Mustang Sampling®

Mustang Intelligent Vaporizer Sampling System® Model 1

Operations Manual

MIV1®

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Introduction

DISCLAIMER

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Mustang Sampling, LLC has engineered this product to perform specific functions, or set of tasks. Modifications to the unit or alternative applications of this product are not authorized without express written consent of Mustang Sampling, LLC.

Potential Hazard Notifications in Manual

This manual will use the convention of labeling Notice, Cautions, and Warnings in this manner;

NOTICE

CAUTION

WARNING

Glossary

BTU – British Thermal Unit
CAL - Calibration
GC – Gas Chromatograph
HTTB – Heat Trace Tube Bundle
LEL - Lower Explosion Limit
LNG – Liquefied Natural Gas
LOTO – Lock-Out / Tag-Out
MAOP – Maximum Allowable Operating Pressure
MFC – Mass Flow Controller
MHR® – Mustang Heated Regulator
MIV – Mustang Intelligent Vaporizer
PLC – Programmable Logic Controller
PS – Power Supply
RTD – Resistance Temperature Detector
VJT® – Vacuum Jacketed Tubing

Introduction

MIV1® Sampling System Overview

The Mustang Intelligent Vaporizer Sampling System® - Model 1 (MIV1®) is a patented technology, designed to vaporize liquid, providing a fresh sample to a continuous online analyzer. This system is designed with enhanced sample quality, through controlled vaporization, accumulation, and homogenization, accomplished through multiple stages. For the analyzer to meet its stated accuracy, the Mustang Intelligent Vaporizer Sampling System ensures the sample to the analyzer is stable. The multi-path design provides redundancy well suited to critical operations.

MIV1 Flow Path

1. Cryogenic liquid enters the MIV1 through the VJT® with temperatures monitored and reported by a resistance temperature detector (RTD)
2. The Cryogenic liquid then passes through a thermal isolator to a manifold which feeds four heated coils.
3. The heated coils instantly vaporize the liquid then the vapor is routed to an exit manifold then through a solenoid valve on the way to an accumulator tank.
4. The Accumulator Tank is equipped with mixing wands that ensure the gas is homogenous.
5. The gas then exits the accumulator in two paths, one leads to the Bypass Mass Flow Controller and the other steams to the analyzers through a Mustang Heated Regulator (MHR).
6. The bypass mass flow controller ensures that there is enough flow into the system to keep the liquid from prevaporizing before reaching the heated coils.
7. The MHR ensures the vapor sample remains in the vapor phase and reduces the pressure of the sample to meet the requirements of the downstream analyzers.

Customer setpoint values are;

- All individual vaporizer temperatures
- MIV1 cabinet temperature
- MHR® temperature and pressure
- Bypass Mass Flow Controller rate

Benefits

- Instantaneous vaporization of a liquid sample
- Prevents post-vaporization hydrocarbon liquid dropout
- Provides a homogenous sample
- Provides an accurate and stable sample to the gas chromatograph
- Supplies samples, including composite and manual grab samples, to multiple analyzers
- SoftView® Monitor – a dedicated software platform for operating, monitoring, trending, and reporting

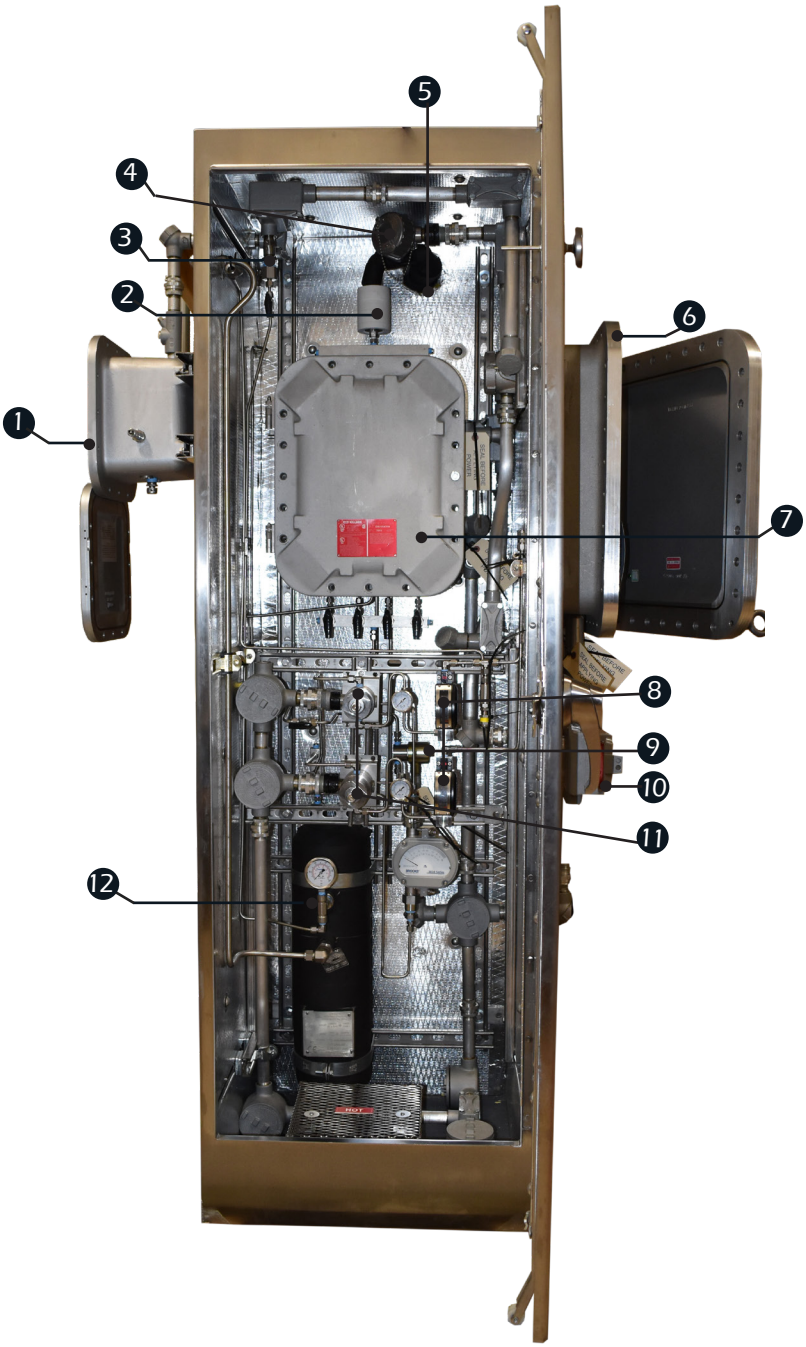
Features

- Continuous gas flow design
- Easy maintenance
- NEMA 4X Enclosure

Certifications

- ATEX/IECEx Certifiable
- Conforms to ISO 8943

Item Number	Description
1	Fast Loop Mass Flow Controller
2	Thermal Isolator
3	Pressure Sensor
4	Mustang Inlet Resistance Temperatue Detector
5	Liquefied Natural Gas Input
6	PID Temperature Controller
7	Multi-Path Vaporizer
8	Flow Meters
9	Cryogenic Solenoid Valve
10	Power Input
11	Mustang Heated Regulator
12	Mustang® Accumulator Cylinder



Technical Specifications

Note: * Connections made up during Installation are noted in red type, all other connections are made at the factory, tested & documented
Note: ** Manual controls are labeled "Manual", all other customer controls managed & set electronically via the PLC

Components	* Mechanical Interface	Electrical Interface	Downstream Component Interfaces	Reports	**Customer Control	Value Range
Power	Field Connection On / Off Switch	Power	Plant Power Feed	N/A	Manual MIV1 Switch or Manual Power Feed Breaker	N/A
Comm Link	Field Connection Comm Link Port	RS232, RS485 and/ or Ethernet RJ45	Control Room	MIV1 Performance	N/A	Communicates MIV1 Performance to Control
VJT	Field Connection ¼" Swagelok Tube - both Inlet & Outlet	N/A	RTD and Vaporizer Inlet Manifold	N/A	Manual Supply Valve at Probe	N/A
RTD	¼" Swagelok® Tube	Power & PLC	MIV1 PLC	Inlet Temperature of Liquid Gas	Monitor Temperature Only	-328°F (-200°C) to 152°F (67°C)
Vaporizers	¼" Swagelok Tube - All	Power & PLC	Vaporizer Heater Temp reported to PLC	Gas Temperature at Vaporizer Outlet	Temperature Control & Manual Vaporizer Outlet Shut-Off Valve	50°F (10°C) - 180°F (82°C), Factory pre-set at 120°F (49°C)
Vaporizer Outlet Manifold Thermocouple	1/4" NPT	Power & PLC	PLC - Solenoid Shut0Off Valve	Vaporizer Outlet Manifold Gas Temperature reported to PLC	Optional - monitor only	N/A
Solenoid Shut-Off Valve	¼" Swagelok Tube	PLC - based on readings from Vaporizer Outlet Manifold Thermocouple	N/A	N/A	N/A	Shuts Down MIV1 if Vaporizer Outlet Manifold Gas Temp falls below temperature set point - typically 50°F (10°C)
Accumulator Pressure Guage	¼" Swagelok Tube	N/A	N/A	Accummulator Tank Pressure	N/A	0 - 1,000 psi

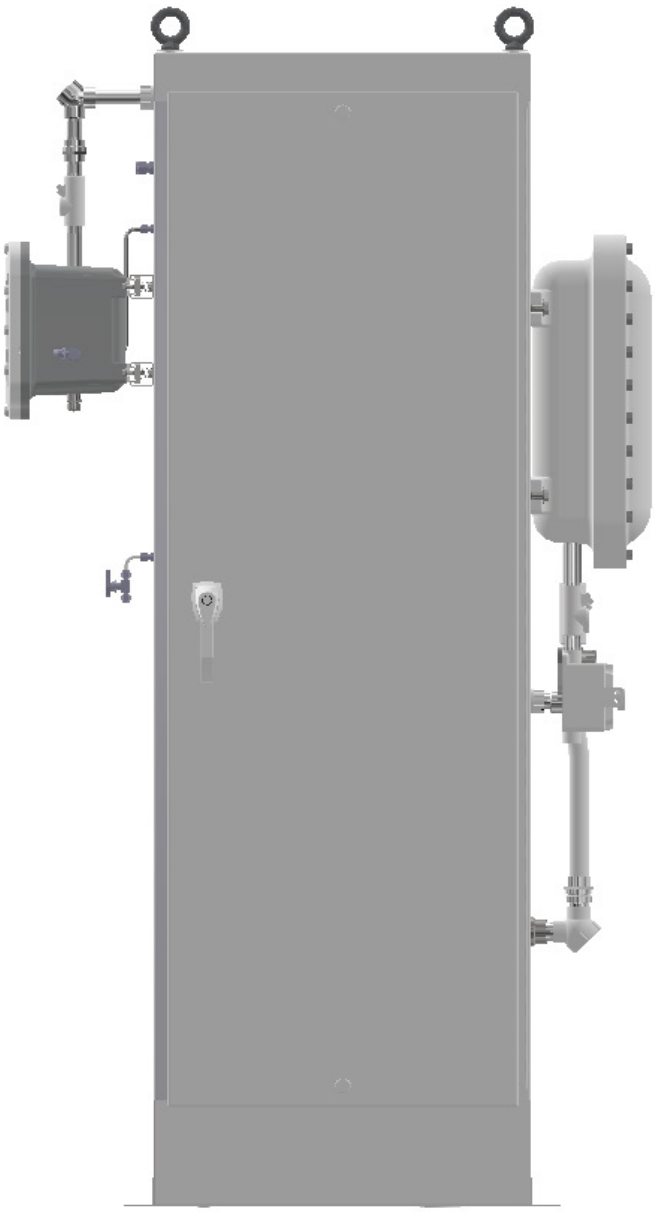
Accumulator Burst Disc Relief Valve	Field Connection ½" Swagelok® Tube	N/A	BOG Header, Flare or waste tube	N/A	N/A	500 psi
Cabinet Heater	N/A	Power & PLC	N/A	Cabinet Temperature	N/A	Factory pre-set at 120°F (49°C)
Bypass Mass Flow Controller	Field Connection ¼" Swagelok Tube - All	Power & PLC	BOG Header, Flare or waste tube	Bypass Flow Rate	Bypass Flow Rate control	Factory pre-set at 28 liters/min or customer's set point - 0 - 60 liters/min.
Backpressure Check Valve - Bypass Mass Flow Controller	¼" Swagelok Tube - All	N/A	Bypass Mass Flow Controller output tube	N/A	N/A	0.34 psi
MHR	¼" Swagelok Tube - All	Power & PLC	Pressure Relief Valve & HTTB	Temperature	Temperature Control through PLC, Manual Pressure Valve	Factory pre-set at 120°F (49°C)
Pressure Relief Valve	Field Connection ¼" Swagelok Tube	N/A	BOG Header, Flare or waste tube	N/A	N/A	45 PSI - but may vary to be application specific
HTTB	Field Connection ¼" Swagelok Tube - All	Electrical Dead Head in MIV1 cabinet conduit	Analyzer	N/A	N/A	N/A

Additional Specifications

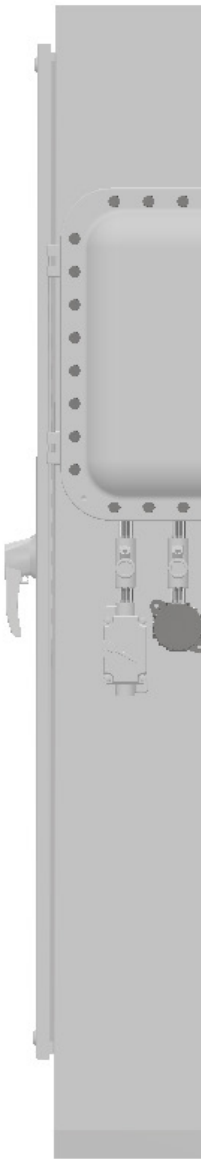
Maximum Allowable Working Pressure	Limited by installed burst disc on Accummulator Tank pressure relief system - 500 psi
Electrical Enclosure Classification	Class 1, Division 1 & 2, Groups C, D and T3 (CE ExII 2 G Ex d II B T3 Gb Zones 1 & 2)
Wetted Materials	Machined parts: 316 Stainless Steel / NACE compliant All other metal parts: stainless steel / NACE compliant; (other materials available upon request)

Mustang Intelligent Vaporizer Sampling Sysem® (MIV1®)

View: Left Side



View: Front Interior



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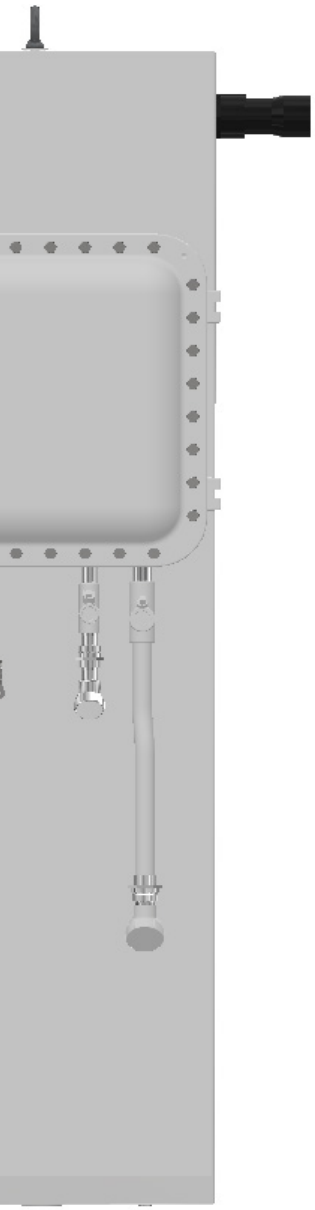


Right Side

PRODUCT SPECIFICATIONS

Maximum Allowable Working Pressure	500 psig at -360°F (35 bar at -218°C) Varies by solenoid selection
Proportional Temperature Control Range	0°F to 200°F (-18°C to 93°C)
Thermal Cut-off	Opens at 230°F (110°C)
Port Sizes	1/4" female NPT
Conduit Connection	3/4" female NPT
Electrical Enclosure Classification	Class 1, Division 1 & 2, Groups C, D, T3 (CE Ex II 2 G Ex d II B T3 Gb Zones 1 & 2)
Wetted Materials	Machined parts: 316 stainless steel/NACE compliant All other metal parts: stainless steel/NACE compliant; (other materials available upon request)
Input Supply Voltage Options	120 VAC, 1950 Watts, 50/60 Hz, ± 10%
	240 VAC, 1950 Watts, 50/60 Hz, ± 10%
Certification Options	AI Atex/IECEx Certifiable
	CE cETLus Certifiable

VAPORIZING: The MIV1® multi-path flash vaporizes liquid samples for introduction into gas analysis systems. Liquid samples are maintained near line conditions until reaching a flash chamber within the vaporizer, preventing pre-vaporization. The energy for vaporization is provided by an electric cartridge heater with sufficiently large surface area to maintain a stable gas temperature throughout the process and send the sample to the Mustang® Accumulator for restructuring.

ACCUMULATING: The Mustang® Accumulator Cylinder is designed with a special mixing wand to aid in the absorption of pressure pulsations and homogenization of gasified LNG.

A vapor return bypass flow control system is controlled by a Brooks mass flow controller. The vapor is sent to the vapor return or flare.

PRESSURE REGULATING: A Mustang Heated Regulator (MHR®) designed to prevent hydrocarbon dew point dropout and reduce sample pressure which is then delivered to the gas chromatograph through a heated sample tube.

MIV1® Commissioning Procedure

CAUTION

Mustang Sampling strongly recommends that Commissioning be performed by Mustang Sampling technicians

Cautions, Warnings & Prohibitions

Do Not Exceed System Pressure or Temperature Ratings.

- Explosion Hazard due to Trapped Pressure
- Exceeding Temperature Limits can damage unit
- Explosion Proof Containers Must Be Closed and Secured During Commissioning and Operations
- Obey Warning Labels on unit

What You Will Need

- Hazardous Work Permit (if required by site)
- Appropriate PPE for the work area including cryogenic materials PPE
- Leak Detection Soap
- Swagelok Gap Inspection Gauge
- LEL Monitor
- Pipe Insulation Materials
- Optimum Pressure for the Gas Analyzer(s)

NOTICE

During the Commissioning procedure the MIV1 cabinet door should remain closed as much as possible and personnel should be stationed at the MIV1 unit

CAUTION

Bypass Mass Flow Controller outlet must be connected to commission the MIV1 unit.

Commissioning can be completed without being connected to the analyzer, but can NOT be commissioned with the Bypass Mass Flow Controller disconnected

Gas vapor needs to be completely accommodated by the Bypass Mass Flow Controller and / or the MHR to analyzer feed. Commissioning begins with the MHR® closed so all gas vapor must be handled by the Bypass Mass Flow Controller.

Commissioning Procedure Overview

1. Pre-Commissioning Inspection
2. Energize Power
3. Start LNG Flow
4. Normal Readings - Commissioning
   - 4.1 Vaporizer Temperatures
   - 4.2 MHR® Temperature
   - 4.3 LNG Inlet Temperature
   - 4.4 Bypass Mass Flow Controller
5. MHR Pressure Optimization
6. Re-Start Procedure When Commision Incomplete

1 Pre-Commissioning Inspection

- Ensure Power is "Off", LNG Flow is "Off" (LNG Flow valve is external to the cabinet located at the LNG pipe take-off into the Vacuum Jacketed Tubing (VJT®) feeding the MIV1 unit)
- Check area for environmental hazards
- Verify Installation Checklist (see Installation Manual)
- Re-check electrical and tubing connections
  - Proper electrical sealing of connections and conduit
  - Swagelok connections checked with Swagelok® Tool
- Ensure the four vaporizer valves and the pressure transducer valve are open and the Mustang Heated Regulator (MHR) pressure valve is closed

WARNING

Conditions Requiring an Immediate Shut Down during Commissioning

- Leaks
- Electrical Component Failure

Shut Down Procedure during Commissioning

- Stop LNG Flow – Close valve at probe and Lock Out / Tag Out per site requirements
- Allow pressure to drop to zero
- Turn Off Unit – secure power and Lock Out / Tag Out

Begin repairs after pressure has been released and temperatures have returned to ambient temperatures

❷ Energize Power

- Turn on SoftView® or customer monitoring software
- Energize power feed to MIV1, and turn on MIV1's power switch
- Check that temperature and pressure components appear to be operating and reporting.
- Verify and monitor Factory Preset Parameters using monitoring software
  - Vaporizer Temperatures – Vaporizer temperatures are preset at 120°F (49°C)
  - MHR Temperature – MHR temperatures are preset at 120°F (49°C)
  - Bypass Mass Flow Controller – preset to 28 liters/minute

CAUTION

If monitoring software malfunctions or communication issues are present shut down and correct before proceeding further.

- Allow electronics and heaters to warm up for 15 minutes before starting LNG flow.
- See **Appendix A - Troubleshooting** if temperatures exceed, or fail to reach preset values.

❸ Start LNG Flow

Final leak test with LNG: This final system test should be administered with all process connections completed, but **before** final insulation of the probe assembly, VJT and inlet manifold.

Equipment needed; Appropriate PPE and work permit (if required). Hand tools, Swagelok Gap Inspetion tool, and LEL monitor. Also needed are towels, or similar drying materials, and appropriate insulating material.

1. The MIV1 should be powered up for at least 15 minutes
2. Through the software, ensure that all heaters are stabilized
3. Open the cryogenic root valve at the probe
4. Allow the unit to flow until the system pressure stabilizes and the inlet temperature reaches - 150 F (-101C). Note that ice will likely begin forming on uninsulated cryogenic surfaces. This may result in a "fog" that could appear as a leak
5. Close the MFC and MHR outlet valves, followed by the 4 valves on the vaporizer outlet manifold. DO NOT CLOSE THE PROBE'S CRYOGENIC ROOT VALVE!
6. Note the system pressure
7. Wait 15 minutes and check the pressure reading
   - During the 15 minute waiting period use an LEL Monitor to leak test the vaporizer outlet manifold, inlet manifold and all additional fittings upstream of the vaporizers, including the cryogenic probe. If there is time remaining in the 15 minute waiting period, or if a drop in pressure is noted during the 15 minute wait period, use the LEL Monitor to leak check all fittings
   - If after 15 minutes the pressure did not drop and no leaks were detected by the LEL Monitor, proceed to step 8.
   - If the LEL Monitor identified leaks, and/or the system's pressure dropped during the 15 minute waiting period:.
     - Open the ball valve on the MFC outlet.
     - Open the 4 outlet manifold valves.
     - Close the cryogenic probe root valve and allow all pressure to bleed off and temperature return to ambient.
     - Wrench test known or suspected fittings and check with Swagelok measurement tool.
       - Begin the test again from step 3
8. Open the MFC Outlet Valve, and then open the four Vaporizer Outlet valves. Then close the cryogenic root valve and allow all pressure to bleed off and for the temperature to return to ambient
9. Once any ice that was formed during the cryogenic leak test has melted way, dry all affected portions of the MIV1 and VJT.
10. Properly insulate the inlet manifold and tubing, as well as the VJT ends and the probe / cryogenic root valve.
11. Continue Commissioning / Startup procedures.

Open valve to start LNG flow

- **Record the time** – all parameters are measured from start of LNG flow, and should be stable after 45 minutes.
  - **Note:** The Bypass Mass Flow Controller requires 45 minutes to thermally stabilize
- Check Inlet Temperature and verify the temperature is falling
  - Inlet Temperature should be approaching cryogenic levels within 15 minutes and should be stable by 30 minutes
    - Shut-Down and fix leaks if any connections are leaking

MIV1® Commissioning Procedure

4 Normal Readings during Commissioning

- Readings will fluctuate initially, but typically stabilize within 45 minutes of start up

4.1 Vaporizer Temperatures

- Vaporizer temperatures may vary when LNG is introduced.
  - Consult **Appendix A - Troubleshooting** section if vaporizer temps exceed 160°F (71°C)
  - Consult **Appendix A - Troubleshooting** if vaporizer temps fluctuate more than +/- 1°F (+/-.6 °C) after 45 minutes and LNG Inlet temp is stable

4.2 MHR Temperature

- MHR Temperature will stabilize at 120°F (49°C) within 15 minutes.
- Consult **Appendix A - Troubleshooting if**
  - MHR temperature fails to reach 120°F (49°C)
  - MHR temp exceeds 130°F (54°C)
  - MHR temp fluctuates more than +/- 1°F (+/-.6°C) 45 minutes after LNG is introduced

4.3 LNG Inlet Temperature

- Inlet temperature should decrease and approach cryogenic levels within 15 minutes of LNG flow
- Inlet Temperatures should be stable at cryogenic levels by 30 minutes
- Consult **Appendix A - Troubleshooting** if Inlet Temperature fails to decrease to cryogenic levels

4.4 Bypass Mass Flow Controller

- Bypass Flow pressure readings should stabilize at 45 minutes.
  - Initially there may be no Bypass reading after LNG flow starts as no vapor is reaching the Bypass Mass Flow Controller
  - Bypass Mass Flow Controller readings should be approaching set point within 30 minutes
  - Consult Appendix A - Troubleshooting section if Bypass readings are not stabilized 45 minutes after admitting LNG

NOTICE

Bypass Mass Flow Controller is responsible for discharging 100% of the vapor flow until the MHR is adjusted after all parameters have stabilized at their set points. This prevents poorly conditioned vapor samples from reaching the analyzer.

5 MHR Pressure Optimization

WARNING

An analyzer must be connected to the MHR's output line before opening or adjusting the MHR's pressure valve!

- Adjust the MHR pressure valve once all MIV1 settings are stable – typically 45 minutes after start of LNG flow
- The MHR's target pressure setting is dependent on the analyzer's requirement
- Find the analyzer manufacturer's recommended pressure settings
- Optimization Procedure
  - Ensure VJT Inlet Temperature is at appropriate cryogenic levels. If Temp is too high;
    - Raise Bypass Mass Flow Controller setting
    - Otherwise consult **Appendix A – Troubleshooting**
  - Adjust the MHR's pressure setting to the Analyzer manufacturer's recommended setting

6 Re-Start Procedure when Commissioning Incomplete

Same as Commissioning Procedure

MIV1® Normal Shutdown & Start-Up Procedures

NOTICE

MIV1 is designed to run 24/7. Routine Shutdown and Restarting is not encouraged

Normal Shut Down Procedure

- Close LNG Feed Valve – Lock Out / Tag Out as required
- Leave Electrical power "On" to the unit

WARNING

If shut down is done for maintenance purposes or long term deactivation, de-energize the electrical feed and lock out / tag out

- Once system pressure has bled down to zero, manually close the MHR®

Normal Start-Up Procedure

Cautions, Warnings and Prohibitions

- Do Not Exceed System Pressure or Temperature Ratings
  - System Pressure – variable, dependent on solenoid installed in the unit.
  - Vaporizer Heater Temperature over 160°F (71°C) for a warm start
- Trapped Pressure Warning – Explosion Hazard
- Exceeding Temperature Limits can damage unit
- Explosion proof enclosures and Cabinet Door Must Be Closed and Secured During Operations
- Obey Warning Labels on unit

Start-Up Procedure

- **Pre-Start Activities**
  - Electrical Power
    - If electrical power to MIV1 is already "On"
      - Check valve positions inside MIV1 cabinet.
      - Skip to "Electrical Power" (next step)
    - If electrical power to MIV1 is "OFF", also check;
      - MIV1 for possible equipment issues
      - Surrounding area for environmental hazards

WARNING

Ensure explosion proof enclosures and the MIV1 cabinet door are closed and secured

- **Electrical Power**
  - If electrical power is already "On" and the control room readings are normal then skip to LNG Supply
  - Restore electrical power if it is not already "On"
    - Monitor Temperature rise in Vaporizer Heaters and MHR for 15 minutes
    - If temperature readings are approaching normal settings after 15 minutes proceed to LNG Supply

WARNING

Shut down if communications issues exist to control room, or if an electrical component fails

If temperatures fail to reach proper temperatures within 15 minutes then go to **Appendix A – Troubleshooting**

- **LNG Supply**
  - Note the time that LNG supply is opened to the MIV1 as proper start-up performance is based on time intervals after starting LNG flow
  - Monitor Inlet Temperature to ensure temperature is dropping into cryogenic levels
  - Inlet Temperature should approach cryogenic levels within 15 minutes and given a stable supply of LNG the Inlet Temperature should be stable by 30 minutes
  - If the LNG Inlet Temperature fails to achieve cryogenic levels within 30 minutes consult **Appendix A - Troubleshooting**
- **Bypass Mass Flow Controller**
  - Monitor Bypass Mass Flow Controller readings
    - Initially there may be no Bypass reading after LNG flow starts as no vapor is reaching the Bypass Mass Flow Controller
    - Bypass Mass Flow Controller readings should be approaching set point within 30 minutes
    - Consult Appendix A - Troubleshooting section if Bypass readings are not stabilized 45 minutes after admitting LNG
- **Optimizing MHR Pressure to the Analyzer**
  - Open the MHR valve once all MIV1 settings are stable – typically 45 minutes after start of LNG flow
  - The MHR's target pressure setting is dependent on the analyzer's requirement
    - Find the analyzer manufacturer's recommended pressure settings
  - Optimization Procedure
    - Ensure VJT Inlet Temperature is at appropriate cryogenic levels. If Temp is too high;
    - Raise Bypass Mass Flow Controller setting
    - Otherwise consult **Appendix A – Troubleshooting**

MIV1® Normal Operations

- Adjust the MHR's pressure setting to the Analyzer manufacturer's recommended setting

Cautions, Warnings & Prohibitions

- Only trained, qualified personnel should operate the unit, or make adjustments to it.
- Trapped Pressure – Explosion Hazard
- Exceeding Temperature Limits can damage unit
- Explosion proof enclosures must be closed and secured during operations. MIV1 cabinet door must be closed during operations
- Obey Warning Labels on unit

Conditions Requiring Immediate Shut Down

- Leaks
- Temperature Deviations – note: individual heaters can be shut off separately. Unit capable of function ing on only two heaters
- Loss of communication with the MIV1, or electrical failure

Systems Monitored

- LNG inlet temperature – should be stable at cryogenic levels
- Vaporizer temperatures – 120°F 49°C), or operator set temperature
- Cabinet Temperature – 120°F 49°C), or operator set temperature
- Bypass Mass Flow rate – Readings should be stable
- MHR temperature and pressure fluctuations from set values – readings should be stable

WARNING

Consult Appendix A – Troubleshooting if operation produces abnormal or unexpected readings

System Performance

- Minimum Pressure - 20 psi (differential is lower limit of Bypass calibration)
- Maximum Pressure - Determined by the solenoid installed in the unit. Solenoid selection is determined by the customer's expected pressures.
- Caution – User is responsible for ensure the unit's pressure limitations are not exceeded.
- Operator should monitor unit for abnormal readings and take remedial action promptly.

NOTICE

If heater temps continue to fluctuate more than +/- 1°F (+/-.6°C)after 45 minutes after start-up - contact the factory for calibration

NOTICE

If a vaporizer heater fails that vaporizer's temperature will start falling. The vaporizer's manual shut-off valve should be closed. This will remove the affected vaporizer from the system and operations may continue. The system enjoys significant redundancy with four individual vaporizers. Contact management to have the vaporizer repaired

NOTICE

Failure to valve off the affected vaporizer before the vaporizer Outlet Manifold's temperature falls to 50°F (10°C) will activate an automatic shutdown function which will close the LNG valve.

Customer Adjustable Settings

NOTICE

Refer to MIV1 Specifications Chart for Factory pre-sets

- Heater temperatures for all four vaporizer heaters and the MHR®(s) are set through the control software
- The Bypass Mass Flow Controller's flow rate may be adjusted in the control software
- The MHR's pressure setting is manually adjustable at the unit, controlling pressure to the analyzer, or optionally, to a mixer system

NOTICE

MHR pressure settings are dependent upon the analyzer's preferred pressure requirements

Automatic Shutdown Functions

Vaporizer Heater Failure

- Failed Vaporizer Heater(s)
  - If an individual vaporizer heater fails the control room should dispatch someone to manually close the outlet valve for that vaporizer.
    - Operations may continue as MIV1 will function normally on just two operational vaporizers
    - Temperature readings may be temporarily affected, depending on how much time has elapsed since shutdown
    - Log the vaporizer for repair

NOTICE

If failed vaporizer heater causes the gas temperature in the vaporizer outlet manifold to fall to 50°F (10°C) or below a solenoid will close a valve and shut off the flow of gas to the gas analyzer

- To restart operations;
  - Valve off the affected vaporizer's output valve with its manual valve
  - When the vaporizer outlet manifold gas temperature rises above 50°F (10°C) system function will automatically be restored
- **Continue Operations** - The system has significant redundancy so operations may continue with the loss of up to two (2) Vaporizers, though the issue needs to be reported and the system repaired as soon as possible
- Temperature readings may be temporarily affected, depending on how much time has elapsed since shutdown

Vaporizer Over-Temperature Condition

- Vaporizer Heater Over-Temperature
  - If an individual vaporizer's temperature reaches 180°F (82°C) the MIV1 system cuts power to that vaporizer.
  - System will restore power once the vaporizer's temperature falls to 160°F (71°C)
  - Complete current operations – even if the vaporizer continues to cycle between power shut-off and restart temperatures
  - Vaporizer Heater temperatures of 180°F (82°C) during normal operations indicates that the unit needs repair. Shut down unit for troubleshooting once current operations have completed

Long Term Storage Procedure

NOTICE

MIV1 is designed to run 24/7. Routine Shutdown and Restarting is not encouraged. Recommend shutting down LNG flow, shut off the MIV1 ball valve and leave power on to the MIV1.

To completely shut down the MIV1 Unit

- Shut down LNG Flow & Lock Out / Tag Out at probe
- Switch off MIV1's internal feed and de-energize power feed to MIV1. Lock Out / Tag Out
- Close the MHR and Bypass ball valve

MIV1 Maintenance and Repair

Typically MIV1 units require little in the way of maintenance, the only recommended annual maintenance item is to perform a System Functional Test – adjusting temperature and pressure settings to check the controls are working.

CAUTION

Mustang Sampling strongly recommends that repair and maintenance be performed by Mustang Sampling technicians

Contact the factory at +1 304 273 5357

Maintenance

Test System Controls

- Perform annually
- No special tools required
- Do not shut down MIV1 for this procedure
- Test – change system settings using the controls and verify the systems responded properly
- If system does not respond consult Troubleshooting Guide – Appendix A, and repair unit

Calibrate MIV1 Measurement Devices

- Perform annually – suggested procedure is to remove all MIV1 measurement devices and replace with calibrated devices to minimize MIV1 downtime. Removed devices can then be calibrated without further affecting operations.
- Special tools required for LNG Pressure Test – See Generic Component Replacement Procedure listed below in Repairs
- MIV1 must be shut down for this procedure
- Procedure – see Generic Component Replacement Procedure listed below in the Repairs section

MIV1® Maintenance & Repair

Item No.	Description
201054	Cryogenic RTD Assembly
16923	Thermocouple - Heater Enclosure
201107	Thermocouple - Heater Coils
201145	Thermocouple - Vaporizer Exit
25610	Accumulator Tank Pressure Gauge
6815	Pressure Gauge - Vaporizer Outlet
201108	Brooks Rotameter - Vaporizer Bypass
201109	Brooks Rotameter - Vaporizer Outlet
21974	Brooks Mass Flow Controller
6761	Relief Valve - Vaporizer Outlet

Repair

Generic Component Replacement Procedure

- Shut down MIV1® – **see Normal MIV1 Shut Down & Start Up Section**
- Wait for temperatures to drop to ambient and for system pressure to drop to zero
- Remove component and install replacement component
- All component junctions are either Swagelok fittings or NPT fittings
  - Swagelok fitting instructions – **see Appendix C**
- Start Up MIV1 – **see Commissioning Procedure**
- Check pressure to GC, adjust if necessary

MIV1 Spare Parts List

(Contact the factory at +1 304 273 5357 for spare parts list)

Mustang® Intelligent Vaporizer Sampling System - Model 1 Spare Parts

Stock Number	Qty	Description
5595	1	Thermostat
14521	1	Intertec CP Varitherm Heater
200249	1	MHR® Repair Assembly
201054	1	Cryogenic RTD Assembly
201058	1	RTD Transmitter
201051	4	WATLOW® CARTRIDGE HEATER
14543	4	Thermal Cut Off Switch
16923	1	Thermocouple
201107	4	Thermocouple
200922	1	Bursting Disc and Holder
21974	1	Brooks Mass Flow Controller
200278	1	Allen-Bradley® PLC
200343	1	Memory Plug in module
200855	1	4 Analog input Plug in module
200344	1	Isolated RS232/485 Plug in module
201007	1	Universal Analog Inputs Expansion Module
201008	1	8 Channel Analog Outputs Expansion Module
200454	1	PLC End Termination Cap
201052	6	Crydom Proportional SSR
201053	8	ETA Thermal Magnetic Breaker 5 amp
201157	1	485 Surge Suppressor
201156	1	Ethernet Surge Suppressor
201056	1	Pressure Transmitter
201145	1	Thermocouple (Outlet Temp)
6761	1	Relief Valve

Appendix

Appendix A – TROUBLESHOOTING GUIDE

Issue	Component	Condition	Action
Temp	Vaporizer	Temp greater than 170°F (77°C)	If during start-up, shut unit down and restart 20 – 30 minutes later. If problem persists contact factory
		Temp reaches 180°F (82°C)	At 180°F (82°C) an automatic shutdown will occur. Note: The system will restart automatically when the heater temps fall to 160°F (71°C). If vaporizer temps cycle several times the unit needs repair - it is safe to complete current operation, but afterwards shut down and contact factory
		Temps fluctuate more than +/- 1°F (+/- .6°C) after 45 minutes	LNG supply is not stable (Pressure and/or flow fluctation).
		A single vaporizer temp reads ± 5°F (2.7°C) from set point	Shut down, troubleshoot heater and fix
		All vaporizer temperatures vary greater than ± 1°F (+/- .6°C)from set point	Indicates an LNG supply problem. Shut down, troubleshoot and fix. Check probe position. Check VJT for proper insulation - frost on VJT jacket indicates loss of vacuum, frost on VJT ends, either supply or MIV1 inlet indicates poor insulation. (poor power quality?) Contact factory
	MHR®	MHR temperature fails to reach 120°F (77°C), or customer setpoint	Contact Factory
		MHR temperature exceeds 130°F (54°C), or customer setpoint plus 10°F (5.5°C)	Contact Factory
		MHR temp fluctuates more than +/- 1°F (+/- .6°C) 45 minutes after LNG is introduced	Verify stable pressure and flow upstream & downstream
	LNG Inlet Temperature	Temp does not approach cryogenic levels within 15 minutes after LNG started	Vacuum Jacketed Tubing may not be insulating as it should
			Insufficient LNG in pipe – poor flow
			Poor probe positioning
		Temp does not reach cryogenic levels within 30 minutes after LNG flow started	Raise the Bypass Mass Flow Controller's reading from the preset 28 liters/minute. The Bypass Mass Flow Controller may be choking the LNG flow
			Vacuum Jacketed Tubing may not be insulating as it should
			Insufficient LNG in pipe – poor flow
			Poor probe positioning
Flow	Bypass Mass Flow Controller	Bypass flow rate dropping to zero	Excessive pressure in BOG Header or disposal system closing the Bypass Mass Flow Controller backflow check valve
		Reading fluctuating after 45 minutes	Flow readings may fluctuate with changes in pressure and flow both upstream and downstream. Bypass readings should catch up and restabilize. Contact factory if readings constantly shift.
	Gas Analyzer	Gas Analyzer flow intermittently insufficient	MIV1 Pressure Relief Valve may be opening and closing. Source of pressure variations need to be found and corrected. Contact Factory
		Gas Analyzer flow insufficient, may be accompanied by dropping Bypass flow rates	Accumulator Tank Burst Disc may have released. Valve off LNG flow, wait for system pressure to release. Contact Factory for repair
Pressure	Accumulator Tank	Pressure reading fluctuating after 45 minutes	Accumulator tank pressure is dependent wholly on system pressure. Verify tank inlet pressures are stable, changes anywhere upstream can affect tank pressures
		Pressure readings drop very low, and GC is not getting sufficient gas flow	Accumulator Tank Burst Disc may have released. Valve off LNG flow, wait for system pressure to release. Contact Factory for repair
	MHR	Fluctuating Reading	Verify stable pressure and flow upstream & downstream

Appendix

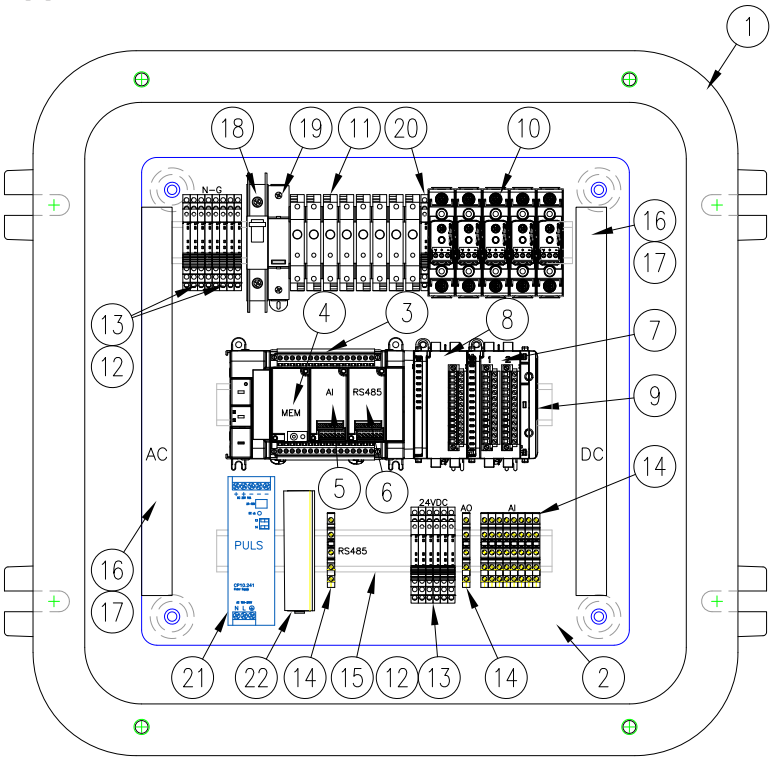
Appendix B – MODBUS Register

Variable Name	Data Type	Address	Read/Write	Comment
CRYO_SV_State	Boolean	000005	R	ON/Off
Enable_HTR1_CRYO	Boolean	000011	R/W	If active, controls the state of the Cryo valve
Enable_HTR2_CRYO	Boolean	000012	R/W	If active, controls the state of the Cryo valve
Enable_HTR3_CRYO	Boolean	000013	R/W	If active, controls the state of the Cryo valve
Enable_HTR4_CRYO	Boolean	000014	R/W	If active, controls the state of the Cryo valve
PLC Fault	Boolean	000020	R	Major Fault - PLC Halted
HTR1_High_Temp_Alarm	Boolean	000021	R	Heater1 has exceeded the upper limit
HTR1_Low_Temp_Alarm	Boolean	000022	R	Heater1 <= Cryo-valve setpoint
HTR1_TC_Alarm	Boolean	000023	R	Heater1 Thermocouple Alarm
HTR2_High_Temp_Alarm	Boolean	000024	R	Heater2 has exceeded the upper limit
HTR2_Low_Temp_Alarm	Boolean	000025	R	Heater2 <= Cryo-valve setpoint
HTR2_TC_Alarm	Boolean	000026	R	Heater2 Thermocouple Alarm
HTR3_High_Temp_Alarm	Boolean	000027	R	Heater3 has exceeded the upper limit
HTR3_Low_Temp_Alarm	Boolean	000028	R	Heater3 <= Cryo-valve setpoint
HTR3_TC_Alarm	Boolean	000029	R	Heater3 Thermocouple Alarm
HTR4_High_Temp_Alarm	Boolean	000030	R	Heater4 has exceeded the upper limit
HTR4_Low_Temp_Alarm	Boolean	000031	R	Heater4 <= Cryo-valve setpoint
HTR4_TC_Alarm	Boolean	000032	R	Heater4 Thermal Couple Alarm
MHR1_High_Temp_Alarm	Boolean	000033	R	MHR has exceeded the upper limit
MHR1_TC_Alarm	Boolean	000034	R	MHR Thermocouple Alarm
MHR2_High_Temp_Alarm	Boolean	000035	R	MHR has exceeded the upper limit
MHR2_TC_Alarm	Boolean	000036	R	MHR Thermocouple Alarm
MFC_No_Flow_Alarm	Boolean	000037	R	MFC Flow = 0
PRESSURE_ALARM	Boolean	000038	R	Accumulator Pressure Alarm
SetPoint_MFC	UINT	400001	R/W	SetPoint Value for the MFC
SetPoint_MHR1	UINT	400002	R/W	SetPoint Value for the MHR
SetPoint_MHR2	UINT	400003	R/W	SetPoint Value for the MHR
SetPoint_HTR1	UINT	400004	R/W	SetPoint Value for HTR1
SetPoint_HTR2	UINT	400005	R/W	SetPoint Value for HTR2
SetPoint_HTR3	UINT	400006	R/W	SetPoint Value for HTR3
SetPoint_HTR4	UINT	400007	R/W	SetPoint Value for HTR4
SetPoint_SV	UINT	400008	R/W	SetPoint Value for Cryo SV Control
SetPoint_HTR_High_Limit	UINT	400009	R/W	Heater control shuts off
SetPoint_HTR_Low_Limit	UINT	400010	R/W	Heater control turns back on
SetPoint_Pressure_Alarm	UINT	400011	R/W	SetPoint Value for the Pressure Alarm
Process_MFC	INT	400012	R	Current MFC Value
Process_MHR1	INT	400013	R	Current MHR Value
Process_MHR2	INT	400014	R	Current MHR Value
Process_HTR1	INT	400015	R	Current HTR1 Value
Process_HTR2	INT	400016	R	Current HTR2 Value

Process_HTR3	INT	400017	R	Current HTR3 Value
Process_HTR4	INT	400018	R	Current HTR4 Value
Process_Oven_Temp	INT	400019	R	Current Oven Tempemp Temperature
Process_LNG_In	INT	400020	R	Current LNG In Temperature
Process_Pressure	INT	400021	R	Current Pressure Value
Process_Stream_Temp	INT	400022	R	Stream Temp after the Vaporizer
MHR1_Temp AO	INT	400023	R	Current MHR AO Value
MHR2_Temp AO	INT	400024	R	Current MHR AO Value
HTR1_Temp AO	INT	400025	R	Current HTR1 AO Value
HTR2_Temp AO	INT	400026	R	Current HTR2 AO Value
HTR3_Temp AO	INT	400027	R	Current HTR3 AO Value
HTR4_Temp AO	INT	400028	R	Current HTR4 AO Value
Cold Junction	INT	400029	R	Current Cold Junction Value
REV_Year	UINT	400600	R	Revision Year
REV_Month	UINT	400601	R	Revision Month
REV_Day	UINT	400602	R	Revision Day

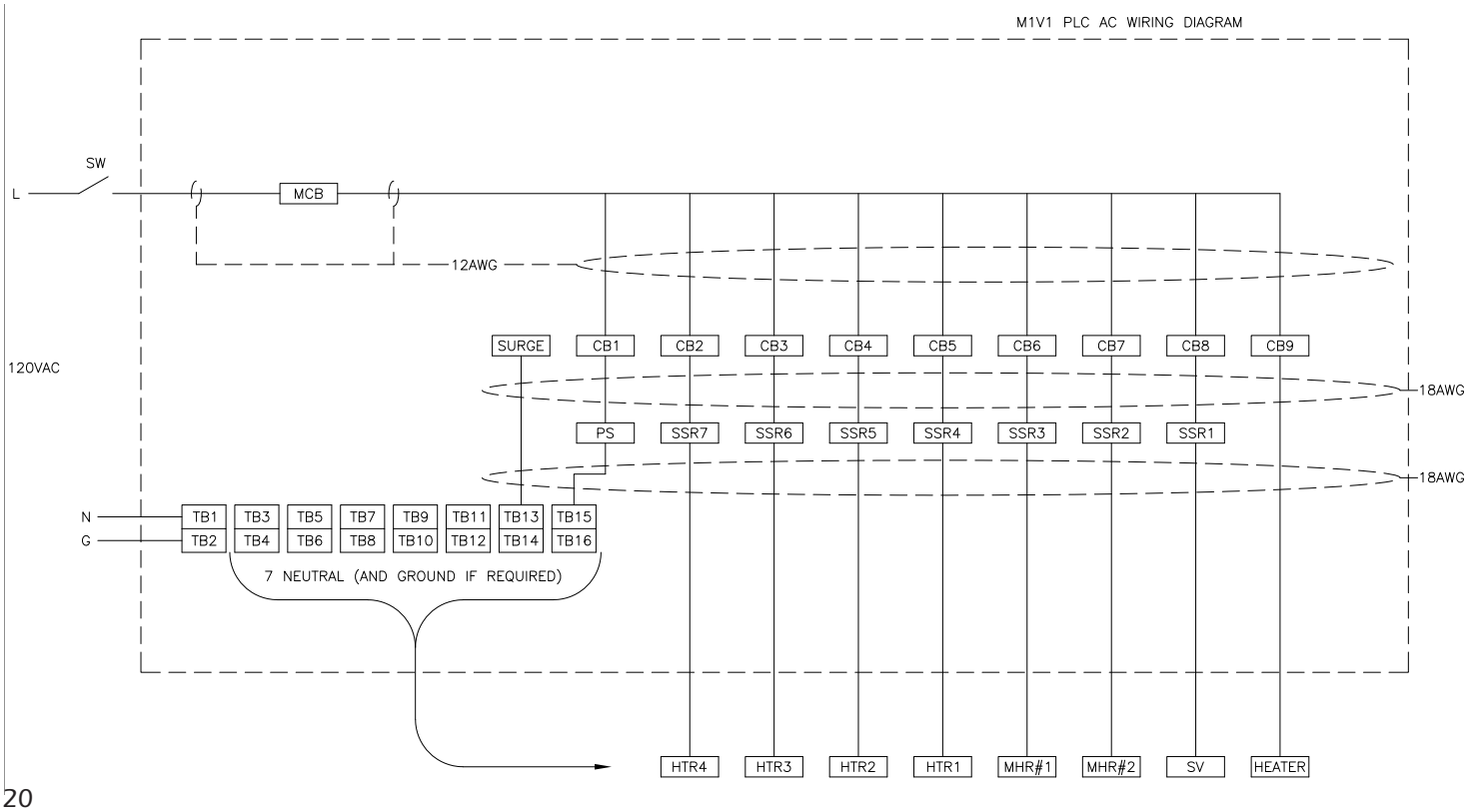
Appendix

Appendix C – PLC ASSEMBLY

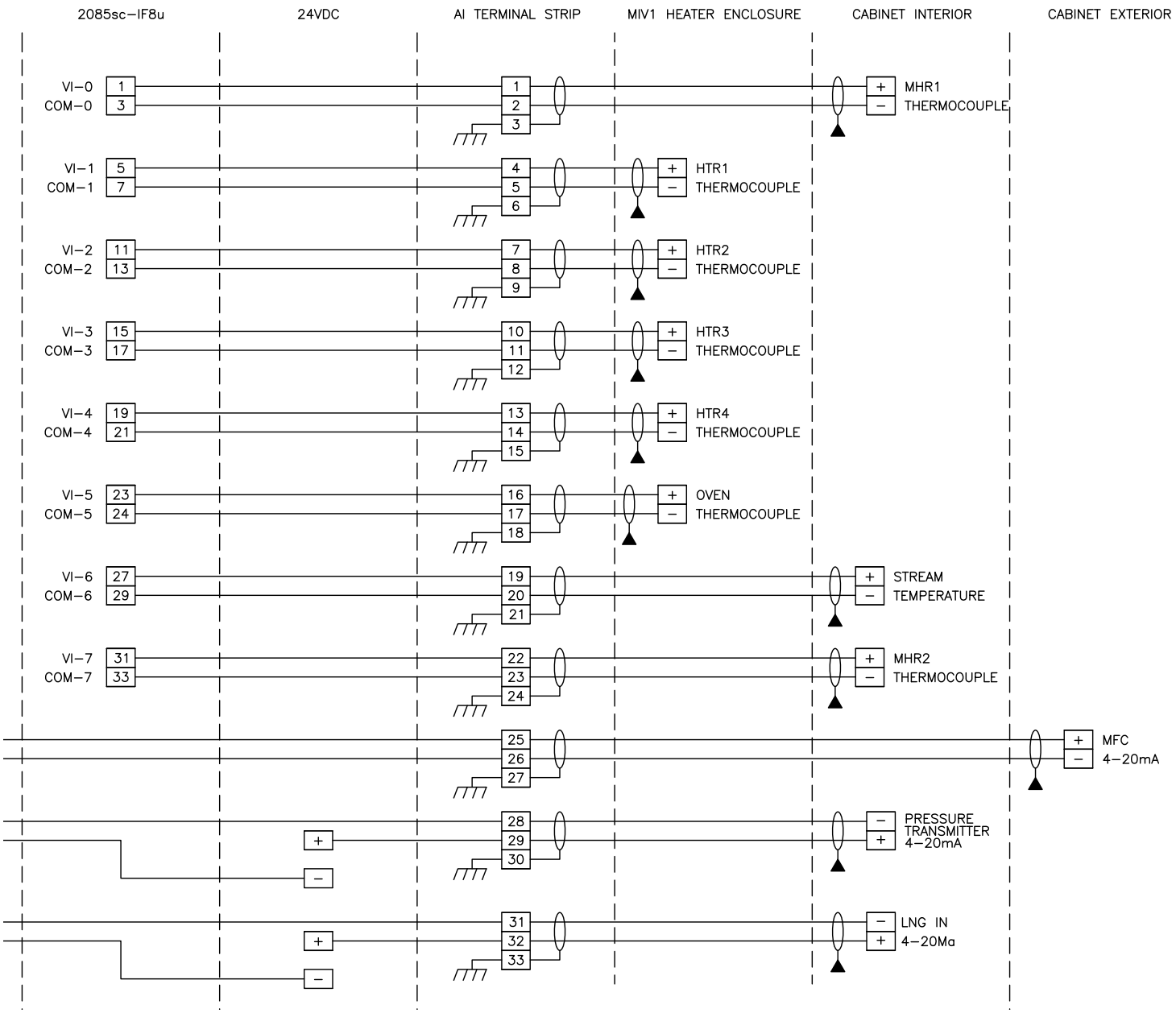


BILL OF MATERIALS				
ITEM	QTY	UOM	DESCRIPTION	ITEM CODE
1	1	EA.	Exd Enclosure with Gasket, Hinge, No rust Bolts	201040
2	1	EA.	16"x16" Aluminum Mounting Panel	201041
3	1	EA.	Allen Bradley PLC 2080–LC50–24QBB	200278
4	1	EA.	Memory Plug in Module 2080–MEMBAK	200343
5	1	EA.	4 Analog Input Plug in Module 2080–IF4	200855
6	1	EA.	Isolated RS232/485 Plug in Module 2080–SERIALISOL	200344
7	1	EA.	Universal Analog Inputs Expansion Module 20855C–IF8u	201007
8	1	EA.	8 Channel Analog Outputs Expansion module 20855C–OF8	201008
9	1	EA.	PLC End Termination Cap 2085–ECR	200454
10	5	EA.	Crydom PMP2425W	201052
11	8	EA.	ETA Thermal Magnetic Breaker 5 amp ETA–201–5	201053
12	14	EA.	Two Tier Feed Through Terminals for AC/DC	5144
13	4	EA.	Bridge FUW Single Terminals 4 Pole	5143
14	10	EA.	Phoenix Contact (AI/AO) DOKD 1.5–TG–.011054 2 Tier w/gnd	14598
15	24	IN	Din Rail	7490
16	54	IN	1"x2" Panduit	14847
17	54	IN	Panduit Cover	845
18	1	EA.	20a CIRCUIT BREAKER 4230–T1–1–0–KO–C–U–20	
19	1	EA.	Surge Protector MERSON SP180U	1557
20	13	EA.	Relay Socket, 2A, W/Solid State Relay DRA–CN240A24	
21	1	EA.	pulse 120VAC to 24VDC Power Supply 10a	--
22	1	EA.	Phoenix Contact DT–LAN–CAT.6+ Ethernet Surge Protector (1"x4")	

Appendix D – ALTERNATING CURRENT

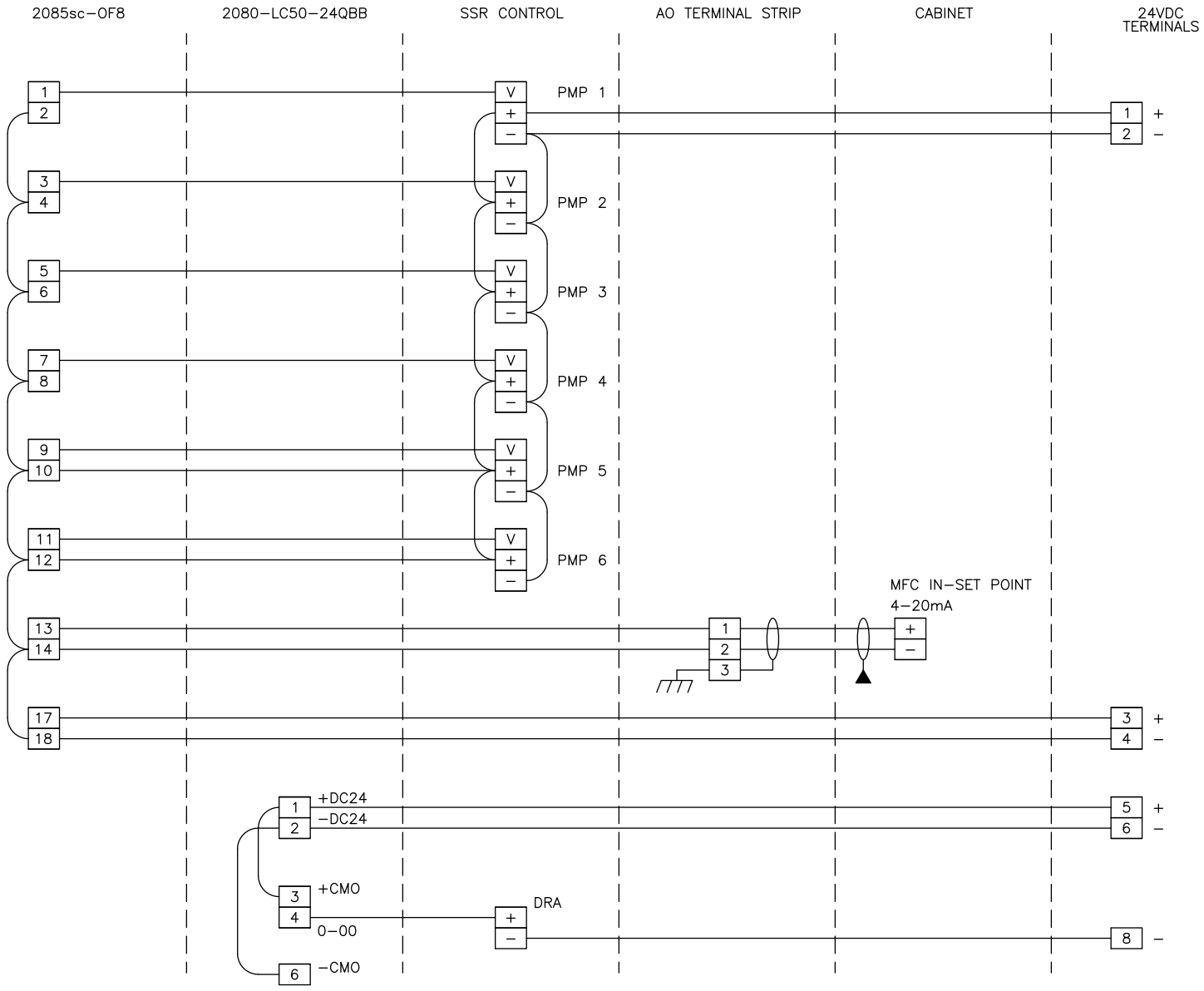


Appendix E – ANALOG INPUT WIRING



Appendix

Appendix F – ANALOG OUTPUT/DIGITAL OUTPUT WIRING



Appendix G – Swaglock

Swagelok® Fittings Guidelines (from Swagelok Website)

Installation Instructions

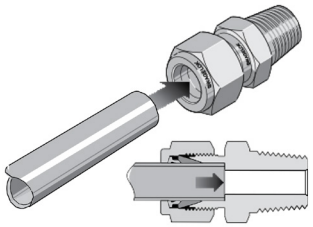
Swagelok tube fittings 1 in ./25 mm and smaller can be installed quickly, easily, and reliably with simple hand tools.

Safety Precautions

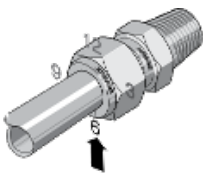
- Do not mix products from different manufacturers – product performance may be compromised.
- Do not bleed system by loosening fitting nut or fitting plug.
- Do not assemble and tighten fittings when system is pressurized.
- Make sure that the tubing rests firmly on the shoulder of the tube fitting body before tightening the nut.
- Use the correct Swagelok gap inspection gauge to ensure sufficient pull-up upon initial installation.
- Always use proper thread sealants on tapered pipe threads.
- Do not mix materials or fitting components from various manufacturers—tubing, ferrules, nuts, and fitting bodies.
- Never turn fitting body. Instead, hold fitting body and turn nut.
- Avoid unnecessary disassembly of unused fittings.
- Use only long reducers in female Swagelok end connections.

Swagelok Tube Fittings (Up to 1 in./25 mm)

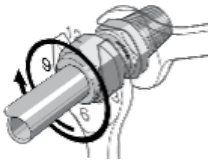
These instructions apply both to traditional fittings and to fittings with the advanced back-ferrule geometry.



- Fully insert the tube into the fitting and against the shoulder; rotate the nut finger-tight.
- **High-pressure applications and high safety-factor systems:** Further tighten the nut until the tube will not turn by hand or move axially in the fitting.
- Mark the nut at the 6 o'clock position.



- While holding the fitting body steady, tighten the nut one and one- quarter turns to the 9 o'clock position.



NOTICE

Check that the fitting is properly tightened using the Swagelok Gap Inspection Gauge. Select the appropriate size and insert between the fitting and the nut. If it will not fit into the gap the fitting has not been sufficiently tightened

Reassembly

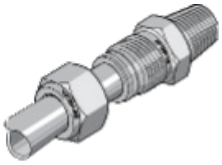
NOTICE

You may disassemble and reassemble Swagelok tube fittings many times.

NOTICE

Always depressurize the system before disassembling a Swagelok tube fitting.

- Prior to disassembly, mark the tube at the back of the nut; mark a line along the nut and fitting body flats.
- Use these marks to ensure that you return the nut to the previously pulled-up position



- Insert the tube with preswaged ferrules into the fitting until the front ferrule seats against the fitting body .
- While holding the fitting body steady, rotate the nut with a wrench to the previously pulled-up position, as indicated by the marks on the tube and flats. At this point, you will feel a significant increase in resistance. Tighten the nut slightly.

NOTICE

Do not use the Swagelok gap inspection gauge with reassembled fittings

Analytically Accurate®
TECHNOLOGY

About Mustang Sampling

Mustang Sampling, LLC is the innovator of Analytically Accurate® solutions within sample conditioning systems. We provide custom solutions of products and services globally to the Natural Gas, Natural Gas Liquids (NGL), Renewable Natural Gas (RNG), Liquefied Natural Gas (LNG) industries including Hydrogen Blending and Carbon Sequestration. Mustang Sampling continues to pioneer integrated control systems, allowing our customers to maintain phase stability from sample extraction at the source through sample analysis. Our products are continuously improved and subjected to the highest quality standards which provides our customers with the best sample conditioning solutions.

About Valtronics Solutions

Valtronics Solutions is a diverse manufacturing and services company within the natural gas, liquefied natural gas, natural gas liquids, petroleum and chemical industries. We provide skids including gas measurement and control systems, monitoring equipment, automation, cabinets and complete analyzer buildings. Our service technicians are fully trained in equipment diagnostics and troubleshooting are capable of rebuilding valves in the field. With over 250 years of skilled experience, our company is dedicated to exceeding customer expectations when fulfilling their needs. Our dedicated staff has driven sustained growth with thousands of customers depending on Valtronics' products and services globally.

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