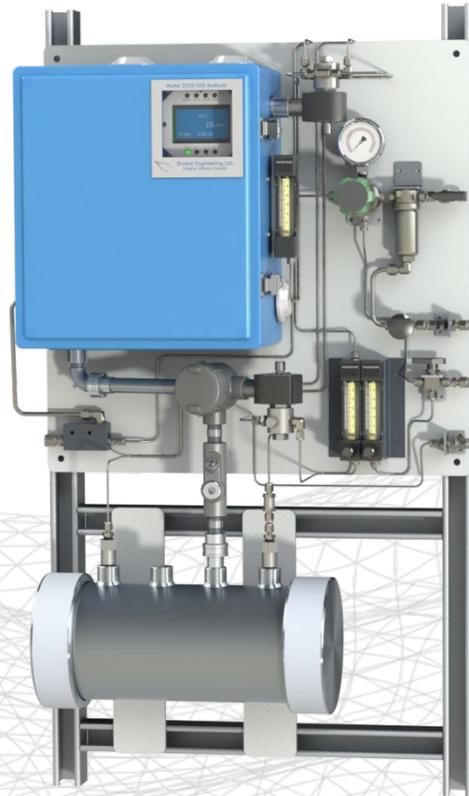


■ Envent

Total Sulfur User's Manual



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1.0 INTRODUCTION

1.1 About This Manual

The Total Sulfur User’s Manual should be used in conjunction with the Hydrogen Sulfide Analyzer Model 330S & 331S User’s Manual. It provides a comprehensive overview of Envent Engineering’s total sulfur addition to the H₂S analyzers, along with detailed installation and startup instructions.

This manual should be read and referenced by anyone responsible for installing, operating, or modifying the Total Sulfur Analyzer. It is essential to familiarize yourself with the content, carefully reading each section to ensure a quick and efficient installation and operation of the analyzer.

The manual includes images, tables, and charts that offer a visual understanding of the analyzer and its functions. Pay close attention to all caution symbols and notes, as they highlight potential hazards and critical information.

1.2 Warranty & Liability Statements

Products produced and supplied by the manufacturer (Envent Engineering Ltd), unless otherwise stated, are warranted against defects in materials and workmanship for up to 36 months from the shipping date or up to 24 months from the start-up date (whichever comes first). During the warranty period the manufacturer can choose to either repair or replace products which prove to be defective.

The manufacturer or its representative can provide warranty service at the buyer's facility only upon prior agreement. In all cases, the buyer has the option of returning the product for warranty service to a service facility designated by the manufacturer or its representative. The buyer shall prepay all shipping charges for products returned to a service facility. The manufacturer or its representative shall pay all shipping charges for the return of products to the buyer. The buyer may also be required to pay round-trip travel expenses and labour charges (at prevailing labour rates) if the warranty has been violated. The warranty may be considered violated for any of the reasons listed below.

1.2.1 Limitation of Warranty

The foregoing warranty shall not apply to defects arising from:

- Improper or inadequate maintenance of the product by the user.
- Improper unpacking or installation procedures.
- Inadequate site preparation.
- Unauthorized modification or misuse of the product.
- Operation of the product in unfavorable environments such as at high temperatures, high humidity, or in corrosive atmospheres.
- Operation of the product outside of the published specifications.

Envent Engineering Ltd carries no responsibility for damage caused during transportation or unpacking, unless otherwise specified in the incoterms.

An extended warranty may be available with certified start-up. Contact Envent Engineering Ltd for details.

1.2.2 Disclaimer

No other warranty is expressed or implied. The manufacturer specially disclaims the implied warranties of merchantability and fitness for a particular purpose. The sole remedy of the buyer shall in no case exceed the purchase price of the analyzer. The manufacturer shall not be liable for personal injury or property damage suffered in servicing the product. The product should not be modified or repaired in any manner differing from procedures established by the manufacturer.

1.2.3 Life Cycle

Envent anticipates producing the current configuration(s) of the H₂S analyzers for a minimum of 3 years. Envent aims to support any products for 10 years from the time of purchase. This timeline may be subject to change depending on component availability from our vendors. Envent reserves the right to redesign the Total Sulfur analyzers at any time, based on technological advances and the availability of parts.

1.3 Safety Information

The procedures and settings outlined in this manual constitute what is considered proper use of the equipment in question. The equipment was designed and tested under the assumption that these procedures and settings will be adhered to. Applying values outside of the provided ranges (such as permitting excessive pressures) or modifying provided procedures is considered improper use of the equipment. Envent Engineering Ltd is not responsible for any injury or property damage caused by improper use of the equipment. Once in the field, the user is solely responsible for the safe operation of the equipment.

1.3.1 Key Symbols

The following symbols are used throughout the manual to call attention to important information. We recommend familiarizing yourself with them before reading further.



Caution signs indicate a potential hazard that, if not properly addressed, could result in improper operation, damage to the equipment or injury to the operator.



Warning signs indicate a potential hazard that, if not properly addressed, could result in serious injury or death.



Indicates a hot surface.



Indicates additional information intended to help clarify an earlier statement or to aid in the reader’s understanding of a given topic.



Indicates electrostatic or shock hazard.

2.0 EQUIPMENT OVERVIEW

2.1 Theory of Operation

Envent Engineering’s H₂S analyzers (Models 330S/DS & 331S/DS) use H₂S sensing tape which reacts only when in contact with H₂S. The total sulfur option involves the addition of a total sulfur reaction furnace (pyrolysis furnace) to a Model 330S or 331S. The furnace converts all sulfur compounds into H₂S, allowing the H₂S analyzer to read total sulfur as per the ASTM D 4468-85 “Standard Test Method for Total Sulfur in Gaseous Fuels by Hydrogenolysis and Rateometric Colorimetry”.

2.1.1 Total Sulfur Reaction

1. A sample gas mixes with hydrogen.
2. The sample gas-hydrogen mixture flows through the reaction furnace and is heated to ~1000°C.
3. The heat in the furnace forces the mixture to react, as shown in the equation below.



Equation 1: Total Sulfur Reaction

4. Hydrocarbon compounds will dissociate to methane.
5. Sulfur-hydrocarbon compounds, such as mercaptans, will dissociate to hydrogen sulfide.
6. Dissociated hydrogen sulfide is then measured by the analyzer as a total sulfur concentration (H₂S included).

2.2 Total Sulfur Reaction Furnace

The Total Sulfur option comes standard with furnace temperature control circuitry. It also consists of a reaction oven, flame arrestors, hydrogen and sample flow meters, and an optional 3-way solenoid valve to allow the user to measure both H₂S and total sulfur on an alternating basis, or the use of an SDS to measure TS consistency.

The furnace has a low temperature switch which will actuate the Analyzer Fault LED and relay upon furnace failure. The low temperature alarm may be present for up to one hour after applying power until furnace reaches operational temperatures.

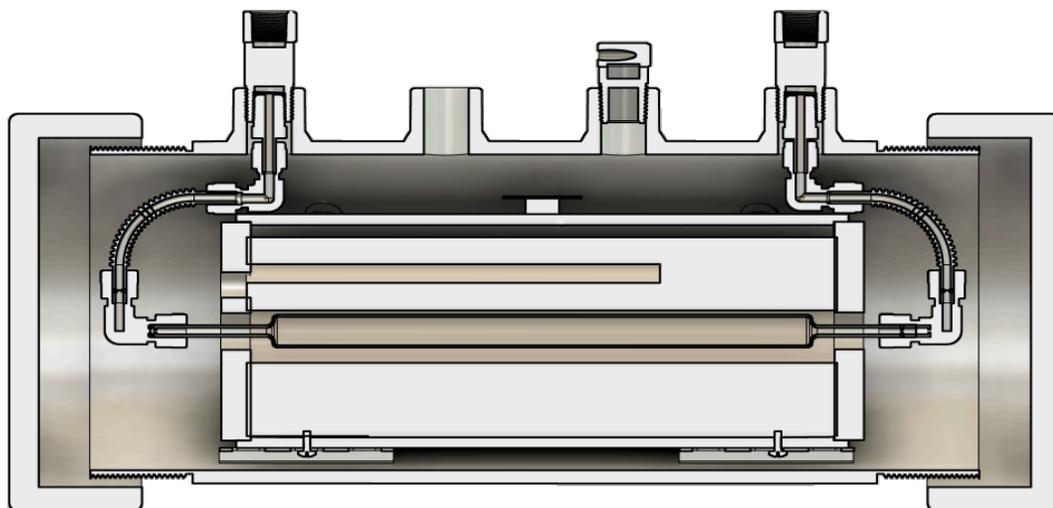


Figure 1: Total Sulfur Oven Cutaway



WARNING:
Dual seal maximum working pressure is 2 PSI.



NOTE:
Leaks can be detected by observing the ball in the H₂/Sample Flow meter during a pressure test.



WARNING:
A lack of flow may indicate a potential failure of the primary seal in the quartz tube/heater assembly.

2.3 Hydrogen



WARNING:

Hydrogen is extremely flammable. Use caution when handling.

The total sulfur analyzer requires ultra-high purity (UHP) hydrogen at a flow of 200-300 cm³/min. UHP Hydrogen has a minimum specified purity of 99.9999%. Lower grades of hydrogen may contain sulfur compounds or other impurities which will cause inaccurate results. Consult the factory calibration sheet for the flow rates for your application.

It is advisable to have at least two bottles on site with dual regulators or a changeover regulator set. The hydrogen regulators must be new and clean. Dual stage, high purity regulators are recommended. Regulators with an elastomer diaphragm (rubber or Buna) are not recommended as they will allow oxygen to diffuse into the hydrogen supply.

The following table will give an estimate of bottle life, in days, based on a K type cylinder (9.25” x 60”) without any leaks or calibration runs. Our calculations are based on a 200 cm³/min (flow of 2 on a A-157-1 flow meter). Assuming each analysis will run 3 times every six hours, Envent suggests the bottle should be checked at least 10 days prior to the estimated end of life.

	Analysis Every 6 Hours	Full Time Flow
2000 PSI	254	25
1500 PSI	190	19
1000 PSI	118	12
500 PSI	59	6

Table 1: Estimated Hydrogen Bottle Life in Days

3.0 UNPACKING & INSTALLATION

3.1 Unpacking

Upon arrival, the packaging should be immediately inspected for any external damage that may have occurred during shipping. If any damage is present, please contact Envent Engineering Ltd and request that the carrier's agent be present when the analyzer is unpacked. If a disagreement arises, the incoterms agreed to by the seller and the customer will overrule any dispute.

Once the integrity of the packaging has been confirmed, open the shipping container, and remove the packing materials from the shipping box. Remove all provided components from the shipping container and inspect them for any damage that may have been sustained during shipping. Compare the provided components to the shipping manifest to ensure that all parts are present.

**CAUTION:**

Quartz reaction tube is fragile and is removed during shipping, handle with care when installing.

**CAUTION:**

Do not apply power, or hydrogen to the reaction furnace until the reaction tube is installed and leak tested.

**HOT SURFACE:**

Total sulfur furnace housing and all components inside of the furnace including the reaction tube, may be hot if not cooled for the appropriate amount of time.

**CAUTION:**

High temperature O-rings must be replaced after each use. Failure to do so will void the warranty.

3.2 Installation or Replacement of Combustion Tube

Use TS furnace exploded view drawing in Appendix A to refer to appropriate parts coinciding with the following steps.

- Step 1** Turn off the total sulfur furnace and let it cool for a minimum of an hour.
- Step 2** Remove the covers from the total sulfur furnace enclosure. (3)
- Step 3** Slide the quartz (high temperature glass) tube into the ceramic furnace. (5)
- Step 4** Substitute the O-rings with new high temperature O-rings if they have been previously used in the oven.
- Step 5** Ensure the high temperature O-ring and ferrule are present and oriented correctly, shown below (figure 2).

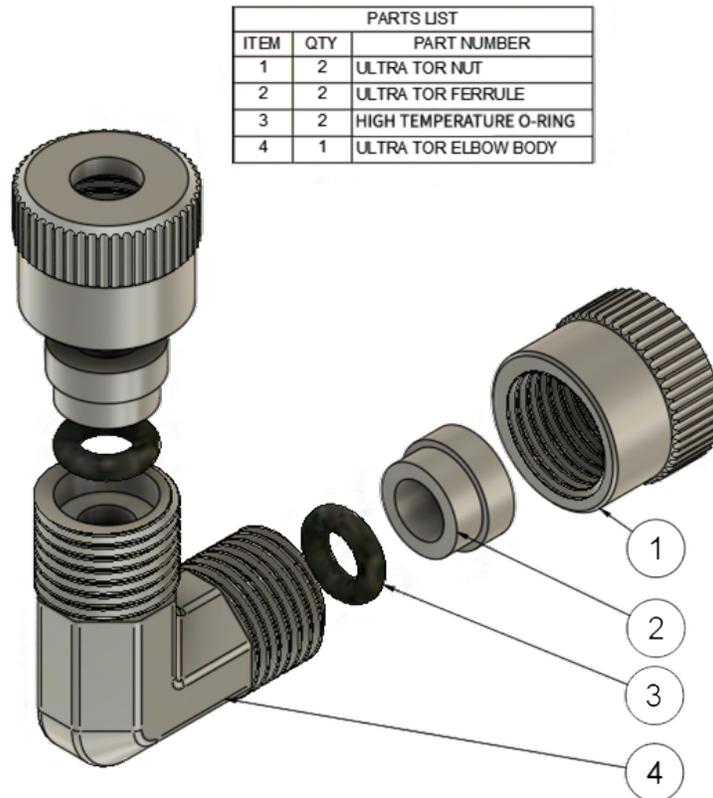


Figure 2: High Temperature O-Rings and Ultra Torr Elbow/Fittings

Step 6 Perform leak check of the total sulfur furnace as per steps in 3.2.2.

3.2.1 Connecting Vacuum Fitting to Quartz Tube

Step 1 With the quartz tube inside of the ceramic furnace, slide the Ultra Torr nut, ferrule, and high temperature O-ring over the end of quartz tube. (Items 1, 2, 3)

Step 2 Gently slide quartz tube into Ultra Torr elbow. (Item 4)

Step 3 Align threads of elbow and nut, then tighten the nut **FINGER TIGHT**. Make sure not to put any lateral pressure on the quartz tube to avoid breaking or cracking it.

3.2.2 Furnace Leak Check

Step 1 Cap the outlet of the furnace to begin the leak check.

Step 2 Set the pressure of inlet to 15 psig and open the flow meter to maximum value.

Step 3 When the ball in the flow meter drops to the bottom of the flowmeter tube, a seal has been established.



NOTE:

If the ball does not drop, a leak is present. Inspect and tighten all fittings, then repeat the previous steps until a seal has been established.



CAUTION:

Do not operate the reaction furnace if a leak is present.

4.0 OPERATION & CONFIGURATION

4.1 Hydrogen Flow & Sample Flow

The Process Flow Diagrams in Appendix A illustrate the typical sample conditioning system used for the 330S & 331S Total Sulfur Analyzers. The Total Sulfur analyzer includes a reaction furnace and an additional flowmeter to control hydrogen flow, which are integrated into the standard H₂S analyzer sample conditioning system. Refer to the Appendices for an overview and dimensional drawings.

Refer to the factory calibration sheet in your analyzer's documentation for the correct sample and hydrogen flow rates. A yellow discoloration on the Tygon tubing connected to the humidifier indicates insufficient hydrogen flow. If this occurs, increase the hydrogen flow or reduce the sample flow by 1. If any flow rates are adjusted, the analyzer must be recalibrated at the new flow rate.

A shortage of hydrogen can cause coking, which is a black carbon build up in the quartz reaction tube. While a light coating of carbon is normal and does not affect operation, excessive coking can lead to plugging of the quartz reaction tube, causing reduced sample flow. Additionally, excessive coking can absorb H₂S, leading to lower-than-expected Total Sulfur (TS) readings.

4.2 Total Sulfur & Hydrogen Control

A pressure switch can be installed to ensure that if the hydrogen drops below 10 psig the analyzer will not switch to the total sulfur stream. This prevents coking of the combustion tube due to lack of hydrogen. See Appendix A for overview and dimensional drawings.

4.2.1 331S/330S TS Only

With a TS only configuration, the analyzer will only ever read the total sulfur values of the process stream. With the TS only configuration, the hydrogen must always be present to allow for proper reactions and prevent coking.

4.2.2 330S/331S H₂S & TS with Mode Switching

Using a single sensor analyzer, it is possible to read both H₂S and Total Sulfur, however, not simultaneously. A solenoid is added to allow to a selection between either running the sample directly to the analyzer (H₂S mode) or through the TS furnace (TS mode). With this configuration, hydrogen will run full time.

330S/331S H2S & TS with Mode Switching and Hydrogen Saver

A second solenoid may be added to shut off the hydrogen gas when in H2S mode. This configuration saves hydrogen usage by a large margin (see table 1). The analyzer is typically programmed to run every 6 hours or alternate between H2S mode and TS mode each analysis; however, any schedule can be built to customer specification.

4.2.3 330SDS/331SDS H2S & TS with Hydrogen Saver

With a dual sensor analyzer (SDS) both the H2S and total sulfur can be measured simultaneously. Sensor one will read the H2S stream while sensor two will read the total sulfur stream. The addition of a solenoid allows the shut-off of the hydrogen if scheduled TS runs are programmed

4.3 Calibration

NOTE:

If the unit was calibrated with an N2 or Air balance, introducing a Methane-balanced stream can cause the analyzer to read higher than the actual value. Calibration with N2 or Air balanced gas still confirms the analyzer's repeatability and stability.



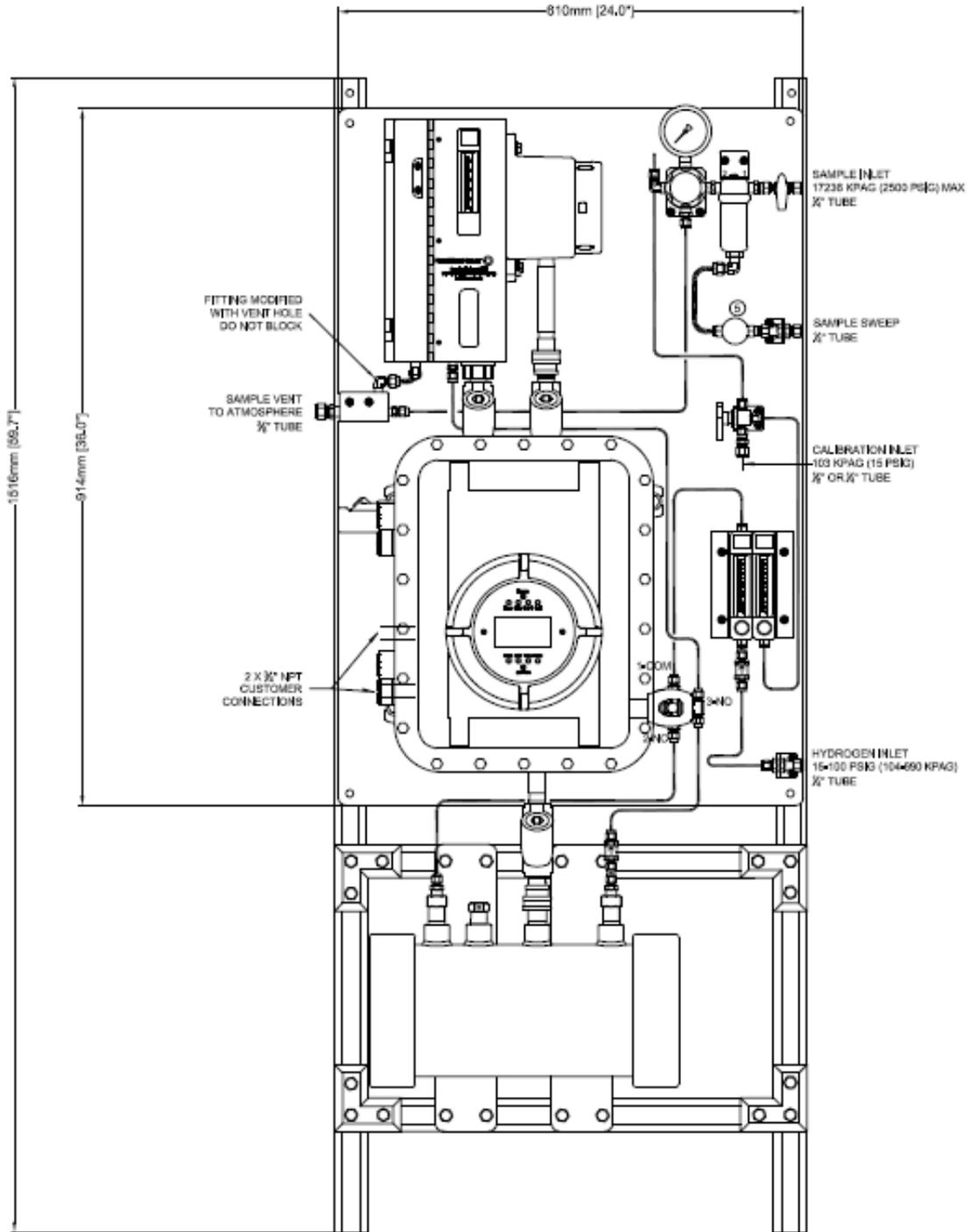
NOTE

Total Sulfur analyzers may detect additional trace sulfur contaminants when calibrated with H2S or COS gas in a Methane background. High-purity Methane-balanced calibration bottles can contain up to 500 ppm of unlisted sulfur contaminants, depending on the manufacturing conditions of the calibration bottle. Envent Engineering recommends using Nitrogen-balanced calibration gas for Total Sulfur analyzers.

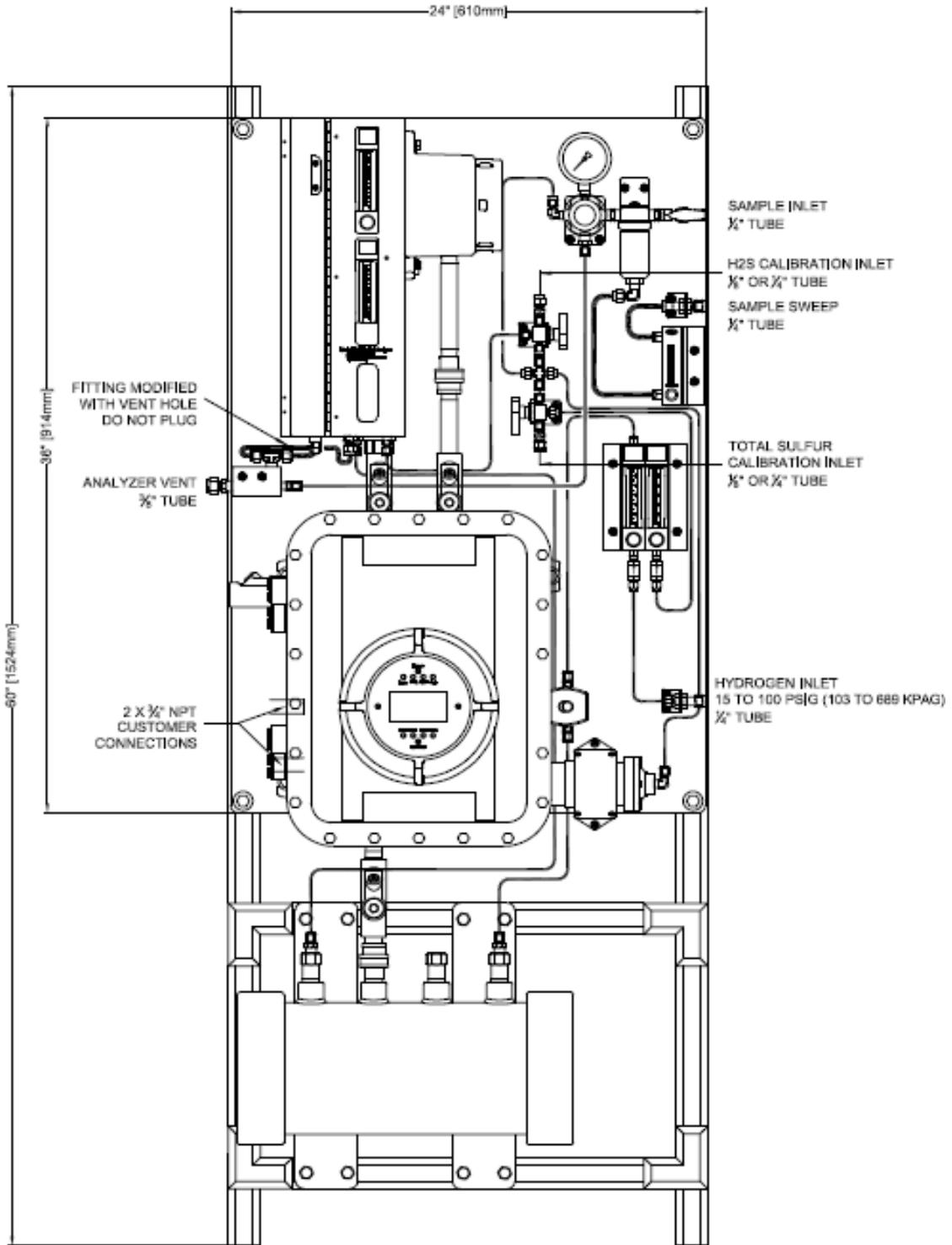
APPENDIX A – DRAWINGS & DIAGRAMS

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330SDS with H2 Saver and H2 Pressure Switch Outline & Dimensional	pg. 14
331S Total Sulfur Outline and Dimensional	pg.15
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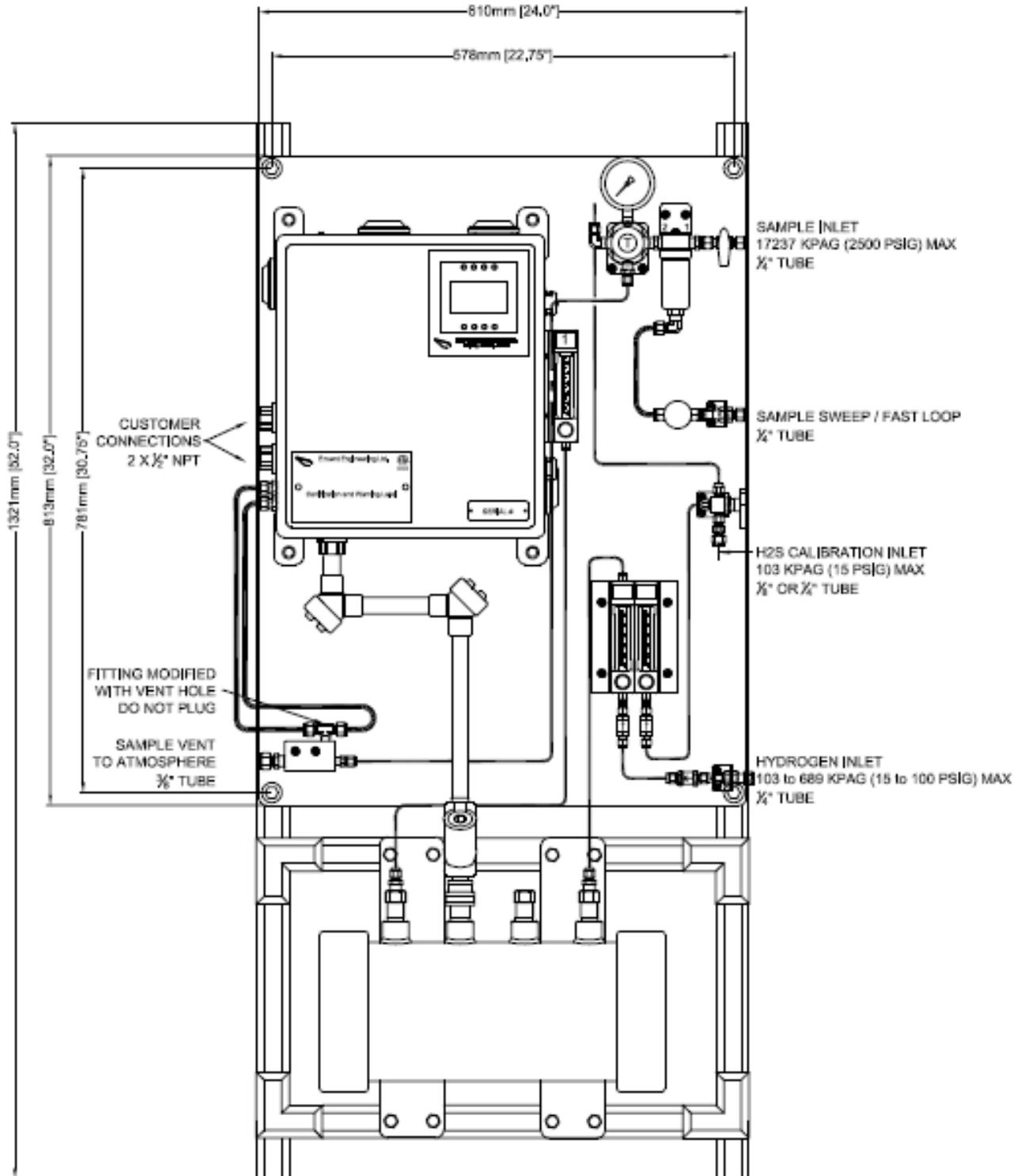
330S with Mode Switching Outline & Dimensional



330SDS with H2 Saver and H2 Pressure Switch Outline & Dimensional



331S Total Sulfur Outline and Dimensional



Total Sulfur Oven Break Down

ITEM	QTY	PART NUMBER
1	1	330425-A TS OUTER ENCLOSURE
2	1	INNER FURNACE ASSEMBLY V2
3	2	330425-B OVEN LID
4	1	TOTAL SULFUR TEMP SWITCH
5	1	330423 TS COMBUSTION TUBE
6	4	HIGH TEMPERATURE O-RING
7	2	SS-4-UT-9 ELBOW UNION
8	2	321-4-X-21 1_4
9	2	SS-400-9
10	2	SS-4TA-1-4 MALE 1_4
11	2	ADA-XFA FLAME ARRESTOR
12	1	1_2 NPT BREATHER DRAIN

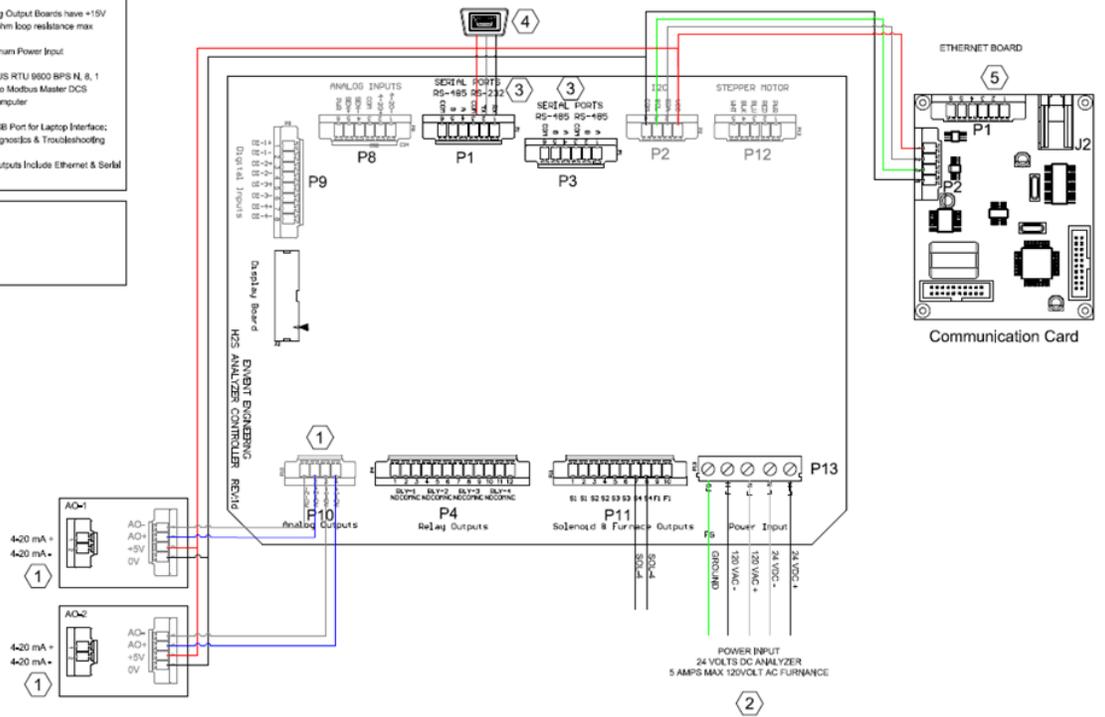
PROJECT Parts Explosion	
TITLE Total Sulfur Assembly	
APPROVED	SIZE
CHECKED	CODE
DRAWN	DWG NO
Ryan Jahn	SCALE 1:3
2022-01-18	WEIGHT
SHEET 1/1	REV

H2S Total Sulfur with Ethernet Card, Pressure Switch and Powered A/O Electrical & Connection

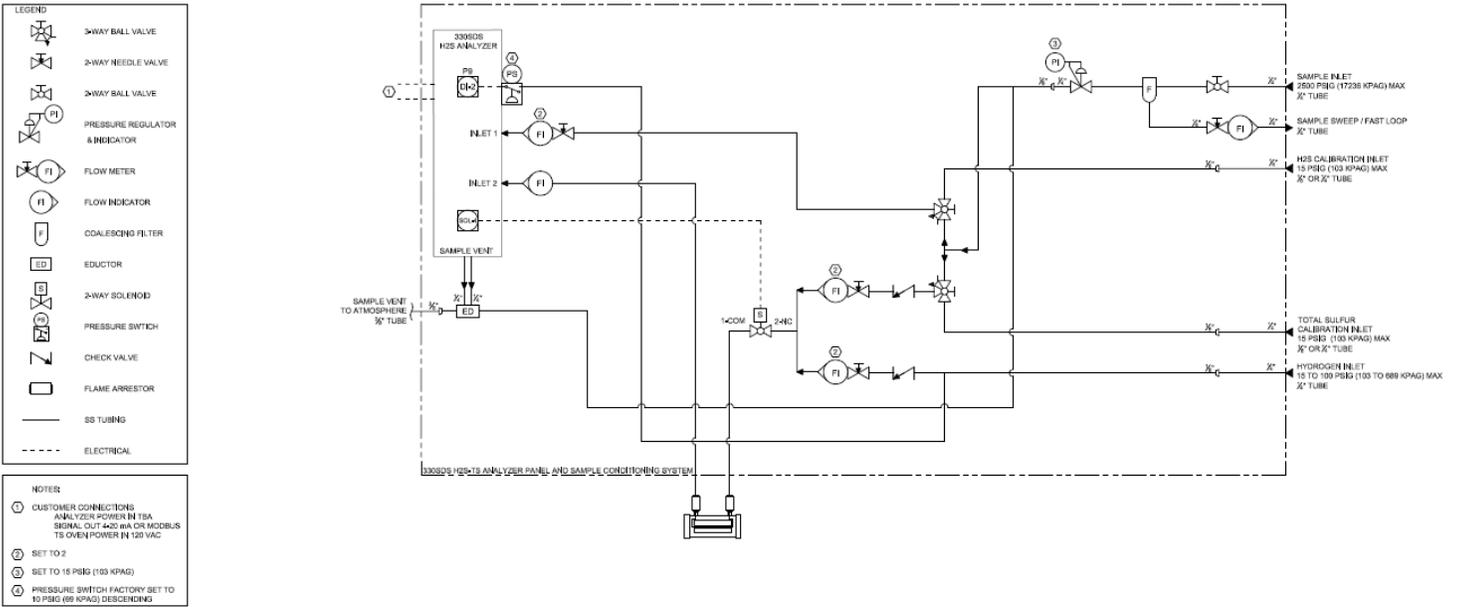
TERMINAL #	TERMINAL DESCRIPTION
P1 SERIAL PORTS	
P1-1	RS-232C RX
P1-2	RS-232C TX
P1-3	RS-232C COM
P1-4	RS-485+ A
P1-5	RS-485- B
P1-6	RS-485-3 COMMON
P3 SERIAL PORTS	
P3-1	RS-485-2 A
P3-2	RS-485-2 B
P3-3	RS-485-2 COMMON
P3-4	RS-485-3 A
P3-5	RS-485-3 B
P3-6	RS-485-3 COMMON
P9 DIGITAL INPUTS	
D1-1	LOW TAPE+
D1-2	LOW TAPE-
D1-3	LOW HYDROGEN PRESSURE+
D1-4	LOW HYDROGEN PRESSURE-
D1-5	
D1-6	OVEN FAIL+
D1-7	OVEN FAIL-
P4 RELAYS	
P4-1	RELAY-1 ND
P4-2	RELAY-1 COM
P4-3	RELAY-1 NC
P4-4	RELAY-2 ND
P4-5	RELAY-2 COM
P4-6	RELAY-2 NC
P4-7	RELAY-3 ND
P4-8	RELAY-3 COM
P4-9	RELAY-3 NC
P4-10	RELAY-4 ND
P4-11	RELAY-4 COM
P4-12	RELAY-4 NC
P11 SOLENOIDS	
P11-1	S1
P11-2	S2
P11-3	S3
P11-4	S4
P11-5	H2 SAVER
P11-6	H2 SAVER
P11-7	TS OVEN
P11-8	TS OVEN
P10 ANALOG OUTPUTS	
P10-1	AO-1+
P10-2	AO-1-
P10-3	AO-2+
P10-4	AO-2-

- NOTES**
- Powered Analog Output Boards have +19V Excitation 500 ohm loop resistance max
 - 16 Gauge Minimum Power Input
 - RS-485 MODBUS RTU 9600 BPS N, 8, 1 Modbus Slave to Modbus Master DCS PLC or Flow Computer
 - RS-232 Mini-USB Port for Laptop Interface: Operations, Diagnostics & Troubleshooting
 - Ethernet card outputs Include Ethernet & Serial

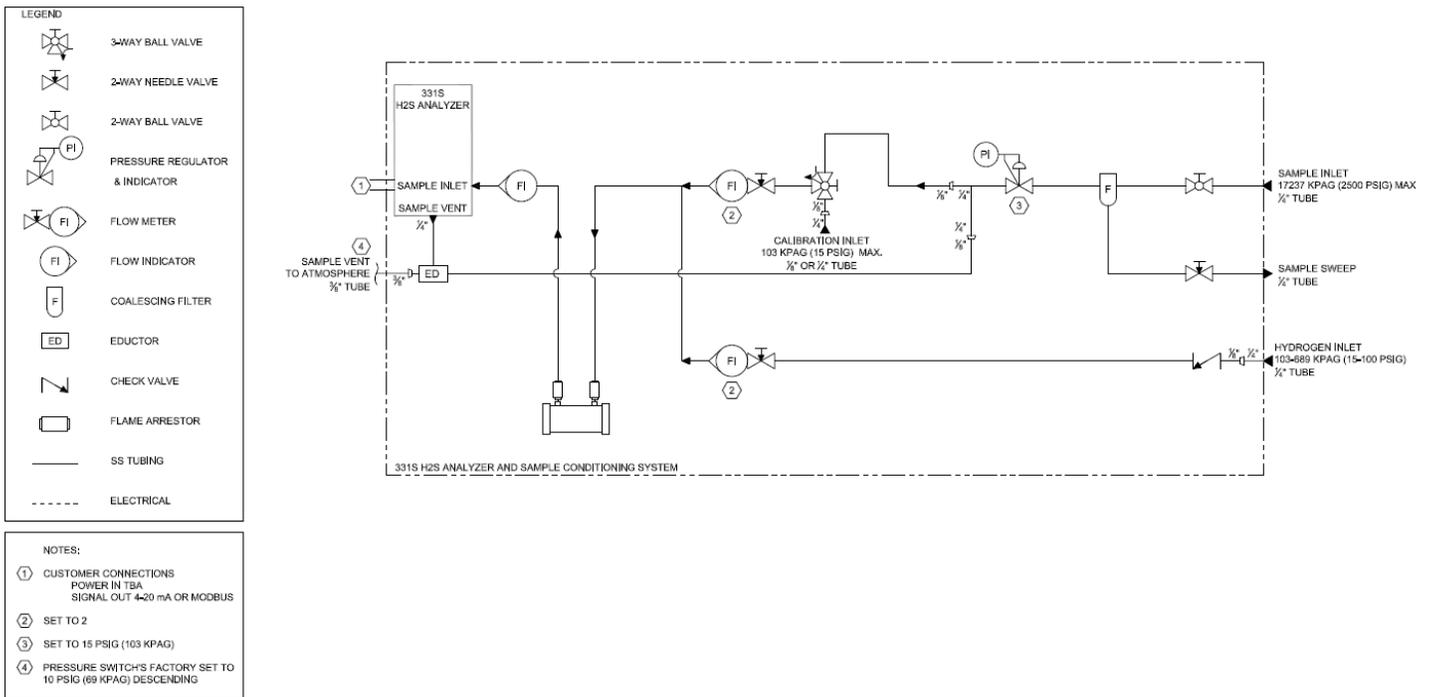
- POWERED ANALOG OUTPUT 1**
 P1 AO-1 +
 P2 AO-1 -
- POWERED ANALOG OUTPUT 2**
 P3 AO-2 +
 P4 AO-2 -



330SDS with H2 Saver and H2 Pressure Switch Process Flow Diagram



331S Total Sulfur Process Flow Diagram



APPENDIX B – RECOMMENDED SPARE PARTS LIST

The spare parts table provided below offers a comprehensive list of all the Total Sulfur analyzer spare parts. To determine which spare parts are applicable to your specific requirements, please consult an Envent sales representative for further assistance.

Spare Parts		
Part Number	Quantity	Description
1000051	1	1/8" 1/3PSIG Check Valve
1000065	1	¼" Elbow
1000123	1	Ultra Torr Elbow
1100107	1	Flex Tube
1100113	1	TS Ceramic Heater
1100115	1	Total Sulfur Temperature Switch
1300281	1	Group BCD Flame Arrestor
2000050	2	13" Chubby Quartz Tube
2000052	4	High Temperature O-Ring for TS Furnace

Table 2: Spare Parts

APPENDIX C – RISKS & SAFETY INFORMATION

Hydrogen Sulfide Properties	
Properties	Description
Physical State	<ul style="list-style-type: none"> ▪ Gaseous above 60 °C
Color	<ul style="list-style-type: none"> ▪ Colorless - No visible sign of H₂S to warn you of its presence
Odor	<ul style="list-style-type: none"> ▪ Characteristic smell of rotten eggs at 0.05 ppm; paralyzes the olfactory nerve around 100 ppm
Vapor Density	<ul style="list-style-type: none"> ▪ Heavier than air (1.19 compared to 1.0 for air). ▪ In gas mixtures, it will be present wherever the gas mixture is found. ▪ Gas mixtures may be heavier or lighter than air, depending upon their vapor density and temperature compared to the ambient atmosphere (usually air). ▪ In its pure state, or as a high proportion of a gas mixture, it may flow or settle into low-lying areas, such as pits, trenches, and natural depressions.
Flammability	<ul style="list-style-type: none"> ▪ Flammable - Flammable at 4.3 - 46 percent vapor concentration in air, by volume. ▪ Burns with a blue flame and gives off Sulphur dioxide (SO₂) gas. SO₂ is also hazardous and irritates the eyes and the respiratory system.
Solubility	<ul style="list-style-type: none"> ▪ Soluble in water and oil, solubility is inversely proportional to fluid temperature.
Corrosiveness	<ul style="list-style-type: none"> ▪ H₂S is one of the most active corrosive components in gas-water-air environments.
Common Locations for H ₂ S	<ul style="list-style-type: none"> ▪ Piping systems, pipelines, wellheads or wellbores, vessels, production facilities, tanks, pits, and low spots, confined or enclosure spaces, shacks or buildings, bermed or diked area, sour spills.

Table 3: Hydrogen Sulfide Properties

Hydrogen Sulfide Quantities and Health Effects	
H2S Exposure	Possible health Effects
Less than 1ppm	<ul style="list-style-type: none"> ▪ You can smell it.
10 ppm	<ul style="list-style-type: none"> ▪ No known health effects for most people. ▪ For 10 ppm or less, the exposure limit is 8 hours - Check your local legislation as they vary. ▪ For 15 ppm, the exposure limit is 15 min with 60 minutes breaks. Check your local legislation as they vary.
20-200 ppm	<ul style="list-style-type: none"> ▪ Eye and respiratory tract irritation and loss of smell. ▪ Headache and nausea - loss of smell after 2 - 5 min. ▪ Respiratory Protection is required beyond this level such as SCBA (Self-contained Breathing Apparatus) and SABA (Supplied Air Breathing Apparatus).
200 - 500 ppm	<ul style="list-style-type: none"> ▪ Above effects, but sooner and more severe. ▪ Loss of breathing and death in 30 min to 1 hour.
500 - 700 ppm	<ul style="list-style-type: none"> ▪ Affects the central nervous system. ▪ Rapid unconsciousness, cessation of breathing, and death.
700 ppm and above	<ul style="list-style-type: none"> ▪ Immediate loss of consciousness. ▪ Permanent brain damage and death in a few minutes even if removed to fresh air at once.

Table 4: Hydrogen Sulfide Quantities & Health Effects

APPENDIX D – FAQ & TROUBLESHOOTING

Question	Answer
What is the oven internal temperature?	~1000 °C
What is the oven external enclosure surface temperature?	~50 °C
Can we read furnace temperature on the display?	No, but there is an oven fail alarm if the operational temperature cannot be maintained.
Do we need Total Sulfur gas for calibration gas?	No. The analyzer can be calibrated using strictly H ₂ S calibration gas, however, the operation of the oven will not be verified.
Does Envent sell calibration Total Sulfur gas?	Contact Envent
How long does a hydrogen bottle last?	Check table in section 2.3
How long does it take the oven to warm up?	Approximately 1 hour

Problems	Possible Reasons	Possible Solutions
No Flow as indicated on flowmeters	Coked quartz reaction tube	Replace tube and potentially fittings
TS reading lower than H ₂ S reading	Coked quartz reaction tube	Replace tube and potentially fittings, and tubing cleaning.
Oven Fail Alarm	Oven hasn't come up to temperature	It can take up to an hour for the oven to come up to temperature from start up
	Temperature switch has failed	Replace temperature switch
Oven won't come up to temperature	Oven element has failed	Replace element
	Oven has been programmed incorrectly	Contact Envent for assistance

CONTACT US

In the event that a situation arises that is not covered by this manual, we encourage you to contact us so that we can help you resolve any issues you may have. Please have this manual readily available when calling for assistance.

For further information on our products or to access our most recently updated manuals and product catalogues, please visit our website at www.enventengineering.com.



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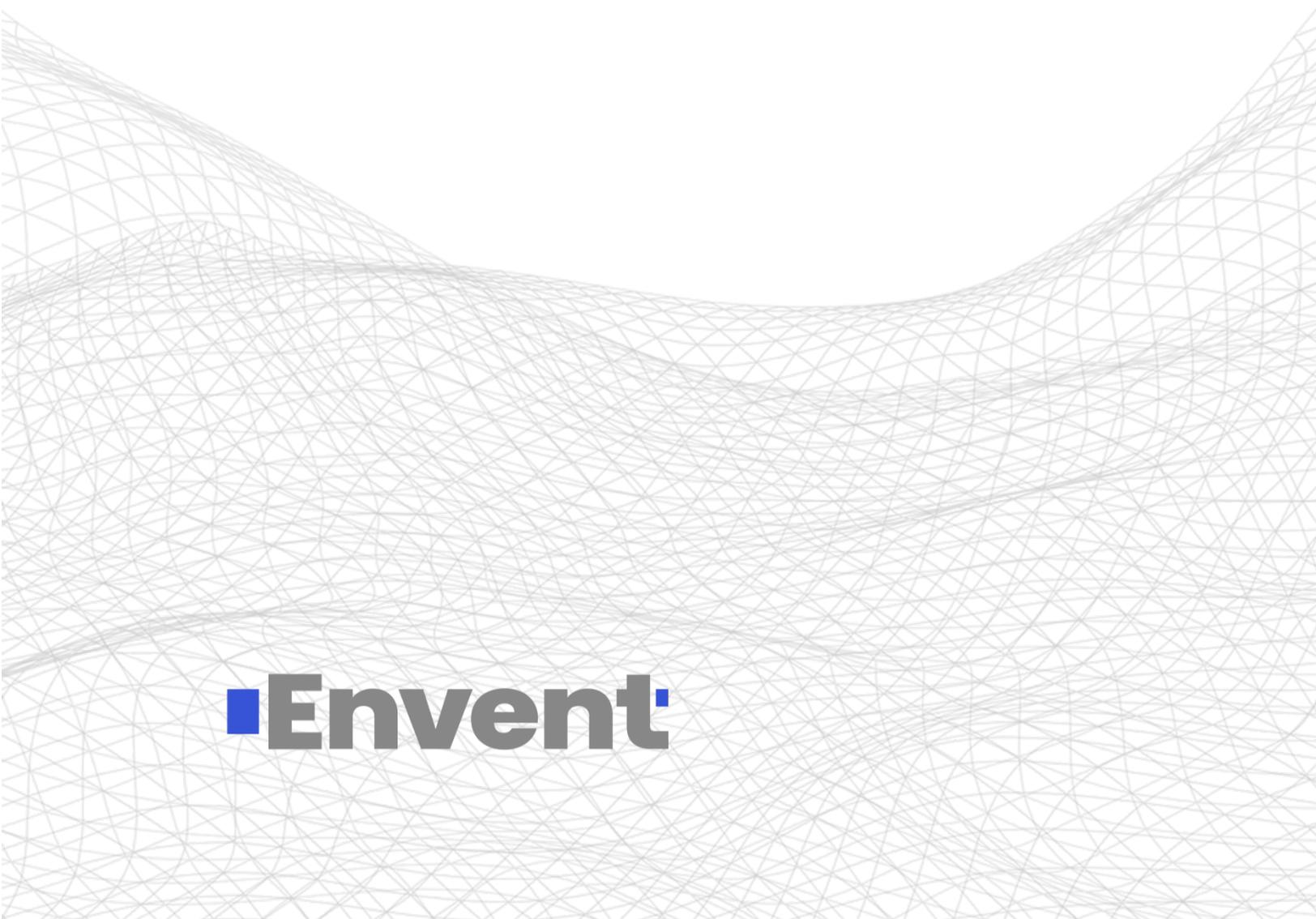
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