

SVI™ 3 Digital Positioner Advanced Performance

Instruction Manual (Rev. E)



About this Guide

This instruction manual applies to the following instruments and approved software:

- SVI3
 - with Firmware version 1.1.1 or higher.
 - with **ValVue™ software** version 3.6 or greater
 - with SVI3 DTM Version 3.10 or Higher
 - with SVI3 DD File 0101 or Higher

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Document Changes

Version / Date	Changes
- / 03-2021	Original Release.
A / 03-2021	Added Online Valve Diagnostics Section. Added Russia and China Regional Contents. Added Handling and Disposal Section.
B / 04-2021	Added Vibration Influence Value.
C / 04-2021	Updated Explosion proof marking from EEx d to Ex d.
D / 01-2023	Model Numbering Chart removed. Stainless Steel housing option and spare parts kits added for Marine applications.
E / 11-2023	Added Section 7.9 : SIL Capability and Safety Function Instructions

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1. Safety Information and Documentation Standards

This section provides safety information including safety symbols that are used on the SVI3 and the safety symbol definition.



Read this entire section before installation and operation.

1.1 Safety Symbols

SVI3 instructions contain WARNINGS, CAUTIONS and Notes, where necessary, to alert you to safety related or other important information. Total compliance with all WARNING, and CAUTION notices is required for safe operation.



Indicates a potentially hazardous situation which, if not avoided, could result in serious injury.



Indicates a potentially hazardous situation, which if not avoided could result in property damage or data loss.

Note: *Indicates important facts and conditions.*

1.2 SVI3 Product Safety

Refer to Product Safety manual ES817 for detailed safety instructions. The SVI3 digital valve positioner is intended for use with industrial compressed air or natural gas systems only (see “Installing an SVI3 in a Natural Gas Environment” on page 35).

Ensure that an adequate pressure relief provision is installed when the application of system supply pressure could cause peripheral equipment to malfunction. Installation must be in accordance with local and national compressed air and instrumentation codes.

General installation, maintenance or replacement

- Products must be installed in compliance with all local and national codes and standards by qualified personnel using safe site work practices. Personal Protective Equipment (PPE) must be used per safe site work practices.
- Ensure proper use of fall protection when working at heights, per safe site work practices. Use appropriate safety equipment and practices to prevent the dropping of tools or equipment during installation.
- Under normal operation, compressed supply gas is vented from the SVI3 to the surrounding area, and may require additional precautions or specialized installations.
- Installation and maintenance must be performed only by qualified personnel. SVI3 repairs are beyond the scope of this manual and must be performed by a MARC (Masoneilan Authorized Repair Center).
- Approved wire seals against ingress of water and dust are required and the 1/2" NPT fittings must be sealed with tape or pipe sealant in order to meet the highest level of ingress protection. Ensure that dust levels are accounted for during installation.
- Wiring and conduit must conform to all local and national codes governing the installation. Wiring must be rated for at least 85° C (185° F) or 5° C (41° F) above max ambient, whichever is greater.
- Area Classification, Protection Type, Temperature Class, Gas Group, and Ingress protection must conform to the data indicated on the label.
- There can be unexpected valve, actuator or positioner movement at any time during installation or operation.

Intrinsically Safe Installation

Products certified as explosion proof or flame proof equipment or for use in intrinsically safe installations MUST BE:

- Installed, put into service, used and maintained in compliance with national and local regulations and in accordance with the recommendations contained in the relevant standards concerning potentially explosive atmospheres.
- Used only in situations that comply with the certification conditions shown in this document and after verification of their compatibility with the zone of intended use and the permitted maximum ambient temperature.

- Installed, put into service and maintained by qualified and competent professionals who have undergone suitable training for instrumentation used in areas with potentially explosive atmospheres.



Before using these products with fluids/compressed gases other than air or for non-industrial applications, consult the factory. This product is not intended for use in life support systems.

Under certain operating conditions, the use of damaged instruments could cause a degradation of the performance of the system, which can lead to personal injury or death.

Installation in poorly ventilated confined areas, with any potential of gases other than oxygen being present, can lead to a risk of personnel asphyxiation.

Carefully unpack the equipment and check it is not damaged. In the case of any damage, notify the manufacturer.

Use only genuine replacement parts which are provided by the manufacturer, to guarantee that the products comply with the essential safety requirements of the European Directives.

Changes to specifications, structure, and components used may not lead to the revision of this manual unless such changes affect the function and performance of the product.

Refer to Product Safety manual ES817 for detailed safety instructions.



Failure to adhere to the requirements listed in this manual can cause loss of life and property.



Before installing, using, or carrying out any maintenance tasks associated with this instrument, READ THE INSTRUCTIONS CAREFULLY.

WARNING

To avoid injury or the process being affected when installing or replacing a positioner on a control valve,

- There can be unexpected valve, actuator or positioner movement at any time during installation or operation.
- If the valve is located in a hazardous area, ensure that the area has been certified as safe or that all electrical power to the area has been disconnected before removing any covers or disconnecting any leads.
- Shut off air supply to the actuator and to any valve mounted equipment.
- Ensure the valve is isolated from the process by either shutting off the process or using bypass valves for isolation. Tag shutoff or bypass valves to guard against turn-on while work is in process.
- Purge air from the actuator and ensure that the valve is in unenergized condition.

Note: The threaded end cover of the SVI3 is a critical component for safety in Hazardous Areas. To ensure safe operation and proper seal, fully engage the cover threads, within the housing, and cover flange area makes contact with the housing, the lock screw is backed out into the cover to prevent the cover from loosening.

WARNING

Isolate the valve from the process and disconnect air tubing from the positioner. Disconnect air fully to avoid injury or process damage.

WARNING

Do not exceed Maximum Actuator pressure or Maximum supply pressure (120 psi) whichever is lower. When the pressure limit is exceeded, damage to equipment or injury to personnel can occur.

CAUTION

Do not use pipe thread sealant tape on pneumatic fittings. It may shred into small particles that can cause instrument malfunction.

CAUTION

Remove any excess pipe thread sealant from the first and second threads to prevent uncured sealant from entering the air lines.

Note: The SVI3 Digital Valve Positioner is designed to operate with clean, dry, oil-free, instrument grade air to ANSI-ISA-57.3 1975 (R1981) or ISA-S7.3-1975 (R1981) or with a sweet natural gas supply.

Note: For small actuators it may be necessary to:

- Use 1/8" tubing for Autotune to work properly.
- Install tamper-proof adjustable needle valve in supply line to SVI; adjust valve closed enough so autotune runs. Then lock valve setting so it can't be tampered or changed.



There can be unexpected valve, actuator or positioner movement at any time during installation or operation.



Do not connect a HART® modem and PC to a control circuit unless the controller is HART compatible or has a HART® filter. Loss of control or a process upset may occur if the controller output circuit is not compatible with HART® signals.

Install in compliance with Hazardous Area rules in accordance with local electrical codes and plant standards using trained specialists. Do not connect a PC or HART® modem to an intrinsically safe circuit except on the safe area side of the barrier. Do not operate a PC in a hazardous area without ensuring compliance with local and plant regulations.



A control circuit must be HART® compatible or have a HART® filter installed. Contact the manufacturers of the controller or DCS. See "Controller outputs are separated internally from ground by a current sense resistor or a control transistor. Dual channel barriers apply excessive loop resistance and cause compliance voltage problems. An Intrinsically Safe galvanic isolator operates with all three types of output channels, isolated, grounded or separated from ground, and provides sufficient compliance voltage. The galvanic isolator must be certified by the manufacturer to be HART® compliant if the HART® connections are supported on the safe area side of the isolator. Consult barrier and isolator manufacturer for devices rated for use with the SVI3 I.S. entity parameters in Hazardous Area Approvals."

- *Comply with current national and local regulations for electrical installation work.*
- *Comply with national and local explosive atmosphere regulations.*
- *Before carrying out any work on the device, power off the instrument or make sure that the locale conditions for potentially explosive atmosphere permit the safe opening of the cover.*

CAUTION

Use of a low impedance voltage source damages the SVI3. The SVI3 input must be a current controlled source. The SVI3 will not function normally if connected directly to a voltage source. However, direct connection to a current source of up to 30 V will not damage the SVI3. A proper current source explicitly enables adjustment of the current in mA, not V.

Note: *When an SVI3 is turned on it is advisable to apply the air supply before applying the electrical input signal.*

1.3 About This Manual

The SVI3 Instruction Manual is intended to help experienced field personnel install, setup, and calibrate an SVI3 in an efficient manner. This manual also provides in-depth information on SVI3 software, digital interfaces, operation, intrinsic safety configurations, and specifications. If you experience problems that are not documented in this guide contact the factory or your local representative. Sales offices are listed on the back cover of this manual.

1.3.1 Conventions Used in This Manual

Conventions used in this manual are as follows:

- Uppercase, italicized letters are used when referencing a term used in the SVI3 display window. For example, when indicating the term mode, as in setup mode, and referring to the display/software operation the convention is to spell mode is all uppercase letters: *MODE*.
- Italics is used for emphasis on important items.
- Fields where data is entered or user-entered data is italicized.
- Actions performed on buttons, checkboxes, etc. appear bolded. For example: Click **Done**.

Note: *Indicates important facts and conditions.*



Indicates a potentially hazardous situation, which if not avoided could result in property or data damage.



Indicates a potentially hazardous situation, which if not avoided could result in serious injury.

1.4 Related Documentation for the SVI3 are available in Resource Center:

<https://valves.bakerhughes.com/resource-center>

- ValVue software documentation: The SVI3 DTM works inside various software (such as PACTware), however it is designed to work best with our ValVue3 software. See the Masoneilan ValVue3 Software Manual (Ref. 31426).
- Masoneilan SVI3 Quick Start Guide (Ref. 34605)
- Masoneilan SVI3 DTM Software Manual (Ref. 34569)

1.4.1 Masoneilan Help Contacts

- Email: svisupport@bakerhughes.com
- Phone: 888-SVI-LINE (888-784-5463)

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2. Introduction

2.1 Overview

The **Masoneilan™ SVI3** is a high performance, HART® based digital valve positioner that combines an optional local display with remote communication and diagnostic capabilities. The SVI3 options board offers and enables the unit to fulfill the broadest range of applications.

The optional pushbutton and LCD display enables local operations of calibration and configuration functions. Remote operations can be performed with ValVue software or any HART® Registered host interface that has been pre-loaded with the SVI3 Device Description file (DD).

The SVI3 DTM and ValVue3 Masoneilan's software facilitates control valve setup and diagnostics. This can be downloaded at

<https://valves.bakerhughes.com/resource-center>.

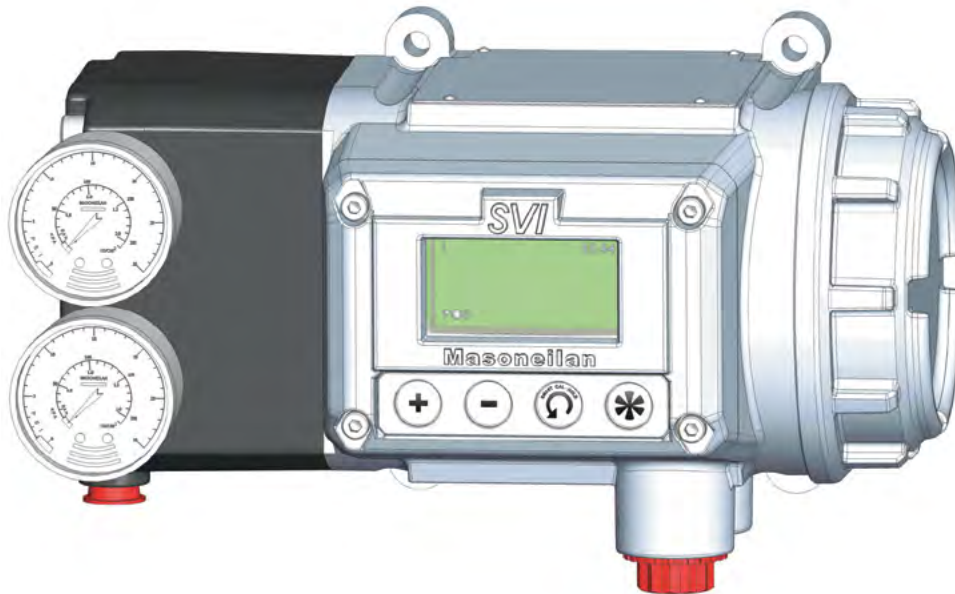


Figure 1 - SVI3 Positioner

2.2 SVI3 Features

The SVI3 Digital Valve Positioner (see Figure1) is suitable for installation indoors or outdoors, and in a corrosive industrial or marine environment and is equipped with the following features:

- Extreme Accuracy
- Extreme Digital Precision
- Valve Position Autotuning
- Local Operation/calibration/ configuration with Optional Flameproof Push Buttons and LCD Digital Display
- Non-contact Magnet Coupled (Hall Effect) Position Sensing for Rotary and Reciprocating Control Valves
- Uniform Hazardous Area Approvals for ATEX, IEC, USA and Canada with Other Approvals Available Upon Request
- Advanced Valve Diagnostics with ValVue Software
- Precise, Quick, Responsive Control of Valve Position
- Configurable High and Low Position Limits
- HART® 7
- Single Acting
- Remote Position Sensor with Options board
- Extreme Reliability
- Automated Valve Commissioning
- One Model for both Rotary or Reciprocating Valves
- Compatible with Air-to-Close or Air-to-Open Actuators
- Sealed Housing with No Moving Shafts, No Shaft Penetration, and Fully Potted Electronics
- Local, Online Diagnostic Condition Monitor: Total Stem Travel, Number of Valve Cycles, Predictive Maintenance Data
- Online Valve Diagnostic KPI's with 1 year of onboard data storage
- User-adjustable Response Times
- Split-range Capability
- Optimized Performance Regardless of Actuator Size
- User Configurable Tight Shutoff at Adjustable Input Signal
- HART® Remote Operation Calibration Configuration Diagnostics Using ValVue software or a HART® handheld communicator
- Stroke Characterization for Linear and Non Linear Response
- Two Contact Outputs User Linked to Various Status and Alarm Flags with Options board
- Optional Pushbutton Display
- Optional Exhaust Routing Manifold to capture all exhaust and vent gas for routing to safe location
- Robust, corrosion resistant 316SS or Aluminum housing

2.3 Physical and Operational Description

The SVI3 is housed in an industrial, tough, weatherproof, corrosion resistant housing that has been designed for operation in hazardous areas. Electrical connections are made through two 1/2" NPT conduit entries. Pneumatic connections are made through two 1/4" NPT ports.

2.3.1 Principle of Operation

The SVI3 is a smart electro-pneumatic positioner that:

1. Receives a 4 - 20 mA electrical position setpoint signal from the controller and compares the position setpoint input signal to the valve position feedback sensor.
2. Uses the difference between the position setpoint and position feedback is analyzed by the position control algorithm to set a servo signal for the I/P converter.
3. Processes the I/P output pressure and amplifies it by using a pneumatic relay that drives the actuator.
4. Assures the error between the setpoint and the valve position feedback is within range, no other correction is applied to the servo signal in order to maintain valve position.

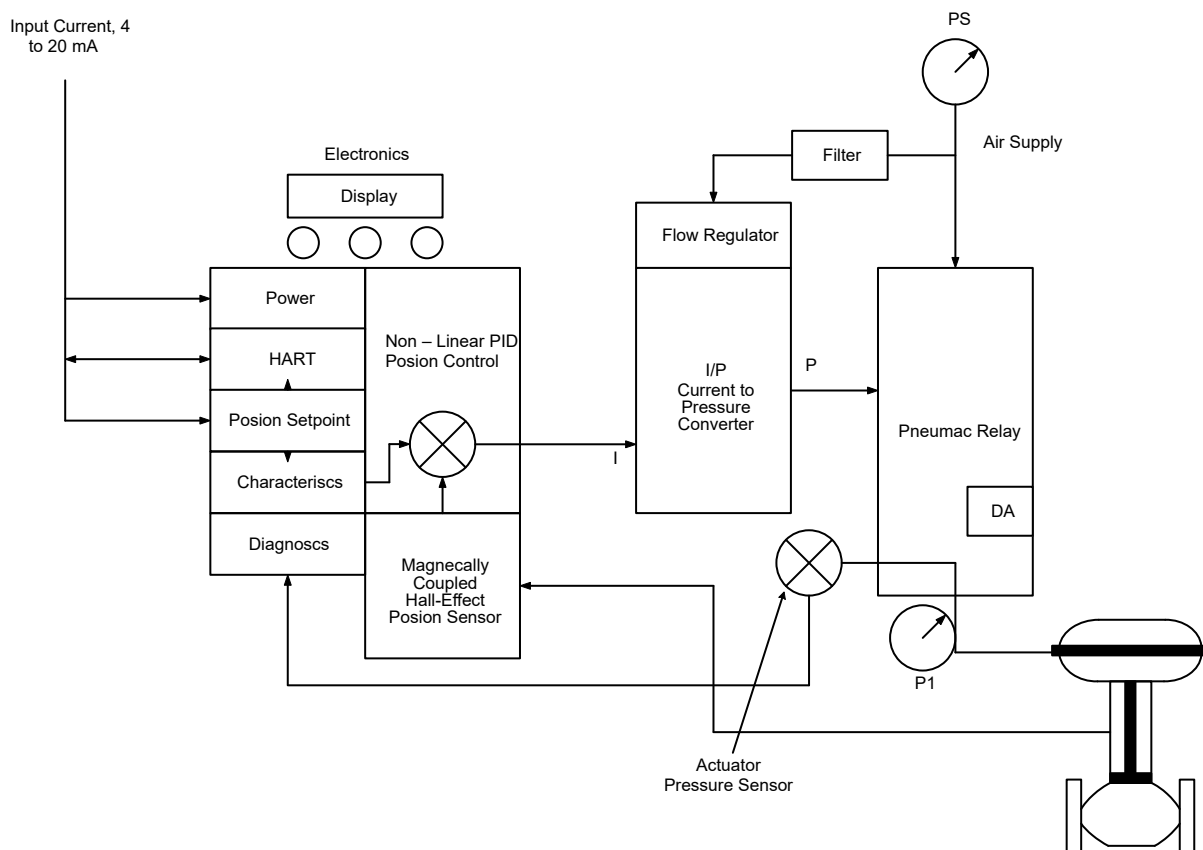


Figure 2 - Block Diagram with I/P Converter and Pressure Sensor

2.3.2 Main Electronics Module

The Main electronics module is the main controller for all the electronics functionality in the SVI3 unit. It performs the functions including HART Communications, actuator position control, valve diagnostics and power management. It also interfaces with external control system (PLC, DCS...). Main module also has Hall Position Sensor, A/D, D/A, Temperature sensor and HART Communication chip.

2.3.2.1 Magnetic Position Sensor

A Hall effect based position sensor uses magnetic field to measure the valve position through the housing wall. It senses the rotation of a magnetic assembly directly mounted on the end of a rotary valve shaft or by a turnbuckle and lever assembly connected to a reciprocating valve shaft.

The output of the Hall sensor provides the position feedback signal to the position control algorithm. The magnetic assembly is environmentally sealed and is entirely external to the electronics housing. This sensor has a maximum travel range of up to 140° rotation.

2.3.2.2 Temperature Sensor

A temperature sensor is located in the electronics module and measures temperature within the enclosure. This measurement is used to provide temperature compensation for the position and pressure sensors and other internal electronic components. The temperature sensor reading is used to provide warning of excessive ambient temperature at the positioner.

2.3.3 Pneumatic Module

The pneumatic module consists of I/P Converter, Pneumatic Relay and Pneumatic Electronics. The Pneumatic electronics board contains pressure sensors and mechanical component compensation circuitry. This module also acts as pass through for display module.

2.3.3.1 Pressure Sensor

There are four pressure sensors in the pneumatic electronics board. they are used for measurement of Ambient, Pilot, Supply and Actuator pressure.

2.3.3.2 Current-to-Pressure Converter, I/P

The I/P converts a current signal to a pressure signal in the following manner. A fixed coil creates a magnetic field proportional to the applied current. The field magnetically pulls a flexure towards a nozzle to increase pressure on the flexure. The pressure on the flexure increases in response to an increase in the coil current. Encapsulation of the coil provides protection from the environment.

2.3.3.3 Single Acting Pneumatic Relay

The single acting pneumatic relay amplifies the pressure from the I/P and increases airflow as required for stable, responsive, actuator performance. The single acting relay operates on any supply pressure that is at least 5 psi (.345 bar, 34.5 kPa) above the required actuator pressure, up to 120 psi (8.3 bar, 830 kPa).

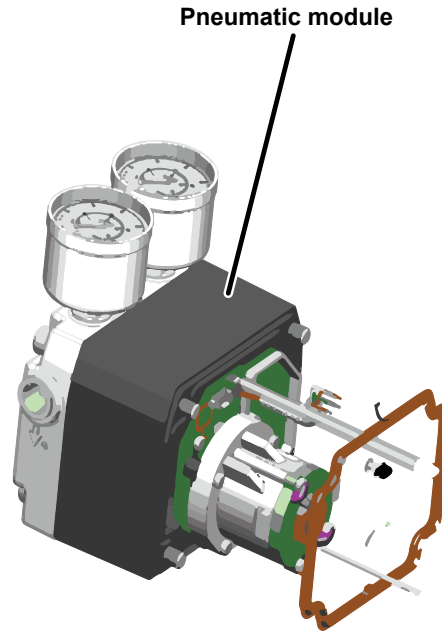


Figure 3 - SVI3 Pneumatic Module with Single Acting Relay

2.3.4 Optional Display Module with Pushbuttons

The optional display and buttons are mounted on the SVI3 cover plate. The four pushbutton switches operating in conjunction with the display permit reading and modification of the instrument operating parameters without a PC or HART® hand-held communicator. These switches perform generic functions - Increase, Decrease, Accept and Smart Cal/Back by movement through a conventional menu structure, See “Using the Digital Interfaces” on page 51. The Switches are operable as indicated on the product label, including when intrinsically safe and flameproof protection concepts are required.

2.3.5 Options Module

Options module is an electronics add-on which extends the positioner functionality. It includes solid state relay based switches, Digital input, 4-20 mA position retransmit, 1-5V process variable input and remote position input. This module has all the required wiring terminations for I/Os and can be field installed if purchased separately.

2.4 ValVue Software

Valvue provides the ability to quickly setup SVI3, monitor operations and diagnose problem.

Note: You must use the ValVue3 software and the SVI3 DTM software to support HART®7. ValVue 2.x will not work.

2.4.1 ValVue and SVI3 DTM Software

You must download the ValVue software and the SVI3 DTM software and install to configure and use the SVI3. For the most recent software visit our SVI3 web site at:

<https://valves.bakerhughes.com/resource-center>

The SVI3 DTM software comes with a trial version of ValVue. For 60 days after the initial installation, The ValVue software provides the FDT frame capability in which the SVI3 DTM software operates. The SVI3 DTM software provides the capability of configuring, calibrating, diagnosing, trending and much more. After the 60 trial period ValVue must be registered for use. ValVue Functionality includes:

- Setup Wizard
- Set calibration parameters
- Monitor status/error indicators
- Remote calibration of the SVI3
- Remote operation of the SVI3
- Trend setpoint, valve position, actuator pressure
- Perform diagnostic test procedures (full version only)
- Remote display of valve position, actuator pressure(s)
- Set configuration parameters
- Input/Output configuration
- Remote configuration of the SVI3
- Backup and restore configuration (clone device)
- Display comparative test results (full version only)

2.4.2 Masoneilan Software Download

Refer to SVI3 DTM & Software manual to download and install the software.

2.5 Advanced and Online Diagnostics

The SVI3 offers various levels of control valve diagnostics. Up to five pressure sensors, plus circuitry that can detect circuit board temperature, loop current, and reference voltage, are available for diagnostics.

For more details on the use of ValVue software, refer to the ValVue User's Guide. Contact the factory or your local representative to obtain licensing information.

3. SVI3 Installation and Set Up

3.1 Physical Dimensions

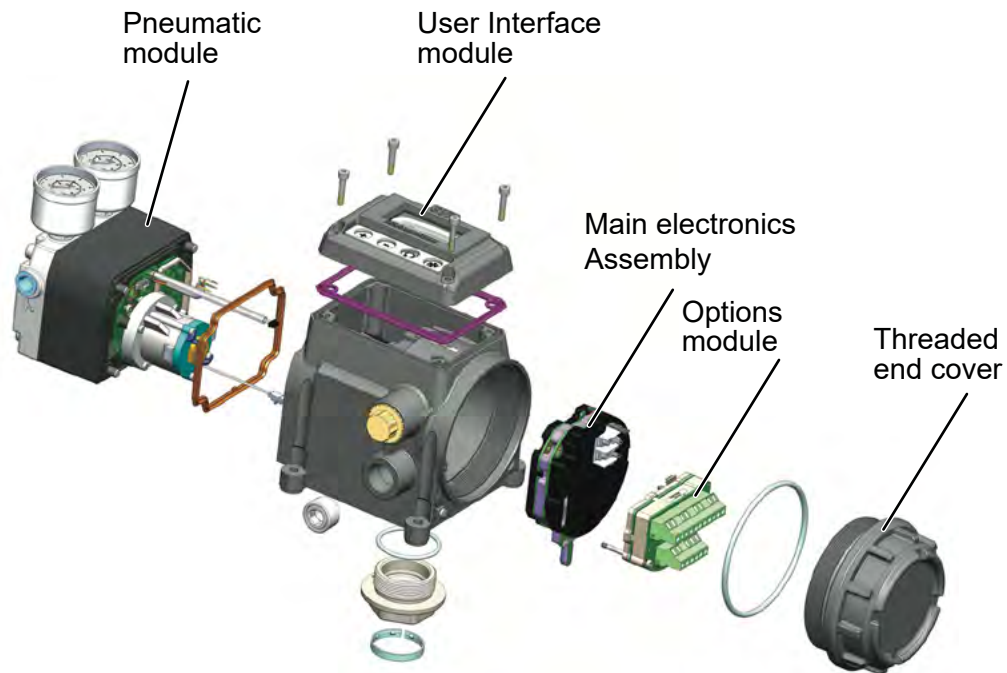


Figure 4 - SVI3 Components

3.1.1 SVI3 Dimensions

Figure 5 illustrates the dimensions for SVI3 single acting models, weights are listed in 6.1 Physical and Operational Specifications (images shown may vary slightly from actual appearance of SVI3)

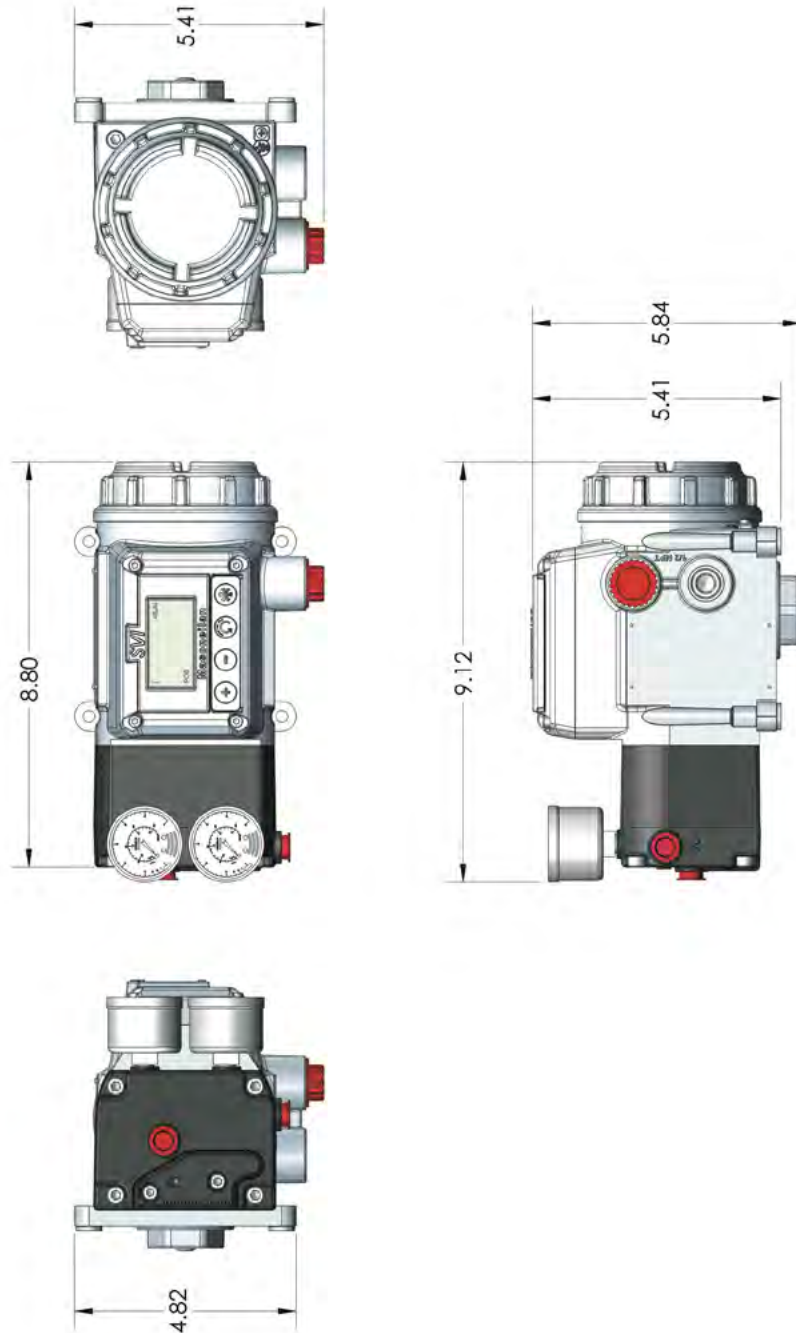


Figure 5 - SVI3 Single-Acting Dimensions

3.2 Pre-Installation Guidelines

Note: Prior to beginning the installation process review the “Safety Information and Documentation Standards” on page 7.

3.3 Installation Steps

Exercise care when unpacking the control valve and its mounted accessories.

If you experience problems that are not documented in this guide call the factory or your local representative. Sales offices are listed on the last page of this document.

Compliance voltage testing is best done before installation. See 7.5 “Determining an SVI Positioner Compliance Voltage in a Control System” on page 111.

The steps necessary to complete the SVI3 installation and software setup are outlined in Table 1.

To ensure proper explosion proof/ingress protection, choose correct cable gland in compliance with the plant/local regulatory wiring practices.

Table 1 - SVI3 Installation Steps

Procedure	Reference
Attach mounting bracket to the actuator.	See 3.4.2 “Mounting the SVI3 on Rotary Valves” on page 25 and 3.4.4 “Mounting the SVI3 on Reciprocating Valves” on page 30 for instructions
Install the SVI3 magnetic assembly (rotary valves only).	See 3.4.2 “Mounting the SVI3 on Rotary Valves” on page 25 for instructions
Assemble the SVI3 on the bracket that is mounted to the valve actuator.	See 3.4.2 “Mounting the SVI3 on Rotary Valves” on page 25 and 3.4.4 “Mounting the SVI3 on Reciprocating Valves” on page 30 for instructions.
Connect the pneumatic tubing and air supply to the SVI3. Natural gas installation considerations (optional).	See 3.5 “Connecting the Tubing and Air Supply” on page 34 for instructions.
Wiring the SVI3.	See 3.6 “Wiring the SVI3” on page 36 for instructions.
Configure/Calibrate using LCD Pushbutton display	See 4.3 “Local Interfaces and Configurations” on page 52, 4.3.5 “Perform Smart Cal” on page 55 and 4 “Tap Fault List to view the full fault code list.” on page 71 for instructions.
Configure/Calibrate using SVI3 DTM with Valve3/AMS	See 4.2 “Configuring and Calibrating with SVI3 DTM with Valve” on page 52 for instructions
Configure/Calibrate using a SVI3 DD files in HART® Communicator/AMS.	See 4.3 “Local Interfaces and Configurations” on page 52 for instructions

Figure 6 shows a **Camflex™ rotary control valve** with an SVI3 mounted as an example of a rotary installation.

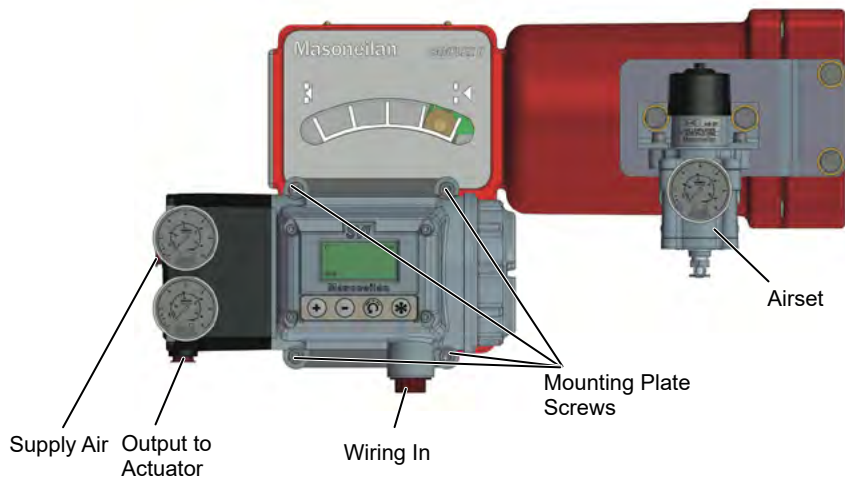


Figure 6 - Sample Rotary Installation

Figure 7 shows a **87/88 Series Actuator** with an SVI3 mounted as an example of a reciprocating installation

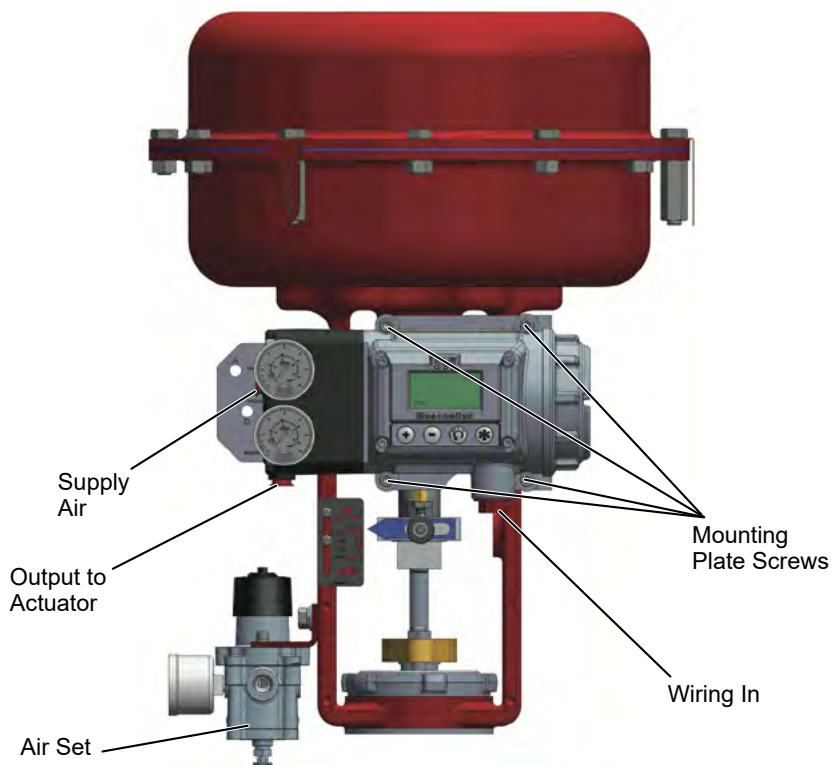


Figure 7 - Sample Reciprocating Installation

3.4 Mounting the Positioner

This section provides installation instructions for mounting an SVI3 on both rotary and reciprocating actuated valves. The mounting process can be broken down into:

- Attach the mounting bracket to the actuator. •Install the magnetic assembly (rotary only).
- Assemble the SVI3 on the mounting bracket.



Mount the SVI3 with the conduit connections down in order to facilitate drainage of condensate from the conduit.

3.4.1 Filter Regulator and Tubing

The use of a Masoneilan filter regulator with a 5-micron filter is recommended for the air supply. Use 1/4" (6.35 mm) minimum tubing between filter regulator, SVI3 and the actuator, with 3/8" (9.53 mm) used for larger actuators. Use a soft setting anaerobic hydraulic seal such as Loctite® Hydraulic Seal 542 for sealing the pneumatic pipe threads. Follow manufacturer's instructions.

Note: Maximum allowable air supply pressure to the SVI3 varies according to actuator and valve size and type. See pressure drop tables in valve specification sheets to determine correct positioner supply pressure. Minimum supply pressure should be 5 to 10 psi (.345 bar - .69 bar) (34.485 - 68.97 kPa) above maximum spring pressure.

3.4.2 Mounting the SVI3 on Rotary Valves

This procedure is used to mount the SVI3 on rotary control valves that have less than 60° rotation, such as a Camflex or a **Varimax™ control valve**. For valves that have rotation greater than 60° refer to "Special Cases" on page 30.



Do not remove the instrument cover or connect to an electrical circuit in a Hazardous Area unless power is disconnected.

Verify that the mounting has not been damaged in shipment for a pre-mounted SVI3.

Record the following information for the configuration checkout:

- Valve Air to Open (ATO) or Air to Close (ATC)
- Actuator pressure rating
- Actuator bench range
- Inherent trim characteristic of the control valve; linear, equal percentage, or other

Note: Refer to the valve data sheet or model number of control valve.

Required Tools

The following tools are needed to complete the rotary valve installation:

- 3/16" Hex Key with tee handle
- 5/32", 1/2" Hex Key
- 3 mm, 4 mm, 5 mm Hex Key
- 7/16" Wrench

To mount the SVI3:

1. Attach the SVI3 rotary mounting bracket to the valve actuator with two 5/16 - 18 UNC flat-head cap screws and tighten using 3/16" Hex Key as shown in Figure 8.

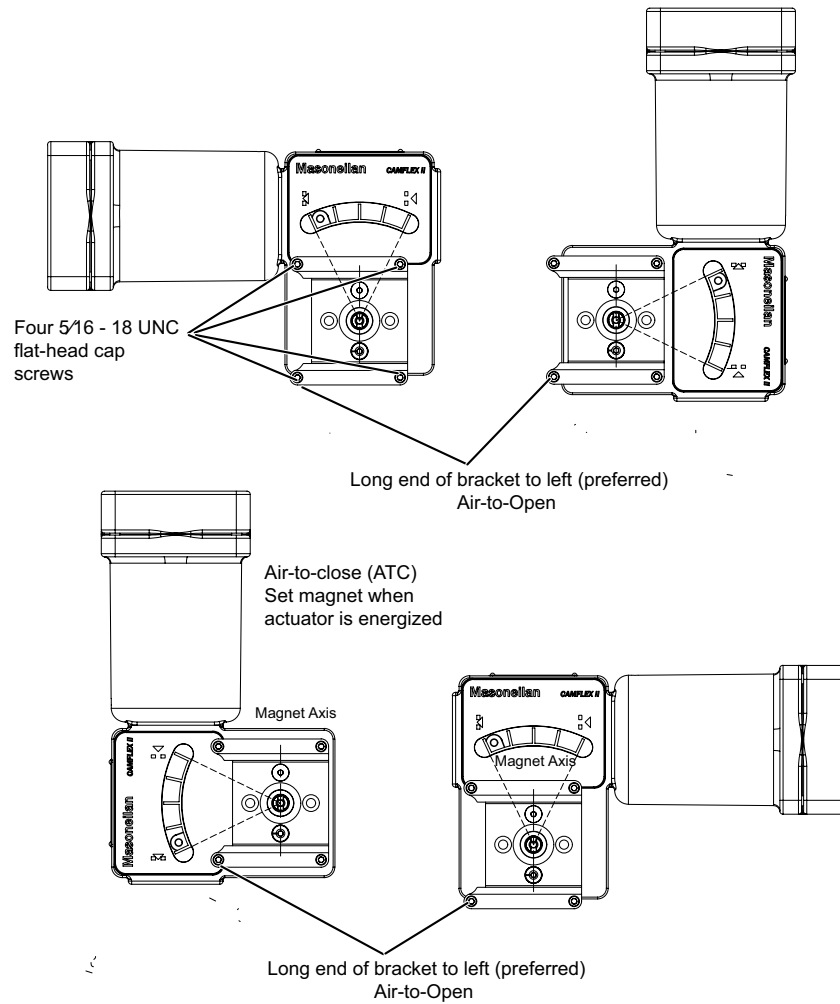


Figure 8 - Camflex II Rotary control valve ATO and ATC Mounting

2. Bolt the extension shaft to the valve position take-off shaft using a 1/4 - 28 UNF socket flathead screw. Secure the machine screw holding the extension shaft with a torque of 144 in-lbs (16.269 N-m) using 5/32" Hex Key.

Note: Upon internal valve pressure the thrust shaft is pushed out to the mechanical stops, usually a thrust bearing. On valves where the valve position take-off is mounted directly on the end of the plug shaft, a Camflex for example, the shaft must be bearing on its stop to properly set up the SVI3 digital valve positioner. During hydrostatic testing the shaft is thrust to its stop and a normally tightened packing retains it in that position.

Note: On vacuum service, the valve shaft can be drawn into the body by the vacuum acting on the shaft, but the magnetic coupling must be assembled flush with the mounting bracket with the shaft pulled fully out to its thrust bearing.

3. Ensure the endplay from the vacuum position to the fully extended position is less than 0.06 in. (1.524 mm).
4. Slide the magnet holder into the extension shaft. The location of the magnets is in the ring of the magnet holder. The magnetic axis is the imaginary line through the center of both magnets (See Figure 9).

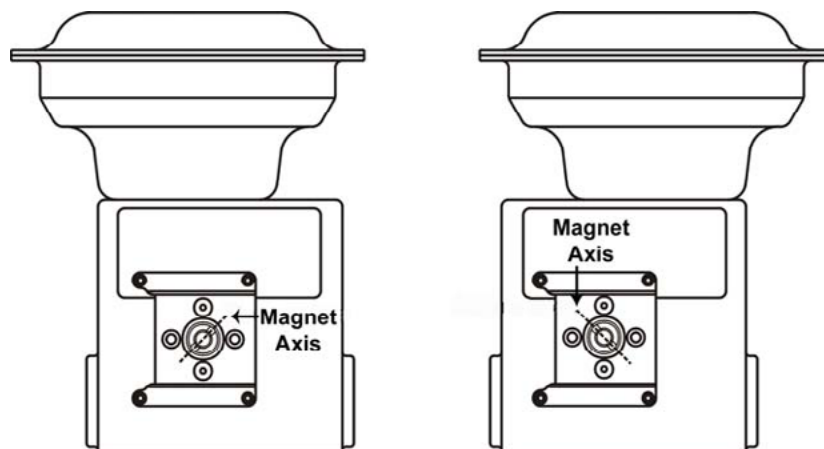
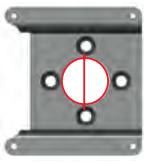
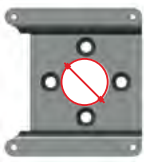
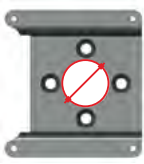
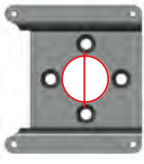


Figure 9 - Magnet Axis

5. Rotate the magnet holder so that the magnet axis is vertical when the valve is in the closed position (see Figure 8). Table 2 shows the general guidelines for travel sensor alignment. Review the table prior to installing the SVI3 on a rotary valve actuator for proper alignment of the magnet.

Table 2 - Travel Sensor Alignment

Rotary Mounting System	Stroke Direction	Magnet Orientation	Valve Position	Sensor Counts
Rotary	<60° Rotation Clockwise or counter clockwise rotation	 (0°)	Closed (0%)	0 +/- 1000
	>60° Rotation Clockwise with increasing setpoint	 (-45°)	Full Open or Full Closed	-8000 +/- 1500 or +8000 +/- 1500
	>60° Rotation Counter Clockwise rotation with increasing setpoint	 (+45°)	Full Open or Full Closed	-8000 +/- 1500 or +8000 +/- 1500
General Rule for other configurations	Any amount of rotation Clockwise or counterclockwise	 (0°)	50% Travel (Mid-Stroke)	0 +/- 1000

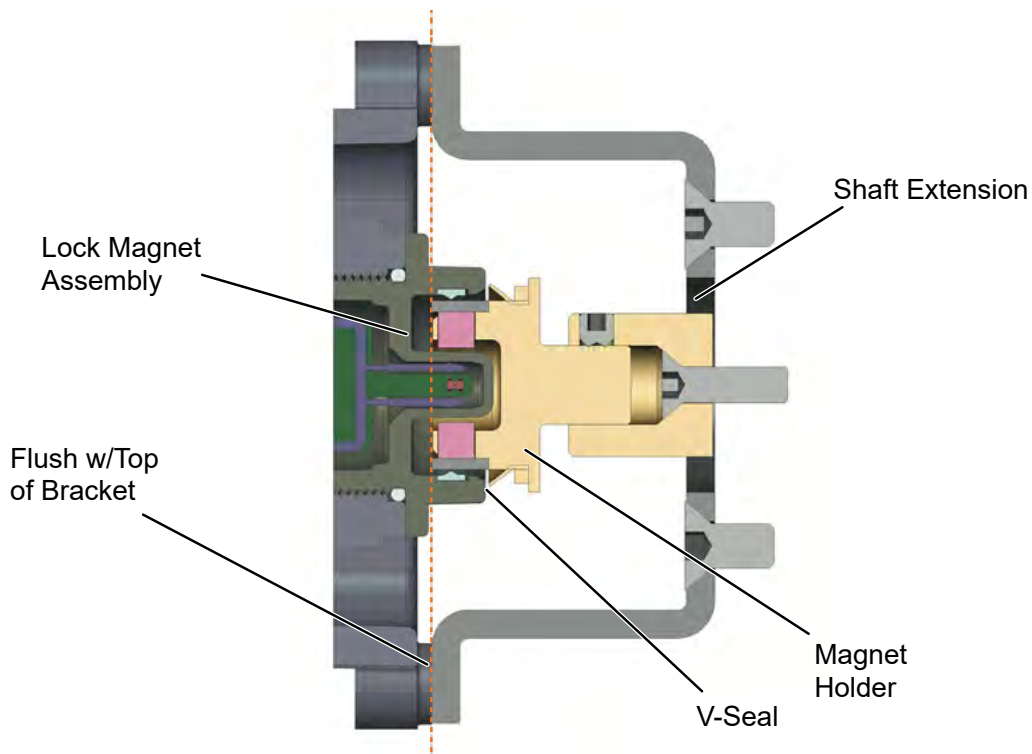


Figure 10 - Camflex II Rotary control valve with Mounting Bracket (Side View)

6. Align the end of the magnet holder flush with the end of the mounting bracket (Red Dotted line in the Figure10 on page 29). Secure the magnet holder with two M6 set screws using 6mm Hex Key.
7. Slide the V-Seal over the magnet holder.
8. Secure the SVI3 onto the mounting bracket with four M6 x 20 mm socket head cap screws using 6mm Hex Key.
9. Ensure that:
 - No interference exists with the position sensor protrusion.
 - Ensure that the V-Seal makes contact with the skirt around the position sensor protrusion on SVI3 housing.

3.4.2.1 Checking the Magnet

There are two methods of checking the SVI3 magnet:

- Perform a visual inspection
- Use SVI3 DTM with Valvue3 to check the magnet

3.4.2.2 Performing a Visual Inspection

Ensure that the magnet is aligned as in Table 2 on page 28.

3.4.2.3 Using SVI3 DTM with Valvue3 to Check Magnet Position

1. Refer to DTM Manual for connection procedure.
2. Read Raw Position data. When the valve is closed, the value should be 60° rotation for rotary valve.

3.4.3 Special Cases

3.4.3.1 Rotary - 90 to 120°

For actuators with 90 to 120° rotation, follow the instructions in “Mounting the SVI3 on Reciprocating Valves” on page 30 except mount the magnet at $\pm 45^\circ$ while the actuator is de-energized as shown in Figure 9 on page 27

3.4.4 Mounting the SVI3 on Reciprocating Valves

This section describes the procedure for mounting the SVI3 on reciprocating valves (using Masoneilan’s 87/88 Multi-Spring actuators as an example).



Do not remove the instrument cover or connect to an electrical circuit in a Hazardous Area unless power is disconnected.

Verify that the mounting has not been damaged in shipment for a pre-mounted SVI3, physically inspect the actuator, linkage. Record the following information for the configuration checkout:

- Valve Air to Open (ATO) or Air to Close (ATC)
- Actuator pressure rating
- Actuator bench range
- Inherent trim characteristic of the control valve; linear, equal percentage, or other.

Note: Refer to the valve data sheet or model number of control valve.

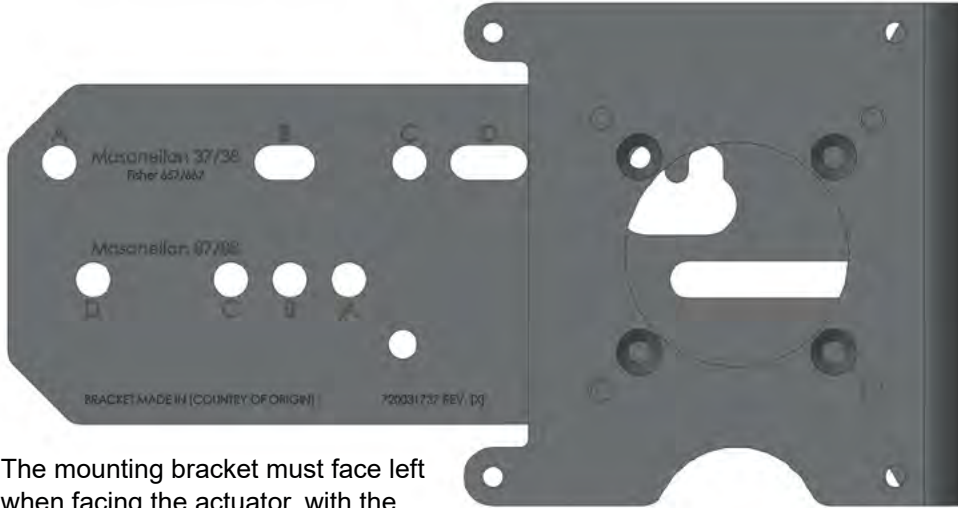
Tools required:

- 7/16” Combination Wrench (2 required)
- 1/2” Combination Wrench
- 4mm, 5mm and 6mm Hex Key Wrenches
- 3/8” Combination Wrench
- Phillips® Head Screw Driver

3.4.4.1 Mounting the SVI3 on a Reciprocating Actuator

The SVI3 mounting assumes that the actuator is in the normal upright position.

1. Ensure that the lever is attached to the magnet assembly and held securely by two M5 flat head screws to ensure that the magnet axis is vertical when the lever is in the valve closed position. Tighten the lever screw securely using 5mm Hex Key.
2. Install One 5/16 - 18 UNC-2A HEX Head Screw loosely with one lock washer and one flat washer. Then slide the bracket into the installed fastener through the mounting slot.
3. Install the second 5/16 - 18 UNC-2A HEX Head Screw in correct mounting hole according to the actuator size and travel distance [Refer Table 3 on page 31 and Figure 11]. Then tighten both fasteners.



The mounting bracket must face left when facing the actuator, with the actuator in the upright position

Figure 11 - Reciprocating Valve Mounting Bracket

Table 3 - Reciprocating Valve Mounting Hole and Turnbuckle Length

Actuator Size Masoneilan	Stroke	Mounting Hole	Lever Hole	Turnbuckle Length
6 and 10	0.5 - 0.8" (12.7 - 20.32 mm)	A	A	1.25" (31.75 mm)
10	0.5 - 0.8" (12.7 - 20.32 mm)	A	A	1.25" (31.75 mm)
10	>0.8 – 1.5" (20.32 - 38.1 mm)	B	B	1.25" (31.75 mm)
16	0.5 - 0.8" (12.7 - 20.32 mm)	B	A	2.90" (73.66 mm)
16	>0.8 – 1.5" (20.32 - 38.1 mm)	C	B	2.90" (73.66 mm)
16	>1.5 – 2.5" (38.1 - 63.5 mm)	D	C	2.90" (73.66 mm)

Table 3 - Reciprocating Valve Mounting Hole and Turnbuckle Length (Continued)

23	0.5 - 0.8" (12.7 - 20.32 mm)	B	A	5.25" (133.35 mm)
23	>0.8 – 1.5" (20.32 - 38.1 mm)	C	B	5.25" (133.35 mm)
23	>1.5 – 2.5" (38.1 - 63.5 mm)	D	C	5.25" (133.35 mm)

4. Select mounting hole A, B, C or D for the stroke of the valve. For example, hole B is shown in Figure 12 for a size 10 actuator with 1.0" stroke.



Figure 12 - Lever for Model 87/88 Multispring Actuator

5. Move the valve to its closed position. For air to:
- Extend, this requires using air pressure in the actuator to fully stroke the actuator.
 - Retract, actuators vent the actuator of air pressure.
6. Apply Loctite® and thread the take-off rod to the actuator stem connector (Figure 13). Ensure that the travel pointer located on the coupling is correctly positioned.
7. Attach the right hand threaded rod end to the lever using a 1/4 - 20 x 0.75" cap screw and nut as shown in Figure 13. The lever hole position to be used depends upon the specific valve stroke. Refer to Figure 12 and the Reciprocating Valve Linkage Selection, Table 3 on page 31.

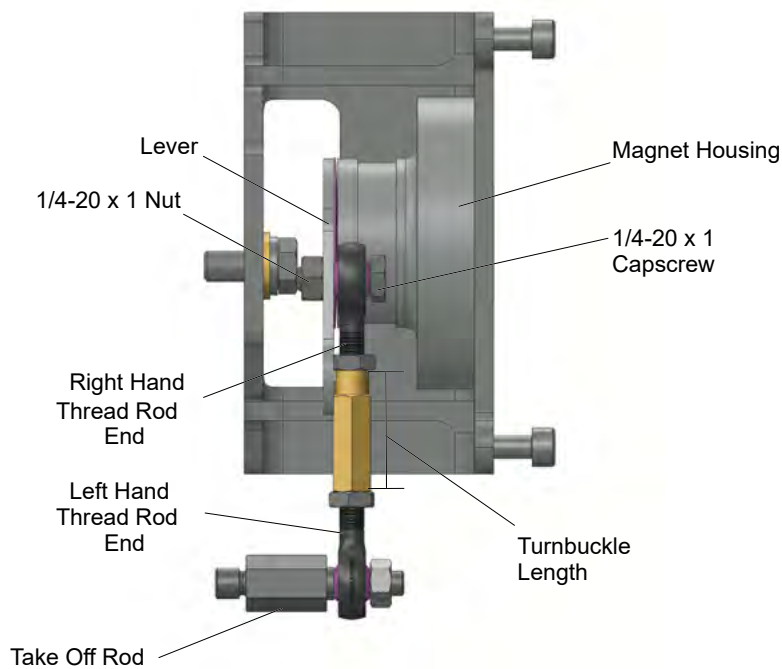


Figure 13 - Reciprocating Linkage

8. Thread the right hand lock nut and turnbuckle onto the right hand rod end approximately two turns. Turnbuckle length is a function of actuator size. (Refer to Table 3 on page 31.).
9. Secure the magnet housing assembly, including the lever and right hand rod end, to the bracket with four M5 X 10 mm flat head screws using 5mm Hex Key (Figure 13).
10. Attach the left hand threaded rod end to the take-off rod with 1/4 - 20 UNC nut and thread the left hand lock nut onto the rod end.
11. Thread the turnbuckle onto the left hand threaded rod end. Refer to Figure 13.
12. Adjust the turnbuckle until the hole in the SVI3 lever is aligned with the indicating hole in the bracket. Tighten both turnbuckle lock nuts.
13. Mount the SVI3 to the bracket and secure with four M6 socket head cap screws using 6mm Hex Key.

3.4.4.2 Using SVI3 DTM with Valve3 to Check Magnet Position

1. Refer to DTM Manual for connection procedure.
2. Read Raw Position data. When the valve is closed, the value should be between ± 1000 for a reciprocating valve.

Performing a Visual Inspection

For reciprocating valves the adjustable link turnbuckle must be parallel to the valve stem. To ensure linearity in positioning verify that the hole in the lever aligns with the indicating hole in the bracket when the valve is in the closed position. Check that the bracket is mounted on the correct holes. (See Figure 11 on page 31 and Table 3 on page 31 for details).

3.5 Connecting the Tubing and Air Supply

This section describes the process for connecting the tubing and air supply to a single acting positioner.

Maximum allowable air supply pressure to the SVI3 varies according to actuator, valve size, and valve type. See Pressure Drop tables in valve specification sheets to determine the correct positioner supply pressure. Minimum supply pressure should be 5 psi to 10 psi (.345 bar - .69 bar) (34.485 - 68.97 kPa) above maximum spring range but must not exceed the rated actuator pressure.

1. Install the air filter/regulator to the air supply port.
2. Connect the air supply to the air filter/regulator input

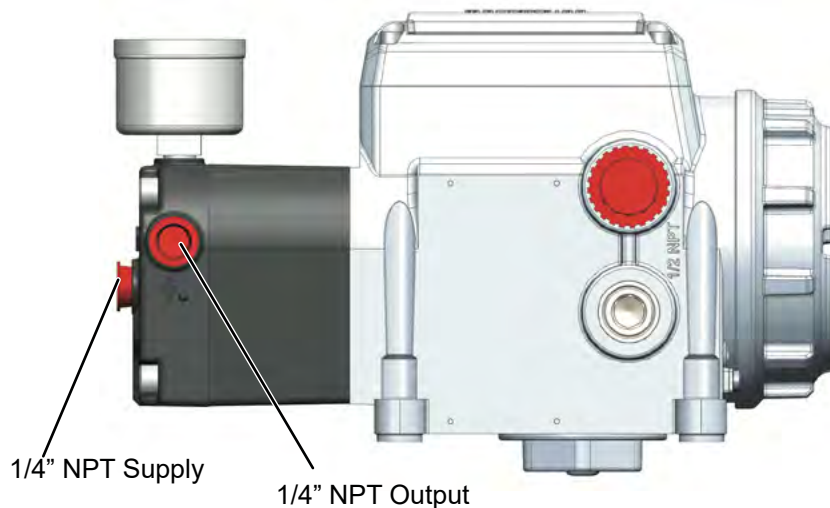


Figure 14 - SVI3 Air Ports on Single Acting Positioner

3. Make sure the following specifications and limits are respected:
 - Supply pressure for single acting SVI3: 20 -120 psi (1.4 - 8.3 bar) (138 - 830 kPa).
 - Minimum tubing diameter 1/4" (6mm x 4mm)
 - Use Wrench Torque for the fittings and Do not apply more than 10 Nm.
4. Turn on the Air supply with air regulator set to Zero.
5. Increase the supply pressure to required range for the particular actuator used.
6. Inspect the tubing connections between the filter-regulator and the positioner for leaks.
7. Verify that the tubing is not bent or crushed.
8. Verify that all fittings are leak tight

3.5.1 Air Supply Requirements

A high quality air supply greatly improves the quality of control and reduce maintenance costs of pneumatic equipment. See ANSI/ISA-7.0.01-1996 - Quality Standard for Instrument Air.

3.5.2 Installing an SVI3 in a Natural Gas Environment



Please refer ES-817 SVI3 Product safety Manual for installation and operation procedures in natural gas environment.

Approximately 2.8 SLPM (5.9 SCFH) @ 30psi of natural gas exhausts from the SVI3 Positioner and vented. For indoor applications, take this into consideration and provide circulation and venting.



Explosion Proof Conduit Fittings must be used for wiring ports. During Operation, None of the electrical contacts can be connected/ disconnected. During Operation, Do not remove/ install Vent cover, End cap or fittings.

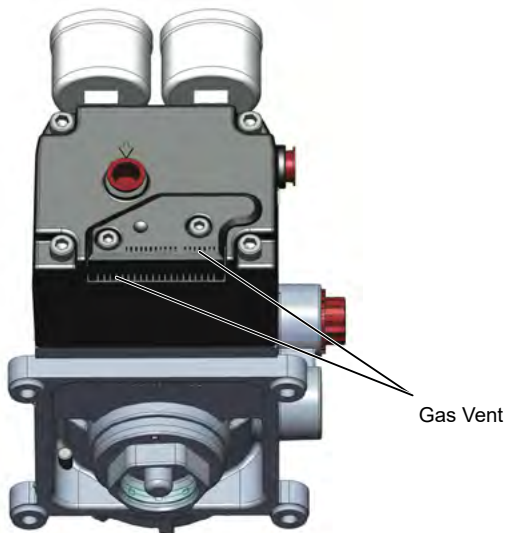


Figure 15 - Single Acting SVI3 Gas Vents

3.5.3 SVI Exhaust Routing Manifold

With an optional kit, it is possible to collect all positioner vent and actuator exhaust gas. For more information, refer to Instructions Manual Ref. 34633.

3.6 Wiring the SVI3

The procedure below outlines wiring the SVI3.



- *There can be unexpected valve, actuator or positioner movement at any time during installation or operation.*
- *Comply with current national and local regulations for electrical installation work.*
- *Comply with national and local explosive atmosphere regulations.*
- *Before carrying out any work on the device, power off the instrument or make sure that the local conditions for potentially explosive atmosphere permit the safe opening of the cover.*

3.6.1 Required Practices for Explosion Proof Installations

Please refer ES-817 Product safety manual for required practices for explosion proof Installations..

3.6.2 Wiring Guidelines

Guidelines for a successful implementation of DC current signal, DC power, and HART® communication to the SVI3:

- Compliance voltage at the SVI3 is approximately 9 V at 20 mA, 11 V @ 4 mA. See “Split Range Applications” on page 112.
- Signal to the SVI3 must be a regulated current in the range 3.2 to 22 mA.
- Controller output circuit must be unaffected by the HART® tones which are in the frequency range between 1200 and 2200 Hz.
- In the frequency range of the HART® tones, the controller must have a circuit impedance of more than 220 Ohms, typically 250 Ohms.
- HART® tones may be imposed by the positioner and a communication device located anywhere on the signaling circuit.
- Cabling must be shielded to prevent electrical noise that would interfere with the HART® tones, with the shield grounded.
- Shield must be properly grounded in only one place.
- For details and calculation methods for wiring resistance, and capacitance and for calculation of cable characteristics, refer to the HART® FSK Physical Layer Specification.
- For split range installations, the output voltage must be sufficient to operate two positioners (11 V @ 4 mA, 9 V @ 20 mA) and the expected voltage drop in the cable.
- Use of a low impedance voltage source damages the SVI3. The current source must be a true high impedance current limiting device. A proper current source explicitly enables adjustment of the current, not the voltage.

- When wiring a position retransmit:
 - Ensure that the position retransmit signal is connected to the control system's analog input card.
 - Ensure the control loop is powered while making make measurements with a meter.

3.6.3 Connecting to the Control Loop

It is important to maintain correct polarity at all times, otherwise the positioner may not operate properly.



Main Terminal connections must be wired using a nominal torque of 1.13 N-m.

Connect the wires as follows (wire size 12 to 22 AWG, 4 mm² to .34 mm²):

1. Strip approximately 1/4 in (6.35 mm) of the insulation at the end of wires.
2. Unscrew the end cover and remove the desired 1/2" NPT plastic cover (Figure 16).

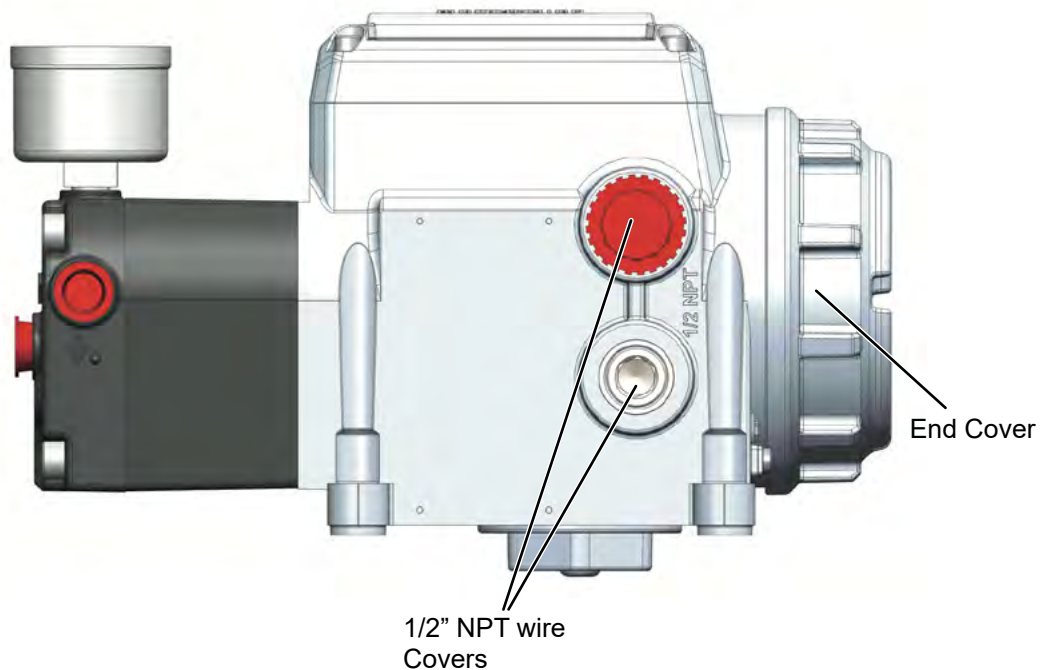


Figure 16 - SVI3 Electrical Gland/Conduit Entries

3. Insert a gland/conduit fitting into the 1/2" NPT opening and tighten it. Use Loctite® as required,
4. Thread the cable through the gland.
5. Locate the correct terminal block on the terminal board (see Figure 17).

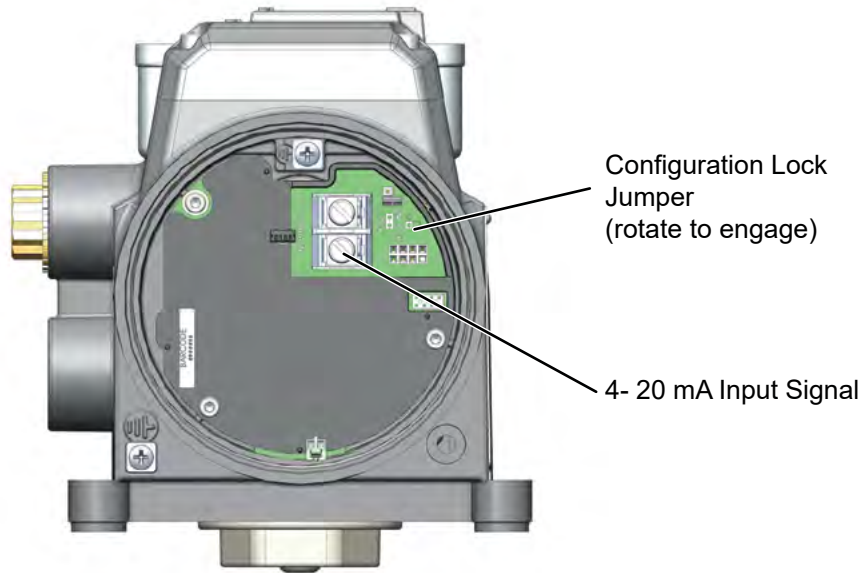


Figure 17 - Connections to Main Electronics Module (via Terminal Board)

6. Unscrew the required connector, insert the control loop wire with correct polarity and tighten the connector screw.
7. Reinstall the cover.

3.6.4 Wiring an Options Board

The options board contains connections for the following:

- Two solid-state switches (SW#1 and SW#2) configurable to various alert/status bits and open/close states.
- 4-20 mA OUT to support position retransmit functions. •Digital Input (DI) connection.
- REMOTE connection to wire a Masoneilan remote position sensor.
- Process Variable (PV) input, a 1-5V input which can accept a position sensor input.

The Options board can be ordered together with positioner or can be purchased separately.



For proper operation, maintain signal polarity + and - respectively.

Options Board Terminal connections must be wired using a wire of 26 AWG to 14 AWG size and terminal torque between 0.5 - 0.6 Nm.

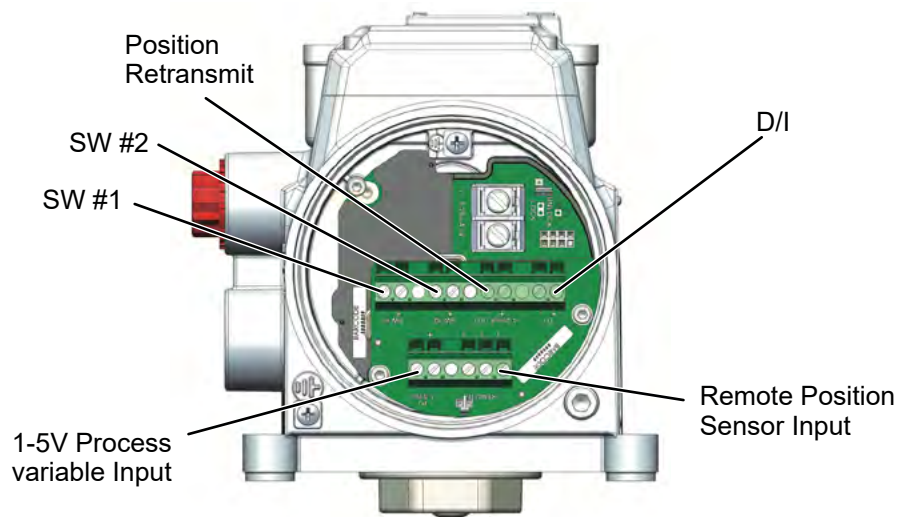


Figure 18 - Connections to Options Electronics Module (via Terminal Board)

1. Strip approximately 1/6 in (4.08 mm) of the insulation at the end of wires.
2. Thread the wire through the gland which was installed during the Control loop connection.
3. Locate the correct terminal block on the Options Module (see Figure 18).
4. Unscrew the required connector, insert the wire with correct polarity and tighten the connector screw.
5. Tighten the gland and Reinstall the cover.

DI Connections

Follow the procedure for “Wiring an Options Board” on page 38 and connect to D/I terminals. Connections to the non-Masoneilan devices depend on their documentation.

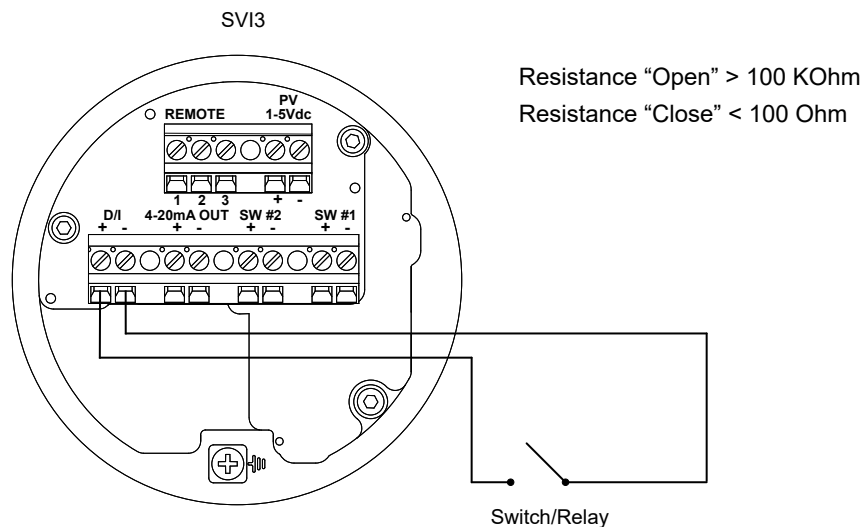


Figure 19 - DI Connections

Output Switches

The SVI3 supports two identical contact outputs, SW #1 and SW #2 (Digital Output switches), that can be logically linked to status bits.

The switches are polarity sensitive and must be connected only to a DC circuit. The switch (+) terminal must be electrically positive with respect to the (-) terminal. If the (+) terminal is negative with respect to the (-) terminal, then the switch will conduct, regardless of switch state.

If the switch is connected directly across the power source, the current will be limited only by the capacity of the power source and the switch can be damaged.

Without a load, when the switch is on (closed) the external voltage would be dropped across the switch. This damages the switch (Figure 20).

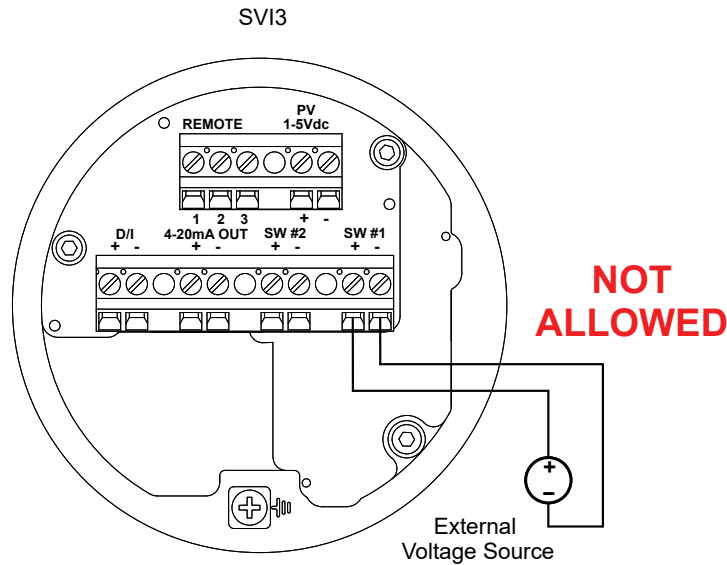


Figure 20 - Switch Installation Drawing without Load: **Configuration Not Allowed**

General Configuration Notes

This section discusses the necessary precautions when configuring a system.

	Switch OFF	Switch ON
V _{SWITCH}	30 VDC max.	≤ 1 V (Switch saturation voltage)
I _{SWITCH}	≤ 0.200 mA (Switch leakage current)	1 A max.



For IS Applications, Maximum Switch Current allowed is 125mA.

CAUTION

Consult with qualified personnel to ensure that electrical requirements for the switch are met.

The maximum voltage that can be applied to the digital switch outputs is 30 VDC. This is an open circuit parameter (the digital switch is in the open state). Under open circuit conditions, the switch current will be less than 0.200 mA.

The switch maximum current rating is 1 A. When the switch is ON, the typical switch voltage is $\leq 1V$.

When the switch is on (closed) the external voltage must be dropped across the load (Figure 20 on page 40).

CAUTION

The load must be designed such that the current in the circuit is $\leq 1 A$ at all times. Some 3rd party devices, such as incandescent lamps or solenoids, require surge and back EMF protection to prevent voltage spikes.

Sample Switch Connection with Inductive load

For example, The External Relay is being controlled by the Output Switch of the SVI3 Options Module. To Avoid damaging the SVI3 Output Switches, We are using 250 Ω Resistor to limit the current to less than 1A. Please consult qualified electrical personnel to calculate the value of resistor to be used. Since the relay coils is a Inductive load, The back EMF when relay is turned off will damage the switch So fly-back diode is used to bypass the transient current. The external relay is powered by 24VDC Supply.

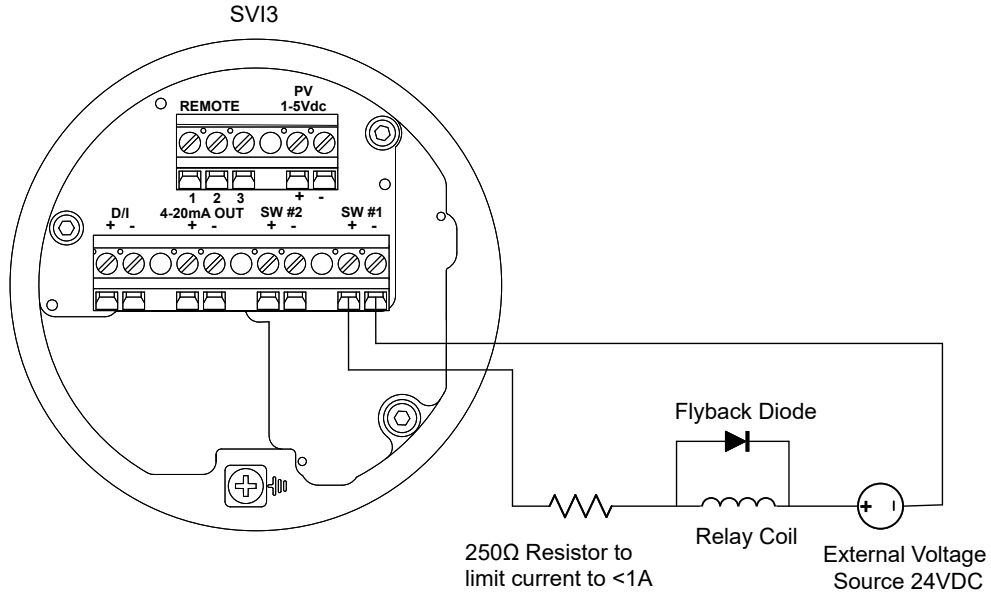


Figure 21 - Switch Installation Drawing: Correct Configuration with Load

Switch Settings

The two digital output switches can be opened or closed in response to conditions that the SVI3 detects. Please Refer SVI3 DTM Manual (Ref. 34569) to learn more about the configurable conditions and procedure to configure them.

Remote Position Sensor Input Connections

Follow the procedure for “Connecting to the Control Loop” on page 37 and connect to REMOTE. See Masoneilan Remote Position Sensor (RPS) Quick Start Guide Quick Start Guide, which is downloadable at <https://valves.bakerhughes.com/resource-center>.

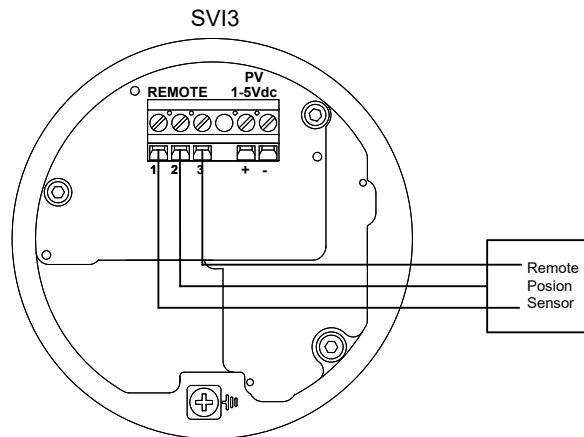


Figure 22 - Remote Position Sensor Input Connections

Retransmit Connections

Follow the procedure for “Wiring an Options Board” on page 38 and connect to 4-20mA OUT. Connections to the non-Masoneilan devices depend on their documentation.

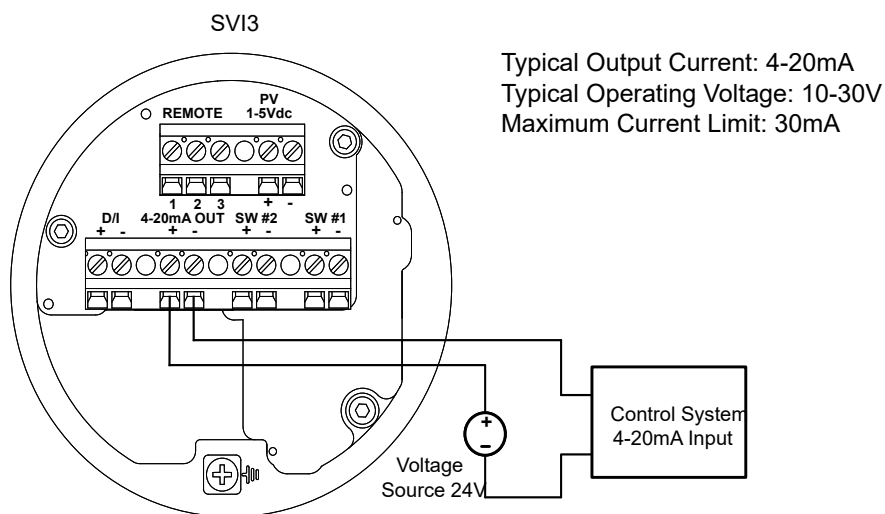


Figure 23 - Retransmit Connections

To troubleshoot retransmit connections:

- The 4-20mA output circuit is a passive output. An external power supply (10V minimum, 30V maximum) is required to energize the circuit.
- Note that the minimum output current is 3.2 mA. If the SVI module loses power and the Retransmit circuit remains powered by the external supply, the current will be 3.2 mA.

1-5V Process variable Input Connections

Follow the procedure for “Wiring an Options Board” on page 38 and connect to 1-5V PV.

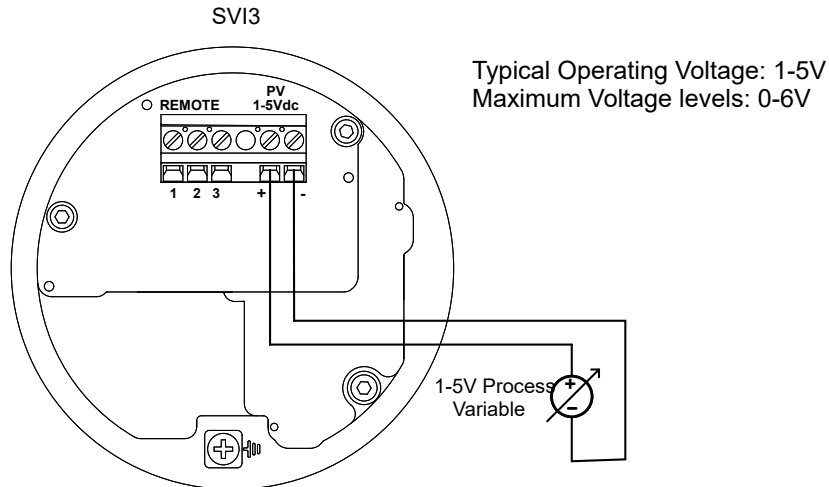


Figure 24 - 1-5V Process variable Input Connections

3.6.5 System Connections

All system connections must comply with the HART® Communications Protocol Specifications. For complete technical information refer to the FieldComm™ Group Document Number HCF-SPEC-11 and the references. The SVI3 is a HART® compliant device of type *Actuator*. It is therefore a receiver of 4 - 20 mA, and cannot have a voltage source applied to its input terminals.

Energy levels are often limited for safe installation in explosive environments. Please refer Product Safety Manual ES817 for information on installation in explosive environments.

The following will not cover all the details for a successful installation, in all cases. That is beyond the scope of this document. It will suffice to explain the requirements as a guide used to obtain necessary components from many sources for a successful installation.

3.6.5.1 SVI3 Setup

Control Systems using Explosion Proof or Conventional I/O Systems must have a compliance voltage greater than 9 V at 20 mA including wiring losses. See “Split Range Applications” on page 112.

Typical Control Systems using Intrinsic Safety methods must have a compliance voltage greater than 17.64 V.

Typical system setups are shown in Figure 25 on page 44, for General Purpose and Explosion Proof (Ex d) Installation Schematic and Figure 26 on page 45, for Intrinsically Safe Installation Schematic. The SVI3 digital valve positioner can be located in a general-purpose or hazardous area protected by Explosion Proof (Ex d) methods. Wiring diagrams are generalized, actual wiring must adhere to Electrical Installation section of manual and local electrical codes. The use of a Handheld Communicator or a HART® modem is not permitted in the Hazardous Area protected by Explosion Proof (Ex d) methods.

Since the process control system, the source of the input signal, is located in a non-hazardous location, setup requires an intrinsic safety barrier be placed between the process control system and the SVI3. If the SVI3 is located in a hazardous area with Intrinsically Safe protection a barrier is not required for a flameproof installation.

Alternatively the system can be installed as Explosion Proof/flameproof.

The SVI3 can communicate with a remote PC running ValVue software via a HART modem connected to the PC's serial port. The PC, which is not intrinsically safe, must be connected to the circuit on the safe area side of the intrinsic safety barrier if the valve is located in a hazardous area.

The SVI3 is polarity sensitive so the positive lead must be connected to the positive (+) terminal and the negative lead to the negative (-) terminal. Reversal of input will not cause damage but the unit will not function.

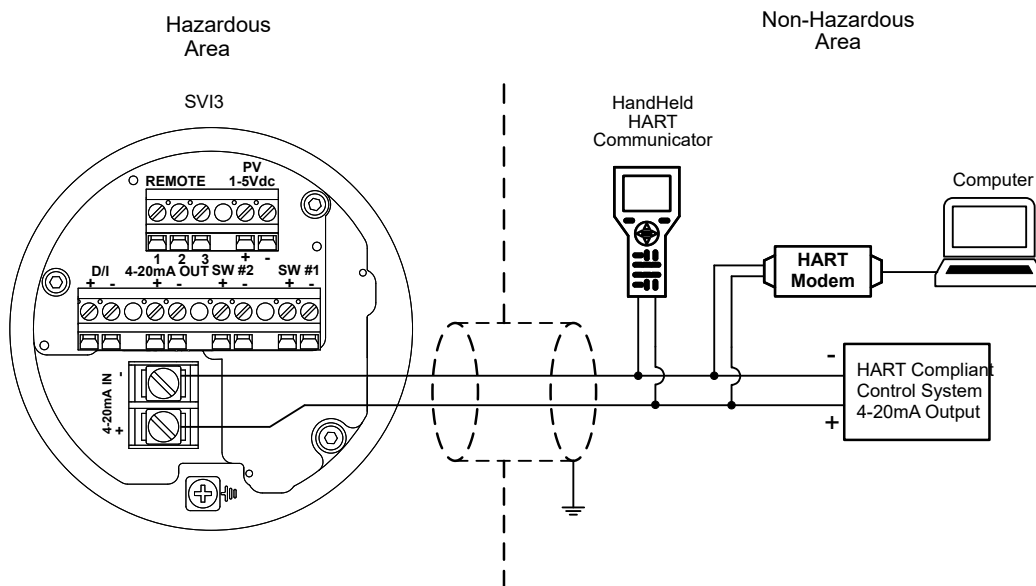


Figure 25 - General Purpose and Explosion Proof Installation

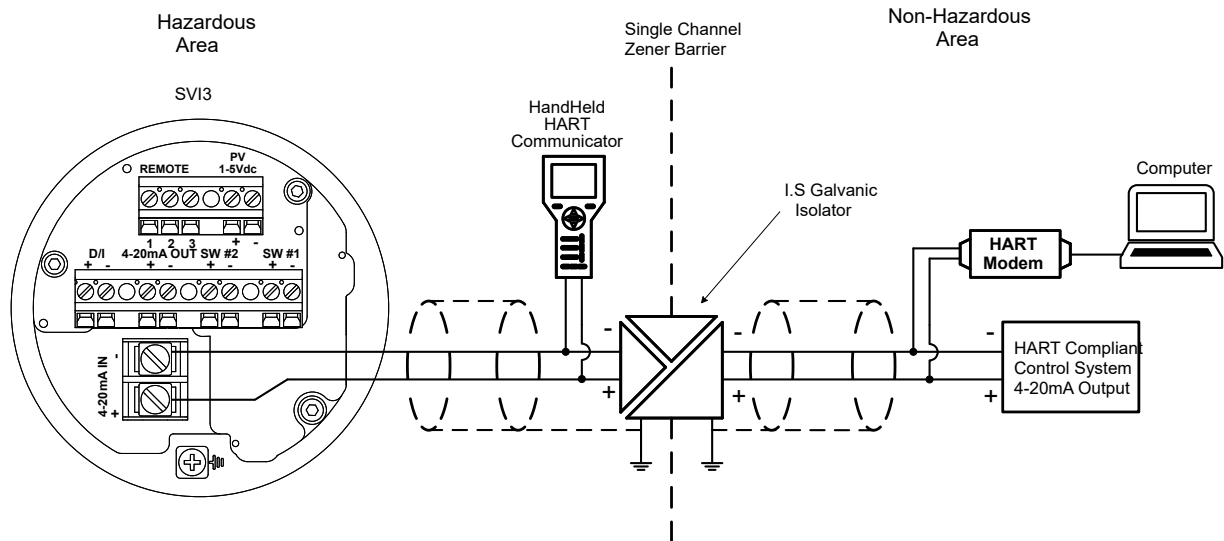


Figure 26 - Intrinsically Safe Installation

3.6.5.2 Grounding Practices

To ensure proper grounding make sure that case and ground connections are made in compliance with the plants normal grounding practices. There must never be more than one ground point for the shield of the signal wiring. Normally ground is connected at the controller or at the intrinsic safety barrier.

The case grounding screws are located on the outside of the case at the lower right of the cover and inside the cover. The case is isolated from all circuitry and can be grounded locally in accordance with applicable codes.

If noise or instability is present, set the positioner to MANUAL mode of operation and manually position the valve over its entire range. If the valve is stable in MANUAL mode then the problem can be noise in the control system. Recheck all wiring connections and ground points.

Note: Improperly or inadequately grounded installations can cause noise or instability in the control loop. The internal electronics are isolated from ground. Grounding the case is unnecessary for functional purposes but grounding the case may be necessary to conform to local codes.

3.6.5.3 Compliance Voltage in Single Drop Current Mode

The SVI3 requires 9.0 V at 20 mA and 11.0 V at 4 mA. Typical smart devices require MORE voltage at higher current. The controller supplying the current has LESS voltage available at higher current. The SVI3 is noteworthy in that it requires LESS Voltage at higher current that complements the characteristic of the source requiring only 9 V at 20 mA. See “Split Range Applications” on page 112.

Table 4 through Table 6 on page 46 provide examples of several SVI3 installations and calculating the compliance voltage necessary to supply 9 V at 20 mA..

Table 4 - Compliance Voltage for Single Channel Zener with 22 AWG Cable

Voltage across SVI3 Control Terminals with 20mA Signal	9.0 V
Drop in single channel Zener barrier with 342 Ohms end to end resistance	6.84 V
Drop in 22 AWG cable, 3000' long (30 Ohms per 1000')	1.8 V
Drop in passive HART®Filter	0.0 V
Voltage required at controller	17.64 V

Conclusion: The control system must have a compliance voltage equal to or greater than 17.64 V; contact the DCS vendor to verify compliance.

Table 5 - Compliance Voltage for Galvanic Isolator with 22 AWG Cable

Voltage at SVI3 at 20mA	9.0 V
Drop in 22 AWG cable, 3000' long (30 Ohms per 1000')	1.8 V
Required voltage at Isolator	10.8 V
Voltage available from Isolator rated to drive 22 mA into 700 Ohm	13.2 V
Voltage required at controller	Not applicable - Isolator sup-plies the power

Conclusion: The compliance voltage issue is not present because the Isolator provides all the necessary voltage.

Table 6 - Compliance Voltage for No Barrier with HART®Filter and Resistor and 18 AWG Cable

Voltage at SVI3 at 20mA	9.0 V
Drop in 220 Ohm resistor	4.4 V
Drop in 18 AWG cable, 6000' long (12 Ohms per 1000')	0.6 V
Drop in passive HART®Filter	2.3 V
Voltage required at controller	16.3 V

Conclusion: The control system must have a compliance voltage equal to or greater than 16.3 V; contact the DCS vendor to verify compliance.

3.7 Power Up

Note: Before powering ON, please ensure that all the safety requirements described by ES-817 Product safety Manual is followed. Additionally follow the Section 1.2 “SVI3 Product Safety”

3.7.1 Air to Open and Air to Close Actuators

3.7.1.1 ATO / ATC

The positioner must be configured as Air-to-Open, ATO, or as Air-to-Close, ATC. This parameter is toggled by the * button.

To determine if an actuator is considered ATO or ATC, perform the following test:

1. Apply the actuators rated pressure to the positioner supply.



Do not exceed actuator pressure rating on the control valve specification sheet. Damage to the valve stem, shaft, or trim can occur.

2. Disconnect the electrical (4 to 20 mA) input signal from the positioner or set it to less than 3.6 mA.
3. Observe the position of the control valve. If it is:
 - Closed the actuator is ATO.
 - Open it is ATC.

3.7.1.2 Actuator Action

It is important to correctly assign the sign + or - of each control variable throughout a control system. Even the control valve subsystem can be complex. Figure 27 and Figure 28 show the action of air to open, ATO, and air to close, ATC, valves when used with SVI3. The figures show a direct acting positioner with linear and percentage characteristics. Some hysteresis is shown for the actuator pressure signal that is caused by friction in typical actuators. The scales are chosen to emphasize the relationships between input current and actuator pressure, so that the failsafe valve position is shown at the lower left of each graph. Note that for an ATC valve, 4 mA represents 100% valve travel not the expected 0%. The controller and other human machine interfaces must correctly show that the valve is open 100% at 4 mA and closed 0% at 20 mA. The graph shows the valve movement and actuator pressure when the Tight Shut-off, T.S., option is set at about 5%, in this example. The valve movement and actuator pressure are also shown at the low current lift-off point at about 3.6 mA, below which the positioner is initializing its settings until power is stabilized.

Positioner input, actuator pressure and valve position relationships

Direct acting positioner with LINEAR characteristic

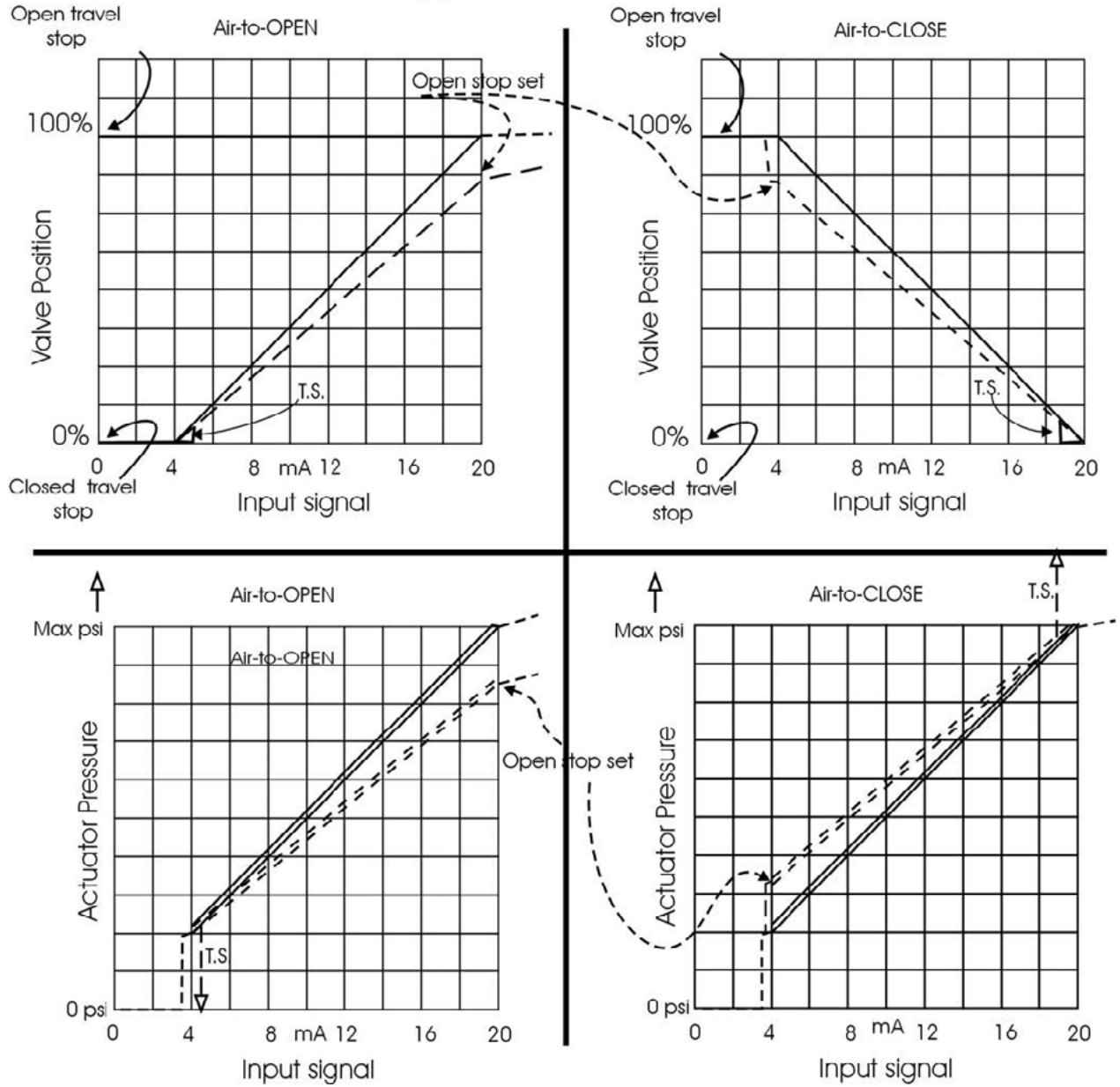


Figure 27 - ATO and ATC Action with Linear Positioner Characteristics

Positioner input, actuator pressure and valve position relationships

Direct acting positioner with EQUAL 50 characteristic

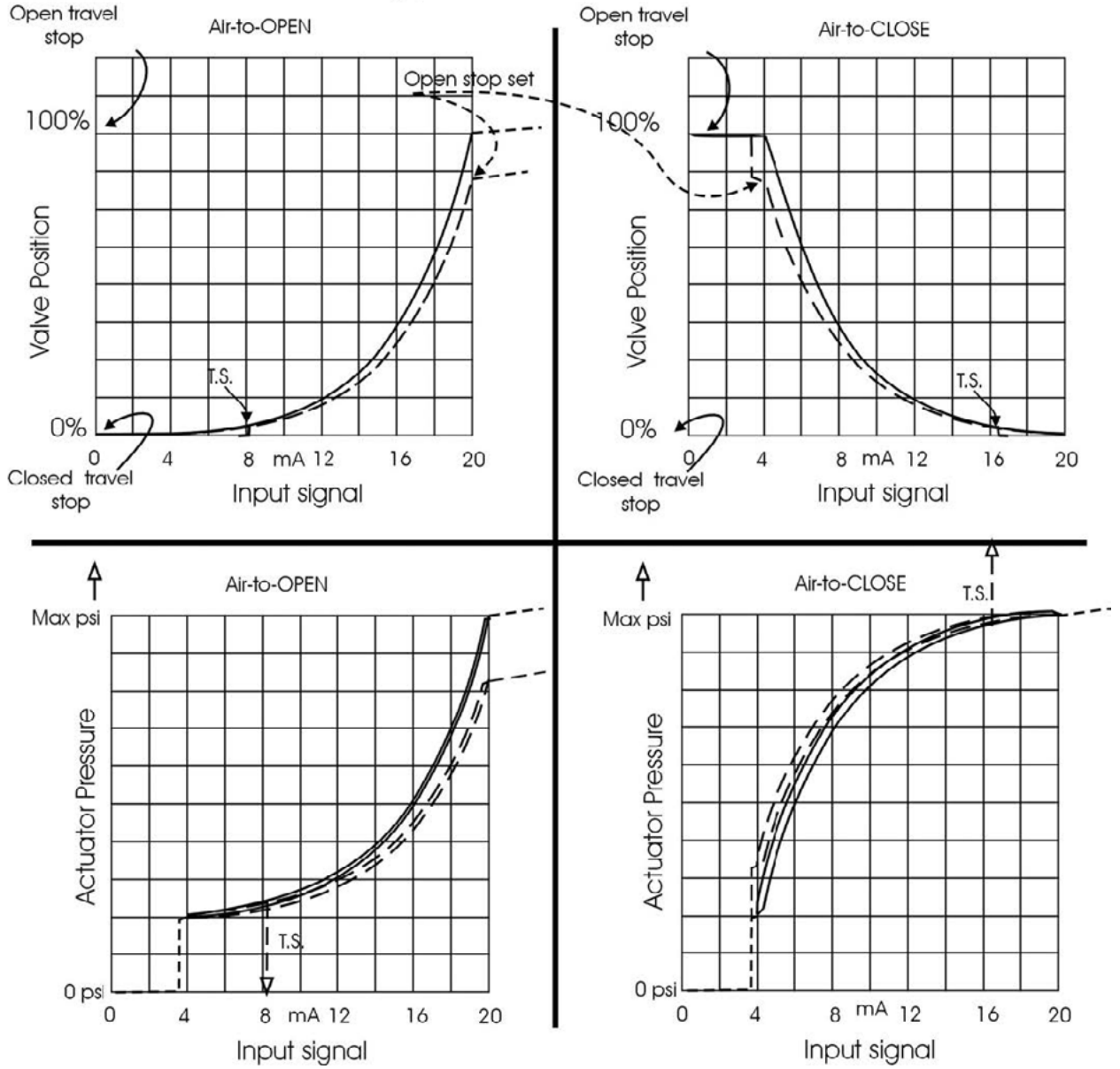


Figure 28 - ATO and ATC Action in Percentage of Positioner Characteristics

3.7.2 Before Powering Up

Before powering up the SVI3, Please ensure that all electrical and pneumatic connections are as per ES-817 SVI3 Safety Manual.

Note: For Hazardous Location Installation information refer to “Specifications and References” on page 89.

3.7.3 Powering Up the SVI3

To power up the SVI3:

1. Connect the Control Loop wiring. Refer “Connecting to the Control Loop” on page 37.
2. Adjust current to 12 mA. On initial power up of a newly installed SVI3, the positioner starts up in NORMAL mode and is operational in the default factory configuration. The following values appear:
 - POS (Position in percentage)
 - PRES: (Pressure - unit of measurement and value) •SIGNAL - Current input in mAAn exclamation point (!) in the top left corner of the display window indicates that there is further instrument status available.
3. Proceed to calibration and configuration.

Note: If the SVI3 is specified without local pushbuttons and display, local operation is not available. Configure and calibrate with SVI3 DTM with Valvue or SVI3 DD files with HART Communicator.

4. Using the Digital Interfaces

4.1 Overview

This section describes three ways to communicate, configure, and calibrate the SVI3. The Smart Valve Interface is capable of:

- Automatically calibrating end stops and tuning parameters
- Calculating, storing, and analysing advanced and online diagnostic information • Improving precision of process control
- Communicating critical information locally and remotely

The three available communication tools listed below offer increasing levels of functionality:

- Local Display and Push Buttons
- SVI3 DTM with Valvue3
- Any HART® capable host loaded with the DD for the SVI3

4.1.1 SVI3 DTM with Valvue

ValVue combines the power of the PC with the features of the SVI3 for ease of use and automation of positioner operation and full access to all data. ValVue is downloaded from the website (<https://valves.bakerhughes.com/resource-center>) and is recommended for set up, service and maintenance where a PC or laptop is permitted. The DTM will seamlessly integrate with ValVue or any FDT frame application or DTM capable asset management system.

4.1.2 SVI3 DD for HART Communicators

SVI3 DD is a Device Description file. The DD File describes the features and functions of a device such as form and content of the menus in the Handheld Communicator. SVI3 DD is available and can be downloaded from <https://valves.bakerhughes.com/resource-center> Refer “Local Interfaces and Configurations” on page 52 for more information

4.1.3 Local Display and Pushbuttons

The most basic and easiest digital interface is the local pushbutton and display option mounted on the SVI3. It is available at any time and provides immediate local access to most configuration, calibration, and fault messages. It is certified for use in approved Hazardous areas as indicated by the product label.

Additionally, in Normal mode the local display shows setpoint, pressure and position information.

4.2 Configuring and Calibrating with SVI3 DTM with Valve

ValVue is the most complete and easiest to use configuration tool. ValVue is downloaded from the website (<https://valves.bakerhughes.com/resource-center>) and provides an interface for configuring and calibrating SVI3. Use of these tools is recommended. See the SVI3 DTM Instruction Manual for the best instructions on how to configure, calibrate, and use the advanced diagnostics features of the SVI3.

4.3 Local Interfaces and Configurations

This section covers the optional local interface consisting of the LCD graphical display and pushbuttons. Operation of the SVI3 Digital Valve Positioner as a local device is controlled through the optional device-mounted pushbuttons and digital display, shown in Figure 29 on page 53. Using the display you can read the input signal, valve position, and actuator pressure and also be notified of faults/alerts within the device.





Using the pushbuttons you can exit from operating mode at any time and step through a menu structure to perform a wide range of manual operation, calibration, configuration, and monitoring functions that are described later in this section. ValVue is used to perform all diagnostics functions. The pushbuttons do not support diagnostics functions.

The SVI3 has two operational modes: NORMAL (normal operating mode) and MANUAL (manual operating mode). In Manual mode, Setup sub-menu can be used, to perform calibration and configuration activities. The SVI3 also has two modes for handling of faults and power-up: Reset and Failsafe.

The SVI3 has an additional function called *Smart Cal*. This function is available using the *Smart Cal/Back* button on the unit's front. Smart Cal configures the unit with an optimal set of operating parameters based on the valve and system configuration.

4.3.1 Pushbuttons

The local pushbuttons are located directly below the display window. The four pushbuttons perform the following functions:

-  permits you to move forward through the menu structure to the next item in the menu, or to increment the value currently shown in the digital display. When used to increase a displayed value, holding this button down causes the value to increase at a faster rate.
-  permits you to move back through the menu structure to the previous item in the menu or decrement the value currently shown in the digital display. When used to decrease a displayed value, holding the button down causes the value to decrease at a faster rate.
-  Smart Cal/Back commences the Smart Cal routine (see “FAILSAFE Menu” on page 67). Hold: Press and hold the *Smart Cal/Back* pushbutton for more than eight seconds to cancel calibration and return to the main screen. This button also has additional Back functionality. This takes you back to the top menu.
-  permits you to select or accept the value or parameter option currently displayed.

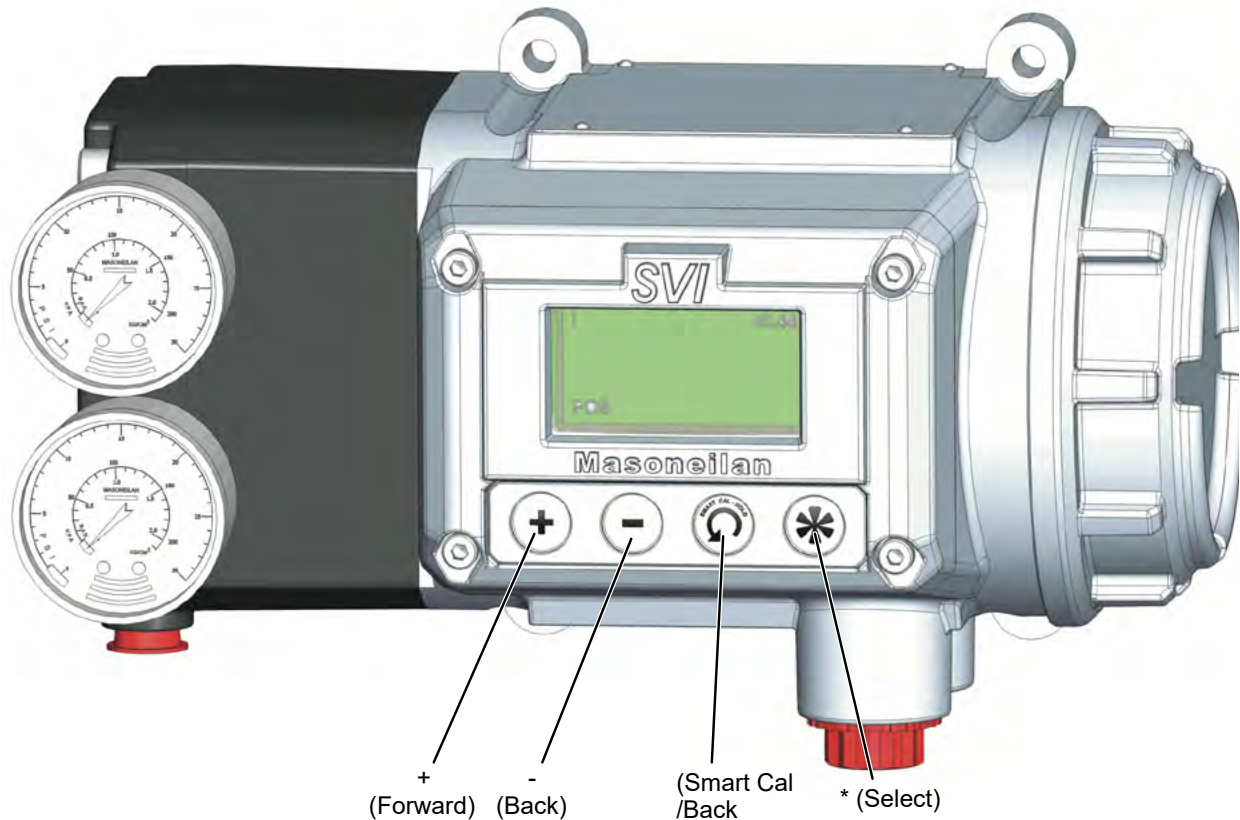


Figure 29 - SVI3 Display

Note: An exclamation point (!) in the SVI3 display window indicates that there is instrument status available.

To determine how to display and select a specific parameter value or configuration option, refer to the menu structure diagrams shown in Figure 31 on page 56 through Figure 32 on page 58. When using these diagrams as a map you can move through the menus to the function you needed.

Note: If the pushbuttons are pushed after being locked by SVI3 DTM, the message *LOCKED* appears. Refer to the SVI3 DTM Manual for instruction about unlocking the pushbuttons.

4.3.2 NAMUR Status

The SVI3 uses the industry standard NAMUR (NE 107) status signal. These signals are displayed both on the local display and within ValVue 3. All potential faults are defined in 5.2.2 Device Status Diagnostics on page 85. Each fault is defined as one of the following:





Failure	Check Function	Out of Specification	Maintenance Required
			

Figure 30 - NAMUR Icons

The definition of these Status Signals is as follows:

Failure

Output signal invalid due to malfunction in the field device or its peripherals.

Check Function:

Output signal temporarily invalid (e.g. frozen) due to ongoing work on the device.

Out of specification:

Deviations from the permissible ambient or process conditions determined by the device itself through self-monitoring or faults in the device itself indicate that the measuring un-certainty of sensors or deviations from the set value in actuators is probably greater than expected under operating conditions.

Maintenance required:

Although the output signal is valid, the wear reserve is nearly exhausted or a function will soon be restricted due to operational conditions

4.3.3 Pushbutton Locks and Configuration-Lock Jumper

Before performing any of these functions with the local display you must first ensure that the pushbuttons are placed in the unlocked mode using SVI3 DTM. The positioner ships in the unlocked mode. See SVI3 DTM Manual for more details.

The SVI3 offers several levels of plant security. It may be desirable, after initial setup, to lock the pushbuttons so that the SVI3 parameters cannot be inadvertently changed by the buttons. Several levels of software modifiable pushbutton locks are provided.

Table 7 - Pushbutton Lock Security Level

Level	Access
Security Level 3	Allow Local Buttons: Buttons on the SVI3 are fully enabled.
Security Level 2	Lock Out Local Calibration and Configuration: Use the buttons to perform operations in normal operating mode and manual mode. Access to calibrate or configure modes is not available. Manual Mode and Normal Mode can be accessed. Access to Calibrate, configure mode and Smartcal functionality is disabled.
Security Level 1	Lock Out Local Manual: Parameters in the normal mode can be accessed. Access to Calibrate, Configure and Manual mode along with Smartcal is disabled. Note that if this level is set while the device is in setup mode, it will remain unlocked till device is put back to normal mode.
Security Level 0	Lock Out All Buttons: The buttons are disabled.

4.3.4 Hardware Configuration Lock

Additional security is achieved using the hardware configuration-lock jumper shown in Figure 17 on page 38. When set to lock position, shorting the two-pin header, configuration and calibration are not permitted by the local interface or by remote communications including Pushbuttons, ValVue and handhelds. This is similar to Security Level 1 shown in the Pushbutton Lock Security Level table. Still access to view normal mode parameters are allowed.

4.3.5 Perform Smart Cal

SMART CAL is a single button calibration sequence which will setup the SVI3 for most valves. By executing this sequence, the SVI3 will automatically calibrate the travel range, and automatically tune itself for optimal process control of the valve. For advanced setup, proceed to utilize the embedded menus in section 4.3.3 Calibration Menu

1. Ensure you are on the Main screen for MANUAL or NORMAL mode.
2. Press and hold the *SMART CAL* pushbutton. It must be held for a minimum of three seconds and a maximum of seven.

Hold for the Smart Cal immediately appears, followed by *Release to start the Smart Cal*.

3. Release the *Smart Cal/Back* pushbutton.

CAUTION

Calibration Moves Value

CANCEL



OK



Note: If Actuator is Air to Close (ATC), users must change action to ATC in pushbutton menu to be sure corresponding input signal (4-20mA) is scaled properly to valve position (100%-0%).

4. Press * to run the calibration and press Smart Cal/Back to cancel.
5. When Calibration runs, it should indicate the status.
6. When Calibration completes, tuneOK should appear.

4.3.6 NORMAL Operating Mode and MANUAL Mode Menus

When you leave the NORMAL mode to go to MANUAL mode the valve is placed in the last position it was in when leaving NORMAL. When in the MANUAL mode the device does not respond to the 4 - 20 mA signal. However, the SVI3 unit can still respond to HART® commands, including HART® commands to position the valve. When you switch to the VIEW DATA or VIEW ERR menus from the NORMAL operate mode menu, the valve is still in NORMAL mode and still responds to the 4 - 20 mA signal.

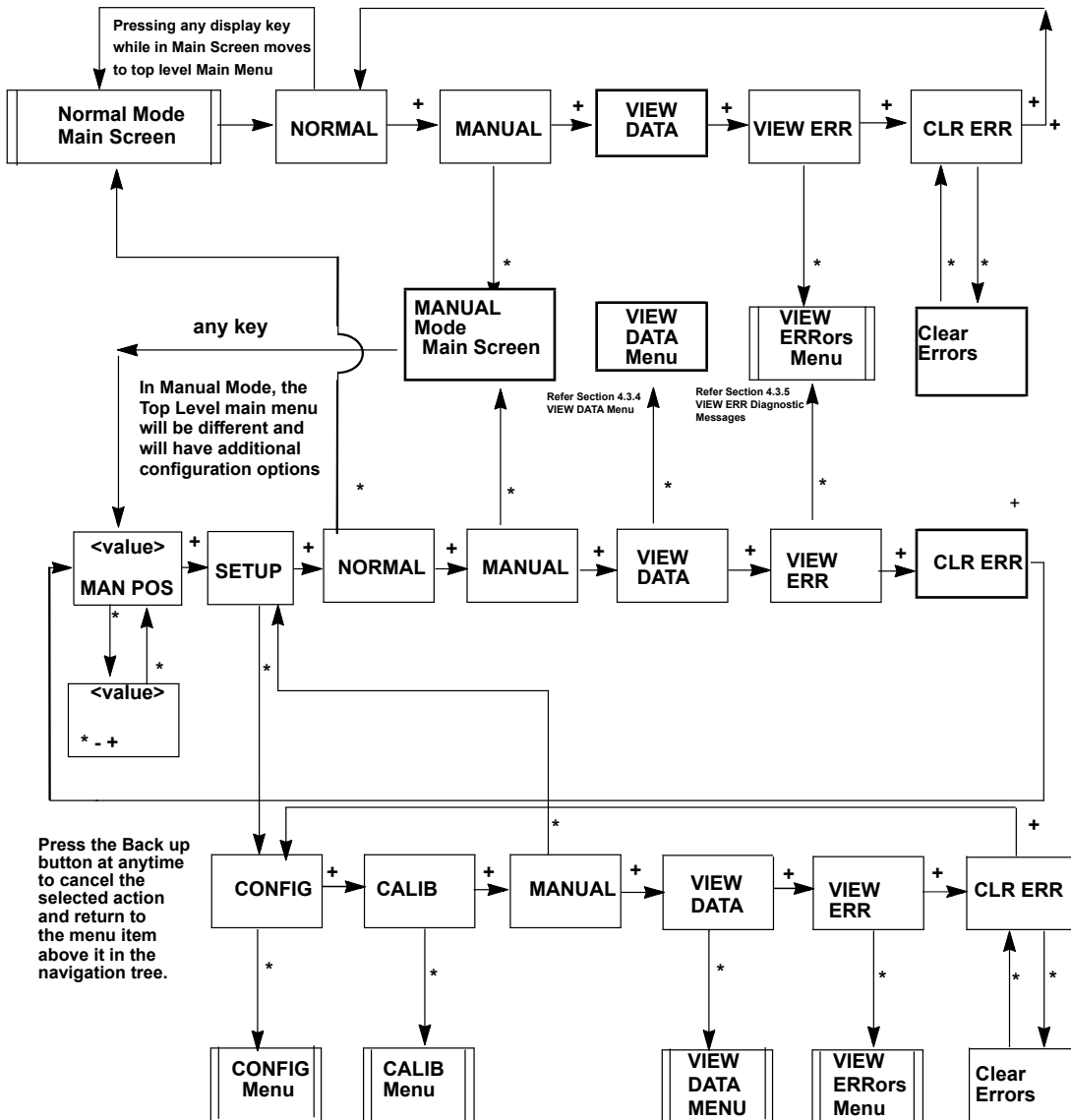


Figure 31 - NORMAL Operation and MANUAL Menu Structures

4.3.7 VIEW DATA Menu

This menu can be entered either from the MANUAL Mode menu or from the NORMAL Mode menu.

The VIEW DATA menu allows you to read the current configuration, calibration, and status information. This information cannot be changed from the VIEW DATA menu. Exiting from the VIEW DATA menu returns the previous menu.

When entered from:

- NORMAL mode, the valve still responds to changes in set point input signal and the values displayed change in accordance with changes in input signal.
- MANUAL mode, the valve is locked in position.

4.3.7.1 Viewing Configuration and Calibration Parameters

To view configuration and calibration parameters:

1. If in the *NORMAL* operating mode, press any button.
2. Press + to move through the options until you reach the VIEW DATA menu item.
3. Press * to go to *VIEW DATA* menu. (This leaves the valve in *NORMAL* mode.) If in *MANUAL* mode, press + repeatedly until the VIEW DATA menu item is reached. Press * to select the *VIEW DATA* mode.
4. To exit from the *VIEW DATA* menu, press * at any menu line. You return to the last menu displayed.

Press the Smart Cal/Back button at anytime to cancel the selected action and return to the menu item above it in the navigation tree.

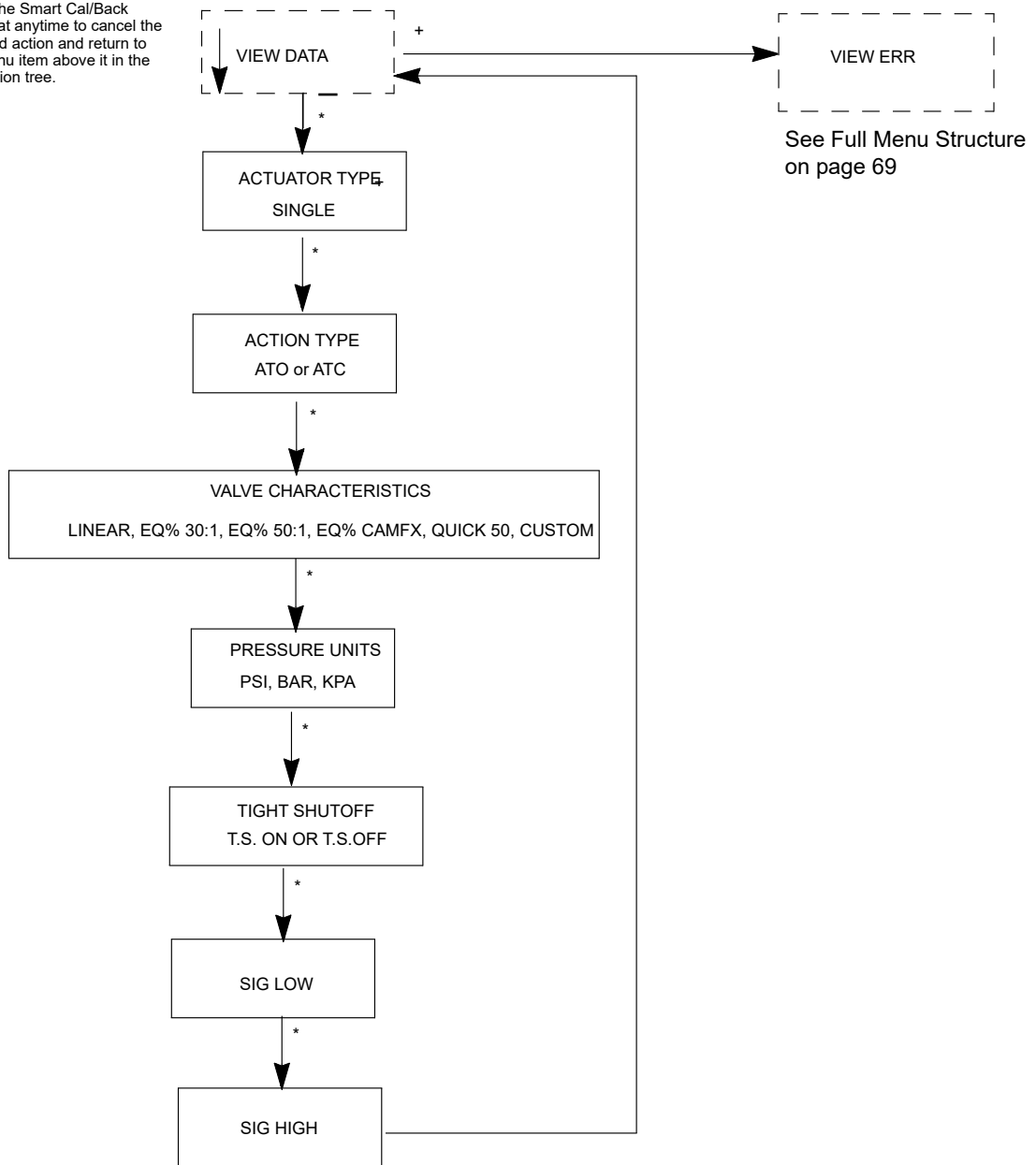


Figure 32 - VIEW DATA Menu

4.3.8 VIEW ERR Diagnostics Messages

Diagnostic messages are viewed with VIEW ERR from the MANUAL Mode menu or from NORMAL Mode menu. The VIEW ERR menu item allows you to read the current status information.

To clear the error messages:

1. Press * at CLR ERR on either the MANUAL or NORMAL mode menus. Exiting from the VIEW ERR menu returns the previous menu.

4.3.8.1 Clear Error Messages

Use this procedure, VIEW ERR, to view fault codes and messages listed in Table 10 on page 76 of this manual. This is useful when clearing a Failsafe from the pushbuttons.

1. Press + in *NORMAL* or *MANUAL* mode to move through the options until you reach the *VIEW ERR* menu item.
2. Press * to go to *VIEW ERR* menu.
3. Press * to display the list of status values.
4. Press + to move forward through the list in sequence. 5. Press – to move back through the list.
6. Press * at any status message to return to the *VIEW ERR* option in your previous mode.
7. Press + to move to *Clear ERR*.
8. Press * to clear all messages (recommended) or press + to move to the next option.

4.3.8.2 Positioner Fault Messages

Table 10 on page 76 lists the fault codes and messages that appear on the display. The table also explains the meaning of each message and a possible cause of the fault.

4.3.8.3 Return to Normal Operation

Always return the positioner to *NORMAL* operating mode to resume control by the input signal. Use this procedure to return to *NORMAL* mode from any menu.

1. Press + or - repeatedly until *MANUAL* or *NORMAL* appears.
2. Press * to return to *NORMAL* operating mode, if *NORMAL* appears.
3. Press * to return to *MANUAL* Mode menu, if *MANUAL* appears.
4. Press + repeatedly until → *NORMAL* appears.
5. Press * to return to *NORMAL* mode and normal operation.

Note: *When entered from NORMAL mode the valve still responds to changes in set point input signal and the values displayed change in accordance with changes in the input signal. When entered from MANUAL mode the valve is in locked position.*

4.3.9 Configure Menu

Because calibration depends on certain configuration options you must perform Configuration before you perform Calibration when installing the SVI3 for the first time. If a change is made in the Air-to-Open / Air-to-Close configuration option or if you move the SVI3 to a different valve or make any change to the valve position linkage, you must run the find STOPS calibration again.

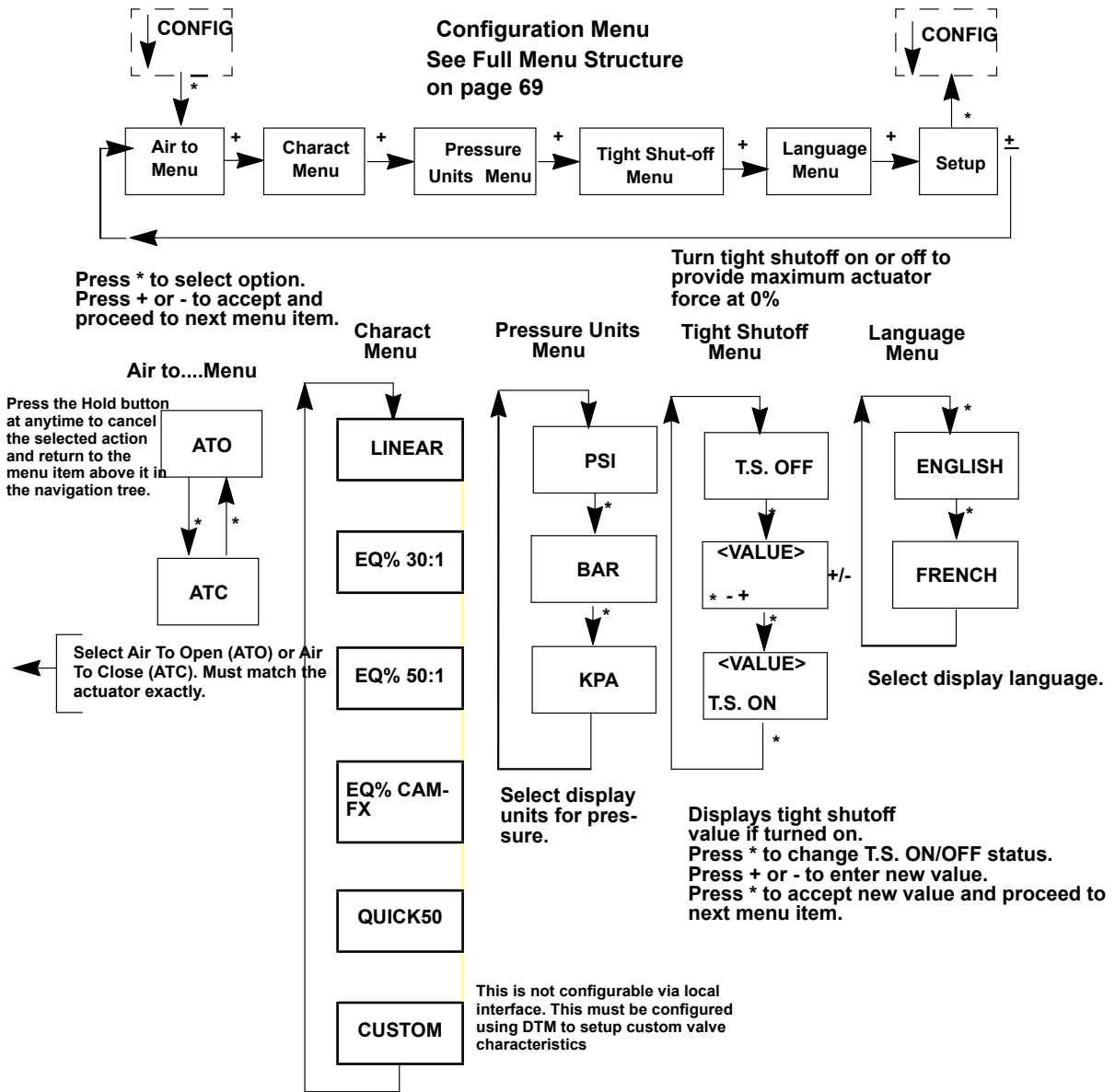


Figure 33 - Configure Menu

4.3.9.1 Valve Characteristics

The positioner must be configured to supply the correct relationship between input signal and valve position. This is called the *position characteristic*. Table 8 on page 61 lists configuring the positioner characteristics.

Use of a linear characteristic is recommended unless the process dynamics or control valve application calls for an alternate characteristic. SVI3 offers a custom characteristic for specialty applications. Prior to selection of custom, the parameters for the custom characteristic must be entered using SVI3 DTM.

Note: The characteristic configured in the positioner is applied in addition to the plug characteristic built into the valve trim. Do not configure a percentage characteristic if the valve has a percentage plug.

Table 8 - Guidelines for Characteristic Choice

Valve Type and Built In Characteristic	Desired Installed Valve Position Characteristic	Standard Positioner Characteristic Selection
Camflex	Linear	LINEAR
Camflex	Equal Percentage	EQUAL50 EQ% CAMFX (when replacing a 4700E)
Varimax	Linear	LINEAR
Varimax	Equal Percentage	EQUAL50
21000 series Model # 21X1X or 41000 series Model # 41X1X with LINEAR TRIM	Linear	LINEAR
21000 series Model # 21X1X or 41000 series Model # 41X1X with LINEAR TRIM	Equal Percentage	EQUAL50
21000 series Model # 21X2X or 41000 series Model # 41X2X with EQUAL PERCENTAGE TRIM	Linear	Not recommended
21000 series Model # 21X2X or 41000 series Model # 41X2X with EQUAL PERCENTAGE TRIM	Equal Percentage	LINEAR
Ball Valve with typical MODIFIED PERCENTAGE TRIM	Linear	Not recommended
Ball Valve with typical MODIFIED PERCENTAGE TRIM	Equal Percentage	LINEAR
Butterfly valve with typical MODIFIED PERCENTAGE TRIM	Linear	Not recommended
Butterfly valve with typical MODIFIED PERCENTAGE TRIM	Equal Percentage	LINEAR
Reciprocating valve with LINEAR TRIM	Linear	LINEAR
Reciprocating valve with LINEAR TRIM	Equal Percentage	EQUAL50
Rotary or Reciprocating valve with EQUAL PERCENTAGE TRIM	Linear	Not recommended
Rotary or Reciprocating valve with EQUAL PERCENTAGE TRIM	Equal Percentage	LINEAR

4.3.9.2 Pressure Units

Select the display units for the optional actuator pressure sensor. The available choices are PSI, BAR or KPA.

The choice applies to both the local LCD display and to the displays with SVI3 DTM or the SVI3 DD with HART Communicator.

1. Press * to move from PSI to BAR to KPA.
2. Press + to continue to scroll through the configuration menu.

4.3.9.3 Tight Shutoff

Tight Shutoff is an optional performance feature that prevents leakage at the closed position. Without this feature, at the closed position with an input signal of 0%, the valve may not be forced tight against the seat with maximum available actuator force or it may be only touching the seat with minimum force. In either case, it is under control, however unwanted leakage or premature trim wear can occur.

To prevent leakage that can occur in the second case, configure TS ON and set a value of position setpoint below which the actuator applies maximum seating force. As the position signal drops toward the TS value, SVI3 moves the valve to the TS position value. When the position reaches the TS value SVI3 applies maximum actuator force.

The TS function has 0.5% deadband to prevent chatter. If TS is set ON at 1%, for example, then the valve begins to open when the setpoint reaches 1.5%.

4.3.9.4 Configuring TS ON

1. Press * to turn TS ON.
2. Press + to increase TS.
3. Press - to decrease TS.
4. Press * when finished to return to the CONFIG menu.
The CONFIG menu displays TS ON.

4.3.9.5 Turning TS OFF

1. Press * to turn TS OFF.
2. Press + to continue scrolling through the menu.

4.3.9.6 Changing Language

The local display language can be English or French. 1. Press * to toggle from ENGLISH to FRANCAIS. 2. Press + to continue to scroll through Config menu.

4.3.10 Calibration Menu

The Calibration menu shown in Figure 34 provides access to all the calibration functions for the SVI3. If a change is made in the Air-To-Open/Air-To-Close configuration option or if you move the SVI3 to a different valve or make any change to the valve mounting kit components, you must run the find STOPS calibration again.

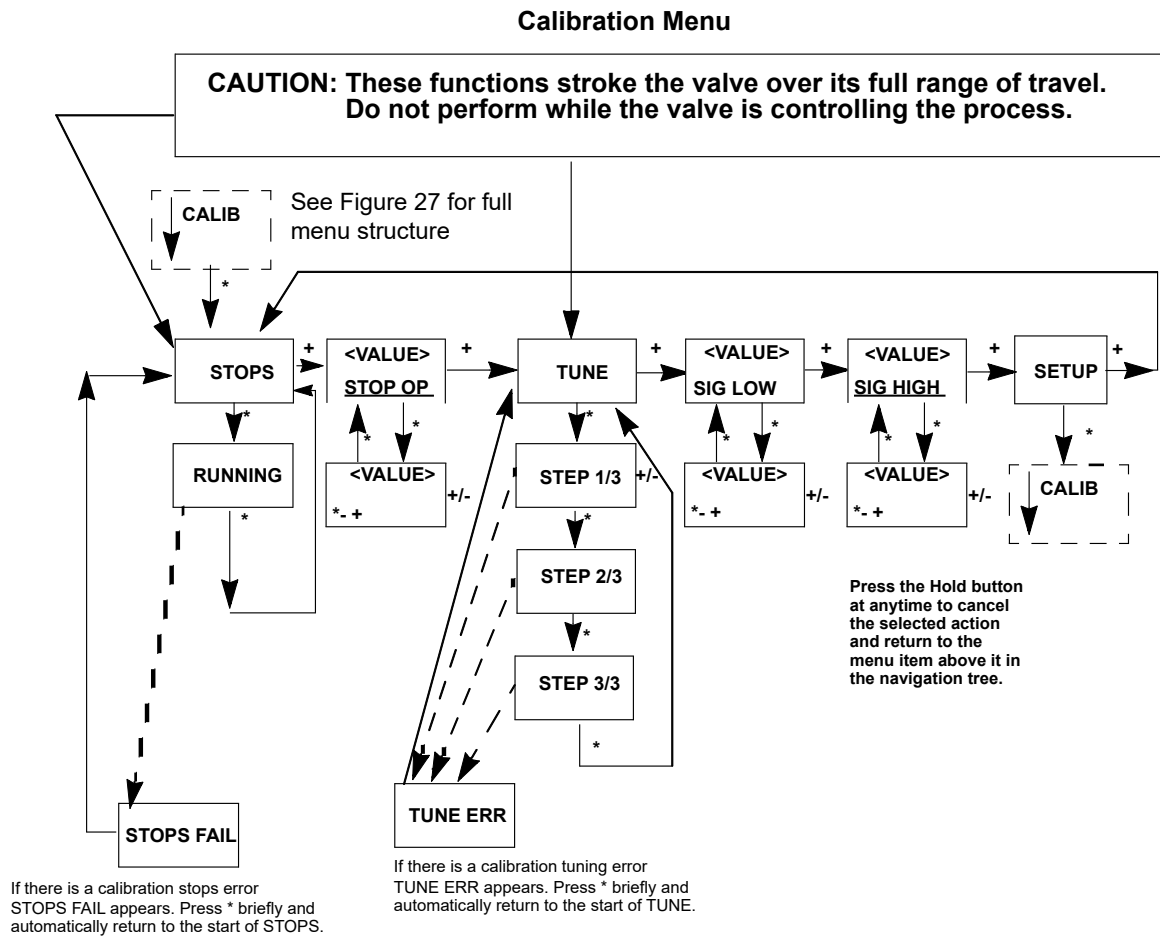


Figure 34 - Calibration Menu

1. **STOPS** - Calibrates the valve travel by moving the valve to the fully closed and fully opened positions. A find stops routine is required to be executed before the device will function, and recommended if any changes to the valve, actuator, or mounting of the SVI occur.
2. **STOP OP** - Allows for rescaling the full travel to a new open position if desired full open stroke is less than actual full open stroke (as found by Find Stop). Use +/- buttons to adjust.
3. **TUNE** - Automatically sets optimal tuning parameters for best performance of the valve system. Valve must be isolated from the process. Task is interrupted when using any button, returning the valve to starting position.
4. **SIG LOW** - Allows for rescaling the mA input signal / setpoint value (typically for split ranged devices) for 0% position. Use +/- buttons to adjust.
5. **SIG HIGH** - Allows for rescaling the mA input signal / setpoint value (typically for split ranged devices) for 100% position. Use +/- buttons to adjust.

4.3.10.1 Calibrating Travel Range using Find Stops

To calibrate the SVI3 (see Figure 34 on page 63):

1. Observe the display following power-up. The SVI3 powers up in the previously active mode either **MANUAL** or **NORMAL** (operating) mode:
 - If in **NORMAL** mode, the display alternates between *POS* and *SIGNAL* indicating Normal mode.
 - If in **MANUAL**, the display alternates between *POS –M* and *SIG* indicating **MANUAL** mode.
2. With **MANUAL** mode displayed, press * to select the **MANUAL** mode.
3. Press any key to enter **MANUAL** menu.
4. Press + to display **SETUP**.
5. Press * to enter **SETUP** mode.
6. In **SETUP** mode press * again; ↓**CONFIG** appears. Pressing + again brings ↓**CALIB**. 7. Select **CALIB** by pressing *. **STOPS** appears.
8. Press * to perform **FIND STOPS**.
The valve moves full open and back to full closed.
9. Observe all warnings.
10. Press * and the valve strokes and automatically calibrates valve travel. 11. After the **STOPS** procedure finishes, press + twice until **TUNE** appears.

4.3.10.2 Correct for Over Travel



During Calibration and Configuration the valve moves. Keep hands clear. Isolate the valve from the process. Calibration functions stroke the valve over its full range of travel.

On some valves the full travel is larger than the nominal travel of the valve and it may be desirable to have the reported 100% position correspond to the nominal travel rather than the full stroke. The STOP OP option allows this correction. Use this procedure to make a correction.

1. From CALIB press * to display *Stops*.
2. Press + to display *STOP OP*.
3. Press * to move valve to the 100% position.
4. Use the + and - buttons to position the valve to the nominal full open position. 5. Press * to accept this position as the new 100% position.

4.3.10.3 Tuning using Auto Tune

To auto tune the SVI3:

1. Press * to begin the Autotune procedure. This takes 3 to 5 minutes and strokes the valve in large and small steps to set the PID parameters for best positioning response. When Autotune proceeds, numerical messages display, indicating the procedure is working.

When Autotune is complete, TUNE appears.

2. Press + repeatedly until ↑ *SETUP* appears.
3. Press * to return to *SETUP* menu ↓ *CALIB* appears.



*DO NOT perform STOPS while the valve is controlling the process.
DO NOT perform Auto Tune while the valve is controlling the process.*

4. If TuneERR appears after autotune completes, manual tuning may be required. Refer to section 7.2 "Troubleshooting Autotune" on page 102 to assist in troubleshooting a TuneERR.

4.3.11 Adjust Input Signal Range

SIG LO displays the input signal that corresponds to the full closed (ATO) or full open (ATC) position of the valve.

1. If the displayed value is:
 - Correct, press + to advance to the next item.
 - Not correct, press * to display value of SIG LO.

2. Use + and – buttons to change the value.
3. Press * to return to menu and move to next item. SIG LO must be between 3.8 and 14.0 mA.
4. *SIG HI* displays the input signal that corresponds to the full open, ATO, or full closed, ATC position.
5. If the displayed value is:
 - Correct, press + to advance to the next item.
 - Not correct, press * to display value of *SIG HI*.
6. Use + and – buttons to change the value.
7. Press * to return to menu and move to next item. *SIG HI* must be between 8.0 and 20.2 mA. SIG HI must be larger than SIG LO by at least 5 mA. Calibration of the positioner is now complete.

Note: *SIG HI* and *SIG LO* allow adjustment of the input current range that corresponds to full valve travel. Normally they are set to 4 and 20 mA. Adjustment is normally required only for split range applications and provides flexibility for unusual applications. A separate ValVue calibration procedure enables adjustment of the current sensing circuit to a precision current reference standard.

4.3.12 FAILSAFE Mode

FAILSAFE mode cannot be selected from any of the previous menus. FAILSAFE mode and display are initiated by detection of a critical fault in the positioner or the valve system. There are two ways to deal with a FAILSAFE condition: correct the problem and clear the error messages *or* run through the FAILSAFE menu, view error messages, enter MANUAL mode and RESET. *RESET* restarts operation.

When failsafe occurs:

1. Press + to move to *VIEW ERR*.
2. Press * to view the first error message. Press + to scroll through all fault messages.
3. Correct the cause of the problem [Refer “Device Status Diagnostics” on page 76] and press + to move to *CLR ERR*.
4. Press * to remove all error messages from memory.
5. Move to the *MANUAL* menu. If you have cleared the errors *RESET* no longer appears.

or

1. Press + to move to *VIEW ERR*.
2. Press * to view the first error message. Press + to scroll through all the fault messages in turn.
3. Move to *MANUAL* menu and enter Manual mode.
4. Select RESET to start the valve from its failsafe condition.
5. Identify and correct errors and select RESET to return to the prior mode (without removing error messages from memory).

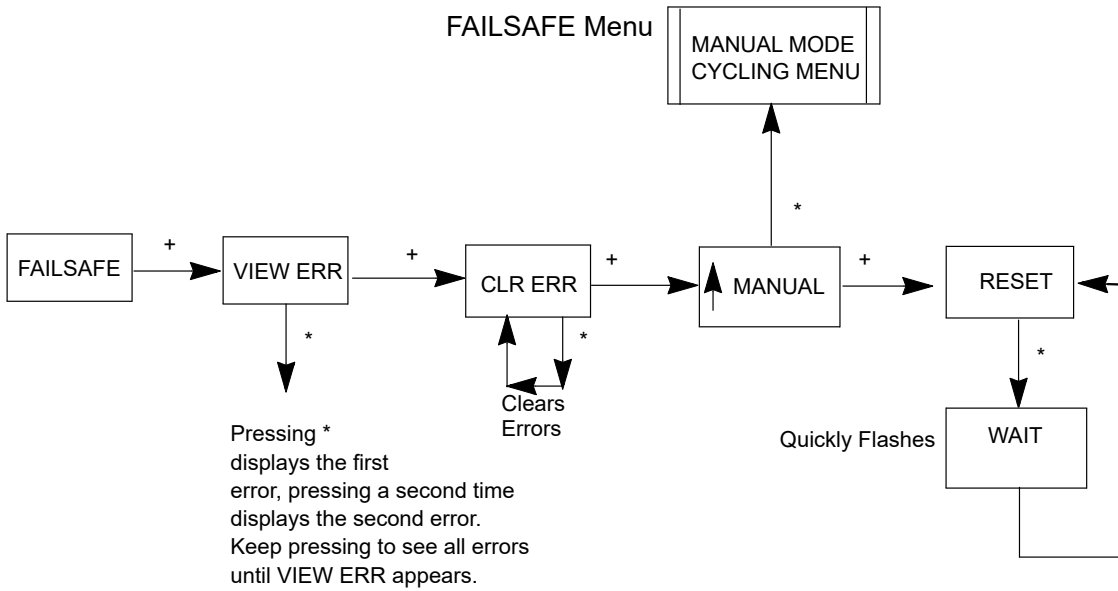


Figure 35 - FAILSAFE Menu

To prevent the valve from moving after reset, put the controller in manual, and set the valve position setpoint to the failsafe position 0% if ATO, 100% if ATC. You can set a special case of FAILSAFE. You can set a Position Error Band and a Position Error Time 2 that forces the valve to its failsafe position if the position error exceeds the band for a time longer than time 2. This can be used on critical loops to force the process to trip if the positioner is unable to control the valve.

4.4 Check-out with SVI3 DD using HART Communications

For communication to a HART® device, there is a Device Description Language. A Device Description, DD, is published by registration with the FieldComm™ Group. When the DD is installed in a host communication device then the host can readily access all the information in the smart field device. The SVI3 DD can be obtained from the website or by contacting your local representative

This section covers a subset of the functions available with HART® using DD interface. If the SVI3 is not configured with DTM and ValVue, and not equipped with the local pushbuttons/display, then the DD interface can be used to perform configuration and calibration routines.

Connect the HART® Handheld Communicator or HART capable host system to the SVI3 as shown in Figure 36 on page 68. Refer to the product manual for the HART® Communicator included with the GE DPI620 or other HART® communication devices.

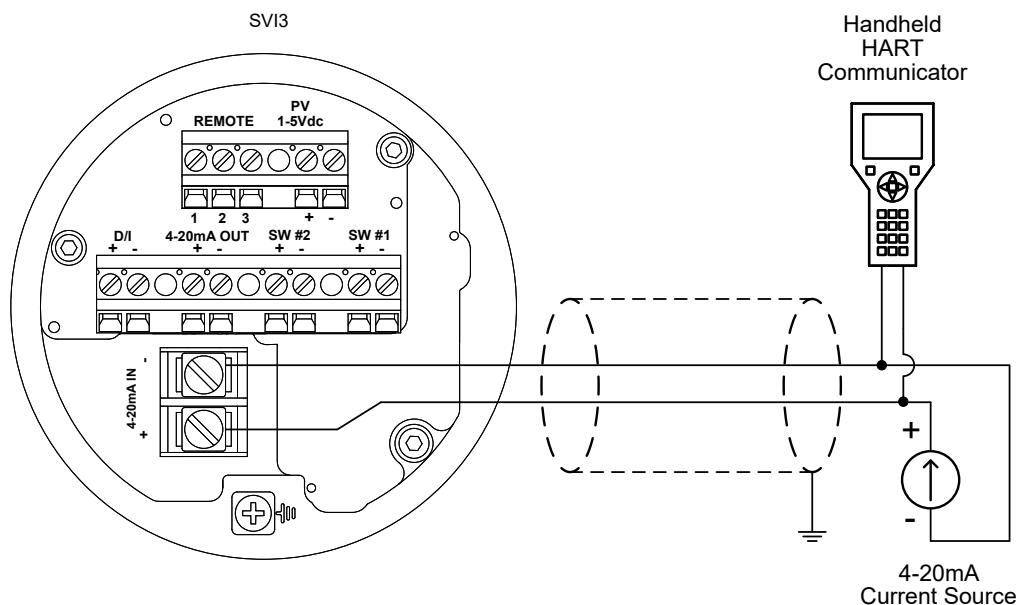


Figure 36 - SVI3 HART® Communicator Connections



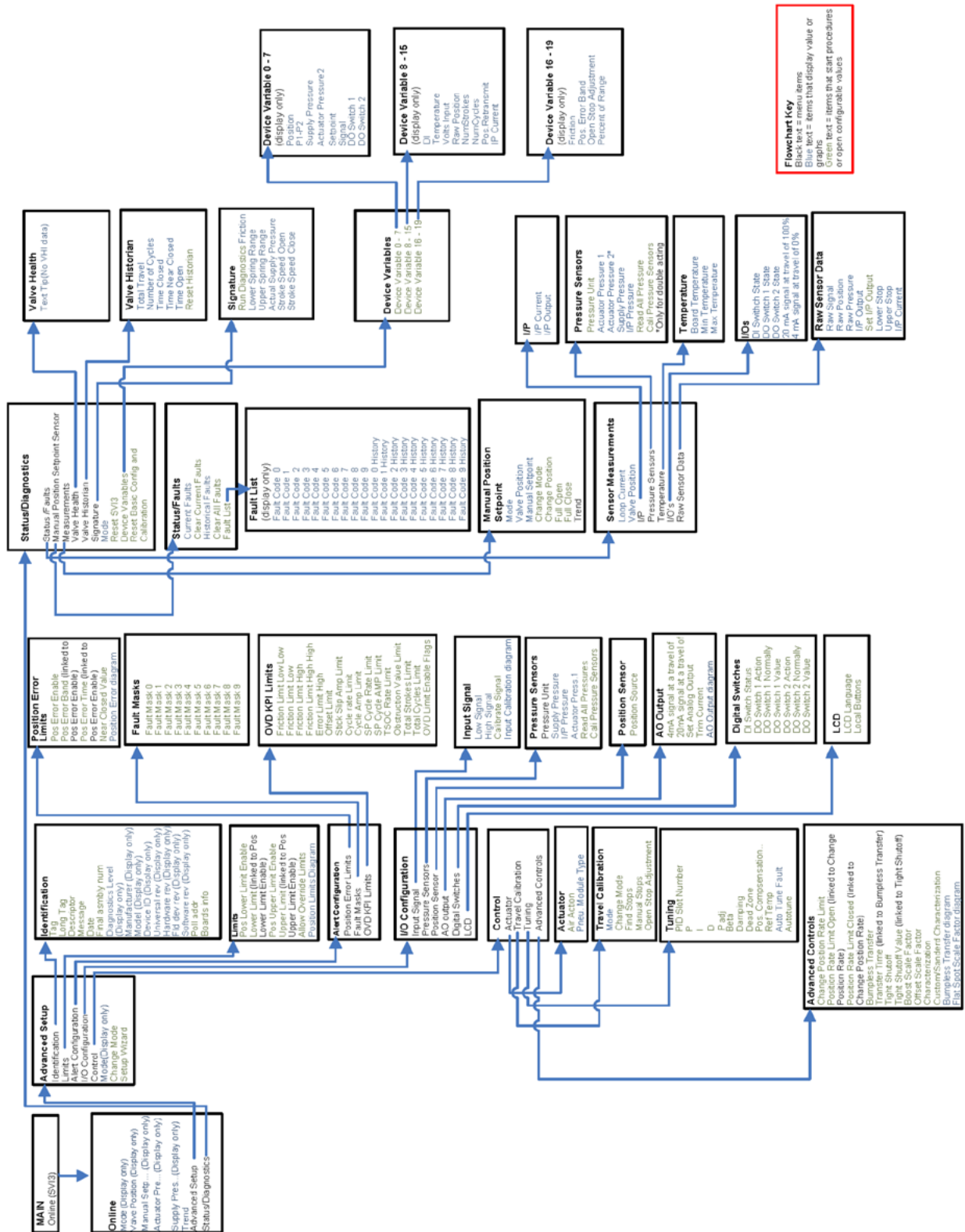
Do not connect a HART® modem and PC to a control circuit unless the controller is HART compatible or has a HART® filter. Loss of control or a process upset may occur if the controller output circuit is not compatible with HART® signal.



Do not connect a PC or HART® modem to an intrinsically safe circuit except on the safe area side of the barrier. Do not operate a PC in a hazardous area without compliance to local and plant regulations.

4.4.1 SVI3 DD Menu Structure

The menu structure shown below starts in the upper left hand corner of the card.



4.4.2 Run Auto Tune

1. Open *HART* screen and tap Online.
2. Tap Device Setup.
3. Tap Manual Setup.
4. Tap Change Mode and change mode to *Setup*.
5. Tap back arrow.
6. Tap Auto Tune. You are led through a series of screens run the process.
7. Tap Change Mode and change back to desired mode.

4.4.3 Run Find Stops

1. Open *HART* screen and tap Online.
2. Tap Device Setup.
3. Tap Manual Setup.
4. Tap Change Mode and change mode to *Setup*.
5. Tap back arrow.
6. Tap Find Stops. You are led through a series of screens run the process.
7. Tap Change Mode and change back to desired mode.

4.4.4 Run Open Stop Adjustment

1. Open *HART* screen and tap Online.
2. Tap Device Setup.
3. Tap Calibration.
4. Tap Valve Travel.
5. Tap Change Mode and change mode to *Setup*.
6. Tap back arrow.
7. Tap Open Stop Adjustment. You are led through a series of screens run the process.
8. Tap Change Mode and change back to desired mode.

4.4.5 Run Diagnostics

1. Open *HART* screen and tap Online.
2. Tap Status/Diagnostics.
3. Tap Signature.
4. Tap Run Diagnostics. You are led through a series of screens run the process.

4.4.6 View and Clear Faults

1. Open *HART* screen and tap Online.
2. Tap Status/Diagnostics.
3. Tap Status/Faults.

On this screen you can tap:

- Current Faults to view only active faults.
 - Clear Current Faults to clear the faults. The faults will reoccur if the cause is not fixed.
 - Historical Faults to view all faults current and past.
 - Clear All Faults to clear current and historical faults.
4. Tap Fault List to view the full fault code list.

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5. Maintenance and Troubleshooting

Check for any damage to the flameproof connections or housing, cracks in the housing or openings in the connections. Notify the manufacturer in case of any damage. Do not exceed the maximum pressure on the nameplate of valves and pneumatic positioners as personal injury and equipment failure may result.

5.1 SVI3 Maintenance and Repair

The SVI3 was designed based on a modular concept. Most sub-assemblies are interchangeable allowing for easy, quick component swapping.

The only maintenance procedures recommended for the SVI3 are:

- Remove and install the cover, for upgrade to display
- Remove and install the Pneumatics Module (containing the IP and Pneumatic relay)
- Addition or replacement of the Options board

5.1.1 Repair

Only qualified service personnel are permitted to make repairs.

Only parts supplied by the factory are permitted. This includes not only the major assemblies but also mounting screws and O-rings. No substitutions with non-Masoneilan parts are permitted.

Repair and replacement instructions are sent in the box with the appropriate kit.

Note: Substitution of components can void safety approvals.

5.1.2 Spare Parts

Table 9 - Spare Parts

Part Number	Description
720085945-999-0000	SVI3 Conduit Entry Plug Spare Part Kit
720085946-999-0000	SVI3 Threaded End Cover Spare Part Kit
720083046-999-0000	SVI3 Option Module Spare Part Kit Standard Construction
720083047-999-0000	SVI3 Option Module Spare Part Kit Construction – Low Temperature
720083048-999-0000	SVI3 Pneumatic Module Spare Part Kit Standard Construction
720083049-999-0000	SVI3 Pneumatic Module Spare Part Kit Construction – Low Temperature
720083057-999-0000	SVI3 User Interface Spare Part Kit Construction
720083059-999-0000	SVI3 Blank Bezel Spare Part Kit Construction
721004398-999-0000	SVI3 Spare Part Electronics Module Kit, Standard Diagnostics Standard Temperature
721004399-999-0000	SVI3 Spare Part Electronics Module Kit, Standard Diagnostic low Temperature
721004397-999-0000	SVI3 Spare Part Electronics Module Kit, Advanced Diagnostic Standard Temperature
721004396-999-0000	SVI3 Spare Part Electronics Module Kit, Advanced Diagnostic Low Temperature
721004400-999-0000	SVI3 Spare Part Electronics Module Kit, Online Valve Diagnostics Standard Temperature
721004402-999-0000	SVI3 Spare Part Electronics Module Kit, Online Valve Diagnostics Low Temperature
721003268-999-0000	Exhaust Routing Manifold Kit, SVI3
721007469-999-0000	SVI3 Marine Threaded End Cover Spare Part Kit
721007470-999-0000	SVI3 Marine Pneumatic Module Spare Part Kit Standard Construction
721007471-999-0000	SVI3 Marine Pneumatic Module Spare Part Kit Construction - Low Temperature
721007472-999-0000	SVI3 Marine User Interface Spare Part Kit Construction
721007473-999-0000	SVI3 Marine Blank Bezel Spare Part Kit Construction

SVI3 Options Module Replacement



SVI3 User Interface Kit Replacement



SVI3 Threaded end cover Replacement



SVI3 Pneumatic Module Replacement Standard temperature Low (Arctic) temperature



SVI3 Conduit Entry Plug Replacement



SVI3 Electronics Module Replacement Standard temperature Low (Arctic) temperature



5.2 Internal Diagnostics

The SVI3 performs internal self-diagnostics and hardware checks. When ValVue or HART® handheld or the local display indicates that there are error messages, then use the following sections to support troubleshooting

5.2.1 Device Status Diagnostics

Table 10 lists the faults, types, possible causes and possible resolutions.

Table 10 - Device Status Diagnostics

Sequence	Byte #	Bit	CMD48 String	DD Text	NAMUR NE107 fault Category	Automatically cleared:	Can be cleared:	Persists across resets:	Cause	Recommended Actions
1	0	0	RESET	Reset	N/A - Information only.	No	Yes	N/A	N/A	No Action.
2	0	1	LOW_POWER	Low Power	Check Function	Yes, when Input current > 3.25 mA	No	No	Input current < 3.15 mA	increase input current > 3.25 mA
3	0	2	ACTUATOR	Actuator Error	Maintenance	Yes; When it detect the condition changes	Yes	No	Unable to position the valve normally. This happens when the integral control is fully saturated for more than 20 Seconds.	<ol style="list-style-type: none"> 1. Check for sufficient air pressure (upper spring range + 10psi) 2. Check for blockage of valve, hand wheel, etc 3. Check for Valve/Actuator Mounting problems 4. Check for air Valve/Actuator Mounting in the positioner actuator system
4	0	3	AIR_SUPPLY_LOW	Low Air Supply Warning	Maintenance	Yes; If no longer detected	Yes	No	Air supply is not turned on or is set below 10 psig.	Increase air supply above spring final value + 10 psig

Table 10 - Device Status Diagnostics (Continued)

Sequence	Byte #	Bit	CMD48 String	DD Text	NAMUR NE107 fault Category	Automatically cleared:	Can be cleared:	Persists across resets:	Cause	Recommended Actions
5	0	4	POSITION_ERROR	Position Error	Maintenance	Yes; If the position error inside the error band	Yes	No	The Valve position feedback does not fall within the user defined T1 value and duration. When T1 is not configured, This fault is not triggered.	<ol style="list-style-type: none"> 1. Check for sufficient air pressure (upper spring range + 10psi) 2. Check for blockage of valve, hand wheel, etc 3. Check for Valve/Actuator Mounting problems 4. Check for air leakage in the positioner actuator system
6	0	5	PNEU_RESET	Pneumatic Module Reset	Maintenance	No	Yes	No	This is triggered when pneumatic module resets and this usually happens when there is a problem in the pneumatic module cable.	<ol style="list-style-type: none"> 1. Check Pneumatics module for loose cabling. 2. Replace Pneumatics Module with known good Pneumatics Module
7	0	6	KEYPAD	Keypad Fault	Maintenance	Yes	Yes	No	Pushbutton failure	<ol style="list-style-type: none"> 1. Check UI module for stuck push buttons and potential foreign objects. 2. Replace UI Module with known good UI Module
8	0	7	MARGINAL_POWER	Marginal Power	Check Function	Yes	Yes	No	Input current < 3.75 mA	<ol style="list-style-type: none"> 1. Increase input current > 3.85 mA. Compare signal to lcd display.
9	1	0	CALIBRATION_FAILED	Calibration Failed	Maintenance	No	Yes	No	Check calibration of the mA input signal sensor or pressure sensors was outside the acceptable range when attempting to calibrate.	<p>Double check that you are calibrating the correct channel, either 4-20ma INPUT or Pressure Sensor. Double check difference between calibrated value and actual</p>

Table 10 - Device Status Diagnostics (Continued)

Sequence	Byte #	Bit	CMD48 String	DD Text	NAMUR NE107 fault Category	Automatically cleared:	Can be cleared:	Persists across resets:	Cause	Recommended Actions
10	1	1	FIND_STOPS_FAILED	Find Stops Failed	Maintenance	Yes, if the "find stops" process succeeds	Yes	No	<ol style="list-style-type: none"> 1. When calibrating stops (Zero / Span) the travel sensor moved outside the acceptable limits. 2. Boosters might be insufficient for large actuator used. 3. Takes more than 3 minutes to move the actuator to requested position. 4. Valve position could not stabilize when deenergizing or when energizing the actuator. 	<ol style="list-style-type: none"> 1. Check for correct magnet orientation and linkages 2. Check if the boosters used are sufficient for the size of actuator used. 3. Check the pneumatic plumbing for air leakage.
11	1	2	AUTOTUNE_FAILED	Autotune Error	Check Function	Yes, if the "self-tune" process succeeds	Yes	No	<p>Device could not tune automatically, need to manually tune system</p>	<ol style="list-style-type: none"> 1. Increase air supply above spring final value + 10 psig 2. Check for air leaks and sufficient current applied to 4-20ma input 3. Refer Section 7.2 Troubleshooting Autotune
12	1	3	STD_DIAGNOSTICS_FAILED	Std Diagnostics Failed	N/A Information Only	Yes, if the "std diagnostics" process succeeds	Yes	No	<p>When running a Standard Actuator Signature, the SVI did not move the valve between 10 % to 90%.</p>	<ol style="list-style-type: none"> 1. Selected speed is too slow. Increase speed for the test by 1. 2. Insufficient air supply, increase air supply 3. Check for limits (tight shutoff, etc)

Table 10 - Device Status Diagnostics (Continued)

Sequence	Byte #	Bit	CMD48 String	DD Text	NAMUR NE107 fault Category	Automatically cleared:	Can be cleared:	Persists across resets:	Cause	Recommended Actions
13	1	4	EXT_DIAGNOSTICS_FAILED	Ext Diagnostics Failed	N/A Information Only	Yes, before a run of an "ext diagnostics" process	Yes	No	When running a Extended Actuator Signature, SVI did not move the valve between the configured travel parameters (i.e. 5 to 95%)	<ol style="list-style-type: none"> 1. Selected speed is too slow. Increase speed for the test by 1. 2. Insufficient air supply, increase air supply 3. Check for limits (tight shutoff, etc)
14	1	5	RTOS_SCHEDULING	Operating System Fault	Failure	No	Yes	No	An internal condition from which the device recovered automatically	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persists, replace the complete device or electronics module
15	1	6	PNEU_TEMPERATURE_SENSOR	Pneu. Temp. Sensor	Failure	No	Yes	No	Temperature Sensor indicates pneumatic module temperature out of range (-55°C to 85°C)	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persists, replace the complete device or Pneumatics module
16	1	7		Reserved (1-7)	N/A - Information only.				N/A	Reserved
17	2	0	BIAS_OUT_OF_RANGE	Bias Out Of Range	Maintenance	Yes	Yes	No	The Fault is set instantaneously when I/P drive current at outside of expected range (10k to 35k counts)	<ol style="list-style-type: none"> 1. Check for sufficient air pressure (upper spring range + 10psi) 2. Check for blockage of valve, hand wheel, etc 3. Check for Valve/Actuator Mounting problems 4. Check for air leakage in the positioner actuator system
18	2	1	IP_OUT_OF_RANGE	I/P Out Of Range	Failure	No	Yes	No	This happens usually when the connection between the IP Unit and Pneumatic module fails. When this is triggered, the valve is driven to failsafe.	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persists, replace the complete device or electronics module

Table 10 - Device Status Diagnostics (Continued)

Sequence	Byte #	Bit	CMD48 String	DD Text	NAMUR NE107 fault Category	Automatically cleared:	Can be cleared:	Persists across resets:	Cause	Recommended Actions
19	2	2	UI_RESET	UI Module Reset	Maintenance	No	Yes	No	UI Module Reset	1. Check UI module for reset state. 2. Replace UI Module with known good UI Module
20	2	3	PNEU_REF_VOLTAGE_	Pneumatic module Vref Failure	Failure	No	Yes	No	Hardware Failure	1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persist, replace the complete device or Pneumatucs module
21	2	4	OPT_REF_VOLTAGE_FAILURE_	Options module Vref Failure	Failure	No	Yes	No	Hardware Failure	1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persist, replace the complete device or Options module
22	2	5	OPT_REF_VOLTAGE_	Options module Vref error	Failure	No	Yes	No	Hardware Failure	1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persist, replace the complete device or Options module
23	2	6	OPT_TEMPERATURE_SENSOR_FAILED	Options temp. sensor Failure	Failure	No	Yes	No	Options Module Temperature Sensor Out of range. This fault is applicable only when the RPS or PV is configured as the position source. The device will go to failsafe.	1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persist, replace the complete device or Options module
24	2	7	OPT_TEMPERATURE_SENSOR	Options temp. sensor error	Maintenance	No	Yes	No	Options Module Temperature Sensor Out of range(-55°C to 85C).	1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persist, replace the complete device or Options module

Table 10 - Device Status Diagnostics (Continued)

Sequence	Byte #	Bit	CMD48 String	DD Text	NAMUR NE107 fault Category	Automatically cleared:	Can be cleared:	Persists across resets:	Cause	Recommended Actions
25	3	0	NVM_CHECKSUM	NVM Checksum Failure	Failure	No	No	No	Firmware Data Test Failure	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persists, replace the complete device or electronics module
26	3	1	RAM_CHECKSUM	RAM Checksum Error	Failure	No	Yes	No	Firmware Data Test Failure	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persists, replace the complete device or electronics module
27	3	2	FW_CHECKSUM	Flash Checksum Failure	Failure	No	No	No	Firmware Data Test Failure	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persists, replace the complete device or electronics module
28	3	3	STACK	Stack Error	Failure	No	Yes	No	Firmware Failure	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persists, replace the complete device or electronics module
29	3	4	FACTORYWRITE	Factory Write Indicator	Failure	No	Yes	No	Mode allowed only for flashing firmware upgrade.	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persists, replace the complete device or electronics module
30	3	5	NVM_TEST	NVM Test Error	Failure	No	Yes	No	Data Storage Self Test Failure.	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persists, replace the complete device or electronics module
31	3	6	OPTION_RESET	Options Module Reset	Maintenance	No	Yes	No	Options Module Reset	<ol style="list-style-type: none"> 1. Check Options module for reset state. 2. Replace Options Module with known good Options Module

Table 10 - Device Status Diagnostics (Continued)

Sequence	Byte #	Bit	CMD48 String	DD Text	NAMUR NE107 fault Category	Automatically cleared:	Can be cleared:	Persists across resets:	Cause	Recommended Actions
32	3	7		Reserved	N/A - Information only.				N/A	Reserved
33	4	0	REF_VOLTAGE	Ref Voltage Failure	Failure	No	Yes	No	Hardware Failure	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persists, replace the complete device or electronics module
34	4	1	POSITION_SENSOR	Position Sensor Failure	Failure	No	Yes	No	Internal positioner sensor not reading proper values	<ol style="list-style-type: none"> 1. Use ValVue to confirm selection of proper travel sensor. 2. Ensure that the mounting kit magnets are moving only +/-65 degrees (sensor should read between -10k to 10k counts w/ no jumps i.e. while traveling in one direction reading -8000cnts, -9900cnts then reading +10,000 cnts) 3. If using remote verify that it is powered and wiper is connected, verify wiper voltage between 0 and 1.25 volts 4. If correct sensor selected, replace electronics module and report the problem at svisupport@bakerhughes.com
35	4	2	CURRENT_SENSOR	Current Sensor Failure	Failure	No	Yes	No	4-20mA input sensor failure detected	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persists, replace the complete device or electronics module
36	4	3	TEMPERATURE_SENSOR	Temperature Sensor Failure	Failure	No	Yes	No	Main Electronics Temperature Sensor failure detected w	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persists, replace the complete device or electronics module
37	4	4		Reserved						Reserved

Table 10 - Device Status Diagnostics (Continued)

Sequence	Byte #	Bit	CMD48 String	DD Text	NAMUR NE107 fault Category	Automatically cleared:	Can be cleared:	Persists across resets:	Cause	Recommended Actions
38	4	5	PRESSURE1	Pressure 1 Fault	Maintenance	No	Yes	No	Output Pressure Sensor 1 Failure or Out of range. This happens when overpressure is applied or Sensor is damaged	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persists, replace the complete device or electronics module
39	4	6	PRESSURE2	Pressure 2 Fault	Maintenance	No	Yes	No	Output Pressure Sensor 2 Failure or Out of range. This happens when overpressure is applied or Sensor is damaged	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persists, replace the complete device or electronics module
40	4	7	PRESSURE3	Pressure 3 Fault	Maintenance	No	Yes	No	Supply Pressure Sensor Failure or Out of range. This happens when overpressure is applied or Sensor is damaged	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persists, replace the complete device or electronics module
41	5	0	PRESSURE4	I/P Pressure Sensor Failure	Failure	No	Yes	No	I/P Pressure Sensor Failure or Out of range. This happens when overpressure is applied or Sensor is damaged	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persists, replace the complete device or electronics module
42	5	1	PRESSURE5	Atmospheric Pressure Sensor Fault	Maintenance	No	Yes	No	Atmospheric Pressure Sensor Failure This happens when Sensor is damaged	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persists, replace the complete device or electronics module

Table 10 - Device Status Diagnostics (Continued)

Sequence	Byte #	Bit	CMD48 String	DD Text	NAMUR NE107 fault Category	Automatically cleared:	Can be cleared:	Persists across resets:	Cause	Recommended Actions
43	5	2	OPTION_CHECKSUM_FAILED	Options F/W image Failure	Failure	No	Yes	No	Options Module Firmware image Failure	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persist, replace the complete device or Options module
44	5	3	NVM_WRITE	NVM Write Fault	Failure	No	Yes	No	Hardware Failure	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persist, replace the complete device or electronics module
45	5	4	IRQ_FAULT	IRQ Fault	Failure	No	Yes	No	Hardware Failure	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persist, replace the complete device or electronics module
46	5	5	OPTION_NO_TC_TABLE_FAILED	Options TempComp Failure	Failure	No	Yes	No	Firmware Failure Option Module Tempcomp table not programmed/Not readable	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persist, replace the complete device or Option module
47	5	6	SELF_CHECK	MCU Internal Malfunction	Failure	No	Yes	No	Main Controller Self Test Failure	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persist, replace the complete device or electronics module
48	5	7	SOFTWARE	Software Error	Failure	No	Yes	No	Firmware Failure	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persist, replace the complete device or electronics module
49	6	0	PNEU_COMMS_ERROR	Pneumatics comm. error	Maintenance	Yes	Yes	No	Hardware Failure	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persist, replace the complete device or Pneumatics module

Table 10 - Device Status Diagnostics (Continued)

Sequence	Byte #	Bit	CMD48 String	DD Text	NAMUR NE107 fault Category	Automatically cleared:	Can be cleared:	Persists across resets:	Cause	Recommended Actions
50	6	1	PNEU_FAILED	Pneumatic Module Failure	Failure	No	Yes	No	The main electronics are unable to communicate with the pneumatics board. The device will be sent to failsafe position	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persist, replace the complete device or Pneumatics module
51	6	2	OPTION_FAILED_CRITICAL	Options Pos. Sensor Failure	Failure	No	Yes	No	If the PV or RPS is configured as position source and the main electronics is unable to communicate to the options module, the device will be sent to failsafe.	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persist, replace the complete device or Options module
52	6	3	OPTION_COMMS_ERROR	Options Module not found	Maintenance	Yes	Yes	No	The main electronics and options module had a brief communications failure	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persist, replace the complete device or Options module
53	6	4	OPTION_FAILED	Options Module failed	Maintenance	No	Yes	No	The main board is unable to communicate to the options module	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persist, replace the complete device or Options module
54	6	5	UI_FAILED	UI Module failed	Maintenance	No	Yes	No	Main board is unable to communicate with the UI module	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persist, replace the complete device or UI module

Table 10 - Device Status Diagnostics (Continued)

Sequence	Byte #	Bit	CMD48 String	DD Text	NAMUR NE107 fault Category	Automatically cleared:	Can be cleared:	Persists across resets:	Cause	Recommended Actions
55	6	6	PNEU CHECKSUM	Pneumatics F/W image Failure	Failure	No	Yes	No	Pneumatics Module Firmware Data Test Failure	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persists, replace the complete device or Pneumatics module
56	6	7	OPTION CHECKSUM	Options F/W image error	Failure	No	Yes	No	Options Module Firmware Data Test Failure	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persists, replace the complete device or Options module
57	7	0	UI CHECKSUM	UI F/W image error	Maintenance	No	Yes	No	UI Module Firmware Data Test Failure	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persists, replace the UI module
58	7	1	PNEU_NO_TC_TABLE	Pneumatics TempComp invalid	Failure	No	Yes	No	Pneumatics Module Tempcomp table not programmed/Not readable	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persists, replace the complete device or Pneumatics module
59	7	2	OPTION_NO_TC_TABLE	Options TempComp invalid	Failure	No	Yes	No	Option Module Tempcomp table not programmed/Not readable	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persists, replace the complete device or Option module
60	7	3	MAIN_NO_TC_TABLE	Main Module TempComp invalid	Failure	No	Yes	No	Main Module TempComp table not programmed/Not readable	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persists, replace the complete device.
61	7	4	REMOTE_POSITION_SENSOR	RPS out of range Failure	Failure	No	Yes	No	Hardware Failure	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persists, replace the RP Sensor and / or Options Module.

Table 10 - Device Status Diagnostics (Continued)

Sequence	Byte #	Bit	CMD48 String	DD Text	NAMUR NE107 fault Category	Automatically cleared:	Can be cleared:	Persists across resets:	Cause	Recommended Actions
62	7	5	AI_PV SENSOR	AI_PV out of range	Failure	Yes	Yes	No	Hardware Failure	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persist, Replace the Options Module.
63	7	6	AI_POS SENSOR	AI/POS out of range Failure	Failure	No	Yes	No	Hardware Failure	<ol style="list-style-type: none"> 1. Remove power to the device for 2 minutes and restart the device. 2. Clear the alarm using ValVue or HART Host 3. If the failure persist, Replace the Options Module.

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6. Specifications and References

6.1 Physical and Operational Specifications

This section provides the physical and operational specifications for the SVI3. Specifications are subject to change without notice. The assigned service life is indicated in the technical data sheet for the product.

Table 11 - Environmental Specifications

Operating Temperature Limits	<ul style="list-style-type: none"> • Standard Temperature Version: -40° F to 185° F (-40° C to 85° C) • Extreme Temperature Version: -67° F to 185° F (-55° C to 85° C)
Storage Temperature Limits	-67° F to 200° F (-55° C to 93° C)
Instrument Air Dew Point	At least 18° F (-7° C) below minimum anticipated ambient temperature
Temperature Effect	< 0.005% /° F typical; -40° F to 180° F (< 0.01% /° C typical; -40° C to 82° C)
Supply Pressure Effect	0.05% per psi unit (.73% per bar unit)
Relative Humidity	10 to 90% non-condensing
Humidity Effect	Less than 0.2% after 2 days at 104° F (40° C), 95% relative humidity.
Insulation Resistance	Greater than 10 G Ohms at 50% RH.
MTBF	49 years based on MIL handbook calculation for electronic parts and field data on mechanical parts
Electromagnetic Compatibility Electrostatic	Electrostatic discharge — No effect with contact discharge level of 4 kV and air discharge level of 8 kV (EN 1000-4-2) Radio frequency interference — 80-1000MHz@10v/m; 1000-2000MHz@3V/m and 2000-2700MHz@1V/m 1kHz 80% AM
Fast Transient Burst	No effect at 2 kV (Coupling clamp EN1000-4-4).
Vibration Influence	4 mm at 5 - 15 Hz - Negligible 2 G at 15 - 150 Hz - Less than 2% of span 1 G at 150 - 2000 Hz - Less than 2% of span
Tropical Environment Compatibility	<ul style="list-style-type: none"> - Fungus resistance per ASTM-G21 - Exposed circuits covered with anti-fungal coating - Positively pressurized housing with insect resistance vents
Magnetic Field Influence	Negligible at 100 A/m (EN61000-4-8) CE MARK certified to EN50081-2 and EN50082-2

Table 12 - Operational Specifications

Power interruption without reset	<100ms
Accuracy	+/- 0.5% Full Span
Hysteresis and Deadband	+/- 0.3% Full Span
Repeatability	+/- 0.3% Full Span
Start-Up Drift	Less than 0.02% in first hour
Long Term Drift	Less than 0.003% per month
Position Travel Limits	Rotary: 18 - 140° Reciprocating: 0.25" - 8" (6 mm - 203mm) Note: Above 8" (203 mm) consult factory for mounting instructions.
Flow Characteristics Applied in addition to the control valve's inherent characteristic.	Linear Equal Percentage (of 50:1 or 30:1) Camflex Quick Opening (inverse of 50:1 equal percentage) Customer Configurable
	Tight shutoff - Yes (0-20% of Input)
Auto Tune SVI3 performs automatic determination of the optimal valve positioner control parameters. In addition to P, I, D, the position algorithm uses damping, symmetry for exhaust and fill time constants, dead zone and magnitude characterization parameters. Auto Tune is optimized for 5% step changes with negligible overshoot. After the Auto Tune process is completed, you can further adjust the positioner tuning parameters to more conservative or to more responsive values.	<ul style="list-style-type: none"> • Proportional gain: 0 to 4, displayed as 0 to 4000 • Integral time: 0 to 100 seconds - displayed as 0 to 1000 (1/10s) • Derivative time: 0 to 200 milliseconds • Dead Zone: 0 to +/-5% (0 to 10% deadband) • Padj: +/- 3000 (depends on P) • (non-linear gain factor: -9 to +9) • Stroke Rate Limiting: 0 to 250 seconds • Position compensation coefficient: 1 to 20 • Boost Scale Factor: 0 to 2 • Offset Scale Factor: 0 to 2
Full open position adjustment	60 to 100% of actual stop
Start Up Time (from no power)	Less than 150 ms
Minimum current to maintain HART®	3.2 mA
HART® Command #3 Mapping	For Single Acting. Primary Value - Valve Position Secondary Value - Actuator Pressure Tertiary Value - Supply Pressure

Table 13 - Input Signal, Power, and Display Specifications

Electrical entries	Two 1/2" NPT Female Ports
Power Supply	Loop powered from 4 - 20 mA control signal
Valve Setpoint	4 - 20 mA. 450 Ohms input resistance
Compliance Voltage Rating	9.0 V at 20 mA, 11.0 V at 4.0 mA
Minimum Current Signal to Start Up	3.2 mA
Impedance Range	Low: 450 Ohms; High: 2750 Ohms
Minimum Input Span for Split Range Operation	5 mA
Upper Range Value for Split Range Operation	Between 8 and 20 mA - Minimum input span > 5mA
Lower Range Value for Split Range Operation	Between 4 and 14 mA - Minimum input span > 5mA
Wire Size	<ul style="list-style-type: none"> • 4-20 mA Input Terminals: 22 AWG to 12 AWG (4 mm² to .34 mm²) • Options Terminal Connections: 26 AWG to 14 AWG (2.5 mm² to .14 mm²) <p>Wiring must be rated for at least 5°C above the highest expected ambient temperature.</p>
Strip Length	<p>Main Terminal Connections : 1/4 inch (6.35mm)</p> <p>Options Module Connections: 1/6 inch (4.08mm)</p>
Digital Communication	HART®Communication protocol revision 7
Local Display Liquid Crystal (optional)	<p>LCD, operable in all certified areas per device label, two lines of nine alphanumeric characters.</p> <p>Display may become slow or unreadable below 0°C.</p> <p>Display is shutdown at -20°C.</p>
Push Buttons	External, Four, push buttons. operable in all certified areas per device label

Table 14 - Construction Material Specifications

Protection	IP66 and NEMA 4x	
Housing and Cover	Chromated Copper Free (Per API RP 14F) Aluminum ASTM A360. Grey Polyurethane Paint with epoxy primer	Stainless Steel (316L)
Weight	Standard Flow Model: • Aluminum - 7.4 lbs./ 3.3 kg	Standard Flow Model: Stainless Steel - 13.80 lbs./ 6.26 kg
Relay and Manifold	Composite polymers and Stainless Steel (300 Series) Standard Temperature, -40°C to 85°C (-40°F to 185°F), Nitrile Diaphragms Extreme Temperature, -55°C to 85°C (-67°F to 185°F), Fluorosilicone Diaphragms	
I/P Motor	Stainless steel (300 & 400 series)	
Mounting Bracket	300 series stainless steel	
Magnet Holder	Corrosion Protected Anodized Aluminum 6061 T6	
Pole Ring	416 stainless steel	
Levers	300 Series stainless steel	

Table 15 - Pneumatics Single Acting Standard Flow

Air Supply	Dry, oil-free, 5 micron filtered air (See ISA S7.3)
Sweet Natural Gas	H ₂ S content not more than 20 ppm
Action	Direct Acting
Supply Pressure	20 -120 psi max. (1.4 - 8.3 bar) Regulate 5 - 10 psi (.345 bar - .69 bar) above actuator spring range. Do not exceed actuator rating.
Air Delivery - Single Acting Relay	410 SLPM (14.5 SCFM) @ 30psi
Air Capacity (flow coefficient)	Loading CV = 0.66 Venting CV = 0.51
Air Consumption	2.8 SLPM (5.9 SCFH) @ 30psi supply 3.4 SLPM (7.2 SCFH) @ 45psi supply
Air Supply Failure	Single Acting Relay On supply failure the actuator output drops. Some overshoot may occur when air pressure returns after a period without air supply pressure. Always set control set point to 0%, and put the process control system in manual, for smooth recovery from air supply failure.
Loss of Input Signal	Output drops to low pressure.
Output Pressure	0-120 psi (8.27 bar) max
Actuator Exhaust and Positioner Vent Collectable	Yes, with optional manifold kit

Table 16 - System Connectivity

HART®Physical Device Type	Actuator Device Type: HART®7: 65AA (170)
DD Registered with FieldComm™Group	Yes, available through FieldComm™ Group
Integration with HART®host software	Integrates with leading DCSs with full DTM and EDD support, including, but not limited to: <ul style="list-style-type: none"> • Baker Hughes / Valvue3 • Emerson DeltaV / AMS • Honeywell / FDM • Yokogawa / PRM • GE MarkVIe ControlST
Diagnostics	Travel odometer, Cycles, Time Closed/Open, Time Near Closed, Alarms, Friction, Stick Slip, Spring Range, Error Offset, RMS Error, Obstruction Detection, Calibration Error, and Setpoint cycling tests Ramp Test: Hysteresis, Deadband, Accuracy, LinearityStep Test: Overshoot, Response resolution, DeadtimeValve Signature: Spring Range, Friction, Seat Profile

Table 17 - HART® Device Information

Item	Definition
Model Name	SVI3
Device Type Code	170 or 0x65AA (firmware 1.x)
Device Revision	1 if firmware 1.x
HART® Protocol Revision	HART® 7
Number of Device Variables	35
Physical Layers Supported	FSK
Physical Device Category	Digital Advanced Valve Positioner, Non-DC-isolated Bus Device

Table 18 variables are returned from HART® command 9.

Table 18 - Device Variables

Variable Code	Variable Name	Unit
0	Position	%
1	Actuator Pressure1	psi
2	Supply Pressure	psi
3	Actuator Pressure2	psi
4	Setpoint	%
5	Signal	mA
6	DO Switch 1	N/A
7	DO Switch 2	N/A
8	DI	N/A
9	Temperature	degC
10	Volts Input	V
11	Raw Position	Raw Counts
12	Number Strokes	Valve Strokes
13	Number Cycles	Direction Changes
14	PosRetransmit	mA
15	IP Current	mA
16	Friction	%
17	Position Error Band	%
18	OpenStopAdjust	%
19	Percentage Range	%
20	Pilot Pressure	psi
21	Stroke Time Open	s
22	Stroke Time Close	s
23	Low Spring Range	psi
24	High Spring Range	psi
25	Reserved	
26	Stick Slip Amplitude	%
27	Stick Slip Ratio	N/A
28	Position Cycle Rate	cycles/hr
29	Setpoint Cycle Rate	cycles/hr
30	Position Cycle Amplitude	%
31	Setpoint Cycle Amplitude	%
32	RMSError	%
33	Tight Shutoff Rate	cycles/hr
34	Device Mode	N/A

6.1.1 Storage

The SVI3 is only IP66 and NEMA 4x rated once fully install in accordance with this manual. If the SVI3 is stored for a long duration, you must keep the housing sealed against weather, fluids, particles, and insects. To prevent damage to the SVI3:

- Use the plugs provided with shipment to plug the 1/4 NPT air connections, on the positioner and on the air filter regulator set.
- Do not allow standing water to accumulate.
- Storage Temperature Range -55°C to 93°C.
- Relative Humidity 10 to 90% non-condensing.

6.1.2 Protection

As a minimum, all positioners are cleaned, fitted with pneumatic and electrical port plastic caps and packed with carton box.

This protection should be left in place until immediately before the positioner is to be fitted into the actuator.

6.1.3 Handling

Do not drop the positioner. Appropriate care when handling positioner should be given, roughness in handling may damage Terminals or Pneumatic/electrical ports

6.1.4 Disposal

Follow instructions carefully on product labels for use and storage to prevent any accidents.

Never store hazardous products in food containers; keep them in their original containers and never remove labels. Corroding containers, however, require special handling. Call your local hazardous materials official or fire department for instructions.

Check with your local environmental, health or solid waste agency for more information on waste management options.

6.1.5 SVI3 Model Numbering

Please refer to SVI3 Fact Sheet Ref. 33486.

If you have bought SVI3 Unit with Part Number SVI3-XXXXXX13,

The equipment that you have just bought was designed, manufactured and tested in accordance with the essential safety requirements of the CU TR 012: 2011



AUTHORIZED CONTACT

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Tel/fax : +7 495 771 72 40

If you have bought SVI3 Unit with Part Number SVI3-XXXXXX12,

The equipment that you have just purchased was designed, manufactured and tested in accordance with the essential safety requirements of the Chinese standard- GB25286.1-2010.



Markings

Flameproof/Explosion-proof

Ex db ia IIC T6...T4 Gb

Intrinsic Safety

Ex ia IIC T6... T4 Ga Ex ia

IIIC T₂₀₀ 91°C Da

Increased Safety/Non-Incendive

Ex ec ic IIC T6...T4 Gc

Protection by Enclosure

Ex ia tb IIIC T₂₀₀ 91°C Db

6.2 Model and Features Comparison

Table 19 - Model and feature comparison

Diagnostic Type	Description	Device Diagnostic Level		
		Standard	Advanced	Online Valve
Measurements (Online)	Supply Pressure	X	X	X
	Time Open	X	X	X
	Time Closed	X	X	X
	Time Near Closed	X	X	X
	Accumulated Valve Strokes	X	X	X
	Accumulated Valve Cycles	X	X	X
	Stroke time Open	X	X	X
	Stroke time Closed	X	X	X
	I/P Current		X	X
	Line Current	X	X	X
	Un-characterized Set Point	X	X	X
	Characterized Set Point	X	X	X
	Un-characterized Position	X	X	X
	Characterized Position	X	X	X
	Temperature	X	X	X
	Min Temperature	X	X	X
	Max Temperature	X	X	X
	CMD 48 Alerts/Positioner Faults	X	X	X
	Actuator 1 Pressure		X	X
	I/P Pressure		X	X

Table 19 - Model and feature comparison (Continued)

Diagnostic Type	Description	Device Diagnostic Level		
		Standard	Advanced	Online Valve
Methods and Procedures (Offline)	Valve metrics trending (Pos, SetPt, Act, Sup)	X	X	X
	Step Test	X	X	X
	Ramp Test	X	X	X
	Standard Valve Signature		X	X
	Extended Valve Signature		X	X
	Signature Storage		X	X
Online Valve Diagnostics (Online)	Friction			X
	RMS Error			X
	Upper Spring Range			X
	Lower Spring Range			X
	Obstruction - Flag			X
	Position of Obstruction			X
	Offset Error			X
	Stick Slip - Flag			X
	Amplitude of Slip in Stick Slip			X
	Confidence Indicator of Stick Slip			X
	Cycle Rate of Position Cycling			X
	Amplitude of Position Cycling			X
	Cycle Rate of Setpoint Cycling			X
	Amplitude of Setpoint Cycling			X
	Tight Shutoff Count			X
	Tight Shutoff Rate			X
Calibration Error			X	

7. Tuning and Advanced Usage

This section shows examples of techniques for achieving superior process results by using SVI3 DTM with SVI3 to simplify maintenance and to achieve the benefits of SVI3's advanced diagnostics capabilities. It is assumed that you are using HART® communications with a modem and SVI3 DTM. Refer to the ValVue3 Instruction Manual for complete instructions on these and other procedures.

7.1 Adjusting Speed of Response

The SVI3 provides in its calibration software the ability to automatically tune the connected valve. The auto tune feature has robust tuning parameters designed to tolerate variations in process characteristics. You can adjust the speed of response of the control valve by adjusting parameters in SVI3. Tuning parameters are adjusted by ValVue, the preferred method, or by the handheld.

7.1.1 Notes on Aggressiveness

Setting Aggressiveness

While the SVI3 DTM and the DD allow you to set Aggressiveness, the pushbuttons do not. In all three methods, however, the Aggressiveness value is inherited from any previously per-formed tuning (Autotune or manual). Once Aggressiveness, and other tuning values are determined, they are stored in NVRAM. The SVI3 provides a user defined Aggressiveness Level for auto-tuning, the allowable range varies from -9 to +9 where 0 (Zero) is consider normal tuning. The Aggressiveness Level influences stroking speed and over-shoot. A negative value SLOWS stroking speed and helps minimize over-shoot. A positive value INCREASES stroking speed and may add some over-shoot. The recommended values for Aggressiveness is 0 for control valves without volume boosters.

In applications with volume boosters and/or quick exhaust valves the Aggressiveness Level is not as influential. For Auto- tuning it is usually between 0 and 3. Reduce the volume boosters sensitivity by opening the integral bypass needle valve about 1 to 2 turns. Use caution when adjusting the needle valve so as to not to damage the seat, close gently to seat and then open 1 or 2 turns

Aggressiveness Dynamic

Lower values of aggressiveness lead to lower PID values and slower response and less overshoot.

Higher values lead to higher PID values and quicker response and more overshoot.

Once you have a preferred aggressiveness and you tune once, all future Autotunes automatically use that same value, until user-changed.

7.2 Troubleshooting Autotune

Autotune, whether using SVI3 DTM, pushbuttons, a DD or a handheld, is the best way to tune the valve. If it does not work:

Note: For small actuators it may be necessary to:

- **Use 1/8" tubing for Autotune to work properly.**
- **Install tamper-proof adjustable needle valve in supply line to SVI; adjust valve closed enough so autotune runs. Then lock valve setting so it can't be tampered or changed**

Step One

Autotune again using recommended tuning parameters for the valve in use. The SVI3 DTM manual offers you instructions in how to enter these parameters in the Autotune procedure. Alternately, try starting tuning from the 50% position.

Table 20 outlines some effects of parameter changes.

Table 20 - Rough Guide to Effects of Changing PID Values

Parameter	Rise Time		Overshoot		Settling Time	
	Increase Value	Decrease Value	Increase Value	Decrease Value	Increase Value	Decrease Value
P	Decrease	Increase	Increase	Decrease	Small Effect	Small Effect
I	Small Effect	Small Effect	Decrease	Increase	Decrease	Increase
D	Small Effect	Small Effect	Decrease	Increase	Decrease	Increase

Step Two

Run Autotune again after ensuring the:

- Air supply is sufficient and there are no air leaks.
- Mounting kit components / turnbuckle/ take off rod are not loose or in an improper position.
- Alarms are cleared
- Boosters are not too aggressive.
- Is the booster by-pass valve closed?
Open by-pass valve ½ turn from closed and Auto- tune again
- Valve does not have excessive friction.
Add some Dead Zone (0.25).
- Mounting is installed correctly.
- Magnet is not out of position.
- Solenoid in supply line should have a Cv that is higher than SVI3 capacity (.6).

Other Issues That Affect Autotune

Valve oscillating fast:

- *P* term too high: reduce *P* by ½ and try again
- Booster too hot (aggressive) open by-pass on booster and try again

Valve oscillation slow - friction:

- Increase *I* term by 20-25%
- Add *Dead Zone* – try 0.25%

Valve moves too slowly:

- *P* term too low, try increasing by 25%
- Stroking time set to non-zero value.

If Actuator is very large:

- Enter a typical value for *P* in the PID parameter in ValVue. SVI3 factory value for *P* is 100; if it is a large valve this may need to be higher to start. In Setup mode enter large value for *P* and run Autotune again (See Table 12).

7.3 Tight Shutoff

7.3.1 Tight Shutoff Application to Protect from Seat Erosion

The Tight shutoff feature can be programmed to prevent valve seat erosion using the full actuator force to eliminate damaging leakage. At a position setpoint of 2%, for example, this function allows full thrust to occur when the input signal is less than 2%. This solves a common cause of valve repair. Do not use tight shutoff if it is necessary to throttle the valve at very small flows.

7.3.2 Tight Shutoff Application to High Pressure Liquid Letdown Valve Trim

When staged trim is used in High Pressure Liquid Letdown Valves, Tight Shutoff can be adjusted to move the valve from the seat to begin throttling at the minimum operable CV level. Using the tight shut-off feature in SVI3 prevents valve seat damage that can occur when throttling at clearance flows. See recommended Tight Shutoff settings in the following table. Tight shutoff can be adjusted with pushbuttons or with ValVue or a HART® communicator.

Table 21 - Tight Shutoff Parameters for High Pressure Liquid Letdown Trim

Masoneilan Valve Type	Valve Trim Type	Set Tight Shutoff	Positioner Characteristics
78400/18400 Series LincolnLog	Any	15%	Linear
41000 Series VRT™ Type S	Partial Stack	6%	Linear
41000 Series VRT Type S	Full Stack	3.5%	Linear
41000 Series VRT Type C	Cage	6%	Linear
28000 Series	Varilog	5%	Linear
Any	Class V Shutoff	2%	Linear

7.4 Using SVI3 DTM Diagnostics

SVI3 advanced features are simple to use with SVI3 DTM software. The following examples illustrate some uses. Please refer to SVI3 DTM Manual full Valve Diagnostics Procedures and information.

7.4.1 Online Valve Diagnostics

7.4.1.1 Overview

The SVI3 Digital Valve Positioner marks a new era in smart valve instrumentation with the introduction of a full suite of Online Valve Diagnostics, designed to improve plant efficiency and process uptime. The Online Valve Diagnostics consist of Key Performance Indicators (KPI's) which are continuously calculated while the valve is in service, providing real insights to actual operating performance of the valve system without the need to take a process offline. With simple configuration of alerts, the SVI3 will automatically notify plant personnel as KPI's begin to drift out of the allowable range, bringing attention to specific situations before they become a problem. Additionally, internal memory has been expanded, providing 1 years' worth of KPI data storage for trending and analysis – thus, collecting and storing data to give operators a safety window for analysis even for those valves in the fleet that were excluded from a planned diagnostic program. Maintenance activities can simply be prioritized across the fleet, utilizing actual operating data over time to drive decision making, ensuring that the valves which need servicing are scheduled.

Understanding the KPI calculations will help with proper setup and support analysis of data for proper actions. The following section defines the KPIs and provided insights to the common use cases.

7.4.1.2 Data Storage

The SVI3 KPI data is continuously calculated and stored directly within the device.

Depending on the run time of the SVI, the following data points are available:

- Current – “Most Recent” data as measured by the device (Upon request)
- Hourly – Each hourly record is the average of the last 60 minutes of measurements (total of 24)
- Daily – Each daily record is the average of the last 24 hourly records (total of 7)
- Weekly – Each weekly record is the average of the last 7 daily records (total of 52)

After 1 year, the oldest data will be moved out and the device will contain only the newest 1 year's data saved.

The data is continuously available through HART via the SVI3 DTM. Users have the option to synchronize the DTM with the SVI3 as often as they want, which will build a more detailed database than what is available on the device itself. For instance, if a user synchronized with the SVI3 every day for 30 days, they would have $24 \times 30 = 720$ hourly, 30 daily, and 4 weekly data points.

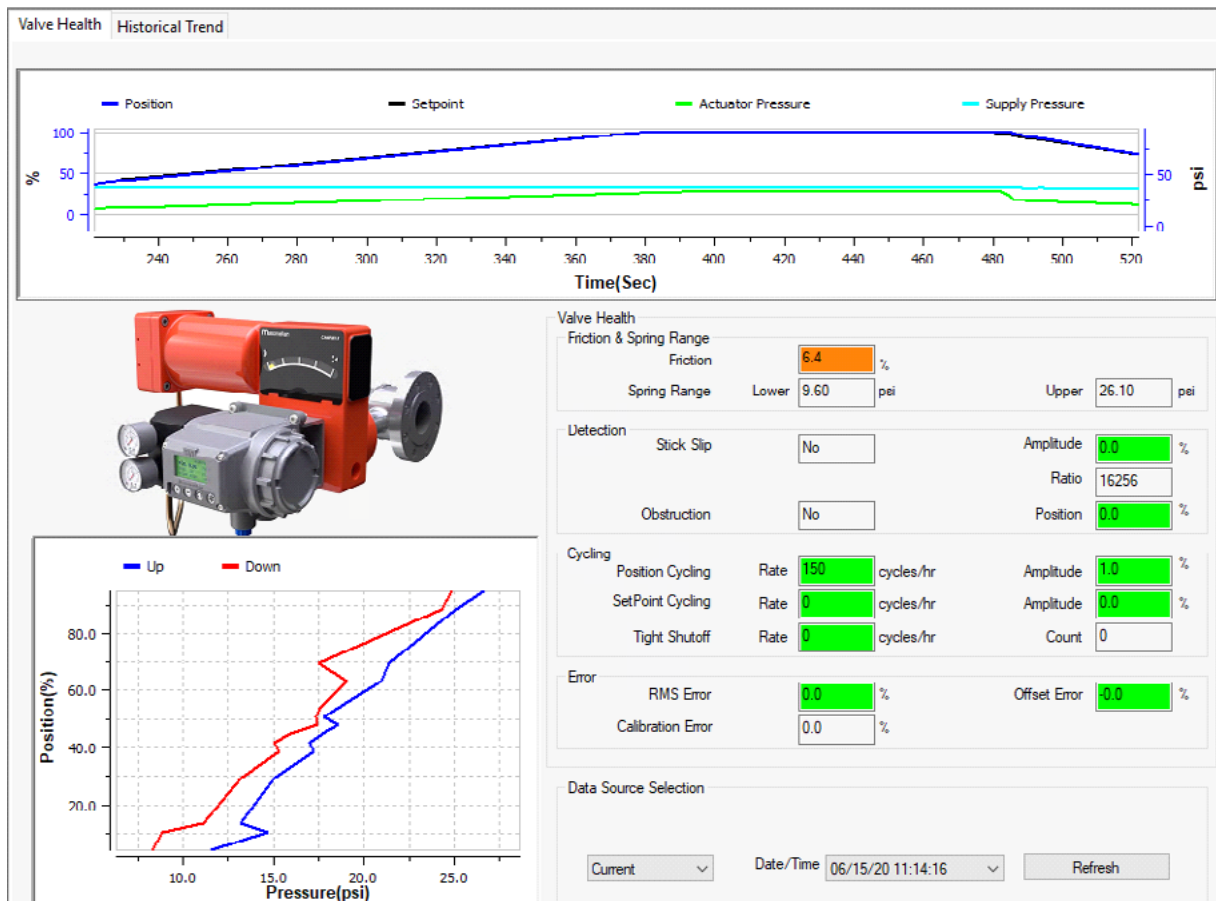
7.4.1.3 Interfaces

The SVI3 with Online Valve Diagnostics is best operated in parallel with the SVI3 DTM (Device Type Manager). The SVI3 DTM provide all access to the advanced features within the SVI3, including online, offline, and continuous diagnostics. For a more detailed instruction regarding the use of the DTM, please refer to the DTM Manual.

Valve Health (DTM)

The Valve Health tab within the Online Diagnostic menu provides real time, read only access to the KPI data. Users can select specific current, hourly, daily, or weekly data points, and display the numerical values for each KPI recorded at that time. Online valve signatures are available for analysis, along with a live trend for comparison against the calculated KPIs. Values are automatically color coded for easy identification of out of spec data.

This interface is best used to request most recent data for analysis, or to pull up specific historical values for investigation.



Historical Trend (DTM):

A Historical Trend view is also available for each KPI. Trending the data is useful when looking at KPI performance over time, and can help identify long term drift, oscillations, or step changes over a specific time period. By Selecting “Sync with Device”, the KPI data will be downloaded from the device to the DTM database. Data will always be appended to the DTM database, so sync’ing often will build out a very detailed database within the DTM.

This interface is best used to monitor a device which has been in operation for some period of time and supports setting proper alert limits for that particular valve system. It is also a great tool for troubleshooting a device, as well as identifying trends to support maintenance or service intervals.



7.4.1.4 Alerts / Limits

The KPIs are continuously monitored by the SVI3 and can trigger a series of configurable alerts if the data was to drift out of the allowable range. Users have the option to enable/ disable each alert, mask the alert to prevent it from publishing over HART, and ability to configure the range or threshold of the alert value. As each application is unique, the limits should be set on a case by case basis. Best practice to initially set the limits (or use defaults), then review the historic diagnostic trends after some period of run-time. Based on the trends, users can adjust limits as necessary to gain best insights of the diagnostics.

Alert Configuration

Position Error Limits
Fault Masks
Valve Health Limits

Valve Health Limit Settings

	Limit Enabled	Mask Faults	Limit Value
Friction Low-Low	<input type="checkbox"/>	<input type="checkbox"/>	0.00 %
Friction Low	<input type="checkbox"/>	<input type="checkbox"/>	5.00 %
Friction High	<input type="checkbox"/>	<input type="checkbox"/>	15.30 %
Friction High-High	<input type="checkbox"/>	<input type="checkbox"/>	50.00 %
RMS Error High	<input type="checkbox"/>	<input type="checkbox"/>	1.00 %
RMS Error High-High	<input type="checkbox"/>	<input type="checkbox"/>	1.50 %
Offset Error	<input type="checkbox"/>	<input type="checkbox"/>	4.90 %
Stick Slip Amplitude	<input type="checkbox"/>	<input type="checkbox"/>	4.90 %
Position Cycling Rate	<input type="checkbox"/>	<input type="checkbox"/>	100 cycles/hr
Position Cycling Amplitude	<input type="checkbox"/>	<input type="checkbox"/>	4.90 %
Setpoint Cycling Rate	<input type="checkbox"/>	<input type="checkbox"/>	500 cycles/hr
Setpoint Cycling Amplitude	<input type="checkbox"/>	<input type="checkbox"/>	4.90 %
Tight Shutoff Rate	<input type="checkbox"/>	<input type="checkbox"/>	1 cycles/hr
Obstruction Position	<input type="checkbox"/>	<input type="checkbox"/>	1.20 %
Total Strokes Exceeded	<input type="checkbox"/>	<input type="checkbox"/>	65000 x1000
Total Cycles Exceeded	<input type="checkbox"/>	<input type="checkbox"/>	65000 x1000

eDD:

KPIs alerts are configurable through the eDD and status bits are available through standard command 48 requests. Few KPIs are also available to read most recent values as dynamic variables. No historical data trending or database functionality is available through the eDD.

7.4.1.5 Valve Health KPIs – Definitions and Use Cases

Friction (Avg%):

Dynamic friction is a very important KPI to consider when identifying changes in the valve performance over time. Friction is calculated away from the stops (not near seat, not near full open). Movement of the valve is necessary for the Friction calculation to be valid. Extremely small and large movements are excluded from friction calculation.

Calculated values will be compared against the programmed limits every hour, or during a read/write of the limits to the device, or at the completion of a standard/extended signature test.

High Friction values may be an indication of problems with valve wear, such as plug/cage/ seal ring interference, or packing gland/stem issues. Low Friction values may be an indication of packing gland wear

Spring Range (Lower/Upper):

The spring range KPI as calculated by the SVI3 will normally be the Operational spring range, as calculations will be performed while the valve is in operation. Operation spring range includes pressure to overcome spring forces, friction added by actuator, valve (packing, guiding surfaces, etc.), and any unbalance forces as added by the process or application.

Spring range is calculated as both a Lower and Upper Spring Range value. Lower spring range is defined as the pressure required to start moving the valve. Upper spring range is defined as the pressure required to fully move the valve to its maximum travel position.

Spring range is calculated from the same data obtained for Friction and on the same time interval (every hour). For Spring range values to calculate, data for roughly 9% of travel is required. Changes in spring range values are important to follow, as contributing factors could indicate spring degradation, friction changes, or process imbalances.

Stick Slip:

Stick Slip is defined as a change in setpoint with no immediate change in travel, followed by an abrupt break free travel movement to catch up to the commanded setpoint. Stick slip is realized within the SVI3 by closely monitoring setpoint and position, looking for instances where setpoint moves smoothly while position moves in jumps.

Like Friction, the Stick Slip data is only collected when travel is not near the stops of the valve and ignores very small movements. If Stick Slip is determined, the stick slip indication will be triggered, along with an amplitude value in % of travel, to quantify the magnitude of the stick slip.

Stick Slip is a useful leading KPI which can typically be diagnosed through the analysis of other KPIs such as friction and helps to determine causes of cycling issues within systems.

Position and Setpoint Cycling:

Cycling processes can be the result of the process, the positioner, or the valve. The SVI3 calculates two cycling values, Setpoint Cycling and Position Cycling, to help determine the cause of cycling process. Setpoint cycling is defined as movement of setpoint in one direction with a sudden change in other direction. Similarly, Position cycling is the movement of position in one direction with a sudden change in the other direction. The cycling KPIs use the same data filter as the stick slip algorithm.

The cycling KPIs, when used along with other KPIs, are good indicators of the source of cycling.

- Process Cycling – If the setpoint and position cycles are similar and there is no evidence of stick slip, or if stick slip is present and setpoint cycle amplitude is twice the stick slip amplitude, then most likely the process is cycling.
- Valve Cycling – If stick slip is present and setpoint cycling is same or less than stick slip, then most likely the valve is causing the cycling.
- Positioner Cycling – If no stick slip is present and the position cycles are much greater than setpoint cycles, then most likely the positioner is causing the cycling (poor positioner tuning).

Error and Offset:

The error KPIs are useful to diagnose differences between setpoint and position, serving as a leading indicator to other valve performance issues. Error is the absolute value of the difference between Setpoint and Position. Offset is the difference between position vs. setpoint, expressed in %, and showing the region +/- (above or below setpoint). Large setpoint changes are ignored until position is within 1% of setpoint or after 5 seconds, whichever happens first. Both error and offset are continuously calculated and are checked against the programmed limits every hour.

Tight Shutoff Cycling:

Tight shutoff cycling is defined as the number of times the positioner enters and then exits tight shutoff mode. The SVI3 detects when it enters tight shutoff mode (setpoint less than tight shutoff threshold). When the setpoint rises above the threshold (plus deadband), the positioner will no longer active tight shutoff mode and a cycle will be counted. A counter is incremented with every cycle calculated, and a rate is determined based on the number of cycles in an hour. If no cycle is determined in 20 minutes, the rate will reset to zero.

Tight shutoff cycling can occur if the DCS is controlling the valve close to the tight shutoff threshold value. Or it can happen if a calibration error exists where the positioner is reporting a much different position value than the actual valve position.

Obstruction:

The obstruction KPI helps to determine if the valve is unable to move in a certain direction in response to a given setpoint. The SVI3 will look for an obstruction by monitoring setpoint and position while the valve is stable (i.e. not moving). If position error exceeds 2% for a specified period of time, then the device will interpret this as an obstruction, and obstruction indicator will be set (either low or high).

Obstruction can help to identify valve problems such as a handwheel blocking valve stroke, a broken stem, or disconnected position feedback components.

Calibration Error:

Calibration Error is a measure of error at the stops of the valve. At the stops, we expect the position to be either 0% or 100%. If any error exists, that difference is reported as a calibration error of the device.

Calibration error can be useful to determine issues with the internal valve components, such as seat erosion, which could cause the lower stop to now register a different position from the original stop calibration when the valve was new.

7.4.2 Continuous Diagnostics

SVI3 continuously gathers critical information that can be used to predict maintenance intervals for control valves. These are:

- Total Travel
- Number of cycles
- Time open
- Time closed
- Time near closed

7.4.3 Monitoring a Valve Bellows Seal

The SVI3 automatically stores the accumulated valve stroke reversals, as Number of cycles. ValVue can be used to periodically retrieve the values and to track the remaining life of a bellows seal or packing. Total travel can also be used to estimate the remaining life of packings and seals.

7.4.4 Critical Service, Cavitation Control Trim

The time near closed, of a valve with severe service when near the seat, can be monitored by ValVue and saved to permanent files to monitor and predict maintenance needs. You can use ValVue to specify the criterion for time-spent-near-closed (a valve position such as 4%, for example). See also Tight shutoff- Application to High Pressure Liquid Letdown Valve Trim.

7.4.5 Diagnostic Valve Tests

The standard diagnostic test performs a full stroke test, and determines stroking speed. The Step Response test moves the valve between several points selected by you and graphically presents the dynamic response for each step. The Positioner Signature test strokes the valve over a travel specified by you and records a signature for comparison with the as-built and with future tests to predict maintenance intervals. The full version of ValVue is required for diagnostic tests.

7.5 Determining an SVI Positioner Compliance Voltage in a Control System

This discussion explains how to determine compliance voltage for an SVI3 positioner. A definition of compliance voltage is: The voltage that must be available at the control system output in order to drive the control current through the SVI3 and all the resistive devices in series with it. Measuring the voltage across the SVI3 terminals doesn't give the true available system compliance voltage as the positioner self-regulates voltage as current flows through it. Additionally, it also doesn't confirm what system voltage is available under load conditions. Therefore, if compliance testing needs to be done, it is best done before installation.

Use a 1K potentiometer as this is the maximum for most analog output cards and at 20 mA this equals 20 VDC, which is a sufficient maximum.

7.5.1 Compliance Test Setup

1. Configure a test setup as in Figure 37.

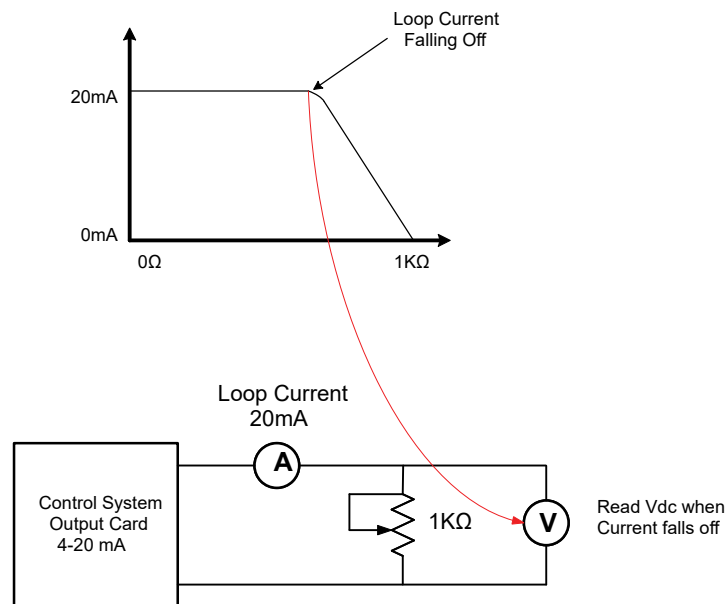


Figure 37 - Compliance Voltage Test Setup

2. Send 4 mA to the test setup.
3. Increase the potentiometer value until the loop current reaches 3.95.
4. Read the voltage across the potentiometer, which should be > 11 VDC.
This is the available system voltage at the minimum output.
5. Send 20 mA to the test setup.
6. Increase the potentiometer value until the loop current reaches 19.95 mA.
7. Read the voltage across the potentiometer, which should be > 9 VDC.
This is the available system voltage at the maximum output.

Table 22 lists some compliance voltage readings at positioner terminals at several currents.

Table 22 - Expected Voltage Range at Positioner Terminals

Current	Compliance Voltage Requirement at Positioner Terminals	Expected Voltage Measured at Positioner Terminals
4 mA	11 V	10 to 11 V
8 mA	10.5 V	9.5 to 10.5 V
12 mA	10 V	9 to 10 V
16 mA	9.5 V	8.5 to 9.5 V
20 mA	9 V	8 to 9 V

7.6 HART Physical Layer Compliance of the Control System

Communications to a SVI3 requires a HART®- compliant communications loop. The HART® protocol specifies the noise level, impedance requirements, and configuration of the loop. The controller or output card of the control system must comply with the Physical Layer Specification.

7.6.1 Impedance Constraints

HART® communication is based on the *talking* device generating an AC current superimposed on the 4 - 20 mA control signal. Two frequencies are generated; 1200 Hz representing the digital value *1* and 2200 Hz representing the digital value *0*. The *listening* device responds to the voltage generated when the AC current flows through the loop impedance. In order to generate a voltage from a current there must be impedance. HART® Protocol requires that this impedance be at least 220 Ohms at the tone signaling frequencies.

HART® compliant current sources are supplied with the correct impedance versus frequency characteristic. In Non-Compliant Current Sources there may be a noise reduction capacitor across the output that lowers the impedance at higher frequencies and thus lowers the signaling voltage. To be certain that at least 220 Ohms of impedance is presented by the current source a resistor can be added in series with the current source. This reduces the effective compliance voltage of the current source by 20 mA times the value of the series resistor. An added resistor is unnecessary during tests with high impedance current calibrators such as the Altek Model 334 Loop Calibrator.

7.6.2 Noise Constraints

HART® Communication depends on converting two frequencies (1200 and 2200 Hz) into digital values *1* and *0*. Noise can cause errors in the conversion. Conventional good wiring practice, such as use of twisted shielded pair cable with the shield grounded at only one point, minimizes the effects of noise.

7.6.3 Capacitance vs. Length of Cable for HART

The FieldComm™ Group specifies cable capacitance requirements to preserve signal strength. Refer to the standards for detailed calculation methods.



Do not connect a HART® modem and a PC to a control circuit unless the controller is HART® compatible or has a HART® filter. Loss of control or a process upset can occur if the controller output circuit is not compatible with HART® signals.

7.6.4 HART Filter Requirements

The control system output interface must allow the HART® frequencies to coexist with the precision 4 - 20 mA DC signal. Circuits that are not designed for HART® may need a HART® filter. Consult the controller or DCS manufacturer for interfacing to a particular system. The HART® communications can cause a non-HART® compliant output circuit to malfunction, in some cases. In other cases the HART® communications tones are disabled by the control circuit.

The SVI3 can be used with non-HART® compliant output circuits but remote communications functionality are not enabled.

If remote maintenance is desired always isolate the control valve from the process and disconnect the non-compliant controller before connecting a current source for power and a HART® master device.

If a HART® filter is required, then its voltage drop must be considered in calculating the compliance voltage.

7.7 Split Range Applications

The SVI3 is designed to operate in split range configurations supporting up to three control valves connected to a single controller output. Minimum input current span for each SVI3 is 5 mA. For each positioner the upper range value is between 8 and 20 mA and the lower range value is between 4 and 14 mA. For example, three devices might be configured with input current ranges of 4 - 9 mA; 9 - 14 mA, and 14 - 20 mA. Split range operation with SVI3 requires special consideration of the compliance voltage. The SVI3 requires at least 9.0 V. Two SVI3 in series requires at least 18.0 V in addition to the voltage drops in wiring and other series devices. Typical controller output current sources rarely deliver 24 V, so the system can become voltage starved. It is possible to boost the compliance voltage of the DCS using a series wired voltage source power supply, as shown in Figure 39 on page 116. The total loop voltage must not exceed the rating for the controller output current source. Contact the DCS vendor to validate this approach.

Note: The internal electronic components are isolated from ground. Grounding the case is unnecessary for functional purposes. Grounding the case may be necessary to conform to local codes. Refer SVI3 DTM Manual to Configure the SVI3 for Split range Applications.

7.7.1 Multiple Output Circuit Control System

ValVue supports HART® devices including, the SVI3 with non-zero polling addresses and supports for multiple SVI3 on the same loop, For Configuring Polling address for Split range applications, Please refer the SVI3 DTM Manual.

7.7.2 Isolators

Another solution is to use an Intrinsic Safety Isolator for each loop as shown in Figure 38 on page 114. A number of manufacturers make suitable isolators designed for use with HART® output circuits. Using an IS Isolator allows up to three SVI3 to be operated from a single 4 - 20 mA DCS output. Each isolator has a low compliance voltage input requirement and a high voltage output capacity.

Up to three isolators can be connected in series to a single controller output and each of them can drive a positioner. Isolators are used to provide compliance voltage and isolation even in installations not requiring intrinsic safety. Consult the manufacturer for detailed installation instructions.

The HART® loop address of each device must be set to 1, 2, and 3 (or other non-zero values) to allow a HART® master to recognize each SVI3 when connected to all three devices on the safe area side of the multiple isolators. When using multiple isolators, do not use 0 for any of the positioners. A 0 causes HART® masters to stop searching for additional positioners.

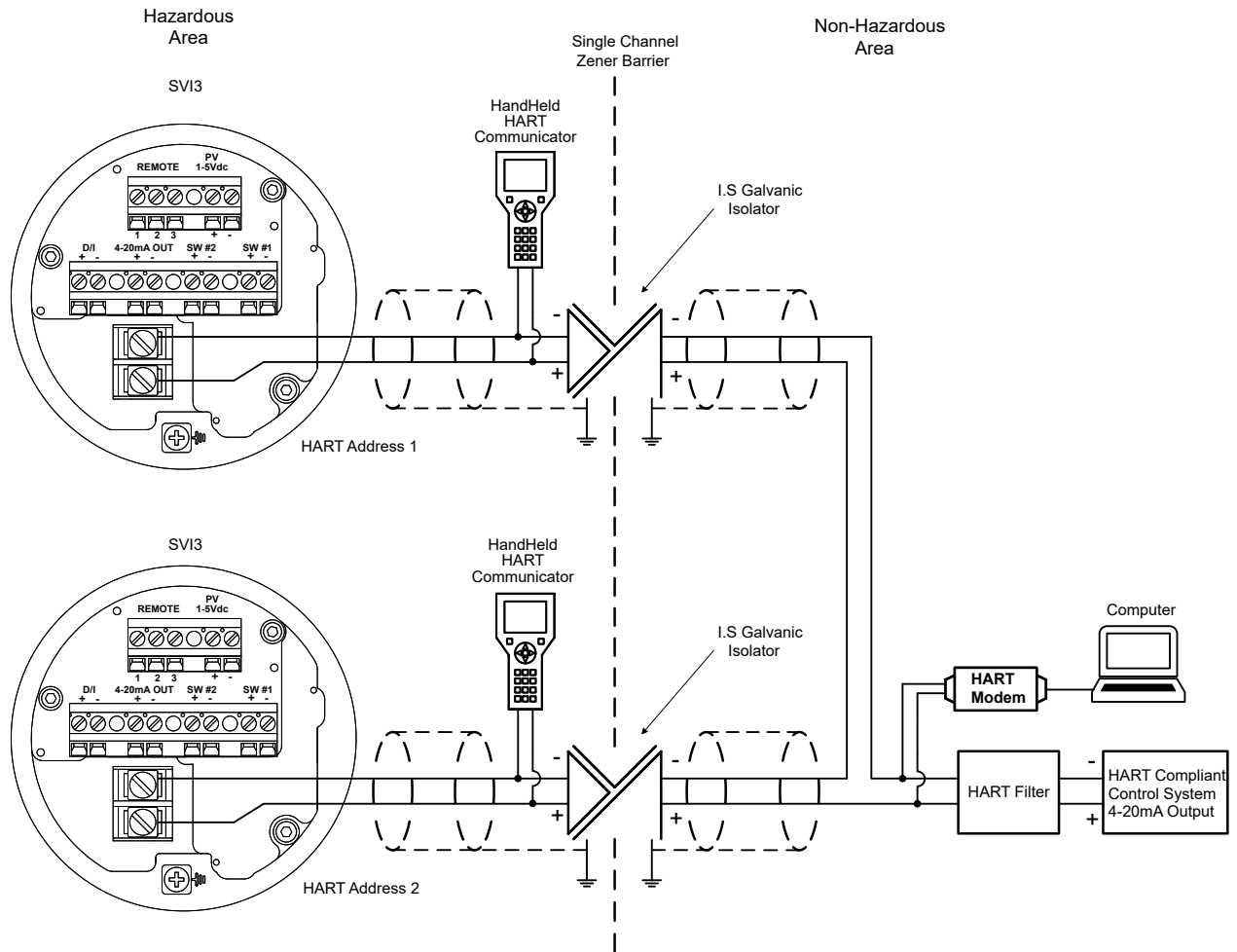


Figure 38 - Split Range with Isolator

7.7.3 Supplemental Power Supply

Another approach is to boost the compliance voltage of the DCS using a supplemental power supply (see Figure 39 on page 116) with the split ranged SVI3 connected in series with the supply. It is not practical to use supplemental supplies when Intrinsic Safety is required. The barriers do not permit adequate voltage. Contact the DCS vendor to verify that the output circuit is compatible with the added voltage. The supplemental voltage must equal 9.0 V for each additional SVI3. Exceeding the values in Table 23 will cause damage if the signal wires are short-circuited.

Table 23 - Supplemental Voltage for Split Range

Number of SVI3s on a Current Loop	Maximum Allowable Supplemental Voltage
1	0
2	9.0 VDC
3	18.0 VDC

7.7.4 Verify Wiring and Connections

Use the following procedure to ensure that the SVI3 split range system is properly powered:

- Connect a DC voltmeter across the input terminals.
- For an input current value between 4 and 20 mA the voltage varies between 11 V and 9 V respective. See “Split Range Applications” on page 112.
- Current is read from the local display or with a milliampmeter installed in series the SVI3.
- When voltage exceeds 11 V check that polarity is correct.
- If voltage is less than 9 V and polarity is correct, voltage compliance of current source is inadequate.
- Connect a milliampmeter in series with the current signal. Verify that source can supply 20 mA to SVI3 input.
- If 20 mA is not attainable, troubleshoot the source and set up.

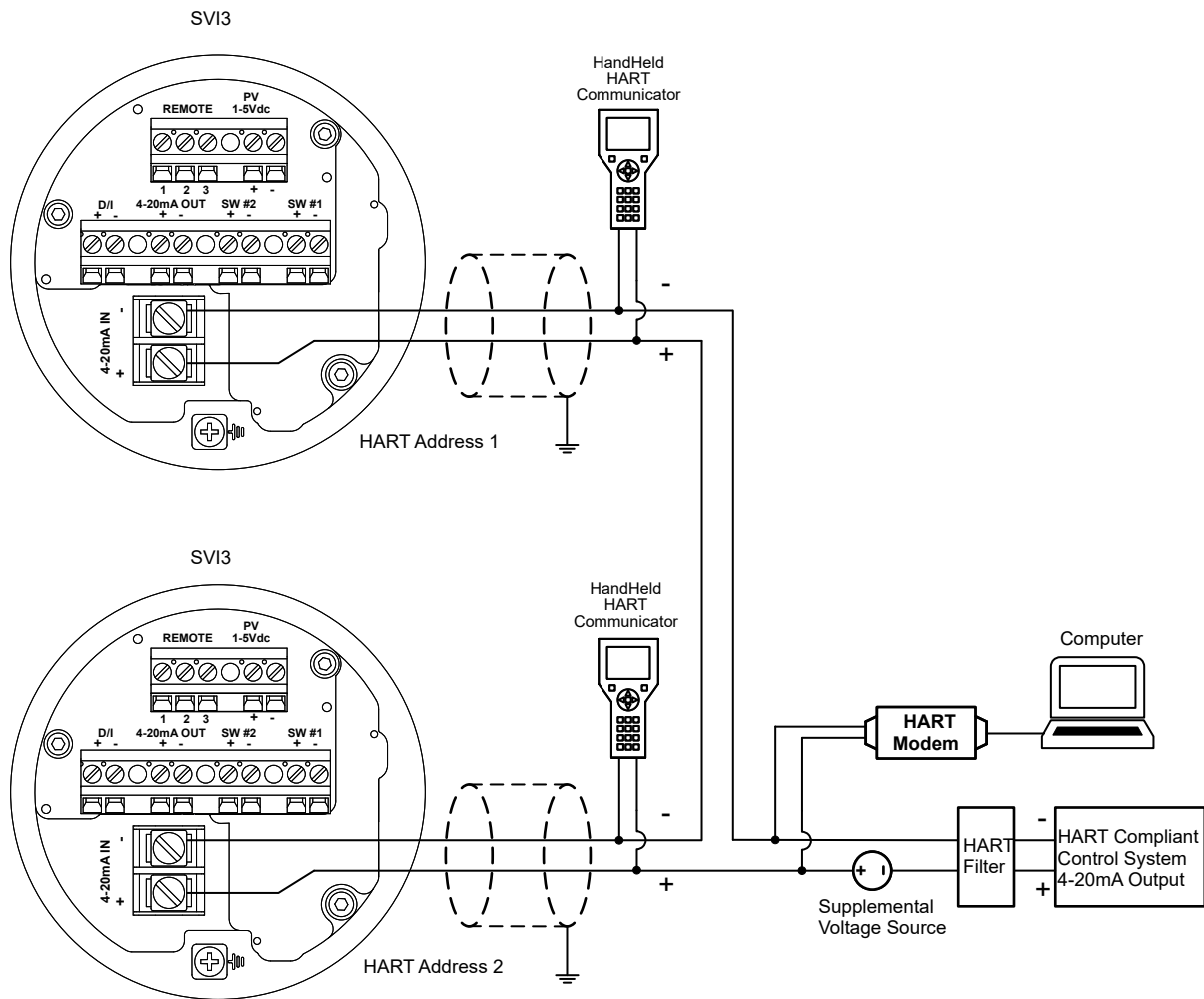


Figure 39 - Split Range with Supplemental Power Supply - Non-Hazardous

7.8 HART Communications with Intrinsic Safety

7.8.1 Overview

When an SVI3 is installed in a hazardous area in accordance with the applicable codes and standards for Intrinsic Safety there are wiring considerations for successful operation in addition to the requirements for safety. The choice and application of intrinsic safety barriers requires special training. For additional information, consult MTL Instruments PLC Measurement Technology Limited: www.mtl-inst.com or R.Stahl, Inc. www.rstahl.com.

All installations must comply with plant standards and local and international electrical codes.

There are three basic barrier types:

- Single channel Zener diode barriers
- Dual channel Zener diode barriers
- Active galvanic isolators

To determine if the installation will perform successfully with HART® communications you must consider HART® filter requirements and HART® barrier compliance.

7.8.2 HART Barrier Compliance

The intrinsic safety barrier must be designed to transmit the HART® signals in both directions. Both passive Zener diode barriers and active galvanic isolators are offered with HART® compliance. Consult the manufacturer or refer to the documents listed at the end of this instruction manual.

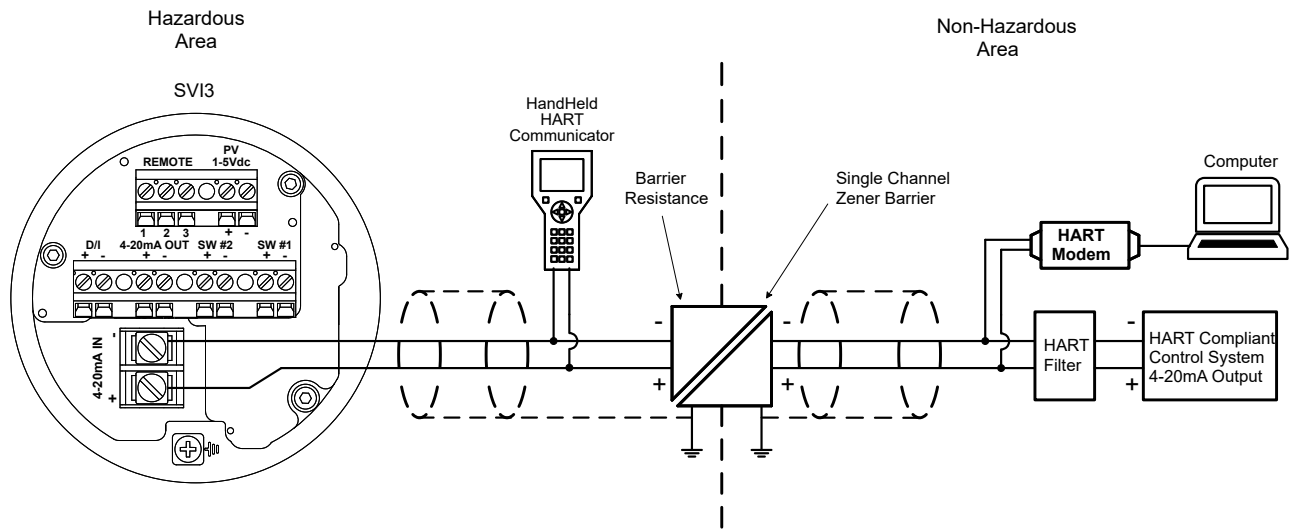


Figure 40 - Intrinsically Safe Installation with Zener Barrier and HART® Filter

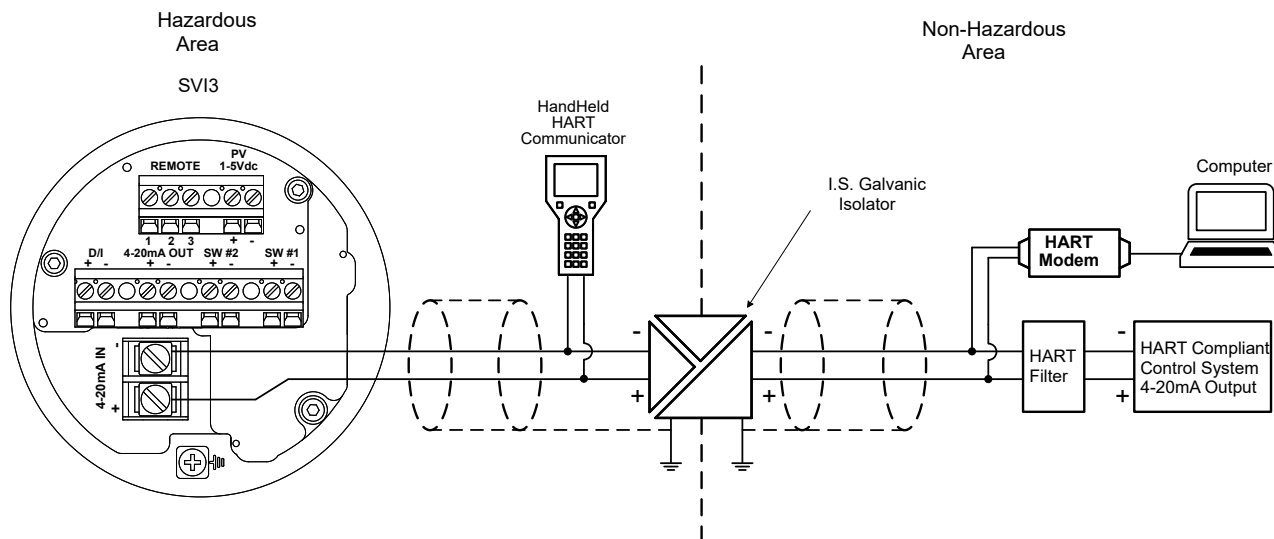


Figure 41 - Intrinsically Safe Installation with Galvanic Isolator



Do not connect a HART® modem and a PC to a control circuit unless the controller is HART® compatible or has a HART® filter. Loss of control or a process upset can occur if the controller output circuit is not compatible with HART® signals.

Note: A control circuit must be HART® compatible or have a HART® filter installed. Contact the manufacturer of the controller or DCS. See HART® Filter Required for Certain Controls System Output Circuits.

7.8.3 Output Channel Isolation

The designer of the signaling circuit where the SVI3 is to be installed must consider the 8 design rules in Wiring Guidelines (see “Wiring Guidelines” on page 36 of this manual). In particular, the control system output interface has analog output channels that are galvanically isolated and share a common ground or are separated from ground by the current control transistor or sense resistor.

- If the outputs are isolated a single channel Zener diode barrier can be used.
- If the outputs share a common ground a single channel Zener diode barrier can be used.
- If the outputs are separated from ground a dual channel Zener barrier is required.

Controller outputs are separated internally from ground by a current sense resistor or a control transistor. Dual channel barriers apply excessive loop resistance and cause compliance voltage problems. An Intrinsically Safe galvanic isolator operates with all three types of output channels, isolated, grounded or separated from ground, and provides sufficient compliance voltage. The galvanic isolator must be certified by the manufacturer to be HART® compliant if the HART® connections are supported on the safe area side of the isolator. See Figure 40 on page 117. Consult barrier and isolator manufacturer for devices rated for use with the SVI3 I.S. entity parameters in Hazardous Area Approvals.

7.9 Capability and Safety Function Instructions

7.9.1 Relevant Standards

IEC 61508 2010 Functional safety of electrical/electronic/programmable electronic safety-related systems.
ANSI/ISA 84.00.01-2004 (IEC 61511 Mod.) Functional Safety – Safety Instrumented Systems for the Process Industry Sector

7.9.2 Terms and Abbreviations

The following terms and abbreviations are related to safety functions of the SVI3 and are used throughout this document:

Safety	Mitigation of unacceptable risk of harm.
Functional Safety	The ability of a system to carry out the actions necessary to achieve or to maintain a defined safe state for the equipment / machinery / plant / apparatus under control of the system.
Basic Safety	The equipment must be designed and manufactured such that it protects against risk of damage to persons by electrical shock and other hazards and against resulting fire and explosion. The protection must be effective under all conditions of the nominal operation and under single fault condition.
Safety Assessment	The investigation to arrive at a judgment - based on evidence - of the safety achieved by safety-related systems.
Fail-Safe State	State where the SVI3 is de-energized and has exhausted Actuator 1 in a single acting configuration.
Fail Safe	Failure that causes the valve to go to the defined fail-safe state without a demand from the process.
Fail Dangerous	Failure that does not respond to a demand from the process (i.e. being unable to go to the defined fail-safe state).
Fail No Effect	Failure of a component that is part of the safety function but that has no effect on the safety function.
Low Demand Mode	Mode, where the frequency of demands for operation made on a safety-related system is no greater than twice the proof test frequency.
Fault Tolerance	Ability of a functional unit to continue to perform a required function in the presence of faults or errors
Safety Accuracy	The measurement error that occurs due to component degradation and failure during the useful life of an instrument.
Type A component	“Non-Complex” component (using discrete elements); for details see IEC 61508-2
Type B component	“Complex” component (using micro controllers or programmable logic); for details see IEC 61508-2

The following acronyms are related to safety functions of the SVI3 and are used throughout this document:

FIT	Failure In Time (1x10 ⁻⁹ failures per hour)
FMEDA	Failure Mode Effect and Diagnostic Analysis
HFT	Hardware Fault Tolerance
MTTR	Mean Time To Repair
PFDavg	Average Probability of Failure on Demand
SFF	Safe Failure Fraction, the fraction of the overall failure rate of a device that results in either a safe fault or a diagnosed unsafe fault
SIF	Safety Instrumented Function, a set of equipment intended to reduce the risk due to a specific hazard (a safety loop)
SIL	Safety Integrity Level, discrete level (one out of a possible four) for specifying the safety integrity requirements of the safety functions to be allocated to the E/E/PE safety-related systems where Safety Integrity Level 4 has the highest level of safety integrity and Safety Integrity Level 1 has the lowest.
SIS	Safety Instrumented System – Implementation of one or more Safety Instrumented Functions. A SIS is composed of any combination of sensor(s), logic solver(s), and final element(s).
λ_{sd}	Rate for Safe Detected failure
λ_{su}	Rate for Safe Undetected failure
λ_{dd}	Rate for Dangerous Detected failure
λ_{du}	Rate for Dangerous Undetected failures

7.9.3 Introduction

This section provides information necessary to design, install, verify, and maintain a Safety Instrumented Function (SIF) utilizing a Masoneilan Smart Valve Interface, SVI3. This manual provides necessary requirements for meeting the IEC61508 and IEC 61511 functional safety standards.

The SVI3 has been assessed by Exida to the requirements of IEC 61508 and is meeting the requirements providing a level of integrity to SIL 3 capable as a Type A, Route 2H device.

The safety function of the SVI3 is designed to open or close a final control element (valve / actuator) within the specified safety time when the SVI3 is de-energized (No pneumatic input to SVI3(<1psi), and/or electrical input signal <2.0mA)

Users are responsible to use the defined failure rates in a probabilistic model of safety instrumented function(SIF) to determine the suitability in part for safety instrument system(SIS) usage in a particular safety integrity level (SIL)

7.9.4 SVI3 Device Description

The SVI3 is a Digital Valve Positioner which can be used together with control valves and actuators capable of satisfying the requirements of functional safety in accordance with IEC 61508. During normal operation, the SVI3 is positioning the valve in response to setpoint signal from the controller. In case of an unsafe situation, the SVI3 can be de-energized by the Control System. With an input signal of <2mA, or loss of Pneumatic supply (<1psi), the SVI3 will de-energize the actuator. Used together with a spring return actuator, the system will place the valve into its designed fail safe

position. The built-in microprocessor is used for valve diagnostics only. The microprocessor has no direct role in performing the designated safety function therefore the SVI3 is considered a Type A device. Because of its capability of monitoring data from its embedded sensors, the SVI3 is capable of validating the health of its integral components under normal operation.

7.9.5 Designing a SIF Using an SVI3

The following must be taken into consideration when designing a SIF (Safety Instrumented Function) using the SVI3:

- Safety Function
- Environmental Limits
- Application Limits
- Design Verification
- SIL Capability
- Connecting the SVI3 to the Controller
- General Requirements

7.9.5.1 Safety Function

When de-energized, the SVI3 allows for the pneumatically actuated spring return valve to move to its fail-safe position. For a single-acting controller the safe state is when the port Actuator 1 is exhausted to a pressure less than 1PSIG (0.069 bar, 6.9 kPa). The valve actuation must automatically move the valve to the safe state when the digital valve controller falls in safe state. The SVI3 is intended to be part of final element subsystem, as per IEC 61508, and the achieved SIL level of the function must be verified by the function designer.

7.9.5.2 Environmental Limits

The designer of a SIF must check that the product is rated for use within the environmental limits as stated in Section 6 – Specifications and References

7.9.5.3 Application Limits

The application of the SVI3 is limited for SIF where the safe state is the de-energized state (shutdown) of the valve. A safe state is achieved by an input signal <2mA, or pneumatic supply <1psi

7.9.5.4 Design Verification

The following describes the design verification criteria for the SIF and the SVI3:

- A detailed Failure Mode, Effects, and Diagnostics Analysis (FMEDA) report is available from Exida. This report details all failure rates and failure modes as well as the expected lifetime.
- The achieved Safety Integrity Level (SIL) of an entire Safety Instrumented Function (SIF) design must be verified by the designer by means of PFDavg calculation, considering redundant architectures, proof test interval, proof test effectiveness, any automatic diagnostics, average repair time and specific failure rates of all products included in the SIF. Each subsystem must be checked to assure compliance with minimum hardware fault tolerance (HFT) requirements. The Exida exSILentia® tool is recommended for this purpose as it contains accurate models for the SVI3 and related failure rates.
- When using an SVI3 in a redundant configuration, include a common cause factor of 5% in safety integrity calculations.
- The failure rate data listed in the FMEDA report is valid only for the useful life time of an SVI3. The failure rates sometimes increase after this time period. Reliability calculations based upon the data listed in the FMEDA report for mission times beyond the lifetime can yield results too optimistic, i.e. the calculated Safety Integrity Level will not be achieved.

7.9.5.5 SIL Capability

The SVI3 meets SIL 3 requirements as outlined below.

Systematic Integrity

The product has met manufacturer design process requirements of Safety Integrity Level (SIL) 3. These are intended to achieve sufficient integrity against systematic errors of design by the manufacturer. A Safety Instrumented Function (SIF) designed with this product must not be used at a SIL level higher than the statement without prior use justification by end user or diverse redundant technology in the design.

Random Integrity

The SVI3's safety critical function is maintained by a Type A Device. Therefore based upon the SFF > 90%, when the SVI3 is used as the sole component in a final element subassembly, a design can meet SIL 3 @ HFT=0.

When the final element assembly consists of many components (SVI3, quick exhaust valve, actuator, isolation valve, etc.) the SIL must be verified for the entire assembly taking into consideration failure rate of each component. This analysis must account for any hardware fault tolerance and architecture constraints.

Safety Parameters

For detailed failure rate information refer to the Failure Modes, Effects and Diagnostic Analysis Report for the SVI3 available from Exida.

SIL Certification

Independently certified by Exida to designed safety function with a PFD in accordance to IEC61508 SIL3 capable.

7.9.5.6 Connecting the SVI3 to the Controller

When connecting the SVI3 to the controller, the user must follow the instructions contained with this instruction manual, including but not limited to section 3 and 7.

7.9.5.7 General Requirements

The following general requirements for the SVI3 must comply to the following:

- The system response time shall be less than process safety time. The SVI3 initiates the system to the fail safe state in less than 100ms upon loss of electrical signal. Response after loss of pneumatic supply can vary based on bleed rate/setpoint demand. Response time is actuator dependent.
- The end user must add the SVI3 response time to actuator/valve response to obtain overall response time.
- All SIS components, including the SVI3, must be operational before process start-up.
- Personnel performing maintenance and testing on the SVI3 has to be qualified to do so.
- The useful life of the SVI3 is discussed in the Failure Modes, Effects and Diagnostic Analysis Report for the SVI3.
- To avoid unwanted or unauthorized modification, the set parameters must be protected. Therefore the hardware lock jumper should be set in the secure (locked) position.

7.9.6 Installation, Operation, Maintenance

SVI3 Installation

Refer to Section 3 – SVI3 Installation and Set Up, contained within this manual

Operation, Setup, Commissioning

Refer to Section 4 – Using the Digital Interfaces, contained within this manual

Maintenance and Diagnostics

Refer to Section 5 – Maintenance and Troubleshooting, contained within this manual

Refer to Section 7.4 – Using DTM Diagnostics, contained within this manual

7.9.7 Proof Tests

The objective of proof testing is to detect failures within an SVI3 and the valve/actuator which it is installed onto, which are not detected by any automatic diagnostic of the system. Of main concern are undetected failures that prevent the safety instrumented function from performing its intended function.

Proof testing frequency or proof test interval, has to be determined in reliability calculations for the safety instrumented functions to which SVI3 is applied. The proof tests must be performed more frequently or as frequently as specified in the calculation in order to maintain the required safety integrity of the safety instrumented function.

The following proof test is recommended. Report any detected failures that compromise functional safety to the factory.

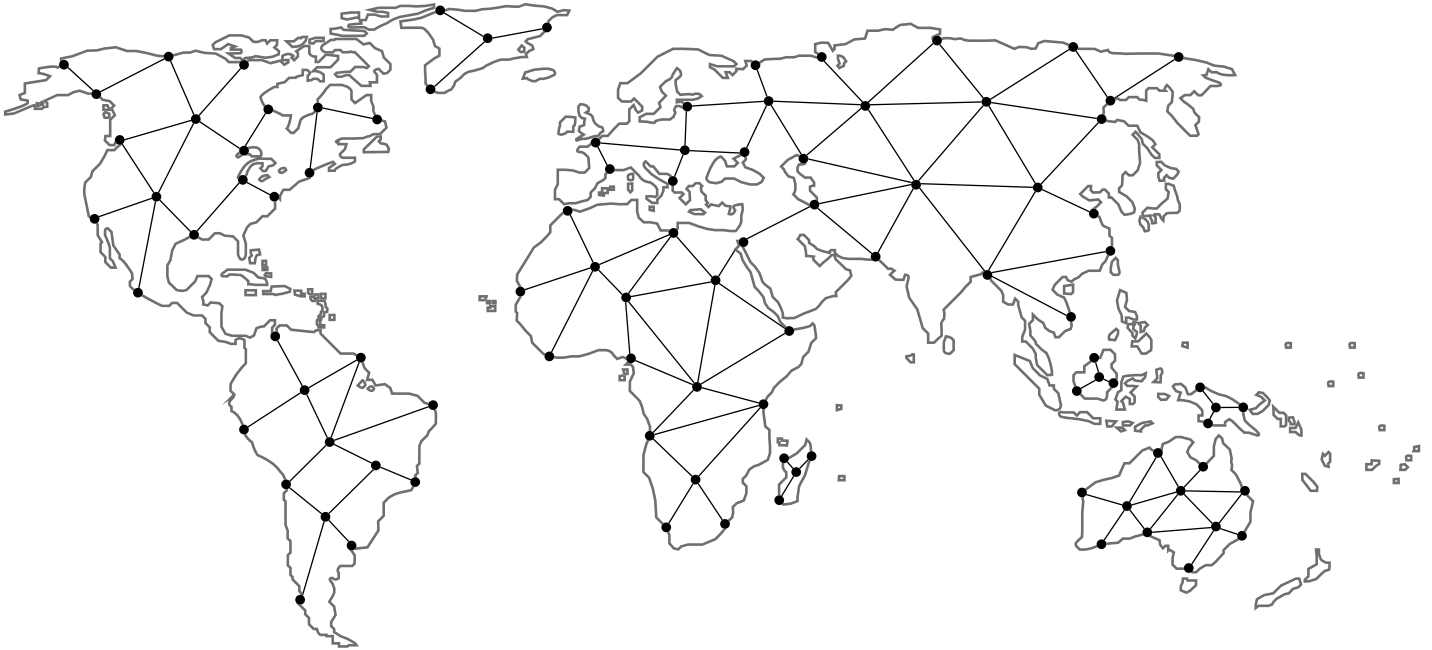
Proof Test Steps

1. Read the SVI3 data record using a HART® handheld device or the SVI3 DTM software. Solve any active faults before proceeding.
2. Bypass the valve, or isolate or take other appropriate action to avoid a false trip, following company Management of Change (MOC) procedures.
3. Inspect the SVI3 for dirty or clogged ports and other physical damage.
4. De-energize the SVI3 and observe that the actuator and valve move. Energize the SVI3 after the valve has moved to its full stroke length. An accumulated value of 100% travel = 1 stroke. The travel does not need to occur in one movement.
5. Inspect the SVI3 for dirt, corrosion or excessive moisture. Clean if necessary and take corrective action to properly clean the air supply. It has to be done in order to avoid incipient failures due to dirty air.
6. Record any failures in your company's SIF inspection database. Restore the loop to full operation.
7. Remove bypass or otherwise restore normal operation.

This test detects approximately 99% of possible DU failures in the SVI3 (Proof Test Coverage). The person(s) performing the proof test of an SVI3 must be trained in SIS operations, including bypass procedures, maintenance and company Management of Change procedures. No special tools are required.

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