Sarasota SG901

Specific Gravity Analyzer
User Guide
P/N HB-SG901

Revision E

Part of Thermo Fisher Scientific

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Revision History

Revision Level	Date	Comments
A	03-2009	Initial release (ECO 6849).
B	06-2010	Revised per ECO 7413.
C	08-2010	Revised per ECO 7494.
D	01-2011	Revised per ECO 7628.
E	01-2012	Revised per ECO 7874.

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Contents

Explanation of Symbols

The following symbols are used in this guide or on the equipment:

Caution: Risk of danger. Refer to user guide.

Warning: Electrical shock hazard.

Warning: Hot surface hazard.

Protective ground

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Warnings

Control of Substances Hazardous to Health

- Know the safety precautions and first aid instructions before you use a hazardous substance.
- Read the label on the container in which the substance is supplied.
- Read the data sheet applicable to the substance.
- Obey the local orders and instructions.

Electrical Safety

Warning Remove all power from the unit before making any connections. Electrocution can result if power is present. ▲

Warning Ensure the power supply is isolated. Take suitable precautions to prevent reinstatement of power while working on the system. ▲

Caution The equipment can be impaired if equipment is not used in a manner specified by the manufacturer. ▲

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Chapter 1
Product Overview

Introduction

Thermo Fisher Scientific's Sarasota SG901 specific gravity analyzer is recommended in applications where specific gravity (SG), molecular weight (MW), or density at reference conditions (D@ref) can be used in the plant instead of density at-line conditions. In applications where the process gas is too dirty, too hot, or at too high a pressure, the Sarasota SG901 allows for pre-conditioning of the process stream so a measurement can be made.

Typical applications include:

- Energy determination
- Blending control
- Standard volume control
- Fuel gas monitoring
- Process efficiency
- SG for density determination at other parts of the process

Configurations

The Sarasota SG901 is available in three standard configurations, or systems, which may be selected based on the condition of the sample stream. They are the basic system, the wet gas system, and the dry gas system.

Note that all three systems may have a steam or electric heater mounted within the enclosure so that the sample gas can be maintained above its dew point. They are also available with the frequency output or headmount option (see "Operation" for more on these options).

Basic System

The basic system is ideal for applications in which the sample stream is already conditioned for other instruments. The analyzer is used in conjunction with an existing gas conditioning system that provides a clean, dry sample at a pressure below 4 bar A (58 psi A). This system consists of a small area dry particle filter, density meter assembly (with integral PT100 temperature element), pressure transmitter, and flow control valve. All components are interconnected by 1/4-inch (6 mm) stainless steel tubing and are housed in a weatherproof cabinet.

Refer to drawings SG91-6002 and SG91-6005 in the drawing appendix.

Dry Gas System

The dry gas system is ideal for applications where the gas is always above its dew point, but the sample is not filtered and is above 4.5 bar A. It is similar to the basic system, but it offers a complete package solution to many applications. The small area dry particle filter is replaced by a larger area filter capable of handling unfiltered product. An inlet pressure regulator, safety vent, calibration point, rotameter, and isolation valves are also included.

Refer to drawing SG91-6001 and SG91-6004 in the drawing appendix.

Wet Gas System

The wet gas system is similar to the dry gas system, but it allows for the measurement of gases with significant moisture content. In addition to all of the dry gas system components, a coalescing filter with auto drain and isolation valve is fitted. Note that the wet gas system is designed to protect the system from occasional upsets when condensate may appear in the stream. If condensate is always in the stream other methods should be used to ensure the stream is above its dew point.

Refer to drawings SG91-6000 and SG91-6003 in the drawing appendix.

Operation

The operation described here is for an instrument fitted with optional components.

The gas sample passes through a high pressure isolating valve, pressure regulator, filter assembly, and isolating valve. Both isolating valves are used during maintenance activities.

Downstream of the isolation valve, immediately before the density meter, the gas pressure is measured by a precision pressure transmitter. The gas then flows through the density meter assembly, the rotameter, and the flow control valve.

A calibration tee, fitted to the inlet pipe of the density meter assembly, allows for tapping to the calibration valve. The calibration tee facilitates purging and accurate calibration of the pressure transmitter and SG system.

With the frequency output option, signal outputs from the transducers are fed to a Thermo Scientific Sarasota density converter, which calculates the density (measured), D@ref, SG, and MW of the gas and provides corresponding 4–20 mA current outputs. All variables and calculated values can be displayed on the front panel of the converter. Alternatively, with the headmount version, the Thermo Scientific Sarasota HME900 field mounted density converter provides a direct HART®compatible output.

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Chapter 2
Installation

Note Installation must be carried out in accordance with local site requirements and regulations. ▲

Refer to the drawings in the drawing appendix for this chapter.

Mechanical Considerations

Cabinet Support Structure

The structure the equipment cabinet will be mounted to shall support four times the weight of the equipment. Refer to the specification appendix for unit weight.

Weatherproof Cabinet

The weatherproof cabinet should be mounted securely to a vertical surface with the process connections at the bottom of the unit. Refer to the dimensional drawings for mounting dimensions.

Pipelines/Sample Tubing

The gas inlet should be connected to a suitable tapping on the sample stream via 1/4-inch bulkhead unions. Inlet piping should be kept as short as possible to minimize system response time.

The pressure available at the inlet to the Sarasota SG901 system should be at least 0.4 bar (6 psi) above the control pressure set in the system to ensure regulation.

Where the ambient temperature can drop below the dew point of the sample gas, the lines should be insulated or heated.

If the sample stream is at high pressure, a pressure reduction system may be used to decrease the standard volume in the sample line.

Safety

Ideally, the exhaust should be vented at near atmospheric pressure. The normal method is to exhaust the system to the flare header. If this is not possible then the system should be exhausted at a pressure of at least 0.4 bar (6 psi) below the control pressure in the analyzer system.

It may be required to feed the safety vent outlet, where fitted, to a disposal system or returned to the gas line for environmental reasons.

Electrical Considerations

Note It is the user's responsibility to ensure that local requirements are met. ▲

Cable Specification

The cable specification for the Sarasota SG901 analyzer is:

BS5308 part 1 : 1986 : type 2

Polyethylene insulated, bedded, single wire armored, PVC sheathed, five twisted pairs with individual screens, core size 0.5 mm^2.

This cable is suitable for underground installation.

Maximum distance for transmission of signal is 1 km.

Other cable types may be used, but they must meet requirements for IS installation.

Safe Areas

When the sample gas is non-flammable and the area is non-hazardous, standard electrical precautions regarding signal cables should be taken in order to minimize problems associated with electrical noise.

Hazardous Areas

In hazardous areas, appropriate care must be taken to meet local system requirements and the certification requirements for the Sarasota SG901 analyzer.

Electrical Installation

Warning Electrical installation must be done by qualified individuals in accordance with local site requirements and regulations. ▲

In general, any mains power required for heaters should be segregated from signal and instrument wiring. Where the signaling is protected by an IS concept, the IS wiring must be segregated from signal wires protected by explosion or flameproof concepts.

Protective Earth Grounding

The SG901 enclosure provides an internal safety ground lug for safety protective earth grounding. The safety ground lug is used to connect the heater AC power input ground line.

Safety Disconnecting Means Requirements

As a permanently connected equipment, the SG901 analyzer requires a switch or circuit breaker as the means for disconnection. The analyzer requires 120 Vac or 240 Vac, 700 W for its smart heater. The customer needs to prepare the switch or circuit breaker according to the following requirements:

1. A switch or circuit breaker must be included in the building installation.

2. It must be in close proximity to the equipment (SG901) and within easy reach of the operator.

3. It must be marked as the disconnecting device for this equipment (SG901).

Frequency Output Option

The connections to the Sarasota SG901 analyzer with the frequency output option include the following:

- Terminals 1 & 2, density meter (24 Vdc) 2-wire current pulse
- Terminals 2, 3, 4, & 5, PT100 4-wire (W, X, Y, & Z)
- Terminals 7 & 8, PTX transmitter input (4–20 mA)

These connections should be made to the Thermo Scientific density converter using four shielded pairs 0.5–1.5 mm square connection cable installed into the terminal box.

The screen of the instrument cable should not be connected to the Sarasota SG901 analyzer.

Headmount Option

The Sarasota SG901 analyzer with the headmount option has a built-in density converter. Connections are available as listed below.

- Terminals 1 & 2, density meter +24V
- Terminals 3 & 4, HART signal terminals (4–20 mA)
- Terminals 5 & 6, PTX supply (24V)

These connections should be made to the built-in density converter using three shielded pairs 0.5–1.5 mm square connection cable installed into the terminal box.

Electric Heater

The electric heater voltage is 110 V or 220 V, 500 W maximum. Connection should be made with a suitable connecting cable via a suitable gland. The gland should mate with the fitting on the terminal box.

Note The heater should be connected via a suitable isolator to allow power to be removed from the heater if the enclosure is to be left open for any significant time. The connection box and connections are indicated in Figure 2–1. ▲

The terminal box is suitable for use in hazardous areas and holds European and North American approvals. The installer should ensure that the box is clean and undamaged with correct types and wire sizes 2–4 mm^2 (14–11 AWG). Overall sheath should be 8.5–14 mm.

Connections for the frequency output and headmount versions are shown in the following diagrams.

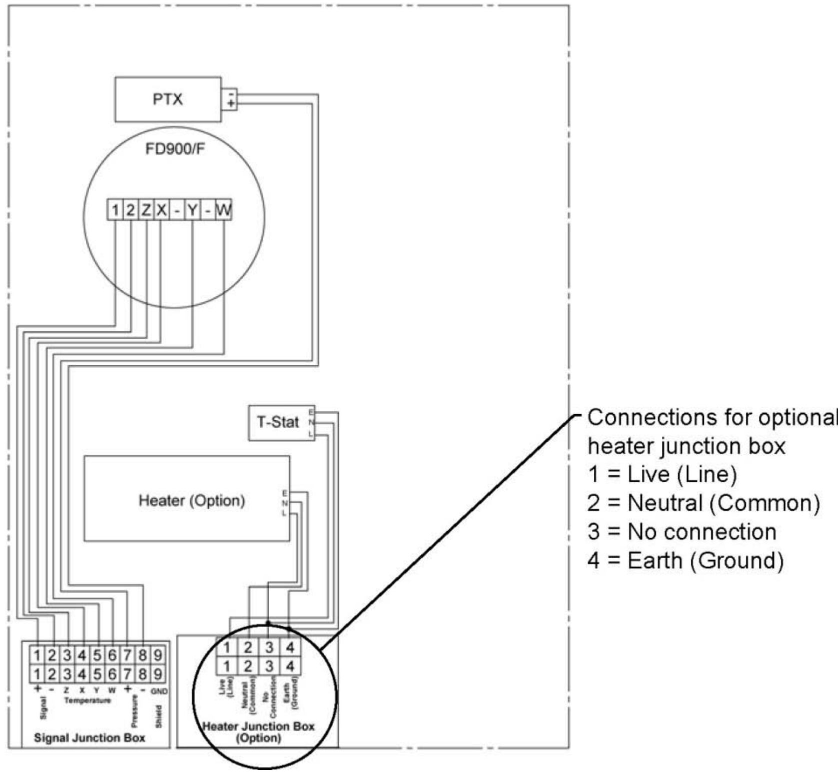

Figure 2–1. Wiring for optional heater junction box, frequency output version

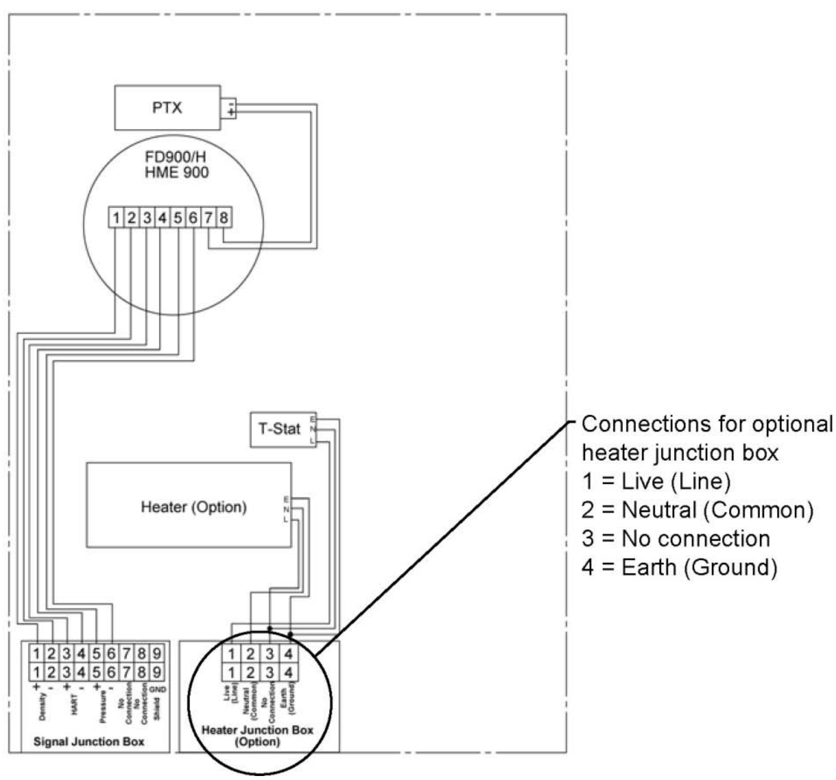

Figure 2–2. Wiring for optional heater junction box, headmount version

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Chapter 3
Commissioning

Warning Refer to the warnings section in the beginning of this manual. ▲

Warning Ensure all local safety rules that apply to this equipment are followed and any permits necessary for the work have been issued. Also ensure obligations under the Health and Safety at Work Act are met. ▲

General

All installation details and wiring should be checked against the recommended methods in this guide and local codes of practice. If zener barriers or isolators are fitted, ensure they are correctly installed and grounded / earthed where appropriate.

Initial Power Up

Frequency Output Option

The Sarasota SG901 with frequency output will have the density meter, PT100, and pressure transmitter powered when power is applied to the density converter. Apply power to the unit. It should be possible to read a period from the density meter, temperature, and pressure. If these readings are not present, remove power from the density converter and check the wiring. If no wiring fault can be found, go to Chapter 7 for troubleshooting.

Headmount Option

The headmount version of the Sarasota SG901 will have power to each loop provided from a DCS or remote DC power supply.

Note The HART signaling requires the supply to be connected to it and will sink 4–20 mA. It does NOT supply current to a passive device. ▲

Sample System

Ensure that operating pressure, temperature, and gas flow available are within specifications.

Note The sample take-out point may have an initial regulator to decrease pressure in the sample line and increase the response of the system. If this is the case, it should be set in the 5–10 bar G range, depending on the sample line length to ensure 5 bar A at the input to the Sarasota SG901 system. ▲

For the basic system, the operating pressure should be within the range of the pressure transmitter (0.3–3.45 bar) and at least 0.4 bar above the exhaust pressure. Ideally, the pressure should be close to 4 bar to minimize pressure measurement errors.

For the dry and wet gas systems, the inlet pressure should be set according to any factory acceptance test (FAT) documents, or close to 4 bar A to minimize measurement errors. However, in some cases, the pressure may deliberately set lower than this for operational reasons.

Note Read any FAT records fully. ▲

Set the flow rate so that the minimum flow rate meets the sample delay requirements of the overall system. The higher the flow rate, the lower the delay time. However, as the flow is increased, the waste exhaust gas volume increases. A flow rate of 5 L/min is suggested as an initial value.

Density Converter

For details on commissioning the selected density converter, refer to the user guide provided with it. Generally, the density converter should be set to perform following tasks:

- Calculate density with VOS correction (VibDim) calibration constants
- Calculate density at reference conditions
- Calculate SG / MW

Chapter 4
Validation

Warning Refer to the warnings section in the beginning of this manual. ▲

General

A calibration tee is provided to facilitate purging of the density meter with a known gas for calibration purposes. Alternatively, if the internal regulator is to be checked, the inlet should be disconnected and the purging gas supply connected in its place. In either case, the pressure measured at the calibration tee with no flow should agree with the 4–20 mA signal from the pressure transmitter.

To validate the system, it is necessary to either introduce a sample gas of known characteristics into the system or take a sample of gas from the system for laboratory analysis. If a sample is taken from the process stream for laboratory analysis, it will be representative of the stream. If a test gas mixture is introduced into the instrument, the mixture used should be representative of the measured process stream. The reason for this follows.

The Sarasota SG901 system measures density, temperature, and pressure. It then calculates density at reference conditions. The calculation of line density and density at reference conditions require values of isentropic exponent (specific heat at constant pressure / specific heat at constant volume) and one of the following: Az and Bz (for the Thermo Scientific Sarasota HME900) or critical temperature and critical pressure (for the Thermo Scientific Sarasota CM515). These constants are calculated based on the expected average gas constituents. If the validation gases are not representative of the process gas, the constants will be in error and the system may not operate to specification. If the validation gas is not representative of the process, it may be required to change the gas constants before validation and then return the constants to the operational values after the test.

Refer to Figure 4–1 for the valves used in system validation.

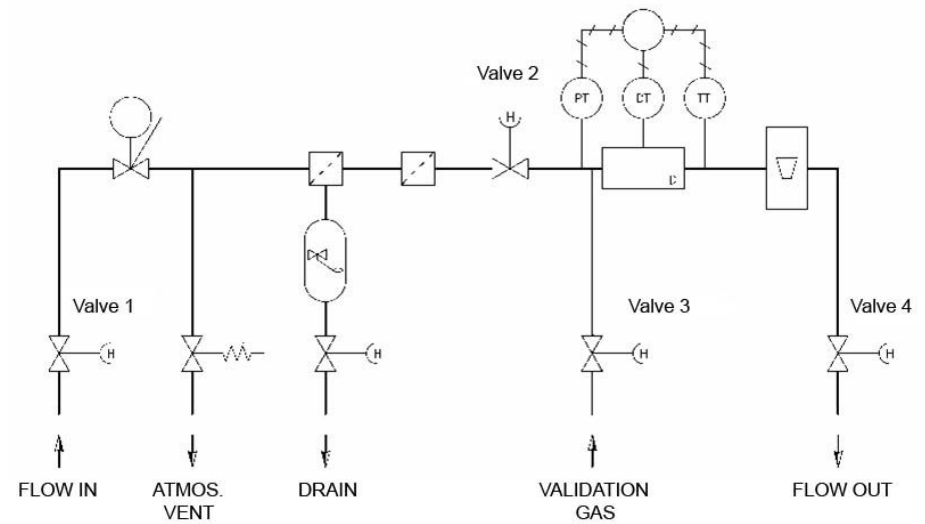

Figure 4–1. System validation flow diagram

Validation with an Injection Sample

Follow these steps to validate the system using an injection sample.

1. Close valves 1 and 2, and open valve 4.

2. Invert the validation gas sample cylinder several times to ensure a good mix.

3. Connect the gas cylinder to the validation gas input via a pressure regulator set to the same pressure as the Sarasota SG901 regulator.

4. Allow the sample to flow at approximately 5 L/min until the reading from the density converter is stable. Note the SG or MW reading, and compare it to the certified SG or MW. The error between the system and the certified value should be within the sum of the uncertainties of the validation gas and the Sarasota SG901. If the error is unacceptable, go to Chapter 7 for troubleshooting.

5. After validation, close the validation cylinder valve and valve 3. Open valves 2 and 1.

Validation with a Process Gas Sample

The process gas sample can be taken out of the validation gas input. However, as the sample is taken, the reading from the system will become unstable. Alternatively, arrangements may be made to leave a sample tee and suitable valve at the sample output (Flow Out).

To take the sample using a sample bladder and the validation gas input connection, follow these steps.

1. Read the SG of the gas in the system.

2. Crack the validation gas input valve (valve 3), and allow gas to flow through the connection for a suitable time to ensure the validation gas tube is full of representative gas.

3. Connect the bladder, and open the valve to fill it.

4. Close the valve. Isolate and remove the bladder.

5. Allow the system to stabilize until it reaches the reading that was present before the sample was taken. If the process gas has changed during the sample and the unit does not return to its previous reading, use an average reading or take the sample again. The sample should be passed to the laboratory for analysis. If the error is unacceptable, go to Chapter 7 for troubleshooting.

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Chapter 5
Calibration

Field Adjustments

Adjustment may be done in the field. However, it is important the thermometry is known to be good before any other adjustment is made.

Adjustment is carried out if the applied reference (standard) does not provide the expected output result. The allowable error of the system will be the sum of the uncertainty of the supplied sample and the acceptable error of the Sarasota SG901 system. For instance, if the acceptable error of the system at the operating point is 0.2% and the uncertainty of the sample is 0.5%, the acceptable error band is ± 0.7%.

SG Definition & Calculation

There are two figures given for SG. Ideal SG is the ratio of the MW of the sample and the MW of air and real SG. Real SG is the ratio of the densities of the sample gas to the density of air at the same reference conditions.

The density meter measures density at actual conditions. To do this, we use the following equation:

$$\rho_m = d'_0 \times \frac{(t - t'_0)}{t'_0} \times \left[2 + K \times \frac{(t - t'_0)}{t'_0}\right],$$

where

$$t'_0 = T0 + TEMPCO \times (T - T_{cal}) + PRESCO \times (P - P_{cal}).$$

$$d'_0 = D0\left[1 - \left(\frac{VIBDIM \times \bar{R}}{a \times t}\right)^2\right].$$

$$a = \left(\frac{ISENEX \times P \times \bar{L}}{\rho_m}\right)^{\frac{1}{2}}.$$

The inputs to the equations are temperature, pressure, period (from the density meter) and isentropic exponent (Cp/Cv). Where the gas matrix is changing the average, isentropic exponent should be used. There is an error associated with the isentropic exponent; however, a relatively large error in isentropic exponent will only make a small error in density. The isentropic exponent will usually be in the range of 1.2–1.4.

From line density, we calculate density at the chosen reference conditions. Where density at reference conditions is calculated as:

$$\rho_c = \frac{\rho_m \times Pref \times T \times Z}{P \times Tref \times Zref},$$

where Z and Zref are the compressibility (divergence from ideal gas equations) at measurement and reference conditions. Z and Zref are calculated using the Redlich Kwong equation of state which uses two constants: Az and Bz (Sarasota HC900 and Sarasota CM200) or critical temperature and critical pressure (Sarasota CM515). These constants can be calculated from tables based on gas mixture, or in cases where the mixture is hydrocarbon, from a built-in fit (Az and Bz from MW).

SG is then calculated by dividing the sample reference density by the density of air at the same conditions.

A full set of equations is included in Appendix E.

Adjustment

System adjustments should only be made after a number of samples have been taken to establish an average error. Failure to do this or attempts to adjust the system based on one reading or sample may actually increase the error. To make an adjustment:

1. Ensure the pressure and temperature readings are an acceptable accuracy.

2. Set the density correction factor (DCF) to 1 and the density offset (Doff) to 0.

3. Take a series of samples and synchronous readings of SG. Have the samples analyzed and calculate the average error.

Correction Calculation

Assuming the thermometry, pressure measurement, supercompressibility calculations, and isentropic exponent are operating correctly, the adjustment can be made using the DCF or the Doff. Either option is acceptable, but the Doff should give better results as long as the span of the system is relatively small.

To calculate the Doff, you will need to know the following synchronous data: average SG error and average line density during the test.

Example

Real SG = 0.88, Displayed SG = 0.8, error = -10%

Line density = 3.84 kg/m^3

Density correction = (Density * (Error %/ 100))

= (3.84 * 0.1) = 0.384 kg/m^3

Change the Doff to 0.384.

Note that if the DCF is used, then

DCF = (1 – (Error % / 100))

In the example, DCF would equal 1.1.

If the applied SG is calculated from MW, compressibility should be taken into account.

Table 5–1 gives compressibility for gases at the specified conditions. Table 5–2 provides the compressibility at reference conditions (Zref) of 0°C and 1.01325 bar A. This can be used to estimate the compressibility (Z and Zref) in the density at reference conditions equation (Ref – 1.01325 bar A and 0°C).

Table 5–1. Gas Compressibility at specified conditions

Gas	Pressure	25°C	30°C	35°C	40°C	45°C
C1	2 bar A	0.9965	0.9967	0.9969	0.9971	0.9973
	3 bar A	0.9948	0.9951	0.9954	0.9957	0.9959
	4 bar A	0.9931	0.9935	0.9939	0.9943	0.9946
C2	2 bar A	0.9849	0.9856	0.9864	0.9870	0.9877
	3 bar A	0.9772	0.9783	0.9794	0.9805	0.9814
	4 bar A	0.9694	0.9710	0.9725	0.9738	0.9751
C3	2 bar A	0.9677	0.9694	0.9710	0.9725	0.9739
	3 bar A	0.9508	0.9535	0.9559	0.9582	0.9603
	4 bar A	0.9333	0.9370	0.9404	0.9435	0.9465
C4	2 bar A	0.9383	0.9420	0.9483	0.9483	0.9512
	3 bar A	Liquid	Liquid	0.9153	0.9203	0.9248
	4 bar A	Liquid	Liquid	Liquid	Liquid	0.8968
C5	2 bar A	Liquid	Liquid	Liquid	Liquid	Liquid
	3 bar A	Liquid	Liquid	Liquid	Liquid	Liquid
	4 bar A	Liquid	Liquid	Liquid	Liquid	Liquid

Gas	Pressure	25°C	30°C	35°C	40°C	45°C
H2	2 bar A	1.0012	1.0012	1.0012	1.0012	1.0012
	3 bar A	1.0018	1.0018	1.0018	1.0018	1.0018
	4 bar A	1.0024	1.0024	1.0024	1.0024	1.0024
CO2	2 bar A	0.9898	0.9904	0.9909	0.9913	0.9918
	3 bar A	0.9847	0.9855	0.9863	0.9870	0.9877
	4 bar A	0.9796	0.9807	0.9817	0.9827	0.9836
N2	2 bar A	0.9955	0.9997	0.9998	0.9998	0.9999
	3 bar A	0.9933	0.9996	0.9997	0.9998	0.9999
	4 bar A	0.9911	0.9994	0.9996	0.9997	0.9998

Table 5–2. Gas compressibility at reference conditions (0°C and 1.01325 bar A)

C1	C2	C3	H2	CO2	N2
0.9976	0.9986	0.9588	1.0006	0.9937	0.9995

Chapter 6
Maintenance

In general, the Sarasota SG901 analyzer is low maintenance. This section provides schedules for preventive maintenance.

Caution Maintenance should be performed only by qualified personnel. ▲

Preventive Maintenance

Preventive maintenance should be done at least once yearly (more often if the process stream is particularly dirty). Preventive maintenance consists of the checking the following:

- Thermometry
- Functionality of heaters, if fitted
- Functionality of the pressure transmitter / density converter
- Filter condition
- Density sensor

To perform maintenance, you will need a clean air supply, a pressure test gauge or calibrator, an accurate thermometer (0.1°C), and other normal tools.

If the density meter requires cleaning, you will also need a spool spanner, suitable solvent, lint-free wipes, and acetone final solvent wash.

Thermometry Check

1. Open the analyzer enclosure, and connect the check thermometer to the sample tube at the entrance or exit of the density meter.

2. Close the door, and allow the system to stabilize.

3. Read the system temperature and the thermometer. The system temperature should be within ± 0.2°C (0.36°F) of the thermometer. If the error is significantly outside this range, the density converter may require calibration. If you have a system with the frequency output option, refer to the manual supplied with the density converter for calibration instructions. If you have a system with the headmount option, the thermometry of the built-in converter cannot be calibrated on site. Contact Thermo Fisher.

Electric Heater Check

If an electric heater is fitted, it should maintain the temperature within the enclosure at ± 2°C (3.6°F) of the set control point. By monitoring the density meter temperature you should read the cabinet temperature. It should be stable (± 2°C/3.6°F).

The surface temperature of the heater is redundantly limited electronically and by a safety fuse at the heat source.

Pressure Transmitter Check

The pressure transmitter / density converter can be checked online by connecting a test gauge to the gas validation input connection. Note that the gauge should be absolute and have an accuracy of 0.1% or better.

To check the system, connect the test gauge (or pressure transducer) to the validation input, and open the valve (valve 3, reference Figure 4–1). The test gauge should match the pressure reading from the density converter. If there is an error, close valve 1 first, and then close valve 4. This will give a more stable reading. If the readings are still in error, either the density converter or the pressure transmitter may require calibration.

The pressure transmitter span and zero can be adjusted by up to five percent independently using the adjusting screws located inside the end of the transmitter (shown in Figure 6–1).

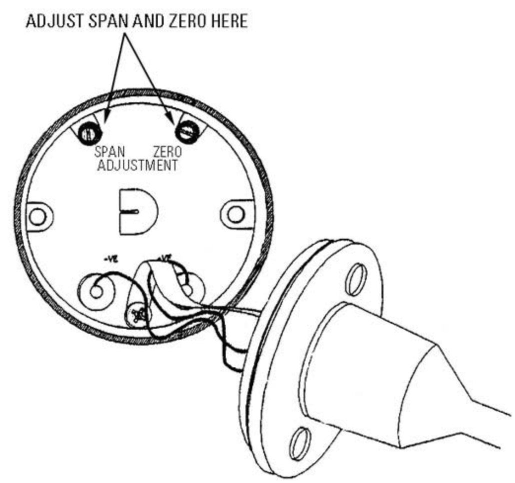

Figure 6–1. Pressure transmitter with cover removed

Filter Condition

You can check the condition of the filter by removing the element and visually inspecting it or by varying the flow through the system and noting the change in pressure. To check the filter using flow:

1. Set the flow to 5 L/min and note the pressure.

2. Change the flow to 10 L/min. Pressure should not change by more than 0.02 bar (0.3 psi).

Density Sensor Check

Follow the steps below to check the density sensor.

1. Set the valves for validation, and purge the system with dry air at low pressure.

2. After several minutes, disconnect the supply while closing valve 4 (reference Figure 4–1).

3. Allow the pressure to drop to atmospheric conditions.

4. When stable, record the density meter period. This period (adjusted for temperature using the temperature coefficient published on the calibration sheet and for the change in density of air at the test conditions) should be within 200 nsec of the Tair published on the sheet. If the Tair is not within specification, the density meter sensor requires cleaning. Refer to the density meter's manual.

If there are no problems, put the system back into service.

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Chapter 7
Troubleshooting & Service

Fault Diagnosis

This section provides troubleshooting steps for the analyzer.

Table 7–1. Fault diagnosis

Symptom	Possible Problem / Solution
Condensation indicated by large variations in density or instrument failing to read density.	1. Condensation may be due to gas cooling on pressure reduction through the regulator. This can be minimized by reducing the flow rate or reducing the pressure at the sample point, since ambient heat will be better able to warm the gas stream and evaporate any condensation in the sample tubing. If excessive cooling is a problem, a heat trace is advisable. 2. Check the filter. 3. If the density meter alarm activates: - Check the filter for condensate. - Close the isolating valve and purge the system via the calibration tee until a density reading is obtained which is correct for the gas used. **Note:** If purging fails, clean the density meter as described in its manual and replace the filter.
Flow rate/system response time is too long or is unstable.	1. Large changes in pressure of the inlet or exhaust may affect flow rate and system response. If the process conditions have been altered, adjust flow at the regulating valve. If the exhaust pressure is unstable, a back pressure regulator may be considered. 2. If the inlet pressure has been increased or is very high, a pre-regulator at the sample point will decrease the standard volume held in the sample transport line and, therefore, the amount of gas that has to be transported to the instrument, improving sample delay time.
Alarms raised by control room type density converter.	Various alarms can be raised by the density converter. If the converter is a control room type, typical alarms include: - Density / Pressure too low: The pressure regulation has failed or filters may be blocked, pressure is too low, density is too low. - Density / Pressure too high: The pressure regulation has failed, or the exhaust return pressure is too high. - Temperature too high / too low: PT100 failure. This alarm may also indicate a process problem.

Symptom	Possible Problem / Solution
Alarms raised by the Sarasota HME900 density converter.	Typical alarms for the Sarasota HME900 density converter are: - Error 01 LSL: Lower sensor limit alarm - Error 02 USL: Upper sensor limit alarm - Error 03 EEPROM: Electrically Erasable Programmable Read-Only Memory error - Error 04 ADC: Analog-to-digital converter error - Error 05: Pressure input error - Error 06: PRT input error - Error 07: Period input error - Error 08 RAM: RAM error - Error 09 ROM: ROM error

Troubleshooting Sarasota SG901 / CM515 Density Systems

This section provides basic troubleshooting steps for problems that may arise when using the Thermo Scientific Sarasota CM515 density converter with the Sarasota SG901 with frequency output.

Caution This section provides troubleshooting guidance to instrument technicians experienced with working on process instruments with low and medium voltage supplies, intrinsically safe or explosion proof / flame proof protected equipment, and connections to pressurized gas systems. Maintenance and troubleshooting should be performed only by qualified personnel. ▲

The Sarasota SG901 consists of three instruments combined with a sample system, which has various options and an optional electric heater or steam enclosure heater mounted in a cabinet. These instruments are:

- Thermo Scientific Sarasota FD900 density meter
- PT100 thermometer element included in the density meter
- Pressure transmitter

Note Users should be familiar with operating the Sarasota CM515 and Sarasota SG901 and with servicing the Sarasota FD900. Refer to the user guides for each instrument (HB-CM515-DG01, HB-SG901, and HB-ID/ FD900). ▲

Note It is assumed that the system is in service and has product running through it. ▲

Table 7–2. Troubleshooting steps for Sarasota SG901 / CM515 density systems

Symptom	Possible Fault	Resolution / Further Investigation
Sarasota CM515 display is blank or backlight is not on.	- No power to instrument. - Display is configured to switch off after a predetermined time.	- If there is no power to the instrument the RUN LED will not be lit. In this case, check power at the terminal connections. - If power is available at the terminals, check the DC voltage available at the EXC V terminals (with respect to Ground). If voltage is available here, the PSU is operational. - If voltage is not available, the PSU is faulty and requires repair. - If power is available and the RUN LED is lit, press the **DISPLAY** key. If the display comes on, it is likely that it is configured to go off after a set period of inactivity. Change the configuration to disable display timeout.
System gives Zero reading for SG.	- Density calculated value is zero or negative.	- If the main density is zero, check the period input. If the period input is close to the expected period (read from the calibration sheet), check if pressure and temperature readings are within the expected ranges. If the period, pressure, and temperature readings are in the correct ranges, verify the entered constants T0, D0, K, TC, and PC are correct as per the calibration sheet 1 (constants for 15°C). - If the temperature is in gross error, check the thermometer connections and configuration. - If the connections are correct at the Sarasota CM515, check the configuration. Also verify the thermometer values are correct at the meter connections (WY and XZ).
System gives Zero reading for SG.	- Temperature is in gross error. - Pressure reading is –ve.	- If the temperature is in gross error, check the thermometer connections and configuration. - If the connections are correct at the Sarasota CM515, check the configuration. Also verify the thermometer values are correct at the meter connections (WY and XZ). Check that any fitted barriers are continuous (no blown barriers fuses).
System gives Zero reading for SG.	- Pressure input is incorrect.	Check the following: - Input is connected correctly. - Voltage available at the pressure transmitter terminals is greater than 8 volts. - Any fitted barriers are continuous (no blown barrier fuses). - Configured Full Scale and Zero are correct and the input is not set to default.
System gives Zero reading for SG.	- Period reads Zero or grossly outside expected values.	Check the following: - Voltage at the density meter terminals exceeds 10 volts. - The density input default value is set to zero (if a non-zero value is set, the meter will use the default value).

Symptom	Possible Fault	Resolution / Further Investigation
System gives wrong value for SG.	- One of the three inputs (pressure, temperature, density) is in error.	- Check that displayed density ($D_{(Line)}$) is the expected value for the process gas at the system pressure and temperature. - Check that $D_{(Ref)}$ is approximately equal to: $$D_{(Re\ f)} = D_{(Line)} \times \frac{P_{(Re\ f)}}{P_{(Line)}} \times \frac{T_{(Line)}}{T_{(Re\ f)}}$$ where P and T are in absolute values. If $D_{(Ref)}$ is not within 1% of the calculated $D_{(Ref)}$ check the values Z and $Z_{(Ref)}$.
System gives abnormal Z and $Z_{(Ref)}$.	- Z or $Z_{(Ref)}$ is outside the range 0.98 to 1.2.	- A gas equation of state other than "Ideal" has been chosen, but Critical Pressure (Pc), Critical Temperature (Tc), or Acentric factor has not been set correctly. Either set the parameters or choose "Ideal" equation. If "Ideal" is chosen, Z and $Z_{(Ref)}$ will default to 1.
None of the above symptoms are apparent but the system gives excessive errors.	- Basic Density is in error.	- Check that VIBDIM constants (Set 1) are in use and that VibDim is per the calibration sheet and in the correct units. - Check that DCF = 1 and D_{off} = 0 (unless the unit history shows that the density output has been adjusted during validation). - If the above are not at fault, the meter should be cleaned and put back in service.
None of the above symptoms are apparent but the system gives excessive errors.	- Pressure is in error.	- If the pressure transmitter calibration is suspect, then recalibrate the pressure transmitter by connecting a reference pressure transmitter or indicator to the Validation gas input. Note that the reference indicator must have an accuracy of 0.1% and be in absolute units. Adjust the pressure using the input pressure regulator, and compare the Sarasota CM515 pressure reading to the indicator reading. - The Pressure input can be corrected by setting the full scale pressure to the full scale indicated by the indicator at 20 mA output from the pressure transmitter. The Zero value can be calculated from: $$Zero = Fs - \left[16 \times \frac{(Fs - Ap)}{(Fs_{mA} - Ap_{mA})}\right]$$ Where: Fs = Measured full scale in Engineering Units at 20 mA Ap = Measured Atmospheric Pressure in Engineering Units Fs_{mA} = 20 mA Ap_{mA} = mA at Atmospheric Pressure

Contact Information

If you have reviewed the troubleshooting section and the unit still is not performing satisfactorily, the local representative is your first contact for support and is well equipped to answer questions and provide application assistance. You can also contact Thermo Fisher directly.

Process Instruments		
1410 Gillingham Lane Sugar Land, TX 77478 USA +1 (800) 437-7979 +1 (713) 272-0404 direct +1 (713) 4573 fax	14 Gormley Industrial Avenue Gormley, Ontario L0H 1G0 CANADA +1 (905) 888-8808 +1 (905) 888-8828 fax	Unit 702-715, 7/F Tower West Yonghe Plaza No. 28 Andingmen East Street, Beijing 100007 CHINA +86 (10) 8419-3588 +86 (10) 8419-3580 fax
A-101, 1CC Trade Tower Senapati Bapat Road Pune 411 016 Maharashtra, INDIA +91 (20) 6626 7000 +91 (20) 6626 7001 fax	Ion Path, Road Three Winsford, Cheshire CW7 3GA UNITED KINGDOM +44 (0) 1606 548700 +44 (0) 1606 548711 fax	
www.thermoscientific.com		

Warranty

Thermo Scientific products are warranted to be free from defects in material and workmanship at the time of shipment and for one year thereafter. Any claimed defects in Thermo Scientific products must be reported within the warranty period. Thermo Fisher shall have the right to inspect such products at Buyer's plant or to require Buyer to return such products to Thermo Fisher's plant.

In the event Thermo Fisher requests return of its products, Buyer shall ship with transportation charges paid by the Buyer to Thermo Fisher's plant. Shipment of repaired or replacement goods from Thermo Fisher's plant shall be F.O.B. Thermo Fisher plant. A quotation of proposed work will be sent to the customer. Thermo Fisher shall be liable only to replace or repair, at its option, free of charge, products which are found by Thermo Fisher to be defective in material or workmanship, and which are reported to Thermo Fisher within the warranty period as provided above. This right to replacement shall be Buyer's exclusive remedy against Thermo Fisher.

Thermo Fisher shall not be liable for labor charges or other losses or damages of any kind or description, including but not limited to, incidental, special or consequential damages caused by defective products. This warranty shall be void if recommendations provided by Thermo Fisher or its Sales Representatives are not followed concerning methods of operation, usage and storage or exposure to harsh conditions.

Materials and/or products furnished to Thermo Fisher by other suppliers shall carry no warranty except such suppliers' warranties as to materials and workmanship. Thermo Fisher disclaims all warranties, expressed or implied, with respect to such products.

EXCEPT AS OTHERWISE AGREED TO IN WRITING BY Thermo Fisher, THE WARRANTIES GIVEN ABOVE ARE IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, AND Thermo Fisher HEREBY DISCLAIMS ALL OTHER WARRANTIES, INCLUDING THOSE OF MERCHANTABILITY AND FITNESS FOR PURPOSE.

Appendix A
Ordering Information

Table A–1. Sarasota SG901 specific gravity analyzer

Code	Model
F	Basic specific gravity analyzer with frequency output, no local display. Includes density meter FD900F, cabinet (IP65 - NEMA 4X), thermometer element, and pressure transmitter for compensation using Thermo Scientific Sarasota CM515 density convertor (other convertors can be used). Notes: Maximum inlet sample pressure of 4 bar. Ambient temperature electronics -20°C to 60°C (gas sample must remain above the dew point within this temperature range).
H	Basic specific gravity analyzer with Sarasota FD900 density meter and smart headmount electronics, includes local display. Includes density meter FD900F, cabinet (IP65 - NEMA 4X), thermometer element, and pressure transmitter for compensation using Thermo Scientific Sarasota CM515 density convertor (other convertors can be used) Notes: Maximum inlet sample pressure of 4 bar. Ambient temperature electronics -20°C to 60°C (gas sample must remain above the dew point within this temperature range).
Code	**System Type**
B	Basic system: See descriptions above.
D	Dry gas: Basic system components plus inlet sample pressure regulator, dry particulate filter, flow indicator, flow control valve, system isolation valves, manual valve for calibration/validation gases. Gas must be above its dew point.
W	Wet gas: Dry gas system components plus coalescing filter with auto-drain (used to remove occasional moisture contamination)
Code	**Spool Material**
Z	Ni-Span C: Use with non-corrosive gases; process temperatures < 75°C (167°F)
Y	FV-520 B: Magnetic stainless steel suitable for all applications
Code	**Certification**
C	CSA Class I, Div 1 Groups B, C, & D (pending)
I	ATEX Intrinsically Safe (barriers not supplied with system; see barrier options in Installation Accessories table) (pending)

Code	Heater Options
N	No heater option
E	Explosion proof electric heater: ATEX EEx dm Zone 1 IIC T3 - Heater voltage 220 Vac / 50/60 Hz or CSA Class 1, Div I, Groups B, C, & D T3 - Heater voltage 110 Vac / 50/60 Hz Standard enclosure with precise temperature control up to 50°C at ± 0.5°C Enclosure ambient temperature range -40°C to +50°C (HME inside enclosure)
H	High temperature explosion proof electric heater: ATEX EEx dm Zone 1 IIC T3 - Heater voltage 220 Vac / 50/60 Hz or CSA Class 1, Div I, Groups B, C, & D T3 - Heater voltage 110 Vac / 50/60 Hz High temp enclosure with precise temperature control at 60°C, 70°C, or 80°C at ± 0.5°C Includes heating system and externally mounted meter electronics. Enclosure ambient temperature range -20°C to +55°C
S	Steam heater: Allows control of standard enclosure temperature at 50°C Customer to provide dry steam of sufficient temperature and pressure Enclosure ambient temperature range -40°C to 50°C
Code	**Options**
N	NACE Conformance: All wetted parts suitable for use in sour gas service; NACE specification MR-01-75
T	Traceable Calibration Certificate: Provides record of all instruments used during calibration and their calibration certificates
M	Wetted parts traceability to EN 10204. Type 3.1 (tubing and density meter only)

Table A–2. Instrument spares

P/N	Description
ZV10-0060	Isolating valve, standard
ZV10-0050N	Isolating valve, NACE
ZC80-0005B	Check valve, standard
ZV10-2550	Check valve, NACE
ZF12-0061	Filter elements for coalescing filter (standard, dry gas system), 10 each
ZF12-0062	Filter elements for coalescing filter (standard, wet gas system), 10 each
ZF10-0030	Filter elements for coalescing filter (NACE, wet and dry gas systems), 10 each
SSG****	Spare spool: consult Thermo Fisher
HD-B0070	Spool lock ring
H90-0030/A	Preset torque spanner
ZR20-0220/B	Viton O-rings for 1.5” BSP end caps, 10 each

P/N	Description
ZV25-0010	Flow control valve
ZV25-0010N	Flow control valve, NACE
ZC01-0400	Bulkhead pipe fitting
ZC27-0010	Test point plug
PC251/252-T	HME spare card set: Includes PC251 Processor and PC252 Safety and Isolation PCBs
Local Display	Local display kit for HME: Includes mounting components and display PCB
ZV90-0026	Smart heater system software: Control & diagnostic software to permit setting temperature set point and diagnostics on heater system. PC requirements: Windows 2000, XP, Vista, 7 with USB interface

Table A–3. Installation accessories

P/N	Description
ZB/MTL/D4 (CM515)	For use with frequency output system with connection to Sarasota CM515 (set of 4 barriers): 2x MTL787S/28V-300 ohm + diode return for power to density meter 2x MTL755/3V 10 ohm AC barriers for 4-wire Platinum resistance thermometer
ZB/MTL/D1	For use with headmount option only (set of 3 barriers): 2x MTL728/28V-300 ohm for density meter power supply and pressure transducer loop power 1x MTL787S/28V-300 ohm + diode return for HART signal loop 4–20 mA
ZB/MTL/D5	Barrier Enclosure - ATEX EEx dp IIC T6 - CSA Class I, Div 1, Groups B, C, & D Explosive Rated For use with headmounted electronics only (set of 3 barriers): 2x MTL728/28V-300ohm for density meter power supply and pressure transducer loop power 1x MTL787S/28V-300ohm + diode return for HART signal loop 4–20 mA output systems. For use where explosive rating required
ZB/ MTL/D6	Barrier Enclosure - ATEX EEx dp IIC T6 - CSA Class I, Div 1, Groups B, C, & D Explosive Rated For use with frequency output system only with connection to Sarasota CM515 (set of 4 barriers): 2x MTL787S/28V-300 ohm + diode return for power to density meter 2x MTL755/3V 10 ohm AC barriers for 4-wire Platinum resistance thermometer. For use where explosive rating required

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Appendix B
Specifications

Results may vary under different operating conditions.

Table B–1. Functional specifications

Range	0–2 SG; consult Thermo Fisher for other ranges.
Accuracy	± 0.2% of 1 sgu
Repeatability	± 0.02% span
Flow range	Ideally 4 to 20 L/min (0.14 to 0.7 ft^3/min)
Temperature coefficient (corrected)	0.01%/°C (0.006%/°F) Note: Correction coefficients applied.
Operating temperature	Standard: -20°C to +60°C (-4°F to +140°F) or as limited by gas dew point. Consult Thermo Fisher for other ranges.
Operating and storage humidity	≤ 98%
Maximum operating altitude	3000 m
Sample inlet pressure	Basic system: 4 bar A (58 psi A). Consult Thermo Fisher for other pressures up to 20 bar (290 psi). Dry or wet gas system: 200 bar (2900 psi) maximum.
Exhaust pressure	Must be less than 4 bar A (58 psi A) and less than the regulated inlet pressure by 0.4 bar A (5.8 psi A).
Environmental rating	IP65 (NEMA 4X)

Table B–2. Physical specifications

Spool materials	Ni-Span C or FV520B
Tubes and fittings materials	Stainless steel (316L/1.4404)
System enclosure materials	304 stainless steel
Electronics enclosure materials	Copper free aluminum grey epoxy finish; plate glass window for headmount local display option
Temperature measurement	High accuracy 1/3 DIN integral 4-wire PT100 (RTD)
Dimensions	Reference the drawing appendix.
Weight	Net: Up to 60 kg (132 lb) depending on system Shipping: Up to 94 kg (207 lb) depending on system
Shipping dimensions	940 x 680 x 270 mm (approximately 37 x 27 x 11 in)
Installation configuration	1/4” tubing compression fitting
Electrical connections	Screw terminals
Power supply	Frequency output option: 16–28 Vdc, 10 mA average (peak 18 mA) Headmount option: 3x 13–28 Vdc, 25 mA
Optional heater power supply	CSA: 120 Vac, 50/60 Hz, 700 W ATEX: 230 Vac, 50/60 Hz, 700 W
Outputs	Frequency option: Frequency related to density on 2-wire current modulated loop, 6–18 mA; 4-wire PT100; 4–20 mA pressure. Headmount option: Analog 4–20 mA related to SG, density, or density derived variable; HART protocol.

Table B–3. Compliance/Certification

Quality assurance	ISO 9001:2000
CE mark	Compliant
Electromagnetic Compatibility	Compliant (EN 61326:1997)
Pressure Equipment Directive (97/23/EC)	SEP (sound engineering practice)
Safe Area Use	As standard
BS EN ISO 15156 / NACE MR0175 Conformance	Optional
ATEX (pending)	EEx ia IIC T4 (without heater) EEx ia IIC T3 (with heater)
CSA (pending)	Class I, Div. 1, Groups B, C, & D
Calibration certification	Calibration traceable to national standards. Calibration certificates supplied as standard. Optional traceable calibration equipment listing available.
Material traceability	Wetted parts traceability to EN 10204. Type 3.1 (tubing and density meter only)

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Appendix C
Drawings

Note Information presented in this chapter has been regenerated from original drawings. Every effort is made to maintain document accuracy. However, in order to enhance legibility, the documents may have been restructured, and some information may have been intentionally excluded. Therefore, the drawings within this guide may not be exact duplicates of the original drawings. ▲

Note Drawings in this manual are included for reference only and may not be the current version. Contact the factory if you need a copy of the latest revision. ▲

Table C–1.

Drawing #	Rev.	Description	Page
SG91-6000	A	General assembly drawing, wet gas system (3 sheets)	C–2
SG91-6001	A	General assembly drawing, dry gas system (3 sheets)	C–5
SG91-6002	A	General assembly drawing, basic gas system (3 sheets)	C–8
SG91-6003	A	General assembly drawing, HT wet gas system (3 sheets)	C–11
SG91-6004	A	General assembly drawing, HT dry gas system (3 sheets)	C–14
SG91-6005	A	General assembly drawing, HT basic gas system (3 sheets)	C–17
AD_6502	B	Wiring diagrams, barrier options (2 sheets)	C–20

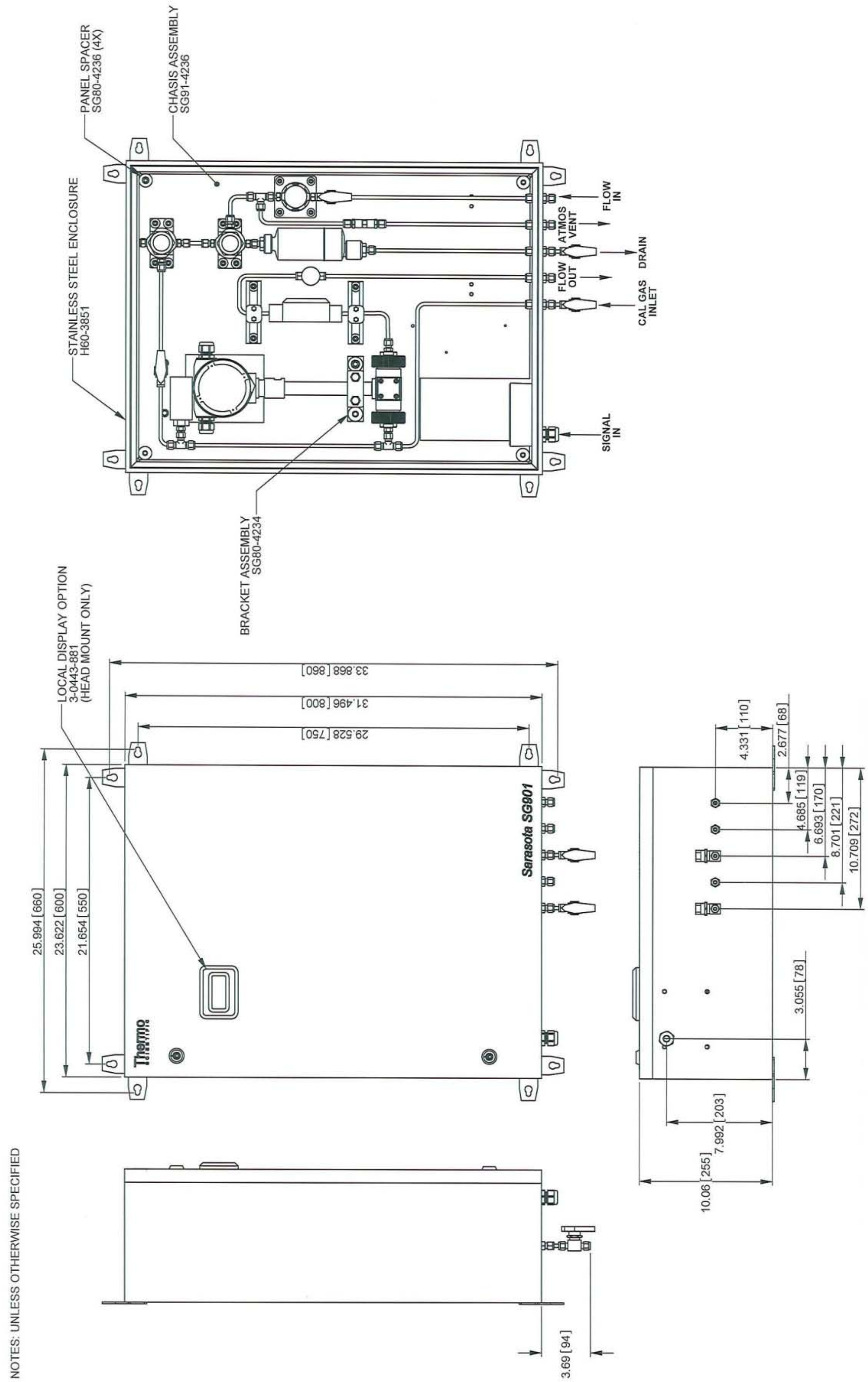

Figure C–1. SG91-6000: General assembly drawing, wet gas system (sheet 1 of 3)

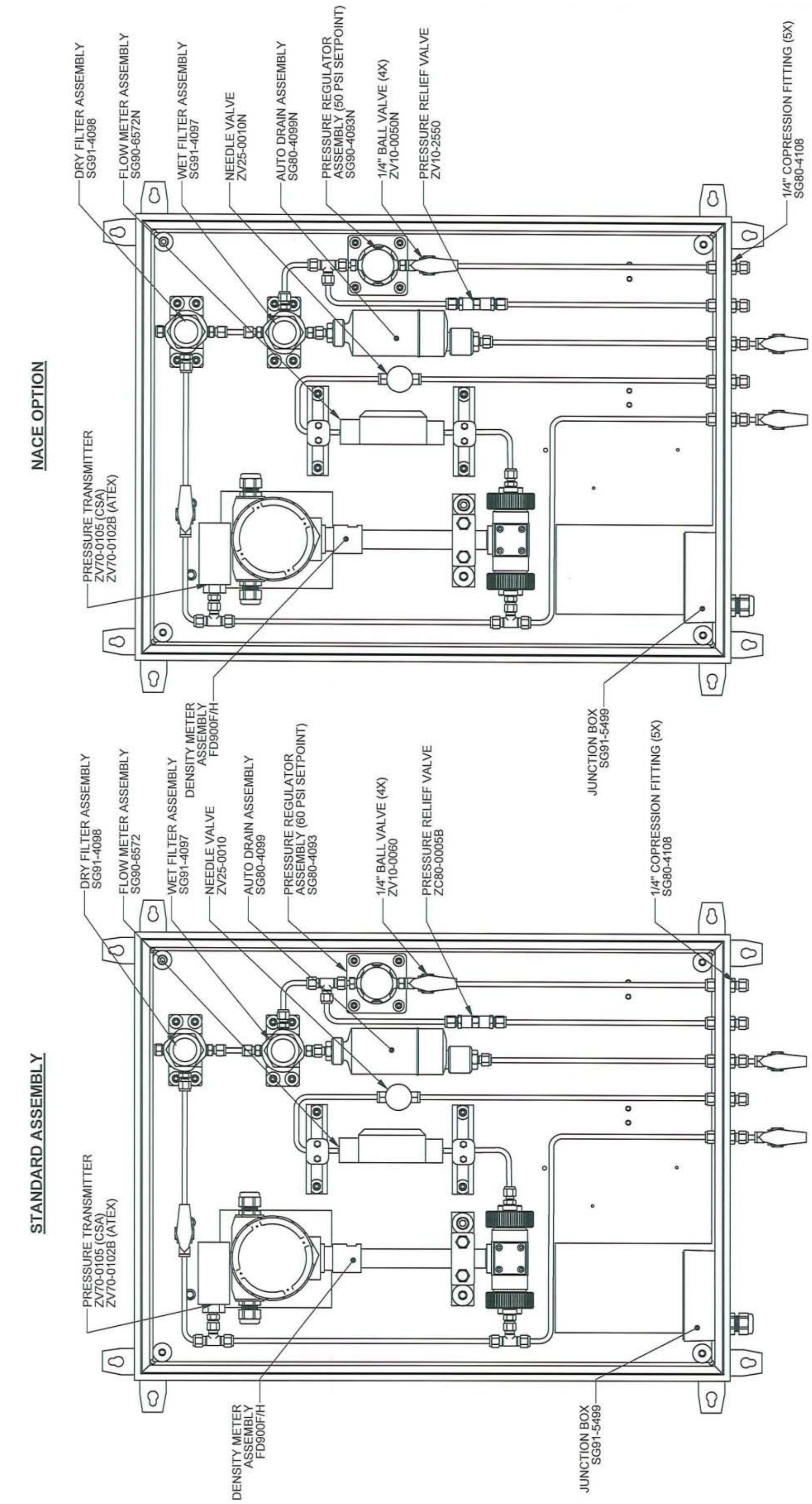

Figure C–2. SG91-6000: General assembly drawing, wet gas system (sheet 2 of 3)

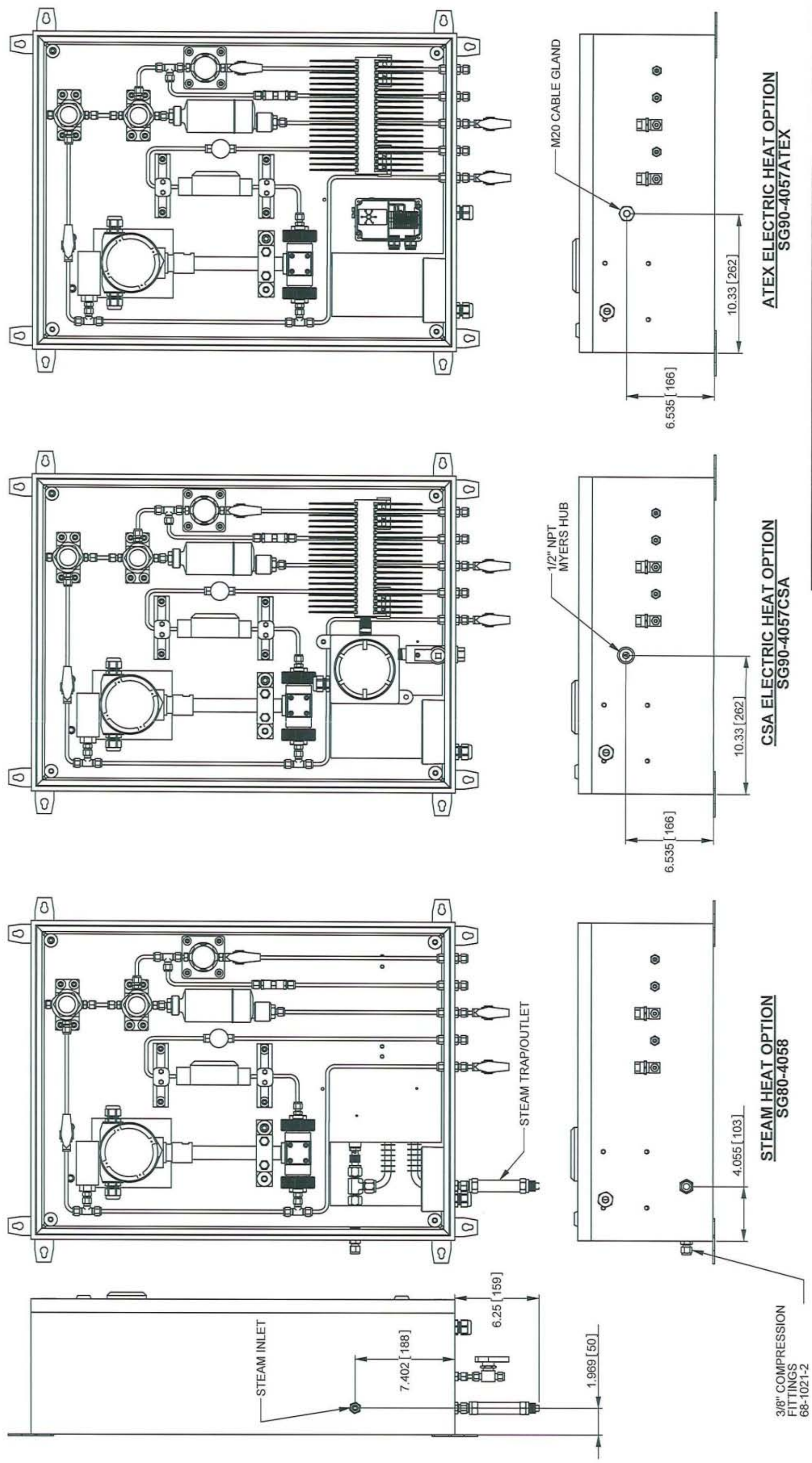

Figure C–3. SG91-6000: General assembly drawing, wet gas system (sheet 3 of 3)

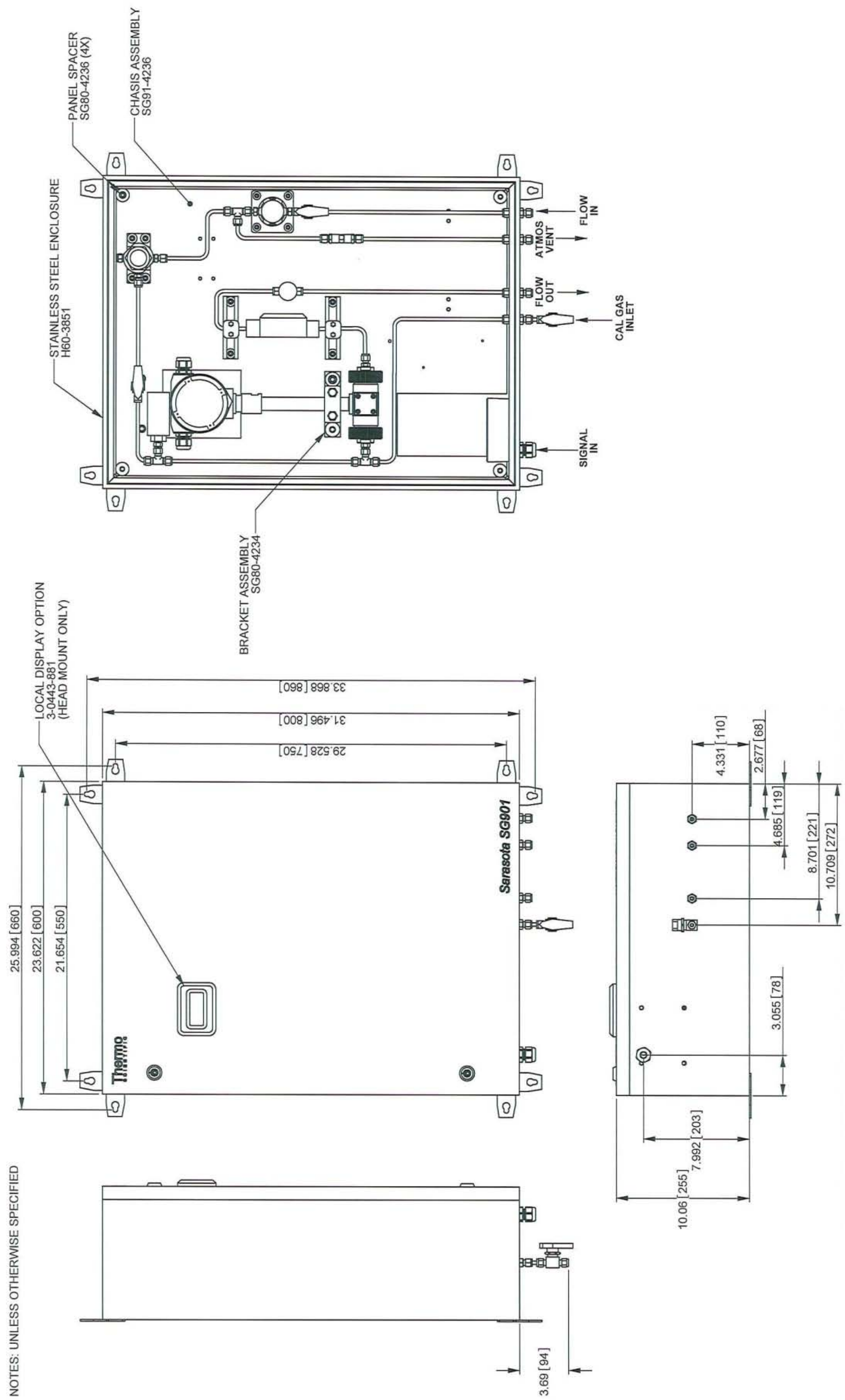

Figure C–4. SG91-6001: General assembly drawing, dry gas system (sheet 1 of 3)

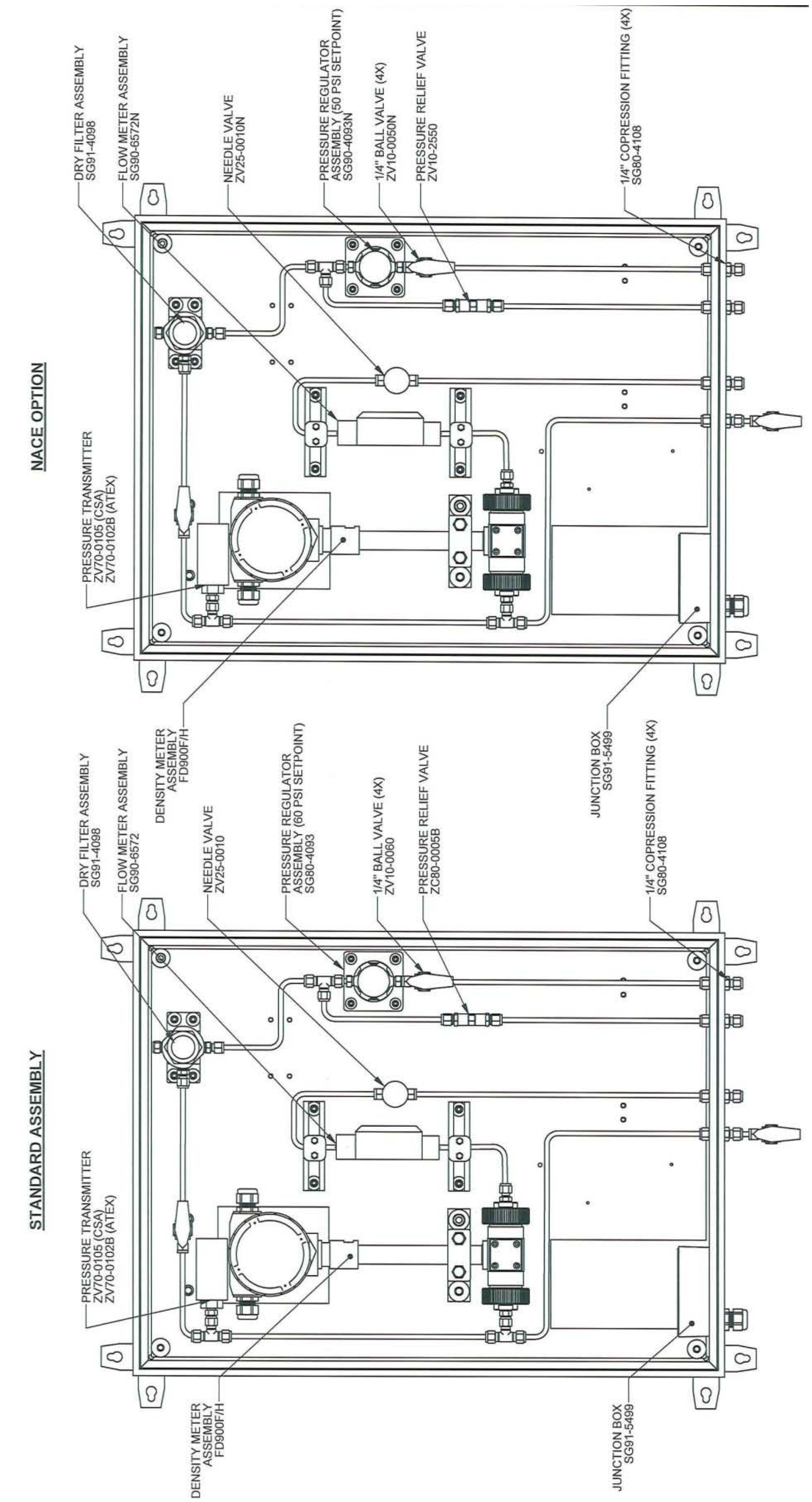

Figure C–5. SG91-6001: General assembly drawing, dry gas system (sheet 2 of 3)

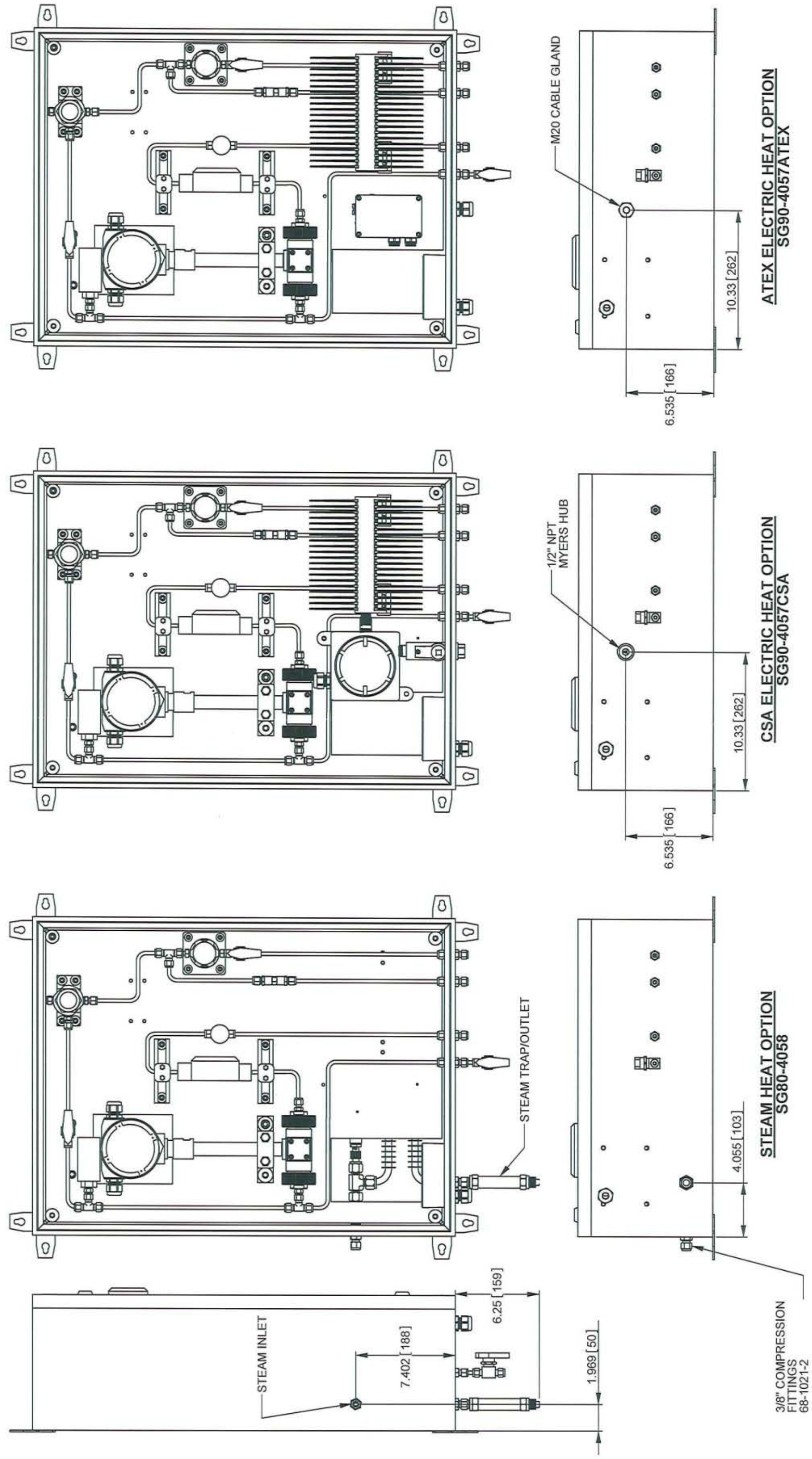

Figure C–6. SG91-6001: General assembly drawing, dry gas system (sheet 3 of 3)

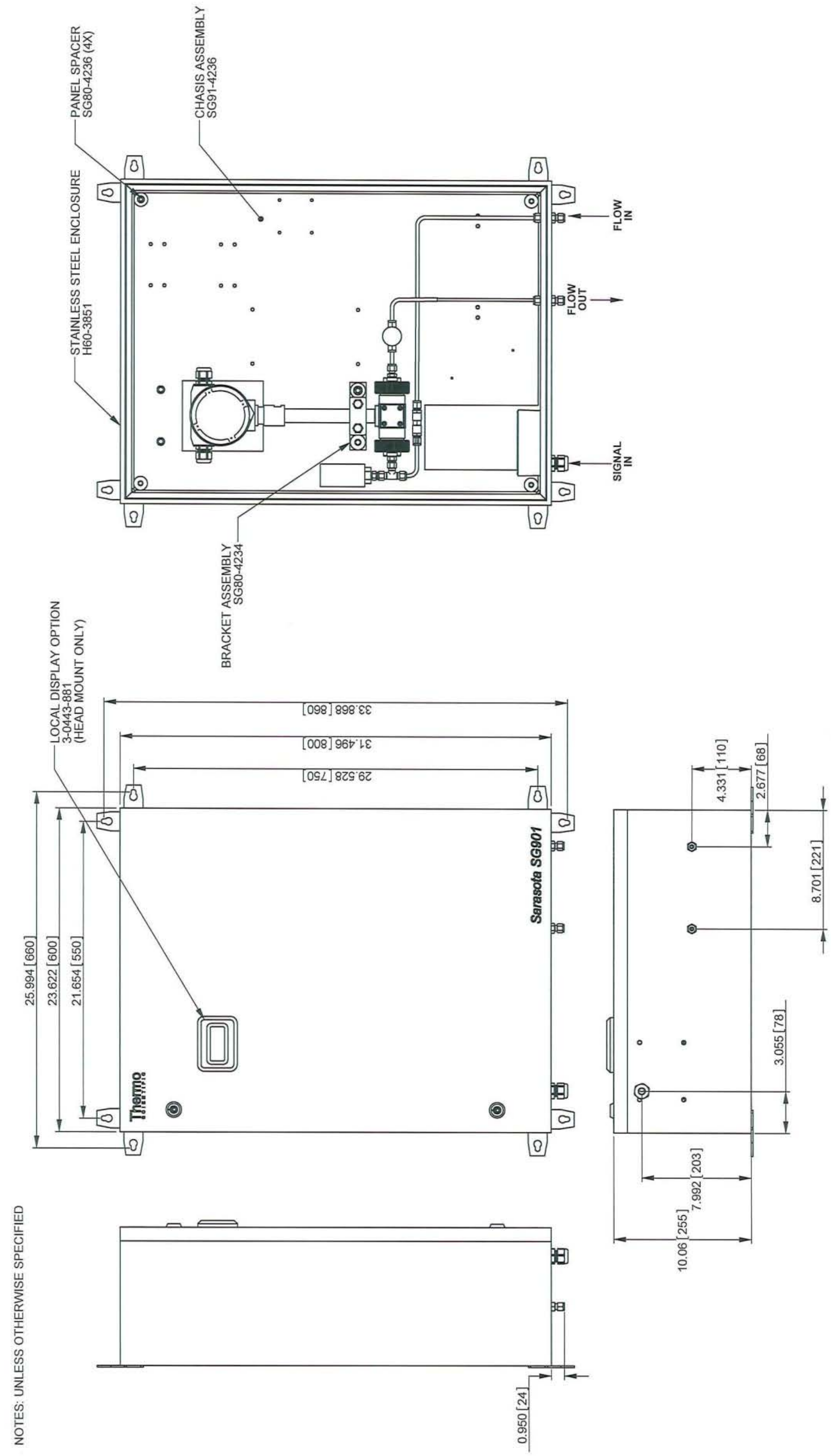

Figure C–7. SG91-6002: General assembly drawing, basic gas system (3 sheets)

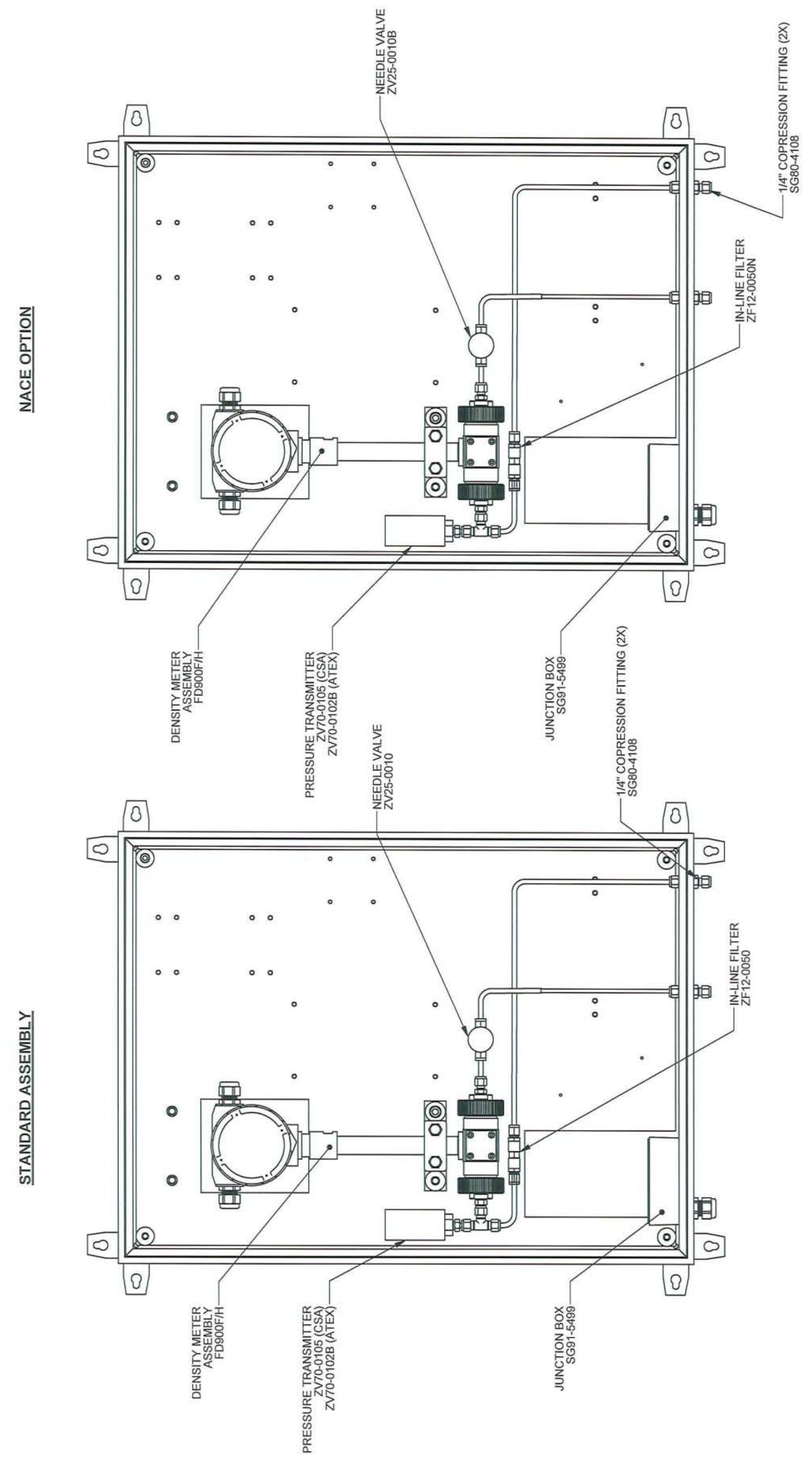

Figure C–8. SG91-6002: General assembly drawing, basic gas system (sheet 2 of 3)

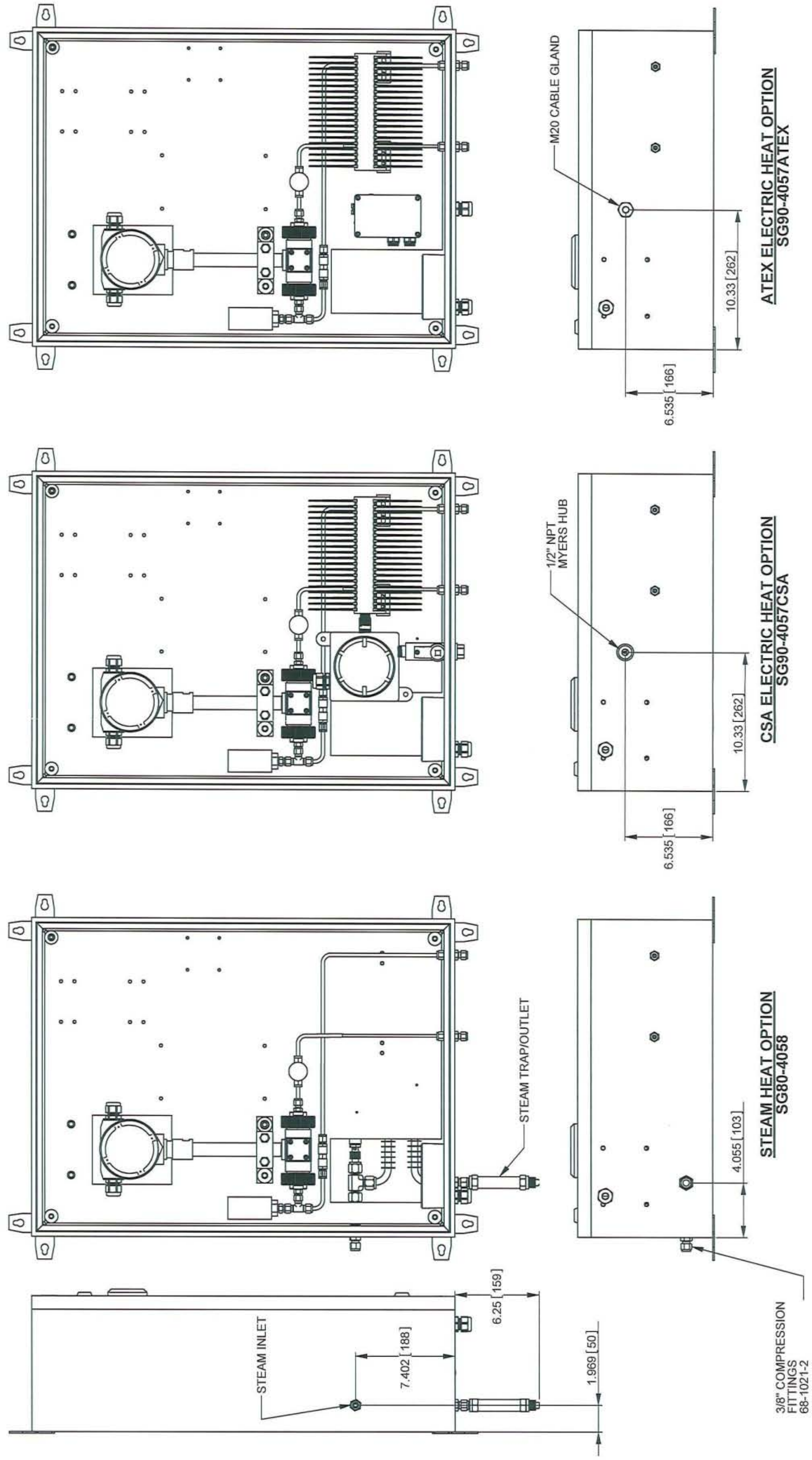

Figure C–9. SG91-6002: General assembly drawing, basic gas system (sheet 3 of 3)

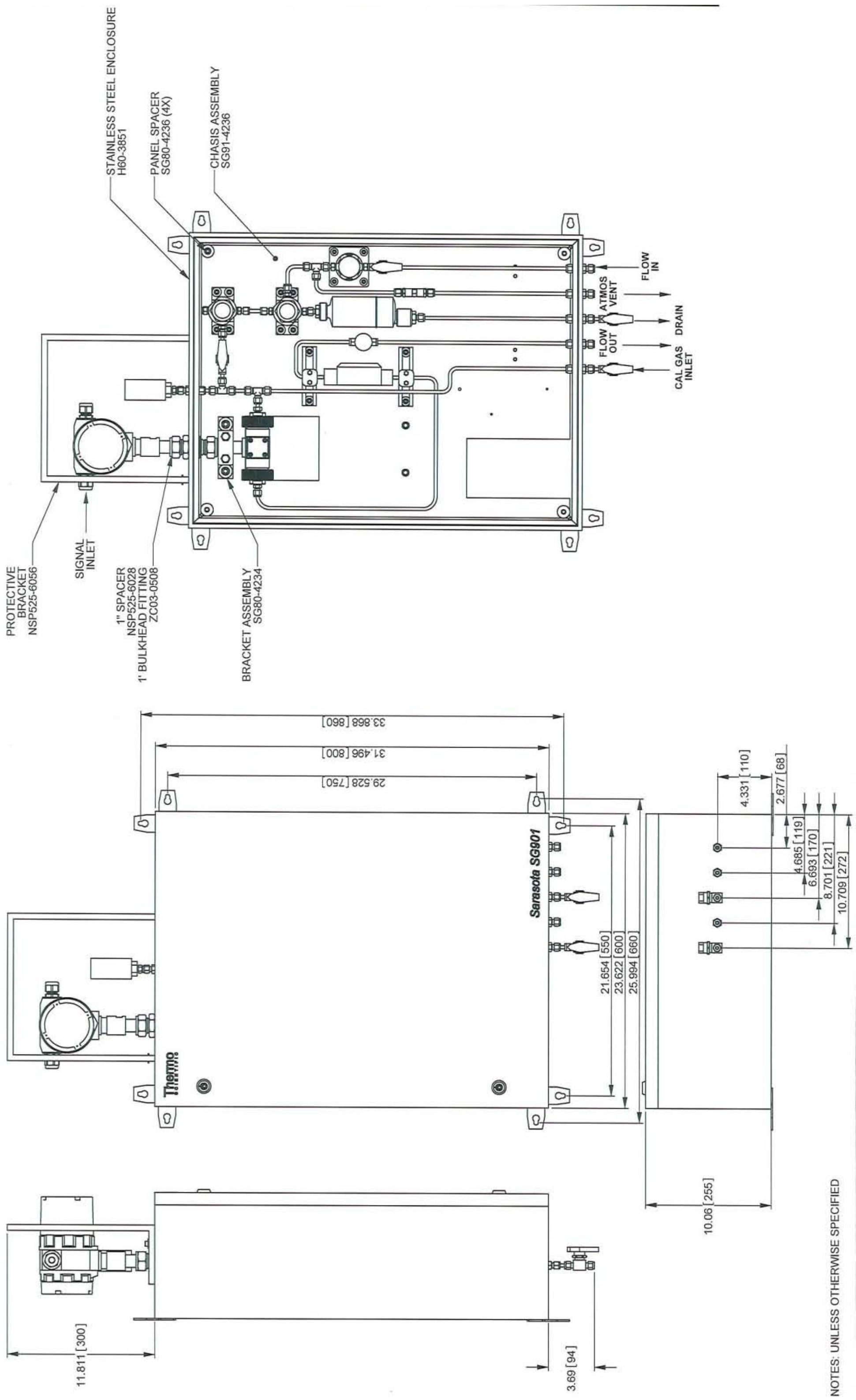

Figure C–10. SG91-6003: General assembly drawing, HT wet gas system (sheet 1 of 3)

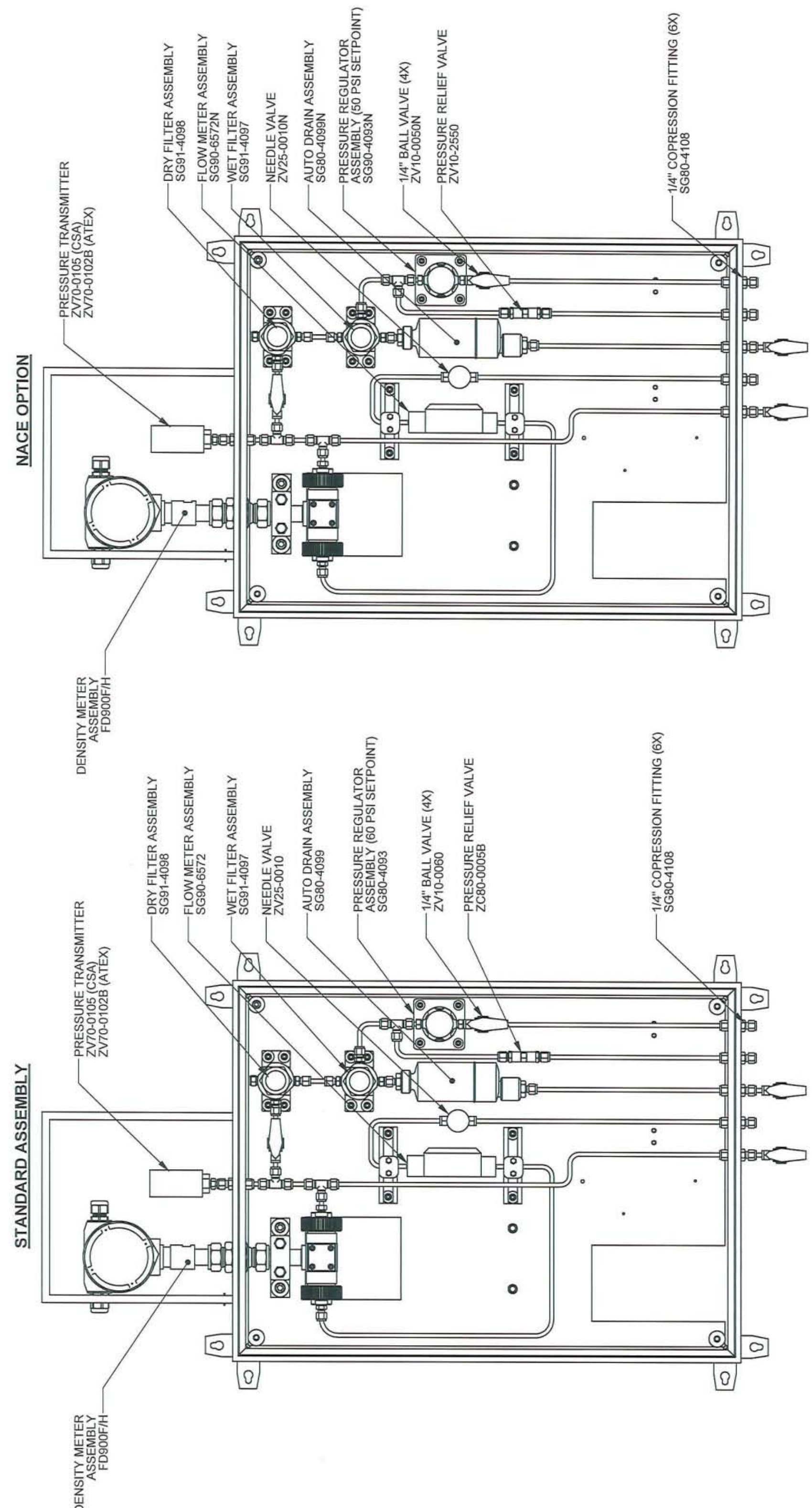

Figure C–11. SG91-6003: General assembly drawing, HT wet gas system (sheet 2 of 3)

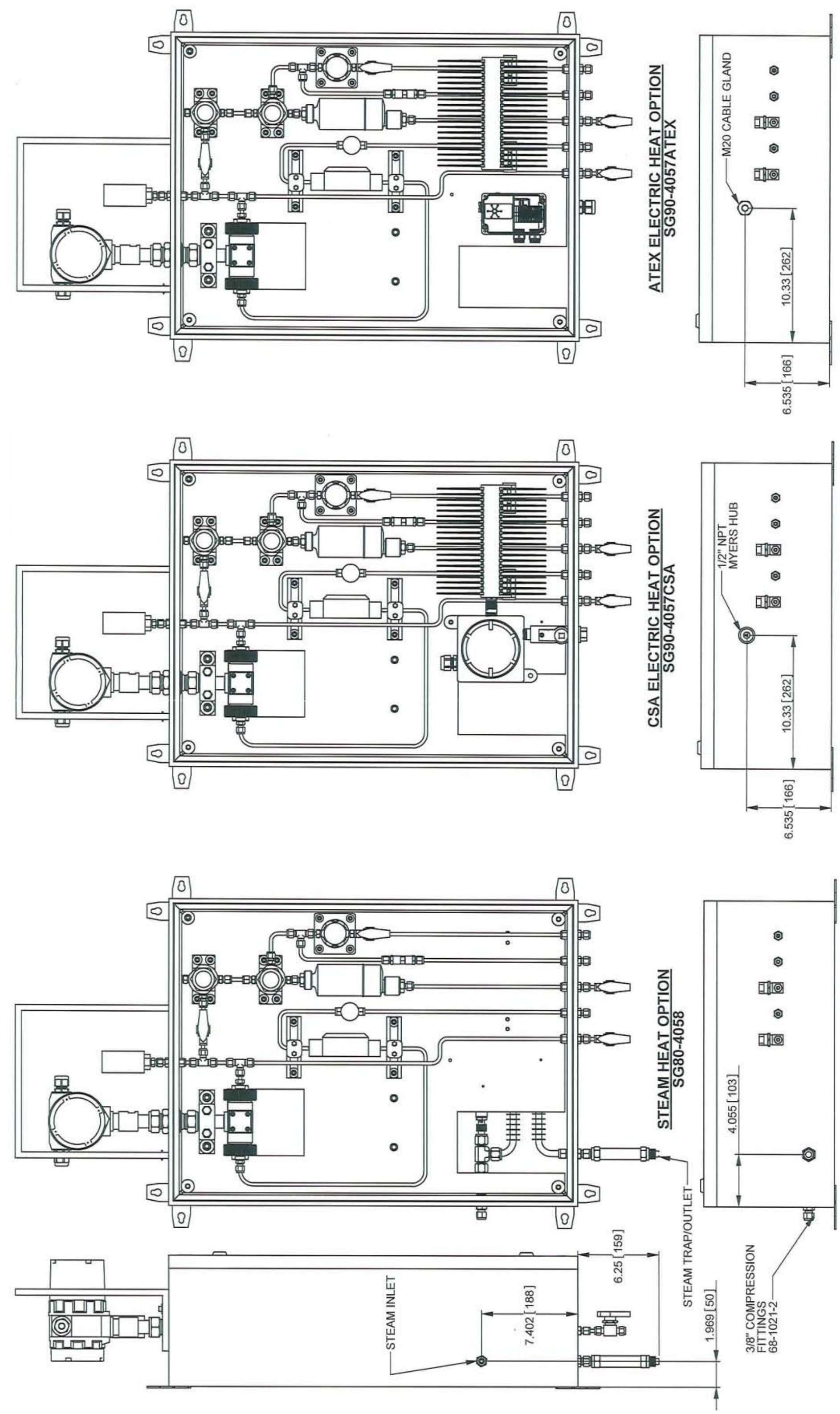

Figure C–12. SG91-6003: General assembly drawing, HT wet gas system (sheet 3 of 3)

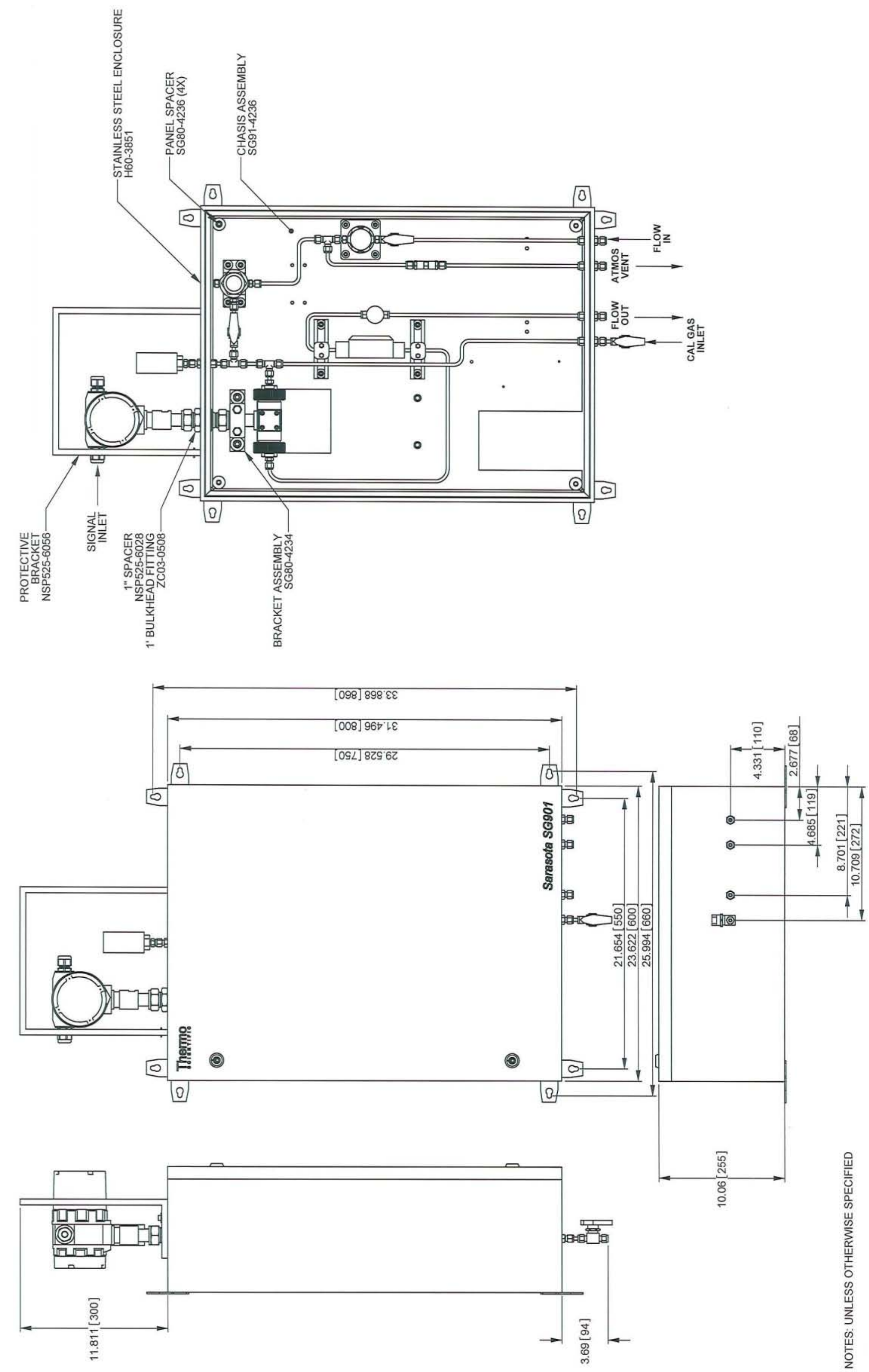

Figure C–13. SG91-6004: General assembly drawing, HT dry gas system (sheet 1 of 3)

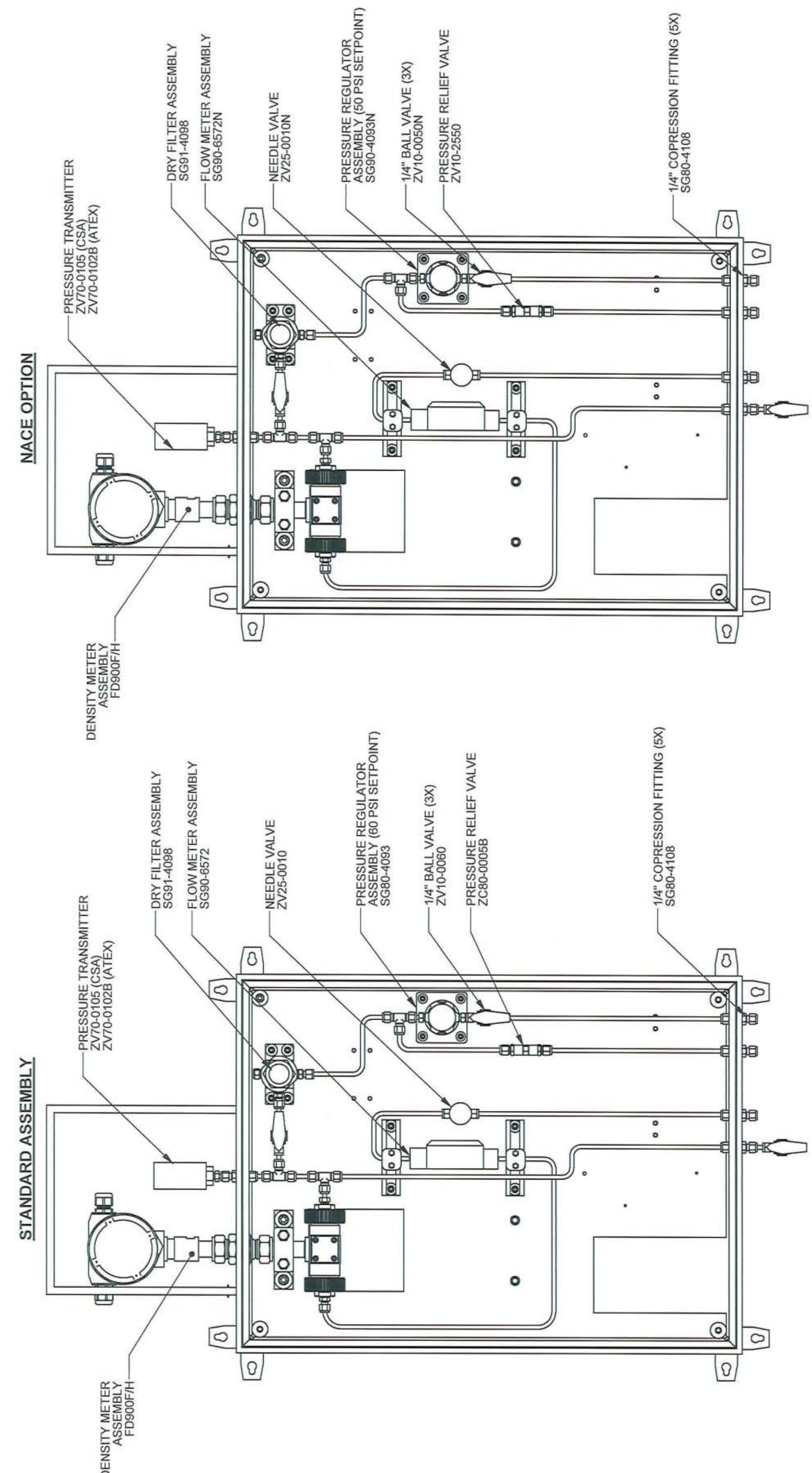

Figure C–14. SG91-6004: General assembly drawing, HT dry gas system (sheet 2 of 3)

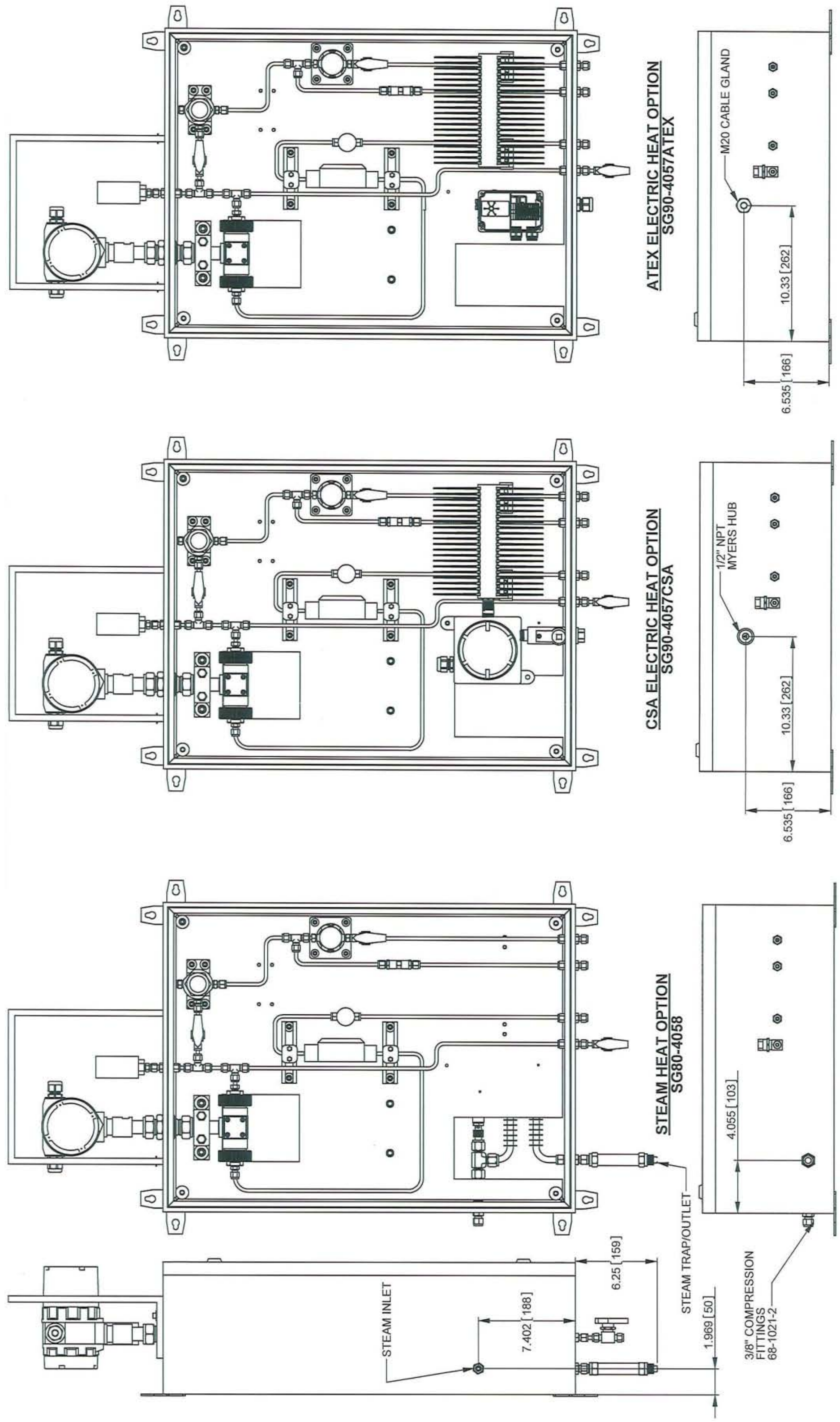

Figure C–15. SG91-6004: General assembly drawing, HT dry gas system (sheet 3 of 3)

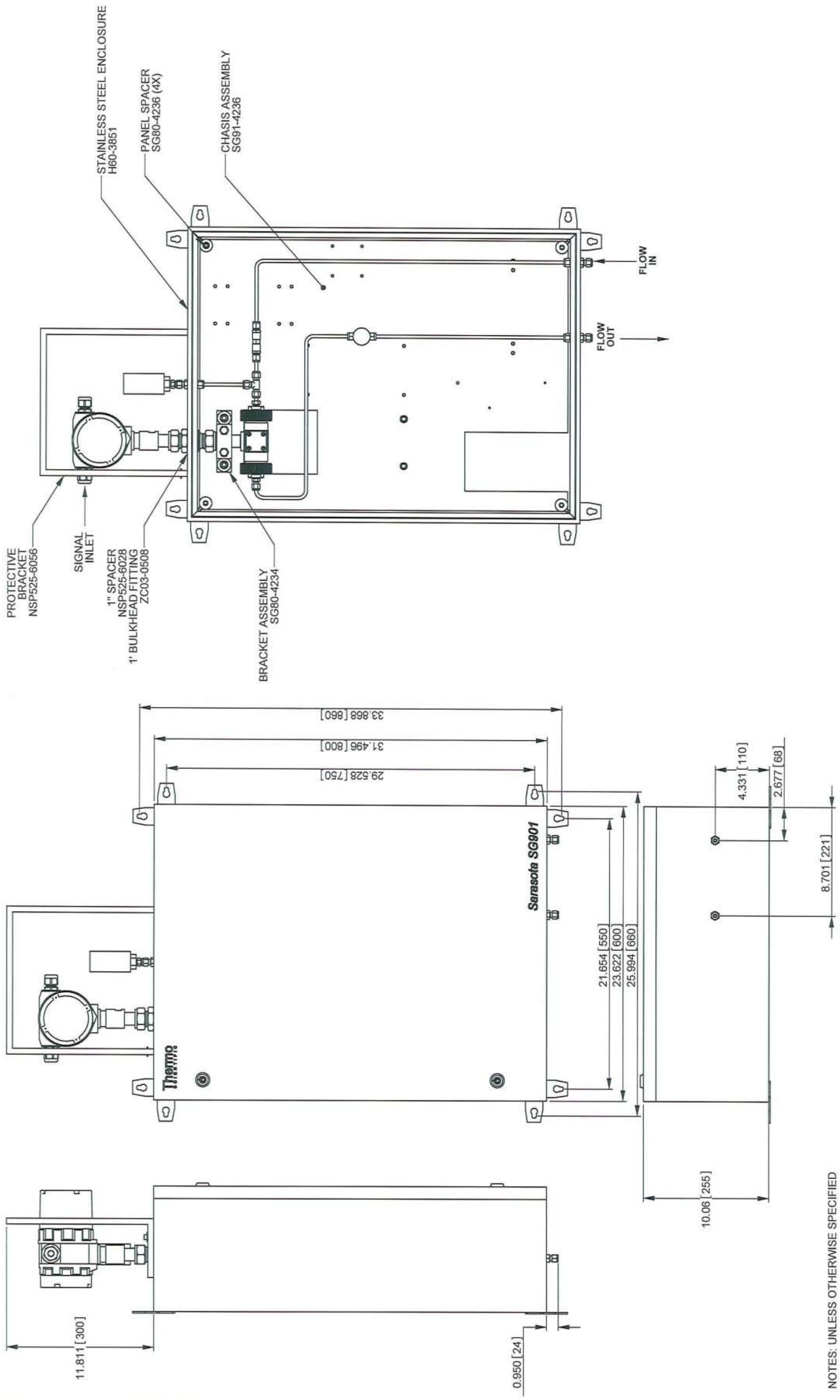

Figure C–16. SG91-6005: General assembly drawing, HT basic gas system (sheet 1 of 3)

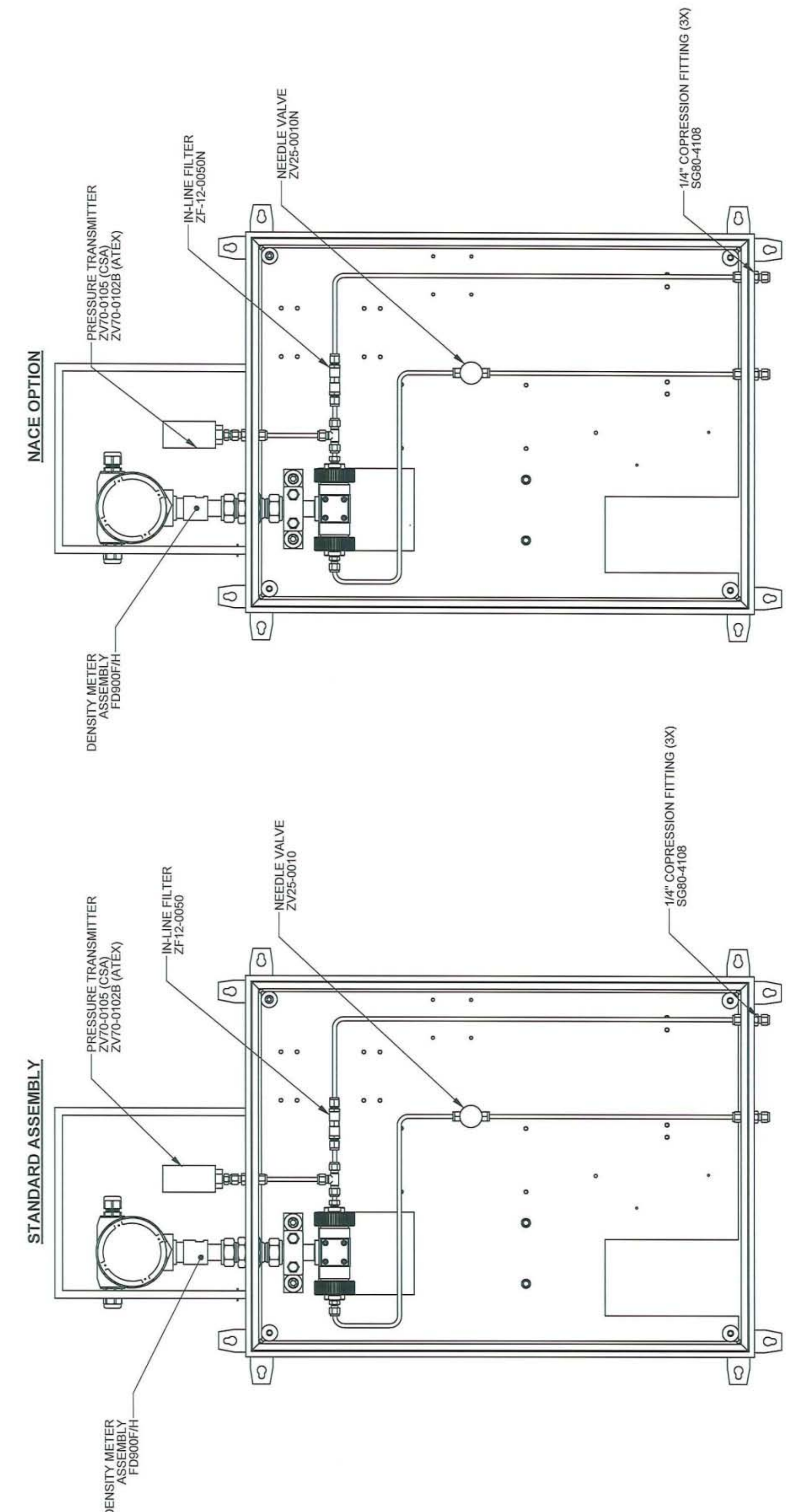

Figure C–17. SG91-6005: General assembly drawing, HT basic gas system (sheet 2 of 3)

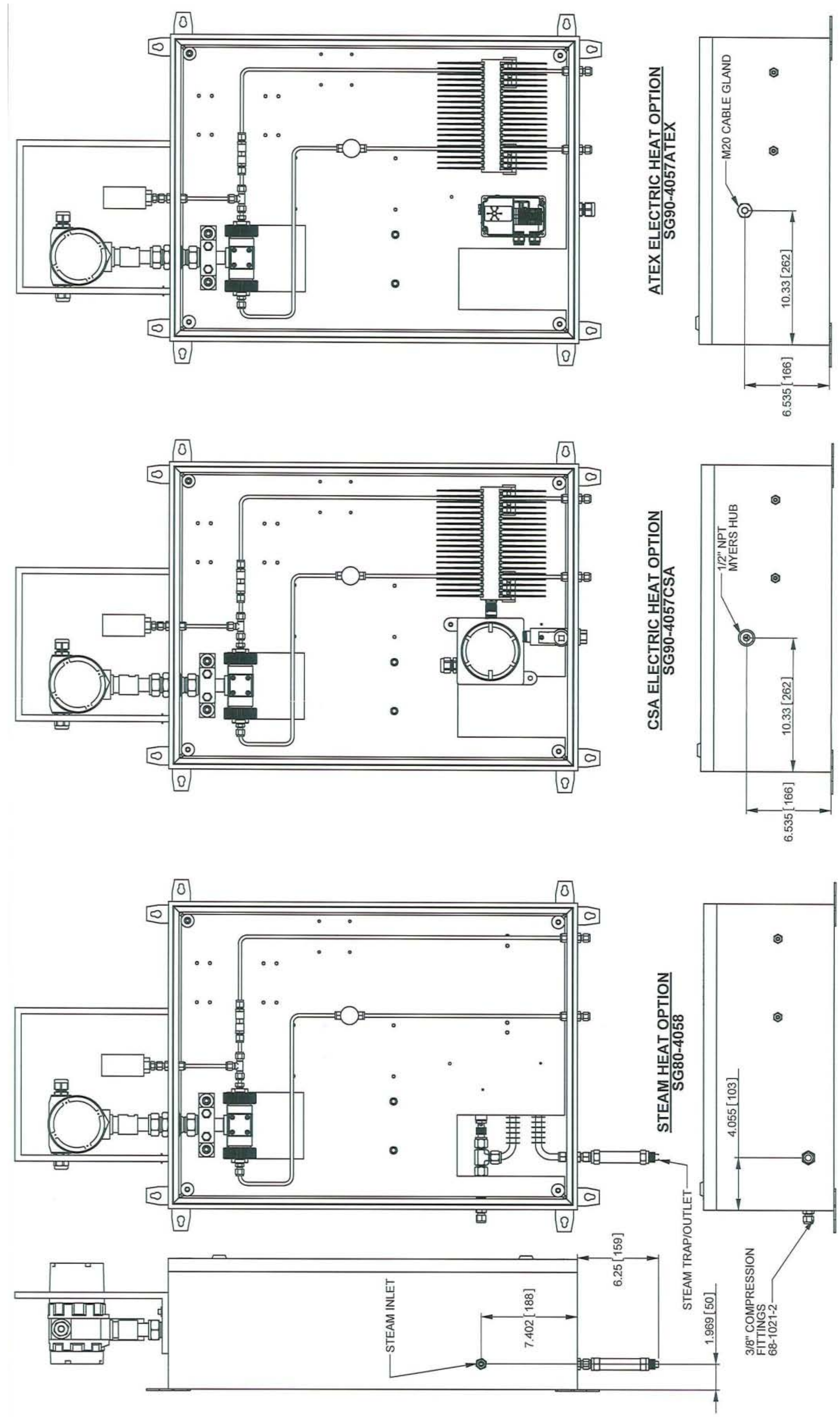

Figure C–18. SG91-6005: General assembly drawing, HT basic gas system (sheet 3 of 3)

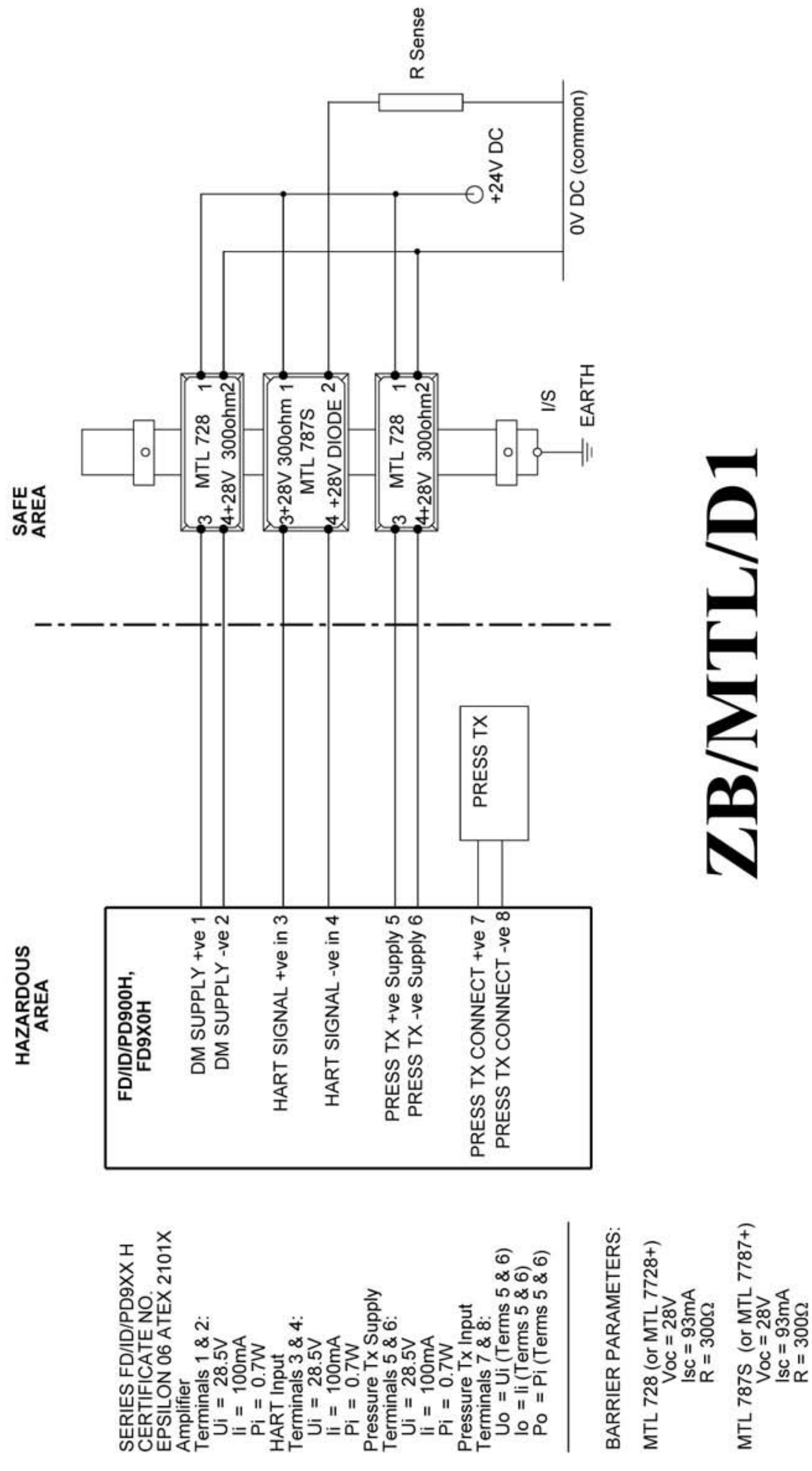

Figure C–19. AD_6502: Wiring diagrams, barrier options (sheet 1 of 2)

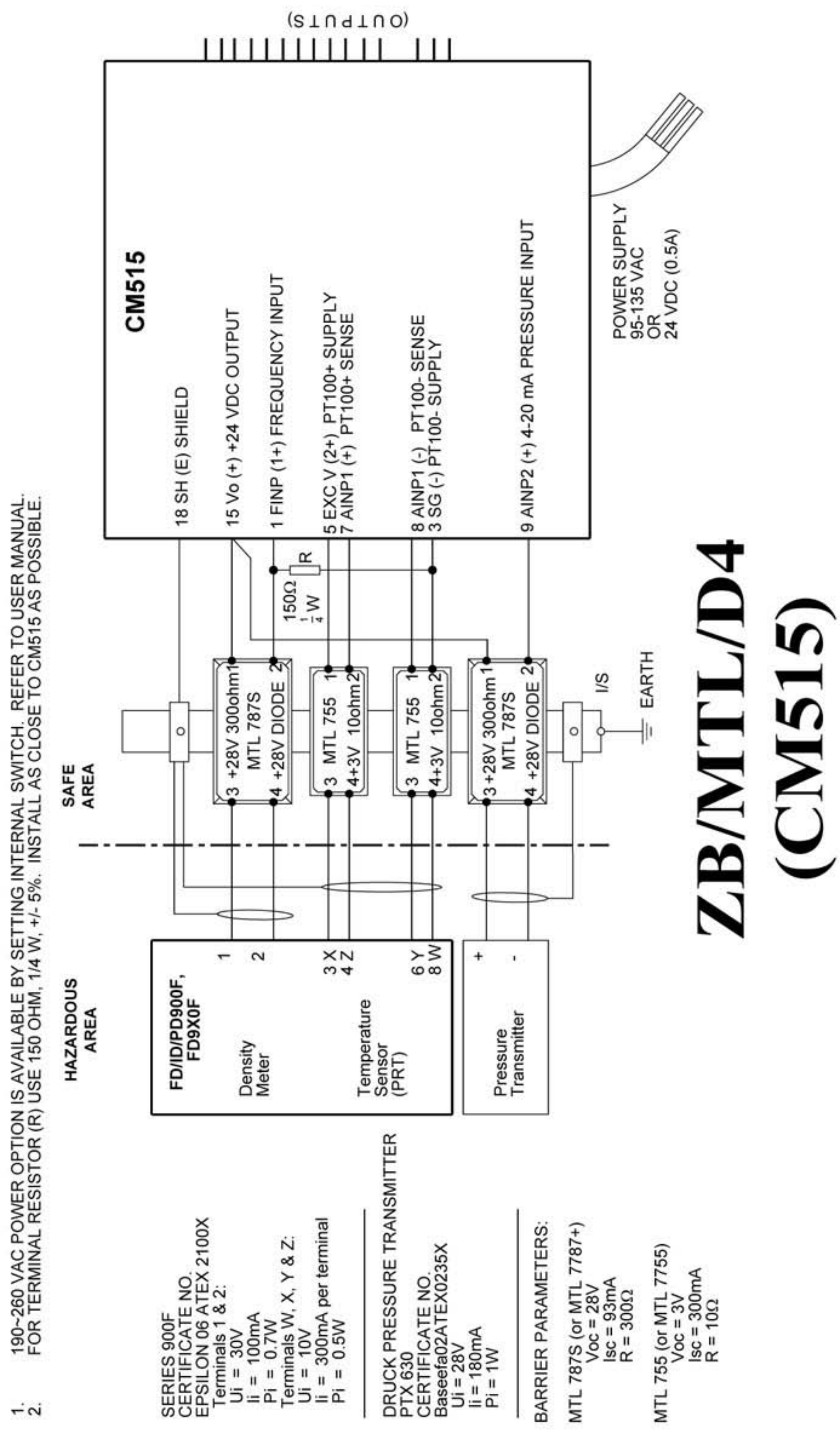

Figure C–20. AD_6502: Wiring diagrams, barrier options (sheet 2 of 2)

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Appendix D
Health & Safety Clearance Form

The Health & Safety (COSHH) Clearance form can be found on the following page. Failure to return this form may result in the meter being returned.

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1410 Gillingham Lane
Sugar Land, TX 77478 USA
Tel: 713.272.0404
Fax: 713.272.2272

HEALTH AND SAFETY (COSHH) CLEARANCE FORM

Failure to comply with this procedure will result in equipment service delays.

This form must be completed for *all* equipment returned to Thermo Fisher Scientific (Thermo Fisher) – Sugar Land Depot Repair. Depot repair personnel are unable to handle any equipment that has been in contact with a process fluid or hazardous material if it is not accompanied by this correctly completed Health and Safety Clearance Form.

All sections of this form must be completed, and the form must arrive at Thermo Fisher prior to the arrival of the equipment. A copy of this form must also accompany the equipment.

Prior to returning any equipment for service, authorization must be obtained from customer service. A Return Material Authorization (RMA) number will be issued and must be entered in Section 1 of this form.

Section 1: Reference Details

RMA #: ______________________

Equipment type: _______________

Serial #: ______________________

Section 2: Process Fluid Information

All substances in contact with the equipment must be declared.

Chemical names (list all): _______________________

____

Precautions to be taken when handling these substances (list all): _________________________________

____

____

Action to be taken in the event of human contact or spillage: ____________________________________

____

Additional information you consider relevant: _______

____

____

Section 3: Shipping Information

Carrier details: ________________________

Tel:__________________ / Fax: ________________

Scheduled delivery date to Thermo Fisher: __________

Section 4: Declaration

Must be authorized ONLY if non-toxic or non-hazardous substances apply.

I hereby confirm that the equipment specified above *has not* come into contact with any toxic or hazardous substances.

Signed: ______________________________

Name: _______________________________

Position: ____________________________________

For/on behalf of: ______________________________

Date: _________________

Must be authorized if toxic or hazardous substances apply.

I hereby confirm that the only toxic or hazardous substances that the equipment specified has been in contact with are named in Section 2, that the information given is correct, and that the following actions have been taken:

1. The equipment has been drained and flushed.
2. The inlet/outlet ports have been sealed, and the equipment has been securely packed and labeled.
3. The carrier has been informed of the hazardous nature of the consignment and has received a copy of this completed form.

Signed: ______________________________

Name: _______________________________

Position: ____________________________________

For/on behalf of: ______________________________

Date: _________________

A copy of this completed form MUST BE HANDED TO THE CARRIER to accompany the equipment.

Appendix E
Equations

The following equations are provided in this appendix:

- Basic density equation
- Rho_{air} & Z_{air}
- Density at Reference Conditions (Gas)
- Compressibility (Gas)
- Reference Compressibility (Gas)
- Gravity / Relative Density (Gas)
- Molecular Weight
- Az & Bz from M

Basic density equation

$$\rho_m = d'_0 \times \frac{(t - t'_0)}{t'_0} \times \left[2 + K \times \frac{(t - t'_0)}{t'_0}\right],$$

where

$$t'_0 = T0 + TEMPCO \times (T - T_{cal}) + PRESCO \times (P - P_{cal}).$$

$$d'_0 = D0 \left[1 - \left(\frac{VIBDIM \times \bar{R}}{a \times t}\right)^2\right].$$

$$a = \left(\frac{ISENEX \times P \times \bar{L}}{\rho_m}\right)^{\frac{1}{2}}.$$

(continued)

If $P = 0$ or d'_0 or $d'_0 < 0.8D0$, then $d'_0 = D0$.

On first cycle, $d'_0 = D0$.

ρ_m = measured line density in kg/m^3 [lb/ft^3]

T0 = calibration constant of spool in μsec

t'_0 = corrected calibration constant of spool in μsec

D0 = calibration constant of spool in kg/m^3 [lb/ft^3]

d'_0= VOS corrected calibration constant of spool in kg/m^3 [lb/ft^3]

K = calibration constant of spool in $kg/m^3/°C$ [$lb/ft^3/°F$]

TEMPCO = temperature coefficient of spool in μsec/°C [μsec/°F]

PRESCO = pressure coefficient of the transducer in μsec/bar [μsec/psi]

VIBDIM = characteristics of vibrating element in mm (in)

ISENEX = isentropic exponent of gas

t = measured period in μsec

T = measured/fixed line temperature in K [°R]

T_{cal} = calibration temperature of densitometer, 288.15K [519.67°R]

P = measured/fixed line pressure in bar A [psi A]

P_{cal} = calibration pressure of densitometer, 1.01325 bar A [14.696 psi A]

L = speed of sound factor, 100000 pa/bar (4633.05567 $lbdw/ft^2/psi$)

R = VOS correction to density 1000 ($10^6/12$).

Rho$_{air}$ & Z$_{air}$

$$\rho_{air} = \frac{J \times Pref}{Tref \times Z_{air}}$$

$$Z_{air} = 1 - J\left[\frac{Pref}{Tref}\right]\left[\frac{A_r}{Tref^{1.5}} - B_r\right]$$

ρ_{air} = density of air at reference conditions

Z_{air} = compressibility factor of air at reference conditions

J = gas constant, 348.362 K.kg/m^3/bar (2.69732428 °R.lb/ft^3/psi)

Pref = reference pressure in bar (psi)

Tref = reference temperature in K (°R)

A_r = Az value for air, 6.18307495 K$^{1.5}$.m^3/kg (239.183045 °R$^{1.5}$.ft^3/lb)

B_r = Bz value for air, 0.0009235295 m^3/kg (0.014793396 ft^3/lb)

Density at Reference Conditions (Gas)

$$\rho_c = \frac{\rho_m \times Pref \times T \times Z}{P \times Tref \times Zref}$$

ρ_c = density of gas at reference P and T in kg/m^3 (lb/ft^3)

ρ_m = measured gas density in kg/m^3 [lb/ft^3]

Pref = reference pressure in bar (psi)

Tref = reference temperature in K (°R)

T = absolute temperature in K (°R)

P = absolute pressure in bar (psia)

Z = gas compressibility factor

Zref = reference compressibility factor

Compressibility (Gas)

$$Z = \frac{1}{1 - B_z \times \rho_m} - \frac{A_z \times \rho_m}{T^{1.5} \times (1 + B_z \times \rho_m)}$$

If B_z x ρ_m > 1, then Z = 1.

Z = gas compressibility

A_z = R-K fluid constant for Z in $K^{1.5}.m^3/kg$ ($°R^{1.5}.ft^3/lb$)

B_z = R-K fluid constant for Z in m^3/kg (ft^3/lb)

ρ_m = measured density of gas

T = absolute temperature in K (°R)

Reference Compressibility (Gas)

On first pass through calculations, Zref = 1.

$$Zref = 1 - G \times \rho_{air} \times \left(\frac{A_z}{Tref^{1.5}} - B_z \right)$$

Subsequently,

If Zref < 0.8, then set Zref = 0.8.

If Zref > 1.145, then set Zref = 1.145.

Zref = reference compressibility

G = relative density (SG)

A_z = R-K fluid constant for Z in $K^{1.5}.m^3/kg$ ($°R^{1.5}.ft^3/lb$)

B_z = R-K fluid constant for Z in m^3/kg (ft^3/lb)

Tref = reference temperature K (°R)

Gravity / Relative Density (Gas)

$$G = \frac{\rho_c}{\rho_{air}}$$

G = relative density (SG)

ρ_c = density of gas at reference pressure and temperature

p_{air} = density or air at reference pressure and temperature

Molecular Weight

$$MW = G \times 28.964$$

MW = molecular weight of gas

G = Relative density (SG)

Az & Bz from MW

$$A_z = (7.25973245 + 1.14078006 \times MW - 3.23133483) \times 10^{-3} \times MW^2$$

$$B_z = (8.21540275 \times 10^{-3}) - \left(2.74198514 \times 10^{-4}\right) \times MW + \left(2.39199357 \times 10^{-6}\right) \times MW^2$$

For Sarasota HME900 with imperial units:

$$A_z = A_z \times 38.683931$$

$$B_z = B_z \times 16.0185$$

MW = molecular weight

A_z= R-K fluid constant for Z in $K^{1.5}.m^3/kg$ ($°R^{1.5}.ft^3/lb$)

B_z = R-K fluid constant for Z in m^3/kg (ft^3/lb)

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Appendix F

Configuration Considerations when Using Sarasota CM515

Purpose

When the Sarasota CM515 density converter is used in a Sarasota SG901 with frequency output system, the density converter can be configured to use different formula schemes to deal with gas compressibility, Critical Pressure, and Critical Temperature parameters. This appendix explains the different formula schemes available in the density converter and shows the basic configuration (in metric) of the Sarasota SG901 / CM515 system.

Equations

When using the Sarasota CM515 for D-ref (Density at Reference), MW (Molecular Weight) or SG (Specific Gravity) measurement, the user has a choice of which equations the converter will use for its calculation.

The equations available in the Sarasota CM515 are briefly described below.

- Ideal Gas: The ideal gas laws are implemented. No compensation is made for gas compressibility (ideal gas law deviations).
- Redlich Kwong (RK): The RK equation of state is implemented. The user must enter an isentropic exponent, critical pressure, and temperature for the gas or an average isentropic exponent and a quasi critical temperature and critical pressure for a gas mixture.
- Soave: This is a modification to RK and can give slightly better results. The user must enter an isentropic exponent, an Acentric factor, and a critical pressure and temperature for the gas or an average isentropic exponent, an average Acentric factor, and a quasi critical temperature and critical pressure for a gas mixture.
- Peng Robinson: This is another variation. The user must enter an isentropic exponent, an Acentric factor, and a critical pressure and temperature for the gas or an average isentropic exponent, an average Acentric factor, and a quasi critical temperature and critical pressure for a gas mixture.

It is suggested that either the Ideal or Soave equation is selected depending on the accuracy required and the gas data available.

There is an option to estimate Cp and Ct from specific gravity using two quadratic curve fits, one for Critical Pressure and one for Critical Temperature.

The curve is in the following form:

$$y = ax^2 + bx + c$$

where

y = either Critical Pressure or Critical Temperature

x = specific gravity

Both isentropic exponent and Acentric factor have to be fixed at the average for the gas mix. If RK is chosen then Acentric factor is not required.

To disable the Cp – Ct estimation, the fixed Cp and Ct should be entered into the Critical Pressure and Critical Temperature base locations while the Critical Pressure and Critical Temperature coefficients A and B are set to zero.

If the quadratic fit is to be used then the coefficients from the quadratic ax^2 + bx + c should be entered as below:

c is entered into the base location.

a is entered into the B coefficient.

b is entered into the A coefficient location.

The curve fit must be in the units chosen for the base location.

The table below gives an example of values to be used for Cp in bar A and Ct in Deg C. The table includes the Critical Temperature, Critical Pressure, and Acentric factor. The suggested fit data showing the coefficients assume an average Acentric factor based on a uniform equal % mix (16.6% of each component). Where the mix is predominately H_2 and CH_4, the Acentric factor should be adjusted to allow for this.

The Acentric factor can be adjusted to fit the normal proportions of the mix by taking the sum of the products of the gas constituent Acentric factor and the volume percent of each constituent.

Table F–1.

	Ct K	CP Bar A	Acentric Factor
H2	33.2	12.9696	-0.22
CH4	190.6	45.94076	0.008
C2H6	305.4	48.83865	0.098
C3H8	396.8	42.45518	0.152
C4H10	452.2	37.99688	0.193
C5H12	496.6	33.74123	0.251

Table F–2.

Data assuming curve fit gives ax^2 + bx +c CT is in K and CP is in bar A.			
Standard Form Coefficients	**a**	**b**	**c**
Sarasota CM515 Coefficients	B	A	Base
CT calc	-61.092	344.82	12.901
CP calc	-17.72	50.606	12.9
Acentric factor	0.0775	Isentropic exp	1.3

Critical Temperature and Critical Pressure

Unlike the Thermo Scientific Sarasota HC900 and Sarasota HME900, the Sarasota CM515 calculates compressibility using Critical Pressure and Critical Temperature rather than Az and Bz, which are derived (partially calculated) constants for the RK equation of state.

Where gas mixtures are used, pseudo Critical Pressure and Temperatures can be calculated. However, in SG applications there is the option of including a quadratic fit where Critical Pressure and Critical Temperature are inferred from SG.

The entry of Critical Pressure and Critical Temperature is arranged such that:

> If the entry of CT or CP is made as a Base figure with the values of Constants A and B set to zero, then the entered base figures are used as CT and CP.
>
> If the constants A and B are entered as non-zero values, then CT and CP are calculated as:

$$\text{CT (or) CP} = \text{Base} \times \left(1 + A \times SG + B \times SG2\right).$$

This allows the user to fit the basic constituents CT and CP values to a quadratic equation and then enter constants Critical Pressure Base, A, and B or Critical Temperature Base, A, and B. An example of this is shown below.

Table F–3.

		ATMOS	K	Bar		
	SG	**Cp**	**Ct**	**CP**	**CT Calc**	**CP Calc**
H2	0.069046	12.8	33.2	12.9696	36.41803155	16.30964
CH4	0.552364	45.34	190.6	45.94076	184.7276523	35.44646
C2H6	1.035683	48.2	305.4	48.83865	304.4954727	46.3046
C3H8	1.519001	41.9	396.8	42.45518	395.7214929	48.88407
C4H10	2.00232	37.5	452.2	37.99688	458.4057127	43.18487
C5H12	2.485639	33.3	496.6	33.74123	492.5481323	29.20699

The above table shows the CP and CT for typical gas constituents. The data was fitted to the curves in the equations below, and the CP Calc in bar and CT Calc in K are shown in the calc results.

Table F–4.

Data assuming curve fit gives ax^2 + bx +c CT is in K and CP is in bar A.			
Standard Form Coefficients	**a**	**b**	**c**
Sarasota CM515 Coefficients	B	A	Base
CT calc	-61.092	344.82	12.901
CP calc	-17.72	50.606	12.9
Acentric factor	0.0775	Isentropic exp	1.3
CT Entered	-4.73545	26.72816061	12.901
CP Entered	-1.37364	3.922945736	12.9

Note that the coefficients a, b, and c relate to the form A * SG^2 + B * SG + C. CT Entered and CP Entered relate the constants A, B, and C to the Entered CT or CP constants for the Sarasota CM515.

Note that A = b/base and B = A/base in each case.

General Configuration (Metric) for SG Measurement

During configuration of the Sarasota CM515, units and number formats are chosen to give sufficient resolution. For example, pressure displayed in bar gives display resolution of 0.001 bar. If this is not sufficient, the kPa may be chosen. However, care should be taken to ensure that the display does not overflow. For entry of numbers, exponential format may be chosen to maximize resolution. For example, the density meter constant K is always close to 1, so in order to enter the value to more than three decimal places, the notation 1.000 10^-3 may be chosen. The entry 1.12345 becomes 1234.5 * 10^-3.

In the Sarasota CM515, configure the items for the menus listed below as shown in the tables on the following pages.

- Variables menu
- Parameters menu
- Input menu
- Output menu
- Alarms menu
- Comms menu
- TM/LOG menu
- Setup menu

Table F–5. Variables menu items

Variables		Units	Resolution	Comments
Display	**Variable Name**			
D-LINE	Density (Line)	kg/m^3	0.001 kg/m^3	
PERIOD	Period	µs	1 ns	
D-REF	Density (Reference)	kg/m^3	0.001 kg/m^3	
TEMP	Temperature	°C	0.1°C	
PRESS	Pressure	bar	0.001 bar	
SG	Specific Gravity	E^-3	0.000001 SGU	
Z-LINE	Compressibility Factor (Line)	E^-3	0.000001	
Z-REF	Compressibility Factor (Reference)	E^-3	0.000001	
MW	Molecular Weight	E^0	0.001 MW	Can be set to E^-3 if greater resolution required.
Tc	Critical Temperature	Kelvin	0.001 K	
Pc	Critical Pressure	bar A	0.001 bar	Critical Pressure is normally only described to 1 DP.
USER INPUT	User input	No options		
USER OUT-A	User output A	No options		
USER OUT-B	User output B	No options		

Table F–6. Parameters menu items

Parameters		Setting	Units	Comments
Display	**Parameter Name**			
DEFLT *unit*	Default Period	0.00		Only set to a value for test purposes.
ATM-PR *unit*	Atmospheric Pressure	101.325	kPa Abs	Entry should be made exactly as it should appear on the display.
T-REF *unit*	Reference Temperature	0.00	°C	May be 15°C in some cases.
P-REF *unit*	Reference Pressure	101.325	kPa Abs	May be 100.000 kPa in some cases.
CALC TYPE	Calculation Type	IDEAL	N/A	
		SOAVE	N/A	Must enter Ct, Cp, and Acentric factor.
DCF *unit*	Line Density Correction Factor	1.0	E^0	
D-OFF *unit*	Line Density Correction Offset	0.00	kg/m³	
VAR INP-X	User Defined Function Input X	Density Line	No options	Not required. Only set for standardization.
VAR INP-Y	User Defined Function Input Y	Temperature	No options	Not required. Only set for standardization.
	User Defined Function Table	No entry	No entry	
K *unit*	Spool K	Cal cert. value * 1000	E^-3	Enter in ns. Cal cert. value is in µs.
D0 *unit*	Spool D0	From cal cert.	kg/m³	
T0 *unit*	Spool T0	From cal cert.	µs	
TEMPCO *unit*	Spool Tempco	Cal cert. value * 1000	ns/°C	Enter in ns. Cal cert. value is in µs.
PRESCO *unit*	Spool Presco	0.0	ns/bar	
VIBDIM *unit*	VIBDIM	15.8		
ISENTR EXP	Gas Isentropic Exponent	1.3		
Tc_0 *unit*	Gas Critical Temperature Base	Single gas Ct or gas mix quasi Ct	Units of Ct (°C or K)	
		12.901	K	

Parameters		Setting	Units	Comments
Display	**Parameter Name**			
Tc _A *unit* Tc _B	Gas Ct Coefficient A	0		
		344.82	No choice. From equation that gives K.	
	Gas Ct Coefficient B	0		
		-61.092	No choice. From equation that gives K.	
Pc _0 *unit*	Gas Critical Pressure Base	Singe gas Cp or gas mix quasi Cp	Units of Cp	
		12.9	bar A	
Pc _A *unit* Pc _B	Gas Cp Coefficient A	0		
		50.606	No choice. From equation that gives bar A.	
	Gas Cp Coefficient B	0		
		-17.72	No choice, but from equation that gives bar A.	
ACENTR FACT	Gas Acentric Factor	Single Gas Acentric Factor or Quasi Acentric Factor for Mix	No units	
		0.0775	No units	

Table F–7. Input menu items

Input		Setting	Units	Comments
Display	**Parameter Name**			
INPUT PERIOD PINP1	Pulse Input 1 Assignment	Density Line	Fixed default	
SIGNAL PINP1	Pulse Input 1 Signal Type	PULSE	Density pulse	
DBNCE PINP1	Pulse Input 1 Signal Debounce	DISABLE		
CUTOFF PINP1	Pulse Input 1 Frequency Cutoff	100		
FILTER PINP1	Pulse Input 1 Filtering	0		
INPUT TEMP AINP1	Analog Input 1 Assignment	Temperature	Fixed default	
TYPE AINP1	Analog Input 1 Signal Type	PT100		
PT-DEF AINP1	Analog Signal 1 Default Type	50	Deg C	Assume heated SG system and set to heater set temperature.
PT-MIN AINP1	Analog Input 1 Minimum Point	0	Deg C	
PT-MAX AINP1	Analog Input 1 Maximum Point	50	Deg C	
INPUT PRESS AINP2	Analog Input 2 Assignment	Pressure	Fixed default	
PRESS AINP2	Analog Input 2 Pressure Sensor Type	ABSOL (Absolute)		
TYPE AINP2	Analog Input 2 Signal Type	4–20 mA		
PT-DEF AINP2	Analog Input 2 Default	3.8	bar A	Set to the regulator pressure setting.
PT-MIN AINP2	Analog Input 2 Minimum Point	0	bar A	
PT-MAX AINP2	Analog Input 2 Maximum Point	4	bar A	
EXCEPT VALUE	Values on Exception	Default		

Table F–8. Output menu items

Output		Setting	Units	Comments
Display	**Parameter Name**			
VAR OUT1	Output 1 Assignment	Specific Gravity		Unless SG not required.
PT-MIN OUT1	Output 1 Minimum	0	SGU	Depends upon customer requirements.
PT-MAX OUT1	Output 1 Maximum	2	SGU	Depends upon customer requirements.
VAR OUT2	Output 2 Assignment	Molecular Weight		Unless MW not required.
PT-MIN OUT2	Output 2 Minimum	2		Depends upon customer requirements.
PT-MAX OUT2	Output 2 Maximum	58		Depends upon customer requirements.

Table F–9. Alarms menu items

Alarms		Setting	Comments
Display	**Parameter Name**		
RELAY ALRM1	Alarm 1 Assignment	SG	Or on other variable according to customer requirement.
TYPE ALRM1	Alarm 1 Type	LO-NC	Low alarm, Normally Closed contacts.
POINT ALRM1	Alarm 1 Setpoint	0.02	
HYST ALRM1	Alarm 1 Hysteresis	0.02	Or 10% below zero value.
RELAY ALRM2	Alarm 2 Assignment	SG	Or on other variable according to customer requirement.
TYPE ALRM2	Alarm 2 Type	HI-NC	High alarm, Normally Closed contacts.
POINT ALRM2	Alarm 2 Setpoint	2.2	Or 10% above full scale.
HYST ALRM2	Alarm 2 Hysteresis	0.1	Or 5% of alarm point.
RELAY ALRM3	Alarm 3 Assignment	Density Line	Setting not important, as this is the equipment fail alarm.
TYPE ALRM3	Alarm 3 Type	AL-NC	Equipment alarm, Normally Closed contacts.
POINT ALRM3	Alarm 3 Setpoint	10	Ignored during running.
HYST ALRM3	Alarm 3 Hysteresis	0.5	Ignored during running.
RELAY ALRM4	Alarm 4 Assignment	Period	

Alarms		**Setting**	**Comments**
Display	**Parameter Name**		
TYPE ALRM4	Alarm 4 Type	LO-NO	Alarm disabled.
POINT ALRM4	Alarm 4 Setpoint	-1	
HYST ALRM4	Alarm 4 Hysteresis	0	

Table F–10. Comms menu items

Comms		**Setting**
Display	**Parameter Name**	
PROTOC RS232	RS232 Protocol	RTU (Modbus RTU)
BAUD RS232	Baud	9600
PARITY RS232	Parity	None
S-BITS RS232	Stop Bits	1
PROTOC RS485	RS485 Protocol	RTU (Modbus RTU)
BAUD RS485	Baud	19200
PARITY RS485	Parity	None
S-BITS RS485	Stop Bits	1
PROTOC INFRA	IR Protocol	ASCII (Modbus ASCII)
BAUD INFRA	Baud	19200
PARITY INFRA	Parity	None
S-BITS RS485	Stop Bits	1
RTU ADDR	Modbus RTU Address	1
ASCII ADDR	Modbus ASCII Address	2
FLASH PORT	Flash Driver Port	RS232

Table F–11. TM/LOG menu items

TM/LOG		Setting
Display	**Parameter Name**	
DATE FORM	Clock Date Format	DAY-M (Day-Month)
CLOCK YEAR	Clock Year	
CLOCK M--DAY	Clock Date (Day-Month)	
CLOCK H--MIN	Clock Time (Hour Min)	
HOUR LOGS	Logging Hours	24
DAY LOGS	Logging Days	31
WEEK LOGS	Logging Weeks	4
MONTH LOGS	Logging Months	12
YEAR LOGS	Logging Years	2
RESET LOGS	Logging Reset	Password protected
REPORT TYPE	Printer Protocol Report Type	REP-01 (hourly logs report)
PRN TYPE	Print Protocol Printer Type	PRN-01 (generic computer printer)

Table F–12. Setup menu items

Setup		Setting	Units	Comments
Display	**Parameter Name**			
DEFAULT VAR	Default Variable	Specific Gravity		Depends upon customer outputs.
SUPPLY VOLT	Transducer Supply	24V		Default is 12V.
T--OUT MODE	Display Timeout Mode	DISABLE		
T--OUT SEC	Display Timeout Period	30		
DISPL TAGS	Display Tags	DEFAULT		
BACK--L T--OUT	Backlight Timeout	DISABLE		
DOCKET RESET	Docket Number Reset	Password protected		
	Password	000000		

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