WOODWARD

Product Manual 26727
(Revision R, 1/2020)
Original Instructions

VariStroke-I (VS-I)
Electro-hydraulic Actuator

Installation and Operation Manual

General Precautions

Read this entire manual and all other publications pertaining to the work to be performed before installing, operating, or servicing this equipment.

Practice all plant and safety instructions and precautions.

Failure to follow instructions can cause personal injury and/or property damage.

Revisions

This publication may have been revised or updated since this copy was produced. To verify that you have the latest revision, check manual *26455*, *Customer Publication Cross Reference and Revision Status & Distribution Restrictions*, on the *publications page* of the Woodward website:

www.woodward.com/publications

The latest version of most publications is available on the *publications page*. If your publication is not there, please contact your customer service representative to get the latest copy.

Proper Use

Any unauthorized modifications to or use of this equipment outside its specified mechanical, electrical, or other operating limits may cause personal injury and/or property damage, including damage to the equipment. Any such unauthorized modifications: (i) constitute "misuse" and/or "negligence" within the meaning of the product warranty thereby excluding warranty coverage for any resulting damage, and (ii) invalidate product certifications or listings.

Translated Publications

If the cover of this publication states "Translation of the Original Instructions" please note:

The original source of this publication may have been updated since this translation was made. Be sure to check manual *26455*, *Customer Publication Cross Reference and Revision Status & Distribution Restrictions*, to verify whether this translation is up to date. Out-of-date translations are marked with ⚠. Always compare with the original for technical specifications and for proper and safe installation and operation procedures.

Revisions— A bold, black line alongside the text identifies changes in this publication since the last revision.

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Warnings and Notices

Important Definitions

This is the safety alert symbol used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

- **DANGER** - Indicates a hazardous situation, which if not avoided, will result in death or serious injury.
- **WARNING** - Indicates a hazardous situation, which if not avoided, could result in death or serious injury.
- **CAUTION** - Indicates a hazardous situation, which if not avoided, could result in minor or moderate injury.
- **NOTICE** - Indicates a hazard that could result in property damage only (including damage to the control).
- **IMPORTANT** - Designates an operating tip or maintenance suggestion.

⚠WARNING

Overspeed / Overtemperature / Overpressure

The engine, turbine, or other type of prime mover should be equipped with an overspeed shutdown device to protect against runaway or damage to the prime mover with possible personal injury, loss of life, or property damage.

The overspeed shutdown device must be totally independent of the prime mover control system. An overtemperature or overpressure shutdown device may also be needed for safety, as appropriate.

⚠WARNING

Personal Protective Equipment

The products described in this publication may present risks that could lead to personal injury, loss of life, or property damage. Always wear the appropriate personal protective equipment (PPE) for the job at hand. Equipment that should be considered includes but is not limited to:

- **Eye Protection**
- **Hearing Protection**
- **Hard Hat**
- **Gloves**
- **Safety Boots**
- **Respirator**

Always read the proper Material Safety Data Sheet (MSDS) for any working fluid(s) and comply with recommended safety equipment.

⚠WARNING

Start-up

Be prepared to make an emergency shutdown when starting the engine, turbine, or other type of prime mover, to protect against runaway or overspeed with possible personal injury, loss of life, or property damage.

Electrostatic Discharge Awareness

NOTICE

Electrostatic Precautions

Electronic controls contain static-sensitive parts. Observe the following precautions to prevent damage to these parts:

- **Discharge body static before handling the control (with power to the control turned off, contact a grounded surface and maintain contact while handling the control).**
- **Avoid all plastic, vinyl, and Styrofoam (except antistatic versions) around printed circuit boards.**
- **Do not touch the components or conductors on a printed circuit board with your hands or with conductive devices.**

To prevent damage to electronic components caused by improper handling, read and observe the precautions in Woodward manual *82715*, *Guide for Handling and Protection of Electronic Controls, Printed Circuit Boards, and Modules*.

Follow these precautions when working with or near the control.

1. Avoid the build-up of static electricity on your body by not wearing clothing made of synthetic materials. Wear cotton or cotton-blend materials as much as possible because these do not store static electric charges as much as synthetics.
2. Do not remove the printed circuit board (PCB) from the control cabinet unless absolutely necessary. If you must remove the PCB from the control cabinet, follow these precautions:
   - Do not touch any part of the PCB except the edges.
   - Do not touch the electrical conductors, the connectors, or the components with conductive devices or with your hands.
   - When replacing a PCB, keep the new PCB in the plastic antistatic protective bag it comes in until you are ready to install it. Immediately after removing the old PCB from the control cabinet, place it in the antistatic protective bag.

Regulatory Compliance

Product Compliance Code: Product certifications are dictated by the product model number, and traceable per the product serial number. For information on which hazardous locations any particular VariStroke is rated for, refer to the Model Number and Model Number information below. Find the Model Number on the nameplate of the VariStroke.

Varistroke Model Number Information

Varistroke Product Line	Valve Size	Configuration	Action		Bore	Stroke		Rod End	Fail-Safe Direction	**Compliance**		Specials
V	XX	X	X	–	XX	XX	–	X	X	**X**	–	XX

Code	Description
0	CE Marked for Ordinary Locations
1	North American Div 1 & 2, ATEX/IECEx Zone 1 & 2
2	North American Div 2, ATEX/IECEx Zone 2
3	North American Div 1 & 2, ATEX/IECEx Zone 1 & 2, EAC
4	North American Div 2, ATEX/IECEx Zone 2, EAC
5	(Reserved for Future Use)
6	(Reserved for Future Use)
7	North American Div 1 & 2, ATEX/IECEx Zone 1 & 2, TIIS
8	(Reserved for Future Use)
9	North American Div 1 & 2, ATEX/IECEx Zone 1 & 2, CCOE
A	North American Div 2, ATEX/IECEx Zone 2, CCOE
B	North American Div 1 & 2, ATEX/IECEx Zone 1 & 2, KCS MARK KOREA
C	North American Div 2, ATEX/IECEx Zone 2, KCS MARK KOREA

European Compliance for CE Marking:
These listings are limited only to those units bearing the CE Marking. Review the Compliance Code table for more information.

EMC Directive Declared to Directive 2014/30/EU of the European Parliament and of the Council of 26 February 2014 on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC)

ATEX Directive: Directive 2014/34/EU on the harmonisation of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres
Zone 1: II 2 G Ex db IIB T4 Gb, Sira 14ATEX1028X
Zone 2: II 3 G Ex nA IIC T4 Gc, Sira 14ATEX5029X

Other European Compliance:
Compliance with the following European Directives or standards does not qualify this product for application of the CE Marking

ATEX Directive: Exempt from the non-electrical portion of the ATEX Directive 2014/34/EU due to no potential ignition sources per EN ISO 80079-36:2016 for Zone 1 installation.

Machinery Directive: Compliant as partly completed machinery with Directive 2006/42/EC of the European Parliament and the Council of 17 May 2006 on machinery.

Pressure Equipment Directive: Compliant as "SEP" per Article 4.3 to Pressure Equipment Directive 2014/68/EU on the harmonisation of the laws of the Member States relating to the making available on the market of pressure equipment.

RoHS Directive: Restriction of Hazardous Substances 2011/65/EU:
Woodward Turbomachinery Systems products are intended exclusively for sale and use only as a part of Large Scale Fixed Installations per the meaning of Art.2.4(e) of directive 2011/65/EU. This fulfills the requirements stated in Art.2.4(c) and as such the product is excluded from the scope of RoHS2.

EAC Customs Union
These listings are limited only to those units with labels, marking, and manuals in Russian language to comply with their certificates and declaration. Review the Compliance Code table for more information.

EAC Customs Union (Marked): Certified to Technical Regulation CU 012/2011 for use in potentially explosive atmospheres per Certificate
RU C-US.МЮ62.B00436
Zone 1: 1Ex d IIB T4 Gb X
Zone 2: 2Ex nA IIC T4 Gc X

Other International Compliance
These listings are limited only to those units bearing the appropriate marking. Review the Compliance Code table for more information.

IECEx: Certified for use in explosive atmospheres per Certificate:
IECEx CSA 13.0041X
Zone 1: Ex db IIB T4 Gb
Zone 2: Ex nA IIC T4 Gc

CCOE (PESO) India: Certified for explosive atmospheres under Petroleum Rules 2002. Zone 1 and Zone 2 per the IECEx certificate above.

TIIS Japan: Code T – Integrated models are certified for use in explosive atmospheres per TIIS Certificate TC21468. Zone 1 and Zone 2 per the IECEx certificate above.

KCs Mark Korea KTL Certified for use in explosive atmospheres.
Zone 1, KTL 17-KA4BO-0458X as Ex db IIB T4 Gb
Zone 2, KTL 17-KA4BO-0459X as Ex nA IIC T4 Gb

North American Compliance:
These listings are limited only to those units bearing the appropriate marking. Review the Compliance Code table for more information.

CSA: Certified for Class I, Div.1 Groups C, D T4 or Class I, Div. 2 Groups A, B, C, D T4. For Use in Canada and the United States. Certificate 2669905.

Special Conditions for Safe Use

Wiring must be in accordance with North American, European, or other International wiring methods as applicable, and in accordance with the authority having jurisdiction.

For Zone 1 or Division 1: Conduit seals must be installed within 18 inches (457 mm) of the conduit entry.

Field wiring must be suitable for at least +85 °C and 10 °C above the maximum fluid and ambient temperatures.

The maximum hydraulic oil temperature is 70 °C continuous.
The following have a maximum constructional gap (ic) less than that required by Tables 1 and 2 of EN 60079-1 and hence are as detailed below:

Table RC-1. Linear Electro-Hydraulic Actuator, Model VariStroke-I

Flame Path	Max Gap, ic (mm) Comment	Min. width of joint L (mm) Comment
Spool to Spacer	0.079	13.46
Sleeve to Spacer	0.079	12.85
Sleeve to Sleeve	0.048	14.76
Sleeve to Housing	0.076	15.85
Sensor to Plate	0.08	36.25
Plate to Housing	0.10	22.91
Plate to Housing	0.10	20.22
Plate to Plate	0.10	22.91

Connect external safety ground terminal to earth ground.

Compliance with the Machinery Directive 2006/42/EC noise measurement and mitigation requirements is the responsibility of the manufacturer of the machinery into which this product is incorporated.

Under certain extreme circumstances, the non-metallic parts incorporated in the enclosure of this equipment may generate an ignition-capable level of electrostatic charge. Therefore, do not install the equipment in a location where the external conditions are conducive to the build-up of electrostatic charge on such surfaces. Proper grounding when used in a fixed installation mitigates this risk. In addition, only clean the equipment with a damp cloth.

Transient protection for the VariStroke-I is to be provided externally by the end user. The transient protection device is to be set at a level not exceeding 140% of the peak rated voltage.

The installation of the VariStroke-I shall only be within a Pollution Degree 2 environment as defined in IEC 60664-1.

⚠WARNING

EXPLOSION HAZARD—Do not remove covers or connect/disconnect electrical circuits unless power has been switched off or the area is known to be non-hazardous.
Substitution of components may impair suitability for Class I, Division 2 or Zone 2 applications.

⚠AVERTISSEMENT

Risque d'explosion -- Ne pas enlever les couvercles, ni raccorder / débrancher les prises électriques, sans vous en assurez auparavant que le système a bien été mis hors tension; ou que vous situez bien dans une zone non explosive.
La substitution de composants peut rendre ce matériel inacceptable pour les emplacements de Classe I, applications Division 2 ou Zone 2.

Safety Symbols


Direct Current


Alternating Current


Both Alternating and Direct Current


Caution, risk of electrical shock


Caution, refer to accompanying documents


Protective conductor terminal


Frame or chassis terminal

Chapter 1.
General Information

Introduction

The VariStroke-I is a linear electro-hydraulic actuator that utilizes a double-acting or spring-assist power cylinder with integrated electronic driver module, servo valve, and redundant MLDTs (Magnetostrictive Linear Displacement Transducer) – based position feedback sensors to precisely control steam turbine valves. The actuator's driver module accepts one or two (redundant) 4–20 mA demand setpoints and compares these setpoints to the sensed actuator shaft position to accurately control output shaft position.

The actuator's output shaft position is controlled by a digital controller with an internal rotary servo valve that ports supply oil to and from its power cylinder piston. This actuator's digital controller architecture allows it to perform stable position control during normal conditions, and responds quickly to desired valve step changes during system or plant transients. The actuator output force is generated only by oil pressure for double-acting power cylinder. For the spring assist, actuator output force is a combination of force from hydraulic pressure and spring. Spring assist cylinder is still working as double acting actuator but it has a spring installed inside the cylinder. Spring can be mounted either on the piston or rod side and it generates force toward the failsafe position. There are three different spring force categories for each cylinder diameter, except for 8" and 10" cylinder bores which need four spring force categories to cover application needs. The springs are rated at about ~1.5%, ~2.5%, ~5.5%, and ~10.5% of stall force at 500-psi supply pressure.

As a means of protecting the turbine, an internal servo valve-return spring forces the actuator to a failsafe position to safely close turbine control valves upon any internal unit failure (electrical input power failure, position sensor failure, processor failure, etc.). Additionally for the spring assist, power cylinder the actuator spring assists in closing the valve in the event of the loss of oil pressure and helps to maintain fail safe position.

The VariStroke-I actuator is a product family with many different models available for purchase depending on the force, stroke, and redundancy required. Servo V45 (flow 212-530l/min) works with 4, 5, 6, 8 and 10 inch actuators. Cylinders are available with standard bore diameters and standard stroke ranges. The VariStroke's unique "variable stroke" capability also allows users to customize/set the actuator's exact maximum stop position in the field to meet their requirement. The VariStroke-I is available as an integrated unit, or as a Remote Servo kit where the cylinder can be mounted up to 3 meters (approx. 10 feet) away from the servo. V45 servo is available also as Servo Only option for users who wish to use their own hydraulic cylinder.

The VariStroke-I is factory and/or field configurable via a computer-based service tool. The actuator's PCI Service Tool uses a simple user-friendly format to allow users to easily configure, calibrate, and adjust all internal functions and response settings. The VariStroke-I also includes a 4–20 mA output channel to indicate output shaft (control valve) position, and unit alarm and shut down relay outputs for use as unit health and status indications.

The total installed cost for this fully integrated actuator is low because it has been completely assembled and tested at the factory. This greatly reduces OEM and end-user fabrication time, testing time, and site assembly time.

The VariStroke Actuator offers the following benefits to the user in comparison to other electro-hydraulic actuators:

Dirt Tolerance

The VariStroke-I actuator is specifically designed for steam turbine applications where turbine lube oil is also used to power the hydraulic turbine control valve actuator(s). Steam turbine applications can be extremely challenging for hydraulic control valve actuators as dirt, metal shavings, water, and other contaminants are common in such oil systems. Also due to the high temperatures at which steam turbines operate, turbine oil breakdown is common, resulting in the creation of a sludge-type substance and the varnishing of internal system components. However, the VariStroke-I actuator is designed to operate reliably within such challenging applications. Its corrosion-resistant materials, single moving rotary valve, 222 N (50 lbf) of chip shear force, and self-cleaning port design allow it to operate in such applications without experiencing undesirable sticking or dragging.

Valve Rack Linearization

Since flow-through single and staged inlet steam valves tend to be non-linear throughout their flow range, turbine controls must be de-tuned to compensate for instability or sluggish control points throughout this range. As a way of allowing turbine control optimization, the VariStroke-I includes an 11-point linearization table to allow turbine OEMs or users to compensate for poor valve linearization by digitally linearizing the control-to-valve flow relationship.

Side Load Capability

A common problem with turbine actuators is oil leaking from their output shaft due to connection to valve rack linkages, which have an arc-type of motion. This motion results in side loading of the actuator shaft, and after long periods may result in shaft-seal wear and resultant oil leakage. Designed for a continuous side load of up to 10% of actuator output, the VariStroke-I actuator incorporates a high-force precision bearing and triple-seal technology on its output shaft to solve this typical application problem.

Chemically Resistant Versions

For steam turbine applications where lube oil contains harsh chemical contaminants (ammonia, hydrogen sulfide etc.), a chemically resistant version of the VariStroke has been developed. Chemically resistant versions feature best in class seals in all wetted locations of the servo actuator and cylinder. Chemically resistant versions provide an optimal solution for extreme chemical resistance while still maintaining VariStroke operating pressure and temperature ranges. Please contact Woodward for available models and information regarding chemical resistance for specific applications.

VS-I Integrated and Remote Construction

The VariStroke-I is made up of the following major components (Figure 1-1):

1. Hydraulic Power Cylinder
2. Rotary Servo Valve
3. Feedback Sensors: MLDT (Magnetostrictive Linear Displacement Transducer) – for power cylinder position controlling
4. Integrated electronic driver module (PCB)

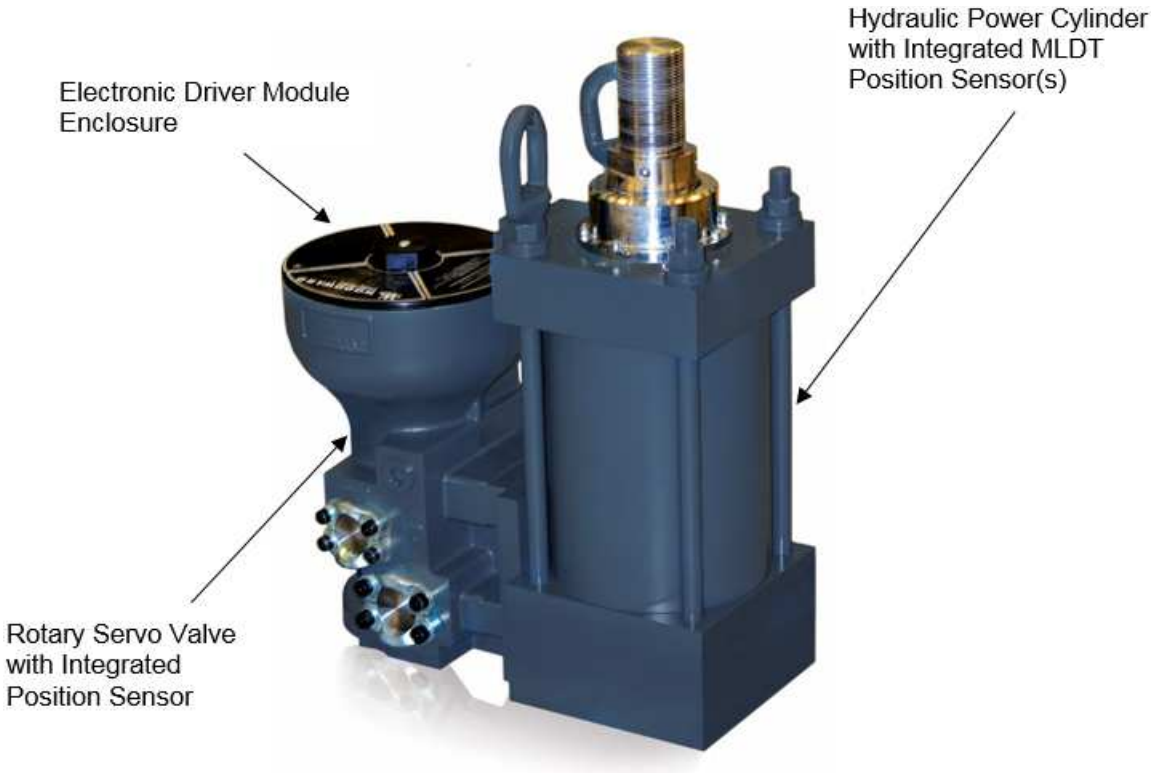

Figure 1-1. VariStroke-I, Key Features

The VariStroke-I Remote Servo Kit (Figure 1-2) contains the same primary components as integrated version, this kit allows the Hydraulic Power Cylinder to be mounted separately from the servo in applications where space is constrained.

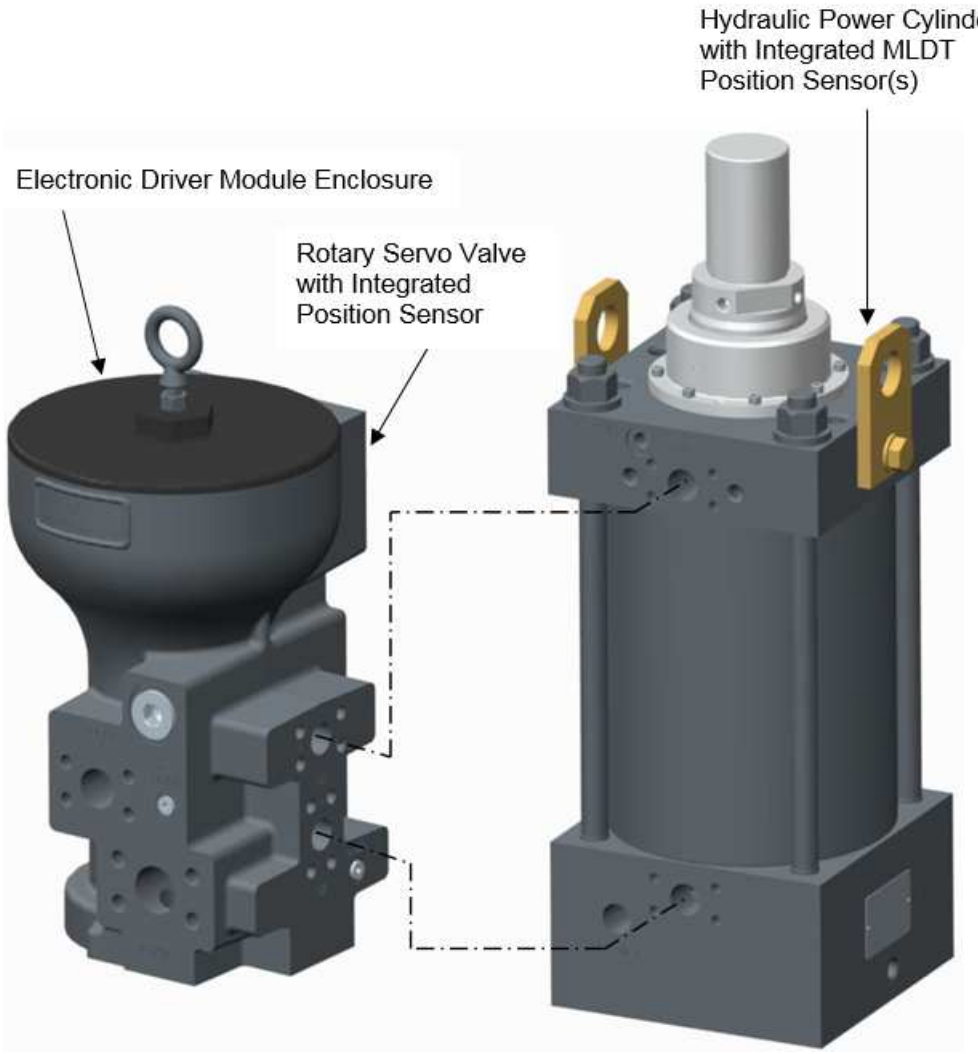

Figure 1-2. VariStroke-I Remote, Key Features

Hydraulic Power Cylinder

The simple and robust design of VS-I hydraulic cylinder (Figure 1-3) is capable of consistent performance for extended periods in challenging environments. Hydraulic cylinder is designed to operate in wide range of hydraulic pressures and with high oil contamination. The actuation stroke range can be adjusted precisely using PC service tool allowing the same actuator to accommodate a variety of strokes.

The hydraulic power cylinder is designed to be field replaceable in turbine shut down condition.

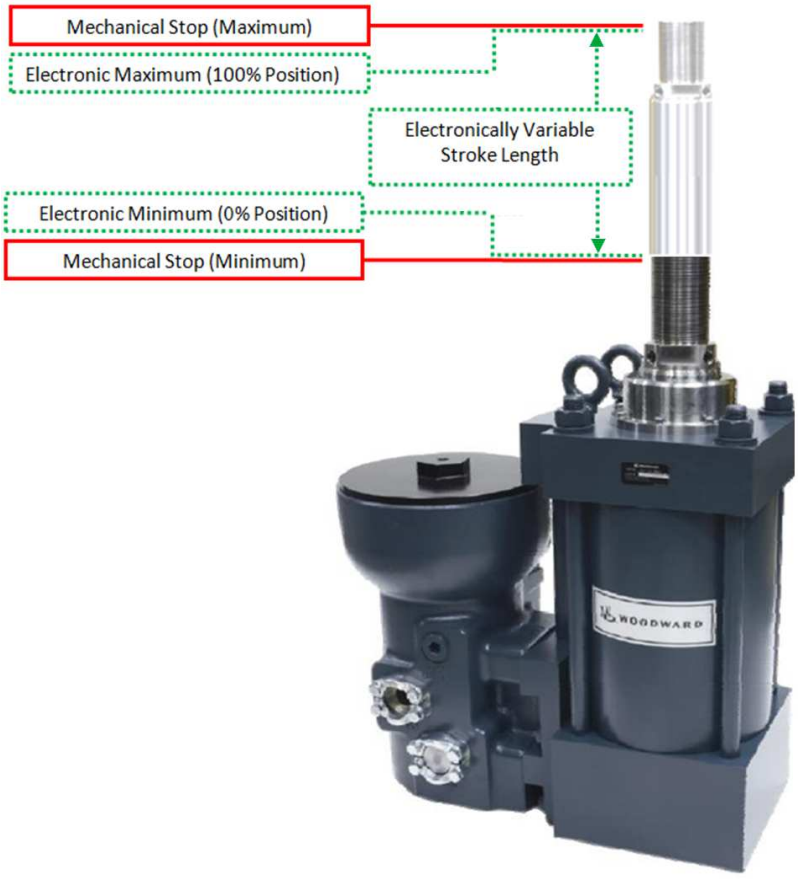

Figure 1-3. Hydraulic Power Cylinder - Stroke Adjustment Options

Rotary Servo Valve

The servo valve has four ports: Supply, two Control Ports, and Drain/Tank. With the hydraulic valve in its middle position, all ports are blocked. As the valve rotates, the supply is connected to a control port while simultaneously connecting the drain to the other control port. The combined action of the servo position controller and cylinder position controller modulate the power cylinder position as necessary to match the input demand.

Additionally, the Remote Servo has an OVBD (Over Board Drain) port which is permanently connected to drain. This port can (optionally) be connected to the OVBD connection on Hydraulic Power Cylinder to drain any leakage pass the primary rod seal.

A unique function of the software is a periodic, symmetrically opposed impulse which flushes silt and debris from the servo valve without causing undue wear called “Silt Buster”. At the interval and amplitude selected by the user, this function provides a very rapid motion of the hydraulic valve allowing any silt to be flushed to the drain passage. This motion is followed immediately by a step of equal amplitude in the opposite direction. The opposing symmetry of the impulse results in no net change in fluid volume to the controlled servo valve, and thus does not interrupt the control of the turbine. This unique function provides a higher degree of stability, reliability, and silt resistance.

If the unit detects any diagnostic shut down condition, or if the detected diagnostic condition prevents reliable control, or if a loss of power occurs, the servo valve return spring forces the valve to connect the appropriate control pressure to drain causing the cylinder to move to the fail-safe position.

Servo Valve Actuator

The VS-I uses a rotary limited angle torque (LAT) actuator. The permanent magnet rotor is directly coupled to the servo valve.

The position of the rotor is measured by a solid state integrated circuit on the PCB which detects the orientation of the sensing magnet on the shaft. The
H-bridge drive is regulated by the microprocessor to precisely control the servo valve position and maintain the cylinder stroke position demand.

Electronic Driver Module Printed Circuit Board (PCB)

The PCB is mounted on top of the housing and performs the following tasks:

- Power Supply
- Isolated Input and Outputs
- Dual Redundant Demand inputs
- Dual Redundant inputs for Final Cylinder Feedback
- Microprocessor based control
- Actuator H-Bridge Drive
- Current Limiting for Thermal Protection
- Advanced Diagnostics
- Discrete Outputs for Fault, Alarm and Shutdown Enunciation

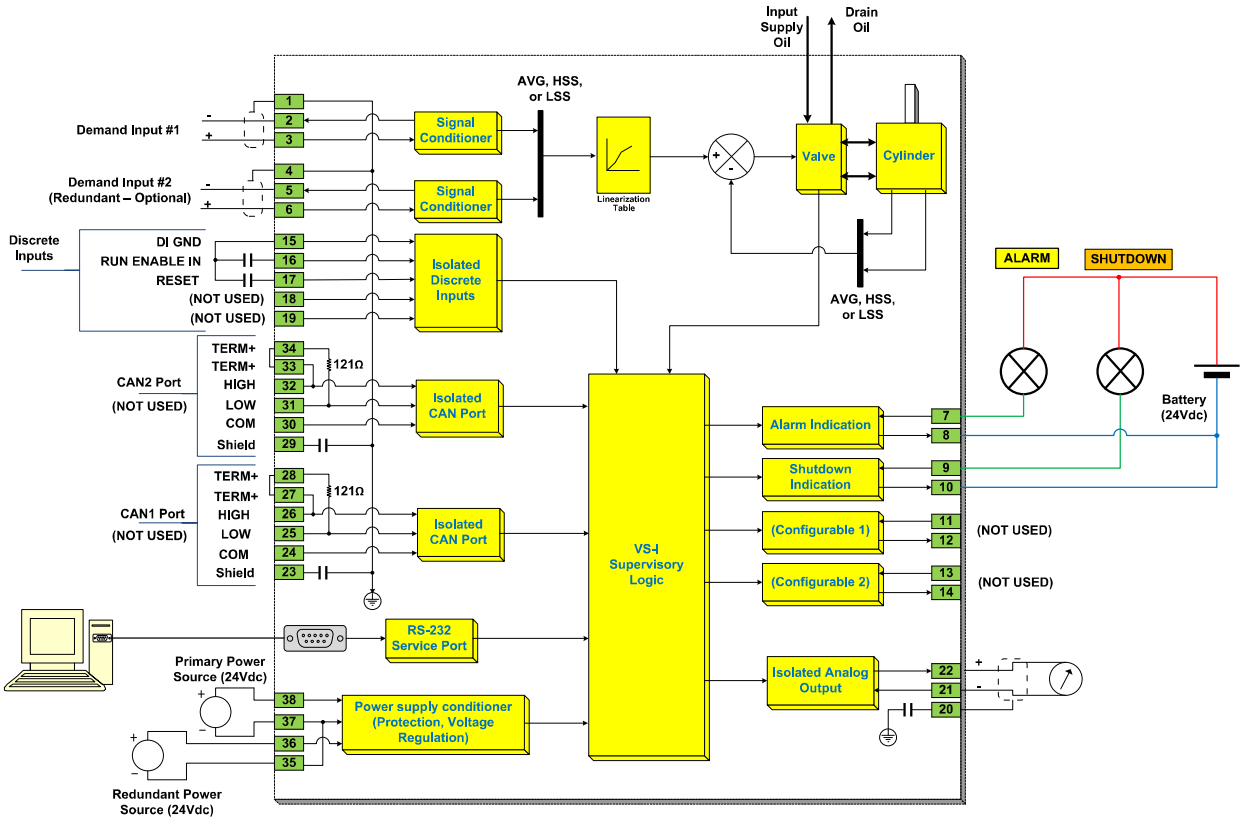

Figure 1-4. Application Example

The shield connections for the Analog Output (terminal #20), CAN1 (terminal #23) and CAN2 (terminal #29) are through capacitors only as indicated in the wiring section of this manual.

The power supply system performs the EMI filtering on the (18 to 32) V (dc) input voltage, generates controlled voltages for several electronics sub-systems and is monitored for proper operation. If input voltage or internal power systems are detected outside of allowable operating ranges, a diagnostic alarm will be enunciated.

Calibration and configuration of alarms and shut down and redundancy operation are configurable via the PC Service Tool.

The primary demand and redundant demand / feedback input signals are designed for a (4 to 20) mA control signal. Each input signal is EMC protected.

Discrete outputs are provided for alarm and shut down enunciation. An internal LED also is illuminated when a fault condition is detected. Cover needs to be removed to see this LED. The configurable discrete output can be customized to output a variety of enunciations using the PC Service Tool. All of the discrete outputs are configurable for normally open or normally closed action using the PC Service Tool.

Cylinder Position Control

The cylinder position controller adjusts the hydraulic power cylinder position to match the feedback signal to the demand. Monitoring of both the servo position controller and cylinder position controller ensures accurate tracking.

The position controller regulates a Pulse Width Modulated (PWM) drive signal to the actuator. The drive current to the actuator is regulated, transiently allowing up to 10 Amps to be provided to move the actuator at its maximum speed and torque. A steady state current limit becomes active after a period of a few seconds to protect the actuator and electronics.

VS-I Remote Servo Only Construction

The Remote Servo (Figure 1-5) has the following major components:

1. Rotary Servo Valve
2. PCB (This information is available in the VS-I Integrated and Remote Construction section above

Rotary Servo Valve

The hydraulic servo valve has five ports: Supply, two Control Ports, Over Board Drain (OVBD), and Drain/Tank. With the hydraulic valve in its middle position, both control ports are blocked. As the valve rotates, supply pressure is connected to a control port while simultaneously connecting the drain to the other control port. The combined action of the servo position controller and cylinder position controller modulate the power cylinder position as necessary to match the input demand. OVBD is permanently connected to drain and can (optionally) be connected to the OVBD connection on Hydraulic Power Cylinder to drain any leakage pass the primary rod seal.

A unique function of the software is a periodic, symmetrically opposed impulse (called "Silt Buster") which flushes silt and debris from the servo valve without causing undue wear. At the interval and amplitude selected by the user, this function provides a very rapid motion of the hydraulic valve, allowing any silt to be flushed to the drain passage. This motion is followed immediately by a step of equal amplitude in the opposite direction. The opposing symmetry of the impulse results in no net change in fluid volume to the controlled servo valve, and thus does not interrupt the control of the turbine. This unique function provides a higher degree of stability, reliability, and silt resistance.

If the unit detects any diagnostic shut down condition, or if the detected diagnostic condition prevents reliable control, or if a loss of power occurs, the servo valve return spring forces the valve to connect the appropriate control pressure to drain, causing the cylinder to move to the fail-safe position.

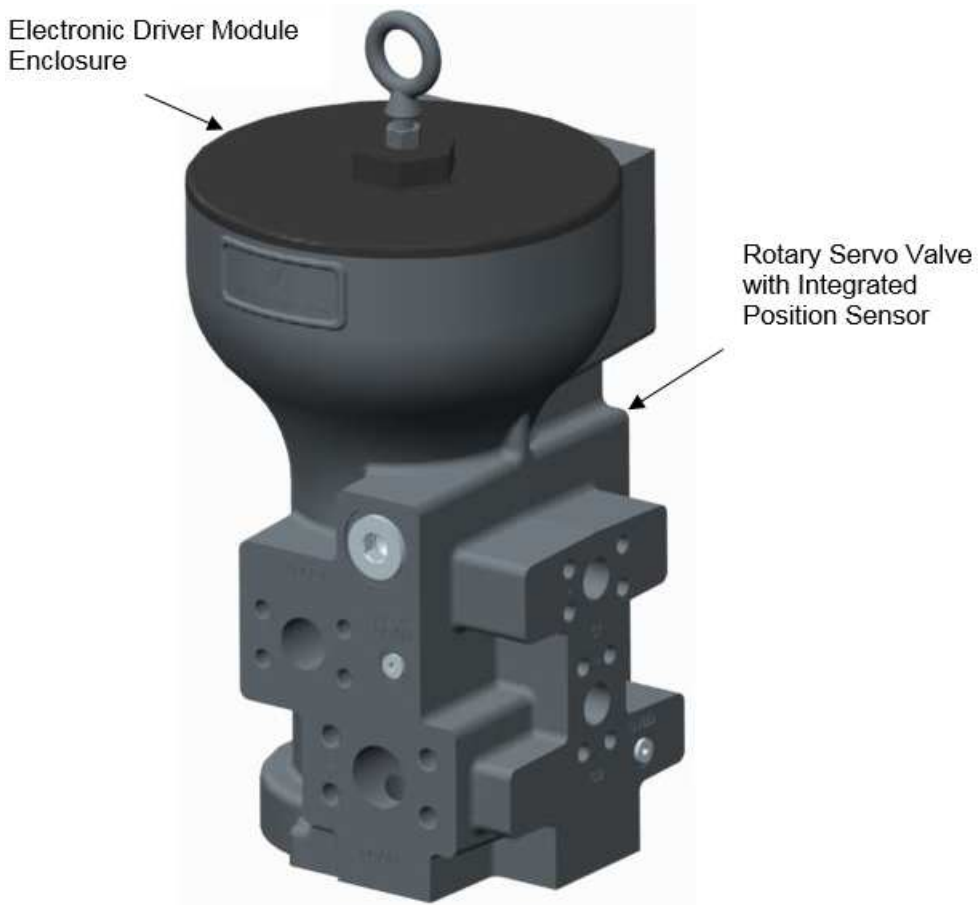

Figure 1-5. VariStroke-I Remote Servo, Key Features

Hydraulic Power Cylinder

The VariStroke Remote Servo can be connected to any hydraulic cylinder, however; proper operation requires that the VariStroke Performance Equation be satisfied (see Chapter 2, Performance Index). In order to control cylinder position, the Cylinder must be equipped with a position feedback sensor. The position sensor must meet the following specifications:

- Output Signal: 4–20 mA
- Input voltage (provided by the VariStroke Circuit Board): 15 Vdc
- Update Rate: ≤1 ms
- Linearity: ±0.04% Full Stroke
- Current Drain: < 100 mA
- Sensor Length must not exceed 2 times the Cylinder Stroke Length

Varistroke Model Number Information

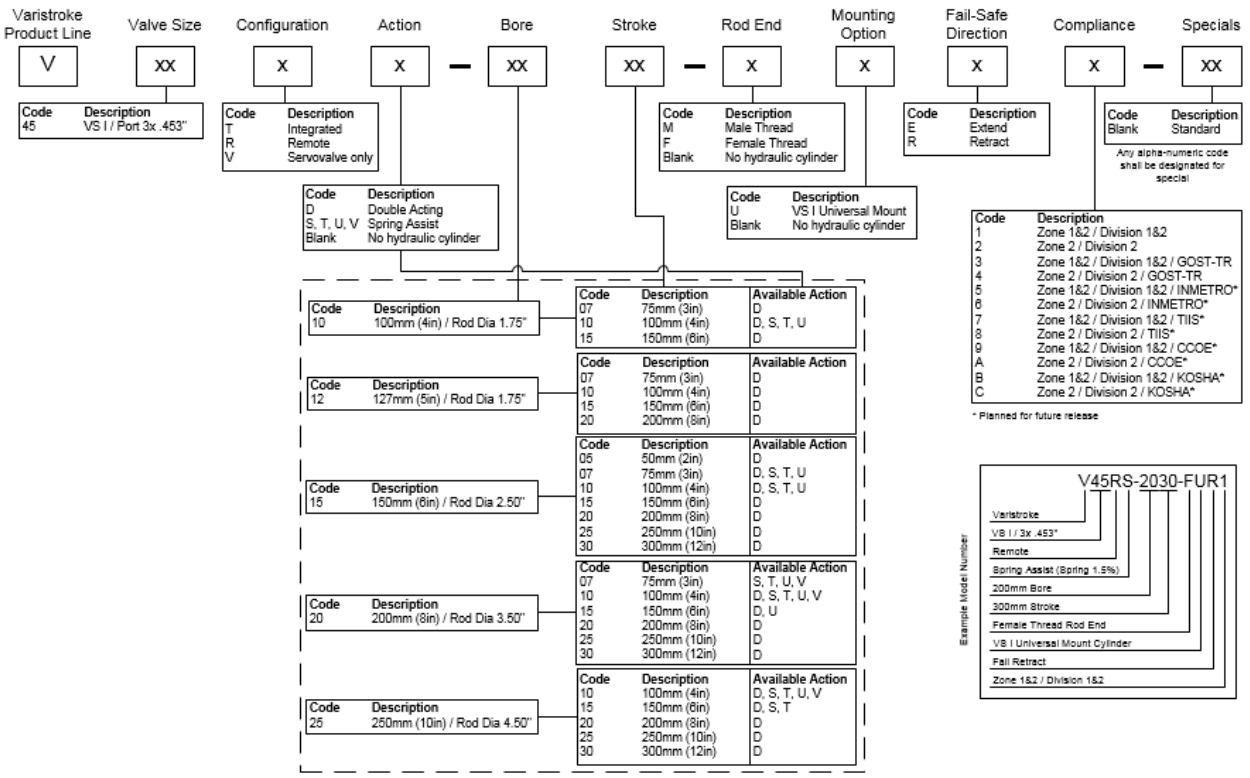

Figure 1-6. Nomenclature and Ordering Number Encoder

Note: Chemically resistant versions are denoted "CR" in the Specials string of the VariStroke model number. Please contact Woodward for available models.

Chapter 2. Specifications

Physical and Performance Specifications

Table 2-1. Bore and Rod Diameter by Valve Size

Bore Diameter (OD)	Rod Diameter (ID)
4 inches (101.6 mm)	1.75 inches (44.5 mm)
5 inches (127.0 mm)	1.75 inches (44.5 mm)
6 inches (152.4 mm)	2.5 inches (63.5 mm)
8 inches (203.2 mm)	3.5 inches (88.9 mm)
10 inches (254.0 mm)	4.5 inches (114.3 mm)

Table 2-2. Available Springs for Spring Assist Cylinders

		Average spring force ± 10% [lbf] (Reference Spring Rate [lbf/in])			
		Spring			
VS Bore [in]	VS Stroke [in]	S	T	U	V
4	4	84 (14)	170 (28)	351 (63.5)	- -
6	3	162 (36)	353 (78.7)	780 (173.3)	- -
	4	162 (27)	353 (59)	780 (130)	- -
8	3	393 (87.3)	793 (176.3)	1578 (350.7)	2996 (700)
	4	393 (75.5)	793 (132.3)	1578 (263)	3035 (505.8)
	6	393 (43.7)	793 (88.2)	1554 (183.3)	3035 (337.2)
10	4	531 (88.5)	964 (160.8)	1968 (327.8)	4116 (686)
	6	531 (59.0)	954 (107.3)	1968 (218.5)	4116 (457.3)

Note: Average spring force was calculated for cylinder @ 50% of mechanical stroke.

Stall Force (extending): Extend Stall force can be obtained from following equation:

$$\text{Extend Stall} = \frac{\pi\, OD^2}{4}\, p \qquad (p \text{ - } \textit{supply pressure})$$

[in² • psi = lbf] or [mm² • MPa = N]

Stall Force (retracting): Retract Stall force can be obtained from following equation:

$$\text{Retract Stall} = \frac{\pi\,(OD^2 - ID^2)}{4}\, p \quad (p \text{ - } \textit{supply pressure})$$

[in² • psi = lbf] or [mm² • MPa = N]

The formulas above are valid for double acting cylinders. For spring-assist actuators, additional spring force and its direction has to be taken in to account.

Extending Slew Rate: Configurable
Retracting Slew Rate: Configurable

Note: Slew Rates for Remote Servo Applications may be 10–15% slower due to pressure drop on servo-cylinder piping.

IMPORTANT

It is highly recommended that inlet supply pressure not decrease by more than 10% of nominal value during slew/step.

Position Accuracy: ±1% of full stroke
Position Repeatability: ±0.5% of full stroke
MLDT Temperature Drift: 0.04% /°C
Failsafe Operation: Internal return spring on servo valve spool force the hydraulic power cylinder to extend or retract (part number depended) in case of electrical signal loss.

Additionally for spring-assist power cylinder internal spring installed in the cylinder generates force toward the fail save position.

⚠WARNING

Make sure that the VS-I hydraulic connections are installed correctly. Equipment damage is possible if the hydraulic connections are attached incorrectly (backwards). Reversed hydraulic connects will cause the actuator to operate backwards, making the fail-safe position opposite of where the user expects it to be.

⚠WARNING

Overspeed / Overpressure

Never close the drain line when supply pressure is present on the VS-I unit, otherwise the control output pressure can increase suddenly and cannot be controlled by the input setpoint. This could cause the turbine to overspeed.

Table 2-3. Environmental Specifications

Ambient Temperature:	(–40 to +85) °C / (–40 to +185) °F
Vibration Resistance:	MIL-STD 810F, M514.5A, Cat. 4 (0.015 G²/Hz, 1.04 Grms)
Shock Resistance:	US MIL-STD-810C method 516.2, procedure 1 (10 G Peak, 11 ms duration, saw tooth)
Corrosion resistance:	Two part epoxy paint coating. Designed for outdoor conditions
Ingress Protection (IEC 60529, IEC 60079-0):	IP66

Table 2-4. Electrical Specifications

Supply Voltage:	(18 to 32) V (dc), 24 V (dc) nominal (use cable at least 1.5 mm² / 16 AWG)
Hold-up time:	7 ms @ 2 A (dc) LAT current
Current Consumption:	2.3 A (MAX) at steady state @ 24 V 10 A transient (100 ms maximum)
Demand Signals #1, 2:	(4 to 20) mA into 200 Ω. >70 dB CMRR. Common Mode Voltage Range ±50 V (dc), Accuracy 0.1% of full scale @ 25 °C

Cylinder Position Feedback Signals #1, 2:	(4 to 20) mA into 235 Ω. >70 dB CMRR. Common Mode Voltage Range ±50 V (dc), Accuracy 0.1% of full scale @ 25 °C
Analog Output Signal:	(4 to 20) mA. Maximum load: 500 Ω. Accuracy 0.5% of full scale @ 25 °C
Discrete Output Signal:	Configurable NO or NC 0.5 A at 24 V (dc), max 32 V (dc) 0.5 A inductive at 28 (dc) 0.2 Henry
Discrete Input Signal:	Contact current 3.8 mA (typ.) @ input closed Max input voltage 32 V (dc), High signal threshold > 7 V; Low signal Threshold < 3 V
Feedback Device (integrated):	MLDT (Magnetostrictive Linear Displacement Transducer)
Connections:	Removable terminal suitable for 0.14 to 2.5 mm² or 12 to 24 AWG stranded wire
Cable Entries:	Analog: 0.750”-14 NPT Power: 0.750”-14 NPT CAN: 0.500”-14 NPT Spare: 0.500”-14 NPT
Grounding connections:	PE Ground; Frame or Chassis Ground
Cable Entry for Remote Cylinder:	Position Sensor: 0.750”-14 NPT

Table 2-5. Cylinder Position Sensor Requirements (Remote Servo Only)

Output Signal:	Analog: 4–20 mA
Input Voltage:	15 Vdc (power provided by VariStroke)
Linearity:	±0.04% Full Stroke
Current Drain:	<100 mA
Sensor Length:	≤ 2 times the Cylinder Stroke Length
Update Rate:	≤ 1 ms
Sensor Cable Length Limit:	3 m (10 feet) maximum between sensor and VariStroke

IMPORTANT

Slower update rates than the one shown in the above requirements could result in excessive limit cycle, wear, and poor position accuracy.

It is for this reason that Woodward does NOT recommend using a combination of LVDTs and Signal Conditioners. This combination will typically result in unacceptable delays in the position sensor update rate.

Woodward recommends that the installer consider Magnetostrictive position sensors and/or DCDTs.

Table 2-6. Hydraulic Specifications

Fluid Type:	Petroleum-based hydraulic fluids as well as fire resistant hydraulic fluids such as Fyrquel EHC
Minimum Supply Pressure:	5.5 bar (80 psi)
Maximum Supply Pressure:	34.5 bar (500 psi)

IMPORTANT

Recommended setting hydraulic system pressure regulator to 110% or less of normal operating pressure to prevent over-pressure.

Proof Pressure:	51.7 bar (750 psig)
Burst Pressure:	86.2 bar (1250 psig)
Fluid Temperature:	(15 to 70) °C / (59 to 158) °F continuous

Fluid Cleanliness Level:	ISO 4406 code 20/18/16 or cleaner
Output Cylinder Action:	Double
Hydraulic Connections for Integrated Actuators:	Hydraulic Supply Port: 1.250 SAE Code 61 Flange Hydraulic Drain Port: 1.500 SAE Code 61 Flange
Hydraulic Connections for Remote Servo:	Hydraulic Supply Port: 1.250 SAE Code 61 Flange Hydraulic Drain Port: 1.500 SAE Code 61 Flange Control ports C1 and C2: 1.000 SAE Code 61 Flange Actuator and Servo OVBD: .438-20 UNF
Pipe Size Between Remote Servo and Cylinder:	Diameter: 25.4 mm (1 inch) minimum Length: 3 m (120 inch) maximum
Supply Fluid Flow:	Refer to following figures for Maximum Transient Flow Rate and Steady State Flow Rate Requirements:

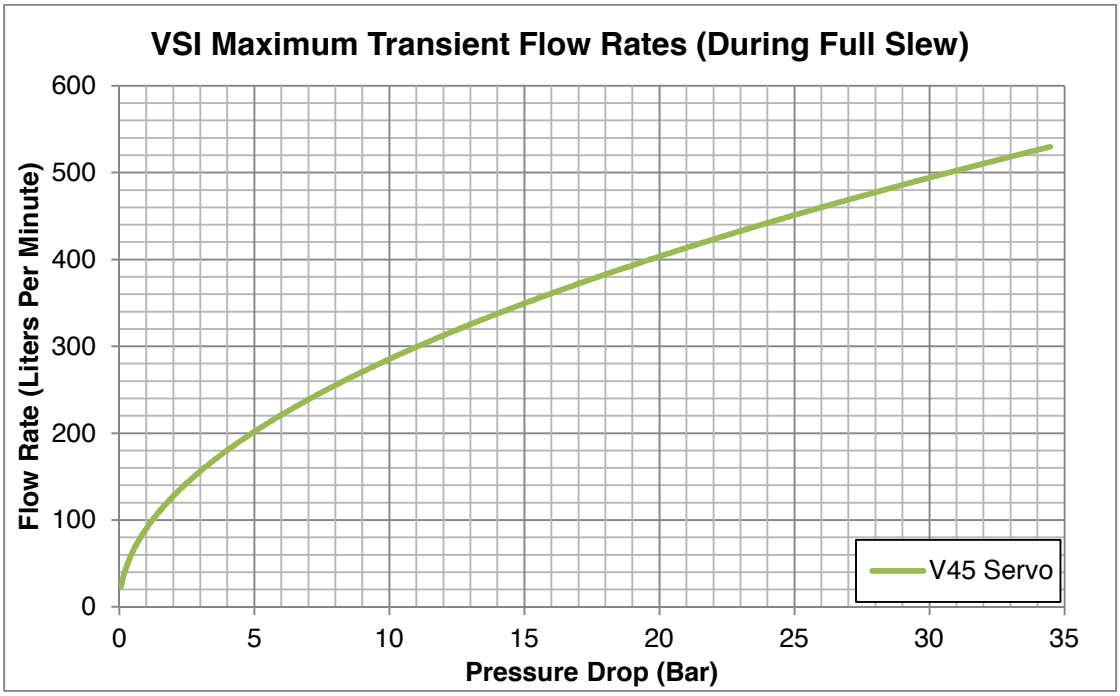

Figure 2-1. VSI Maximum Transient Flow Rates (During Full Slew)

IMPORTANT

The figure above shows the estimated hydraulic flow necessary to maintain optimum performance of the VS-I. If the flow supplied to the actuator is lower than what is specified, the actuator will continue to operate, but at reduced performance.

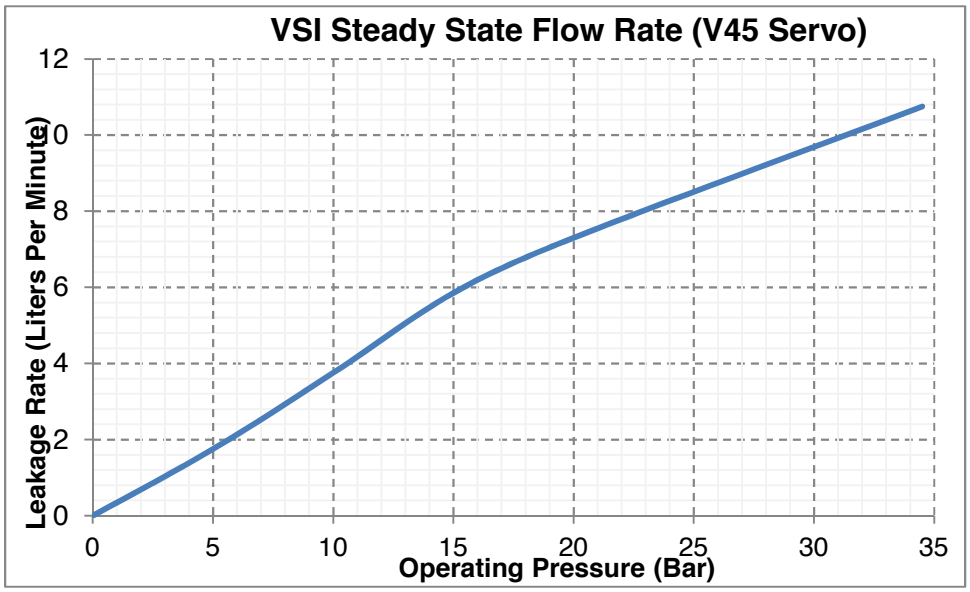

Figure 2-2. Steady State Flow Rate

IMPORTANT **The figure above shows the estimated hydraulic flow necessary during steady state operation for the V45 servo valve.**

Special Ambient Temperature Specifications / Allowances

WARNING **The following information applies only to a VariStroke-I installed in a non-hazardous (Ordinary) location. If the VariStroke-I is installed in to a Hazardous (Zones or Divisions) environment, the Special Ambient Temperature Allowances do NOT apply. Maximum ambient and hydraulic fluid temperatures must be kept within the standard ratings.**

The VariStroke comes equipped with multiple features that allow hydraulic fluid to constantly flow through the servo valve and power cylinder during normal operation. This allows the hydraulic fluid to act as a coolant on many of the critical components. The table below shows that the VariStroke can be safely operated above the standard Ambient Temperature rating so long as the hydraulic fluid supplied to the VariStroke can be reliably maintained at the specified temperatures.

Table 2-7. Special Ambient Temperature Specifications/Allowances

Hydraulic Fluid Temperature	Allowable Ambient Temperature for Servo Valve / Integrated Actuator	Allowable Ambient Temperature for Remote Cylinder
50 °C	105 °C	105 °C
60 °C	95 °C	105 °C
70 °C	85 °C	95 °C

Performance Index

The VariStroke product line is designed to bring a multitude of benefits to the actuation market place. One the primary benefits a customer will realize is the VariStroke's ability to combine high-speed actuation with low-pressure hydraulic systems. To accomplish this, the VariStroke has utilized one of the largest, commercially available servo valves in the world. This large servo valve allows the VariStroke to operate at high speeds with only a single stage (i.e. no intermediate relay valves or second stage spool valves).

With this benefit, customers have quickly realized that they may have the ability make full strokes their steam valve actuators much faster than they have in the past and, at the same time, still have very good small signal & steady state response. While this combination of performance attributes (fast slew speeds and good small signal response) is a primary feature of the VariStroke, there are limitations when paring a large servo valve with a relatively small cylinder volume.

Before purchasing or installing a VS-I actuator, the user should verify that actuator will be operate properly. As shown in the relationship below, the performance of the VS-I is dependent on Servo Valve size, supply pressure, and the used cylinder volume. If the relationship below is satisfied, the actuator will operate smoothly, with minimal overshoot and limit cycle.

IMPORTANT

If the relationship below is NOT satisfied, the actuator performance will be compromised, resulting in excessive limit cycle and accelerated wear. The actuator will also output a "Performance Index Warning" alarm that cannot be disabled.

$$\boldsymbol{VS_{Constant}} * \frac{\sqrt{\boldsymbol{P_{supply}}}}{\left(\frac{\boldsymbol{\pi} * \boldsymbol{D_{cyl}^2}}{\boldsymbol{4}} * \boldsymbol{L_{stroke}}\right)} \leq \boldsymbol{1}$$

Where:

$P_{supply} = Supply\ Pressure\ in\ \boldsymbol{BAR}$

$D_{cyl} = Cylinder\ Diameter\ in\ \boldsymbol{Centimeters}$

$L_{stroke} = Stroke\ Length\ in\ \boldsymbol{Centimeters}$

Note: This is the **used** maximum stop position. It may or may not equal the Cylinder Length.

$VS_{Constant} = Varistroke\ Constant$ = 180

Figure 2-3 shows a graphical representation of the performance relationship for 4" (100mm), 5" (127 mm), and 6" (150mm) Bore Actuators. There are no limits for stroke-pressure combinations for bigger i.e. 8" (200mm) and 10" (250mm) Bore Actuators.

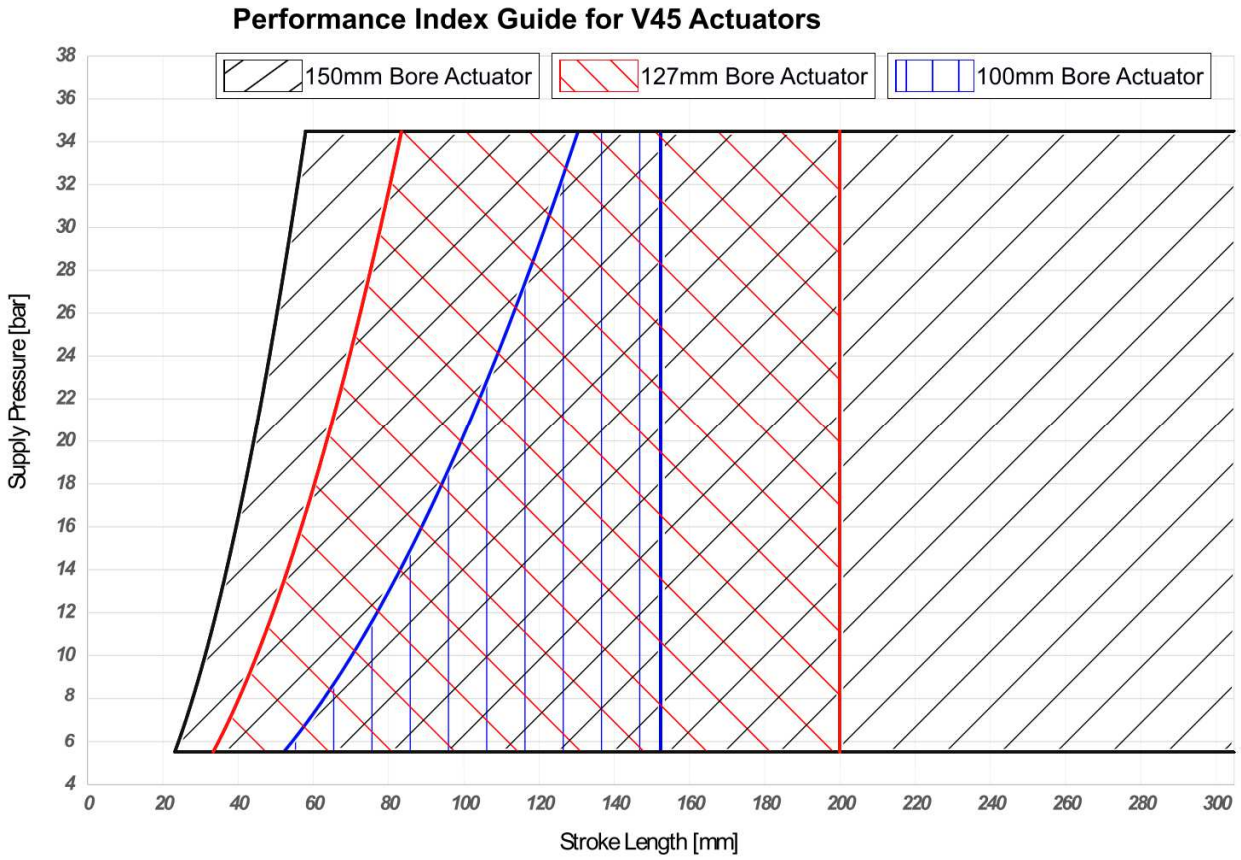

Figure 2-3. Performance Chart for 4", 5", and 6" Bore Actuators

Diagrams

Functional Block Diagram

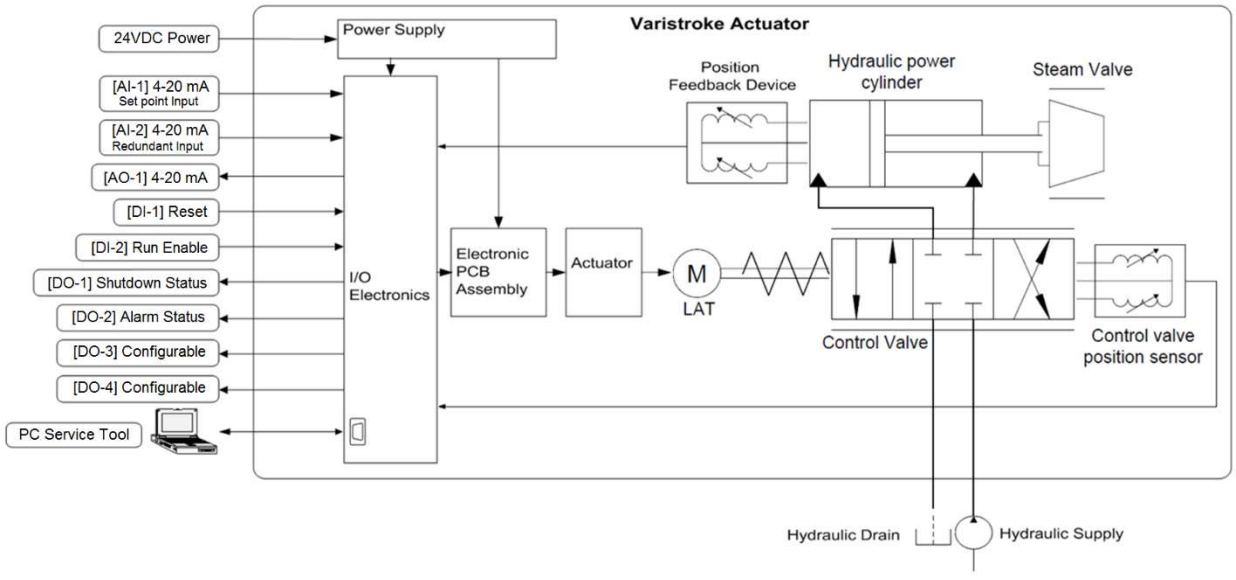

Figure 2-4. Basic Device Block Diagram without Trip Function

VS-I Integrated Hydraulic Schematic

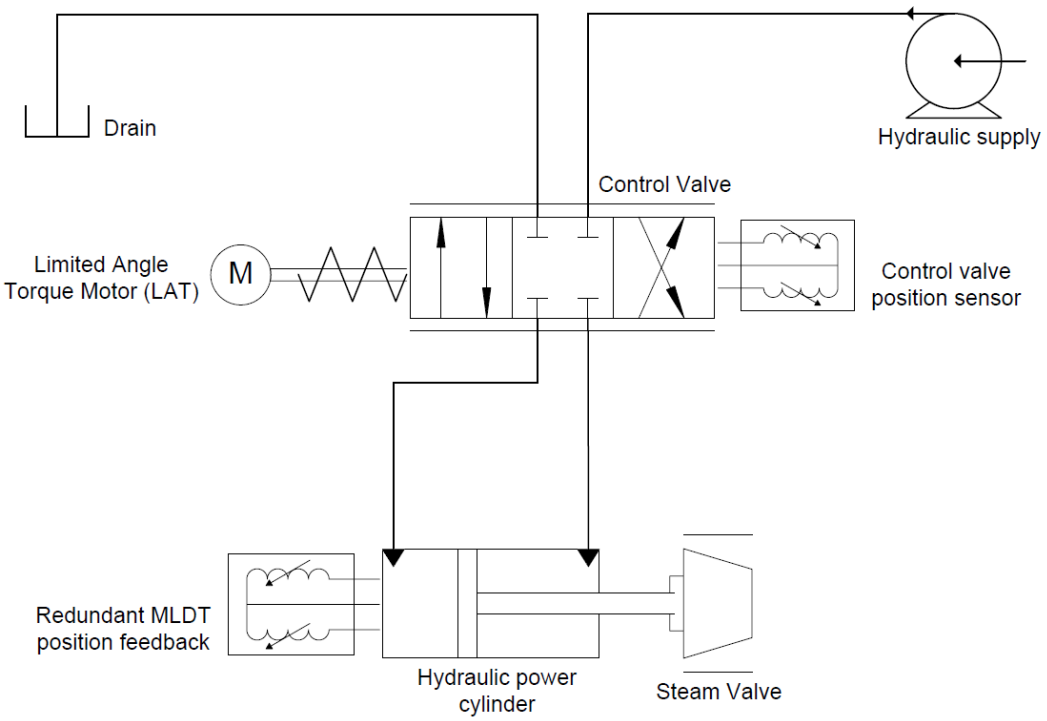

Figure 2-5. VS-I Integrated Hydraulic Schematic

VS-I Remote Servo Hydraulic Schematic

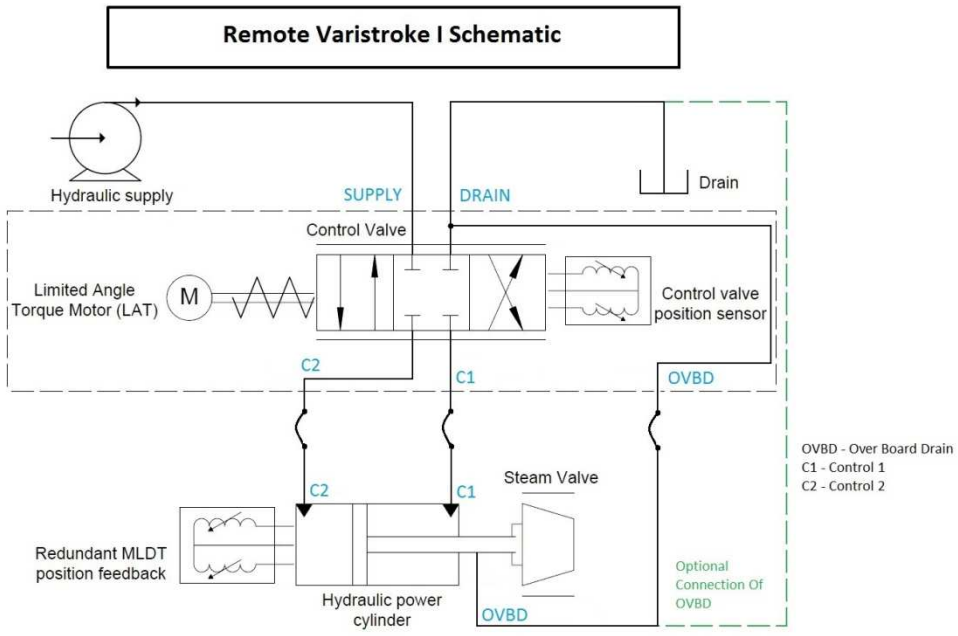

Figure 2-6. VS-I Remote Hydraulic Schematic

VS-I Servo Only Hydraulic Schematic

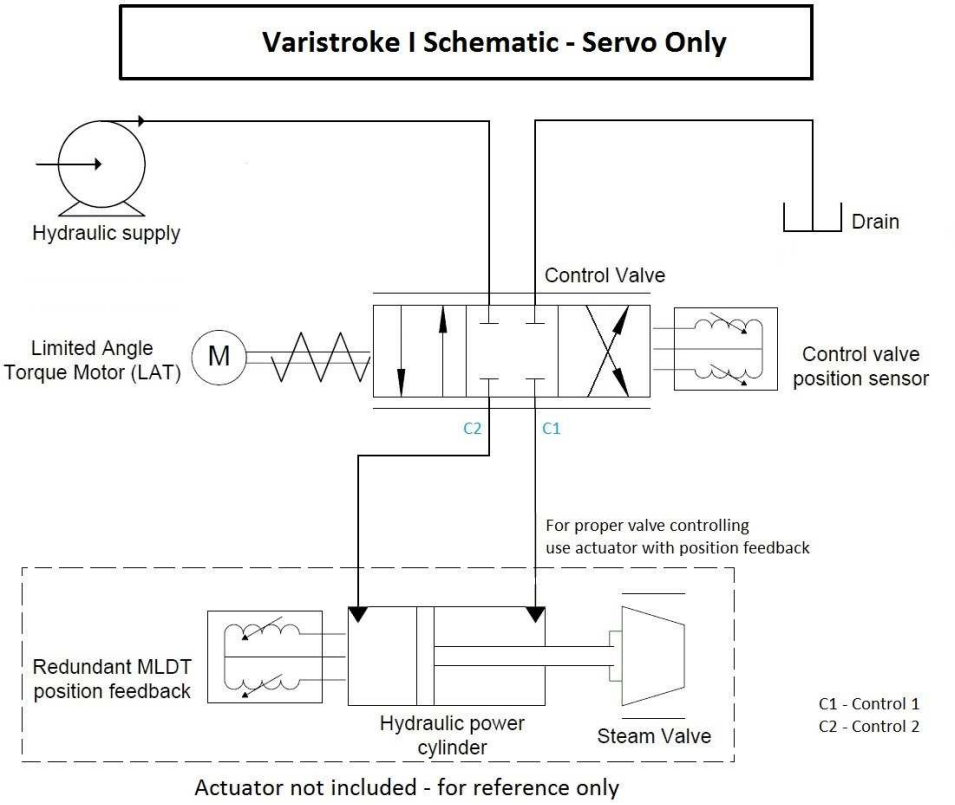

Figure 2-7. VS-I Remote Servo Hydraulic Schematic

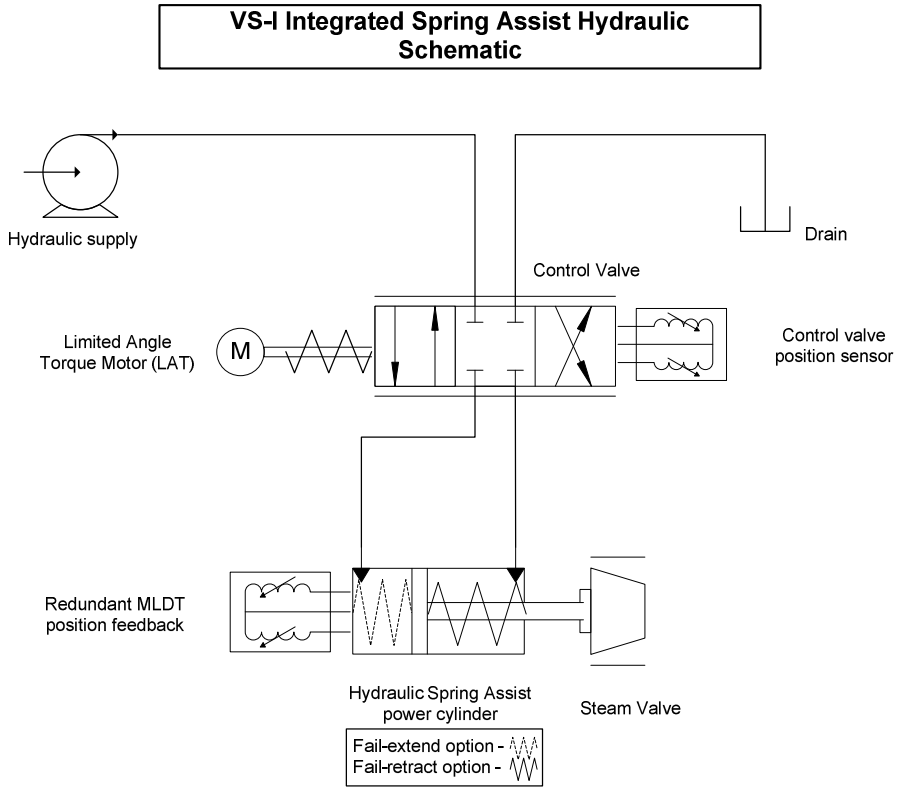

Figure 2-8. VS-I Spring Assist Integrated Hydraulic Schematic

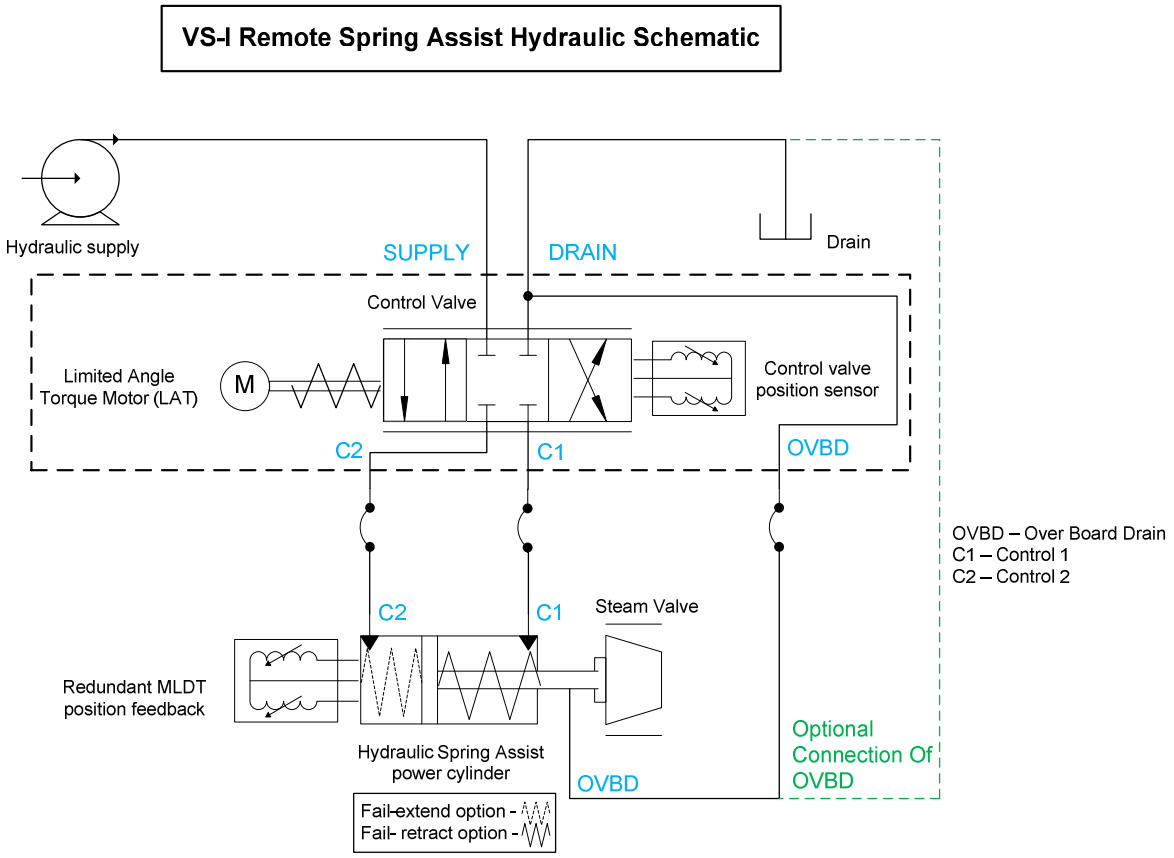

Figure 2-9. VS-I Spring Assist Remote Hydraulic Schematic

Outline dimensions and installation features for specific models are in the appropriate appendix in the Appendices section (at the end of this manual) according to the below table.

Table 2-8. VS-I Installation Drawings

Woodward Model Number	Description	Appendix Number
V45TD-10XX	V45 Servo, 4-inch (100mm) Bore Integrated Servo-Cylinder	A
V45TD-12XX	V45 Servo, 5-inch (127mm) Bore Integrated Servo-Cylinder	B
V45TD-15XX	V45 Servo, 6-inch (150mm) Bore Integrated Servo-Cylinder	C
V45TD-20XX	V45 Servo, 8-inch (200mm) Bore Integrated Servo-Cylinder	D
V45TD-25XX	V45 Servo, 10-inch (250mm) Bore Integrated Servo-Cylinder	E
V45RD-10XX	V45 Servo, 4-inch (100mm) Bore Remote Servo-Cylinder	F
V45RD-12XX	V45 Servo, 5-inch (127mm) Bore Remote Servo-Cylinder	G
V45RD-15XX	V45 Servo, 6-inch (150mm) Bore Remote Servo-Cylinder	H
V45RD-20XX	V45 Servo, 8-inch (200mm) Bore Remote Servo-Cylinder	I
V45RD-25XX	V45 Servo, 10-inch (250mm) Bore Remote Servo-Cylinder	J
V45TX-1010	V45 Servo, 4-inch (100mm) Bore Integrated Spring Assist Servo-Cylinder	K
V45TX-15XX	V45 Servo, 6-inch (150mm) Bore Integrated Spring Assist Servo-Cylinder	L
V45TX-20XX	V45 Servo, 8-inch (200mm) Bore Integrated Spring Assist Servo-Cylinder	M
V45TX-2510	V45 Servo, 10-inch (250mm) Bore Integrated Spring Assist Servo-Cylinder	N
V45RX-1010	V45 Servo, 4-inch (100mm) Bore Remote Spring Assist Servo-Cylinder	O
V45RX-15XX	V45 Servo, 6-inch (150mm) Bore Remote Spring Assist Servo-Cylinder	P
V45RX-20XX	V45 Servo, 8-inch (200mm) Bore Remote Spring Assist Servo-Cylinder	Q
V45RX-2510	V45 Servo, 10-inch (250mm) Bore Remote Spring Assist Servo-Cylinder	R
V45V	V45 Remote Servo Version	S

Notes

1. These general reference outline drawings apply to Woodward VS-I only. Consult Woodward for the latest outline drawing.

2. Installation Orientation:
   a. Cylinder - any orientation is acceptable.
   b. Servo valve - any orientation except upside down. Recommend vertical orientation.

3. Service Manual Replacement Parts:
   a. Servo Valve – Consult Woodward for part number
   b. Hydraulic Power Cylinder – Consult Woodward for part number
   c. Manual – Consult Woodward for part number
   d. Shaft Seals Kit(s) - Refer to Chapter 7 for additional details
   e. Electronics module (PCB) – Consult Woodward for part number

Chapter 3.
Installation

Receiving Instructions

The VS-I is carefully packed at the factory to protect it from damage during shipping; however, careless handling during shipment can result in damage. If any damage to the VS-I is discovered, immediately notify both the shipping agent and Woodward.

Unpacking Instructions

Carefully unpack the VS-I and remove it from the shipping container. Do not remove the hydraulic, electric blanking covers and hydraulic power cylinder's output threaded shaft mesh until you are ready to mount the unit.

⚠WARNING

The external ground lugs shown on the installation drawing must be properly connected to ensure equipotential bonding. This will reduce the risk of electrostatic discharge in an explosive atmosphere.

⚠WARNING

External fire protection is not provided in the scope of this product. It is the responsibility of the user to satisfy any applicable requirements for their system.

⚠WARNING

Take care not to damage the electronics cover's seal, the cover surface, the threads, or the VS-I housing mating surface while removing or replacing the cover.

⚠WARNING

For Division 1/Zone 1 products: Proper torque on all joints is very important to ensure that the unit is sealed properly.

⚠WARNING

For lifting and transportation, use lifting straps fitted through both lifting lugs provided with the product. Support the VS-I in a vertical position during transportation.

⚠CAUTION

Due to typical noise levels in engine and turbine environments, hearing protection should be worn when working on or around the VS-I.

⚠CAUTION

The surface of this product can become hot enough or cold enough to be a hazard. Use protective gear for product handling in these circumstances. Temperature ratings are included in the specification section of this manual.

Installation Instructions

General

See the outline drawings and Specifications for:

- Outline dimensions
- Hydraulic connections and fitting sizes
- Electrical connections
- Weight of the VS-I

A vertical actuator position is generally preferred to conserve floor space as well as ease of making electrical and hydraulic connections. However, the VS-I can be mounted in any attitude. Recommend that the Remote Servo not be mounted upside-down to minimize the possibility of hydraulic oil dripping onto the circuit board.

Allow space for removal of the top cover for access to the terminal blocks and to see the status LEDs on the printed circuit board.

If the VS-I actuator is to be installed in close proximity to uninsulated/unshielded steam valves or piping, radiation heat shields should be installed between the actuator and these hot surfaces.

The Integrated VS-I is designed for support by the Hydraulic Power Cylinder Mating bottom or top surface. For each individual VS-I actuator bolt pattern, bolts and bolting torques recommendation needs to be followed as per Table 3-1.

For Remote Servo Kit installation, both Cylinder and Servo have their own mounting requirements. See the following drawings and table for bolt pattern position tolerances, thread sizes and recommended torques. The Hydraulic Cylinder can be bottom or top mounted while the Servo only has one mounting interface.

Installation Dimensions for Integrated Actuator

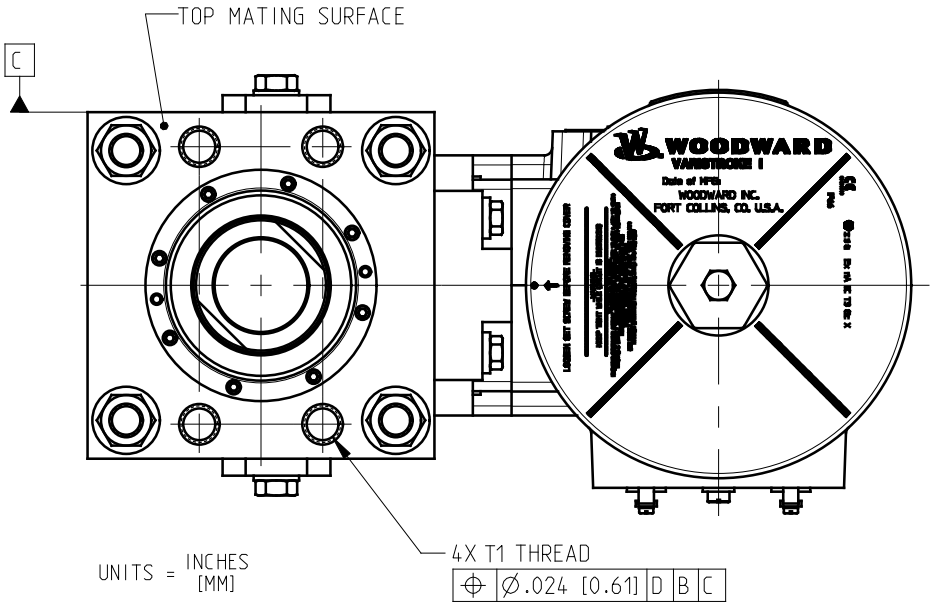

Figure 3-1a. VS-I Integrated Product Installation Interface - Bolting Pattern and Installation Features

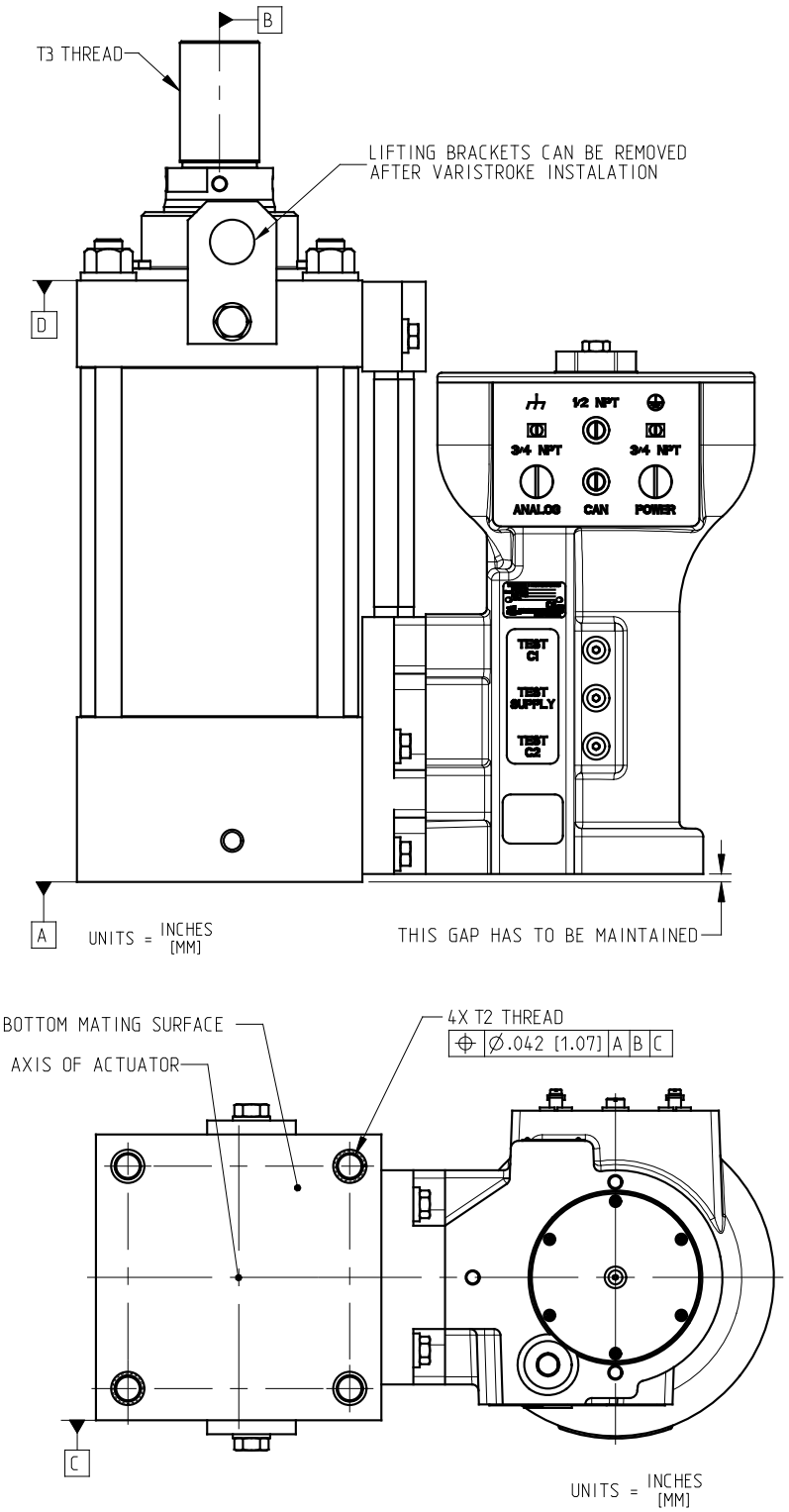

Figure 3-1b. VS-I Integrated Product Installation Interface - Bolting Pattern and Installation Features

Installation Dimensions for Remote Servo Kit

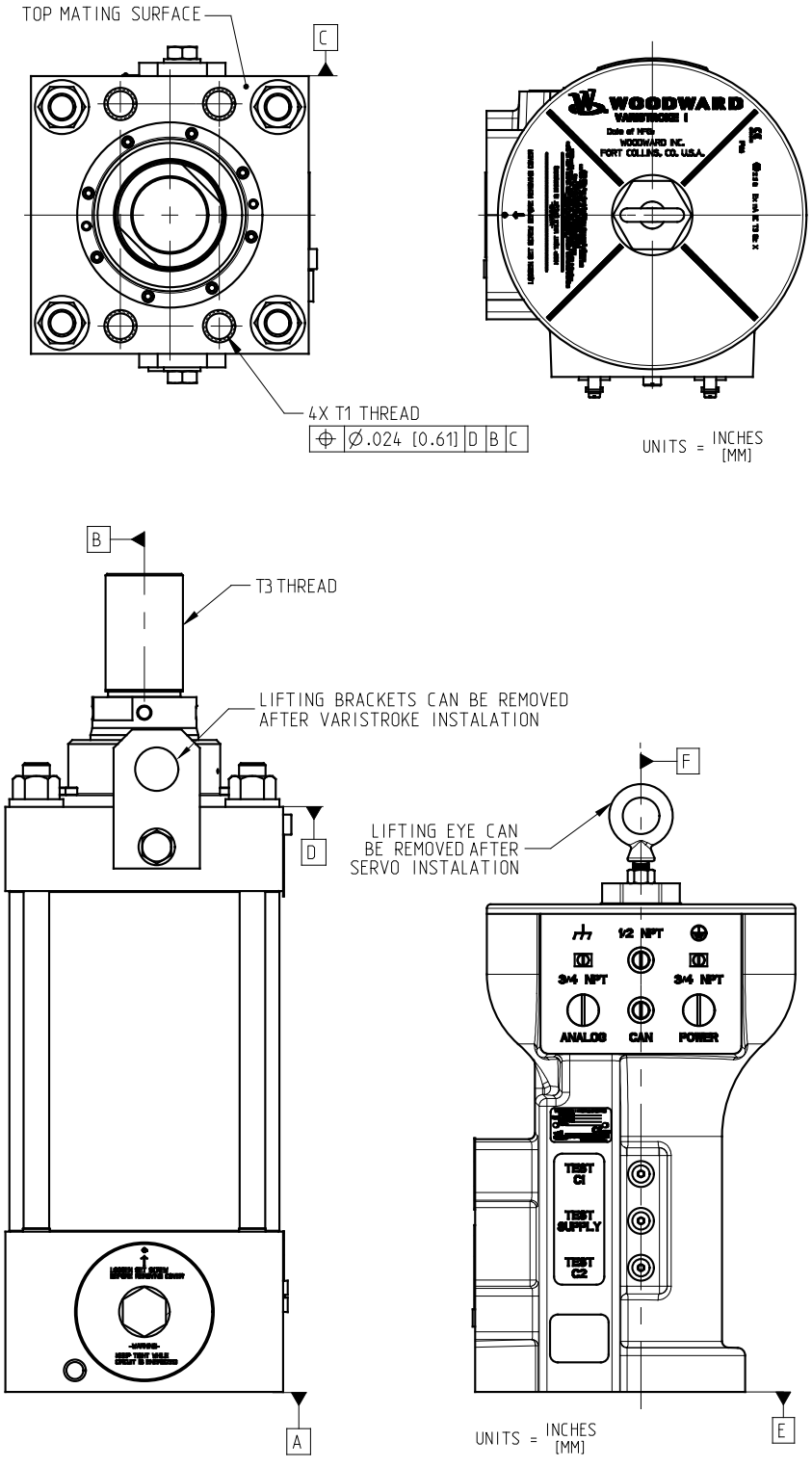

Figure 3-2a. VS-I Remote. Product Installation Interface - Bolting Pattern and Installation Features

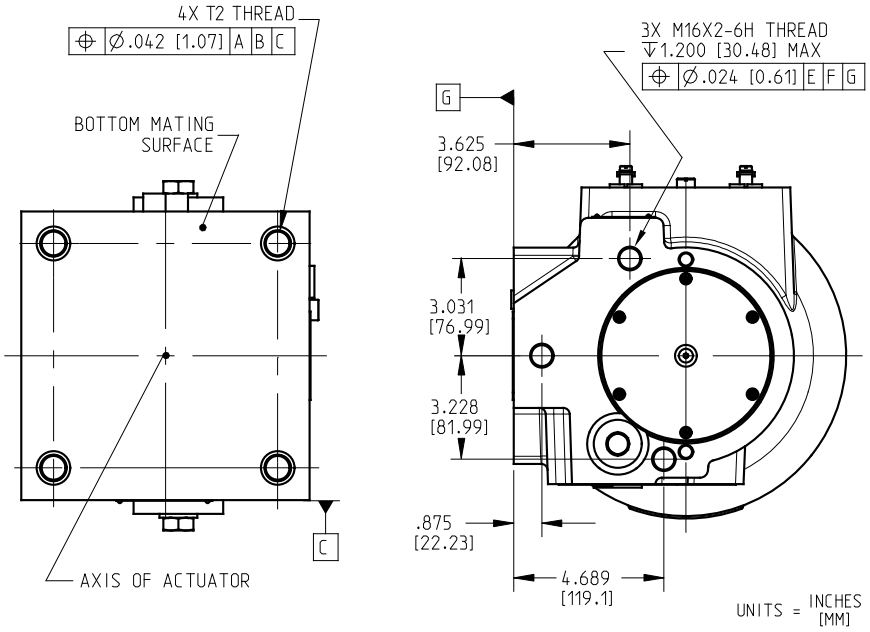

Figure 3-2b. VS-I Remote. Product Installation Interface—Bolting Pattern and Installation Features

Table 3-1. VS-I Installation Bolts and Bolting Torques Recommendation

VariStroke Cylinder Bore Size inch (mm)	Size *M=Male F=Female*	Min Thread Engagement inch (mm)	Min Bolt Grade	Bolting Torque lbf-ft. (Nm)	Thread Tol. Class Male/Female
Thread "T1" & "T2"					
4 (100)	M14x2	1.20 (30.5)	10.9	50-55 (68-75)	6H
5 (127)	M16x2	1.60 (40.6)	10.9	110-120 (149-163)	6H
6 (152)	M16x2	1.60 (40.6)	10.9	110-120 (149-163)	6H
8 (200)	M24x3	1.60 (40.6)	10.9	270-300 (366-407)	6H
10 (254)	M30x3.5	1.60 (40.6)	10.9	365-400 (495-542)	6H
Thread "T3"					
4 (100)	M–M30x2 F–M26x1.5	1.40 (35.6)	N/A	N/A	6g/6H
5 (127)	M–M30x2 F–M26x1.5	1.40 (35.6)	N/A	N/A	6g/6H
6 (152)	M-M48x2 F-M33x2	1.80 (45.7)	N/A	N/A	6g/6H
8 (200)	M-M64x3 F-M48x2	2.20 (55.9)	N/A	N/A	6g/6H
10 (254)	M-M64x3 F-M48x2	2.20 (55.9)	N/A	N/A	6g/6H

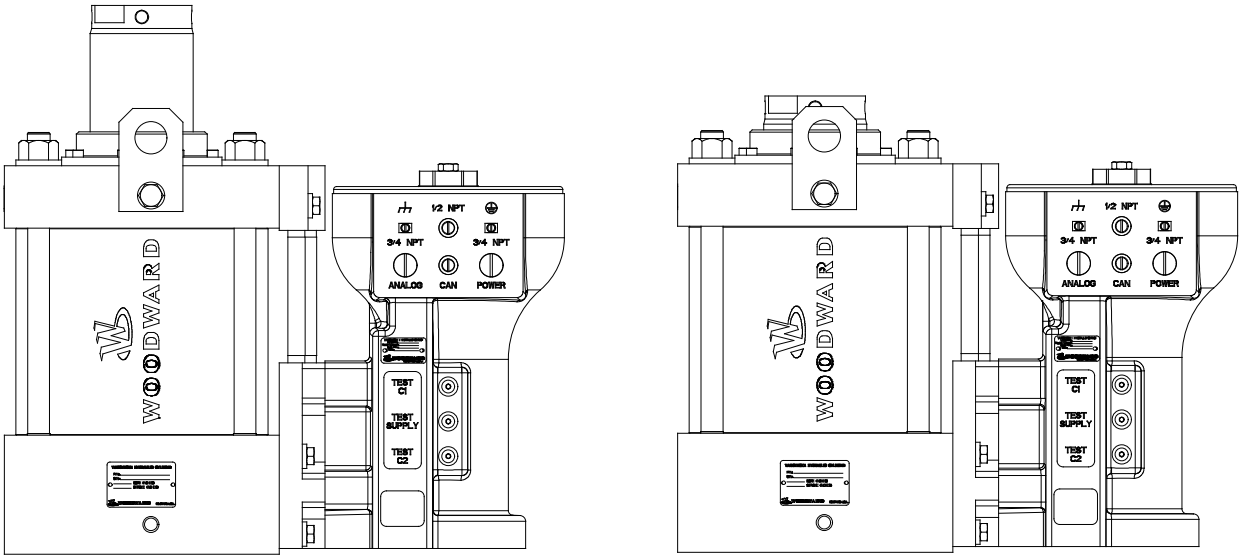

Figure 3-2c. Hydraulic Rod position for different cylinders versions

Fail Extend, Spring Assist Cylinders with no hydraulics have cylinder rod in fully extended position. For all fail retract spring assist cylinders the hydraulic rod is in retract position without hydraulic pressure.

Installation Dimensions for Servo Only

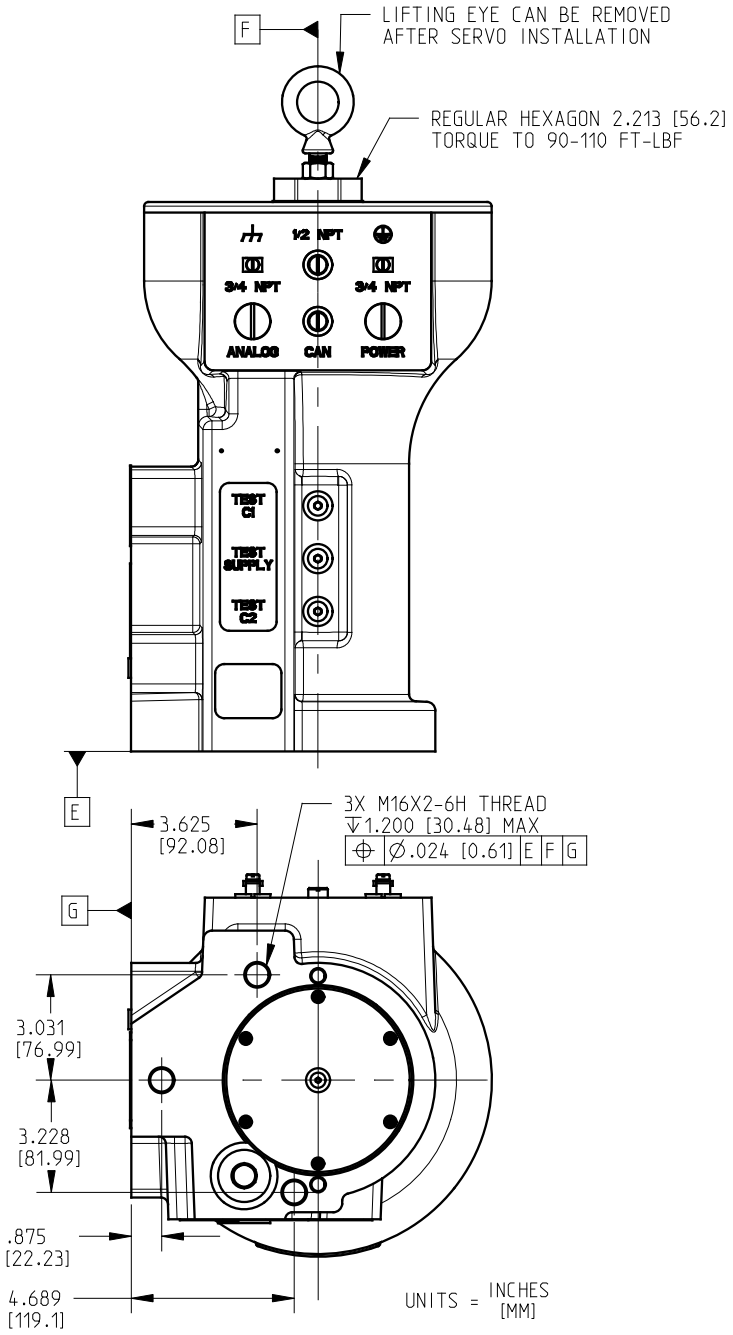

Figure 3-3. VS-I Remote Servo. Product Installation Interface - Bolting Pattern

NOTICE

Minimum Bolt Grade, Bolting Torque and Thread Engagement Recommendation is valid for low carbon steel mounting surface to which product is bolted. For different configuration please consult Woodward for torque and bolts grade recommendations.

Lifting

VariStroke comes equipped with lifting brackets for vertical lifting. When transporting, use both brackets as shown below. Remote Servo and Remote Cylinder have their own, separate lifting features. Transport both Integrated and Remote Servo units in either the vertical or the horizontal position.

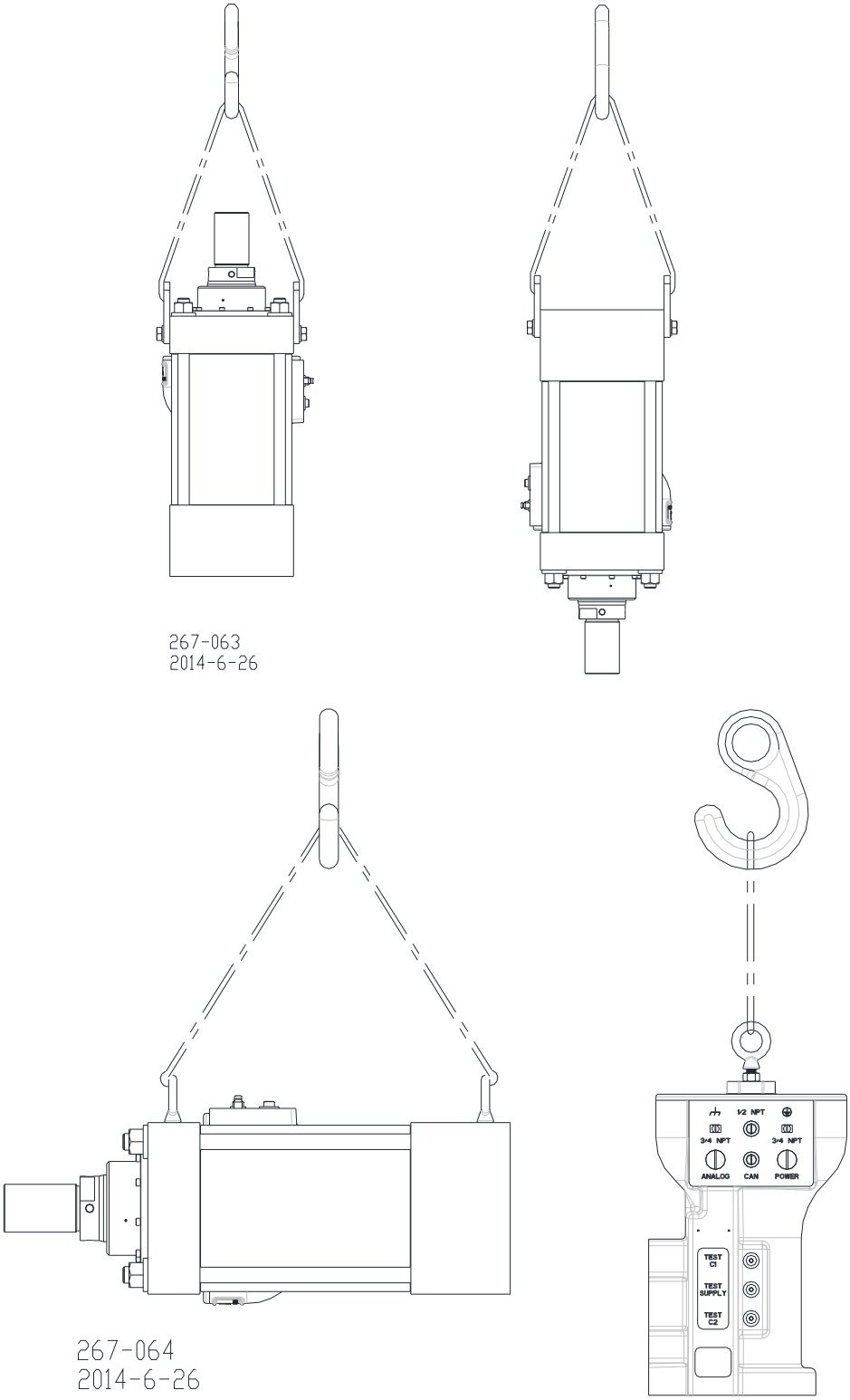

Figure 3-4. VS-I Lifting Positions

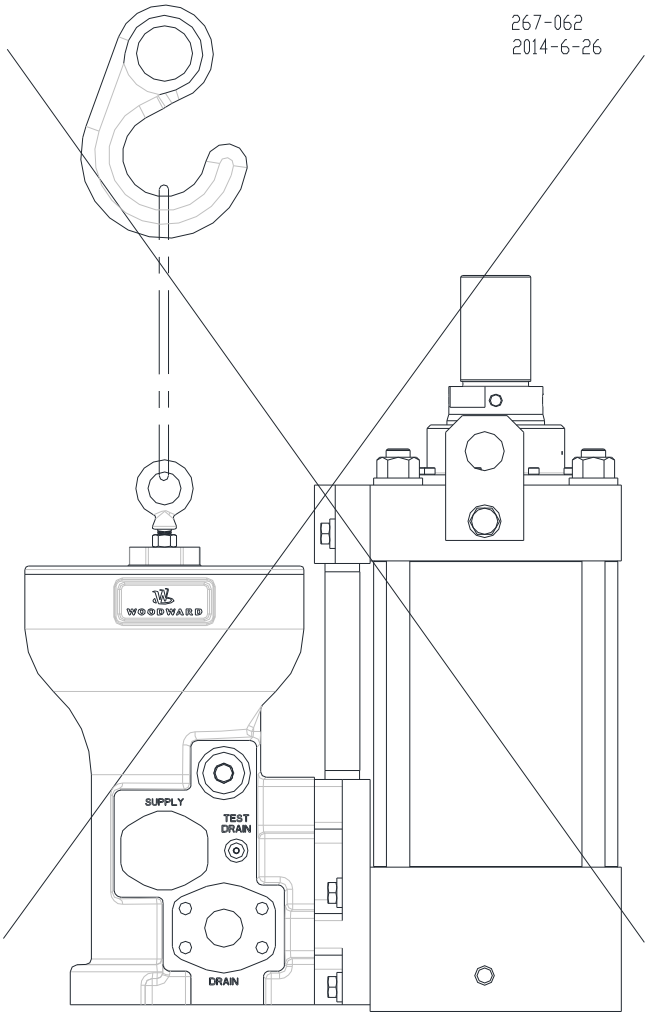

Figure 3-5. Incorrect Lifting Method

⚠WARNING

The VS-I Actuator is designed for support by the hydraulic power cylinder mating surface. Additional supports are neither needed nor recommended.

The servo valve is not designed to carry any load resulting from field mounting. For VS-I Integrated, the user is obligated to maintain the minimum required gap between servo valve and the actuator installation surface. For reference see outline drawing (Figure 3-1).

Any mounting deviation from the one recommended by Woodward might cause assembly damage, improper performance or operator injury risk.

Improper mounting might be considered as a violation of warranty conditions.

⚠WARNING

Maximum allowable linkage misalignment is 5°. It is highly recommended that the customer strictly warn the installer of this. Assure required pattern tolerance is adhered to based on interface as shown in Figures 3-1 and 3-2.

⚠WARNING

Ensure that the linkages and couplings connecting the VS-I output shaft to the turbine are appropriately sized and are able to withstand the stall force and dynamic loads.

⚠WARNING

The lifting eye located on the top of the VS-I Servo Valve is intended to lift ONLY the servo itself, not integrated servo-cylinder configurations.

⚠WARNING

Make sure that the crane, cables, straps, and all other lifting equipment used for VS-I lifting is able to support the VS-I weight. See outline drawings for VS-I weights.

⚠WARNING

When transporting the Hydraulic Cylinder in an upside-down position, the cylinder rod must be properly secured against uncontrolled rod movement.

Hydraulic Connections

For the Integrated VS-I, there are two hydraulic connections that must be made to each actuator:

- 1.250 SAE J518 Code 61 Flange for Hydraulic Supply Port
- 1.500 SAE J518 Code 61 Flange for Hydraulic Drain Port

Note: SAE J518, JIS B 8363, ISO/DIS 6162 AND DIN 20066 are interchangeable, except for bolt sizes/threads. The VS-I uses metric bolt sizes.

For the VS-I Remote Servo Kit and Servo Only options, there is an additional hydraulic connection between servo and cylinder:

- 1.000 SAE J518 Code 61 Flange for Hydraulic Control Ports
  Note: SAE J518, JIS B 8363, ISO/DIS 6162 AND DIN 20066 are interchangeable, except for bolt sizes. VS-I uses metric bolt sizes.)
- Maximum Pipe Length between Remote Servo and Cylinder : 3 meters

Hydraulic connection tightening torques:

- Hydraulic Supply:
  4x M10x1.5 Screws Torque to (34 to 48) N·m, (25 to 35 lb-ft)
- Hydraulic Drain:
  4x M12x1.75 Screws Torque to (48 to 61) N·m, (35 to 45 lb-ft)
- Control ports, C1 and C2 (Remote and Remote Servo):
  4x M10x1.5 Screws Torque to (34 – 48) Nm, (25 - 35 lbf-ft)
- OVBD Straight Thread port: Torque to (7 – 8) Nm, (65 - 69 lbf-in).

⚠CAUTION

Before installing the VS-I, all hydraulic lines must be thoroughly flushed.

Make provisions for proper filtration of the hydraulic fluid that will supply the actuator. Design the system filtration to assure a supply of hydraulic oil with a target cleanliness level of ISO 4406 code 20/18/16 or cleaner.

Construct the tubing connected to the actuator and/or servo to eliminate any transfer of vibration or other forces to the actuator.

The hydraulic supply to the servo is to be 32 mm (1.25 inches) tubing capable of supplying 530 L/min (140 US gal/min) at 34.5 bar / 500 psig.

The hydraulic drain should be 38 mm (1.5 inches) tubing or larger and must not restrict the flow of fluid from the actuator. The drain pressure must not exceed 10% of supply pressure or 3.4 bar (50 psig), whichever is less, under any condition.

Maximize pipe diameters to both the Supply and Drain connections, within reason, to ensure minimal flow losses and restrictions. For the same reason, keep pipe lengths to a minimum.

For Remote Servo-Cylinder connection, use 25 mm (1 inch) tubing to minimize servo-actuator plumbing flow restrictions. Recommend rigid/steel tubing for these connections.

IMPORTANT **It is highly recommended that inlet supply pressure not be allowed to decrease by more than 10% of nominal value during slew/step.**

The hydraulic supply capacity should be large enough to supply the required slew rate of the attached servo system (See Hydraulic Supply Specifications). Significant reductions in dynamic performance, slew speed, and load capacity when the VS-I does not receive the required flow and pressure. **It is strongly recommended that a high volume hydraulic accumulator be positioned on the supply line *as close to the VariStroke actuator as possible* in order to maintain supply pressure and flow.** The supply pressure at the actuator inlet should remain within 10% of the set operating pressure during a full slew. See Figure 3-6 below.

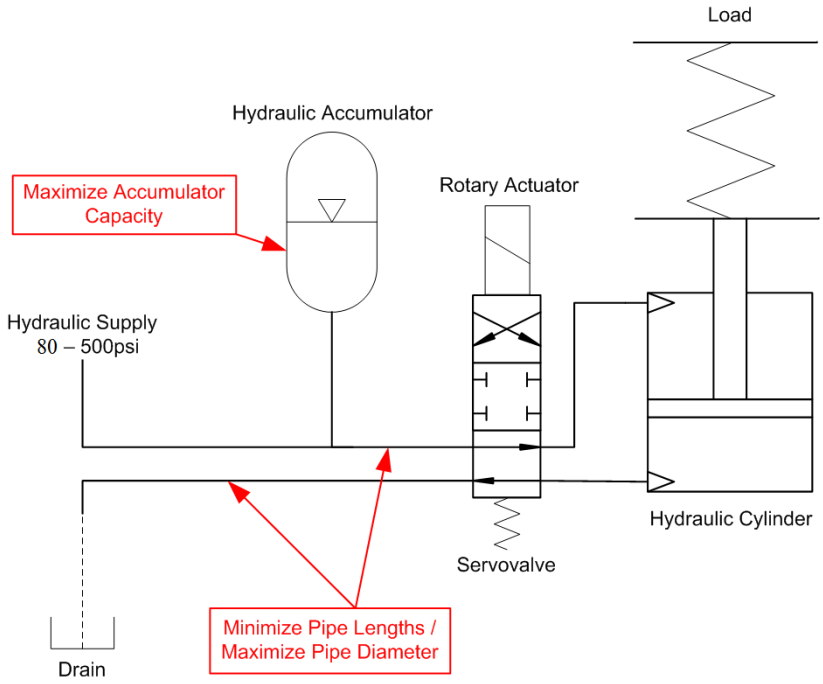

Figure 3-6. Suggested Configuration

WARNING **Do not remove any test port connection plugs when hydraulic supply pressure is applied. All required hydraulic connections must be made before hydraulic pressure is applied. Hydraulic test ports provided for use by authorized service personnel only.**

IMPORTANT

For step demands and/or trip movements actuator may generate pressure spikes in supply line due to water hammer effect. Hydraulic accumulator in supply line installed close to the VariStroke can considerably reduce or eliminate this effect.

Electrical Connections

Figure 3-7 shows an overall electrical wiring diagram. Detailed wiring requirements for these connections will follow in the remainder of the Electrical Connections section. The RS-232 connection is covered in Chapter 4 (Installing and Running the PC Service Tool).

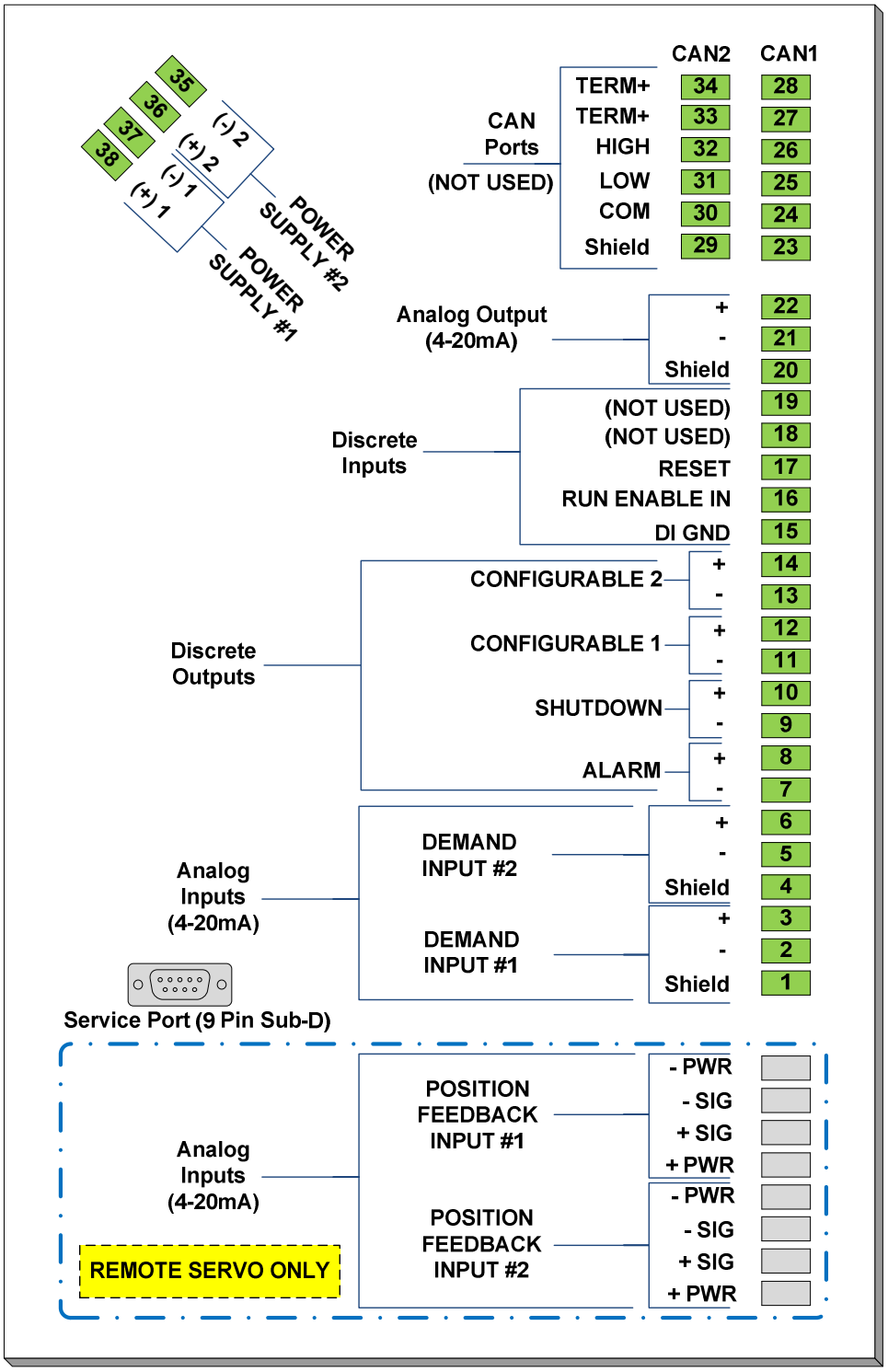

Figure 3-7. Electrical Wiring Diagram

Input Power

The VS-I requires a power source capable of supplying the necessary output voltage and current at full transient conditions. The maximum power in watts (W) of a DC source is calculated by multiplying the rated output voltage by the maximum output current capability. The calculated power rating of the supply should be greater than or equal to VS-I requirements. The electrical power supply should be able to provide 2.3 A at 24 V (dc) continuously, with a peak of 10 A for 100 ms, 6 A for 4 seconds.

Cable selection and sizing are very important to avoid power loss during driver operation. The power supply input at the driver's input terminal must always provide the required nominal voltage for the driver.

The input power wire must comply with local code requirements and be of sufficient size such that the power supply voltage minus the IR loss in the two lead wires to the VariStroke driver does not drop below the driver input minimum voltage requirement.

The VS-I is not equipped with an input power disconnect. A means of disconnecting input power to the VS-I must be provided for safe installation and servicing.

The VS-I is not equipped with input power protection. A means of protecting input power to the VS-I must be provided. Breakers or fuses are intended to protect installation wiring and power sources from faults in the VS-I or wiring. A circuit breaker meeting the requirements from the table below, or a separate protection with the appropriate ratings, may be used for this purpose.

Table 3-2. Recommended Fuse Ratings or Circuit Breakers.

Components	Input Voltage	Steady State Input Current	Maximum Transient Input Current	Maximum Power	Maximum Slow Blow Fuse / C.B. Rating
VS-I	(18 to 32) V (dc) 24 V (dc) nominal	3.1 A @ 18 V (dc)	10 A	340 W (100 ms)	20% above Steady State Current

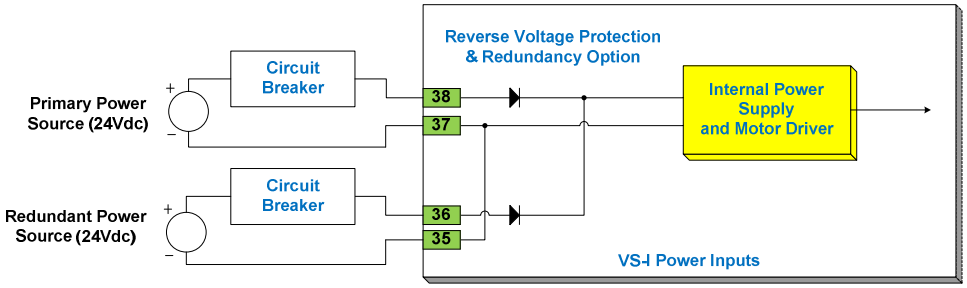

Figure 3-8. Power Supply Input Connections

The VS-I is capable of connecting two redundant power supplies.

Table 3-3. Terminal Assignment for this Option Usage.

	Power Input (+)	Power Input (-)
Power Supply #1	Terminal # 38	Terminal # 37
Power Supply #2	Terminal # 36	Terminal # 35

⚠WARNING **If redundancy option is not used, both (+) signals (Terminal #36 and Terminal #38) should be connected together on the terminal.**

Although the VS-I is protected against input voltage transients, good wiring practices must be followed. The following drawings illustrate correct and incorrect wiring methods to the power supply.

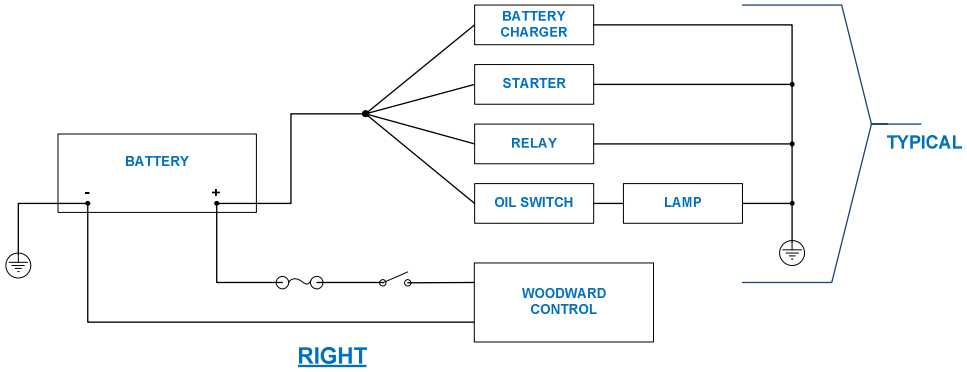

Figure 3-9. Correct Wiring to Power Supply Input

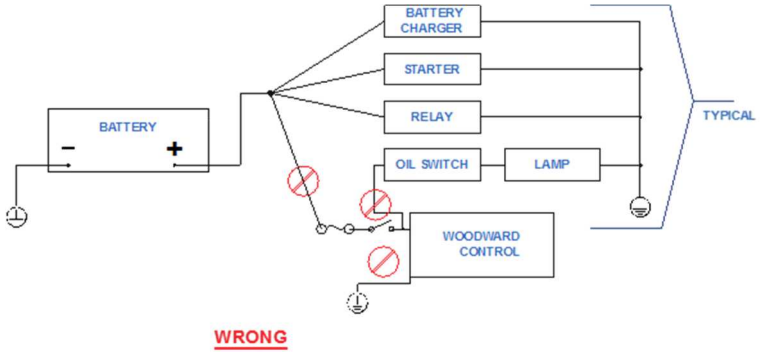

Figure 3-10. Example of Incorrect Wiring to Power Supply Input

Power Wiring Requirements

- Keep these inputs separated from low level signals to reduce signal noise
- Wire Gauge Requirements: 1.5…2.5 mm² / 12…16 AWG
- Maximum Wiring Distance: 30 m

Unit Grounding

Ground the unit housing using the designated PE ground connection point and EMC ground connection point (see installation drawings).

For the PE connection, use required type (typically green/yellow, 2.5 mm² / 12 AWG) as necessary to meet the installation safety ground requirements. For the EMC ground connection, use a short, low-impedance strap or cable (typically > 3 mm² / 12 AWG and < 46 cm / 18 inches in length). Torque the ground lugs to 5.1 N·m (3.8 lb-in).

IMPORTANT **In cases where the EMC ground configuration also meets installation safety ground requirements, no additional PE ground is required.**

Wiring Strain Relief

Tie down points and ratcheting tie wraps are provided to secure the wiring to the top of the PCB cover. This helps prevent wire strain from being transmitted to the connection at the terminal block and to keep the wiring from chafing on the cover when tightening and under vibration. Failure to secure the wiring could result in intermittent connections resulting in alarm or shut down conditions.

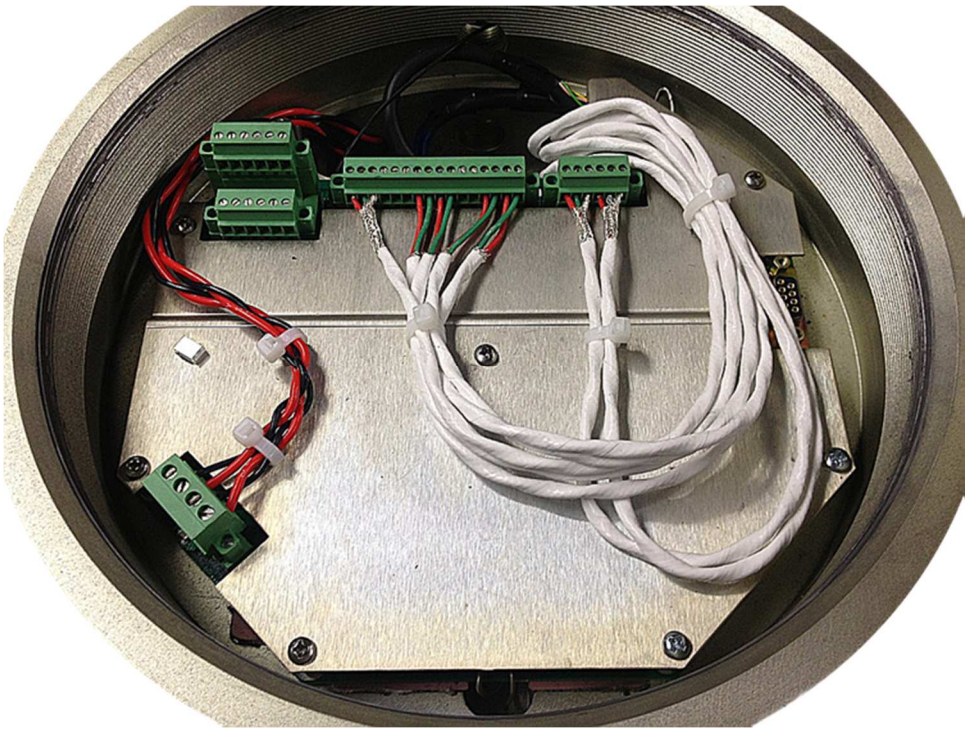

Figure 3-11. Recommended Wiring Strain Relief

Shielded Wiring

Use shielded cable for all analog signals. Terminate shields as shown in the following sections. Avoid routing power supply and signal wires within the same conduit or near each other within the unit. When bundling the field wiring inside the unit, separate the unshielded power and discrete inputs/outputs from the shielded analog signals.

Shield Installation Notes

- Wires exposed beyond the shield should be as short as possible, not exceeding 50 mm (2 inches).
- Keep the shield termination wire (or drain wire) as short as possible, not exceeding 50 mm (2 inches), and where possible the diameter should be maximized.
- Installations with severe electromagnetic interference (EMI) may require additional shielding precautions. Contact Woodward for more information.
- Do not ground shield on both ends, except where permitted by the control-wiring diagram.

Failure to provide shielding can produce future conditions, which are difficult to diagnose. Proper shielding, at the time of installation is required to ensure satisfactory operation of the product.

IMPORTANT

Strip wires away from the PCBA chamber to avoid to the possibility of conductive strands contacting the PCBA.

Demand Analog Inputs

There are two demand analog inputs to the VS-I. Demand Input #1 is dedicated to the demand input. For application where reliability is critical, the Demand Input #2 can be configured for a redundant demand input.

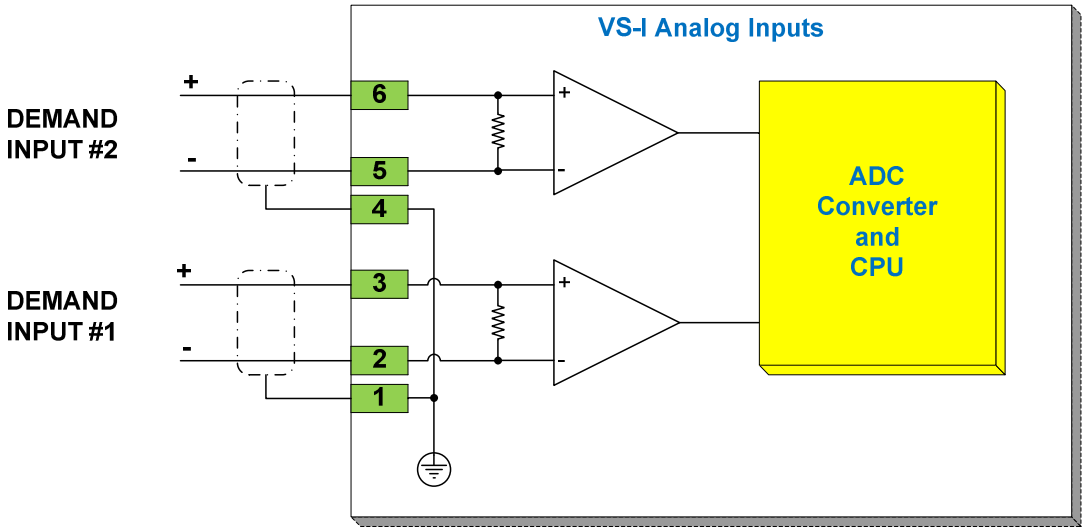

Figure 3-12. Analog Input Connections

Calibrated Accuracy: 0.1% of full range
Input Range: (0 to 25) mA, the recommended maximum range is (2 to 22) mA
Maximum Temperature Drift: 200 ppm/°C
Input Impedance: 200 Ω ±10%
Common Mode Voltage Range: ±50 V(dc)
Common Mode Rejection Ratio: 70 db @ 50 Hz & 60 Hz
Isolation: 400 kΩ from each terminal to circuit common, 500 V(ac) to chassis ground

Analog Input Wiring Requirements:

- Individually shielded twisted pair cable
- Keep this and all other low level signal cables separated from input power cables to avoid unnecessary coupling (noise) between them.
- Wire Gauge Range: (0.14 to 1.5) mm² / (16 to 24) AWG
- Shielding: per drawing above

Cylinder Position Feedback Analog Inputs (Remote Servo Only)

There are two Final Cylinder Position Feedback analog inputs. Refer to the service tool chapter for information on configuring these inputs.

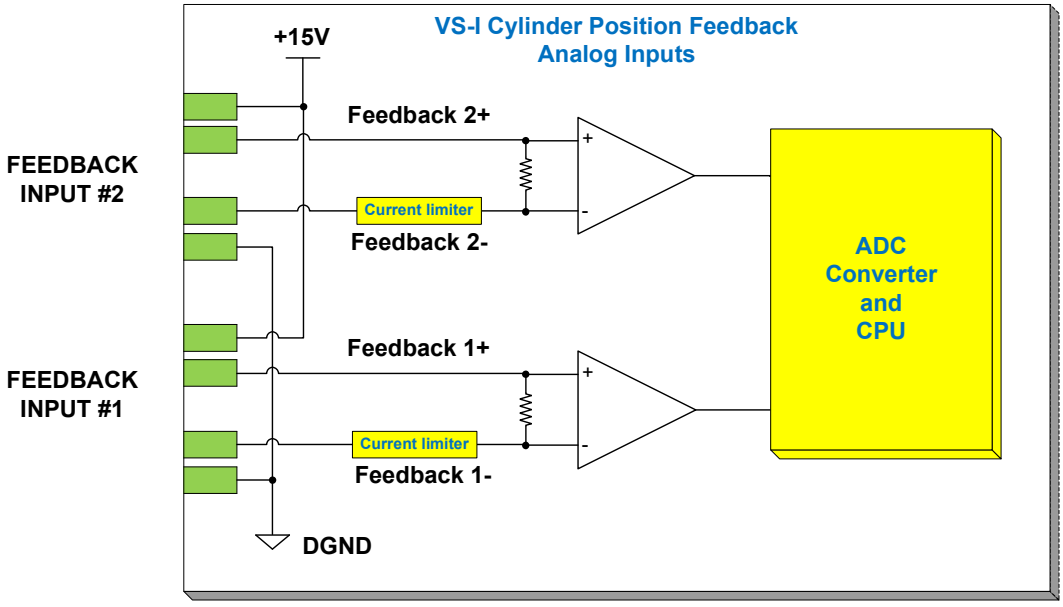

Figure 3-13. Final Cylinder Position Feedback Analog Input Connections

Input Range: (0 to 25) mA, the recommended maximum range is (2 to 22) mA
Current Limit: 30 mA @ 25 °C
Calibrated Accuracy: 0.1% of full range @ 25 °C
Maximum Temperature Drift: 200 ppm/°C
Input Impedance: 235 Ω ±25 Ω
Loop power: +15 V ±0.5 V over temperature range
Max output current: 200 mA total (100 mA per sensor)
Common Mode Voltage Range: ±50 V(dc)
Common Mode Rejection Ratio: 70 dB @ 50 Hz & 60 Hz
Isolation: 500 V(ac) to chassis ground

⚠WARNING **Overloading +15 V power output will result in unit reset and shut down.**

The following drawings illustrate correct and incorrect wiring methods to the Cylinder Position Feedback Analog Inputs.

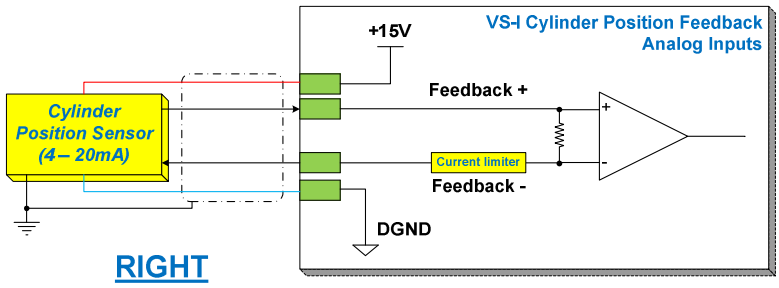

Figure 3-14. Cylinder Position Sensor Wiring Diagram When Using Vs-1 Internal Power

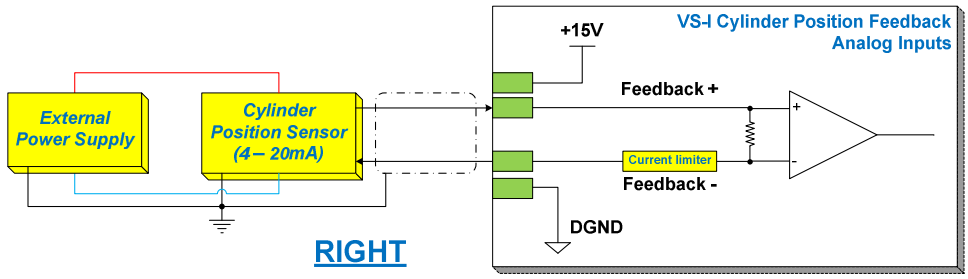

Figure 3-15. Cylinder Position Sensor Wiring Diagram When Using External Power Supply

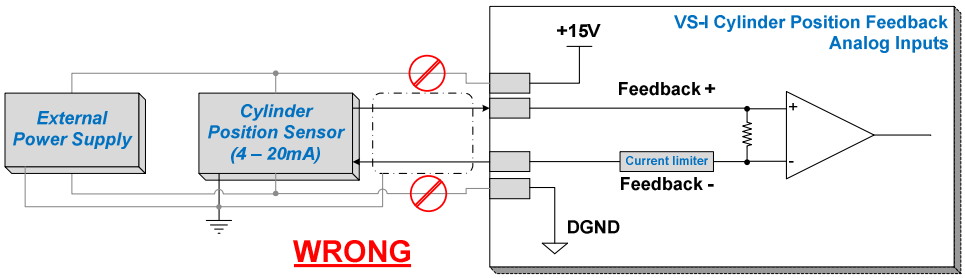

Figure 3-16. Example of Incorrect Cylinder Position Sensor Connection When Using External Power Supply

⚠WARNING

When using external power supply, do NOT connect it to VS-I driver power outputs on the Position Feedback terminals. This may result in permanent damage to the VS-I driver.

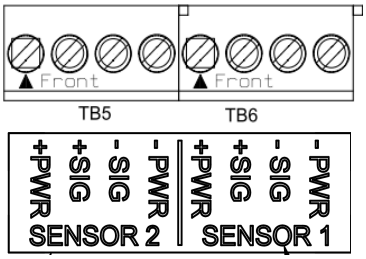

Figure 3-17. Cylinder Position Connectors

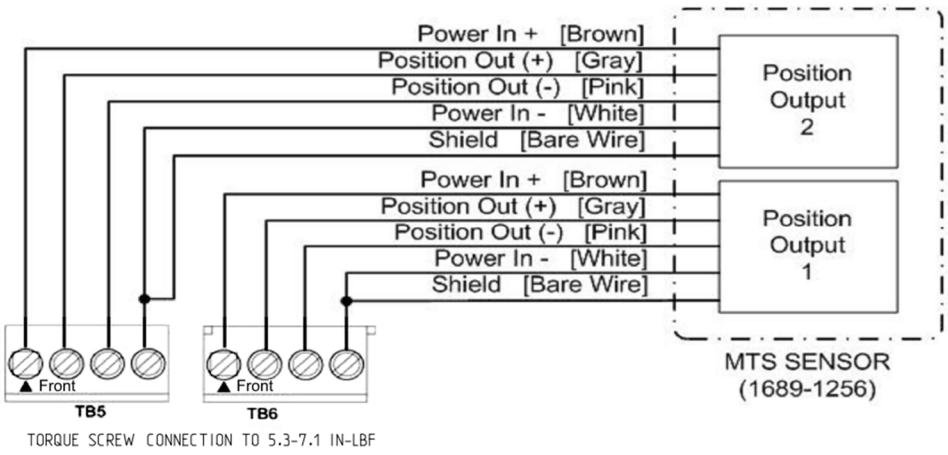

Figure 3-18. Cylinder Position Sensor Connection Scheme with MTS Sensor

Cylinder Position Feedback Analog Input Wiring Requirements:

- Individually shielded twisted pair cable
- Keep this and all other low level signal cables separated from input power cables to avoid unnecessary coupling (noise) between them.
- Wire Gauge Range: (0.14 to 1.5) mm² / (16 to 24) AWG
- Shielding: per drawing above
- Cable length: less than 3 m (10 feet)

Analog Output

The analog output of the VS-I is in the form of a (4 to 20) mA output and can drive load resistance from 0 up to 500 Ω. This output can be configured. Refer to the service tool chapter for configuration information. The design of this output is for monitoring and diagnostic purposes only, and not intended for any type of closed loop feedback.

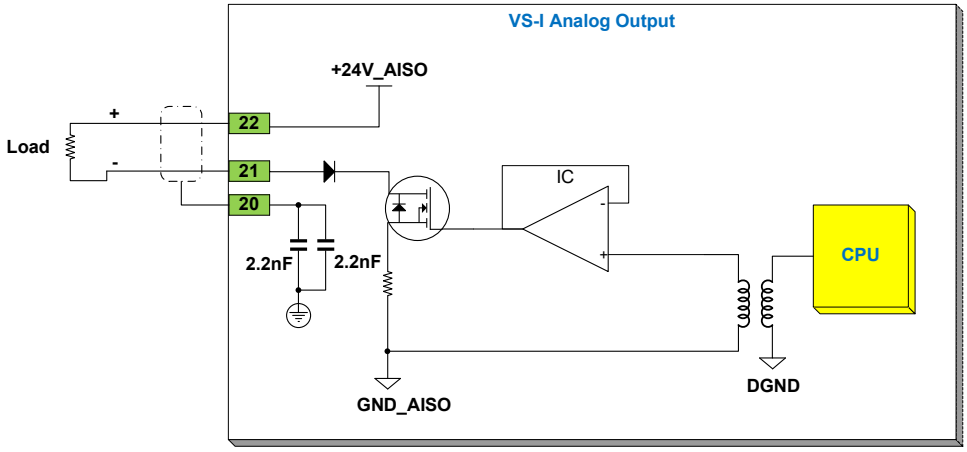

Figure 3-19. Analog Output Connection

Calibrated Accuracy: ±0.5 % of full range, (0 to 25) mA
Output Range: (2 to 22) mA
Load Range: 0 Ω up to 500 Ω (for output up to 25 mA)
Maximum Temperature Drift: 300 ppm/°C
Isolation: 500 V (ac) from circuit common, and chassis

Analog Output Wiring Requirements:

- Individually shielded twisted pair cable
- Keep this and all other low level signal cables separated from input power cables to avoid unnecessary coupling (noise) between them.
- Wire Gauge Range: (0.14 to 1.5) mm² / (16 to 24) AWG
- Shielding: per drawing above

Discrete Inputs

The VS-I has four discrete inputs. External power is not necessary for these inputs as the isolation is provided internally. The discrete inputs have an internal pull-up resistor and are inverted at the processor, such that an open circuit is the passive low state. The high state is achieved when the input is pulled low by an external contact to the isolated ground terminal provided. There are four inputs and one ground terminal (DI GND) provided, so it is necessary to share the one ground if more than one input is used.

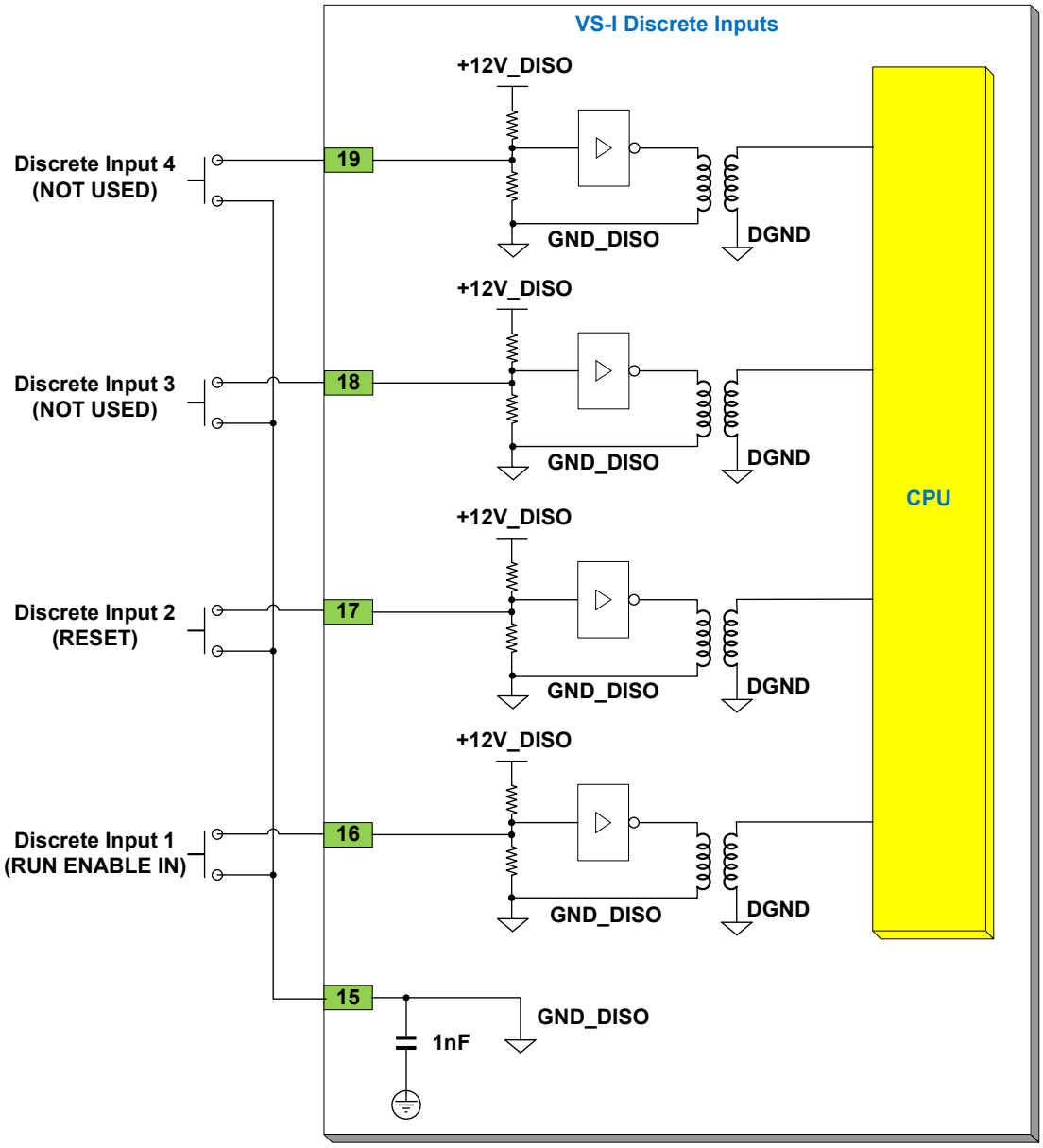

Figure 3-20. Discrete Inputs Connections

Contact Types: The inputs will accept either a dry contact from each terminal to ground or an open drain / collector switch to ground. Approximately 3 mA is sourced from the input for dry contact operation.

Trip Points:

- If the input voltage is less than 3 V, the input will detect a high state.
- If the input voltage is greater than 7 V, the input will detect low state.
- The hysteresis between the low trip point and the high trip point will be greater than 1 V.

Isolation: 500 V (ac) from Digital Common and chassis.

Wiring Requirements

- Keep this and all other low level signal cables separated from input power cables to avoid unnecessary coupling (noise) between them.
- Wire Gauge Range: (0.14 to 1.5) mm² / (16 to 24) AWG
- Shielding: these inputs are unshielded; however, keep the wires in a twisted configuration for noise immunity.

Discrete Outputs

There are four Discrete Outputs on VS-I. Configuration of the outputs is normally open / normally closed. Refer to the service tool chapter for configuration information. Wire the outputs to switch load from positive supply or switch load to ground. Woodward recommends that the output be used as a high side driver as shown in the diagram below. This configuration makes some common wiring faults to ground more detectable in the user system. The user must supply the external 24 V supply for the output to function properly.

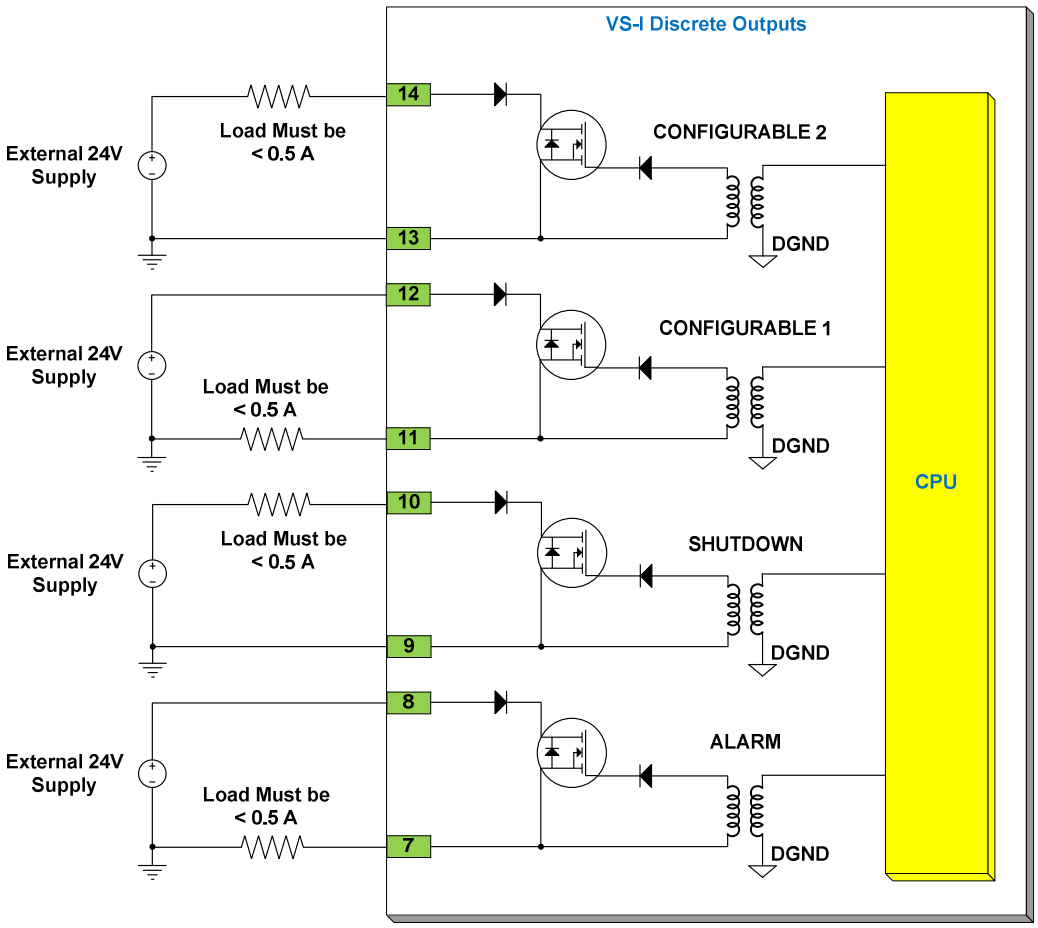

Figure 3-21. Discrete Output Connections

Hardware Configuration Options: You may configure the outputs as high-side or low-side drivers, but the recommended configuration is high-side driver if possible.

External Power Supply Voltage Range: 18-32 V
Maximum Load Current: 500 mA
Protection:

- The outputs are short circuit protected
- The outputs are recoverable after short circuit is removed

Response Time: Less than 2 ms
On-state Saturation Voltage: Less than 1 V @ 500 mA
Off-state Leakage Current: Less than 10 µA @ 32 V
Isolation: 500 V (ac) from digital ground and chassis

Wiring Requirements:
- Keep this and all other low level signal cables separated from input power cables to avoid unnecessary coupling (noise) between them.
- Wire Gauge Range: (0.25 to 1.5) mm² / (16 to 22) AWG
- Shielding: these outputs are unshielded, however the wires should be kept in a twisted configuration for noise immunity.

CAN Communication

NOTICE

CAN communication is not yet available in current VS-I models.

The VS-I has (2) CAN ports.

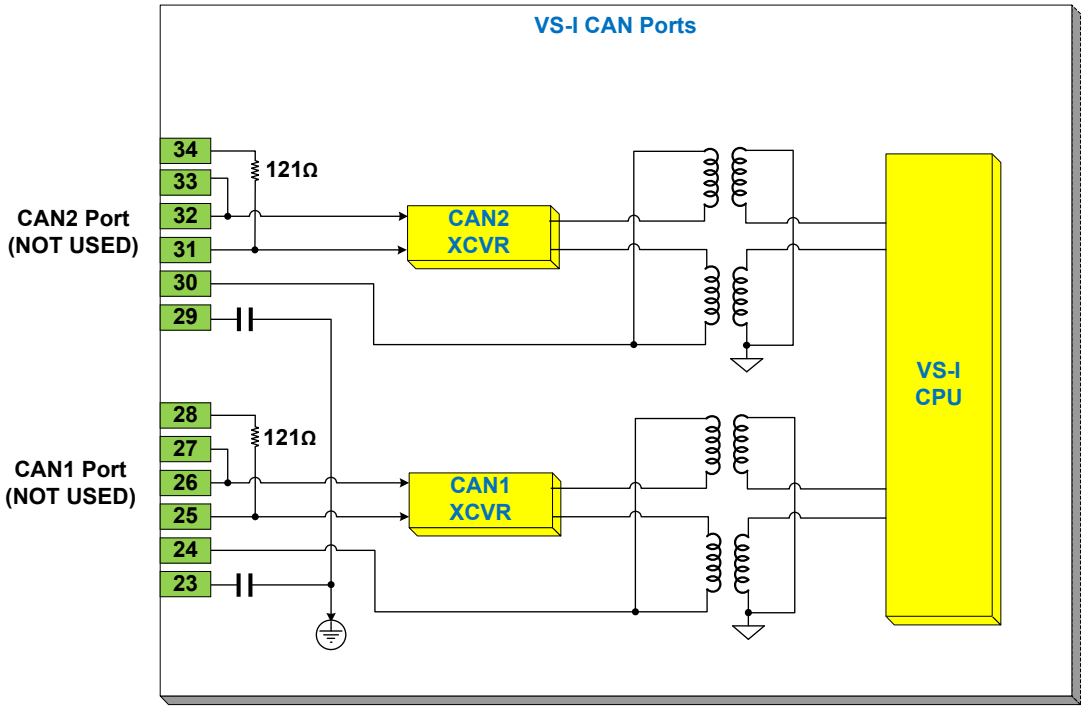

Figure 3-22. CAN Ports Connections

CAN Specification:
- Interface Standard: CAN 2.0 A/B (configured in the CPU)
- Network Connections: (2) separate connectors
- Network Isolation: 500 V (ac) to chassis, input power, I/O channels, between CAN ports
- Network Termination: (121 ±10) Ω built into the each port of VS-I
- Cable / Part Number: 2008-1512 (120 Ω, 3-wire, shielded twisted pair)—Belden YR58684 or similar

CAN Cable Shield Termination & Exposed Cable Limitations

For robust communications performance, the CAN cabling needs to minimize the exposed, non-shielded cable section that occurs at terminal blocks. The exposed length of CAN wiring must be limited to less than 3.8 cm (1.5 inches) from the end of the shield to the terminal block. This limits the total length of exposed wiring during a series or daisy chain connection on each side of the terminal block to 7.6 cm (3 inches).

CAN shields are terminated to chassis (EARTH) through a capacitor-resistor network. However, the shield must also be directly terminated to chassis (Earth) at one point in the network.

IMPORTANT

Always use shielded cables for improved communications in industrial environments. Wire terminations at the node should expose as little un-shielded cable as possible (less than 25 to 38 mm / 1.0 to 1.5 inches).

Wiring

The VS-I has four NPT wiring entries: two ¾ inch (19.05 mm), two ½ inch (12.7 mm).

When wiring using cable and cable glands, the gland fitting must meet the same hazardous locations criteria as the VS-I. Follow all installation recommendations and special conditions for safe use that are supplied with the cable gland. The cable insulation must have a temperature rating of at least 85 °C and 10 °C above the maximum ambient and fluid temperature.

Strip the cable insulation (not the wire insulation) to expose 12 mm (1/2 inch) of the conductors. Strip the wire insulation 5 mm from each conductor. Mark wires according to their designation and install connectors, if required.

Remove the top access cover. Pass the wires through the cable gland (not provided) or conduit fitting and attach to the printed circuit board terminal blocks in accordance with their wiring diagram. Snap the terminal blocks into the header terminal blocks on the PCB. Tighten the terminal block flange screws to 0.5 N·m (4.4 lb-in). Replace the top access cover and tighten until the O-ring seal is compressed and the cover is fully seated against the housing.

Install the PE ground and EMC ground straps to the lugs provided. Tighten to 5.1 N·m (45 lb-in).

Tighten the cable gland fitting per manufacturer's instructions or pour the conduit seal to provide strain relief for the cable and to seal the interface between the wiring cable and the VS-I.

Chapter 4.
Service Tool Installation

System Requirements

The minimum system requirements for the Service Tool software are:

- Microsoft Windows® 7, Vista SP1 or later, XP SP3 (32 & 64-bit); Support of XP ended on 2014 April 8
- Microsoft .NET Framework ver. 4.0 & Hot Fix KB2592573
- 1 GHz Pentium® CPU
- 512 MB of RAM
- Minimum of 800 by 600 pixel screen with 256 colors
- Recommended screen resolution of 1024 X768 or higher
- 9 pin-D Serial Port (RS232)
- Woodward ToolKit Software

Setup

The VS-I includes a software-based Programming and Configuration tool (PCT) that can be loaded onto a computer and used to:

- Change maximum stop position and cylinder size settings.
- Calibrate the final cylinder.
- Configure the inputs and outputs
- View diagnostic flags

⚠WARNING **An unsafe condition could occur with improper use of these software tools. Only trained personnel should have access to these tools.**

The PC Service Tool or Programming and Configuration Tool is a software application which runs on Windows-based PC or laptop. It requires a physical RS-232 connection between the computer and the VS-I. Make the physical connection by connecting to the VS-I at the Service Port (RS-232).

Use a straight-through serial cable (not null modem). For newer PCs or laptops with USB ports, a USB-to-serial converter is required.

Information regarding the adapter kits is unclear. The converter kit also contains an extension cable, but this is not mentioned.

- 8928-1151 Converter Kit contains:
  - (1) USB-to-Serial Converter
  - (1) 10-ft DB9F to DB9M extension
- 8928-7323 Cable It contains:
  - (1) 10-ft DB9F to DB9M extension

  Note: this cable has two nuts on the screws on the female end that need to be removed prior installing this end.

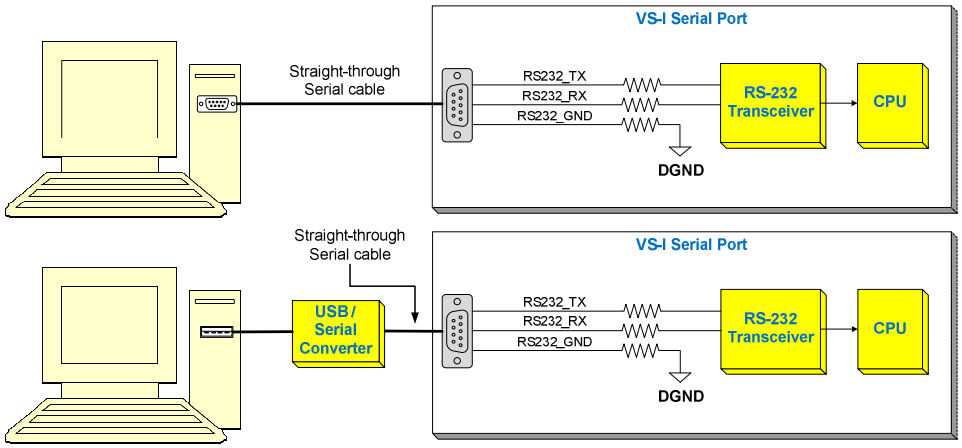

Figure 4-1. Service Port Connections

WARNING

Do not to damage the cover seal, the cover surface, the threads, or the VS-I surface while removing or replacing the cover. Damage to sealing surfaces may result in moisture ingress, fire, or explosion. Clean the surface with rubbing alcohol if necessary. Inspect the cover joint surfaces to ensure that they are not damaged or contaminated.

Installing the VariStroke-I Service Tool

Use the following installation procedure to install the VariStroke-I Service Tool (Programming and Configuration Tool).

Locate/obtain VS-I Service Tool Installation CD provided with each VS-I. (Alternatively, you may download the VS-I Service Tool Installation file from Woodward's website [**www.woodward.com/software**]).

To run the installation program follow the installation instructions (shown below).

1. Double click on the install file 9927-2177_xxx.exe.
   Note: xxx is a placeholder for the revision of the install package i.e. 9927-2177_NEW.exe. or 9927-2177_A.exe are examples of Rev NEW and Rev A versions.
2. The Tool launches and the Welcome screen is displayed. Click on “Next”.

Figure 4-2. Service Tool Welcome Screen

3. The EULA screen appears. Accept the terms of the License Agreement then click “Next” to continue.

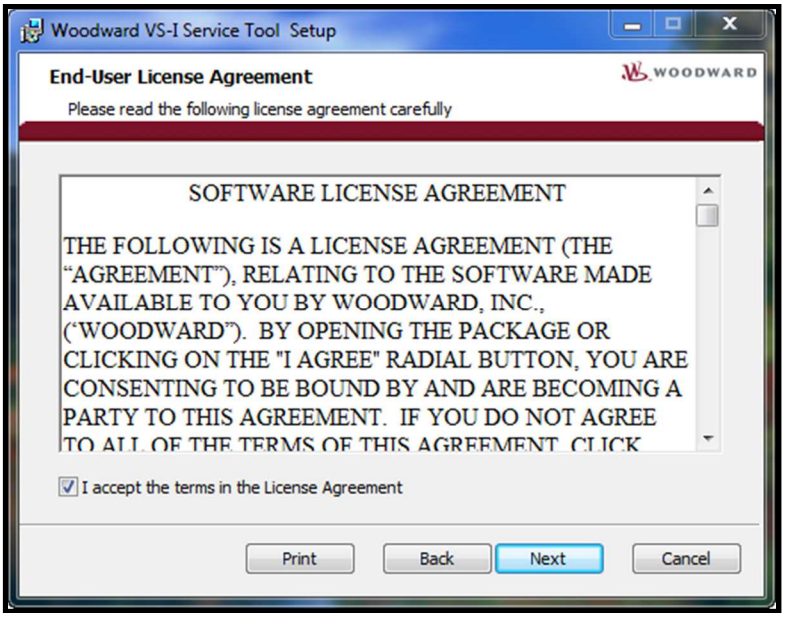

Figure 4-3. End-User License Agreement Screen

4. The Install page appears. “Create shortcut for this program on the desktop” is set as the default. Uncheck this box if you do not want a Service Tool icon on your desktop. Click on “Install”.

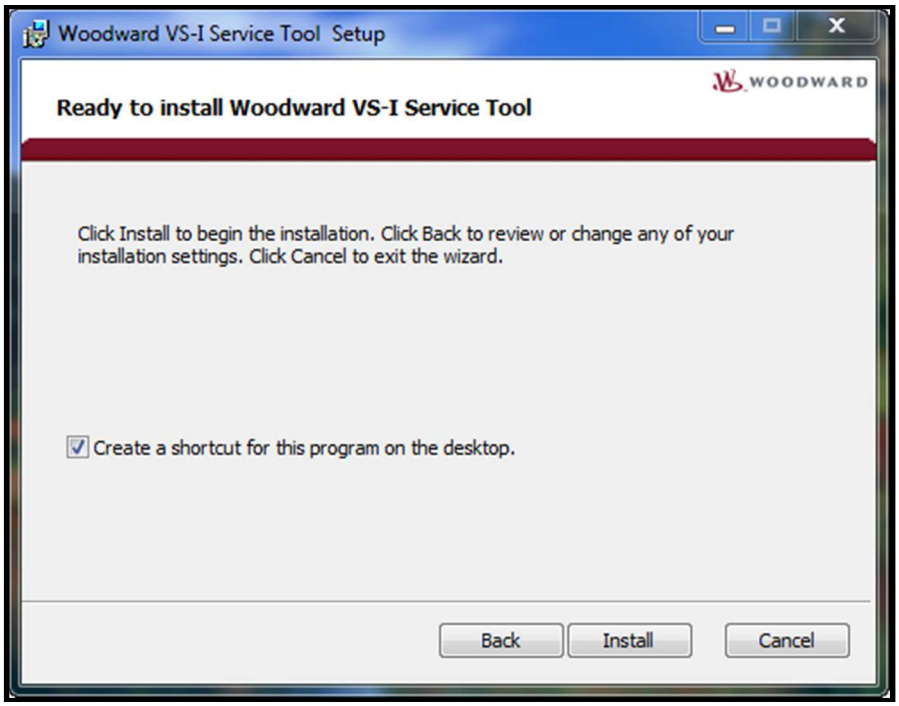

Figure 4-4. Service Tool Installation Screen

5. The Installation of the Service tool will proceed.

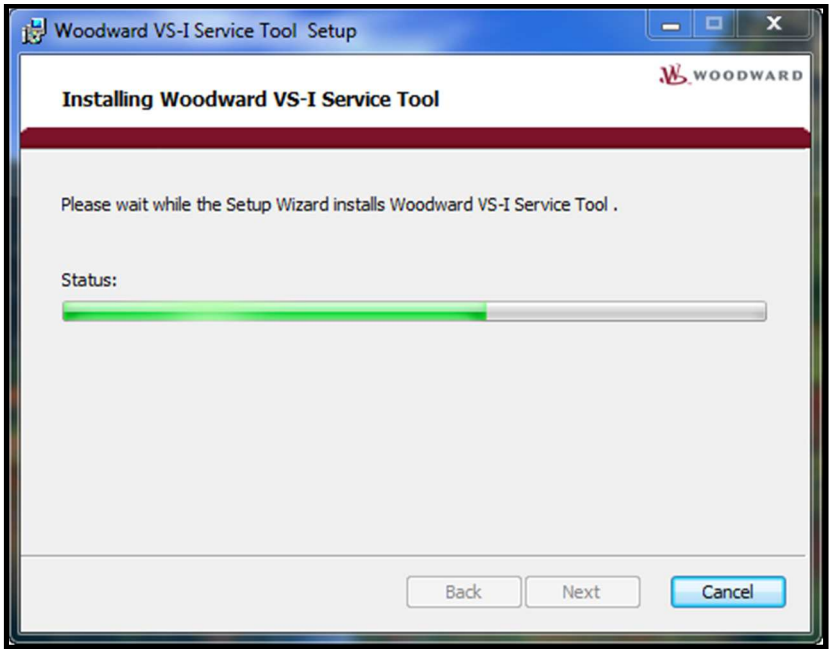

Figure 4-5. Service Tool Installation Progress Screen

6. When the installation is finished, the Installation Complete screen will appear. The “Launch when setup exits” box in the lower left is unchecked by default. You do not want to launch the Service tool until the VS-I has been connected to the computer through a serial cable. At launch the Service tool detects which COM port is connected to the VS-I.

NOTICE

If you launch the service tool application before you connect the serial cable between the computer and the VS-I the service tool will not detect the new serial connection. To detect the connection you will have to exit and re-launch the service tool.

7. When you click on “Finish”, you will exit the installation wizard.

Figure 4-6. Installation Complete and Finish Screen

Connecting to the VariStroke-I

1. To connect to the VariStroke-I (VS-I) connect a serial cable between the computer and the VS-I driver then double-click on the service tool icon on the desktop. The service tool will launch and the next screen you will see will be the Home Screen of the VS-I service Tool.

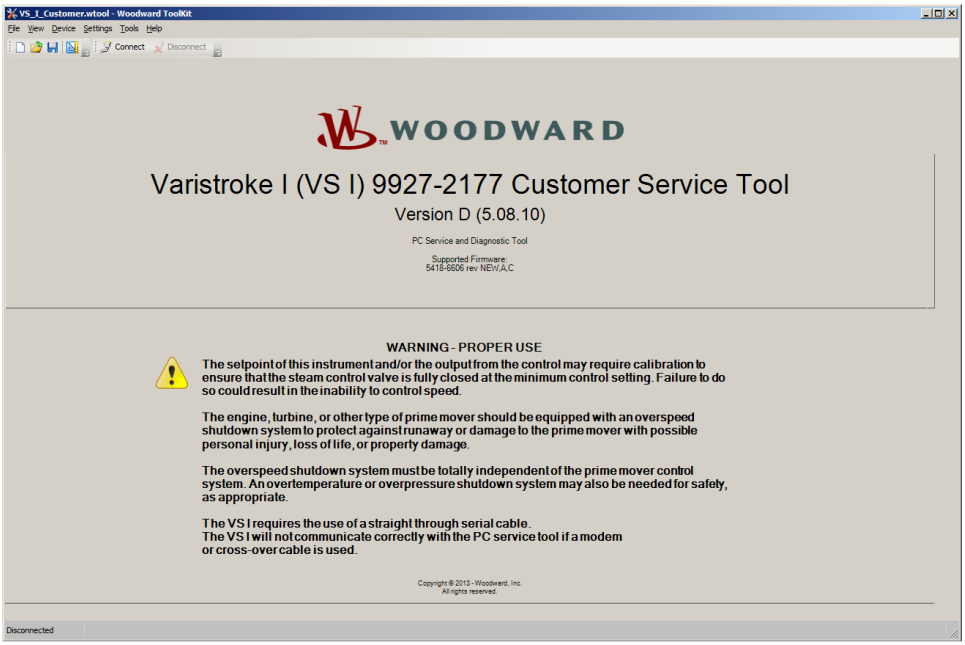

Figure 4-7. VS 1 Service Tool Home Screen

2. Press the “Connect” button in the ribbon at the top of the service tool screen. You will see the following screen.

3. Select the network connection to which the serial cable is connected. Select your available network and then set “Baud Rate” to “AutoDetection”. Press the “Connect” button.

4. The Service Tool will connect to the VS-I within a few seconds. When it does the “Connect” button in the ribbon is grayed-out and the “Disconnect” button is activated. The Service tool is now connected and communicating with the VS-I and you can calibrate, configure, and control the VS-I through the service tool.

5. When you want to end your session and disconnect the Service Tool from the VS-I press the “Disconnect“ button. The Service tool will cease communication with the VS-I, the “Disconnect” button will be grayed-out and the “Connect” button will be activated. The service tool is now ready to communicate with the VS-I the next time you press the “Connect” button.

Chapter 5.
Calibration and Monitoring

Introduction

The VS-I Service Tool is organized in to a series of pages that allow the VS-I to be set up for proper operation. The following section will outline the various pages and their functions.

⚠WARNING

The engine, turbine, or other type of prime mover should be equipped with an overspeed shutdown system to protect against runaway or damage to the prime mover with possible personal injury, loss of life, or property damage.

The overspeed shutdown system must be totally independent of the prime mover control system. An overtemperature or overpressure shutdown system may also be needed for safety, as appropriate.

⚠WARNING

An unsafe condition could occur with improper use of these software tools. Only trained personnel should have access to these tools.

System Information

System Information is displayed along the left hand side of the Service Tool screens. This provides general information about the product status.

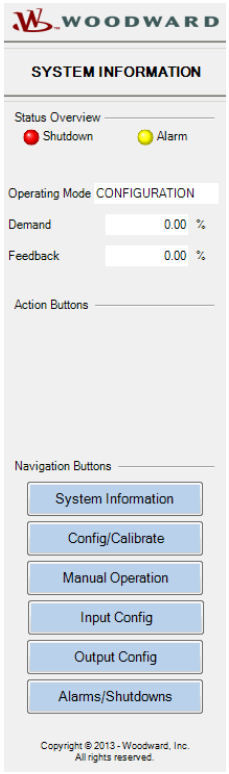

Figure 5-1. System Information and Status Overview Screen

Shutdown LED: When this LED indicator is illuminated, this invokes a shutdown condition. The unit receives a command to shut down or has detected an operating condition, which adversely affects the unit's ability to operate reliably and predictably. Refer to Chapter 7 for a list of shutdown conditions.

Alarm LED: When this LED indicator is illuminated, the unit has detected an operating condition, which is outside of recommended operating parameters, but the VS-I is still operating. The cause of alarm conditions should be determined and corrected to prevent damage to the turbine, VS-I, or other auxiliary equipment. Refer to Chapter 7 for a list of Alarm conditions.

Operating Mode: Shows the status of the driver. Possible states are:

STARTUP - Initialization is in progress

SPRING_CHK - Initialization of the system is currently testing the spring.

ANALOG_DMD - Normal operating mode when the cylinder position is selected by the analog input demand signals(s). There is an option of one or two demand signals on the Input configuration page.

SHUTDOWN - This "smart" button only appears when the VS-I is running and can be shut down. This state may have occurred because the analog inputs are not in the 4–20 mA range, or the Run Enable discrete input is selected and not on, or the Shutdown button has been pressed. After checking that the analog demands and the Run Enable are OK, refer to Chapter 7 for a list of Shut down conditions if the problem persists.

CONFIGURATION - The system is ready to receive the configuration or calibration information. When this process is completed and saved, turn on the input signals to re-enable normal operation.

CSD_FETS -This means the system is shut down due to a critical error. Please check your input power and connections and then reset the system. If the problem persists, service may be required.

CSD_CURR - The system is shut down due to a critical error. Please reset the system. If the problem persists, service may be required.

CSD_SERVO - The system is shut down due to a critical error. Please check the connections to the final cylinder feedback and then reset the system. If the problem persists, service may be required.

Demand and Feedback:
The Demand and Feedback indicators show the current demanded position and measured feedback position of the final cylinder.

Shutdown Button:
Pressing this button will invoke a shutdown condition.

Navigation Buttons:
Pressing these buttons will navigate you to the most commonly used pages of the VS-I Service Tool. You may access pages by using the dropdown menu at the top of the Toolkit Window.

System Information Page

This page will display system information about the VS-I servo that is currently connected to the PC Service Tool.

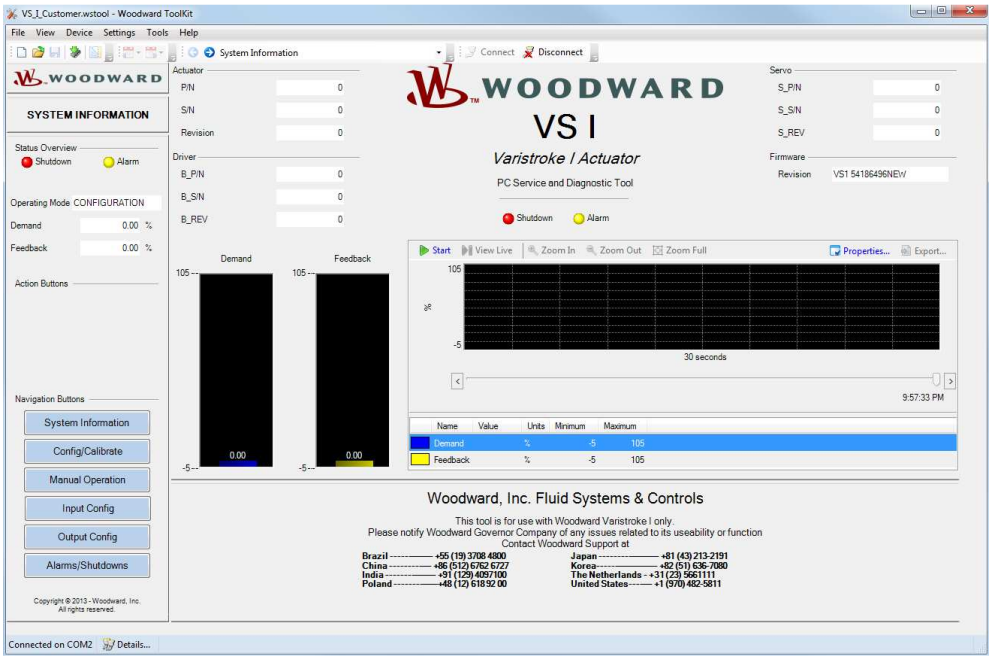

Figure 5-2. System Information Page

Actuator P/N, S/N, Revision: These fields display the Actuator Assembly Part Number (P/N), Serial Number (S/N), and Revision Number. This information is entered automatically by the VS-I software.

Driver P/N, S/N, Revision: These fields display the Electronic Driver Part Number (B_P/N), Serial Number (B_S/N), and Revision Number. This information is entered automatically by the VS-I software.

Servo P/N S/N, Revision: These fields display the Servo Valve Part Number (S_P/N), Serial Number (S_S/N), and Revision Number. This information is entered automatically by the VS-I software.

Firmware Revision: This field displays the firmware part number and revision to the software programmed into the VS-I driver. This information is entered automatically by the VS-I software.

Demand & Feedback Bar Charts: These bar charts display the current demanded position and measured feedback position of the final cylinder.

Trending Plot / Graph: This graph will display the current demanded position and the measured feedback position of the final cylinder with respect to time. Press the “Start” button in the upper left hand corner of the graph to see the current cylinder position on the chart.

Configuration and Calibration

WARNING

To prevent personal injury or death and damage to equipment, the controlled prime mover must not be allowed to run or operate during any of the following procedures. The main steam valve or main fuel control must be turned off to prevent operation of the controlled system.

The Configuration and Calibration page can be used to set the VS-I operating pressure to the desired value and to start the calibration process.

NOTICE

To enable the Configuration and Calibration functions of the VS-I you must set the RUN ENABLE line low and/or put your analog input demand(s) below 2 mA (suggest 0 mA).

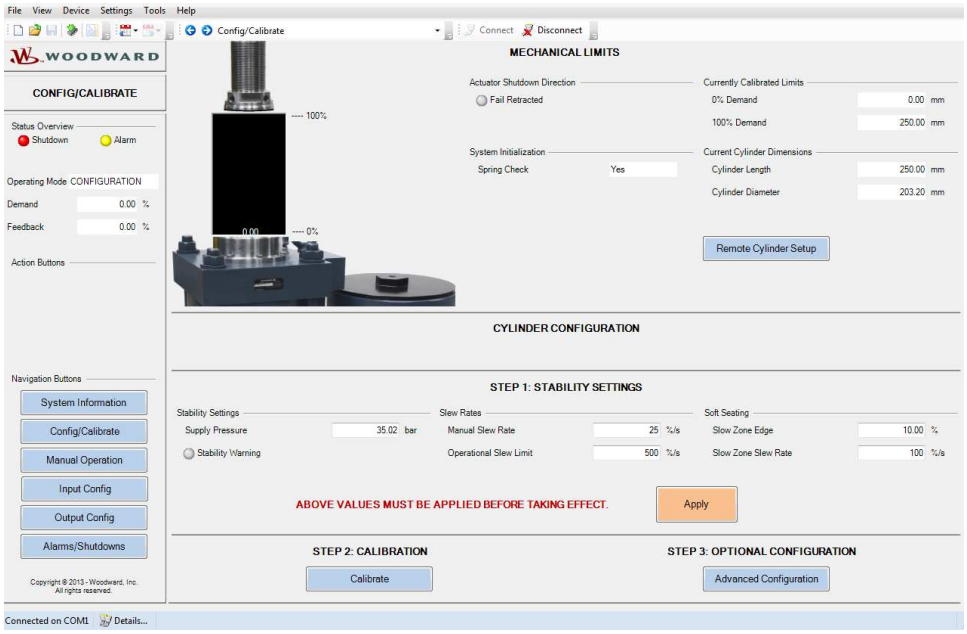

Figure 5-3. Configuration/Calibration Page

Actuator Shutdown Direction

Fail Retracted / Fail Extended: This indicates the fail-safe direction of the actuator. Any shut down or loss of input power will result in the actuator moving in the fail-safe direction.

System Initialization

Spring Check: Upon startup and reset commands, the VS-I performs a brief test to ensure that the servo valve return spring is functioning properly. This is performed before moving the actuator away from the fail-safe position and will not move the actuator. This critical safety function cannot be disabled by anyone other than authorized Woodward personnel.

Currently Calibrated Limits

0% Demand: This value is the minimum travel of the cylinder stroke. Calibration is done at the factory but can be changed as part of the calibration process (Step 2).

100% Demand: This value is the maximum travel of the cylinder stroke. Calibration is done at the factory but can be changed as part of the calibration process (Step 2).

Current Cylinder Configuration

Cylinder Length / Diameter: Displays the currently calibrated dimensions of the cylinder. These values display for reference only. Modify these values by pressing the Remote Cylinder Setup button.

Remote Cylinder Setup

NOTICE

If the VariStroke unit came from the factory as an Integrated unit with a cylinder attached, these values should NOT be changed.

This screen is used ONLY when the user must modify the cylinder and position sensor parameters. This is commonly used when setting up a VariStroke Servo Only with a cylinder that was not manufactured by Woodward.

Cylinder Length: This value must equal the physical stroke range of the hydraulic cylinder. This dimension is used by the VariStroke controller to automatically tune the actuator.

Cylinder Diameter: This value must equal the bore diameter of the hydraulic cylinder. This dimension is used by the VariStroke controller to automatically tune the actuator.

Position Sensor Length: Use this value to scale 0 to 100% positions of the VariStroke in to millimeters. This must equal the full length of the cylinder position sensor. Position Sensor Length is defined as the distance measured between the 4 mA position and 20 mA position of the sensor. It is recommended that the Position Sensor Length be slightly longer than the Cylinder Length in order to ensure the sensor output is always within the usable (4–20 mA) range. For a list of standard / Woodward position sensor lengths used in Integrated and Remote Servo Kits, refer to the table shown in Chapter 7: Repair and Troubleshooting.

Reverse Acting: The user by use this field if he wishes to invert the cylinder behavior based on the input demand. If the field is set to “Yes”, the minimum input demand (4 mA) will result in cylinder moving to the 100% position.

Cylinder Configuration

Before starting the configuration, the unit must be in a safe and shut-down state. The unit can be shut down by putting 0 mA onto the analog inputs or by opening the “run enable” discrete input (note: the “Run Enable” must be set to “used”). The unit must also not have any active faults, such as a Cylinder Tracking Fault. If there are active faults that prevent the unit from being in configuration mode, the faults should be analyzed and disabled (see Chapter 7: Repair and Troubleshooting).

Step 1—Stability Settings

Use the cylinder configuration section to input the hydraulic supply pressure.

Supply Pressure:

To set the Supply pressure (Step 1):

1. Input the hydraulic supply pressure (bar) into the Supply Pressure control indicator and press the Apply button. Based on this pressure, the VS-I driver will automatically tune itself to provide optimum performance.
2. For confirmation, two additional control buttons will appear, “Cancel/Revert Configuration” and “Save Configuration”. Press the “Save Configuration” button to save the new cylinder pressure value. Press “Cancel/ Revert Configuration” to revert back to the previous saved cylinder supply pressure.
3. After pressing the “Save Configuration” button the data will be transferred to the VS-I.

NOTICE

Failure to input the correct Supply Pressure can result in unstable actuator performance. Ensure that this setting is correct and that the system pressure regulators do not allow more than a ±10% variation in Supply Pressure.

NOTICE

Stability: Certain combinations of Supply Pressure and Cylinder Volume can cause the actuator to operate at reduced performance. See Chapter 2: Performance Index for more information on this Alarm.

Slew rates:

- **Manual Slew Rate:** This adjustment allows the user to limit the slew rate when in Manual Operation. Consider lowering this value if the attached linkage and valve are not robust.
- **Operational Slew Limit:** This adjustment allows the user to limit the slew rate when in Normal Operation. Consider lowering this value if the linkage and valve attached are not robust. Also, consider using the Soft Seating to lower valve seating velocities.

NOTICE

The Soft Seating feature will not function in some shut down conditions. Loss of cylinder position feedback, loss of electrical power, or an internal electronics fault will result in loss of the Soft Seating functionality.

Soft seating: The VS-I Soft Seating function allows the actuator to have a different slew rate limit when positioned within the lower 0% to 25% of the user-calibrated stroke. This feature provides a behavior similar to that of a conventional hydraulic cushion. You may use this function to limit the steam valve seating velocity in order to lengthen the life of the valve.

- Slow Zone Edge: This adjustment sets the position at which the actuator slew rate limit will switch from the Operation Slew Rate Limit to the Slow Zone Velocity.
- Slow Zone Velocity: This adjustment sets the slew rate limit of the actuator when position below the Slow Zone Edge value. Consider lowering this value if valve-seating velocities are higher than desired.

NOTICE

Incorrect Slew Rate Limits and Soft Seating adjustments can result in high seating velocities that may damage equipment.

⚠WARNING

Configuration of the Slow Zone settings and Slew Rate Limits can result in excessively slow closing speeds.

The engine, turbine, or other type of prime mover should be equipped with an overspeed shut down device to protect against runaway or damage to the prime mover with possible personal injury, loss of life, or property damage.

Step 2—Calibration

To calibrate, start by pressing the Calibrate button (Step 2). Upon pressing the Calibrate button, there are two options available on the left side of the page: “Find Minimum Stop” and ”Find Minimum AND Maximum Stop” (see screens and details below). Select one of these options and run before any further configuration can take place.

WARNING

The Calibration features will cause the actuator to move. Ensure all personnel are clear of moving components before initiating the calibration sequence.

CAUTION

Potential damage to linkage and/or attachments can occur if the linkage and/or attachments are not designed to withstand the full stall force of the actuator at the supplied operating pressure. It is the installer's responsibility to verify the structural capabilities of the linkage and/or attachments. IF the linkage and/or attachments CANNOT WITHSTAND THE FULL STALL FORCE of the actuator DO NOT USE FIND MINIMUM AND MAXIMUM STOPS. Instead, Find Minimum Stop must be used.

Find Minimum Stop

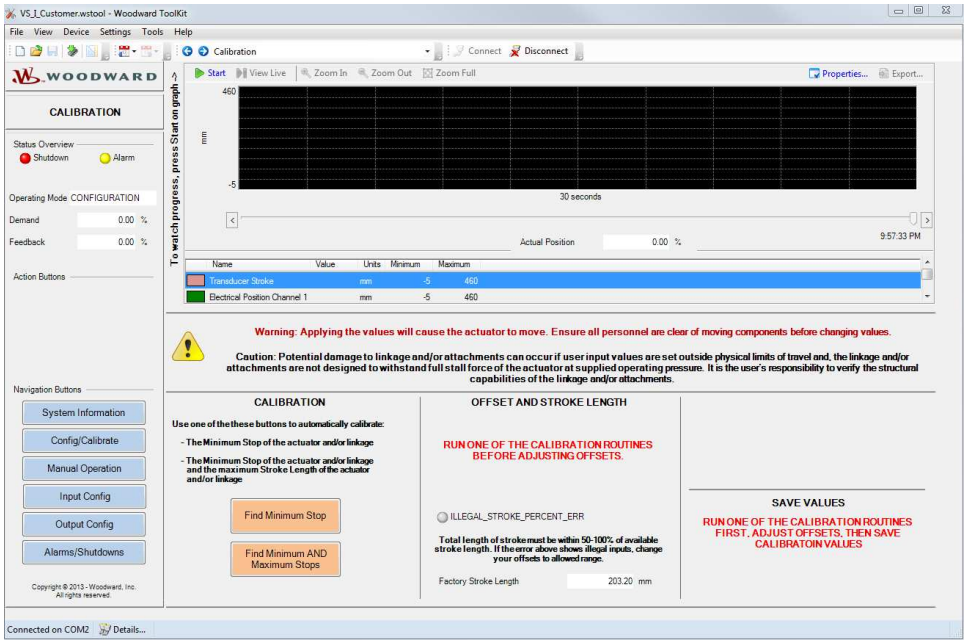

Figure 5-4. Service Tool Calibration Screen

IMPORTANT

CLEAR ALL SHUTDOWNS in order to proceed with calibration. These shutdowns display on the "Alarms/Shutdowns" page of the PC Service Tool. It may be necessary to temporarily disable certain shut downs to complete the calibration.

If the cylinder is not at the factory/default 0% position after initial installation, a "Cylinder Tracking Fault" will commonly be an active shut down. This shut down should be disabled or toggled to an alarm until calibration is complete.

To use the Find Minimum Stop option, press the “Find Minimum Stop” button. The Find Minimum Stop feature allows the user to scale the desired minimum position offset and maximum stop position to the 4 to 20 mA demand input range. After pressing the Find Minimum Stop button, the following screen will appear.

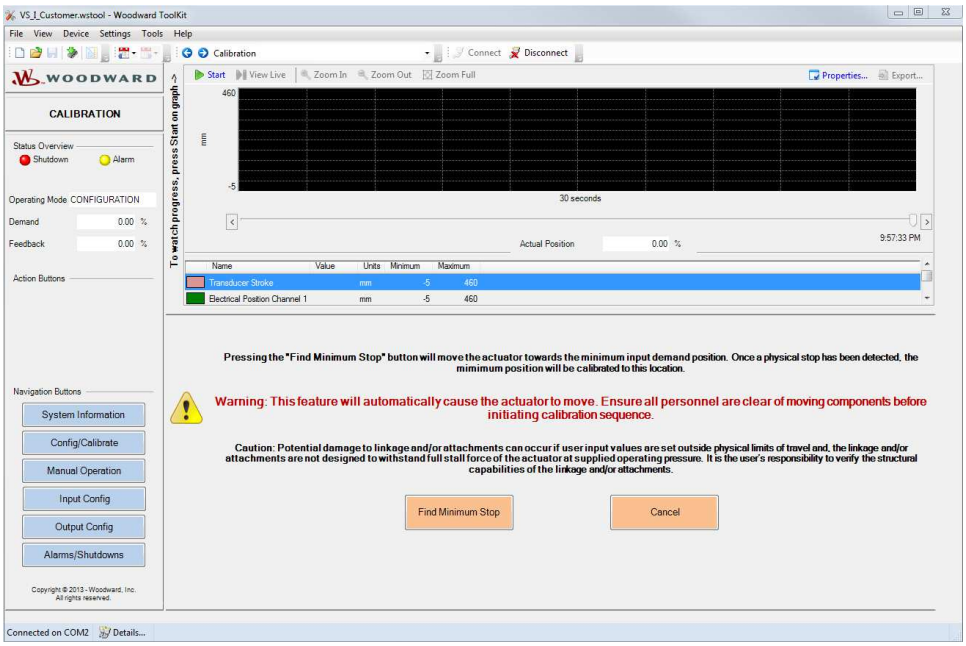

Figure 5-5. Calibration Find Minimum Stop Screen

Press the “Find Minimum Stop” button. Pressing this button will slightly open the VS-I servo valve, causing the actuator to slowly move toward the minimum/fail-safe position. Once a physical stop is contacted, the servo valve will close and the VS-I will automatically configure this as the minimum (4 mA demand) position.

View and monitor actuator movement using the trend chart. To do so, press “Start” at the top left corner of the trend chart.

Cancel Button: Pressing the Cancel button will cause the Find Minimum Stop process to stop and the service tool to return to the Calibration page.

Find Minimum AND Maximum Stops

IMPORTANT

ALL SHUTDOWNS must be cleared in order to proceed with calibration. These can be seen on the “Alarms/Shutdowns” page of the PC Service Tool. It may be necessary to temporarily disable certain shut downs to complete the calibration.

If the cylinder is not at the factory/default 0% position after initial installation, a “Cylinder Tracking Fault” will commonly be an active shut down. This shut down should be disabled or toggled to an alarm until calibration is complete.

The Find Minimum and Maximum Stops feature will determine the usable stroke range by moving the VariStroke to the minimum and maximum limits of travel at a controlled velocity. The control will slightly open the VS-I servo valve, causing the actuator to slowly move toward the minimum/fail-safe position. Once a physical stop is contacted, the servo valve will close and the VS-I will automatically configure this as the minimum (4 mA demand) position.

Immediately after this, the VS-I servo valve will slightly open in the opposite direction to slowly move the actuator toward the maximum position. The actuator will move a small distance off the minimum stop, pause for a brief moment to determine an acceptable slew rate, and then continue to move toward the maximum position. Once a physical stop is contacted, the servo valve will close and the VS-I will automatically configure this as the maximum (20 mA demand) position. These limits of travel are automatically scaled to 4 mA (minimum) to
20 mA (maximum) demand levels.

Press the “Find Minimum AND Maximum Stops” button. A confirmation screen will appear with two buttons “Find Minimum AND Maximum Stops” and Cancel. Once the “Find Minimum AND Maximum Stops” button has been pressed the calibration cycle will start and the following screen will appear. To cancel the Find Minimum AND Maximum Stops sequence and return to the previous screen press “Cancel”.

Actuator movement can be monitored and viewed using the trend chart. To do so, press “Start” at the top left corner of the trend chart.

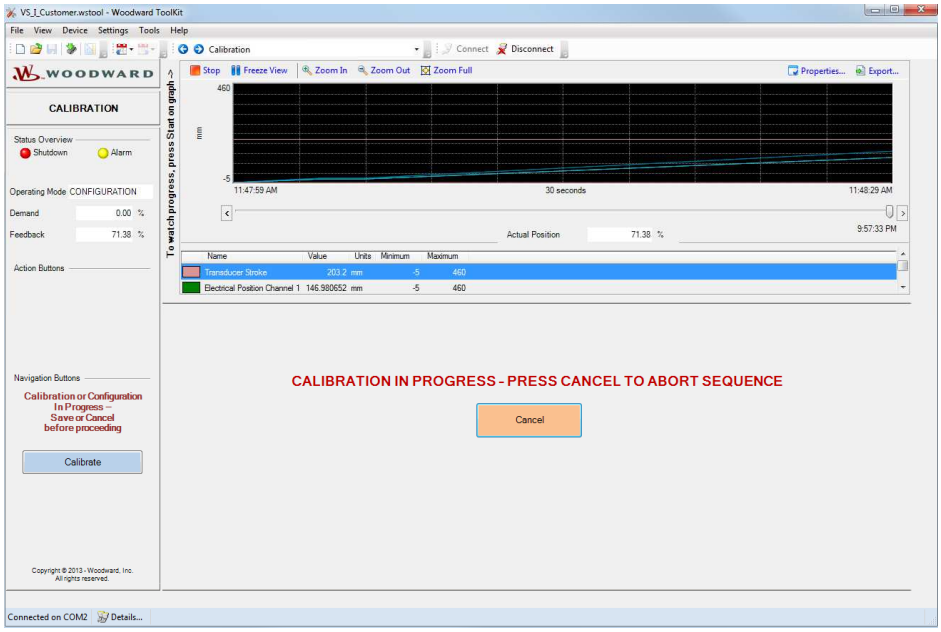

Figure 5-6. Calibration in Progress Screen

Set Offset and Maximum Stop Position

IMPORTANT

If one of the calibration routines has already been run, or the user wishes to adjust these values based on the factory calibration, the "Adjust Minimum Offset and Maximum Position" button may be pressed. This will skip the automatic calibration process.

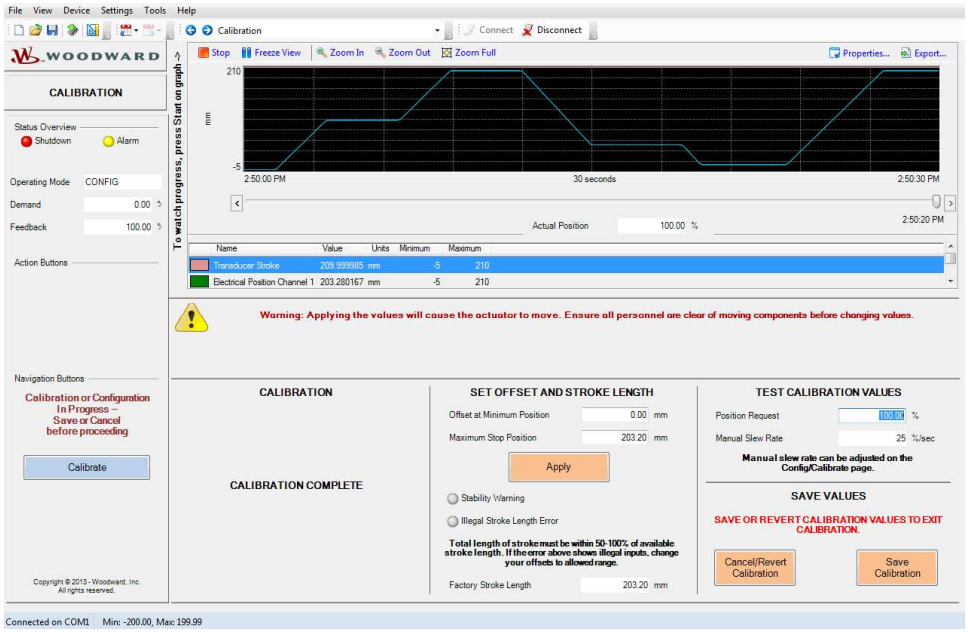

Figure 5-7. Calibration Complete Screen

After either calibration routine is run, the service tool will return to the Calibration page where setting the desired "Offset at Minimum Position" and "Maximum Stop Position" is now allowed. The Maximum Stop Position minus the Offset at Minimum Position must not be less than 40% of the Factory Maximum stop position shown on at the bottom of this page, or an Illegal Stroke Percent Error will appear.

The "Offset and Minimum Position: and "Maximum Stop Position" settings are presented in millimeters for user convenience. If a specific stroke length is required, the user shall adjust these parameters while verifying the actual actuator minimum and maximum positions. Some small variation between these parameters and the actual stroke is allowed, and the final stroke will be linear between the actual minimum and maximum positions.

After changing the "Offset at Minimum Position" and "Maximum Stop Position", press the Apply button.

During this process, the "Position Request" on the right side of the page can be used to manually position the actuator during this process. The "Manual Slew Rate" is also shown, but is for reference only. "Manual Slew Rate" can be changed on the Config/Calibrate page, before entering the Calibration mode.

IMPORTANT

If calibration was performed with linkage attached, a small negative number can be input into the "Offset at Minimum Position" field to provide additional valve seating force. *It is the installer's responsibility to verify the structural capabilities of the linkage and/or attachments.*

Saving the Calibration Settings

To save the new “Offset at Minimum Position” and “Maximum Stop Position” settings, press the “Save Calibration” button.

Press the “Cancel/Revert Calibration” button to discard the changed values and to exit the calibration.

Manual Operation

WARNING

To prevent personal injury or death and damage to equipment, the controlled prime mover must not be allowed to run or operate during any of the following procedures. The main steam valve or main fuel control must be turned off to prevent operation of the controlled system.

To enable manual Operation the RUN ENABLE line must be low and/or the analog input demands must be at less than 2 mA (0 mA recommended). The VS-I can be put into manual mode by pressing the Manual Operation button. The VS-I can be returned to normal operation by pressing the Exit button, by enabling Run Enable, or by supplying an analog input demand level.

When the VS-I is in manual mode, you can enter a desired position. The VS-I will move the final cylinder to that position at a rate given on the Configuration page. If the VS-I is in normal operation, this page can be used just to track that operation.

Press the “Start” button in the upper left hand corner of the graph to view trending data.

Manual Operation Page

Once the Manual Operation button is pressed, the following screen displays below the trend chart. Monitor and view actuator movement using this trend chart. To do so, press “Start” at the top left corner of the trend chart. To change the cylinder position, change the Position Request value (see below).

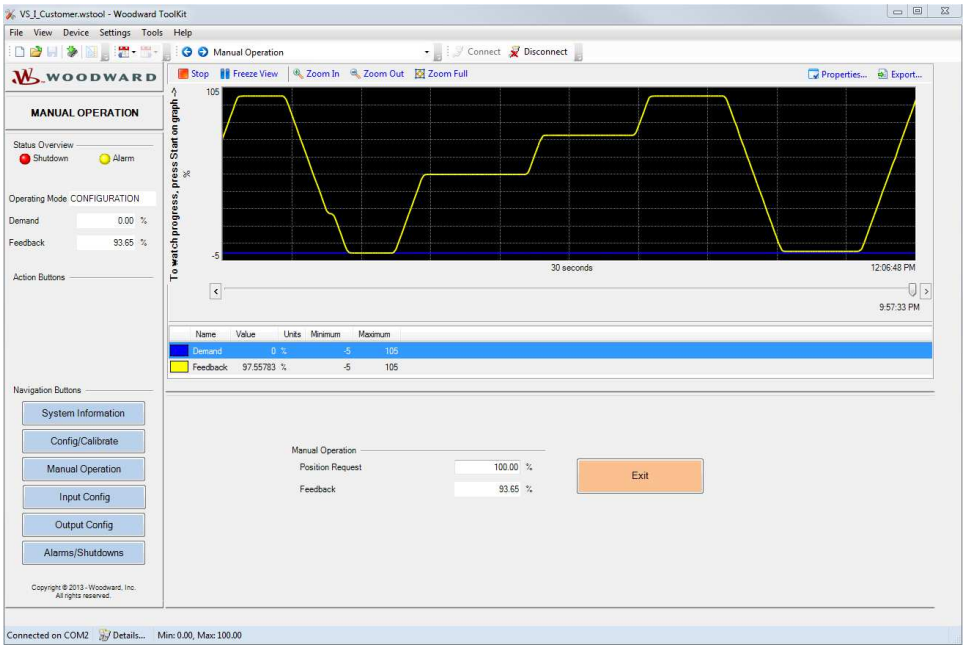

Figure 5-8. Manual Operation Screen

Chapter 6. Configuration

Input Configuration

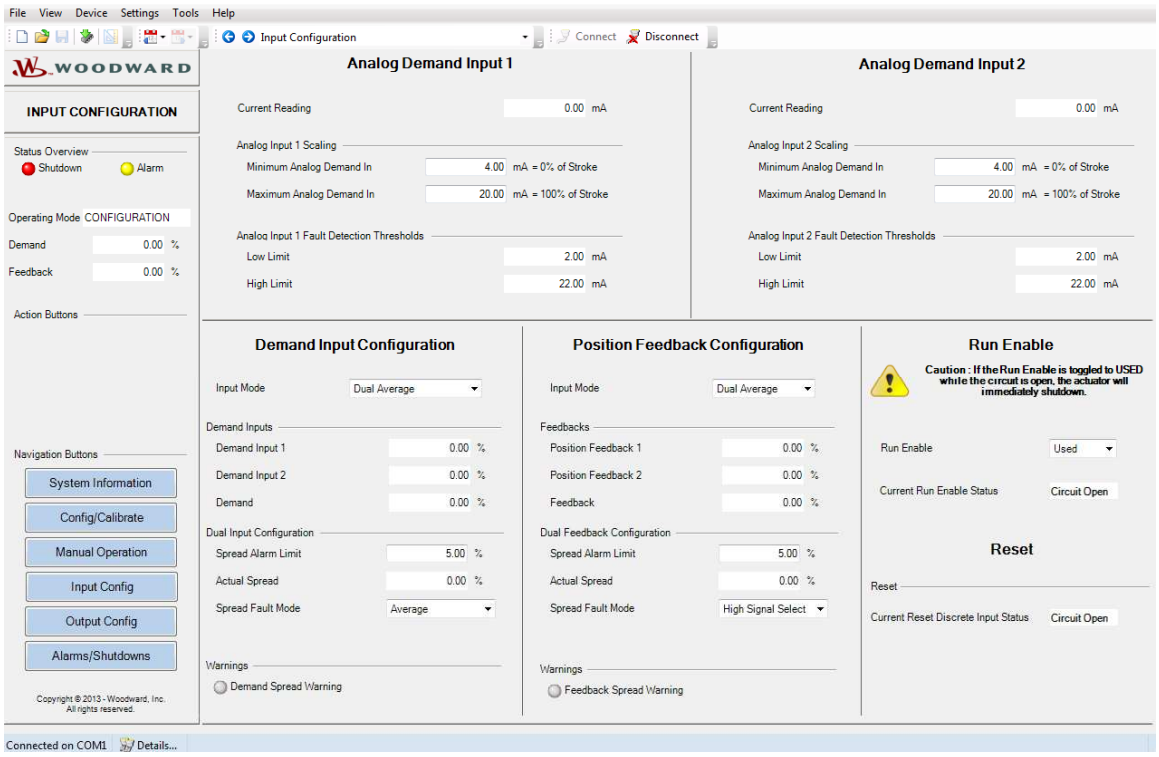

Figure 6-1. Input Configuration Screen

The analog input settings including scaling and diagnostics levels are displayed from this screen. The values of the current operational and diagnostic settings are also displayed.

Analog Demand Inputs 1&2

Current Reading: Displays the current value of the analog input signal in mA and percent of full stroke for the analog input channels 1 and 2.

Analog Input Scaling

Minimum Analog Demand In: Indicates the minimum input demand current (4 mA default) that is used to position the actuator to 0%. Note only after VS-I shut down may values be saved.

Maximum Analog Demand In: Indicates the maximum input demand current (20 mA default) that is used to position the actuator to 100%.

Fault Detection Thresholds, High/Low Limit: Displays the fault detection limits of the analog demand signals. Any demand signal below the Low Limit or above the High Limit will trigger an alarm.

Demand Input Configuration

Input Mode: Allows selection of Single Channel 1, Single Channel 2, Dual Averaging, Dual Low Signal Select, and Dual High Signal Select. If a Dual mode is selected, but only 1 signal is supplied, the actuator will operate while outputting an alarm for the other signal.

Demand Inputs

Demand Input 1 / 2: Displays the value (in percent position) of the individual demand signals.

Demand: Displays the value (in percent position) of the demand signals after they have been averaged, low signal selected, or high signal selected.

Dual Input Configuration: These fields will only be displayed when the Input Mode is set to one of the Dual options.

Spread Alarm Limit: Indicates the difference allowed between Demand Input 1 and Demand Input 2 before the Demand Spread Warning flag is set. The action of this flag can be configured on the Alarms/Shutdowns page (by pressing the Configure Alarms and Shutdowns button).

Actual Spread: The difference in percent between the dual inputs.

Spread Fault Mode: This field determines which of the two demand inputs is used after the Actual Spread exceeds the Spread Alarm Limit. It can be set to Low Signal Select, High Signal Select, or Average.

Demand Spread Warning: When lit, this light indicates that the Input Spread Alarm Limit (the difference between demand signals) has exceeded the configured value.

Position Feedback Configuration

Input Mode: Allows selection of Single Channel 1, Single Channel 2, or Dual Averaging. If Dual Averaging is selected, but only one signal is supplied, the actuator will operate while outputting and alarm for the other signal.

Feedbacks

Position Feedback (1 and 2): Shows the current position of the cylinder in percent.

Feedback: This indicator shows the value that is being used for control based on the Input Mode selection.

Dual Feedback Configuration: These fields will only be displayed when the Input Mode is set to one of the Dual options.

Spread Alarm Limit: Indicates the difference allowed between Position Feedback 1 and Position Feedback 2 before the feedback spread warning flag is set. The action of this flag can be configured on the Alarms/Shutdowns page (by pressing the Configure Alarms and Shutdowns button).

Feedback Spread Warning: When lit, this light indicates that the Feedback Spread Alarm Limit (the difference between the cylinder feedback signals) has exceeded the configured value.

Run Enable

⚠WARNING **If the Run Enable is toggled to USED while the circuit is open, the actuator will immediately shut down.**

Run Enable: This input either enables or disables the Run Enable functionality. If Used is selected, and the Run Enable circuit is opened, then the system will ignore the analog demand input signals and shut down. This allows internal setup and calibration without turning off or disconnecting the demand(s). If the Run Enable is set to Used, the Run Enable circuit must be closed before resuming normal operation.

If the Run Enable is set to Not Used, the actuator will ignore the Run Enable circuit.

Reset

The VariStroke has a dedicated, discrete input for resetting the driver. The actuator will clear all alarms and shut downs when this circuit is closed. The actuator will then resume operation as long as valid demand signals are present and there are no active shut downs.

IMPORTANT **The actuator driver can also be reset by power cycling, pressing the reset button on the Alarms/Shutdowns page of the Service Tool, or by stepping the Analog Demand Inputs from 0 to 4 mA.**

Output Configuration

Output Configuration Page

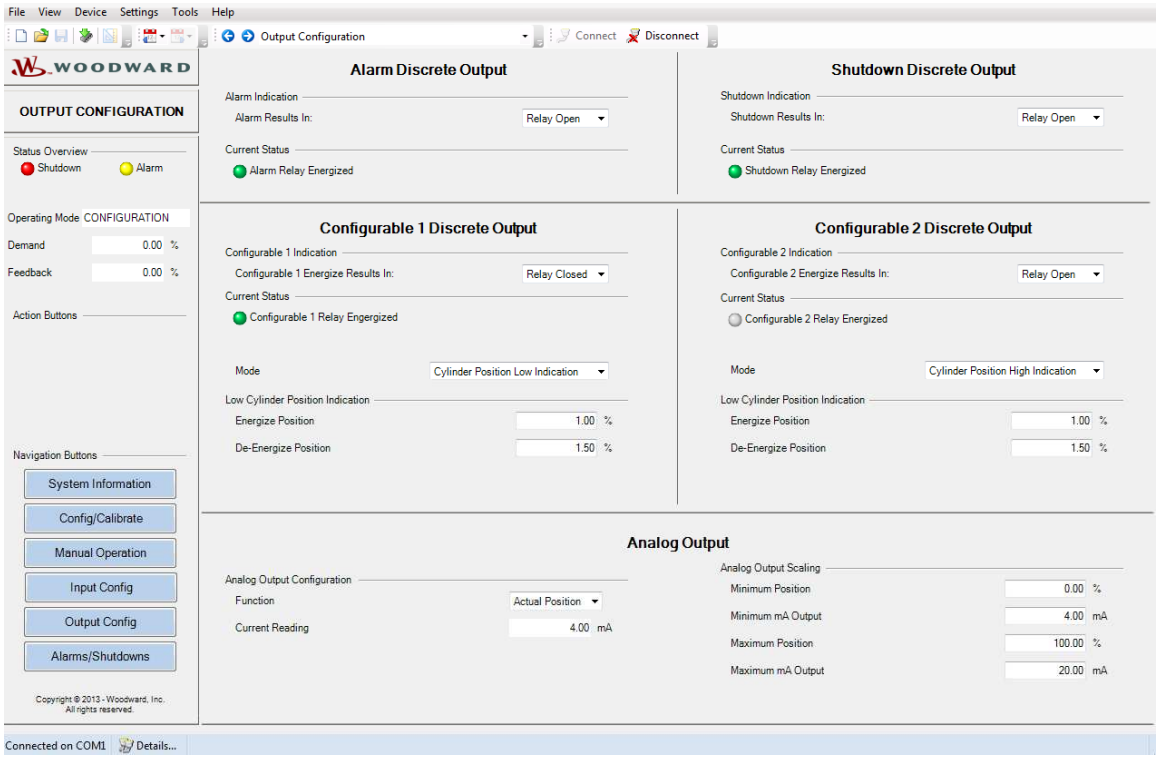

Figure 6-2. Output Configuration Screen

Alarm / Shutdown Discrete Outputs

Alarm / Shutdown Indication: Any flag marked as an alarm will cause the discrete output relay to energize.

Alarm / Shutdown Results In: Sets the state at which the discrete output relay will be when energized.

Alarm / Shutdown Relay Energized: Indicates the current state of the discrete output.

Configurable 1 / 2 Discrete Outputs

Energize Results In: Sets the state at which the discrete output relay will be when energized.

Current Status: Indicates the current state of the discrete output relay.

Mode: Configures the discrete output mode to one of the following options.

- **Unused/Manual:** Sets the discrete output to unused. This mode can also be used to manually toggle the output by switching the “Energize Results” In configuration.
- **Alarm Indication:** Sets the discrete output to energize when any alarm is active.
- **Shutdown Indication:** Sets the discrete output to energize when any shut down is active.
- **Alarm and/or Shutdown Indication:** Sets the discrete output to energize when any alarm and/or shut down is active.
- **Internal Fault Indication:** Sets the discrete output to energize when the Internal Fault alarm is active.
- **Cylinder Position Low Indication:** Sets the discrete output to energize whenever the cylinder is below the configured “Energize Position”. The output will de-energize once the cylinder is above the configured “De-Energize” position. Note: these configurable fields will only be displayed when the Mode is set to “Cylinder Position Low Indication”.
- **Cylinder Position High Indication:** Sets the discrete output to energize whenever the cylinder is above the configured “Energize Position”. The output will de-energize once the cylinder is below the configured “De-Energize” position. Note: these configurable fields will only be displayed when the Mode is set to “Cylinder Position High Indication”.

Analog Output

Analog Output Function: This function is used to select what functionality drives the actuator.

- **No Output:** No output will be sourced.
- **Input Demand:** The Analog Output will equal the Demand Input.
- **Actual Position:** The Analog Output will equal the Feedback Position based on the configurable Analog Output Scaling.

Current Reading: Analog Output reading in mA.

Analog Output Scaling: These settings are only visible when the analog output Function is set to “Actual Position”.

Maximum Position: Sets the position at which the analog output will equal the value set in the **Maximum mA Output** field.

Minimum Position: Sets the position at which the analog output will equal the value set in the **Minimum mA Output** field.

Advanced Configuration

Advanced Configuration Page

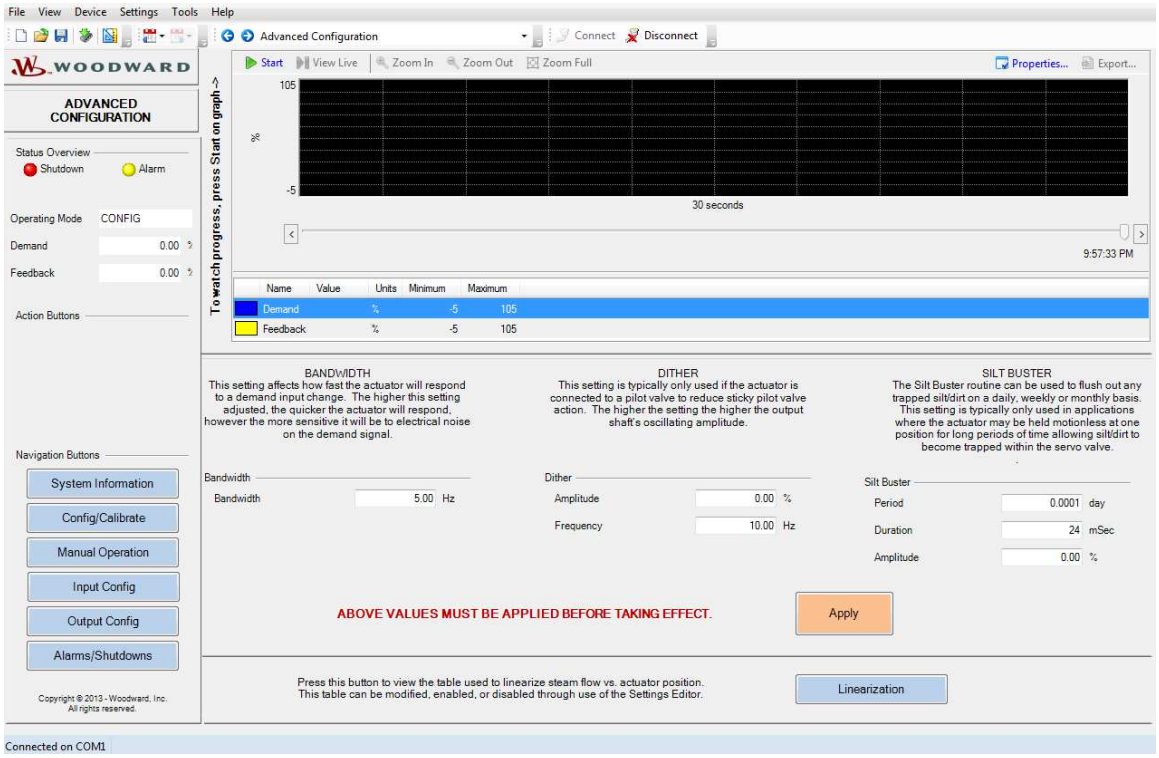

Figure 6-3. Advanced Configuration Screen

Bandwidth: Adjusts how fast the actuator will respond to a demand input change. The higher the setting adjusted, the faster the actuator will respond, but the more sensitive it will be to electrical noise on the demand signal.

Dither: Typically used if the actuator is connected to a pilot valve to overcome sticky pilot valve action. The higher the setting, the higher the output shaft is oscillating amplitude.

IMPORTANT

It is recommended that the Dither function NOT be used unless it is deemed absolutely necessary. Excessive dither will result in accelerated wear.

Silt Buster: The Silt Buster routine can be used to flush out any trapped silt/dirt on a daily, weekly, or monthly basis. This setting is typically used in applications where the actuator may be held in one position for long periods, allowing silt/dirt to become trapped within the servo valve.

Linearization

This table is used to linearize steam flow to actuator position. It can only be modified when the actuator is shut down.

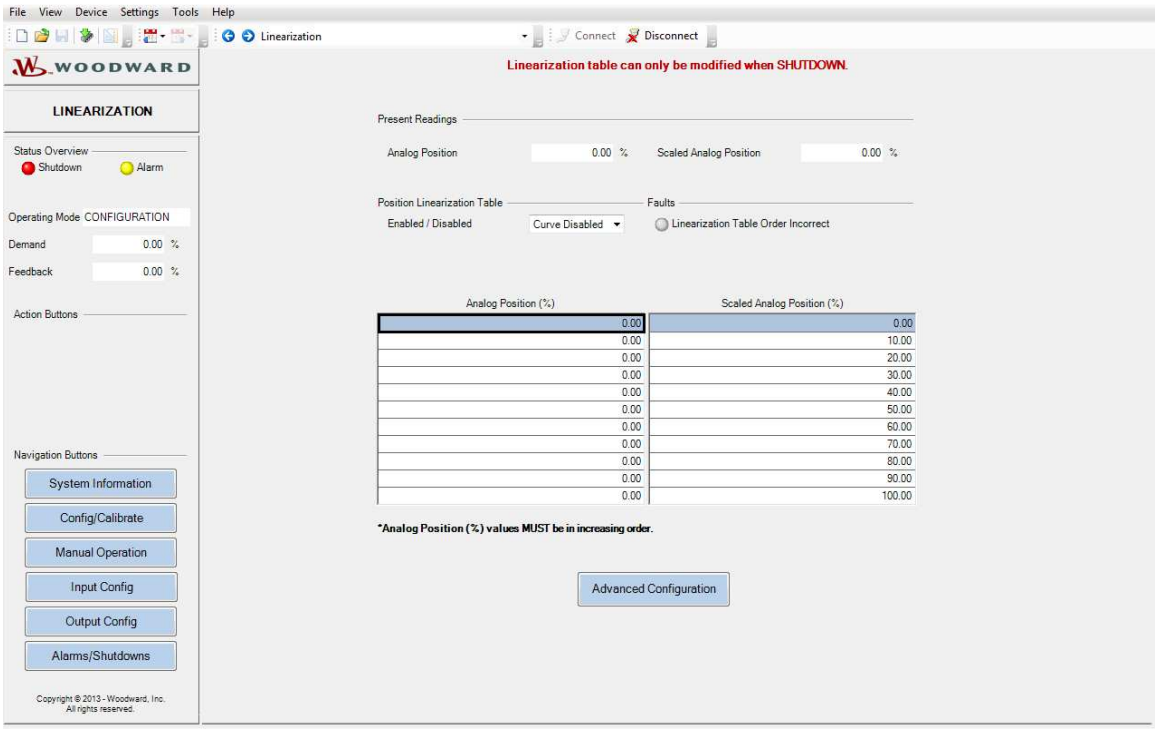

Figure 6-4. Linearization Screen

Enabled / Disabled: Enables or Disables the demand curve (linearization) functionality.

Linearization Table Order Incorrect: This Alarm will activate if the Analog Position values are not set in numerically increasing order (from top to bottom)

Analog Position (%): These are analog demand positions that will be converted to the Scaled Analog Position when the Linearization Curve is enabled.

Scaled Analog Position (%): These are the cylinder output positions (steam valve position) that will result when the demand is equal to the values put in to the Analog Position column.

Alarms/Shutdown

Alarms/Shutdown Page

This page displays the diagnostic information on the most typical Alarms and Shutdowns. These diagnostics as well as more advanced diagnostics are shown on the “System Status” page. Some of the Alarms and shut downs are configurable.

Logged errors contained in non-volatile memory until you reset the log.

Illuminated Alarm/Shutdown LEDs show the active state. You can reset the error system to clear the current flags, but any that are still active will remain set.

Chapter 7: Troubleshooting describes these errors and their remedies.

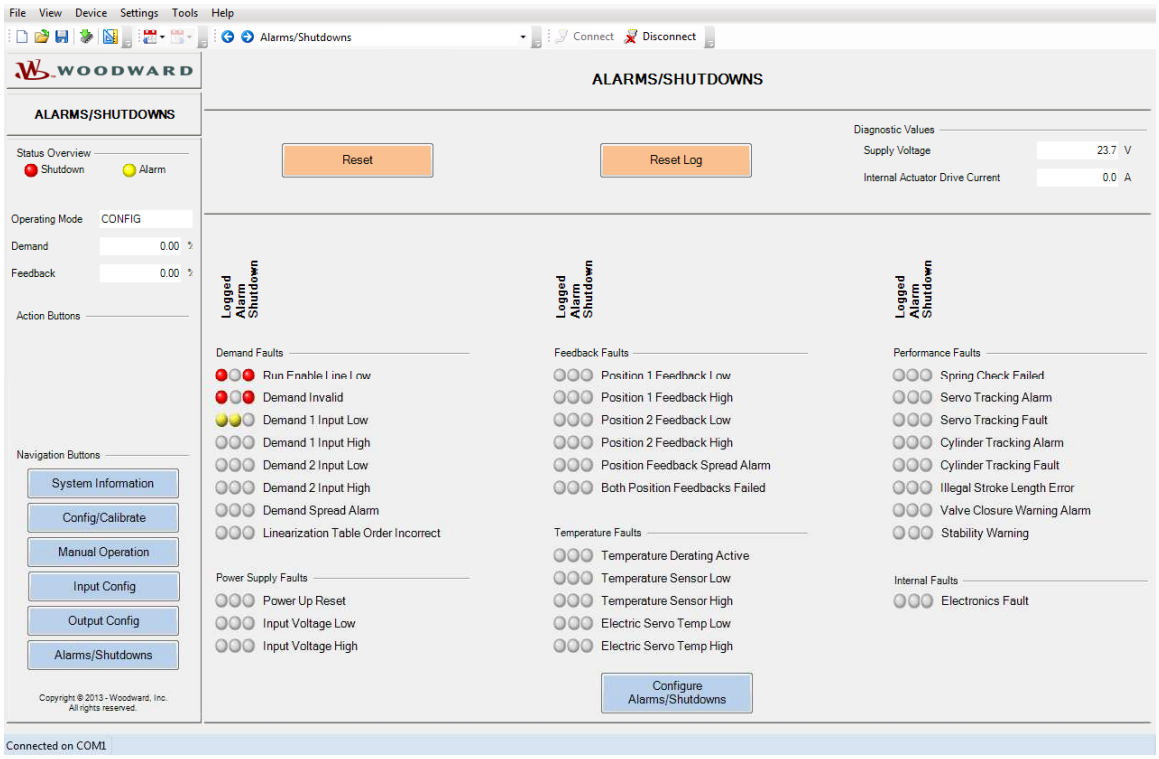

Figure 6-5. Alarms and Shutdowns Screen

Diagnostic Values:

Supply Voltage: Indicates the supply voltage value.

Internal Actuator Drive Current: Indicates the actuator drive current.

Configure Alarms/Shutdowns Page

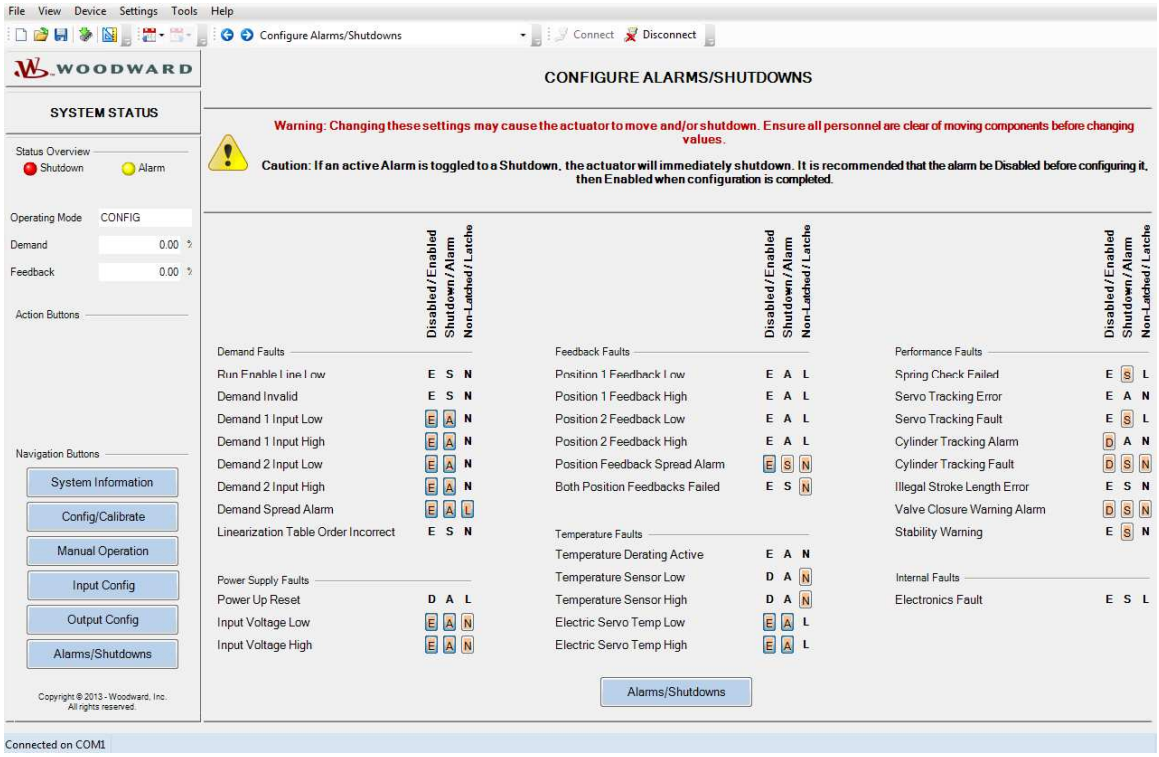

Figure 6-6. Alarms and Shutdowns Configuration Screen

From the Alarm/Shutdown Configuration page, some of the alarms and shut downs can be configured. Editable faults are shown as colored buttons on the page. The colored buttons can be configured based on the following descriptions:

⚠WARNING

Changing these settings may cause the actuator to move and/or shut down. Ensure all personnel are clear of moving components before changing values. If an active Alarm is toggled to a Shutdown, the actuator will immediately shut down. It is recommended that the alarm be disabled before configuring it and then re-enabled when configuration is completed.

Enable/Disable (E/D): Enables or disables the alarm/shut down.

Note: Even if an active alarm/shut down is disabled, shows as active on the Alarms/Shutdowns page; however, it will have no effect on the general Alarm or Shutdown indications.

Alarm/Shutdown (A/S): Determines the action that will take place when the alarm is active and enabled.

Latching/Non-Latching (N/L): When set to Latching, a triggered alarm will remain active until the driver is reset. When set to Non-Latching, a triggered alarm will de-activate once the problem is remedied.

Saving and Loading Settings

It is highly recommended that the user save the VS-I settings after calibration and configuration. Save these settings for the user's future reference. These settings can also be loaded in to another VS-I should the unit ever be replaced.

To save the VS-I settings, click on Settings in the ribbon at the top left of the page and select "Save from Device to file…"

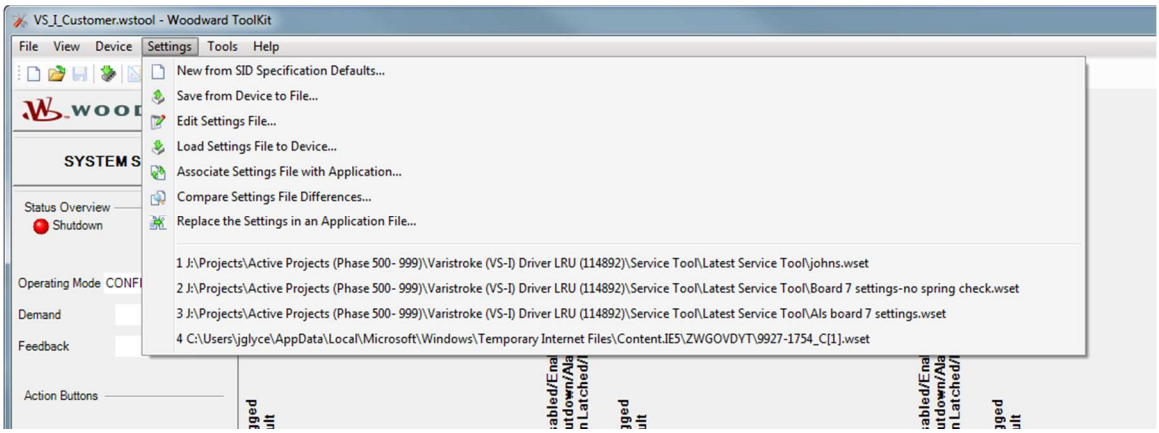

Figure 6-7. Settings Menu

To load settings from a PC to the VS-I, click on Settings in the ribbon at the top left of the page and select "Load Settings File to Device…"

Chapter 7.
Repair and Troubleshooting

WARNING

To prevent possible serious personal injury, or damage to equipment, be sure all electric power, hydraulic pressure, and rod end force have been removed from the actuator before beginning any maintenance or repairs.

WARNING

Due to typical noise levels in turbine environments, hearing protection should be worn when working on or around the VS-I actuator.

General

The VariStroke-I is warranted to be free from defects in materials and workmanship, when installed and used in the manner for which it was intended, for a period of 36 months from the date of shipment from Woodward.

It is recommended that all repairs and servicing of the VS-I be performed by Woodward or its authorized service facilities.

Use of a cable gland or stopping plug that does not meet the hazardous area certification requirements, thread form, or thread size will invalidate the suitability for hazardous locations.

Never remove or alter the nameplate as it bears important information, which may be necessary to service or repair the unit.

Shaft Seal Replacement

Shaft seal replacement kits may be ordered from Woodward corresponding to product bore sizes as follows:

4” Bore: 8935-1216-10
5” Bore: 8935-1216-12
6´´Bore: 8935-1216-15
8” Bore: 8935-1216-20
10” Bore: 8935-1216-25

Refer to Figure 7-1 which displays all part numbers corresponding to each seal kit. The location and assembly orientation of each kit component must be installed as depicted in Figure 7-1.

OPTIONS CHART					
BORE SIZE:	4″	5″	6″	8″	10″
KIT P/N:	8935-1216-10	8935-1216-12	8935-1216-15	8935-1216-20	8935-1216-25
INDEX #	P/N	P/N	P/N	P/N	P/N
2	1355-237	1355-237	1355-429	1355-438	1355-1109
3	1355-427	1355-427	1355-430	1355-442	1355-551
4	1355-453	1355-453	1355-438	1355-1109	1355-1111
5	1355-1442	1355-1442	1355-1589	1355-501	1355-1049
6	N/A	N/A	1381-1109	1381-1142	N/A
7	N/A	N/A	1381-1116	1381-1091	N/A
8	1382-1132	1382-1132	1382-1129	1382-3061	1382-1121
9	1382-3068	1382-3068	1382-1227	1382-1217	1382-1206
10	1550-1075	1550-1075	1550-1078	1550-1108	1550-1142
"A"	72-96 IN-LB	72-96 IN-LB	72-96 IN-LB	72-96 IN-LB	120-132 IN-LB

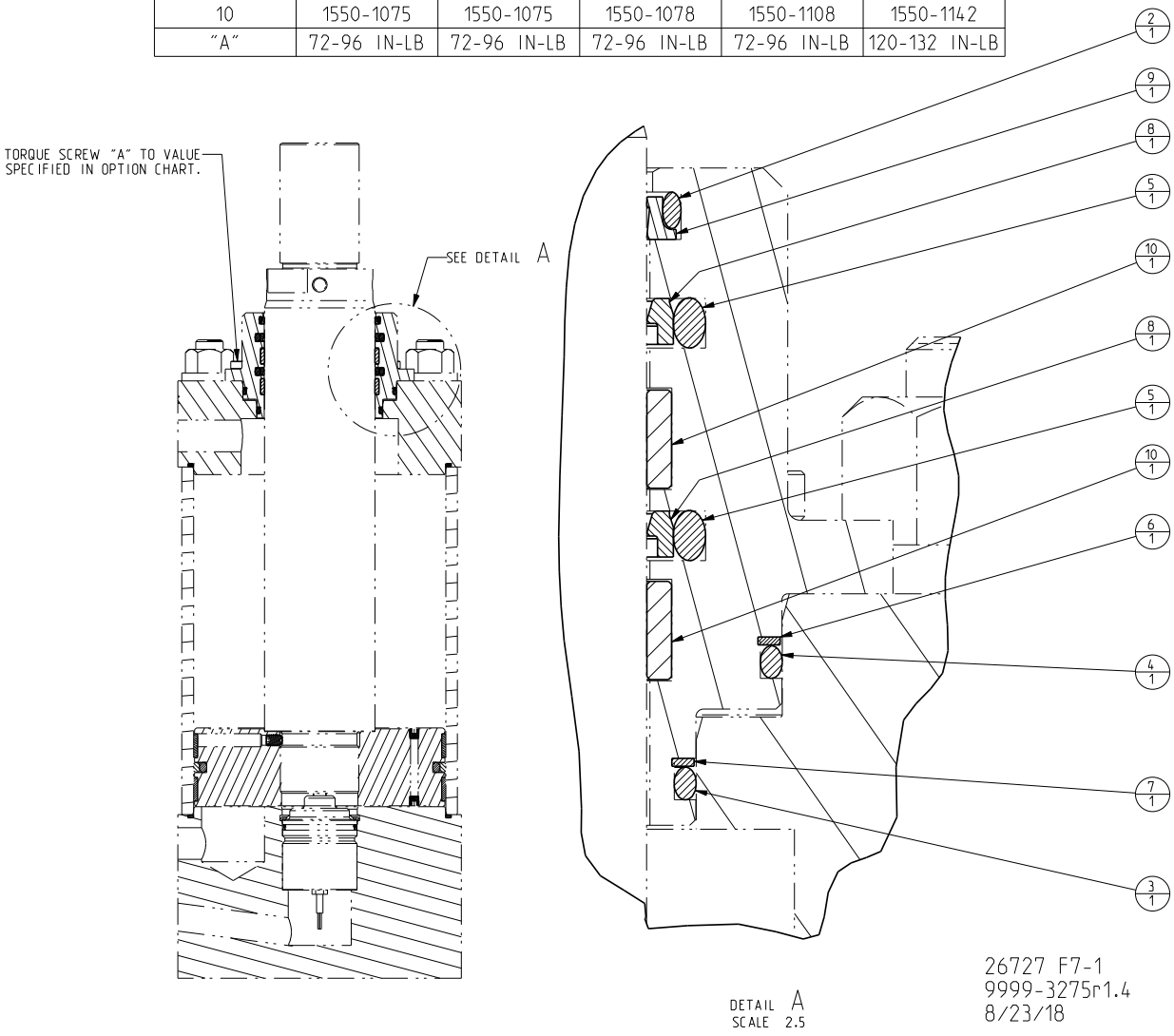

Figure 7-1. Shaft Seals Replacement Kits and Installation

Servo Valve / Hydraulic Cylinder Replacement

Before performing any repairs or replacement procedures to the VS-I, all Product Support Options listed in Chapter 8 should be understood and considered.

If it is determined that a Servo Valve or Hydraulic Cylinder must be replaced, replacement procedures can be found in Woodward manual 26836, *VariStroke-I Replacement Procedures*.

Troubleshooting

General

The following troubleshooting guide will help you isolate trouble with the servo valve, hydraulic power cylinder, control circuit board, wiring, and system problems. Recommend troubleshooting beyond this level ONLY when complete facility control testing is available.

Troubleshooting Procedure

This table is a general guide for isolating system problems. In general, most problems are a result of incorrect wiring or installation practices. Make sure that the system wiring, input/output connections, controls and contacts are correct and in good working order. Complete the checks in order. Each check assumes completion of the preceding checks and correcting any problems.

⚠WARNING

Be prepared to make an emergency shut down of the turbine, or other type of prime mover, to protect against runaway or overspeed with possible personal injury, loss of life, or property damage.

⚠WARNING

EXPLOSION HAZARD—Do not remove covers or connect/disconnect electrical connectors unless power has been switched off or the area is known to be non-hazardous.

⚠WARNING

ELECTRICAL SHOCK HAZARD—Follow all local plant and safety instructions/precautions before proceeding with Troubleshooting the VS-I Control.

⚠WARNING

Properly connect the external ground lugs shown on the installation drawing to ensure equipotential bonding. This will reduce the risk of electrostatic discharge in an explosive atmosphere.

Table 7-1. VS-I General Troubleshooting Guide

Problem	Cause	Remedy
Shut down Detection: Shut down command sent by Service Tool, Analog Demand out of range, digital communication protocols (CAN open), Run Enable, or diagnostic.	It is normal for this to occur when a shut down position has been commanded from an external source. I.E. Service Tool, Digital Communication or Discrete Input. This is also normal when the Analog Demand signal has been turned off or set out of range.	Take away command and reset VS-I for normal operation. Ensure the VS-I has a valid demand signal.
	Unexpected command from digital communication.	Take away command and reset VS-I for normal operation.
	Discrete input wiring problem.	Fix wiring problem.

	Run Enable configuration problem.	Ensure the Used / Not Used settings inside the VS-I match the Active/Inactive settings of the controller. Settings can be modified using the Service Tool. If the Run Enable is not used, disable this function using the Service Tool.
	Critical Alarm / Diagnostic triggered a shut down	Using the Service Tool, view the Alarms / Shutdowns page to determine the fault. Use the remainder of this chapter to determine the cause and solution to the fault.
	Position Sensor Loop Power Output Overloaded (Remote Servo Only)	Ensure position sensor wiring and power supply are connected correctly. See Chapter 3: Cylinder Position Feedback Analog Inputs
Alarm Detection: Alarm or Shut down is detected.	Diagnostic triggered an Alarm and/or Shut down	Using the Service Tool, view the Alarms / Shutdowns page to determine the fault. Use the remainder of this chapter to determine the cause and solution to the fault.