage known, introduce a known concentration of span gas.
	Defective input board or BNC connection	Identify the defective component and replace.
	Noise pick-up by recorder or data logger	Check analog cable shielding and grounding.
		Try to localize source of noise by comparing analog signal to data collected through RS-232 or Ethernet.
Excessive response time	Averaging time is not set correctly	Go to Averaging Time (Main Menu) and verify setting (should be one minute).
	Instrument is not drawing in sample at normal flow rate	Check sample flow and pressure readings (Diagnostics menu).
		Use an independent flow meter to check flows at the Hg(0) or Hg(t) inlet and exhaust bulkheads (they should match). Instrument should be in Manual mode with either Hg(0) or Hg(t) selected.
		Perform a leak test.
	Hg is being adsorbed and/or released by dirt	Replace any lines made of vinyl or other plastics with fresh Teflon.

Malfunction	Possible Cause	Action
	in the tubing or filters of the sampling system, or inside the instrument	
	Hydrator gas leak or no water	Check to see if bottom reservoir has water. Locate gas leak and repair.
Analog signal doesn't match expected value.	Firmware has not been configured	Verify that the selected analog output has been properly configured to match the data system. Refer to "Analog Output Testing" in the "Servicing" chapter.
	Analog output goes above full-scale value or below zero	By default, a 5% over and underrange on the analog outputs is provided. If this is not desirable due to system restrictions, it may be turned off in the Instrument Controls > I/O Configuration > Analog Output Config screens.
	Recorder is drawing down output	Verify that the recorder or data logger input impedance meets minimum requirements.

Service Locations

For additional assistance, Thermo Fisher Scientific has service available from exclusive distributors worldwide. Contact one of the phone numbers below for product support and technical information or visit us on the web at www.thermo.com/aqi.

1-866-282-0430 Toll Free

1-508-520-0430 International

Chapter 5
Preventive Maintenance

This chapter describes the periodic maintenance procedures that should be performed on the system instruments and components to ensure proper operation. For instrument-level preventive maintenance information, refer to the manuals for the individual instruments.

Since usage and environmental conditions vary greatly, you should inspect the system components frequently until an appropriate maintenance schedule is determined.

IMPORTANT NOTE The 81*i* has been calibrated at the factory against a NIST traceable vendor prime. Any adjustments made will void NIST traceability. ▲

This chapter includes the following maintenance information and replacement procedures:

Safety Precautions

Read the safety precautions before beginning any procedures in this chapter.

WARNING The service procedures in this manual are restricted to qualified representatives. ▲

System Preventive Maintenance

Table 5–1 provides a list of components and supplies that require periodic maintenance.

Table 5–1. Preventive Maintenance Schedule

Task	Time Required	Monthly	Quarterly	Semi Annually
Cleaning Sample Lines (Total / Elemental)	6 Hours			
Check Indicating Silica Gel on Dryer	30 Minutes	X		
Replace Dryrite	30 Minutes			X
Replace Carbon	30 Minutes			X
Replace Purafil	30 Minutes			X
Replace Air Clean-up Filters	15 Minutes			X
Hydrator	15 Minutes	X		
Heated umbilical - Cleaning the Total and Elemental lines	4 Hours		X	
Replace Transport Pump	15 Minutes		As required	

Heated Umbilical

The heated umbilical keeps mercury from adhering to the PFA tubing. The umbilical connects the microprocessor-driven probe control unit to the stack probe and mercury converter.

The umbilical contains heated PFA transport tubing, signal and power cables. The heated umbilical contains eight lines, three heated PFA lines and five unheated lines.

The three heated PFA lines consist of:

- Two lines for the total and elemental mercury, ¼-inch diameter, 0.040-inch wall thickness
- One line for the 81*i*, 3/8-inch diameter, 0.062-inch wall thickness

The remaining five unheated lines are for the dilution air, vacuum, blowback, eductor air, and one is a spare.

Four to five electrical connectors plug into the 82*i*. An umbilical more than 200 feet long requires five connectors.

The 82*i* controls the temperatures of the heated umbilical line. The 82*i* is capable of controlling two zones (in parallel). The connector labels are A1 and A2. A1 is the primary and A2 is for the +200 foot-long power. Each one of these connectors also has two, type K thermocouples. Use the A2 thermocouples for troubleshooting only. The A1 connector has the *controlling* thermocouple along with a spare. Refer to **Figure B–4** on page B-5.

- Connector B is for the four heaters at the probe, stinger, converter, probe heater, and oxidizer heater.
- Connector C is for the 4-20 mA pressure transducers up at the probe, venturi, orifice pressures for the 83*i*, and orifice the 83*i* GC.
- Connector D is for controlling the valves, orifice cal, filter cal, filter blowback, stinger blowback, and the oxidizer valves.

Heated Umbilical Maintenance

Use the following procedure to clean the Total and Elemental lines. Refer to **Table 5–1** for the recommended cleaning schedule.

Cleaning Materials Required:

5% solution of nitric acid mixed with DI water

Distilled water

1. Turn the power OFF to the umbilical or set it to 50 °C.
2. Disconnect the Total and Elemental lines from the 80*i*.
3. Disconnect the Total and Elemental lines up at the 83*i*.
4. Place a collection container at the CEMS rack and insert either the Total or the Elemental line into it.
5. Go up to the probe and pour one quart of distilled water (DI); let it drain down the line. Ensure there are no low spots where water can collect.
6. Pour in one quart of dilute nitric acid solution (5% solution of nitric acid mixed with DI water); allow to drain.
7. Flush with one quart of DI water again.
8. Repeat Steps 5 through 7 and then purge both lines with zero air for approximately one hour.

9. Reconnect tubing and turn ON or set umbilical to the operating temperature (~120 °C).

Note The recommended umbilical cleaning interval is site specific. Inspect the umbilical periodically until you establish a cleaning schedule appropriate for your site. ▲

Service Locations

For additional assistance, Thermo Fisher Scientific has service available from exclusive distributors worldwide. Contact one of the phone numbers below for product support and technical information or visit us on the web at www.thermo.com/aqi.

1-866-282-0430 Toll Free

1-508-520-0430 International

Chapter 6
Optional Equipment

The Mercury System is available with the following options:

- "Mercuric Chloride Generator" on page 6-1
- "Heated Hovacal Line" on page 6-1
- "Hydrator" on page 6-1
- "Zero Air Supply" on page 6-7
- "Nitrogen Generator" on page 6-7

Mercuric Chloride Generator

The TFS Mercuric Chloride Generator (oxidizer) uses a patented process by which chlorine gas is mixed with elemental mercury (**Figure 1–6**). This mixing is done a short distance from the probe injection point to help minimize contact of mercuric chloride with cold spots. Mercuric chloride ($HgCl_2$) will adsorb or react on any "cool" surface (below 190 °C). The chlorine is supplied by a small cylinder (900 ppm Cl_2 in N_2 Balance), and the elemental mercury is supplied by the Model 81*i* elemental Hg generator

An oxidized mercury source is required in order to comply with 40 CFR Part 75 which states that a system integrity test needs to be performed once a week.

Heated Hovacal Line

The Heated Hovacal Line allows for ionic Hg calibrations utilizing Hovacal equipment.

Hydrator

The Hydrator humidifies calibration gas, improves system response, and provides more complete recovery (**Figure 1–9**).

Hydrator Installation

Use the following procedure to install the Hydrator.

System Preparation

Remove CDA to system by closing the air handling inlet valve on the side of the rack. Monitor pressure gauge on the regulator assembly and proceed when pressure drops to zero psi.

Equipment Installation on Rack Exterior

Use the following procedure to mount the Hydrator on the rack exterior.

1. Mount the Hydrator assembly in the location specified. Be aware that the unit will be mounted in the upright position, as shown in **Figure 6–1**. Use appropriate stainless steel hardware, such as 1/4 -20 to mount the assembly to the rack.

2. If retrofitting a fielded system, use the through-holes on the Hydrator mounting tabs to mark the mounting hole location, and taking care not to over-penetrate, drill mounting holes using the appropriate drill/bit setup. Use appropriate stainless steel hardware, such as 1/4 -20 to mount the assembly to the rack.

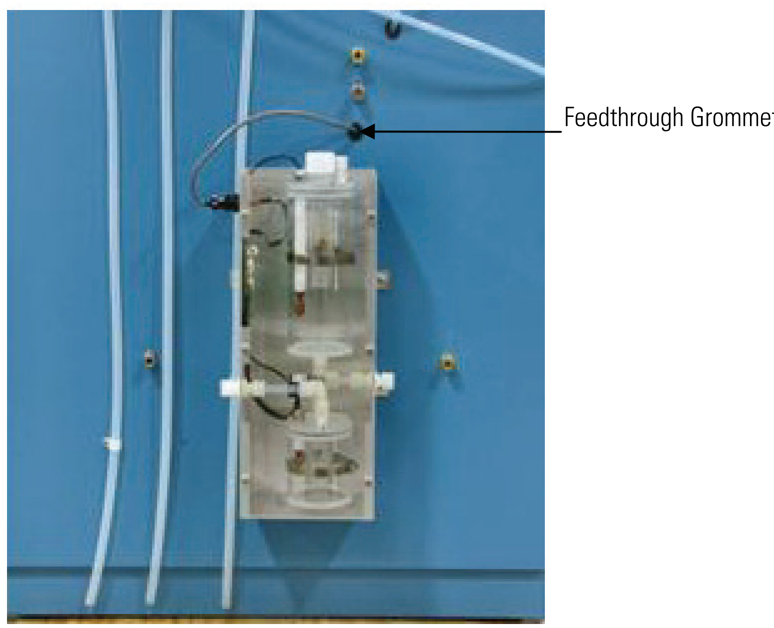

Figure 6–1. Hydrator Mounted Outside Rack

3. Connect the modular eight-pin connector to the Hydrator bulkhead connector located at the top left of the unit when viewed from the

front. Run this cable to the rear of the 80*i*, utilizing available feedthrough grommets (**Figure 6–1**).

Equipment Installation on Rack Interior

Use the following procedure to mount the Hydrator on the rack exterior.

1. Mount Hydrator assembly at the rear of the instrument rack on the panel provided. Keep in mind the unit will be mounted in the upright position as shown in **Figure 6–2**. Use appropriate length 1/4 -20 stainless steel hardware to mount the assembly to the panel.

Figure 6–2. Hydrator Mounted Inside Rack

2. Connect the modular eight-pin connector to the Hydrator bulkhead connector located at the top left of the unit when viewed from the front. Run this cable to the rear of the 80*i*, utilizing the available Panduit tray, and leave an adequate "service loop" at the rear of the 80*i* to facilitate sliding the instrument out of the rack.

Retrofit Instructions For Fielded Mercury Systems

Use the following procedure to retrofit the Hydrator on a fielded Mercury System.

1. Determine Hydrator location.

   When selecting a location, the primary determining factor should be ease of plumbing the assembly and the available lengths of required tubing prior to operation. Carefully evaluate likely locations and determine the best overall fit.

2. Use the holes on the Hydrator mounting tabs to mark through-hole location, and taking care not to over-penetrate, drill mounting holes using the appropriate drill/bit setup. Use appropriate stainless steel hardware to mount the Hydrator.

Electrical Connections

1. Attach the two 37-pin terminal boards supplied with the kit to the corresponding 37-pin connectors on the rear of the 80*i*, and secure with the supplied hardware.

2. Terminate additional harness wires to the jacket of the cable with a small tie strap.

Note Pinout diagram shows only 24 "active" termination points. ▲

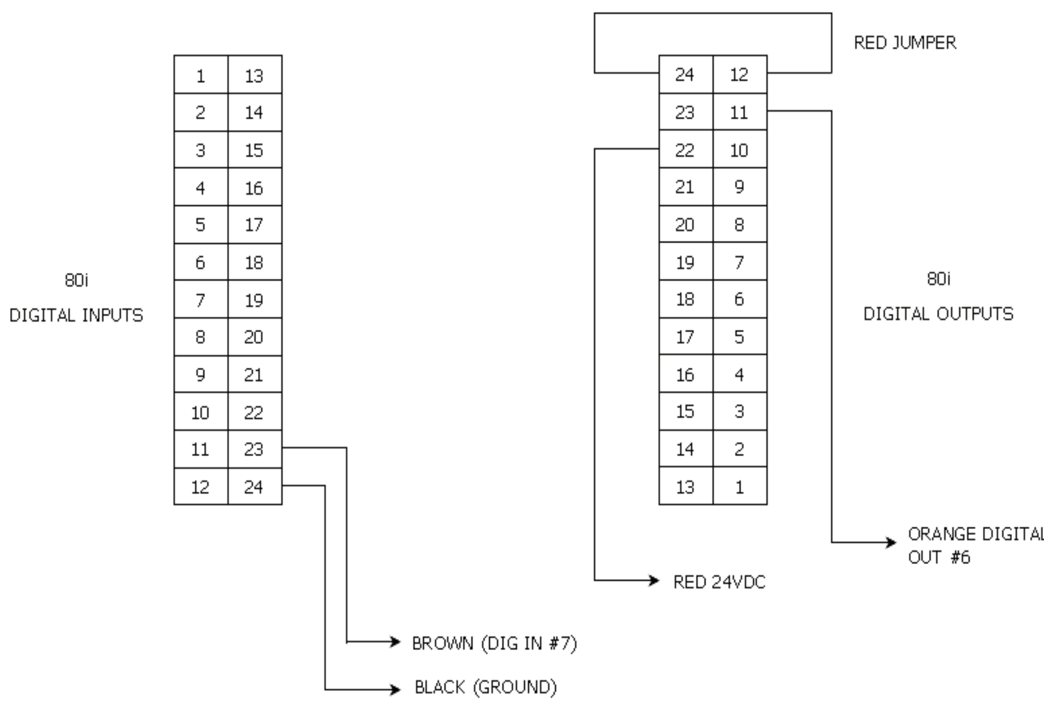

Figure 6–3. Hydrator Electrical Pinout Diagram

Pneumatic Connections

1. Remove 3/8-inch Teflon Umbilical Line 3, (if previously installed), from "PROBE" output of 81*i*. Attach this line to the output of the Hydrator. This is the 3/8-inch Kynar fitting on the right of the Hydrator when viewed from the front.

Note If performing a field retrofit and the umbilical line was cut short, use the 3/8-inch Teflon tubing and Kynar union fittings supplied with the retrofit kit to reach the Hydrator output fitting. ▲

2. Take enough 3/8-inch Teflon tubing to run from the input (left side as viewed from front) of the Hydrator to the 3/8 – 1/4-inch reducing union where Umbilical Line 3 was prior to relocation during Step 1.

3. Open the 81*i* and flip the check valve 180 degrees so that the arrow is facing the back of the instrument.

4. Check tightness of the fittings internal and external to the Hydrator, and apply air to system by opening the air handling inlet valve.

80*i* Input/Output Configuration

1. At the 80*i* Main Menu, select Instrument Controls > I/O Configuration > **Output Relay Settings**, and press ↵.

2. With the arrow keys, select #6, and press ↵.

3. Press ↵ again to set the Logic State to "NCL."

4. Select Instrument State, Choose Signal Type, **Non-Alarm**, then select Sample Mode located at the ***bottom*** of the list.

5. Return to the I/O Configuration menu, Digital Input Settings and press ↵.

6. With the arrow keys select #7, and press ↵.

7. Select Instrument Action, and press ↵.

8. Ensure that Logic State reflects "Open," change by pressing ↵.

9. Select Choose Action > **Hydrator Alarm**, and press [↵].

   The Hydrator will now fill during 80*i* “Sample” gas mode.

Functional Check

1. Remove the reservoir cap and fill the reservoir with deionized water ¾ full. Replace cap.

2. At the 80*i* Main Menu, select Instrument Controls > Gas Mode > **Sample**.

   The Hydrator solenoid valve should energize, allowing deionized water from the upper chamber to fill the lower chamber.

3. Check for water leaking from between the two canisters as the fill action occurs. Bubbles will appear as the chamber fills and will cease when the lower chamber float switch rises with the water level and closes at the top of its travel. This action will open the circuit, and the solenoid valve will de-energize, stopping water flow.

4. Remove the upper chamber cap and top off to ¾ full. Replace cap.

5. At the 80*i* Main Menu, select Instrument Controls > Gas Mode > **System Span**.

   The 81*i* gas mode will change, and Hg calibration gas will begin to flow across the surface of the water in the lower canister of the Hydrator. This is visible to the naked eye as the surface of the water ripples from the ~10 lpm of gas flows across it.

6. Leak check all fittings and mating surfaces sealing gas pressure with Snoop® leak test solution or a suitable substitute. Repair any leaks as required.

7. Select Sample mode on the 80*i*. The ripple across the lower canister water should stop

   The Hydrator is now ready for operation.

Zero Air Supply

The Zero Air Supply has been designed to provide oil-free and particulate-free, dry air from plant air. Zero Air Supply components include an oil mist coalessor, water coalessor with auto drain, particulate filter, accumulator tank, heatless air dryer, and regulator (**Figure 1–11**).

Nitrogen Generator

The Thermo Scientific MaxSense® Nitrogen Air Handling System (Nitrogen Generator) converts air to nitrogen (N_2). Nitrogen is used as a carrier for Hg calibration gas (from the 81*i*), and is also used as a dilution gas for sample measurements originating in the 83*i* or 83*i* GC.

The Nitrogen Generator utilizes prime components of the Thermo Scientific Zero Air Supply to condition the air prior to N_2 generation, and Thermo Fisher Scientific offers a retrofit kit to enhance an existing zero air supply with nitrogen.

By using a three-way valve, the Nitrogen Generator can also be operated in Bypass mode, which diverts airflow around the N_2 generator to provide instrument-grade air to the Mercury System. This may be beneficial for testing applications, and when routine maintenance on N_2 components is required. If this feature is not within the scope of the application, simply vent to atmosphere.

Specifications

Refer to **Table 6–1** for a description of the Nitrogen Generator specifications. Also refer to the product data sheet that follows.

Table 6–1. Nitrogen Generator Specifications

Parameter	Specification	Comments
Min/Max Operating Pressure	70 psig/175 psig	
Nitrogen Output Purity	99% @ 100 psig	Less at lower output pressure
Nitrogen Flow Rate	60 SCFH @ 100 psig	
Dew Point Temperature	<-50 °C	
Min/Max Air Inlet Temperature	4 - 60 °C	
Recommended Inlet Air Temperature	25 °C	
Recommended Ambient Temperature	25 °C	
Storage Temperature Range	0 – 30 °C	
Ambient Environmental Conditions	Indoor use	Standard atmospheric conditions

Parameter	Specification	Comments
Mounting	Wall mount Rack side mount	Standard UniStrut and UniStrut accessories
Dimensions	42 L X 39 W X 10 H	
Weight	~75 lbs. (~34 Kg)	Fully Equipped with Consumables

Note The nitrogen membranes separate oxygen from pressurized air. The composition of the product is determined by measuring the residual oxygen content. The nitrogen content is calculated by subtracting the residual oxygen content from 100% air. Air is composed of nitrogen (78.1%), oxygen (20.9%), Argon (0.9%), CO_2 (0.03%), and some traces of inert gases. Therefore, it should be kept in mind that the value that is normally called the nitrogen content is actually the inert gas content. The nitrogen product should, with the exception of the reduced oxygen content, be treated as pressurized air. ▲

MaxSense® Product Data Sheet

Minimum Nitrogen Production Capacity in bar(g) and SCFH

Nitrogen Purity %	-	99.50		99.00		98.00		97.00		96.00		95.00	
bar(g)	PSI	Nm3/H	SCFH	Nm3/H	SCFH	Nm3/H	SCFH	Nm3/H	SCFH	Nm3/H	SCFH	Nm3/H	SCFH
4.00	58.00	0.76	26.84	1.13	39.90	1.69	59.67	2.23	78.74	2.76	97.46	3.36	118.64
5.00	72.50	0.95	33.54	1.41	49.79	2.12	74.86	2.78	98.16	3.46	122.17	4.19	147.95
6.00	**87.00**	**1.19**	**42.02**	**1.77**	**62.50**	**2.67**	**94.28**	**3.35**	**118.29**	**4.37**	**154.30**	**5.27**	**186.08**
7.00	**101.50**	**1.39**	**49.08**	**2.07**	**73.09**	**3.11**	**109.81**	**3.91**	**138.06**	**5.09**	**179.73**	**6.15**	**217.16**
8.00	116.00	1.59	56.14	2.36	83.33	3.56	125.70	4.46	157.48	5.82	205.50	7.03	248.23
9.00	130.50	1.75	61.79	2.63	92.87	4.03	142.30	5.30	187.14	6.60	233.05	8.00	282.48
10.00	145.00	1.99	70.27	2.95	104.16	4.45	157.13	5.58	197.03	7.28	257.06	8.79	310.37
11.00	159.50	2.08	73.44	3.14	110.87	4.80	169.49	6.22	219.63	7.93	280.01	9.62	339.68
12.00	174.00	2.17	76.62	3.33	117.58	5.16	182.20	6.87	242.58	8.58	302.96	10.40	367.22

Air Consumption at Minimum Capacity

Nitrogen Purity %	-	99.50		99.00		98.00		97.00		96.00		95.00	
bar(g)	PSI	Nm3/H	SCFH	Nm3/H	SCFH	Nm3/H	SCFH	Nm3/H	SCFH	Nm3/H	SCFH	Nm3/H	SCFH
4.00	58.00	5.79	204.44	6.21	219.28	6.95	245.40	7.57	267.30	8.02	283.19	8.72	307.90
5.00	72.50	7.24	255.64	7.77	274.36	8.69	306.84	9.46	334.03	10.00	353.10	10.90	384.88
6.00	**87.00**	**8.94**	**315.67**	**9.56**	**337.56**	**10.70**	**377.82**	**11.40**	**402.53**	**12.70**	**448.44**	**13.70**	**483.75**
7.00	**101.50**	**10.40**	**367.22**	**11.20**	**395.47**	**12.50**	**441.38**	**13.30**	**469.62**	**14.80**	**522.59**	**16.00**	**564.96**
8.00	116.00	11.90	420.19	12.70	448.44	14.20	501.40	15.20	536.71	16.90	596.74	18.30	646.17
9.00	130.50	13.30	469.62	14.50	512.00	16.10	568.49	18.00	635.58	19.10	674.42	20.80	734.45
10.00	145.00	15.10	533.18	16.20	572.02	17.80	628.52	19.00	670.89	21.10	745.04	22.90	808.60
11.00	159.50	17.30	610.86	18.50	653.24	20.20	713.26	21.20	748.57	23.80	840.38	25.00	882.75
12.00	174.00	18.00	635.58	19.60	692.08	21.70	766.23	23.40	826.25	25.70	907.47	27.20	960.43

Typical Operating Pressures/Flows

Sources of Compressed Air

Dedicated compressor: A source that is designed to supply compressed air only to the N_2 system. This compressor system may or may not incorporate a storage tank to smooth pressure and flow fluctuations. The air supply volume and pressure produced MUST be matched to the demand of the N_2 system.

Generator Performance

For a given product flow, the purity of the nitrogen product is higher at higher operating pressures. For optimum energy efficiency, operation at a membrane pressure of 90 psig (150 psig compressor) is recommended. The operating range of the nitrogen membrane modules is 70 – 175 psig.

Recommended Configuration

The Nitrogen Generator system must be supplied with 85 - 100 psig compressed, dry air (CDA) at the inlet regulator. The Thermo Scientific Air Handling System feeding the Nitrogen Generator will have a potential pressure drop of <10 psig, meaning the Nitrogen Generator air input could drop as low as 75 psi. This pressure would result in a nitrogen output purity of approximately 97%. Although verified at the factory, the gauge on the inlet regulator may lose accuracy over time. Verify plant air pressure with a NIST-traceable pressure gauge to determine if it is adequate to operate the Nitrogen Generator system.

Retrofitting Older Systems

A kit is available for retrofitting a fielded Mercury System with the Nitrogen Generator. Contact Thermo Fisher Scientific for detailed information.

Appendix A
Warranty

Seller warrants that the Products will operate or perform substantially in conformance with Seller's published specifications and be free from defects in material and workmanship, when subjected to normal, proper and intended usage by properly trained personnel, for the period of time set forth in the product documentation, published specifications or package inserts. If a period of time is not specified in Seller's product documentation, published specifications or package inserts, the warranty period shall be one (1) year from the date of shipment to Buyer for equipment and ninety (90) days for all other products (the "Warranty Period"). Seller agrees during the Warranty Period, to repair or replace, at Seller's option, defective Products so as to cause the same to operate in substantial conformance with said published specifications; provided that (a) Buyer shall promptly notify Seller in writing upon the discovery of any defect, which notice shall include the product model and serial number (if applicable) and details of the warranty claim; (b) after Seller's review, Seller will provide Buyer with service data and/or a Return Material Authorization ("RMA"), which may include biohazard decontamination procedures and other product-specific handling instructions; and (c) then, if applicable, Buyer may return the defective Products to Seller with all costs prepaid by Buyer. Replacement parts may be new or refurbished, at the election of Seller. All replaced parts shall become the property of Seller. Shipment to Buyer of repaired or replacement Products shall be made in accordance with the Delivery provisions of the Seller's Terms and Conditions of Sale. Consumables, including but not limited to lamps, fuses, batteries, bulbs and other such expendable items, are expressly excluded from the warranty under this warranty.

Notwithstanding the foregoing, Products supplied by Seller that are obtained by Seller from an original manufacturer or third party supplier are not warranted by Seller, but Seller agrees to assign to Buyer any warranty rights in such Product that Seller may have from the original manufacturer or third party supplier, to the extent such assignment is allowed by such original manufacturer or third party supplier.

In no event shall Seller have any obligation to make repairs, replacements or corrections required, in whole or in part, as the result of (i) normal wear and tear, (ii) accident, disaster or event of force majeure, (iii) misuse, fault or negligence of or by Buyer, (iv) use of the Products in a manner for which they were not designed, (v) causes external to the Products such as, but not limited to, power failure or electrical power surges, (vi) improper storage and handling of the Products or (vii) use of the Products in combination with equipment or software not supplied by Seller. If Seller determines that Products for which Buyer has requested warranty services are not covered by the warranty hereunder, Buyer shall pay or reimburse Seller for all costs of investigating and responding to such request at Seller's then prevailing time and materials rates. If Seller provides repair services or replacement parts that are not covered by the warranty provided in this warranty, Buyer shall pay Seller therefor at Seller's then prevailing time and materials rates. ANY INSTALLATION, MAINTENANCE, REPAIR, SERVICE, RELOCATION OR ALTERATION TO OR OF, OR OTHER TAMPERING WITH, THE PRODUCTS PERFORMED BY ANY PERSON OR ENTITY OTHER THAN SELLER WITHOUT SELLER'S PRIOR WRITTEN APPROVAL, OR ANY USE OF REPLACEMENT PARTS NOT SUPPLIED BY SELLER, SHALL IMMEDIATELY VOID AND CANCEL ALL WARRANTIES WITH RESPECT TO THE AFFECTED PRODUCTS.

THE OBLIGATIONS CREATED BY THIS WARRANTY STATEMENT TO REPAIR OR REPLACE A DEFECTIVE PRODUCT SHALL BE THE SOLE REMEDY OF BUYER IN THE EVENT OF A DEFECTIVE PRODUCT. EXCEPT AS EXPRESSLY PROVIDED IN THIS WARRANTY STATEMENT, SELLER DISCLAIMS ALL OTHER WARRANTIES, WHETHER EXPRESS OR IMPLIED, ORAL OR WRITTEN, WITH RESPECT TO THE PRODUCTS, INCLUDING WITHOUT LIMITATION ALL IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. SELLER DOES NOT WARRANT THAT THE PRODUCTS ARE ERROR-FREE OR WILL ACCOMPLISH ANY PARTICULAR RESULT.

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Appendix B
System Reference Drawings

This appendix provides the system reference drawings.

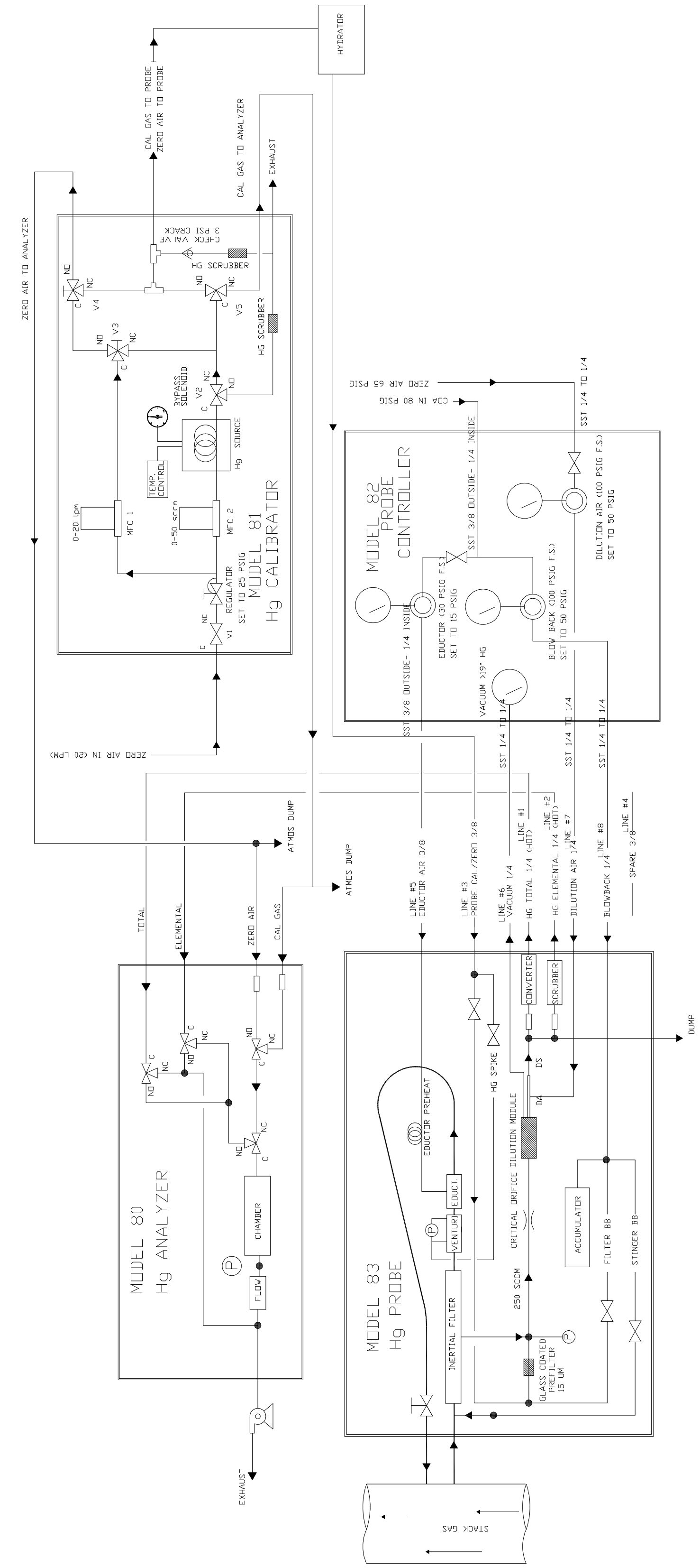


Figure B–1. 83*i* System Plumbing Diagram 103013-00

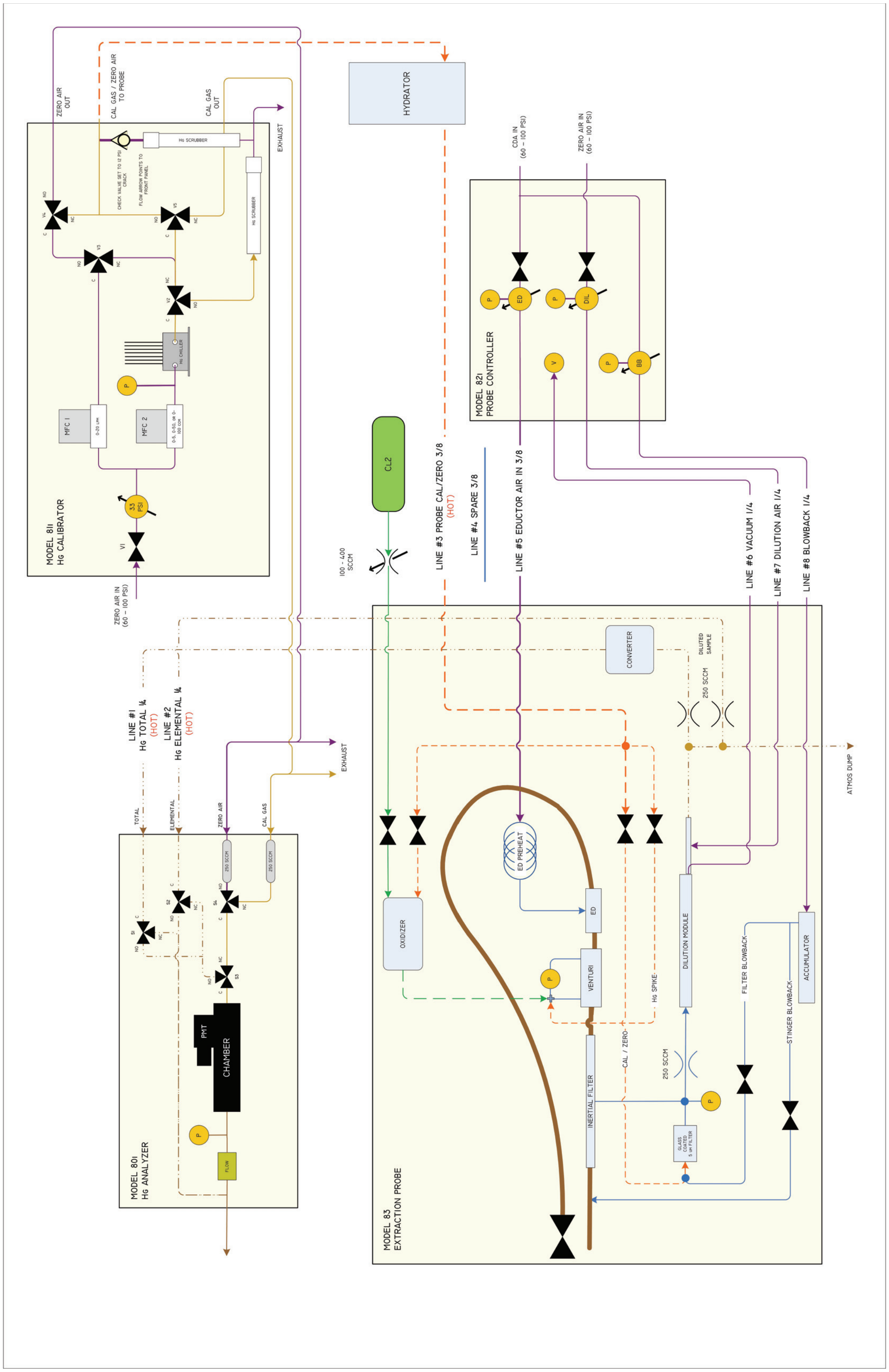


Figure B–2. 83*i* with Oxidizer System Plumbing Diagram 103013-01

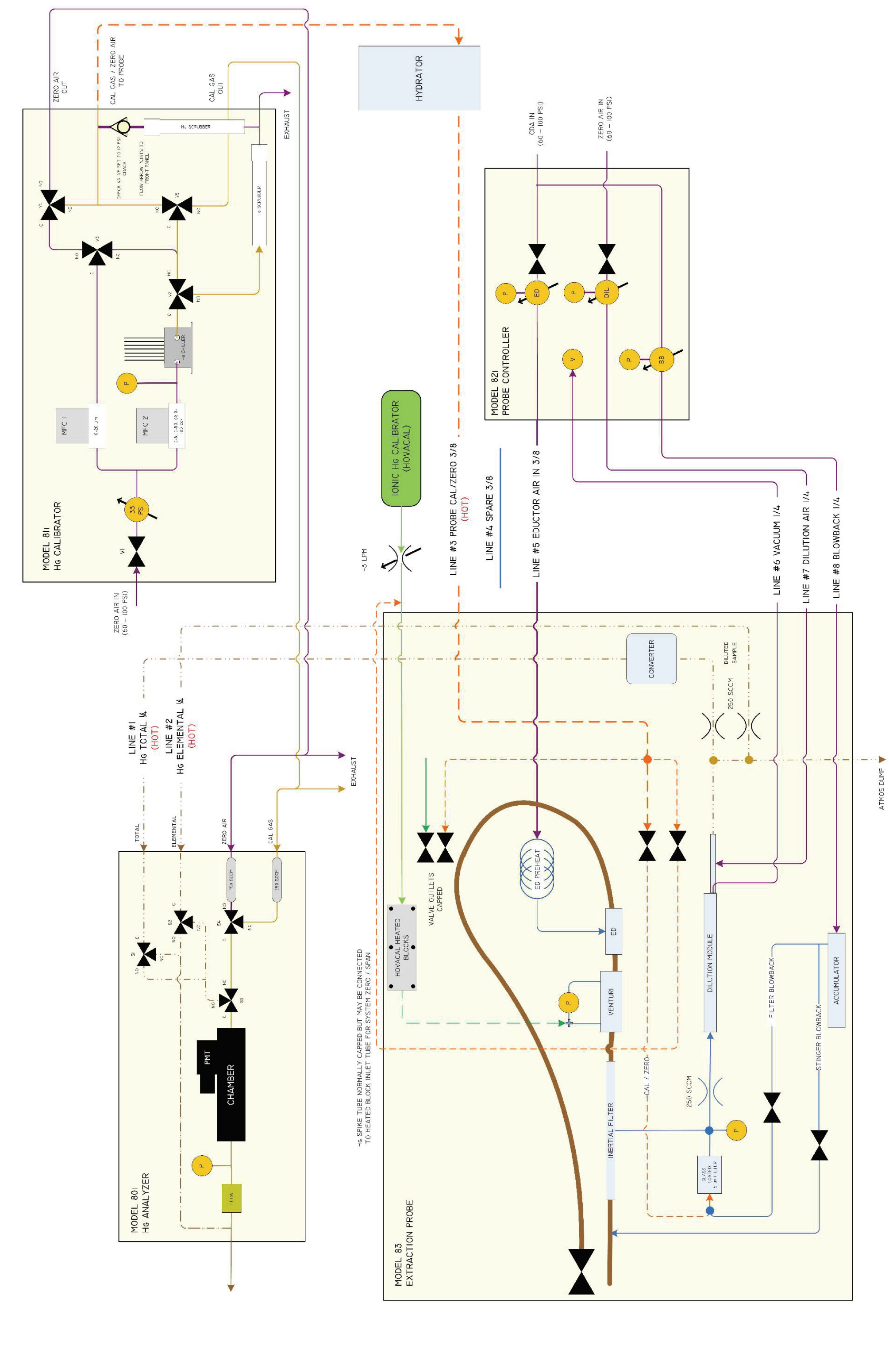
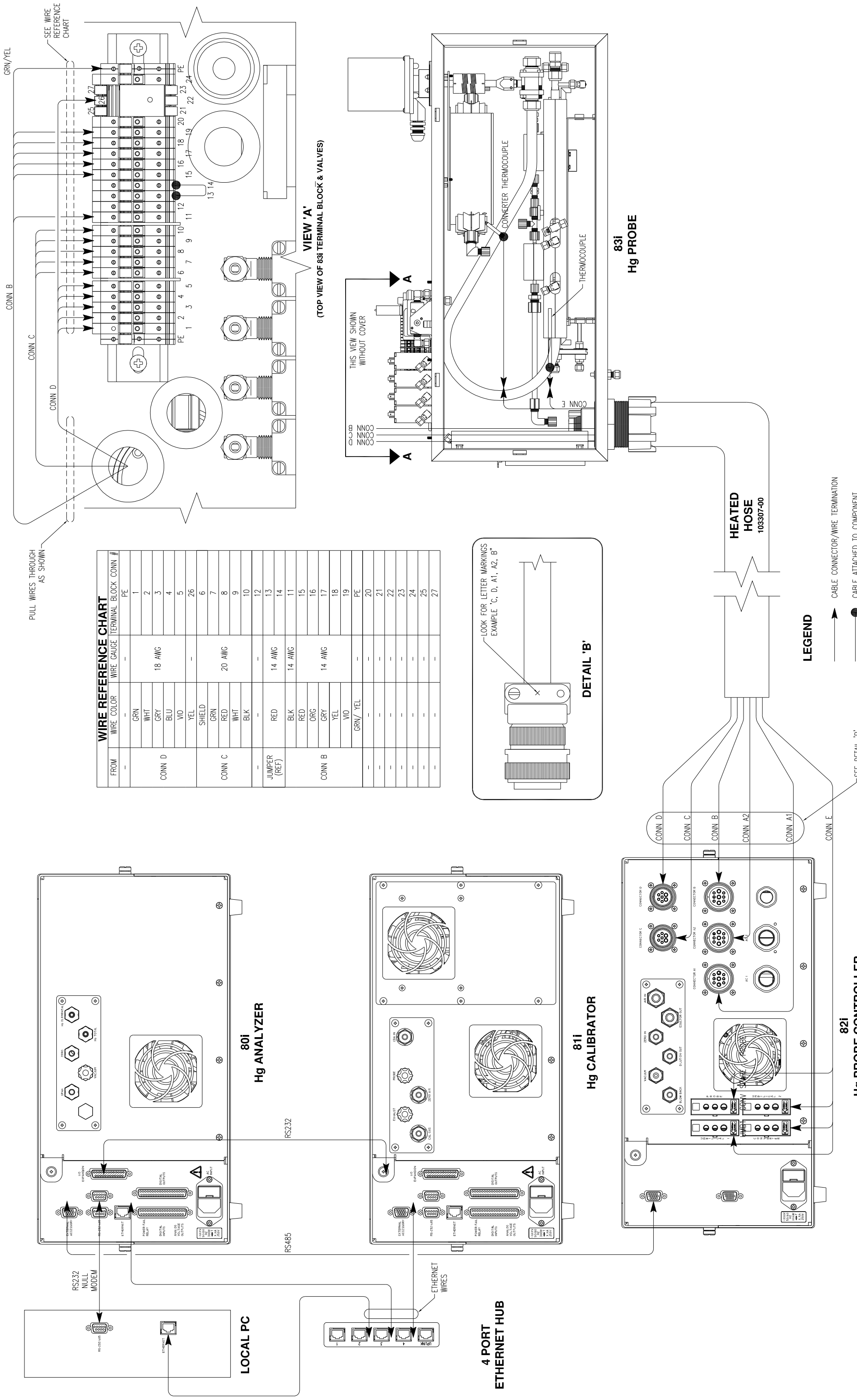


Figure B–3. 83*i* with Heated Hovacal Line System Plumbing Diagram 103013-02



WIRE REFERENCE CHART

FROM	WIRE COLOR	WIRE GAUGE	TERMINAL BLOCK CONN #
–	–	–	PE
CONN D	GRN	18 AWG	1
	WHT		2
	GRY		3
	BLU		4
	VIO		5
	YEL	–	26
CONN C	SHIELD	20 AWG	6
	GRN		7
	RED		8
	WHT		9
	BLK		10
–	–	–	12
JUMPER (REF)	RED	14 AWG	13
			14
CONN B	BLK	14 AWG	11
	RED	14 AWG	15
	ORG		16
	GRY		17
	YEL		18
	VIO		19
	GRN/ YEL	–	PE
–	–	–	20
–	–	–	21
–	–	–	22
–	–	–	23
–	–	–	24
–	–	–	25
–	–	–	27

Figure B–4. 83*i* Electrical and Plumbing Installation 103535-00

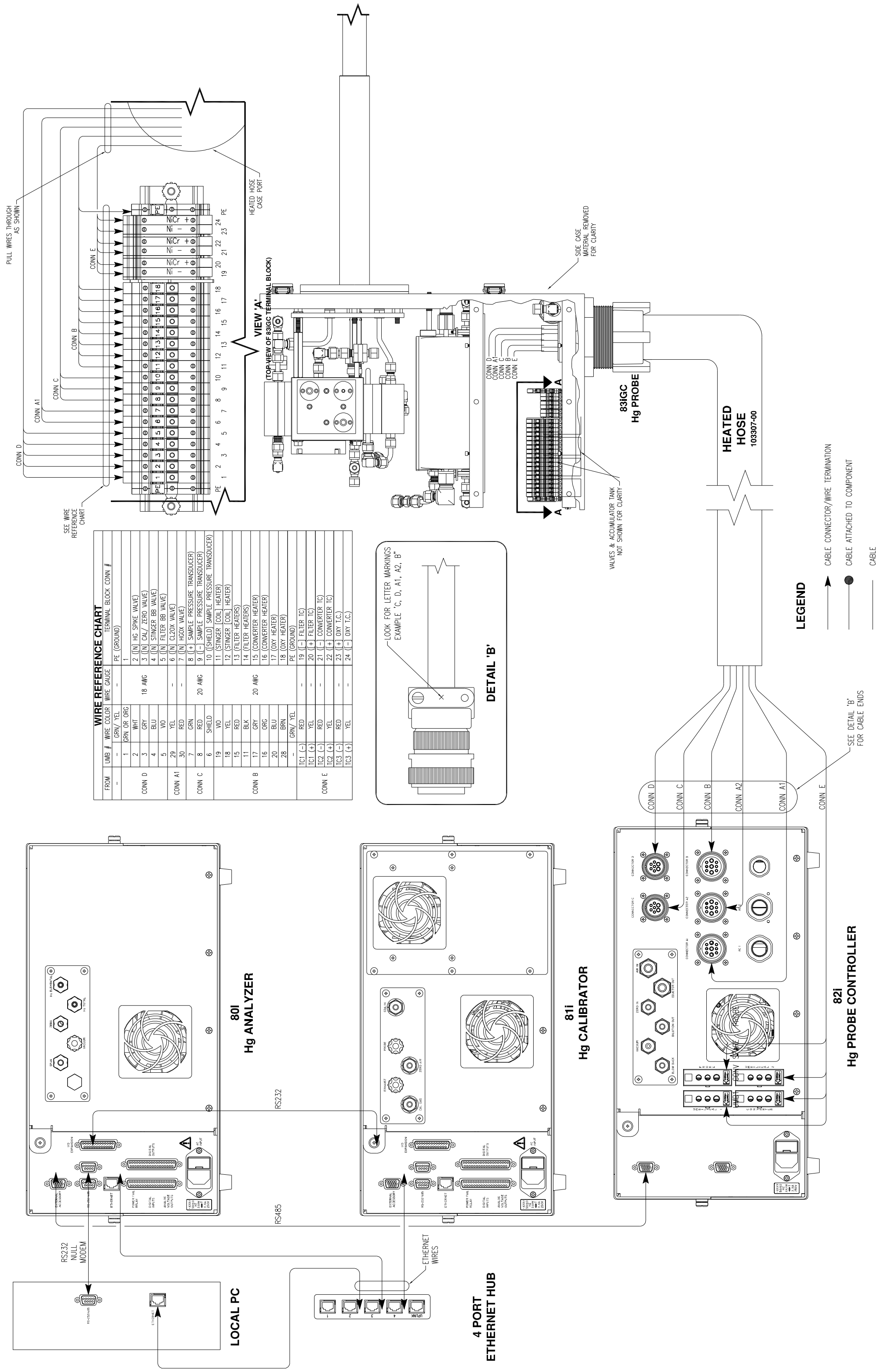


Figure B–5. Wiring Interconnection with 83*i* GC

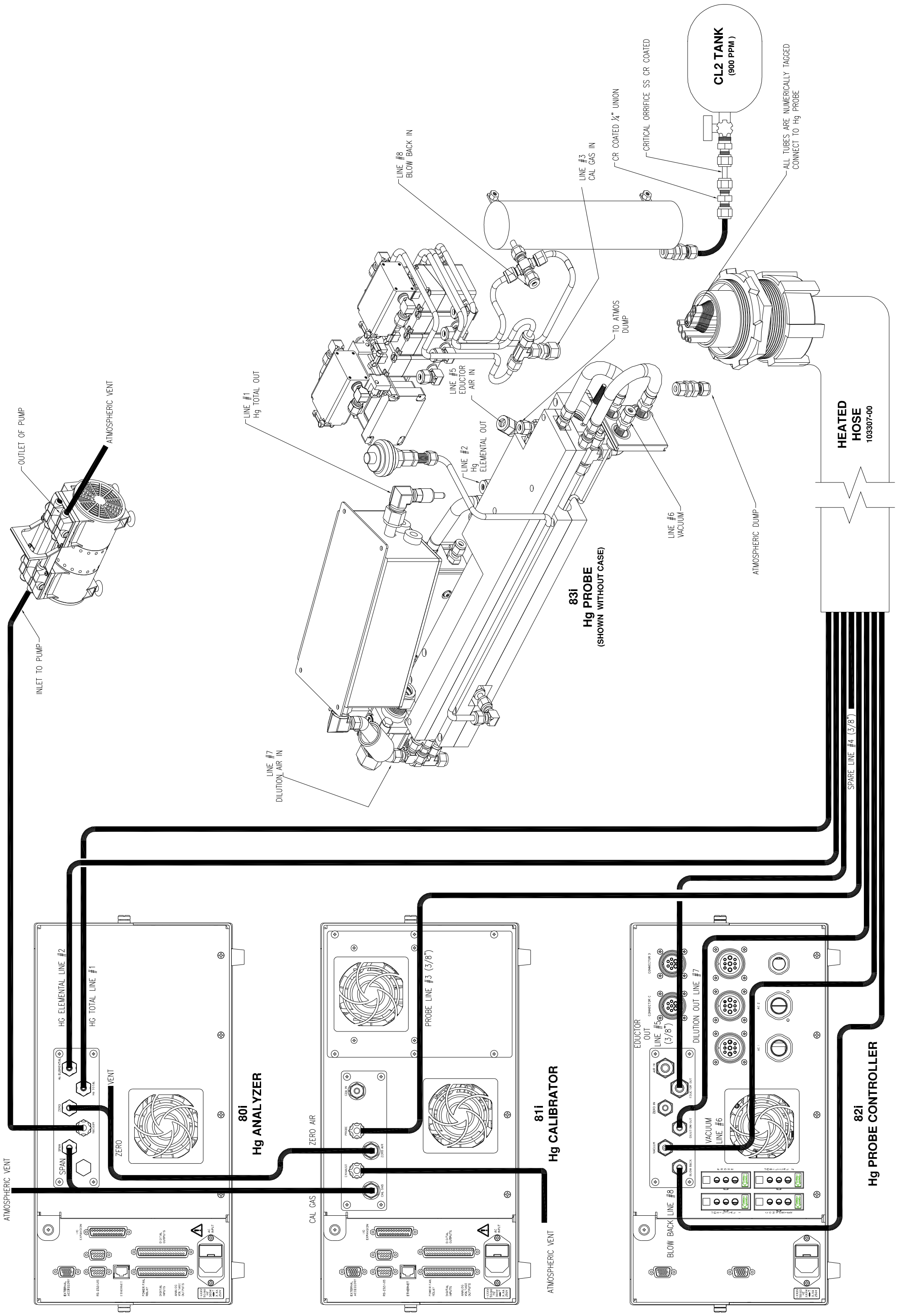


Figure B–6. 83*i* with Oxidizer Electrical and Plumbing Installation 103535-01

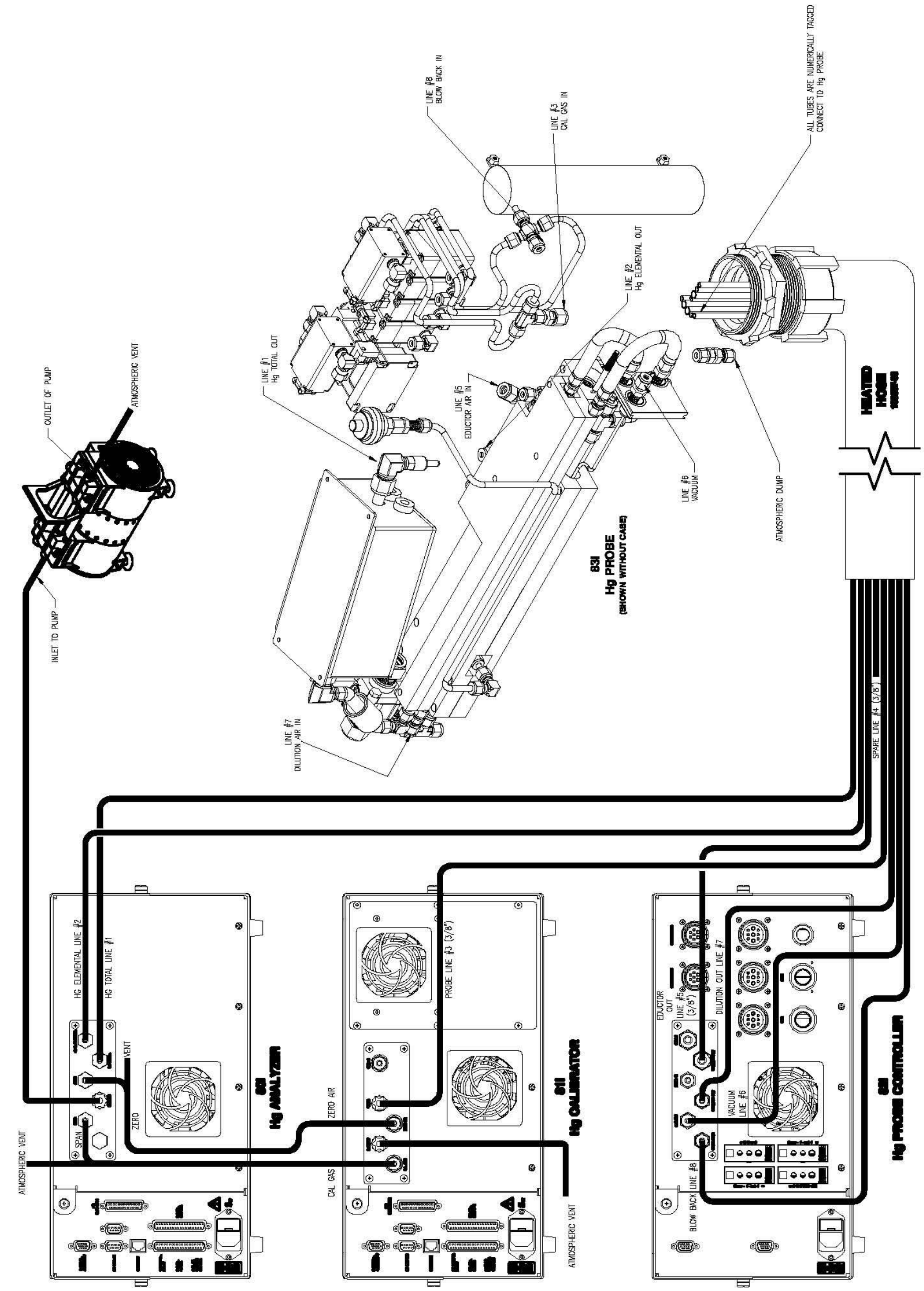


Figure B–7. 83*i* with Heated Hovacal Line Electrical and Plumbing 103535-02

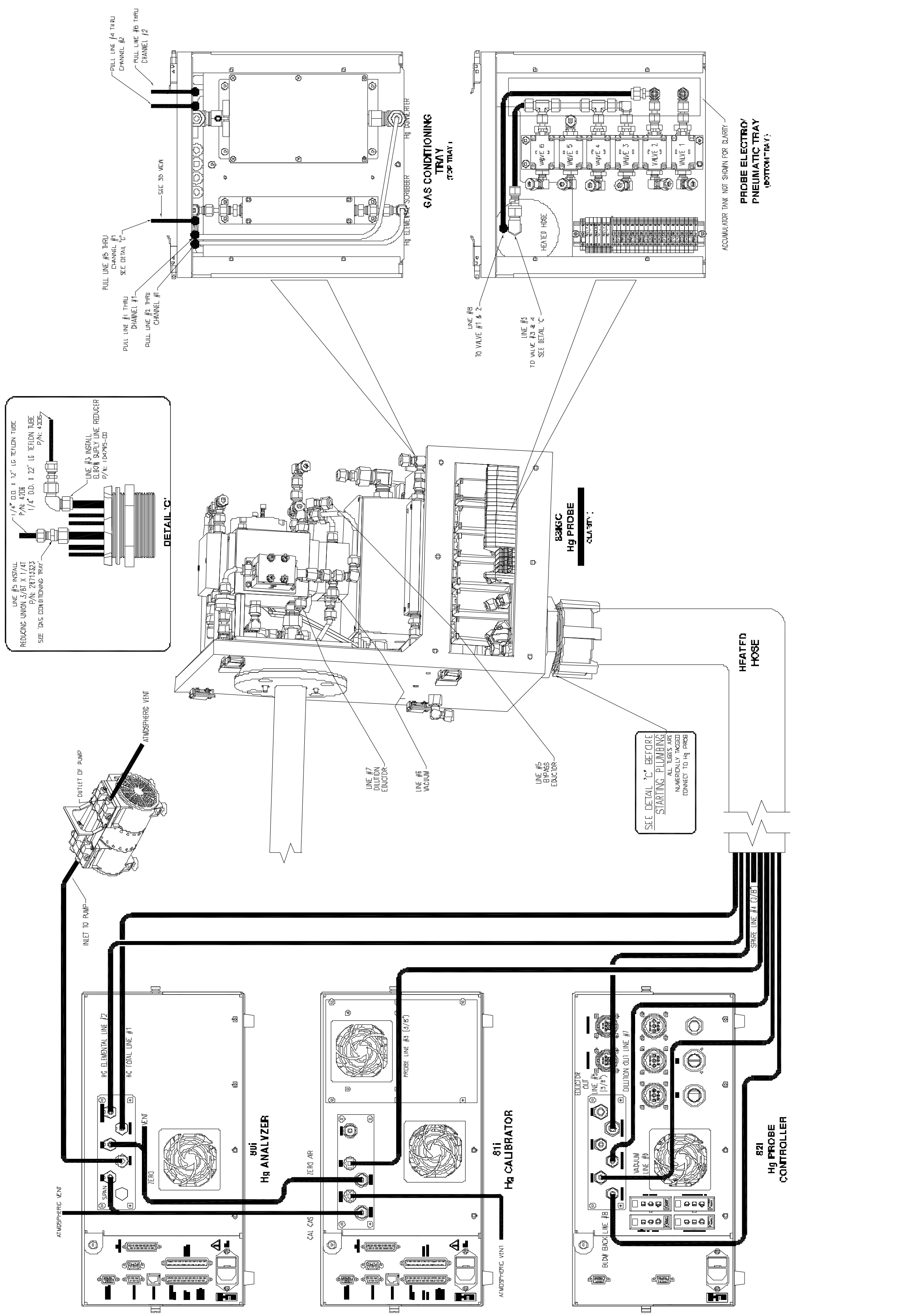


Figure B–8. Tubing Interconnection with 83*i* GC

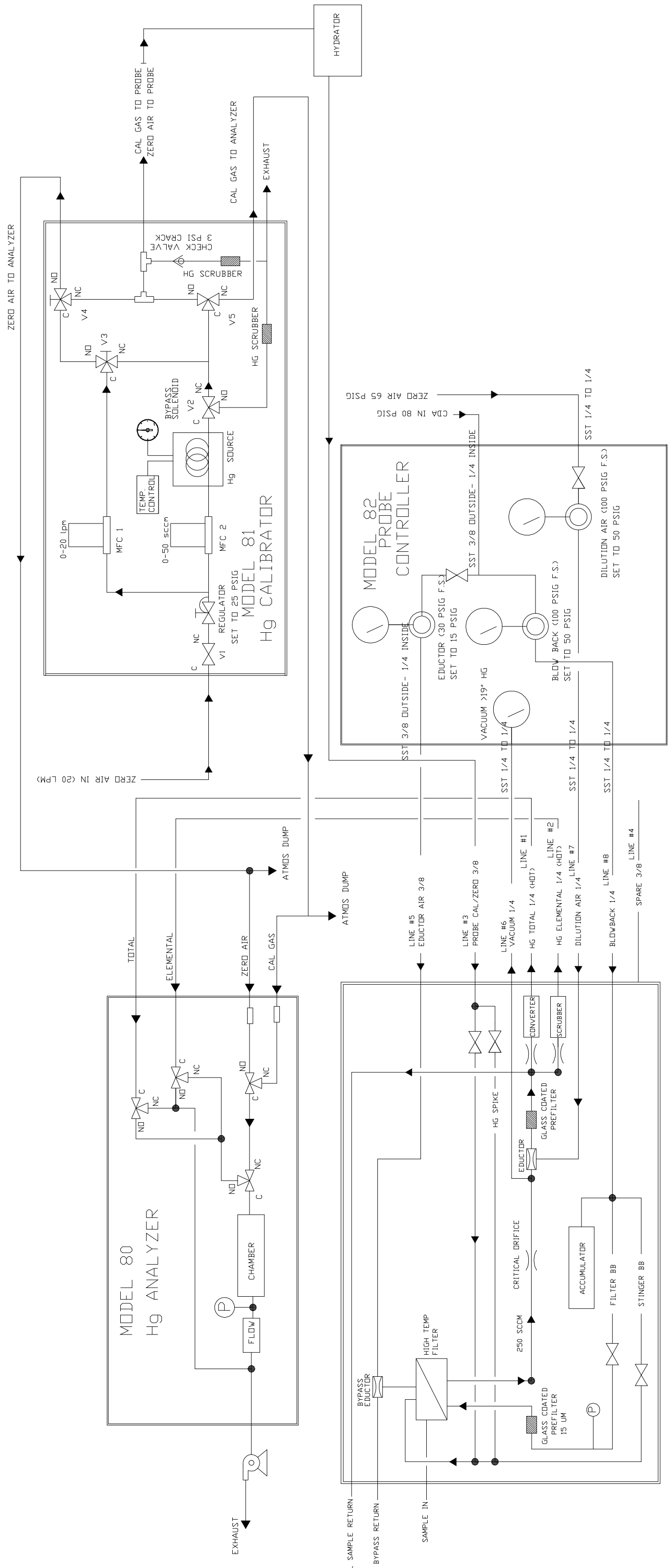


Figure B–9. 83*i* GC Plumbing System Diagram 104358-00

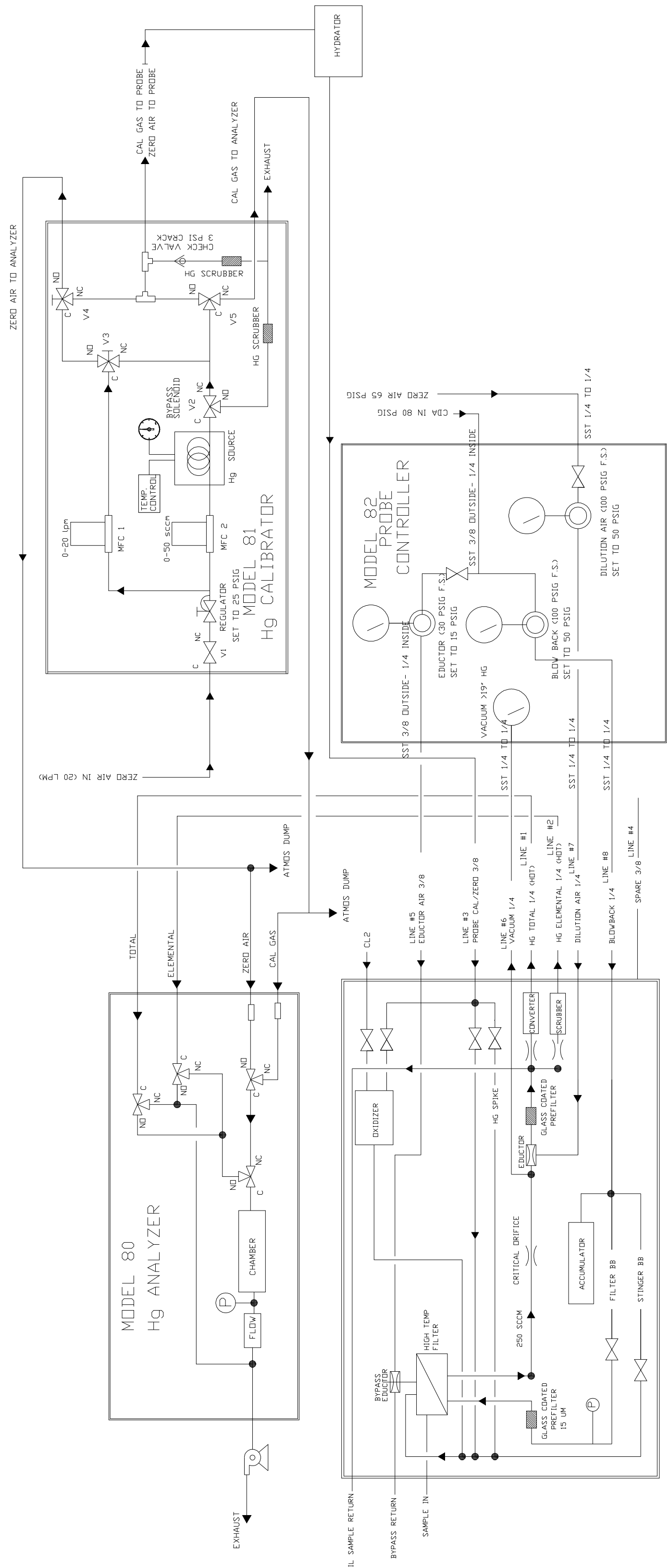


Figure B–10. 83*i* GC with Oxidizer Plumbing System Diagram 104358-01

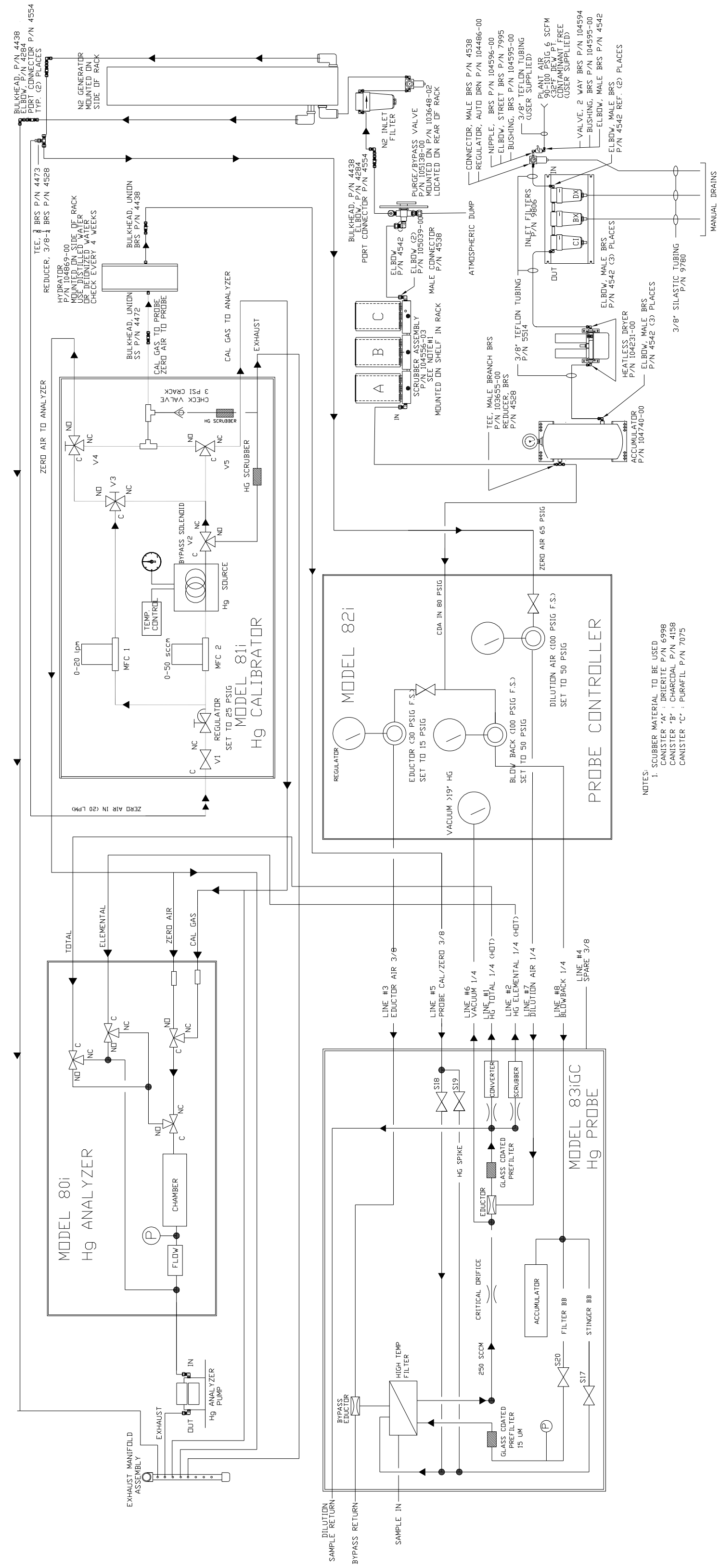


Figure B–11. Interconnection Schematic

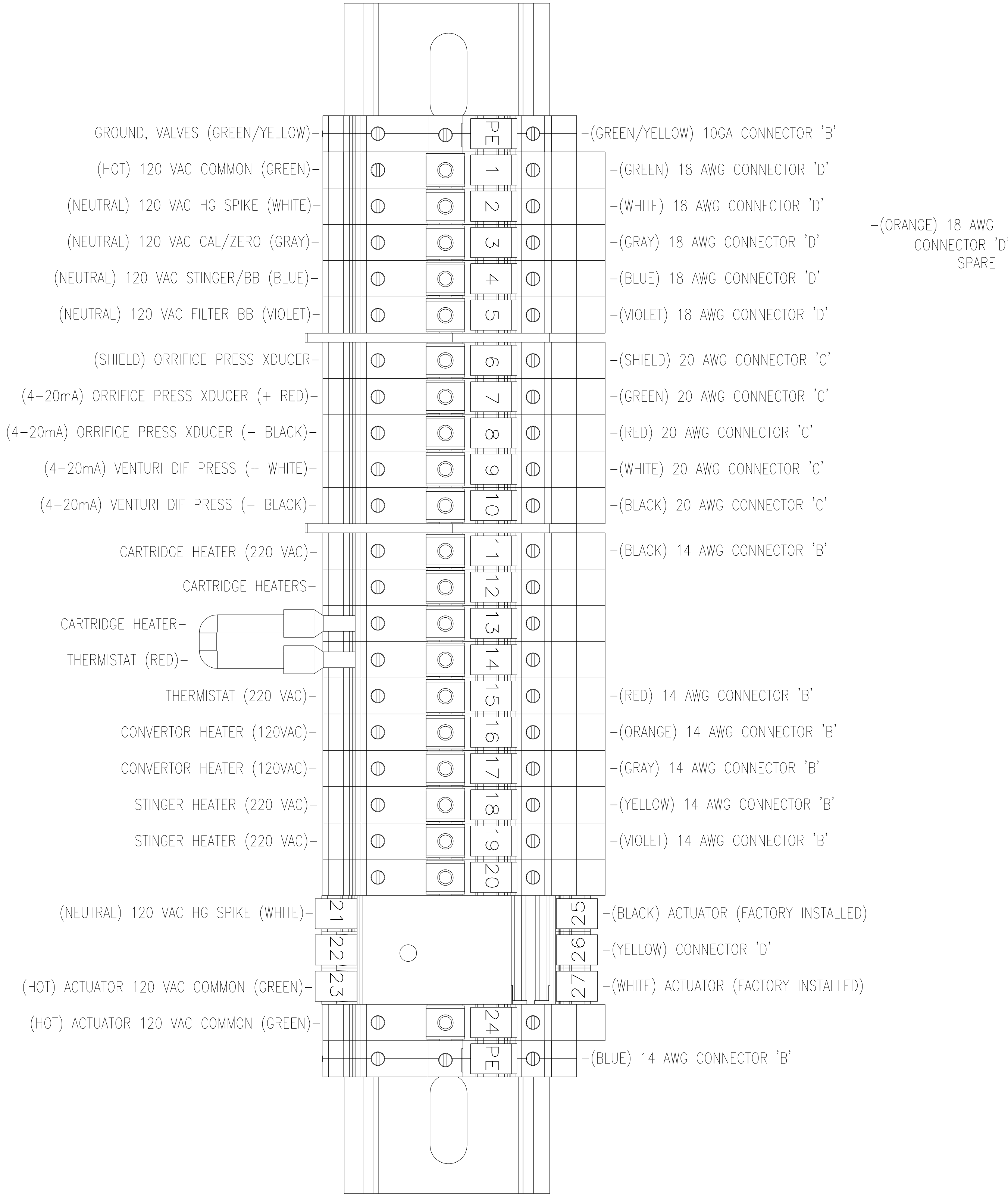


Figure B–12. 83*i* Terminal Block Wiring Diagram 104588-00

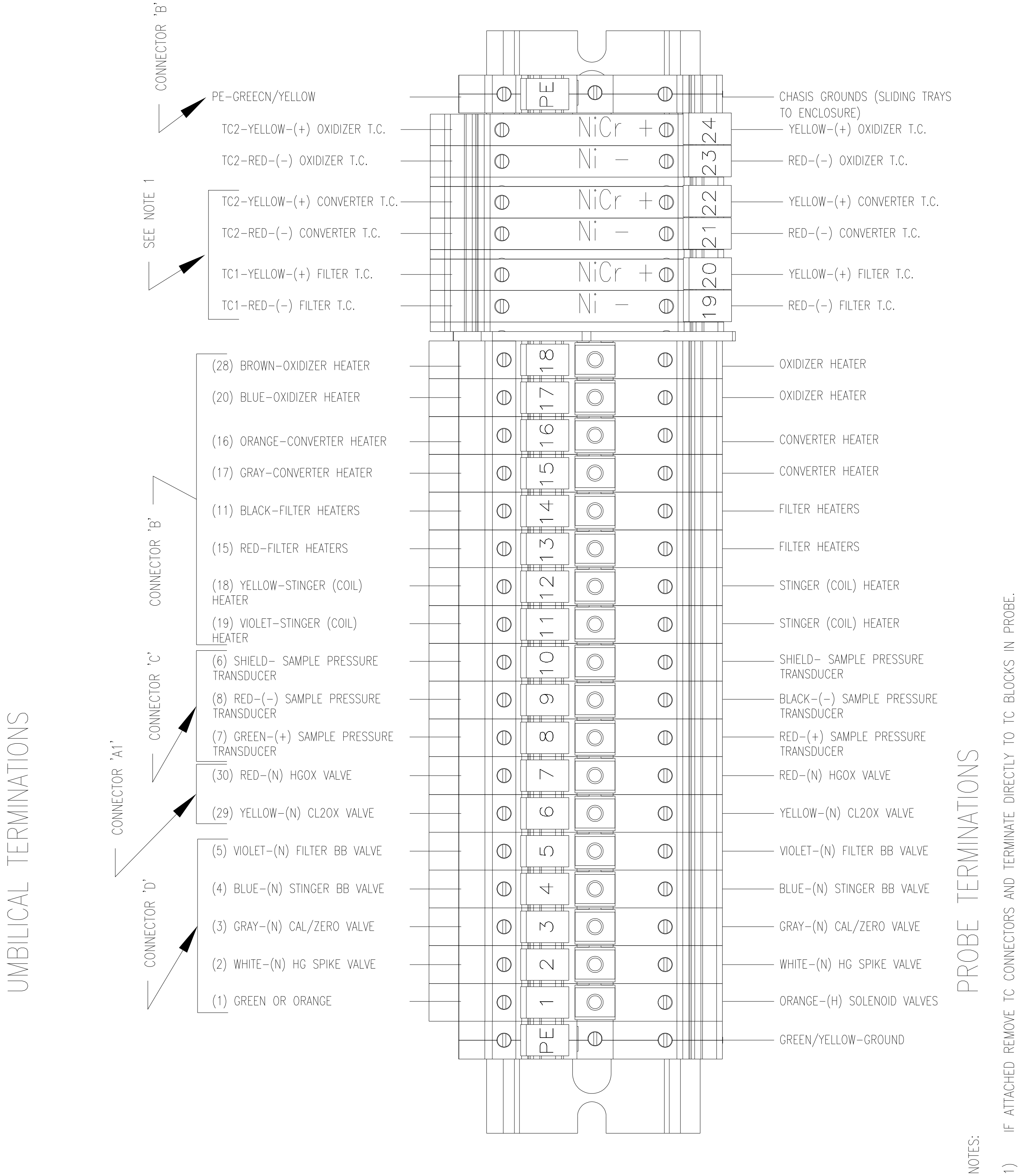


Figure B–13. 83*i* GC with Oxidizer Terminal Block Wiring Diagram 104734-00

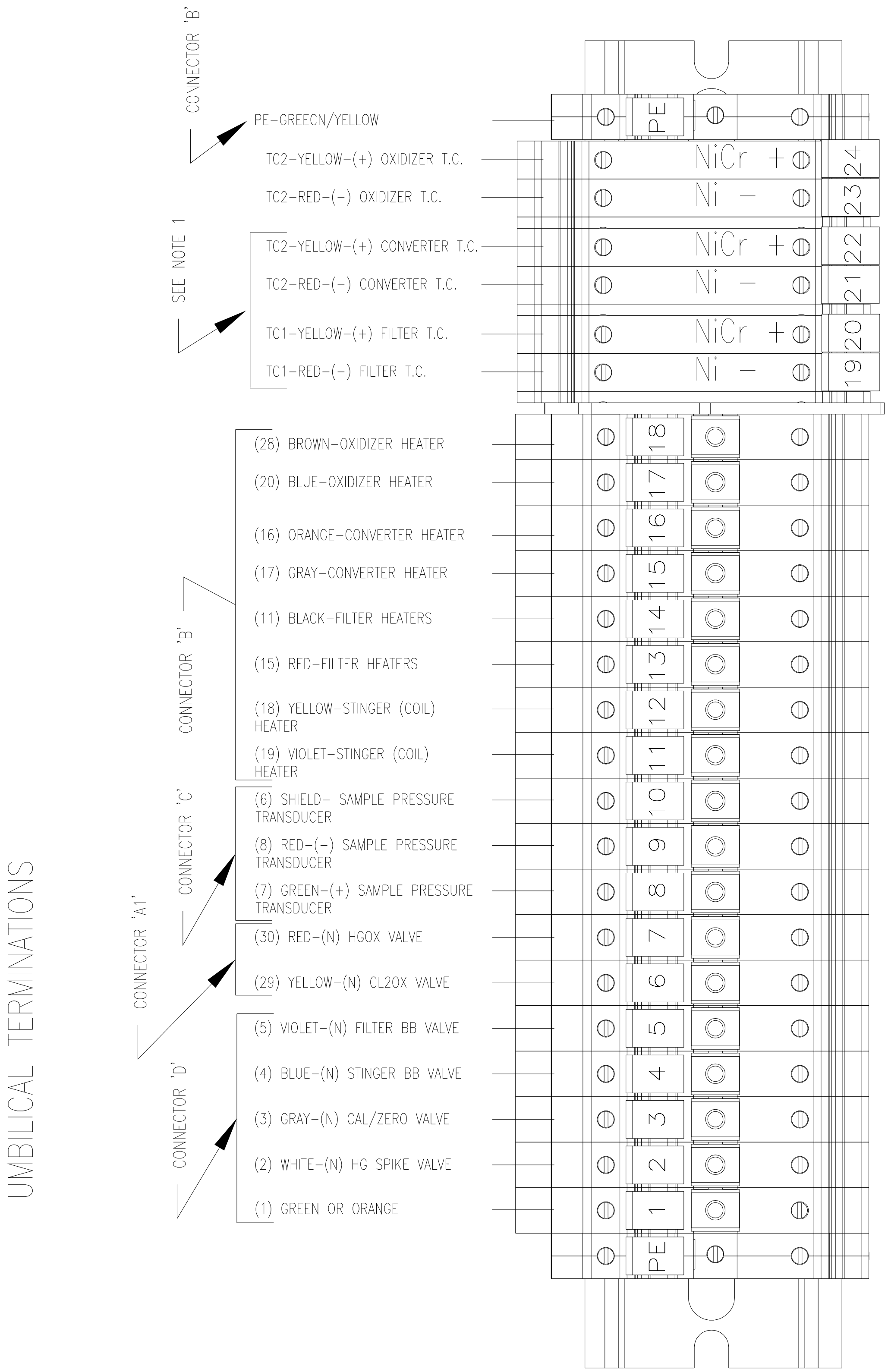


Figure B–14. Umbilical Wiring Detail

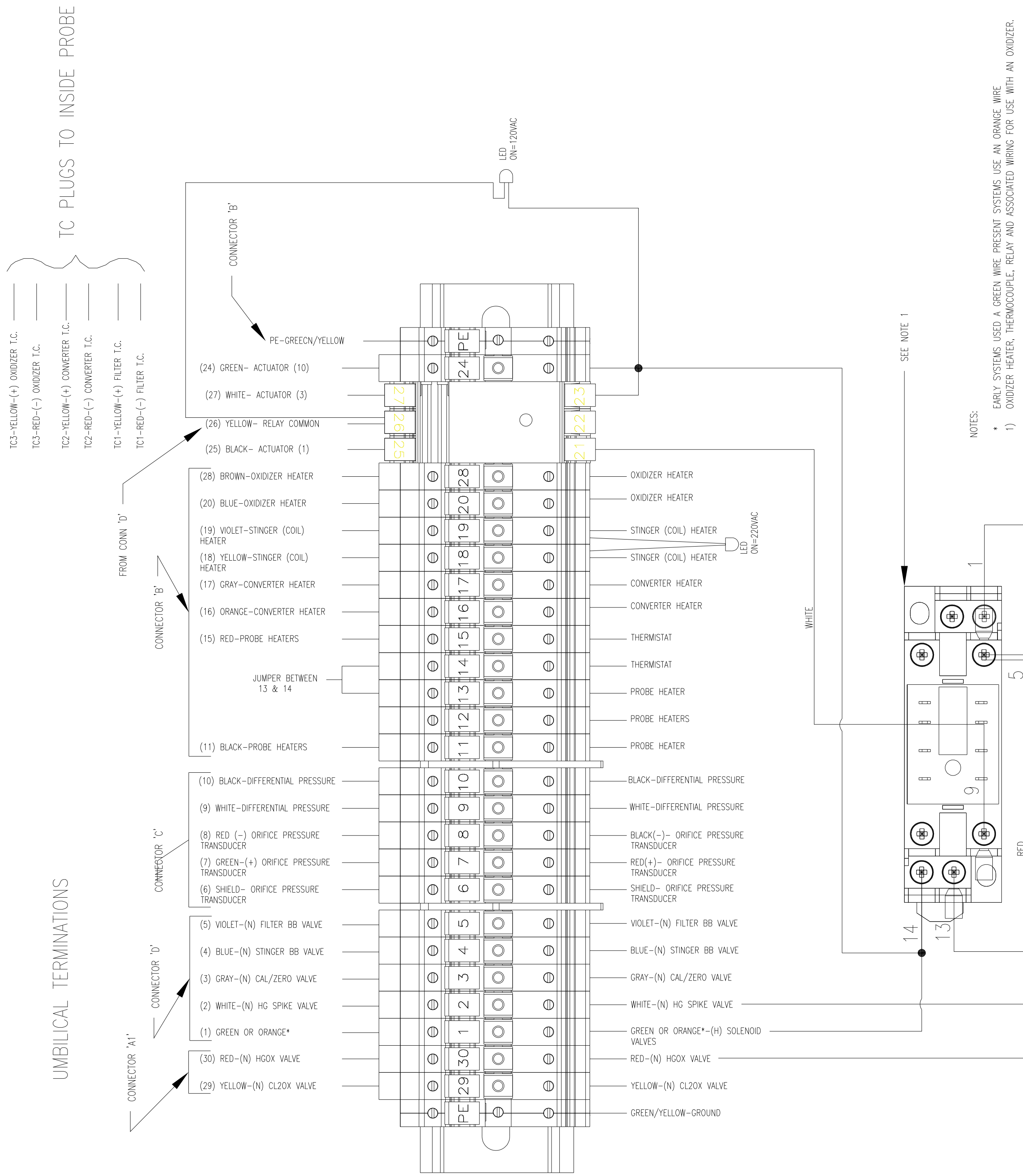


Figure B–15. Model 83*i* with Oxidizer Terminal Block Wiring Diagram 105507-00

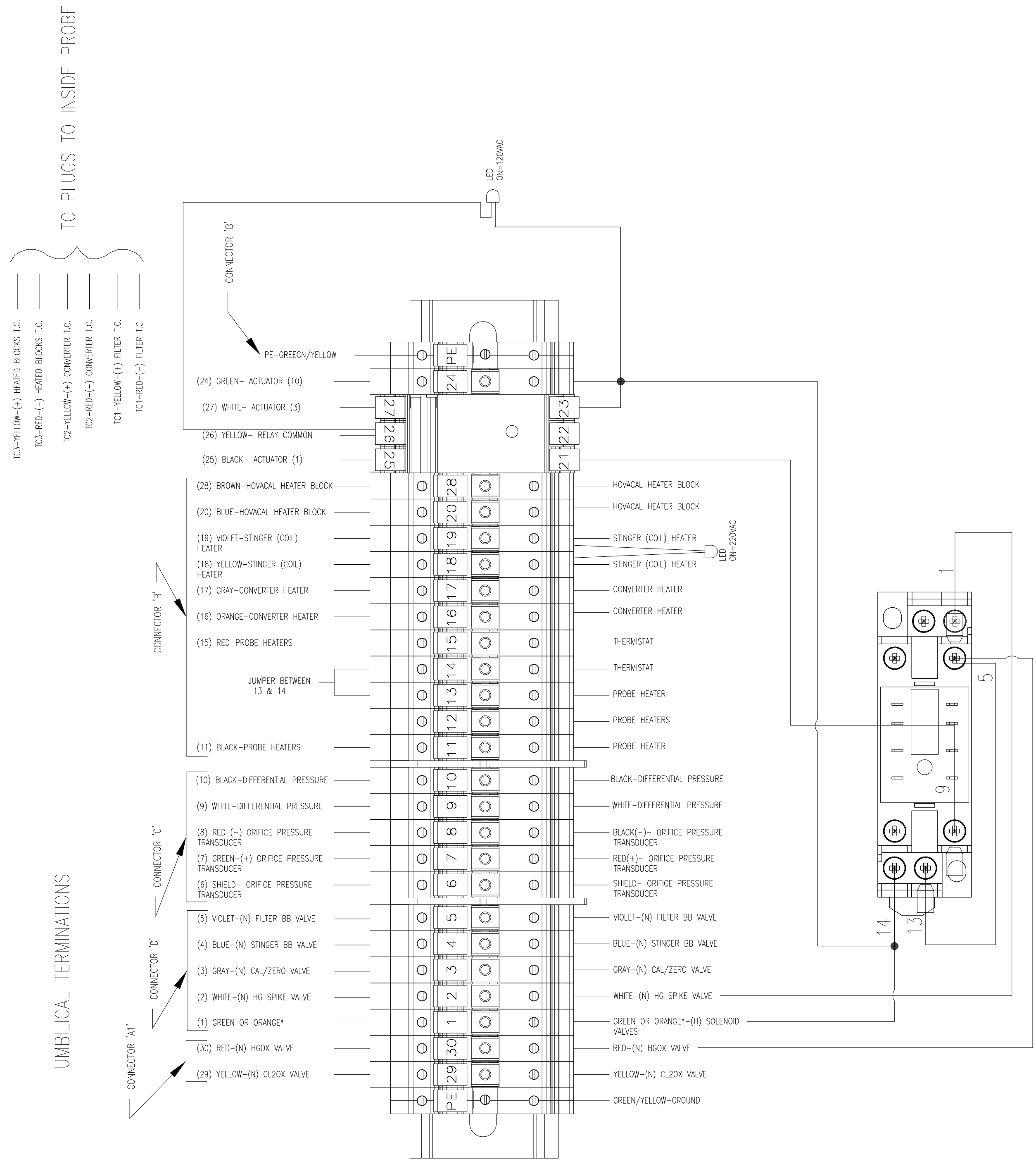


Figure B–16. Model 83*i* with Heated Hovacal Line Terminal Block Wiring Diagram 105507-01

Appendix C
Flowcharts of Menu-Driven Firmware

This section presents detailed flowcharts for the 80*i* and the 81*i* menu-driven firmware and are provided here for convenience in navigating the Mercury System menus and screens.

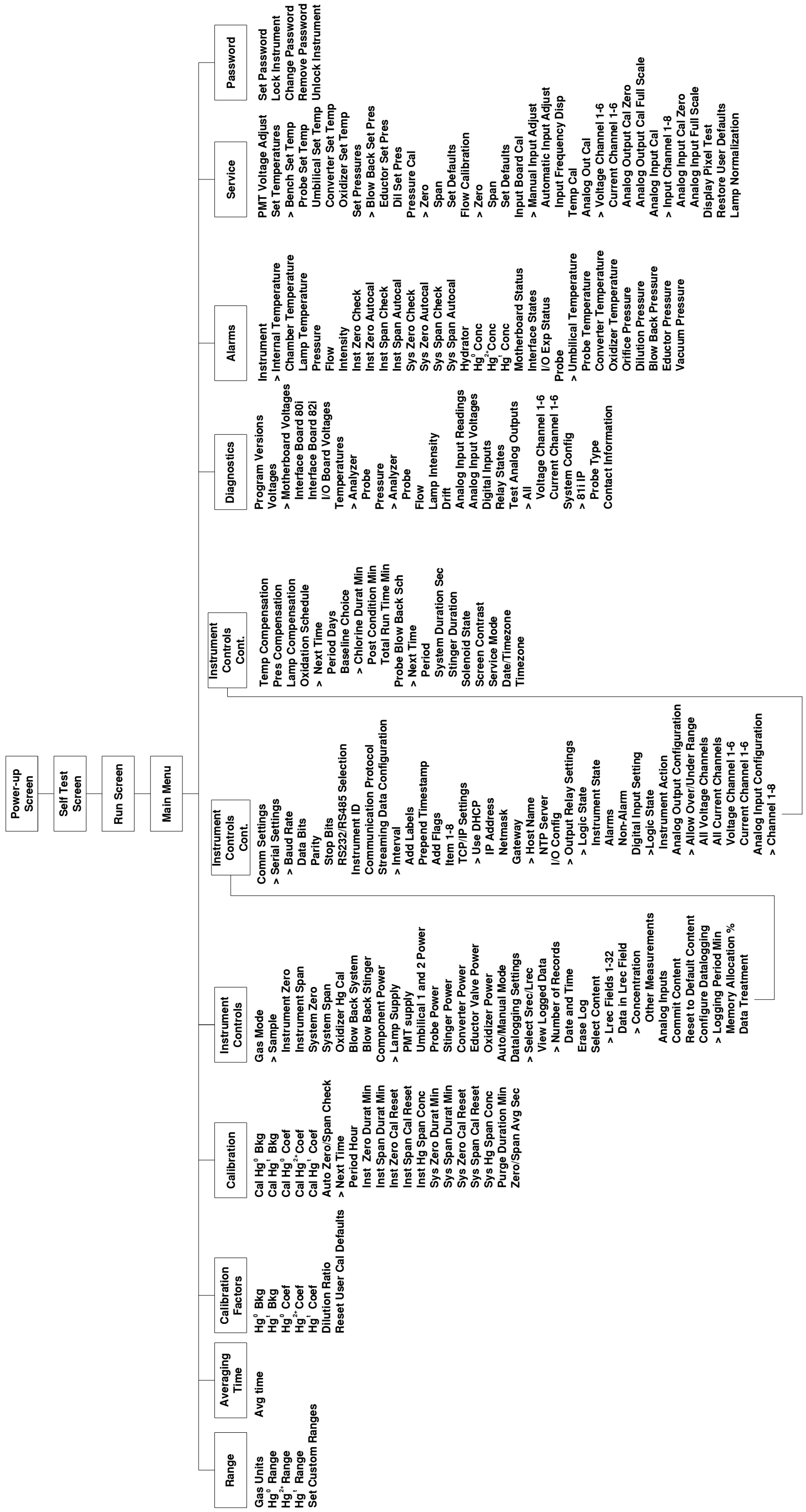


Figure C–1. Model 80*i* Flowchart of Menu-Driven Firmware

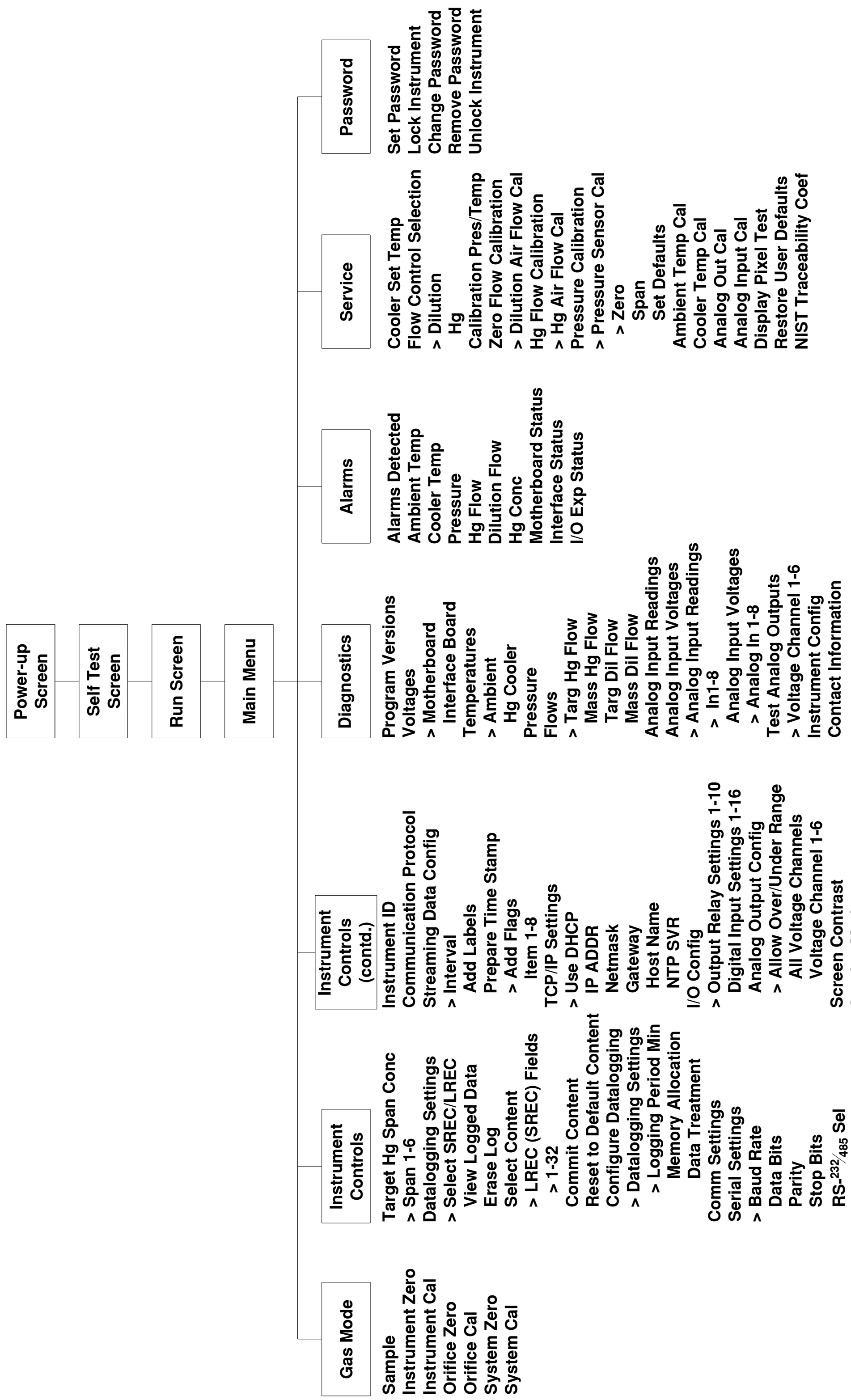


Figure C–2. Model 81*i* Flowchart of Menu-Driven Firmware

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