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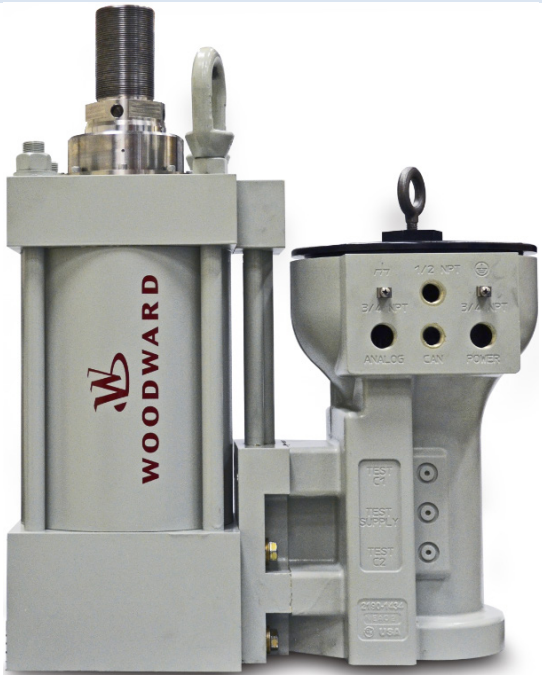
WOODWARD

Product Manual 35119
(Revision C, 4/2025)
Original Instructions



VariStroke-GI (VS-GI) Electrohydraulic Actuator

Installation and Operation Manual

Released

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. The latest version of most publications is available on the Woodward website.

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If your publication is not there, please contact your customer service representative to get the latest copy.

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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.

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Always compare with the original for technical specifications and for proper and safe installation and operation procedures.

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

Manual 35119

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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, as 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 place the old PCB in the antistatic protective bag after removing it from the control cabinet.

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 VariStroke product is rated for, refer to the Model Number and the diagram in Chapter 7.

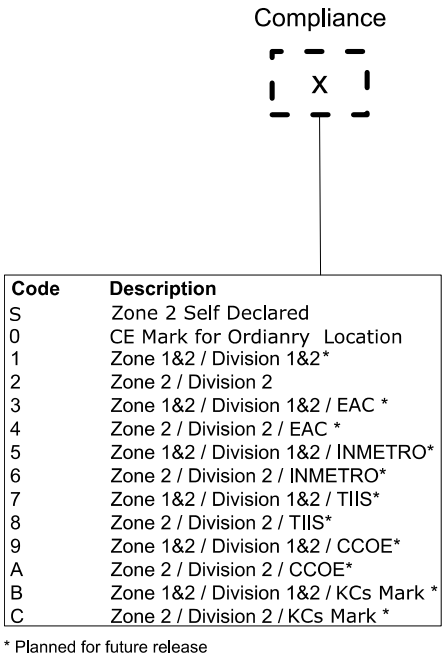


Figure R-1. Product Compliance Code

European Compliance for CE Marking
These listings are limited 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 harmonization of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres
Zone 2: II 3 G Ex nA IIC T4 Gc

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 2 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.

Other International Compliance
These listings are limited to only 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 2: Ex nA IIC T4 Gc

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.

Conduit barriers are not required for Zone 2 or Class I, Division 2 installation. A conduit seal must be installed within 457 mm (18 inches) of the conduit entry when the valve is used in Zone 1 or Class I, Division 1 hazardous locations.

Field wiring must be suitable for at least 90 °C.

The maximum hydraulic oil temperature is 70 °C continuous.

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.

The flameproof joints are not intended to be repaired. Contact Woodward for information on the dimensions of the flameproof joints. Return to Woodward for repair and maintenance.

⚠WARNING

EXPLOSION HAZARD—Do not connect or disconnect while circuits are live unless area is known to be non-hazardous.
Substitution of components may impair suitability for Zone 2 applications.

⚠WARNING

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 applications Classe I, 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

Table 1-1. Woodward Reference Literature

Manual 35148:	*VariStroke-I Service Tool*
Manual 25071:	*Oils for Hydraulic Controls*
Manual 25075:	*Commercial Preservation Packaging for Storage of Mechanical-Hydraulic Controls*
Manual 26455:	*Woodward Energy Segment Customer Publications: Cross-Reference by Application Revision Status & Distribution Restrictions*
Manual 35132:	*VariStroke-DX Duplex Hydraulic Servo Skid*
Manual 35163:	*VariStroke Power Cylinder*
Manual 82715:	*Guide for Handling and Protection of Electronic Controls, Printed Circuit Boards, & Modules*
Manual 51629:	*Observed Field Installation Issues with VariStroke-I*
CMM-03002:	*VariStroke-I (VS-I) Family* - Component Maintenance Manual, Bronze Level
CMM-03013:	*VariStroke-DX (VS-DX)* - Component Maintenance Manual, Bronze Level
Customer Service Tool Training Videos:	YouTube - Woodward Inc, Training and Products Channel: https://www.youtube.com/channel/UC0Ogv5ntWU2OXxshcYYt6Mg
9927-2915	VariStroke Sizing Tool (software to select the proper size of VS based on load, supply and drain pressure, application stroke and fail direction)

Table 1-2. Abbreviations and Definitions

VS-I	VariStroke-I Servo Product Family
VS-GI	VariStroke-I Single Acting
Demand	This term describes the reference value for the position. It is also used in situations where the term position demand is used. This is synonymous to the industry term position setpoint.
Customer Service Tool	The PC software providing capabilities to configure, monitor, and diagnose the VariStroke-I servo.
PCBA / PCB	Printed Circuit Board Assembly
MLDT	Magnetostrictive Linear Displacement Transducer
DI	Discrete Input
DO	Discrete Output
AISF	Authorized Independent Service Facility
OVBD	Overboard Drain
DV	Dump Valve
TTV	Trip and Throttle Valve
PST	Partial Stroke Test
DX	DX Skid – Redundant servo for critical applications

The VariStroke-GI is a linear electrohydraulic actuator family that utilizes an integrated servo valve and electronic driver module with a single acting or spring-assist power cylinder. The power cylinders are equipped with redundant Magnetostrictive Linear Displacement Transducer (MLDT) position feedback sensors to precisely control steam turbine valves. The electronic 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 the power cylinder output shaft position.

Advanced, model-based digital control algorithms, which are processed within the electronic driver module, regulate the rotary 3-way servo valve to port supply oil to and from the power cylinder for precise and responsive performance. This model-based control architecture allows the VariStroke servo to provide very stable position control during normal conditions and responds quickly with minimal overshoot or undershoot to desired valve position changes during system or plant transients.

As a means of protecting the turbine, an internal servo valve return spring forces the actuator to a fail-safe 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 oil pressure loss and helps to maintain the fail-safe position.

The VariStroke-GI servo valve and actuator are based on a 3-way servo valve and single acting actuator configuration. The actuator output force in the opening direction is generated by the supplied oil pressure applied to one side of the single-acting power cylinder. In the closing direction, the force to close must be provided by an external loading system and/or by an internal return spring in the power cylinder. In the closing direction, the slew rate is entirely dependent on these return forces.

Depending on the application, the customer may choose either a standard single acting cylinder or a spring-assisted version. Various internal spring options can be selected to optimize performance in the closing direction (recommended for low external load applications). The return spring can be specified for installation on either side of the piston to provide force toward the fail-safe direction. The VariStroke-GI product family also includes various sizes of power cylinder bore, stroke, and return spring options with provision for an additional dump valve feature to improve the response time in the closing direction. A supplemental dump valve assembly can be installed on single acting actuators. This enables a significant improvement in slew rate, which may be desirable especially for long stroke applications. Installation of the dump valve requires a separate additional hydraulic connection for its pilot pressure, and the addition of an interposing relay. The dump valve solenoid signal can be controlled via the discrete outputs of the VariStroke servo control PCB or via an external 24VDC source.

The VariStroke-GI actuator is a product family with many different models available depending on the force, stroke, and redundancy required. Cylinders are available with standard bore diameters and standard stroke ranges. The VariStroke's unique "variable stroke" capability allows users to customize the actuator's exact maximum stop position in the field to meet their requirement. The VariStroke-GI is available as an integrated unit, or as a remote servo kit where the cylinder can be mounted up to three meters (approximately 10 feet) away from the servo, or as a VariStroke DX Skid. The V45-GI servo is also available as a servo only option for users who wish to use their own hydraulic cylinder. See Chapter 2 for further description of the available sizes and return spring options.

The VariStroke-GI performance and features are configurable via a PC-based service tool. The Customer 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-GI also includes a 4–20 mA output to indicate power cylinder shaft (control valve) position, and unit alarm and shut down relay outputs for use as unit health and diagnostic 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 or end-user fabrication time, site assembly time, and setup and calibration time.

For information on how to configure, calibrate, and adjust all internal functions see manual 35148.

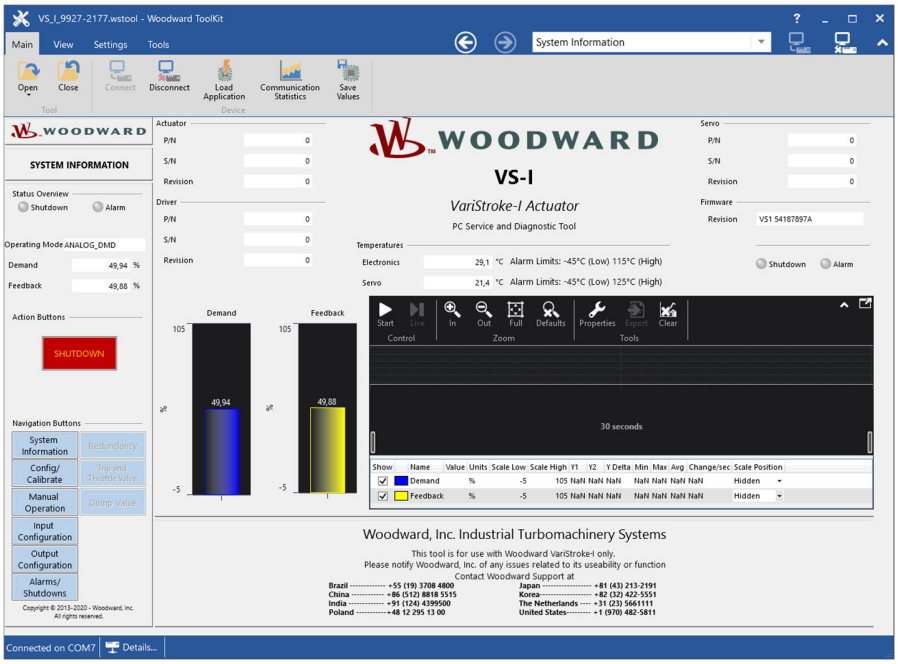


Figure 1-1. Customer Service Tool Screen

The VariStroke Actuator offers the following benefits as compared to other electrohydraulic actuators:

Dirt Tolerance

The VariStroke-GI 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 since dirt, metal shavings, water, and other contaminants (babbitt, ammonia, etc.) are common in such oil systems. Due to the high temperatures at which steam turbines operate, turbine oil breakdown is common, resulting in the creation of a sludge and/or the varnishing of internal system components. However, the VariStroke-GI 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 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-GI 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 the connection to valve rack linkages, which have an arc type motion. This motion results in side-loading of the actuator shaft, which after long periods may result in shaft-seal wear and oil leakage. Designed for a continuous side load of up to 10% of the actuator output, the VariStroke-GI actuator incorporates a high-force, triple-seal, output shaft bearing system to solve this typical application problem.

VS-GI Integrated and Remote Construction

The VariStroke-GI is made up of the following major components (Figure 1-2a):

1. Rotary servo valve with integrated electronic driver module (PCB)
2. Hydraulic power cylinder with feedback sensors:
   Magnetostrictive Linear Displacement Transducer (MLDT) – For power cylinder position control
3. Optional dump valve assembly

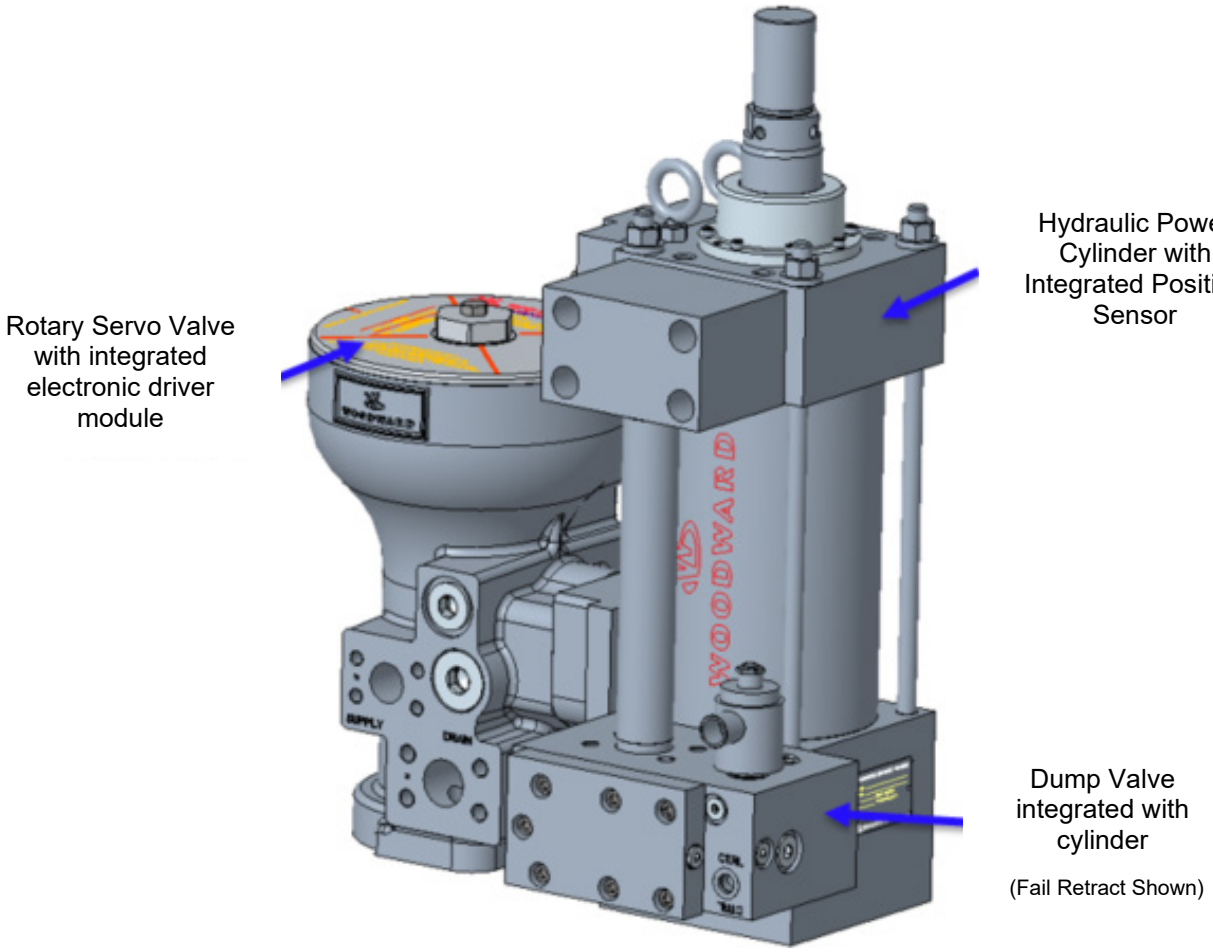


Figure 1-2a. VariStroke-GI, Key Features

The VariStroke-GI Remote Servo Kit (Figure 1-2b) contains the same primary components as the integrated version. This kit allows the hydraulic power cylinder to be mounted separately from the servo in applications where space is constrained.

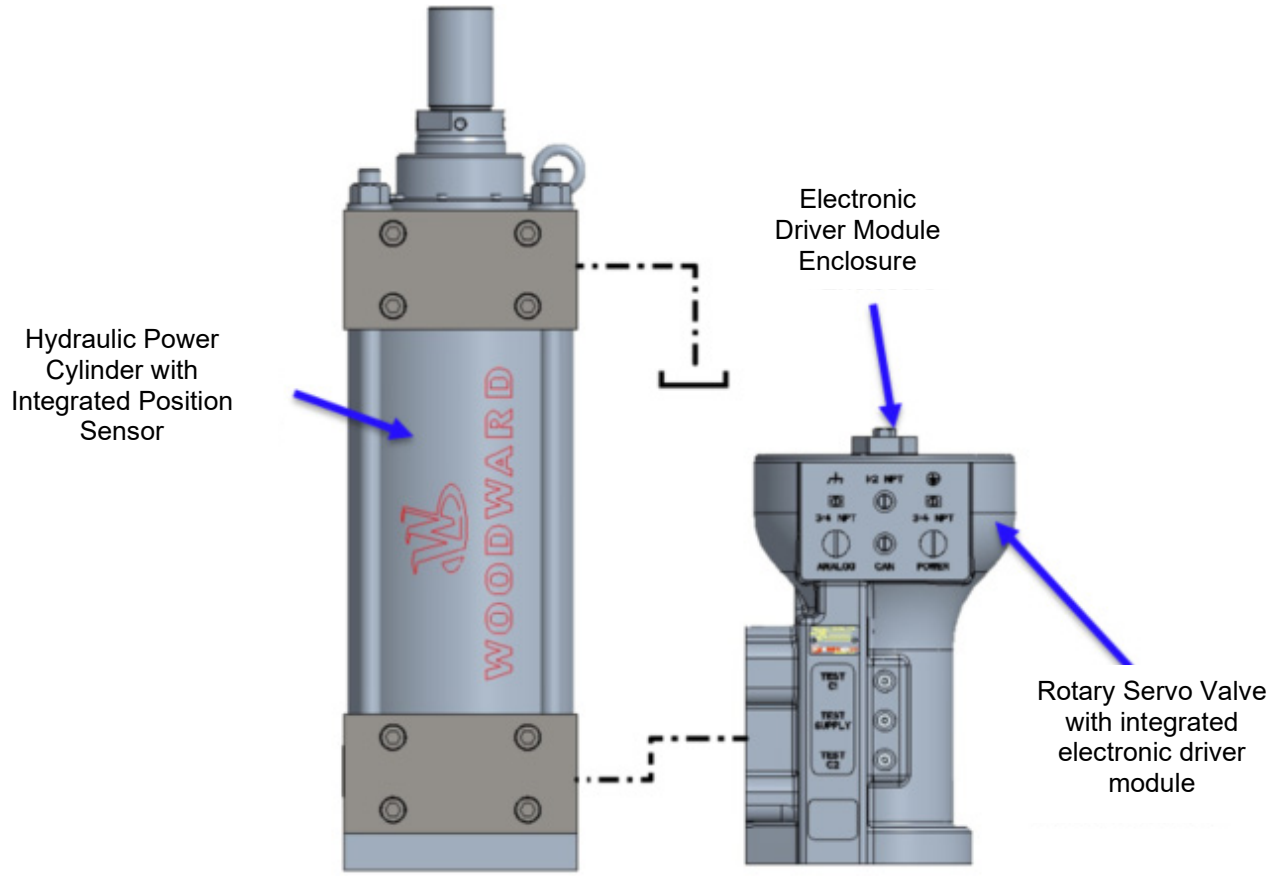


Figure 1-2b. VariStroke-GI Remote, Key Features

Hydraulic Power Cylinder

The simple and robust design of the VariStroke-GI hydraulic power cylinder (Figure 1-3) is capable of consistent performance for extended periods in challenging environments. The power cylinder is designed to operate in a wide range of hydraulic pressures and with high oil contamination. The actuation stroke range can be adjusted precisely using the Customer Service Tool, allowing the same actuator to accommodate a variety of strokes.

The hydraulic power cylinder is designed to be field replaceable (during a normal turbine service or repair interval).

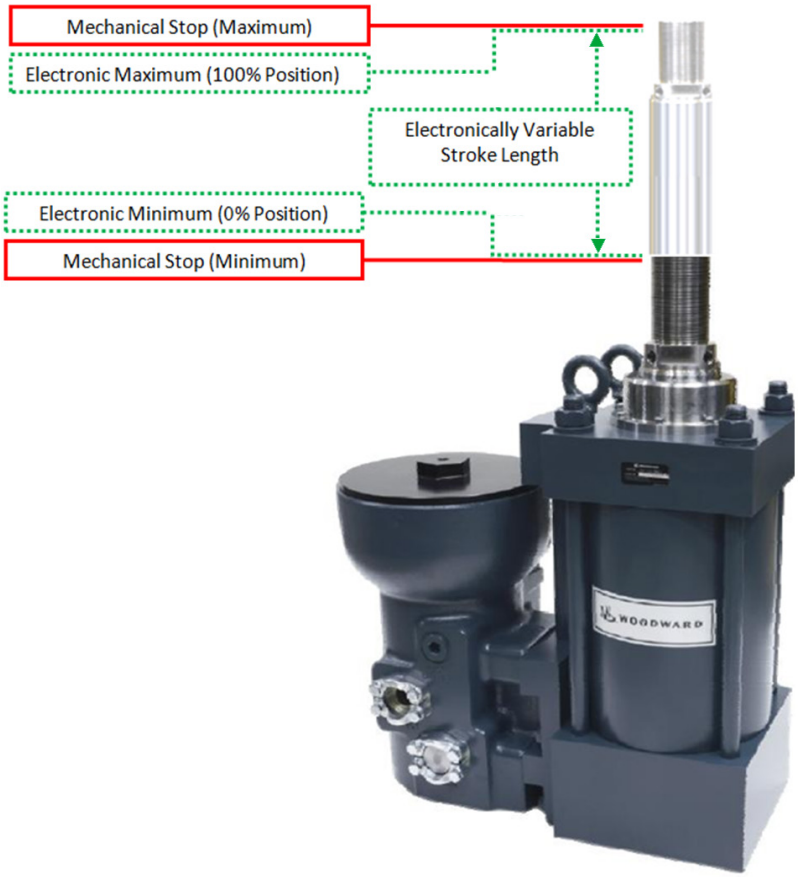


Figure 1-3. Hydraulic Power Cylinder - Stroke Adjustment Options

Rotary Servo Valve

The servo valve has three ports: supply, control, and drain/tank. With the hydraulic valve in its mid or null position, all ports are blocked. As the valve rotates in response to the control setpoint signal, the supply is either connected to the control port, or the control port is connected to drain. The integrated action of the servo position control loop (inner loop) and the power cylinder position control loop (outer loop) modulate the power cylinder position as necessary to match the setpoint.

A unique function of the VariStroke-GI electronic driver module software is a periodic, symmetrically-opposed impulse, which flushes silt and debris from the servo valve without causing any noticeable change in power cylinder position or resulting in wear, as can occur when using dither. This function is referred to as the “silt buster”. At the interval and amplitude selected by the user, this function provides a rapid motion of the servo 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 and reliability, while also preventing the accumulation of silt or varnish.

An additional feature of the electronic driver module software is an extensive set of diagnostics. If the unit detects any diagnostic condition which prevents reliable control, an alarm or shutdown behavior can be initiated. In the case of a critical shutdown, or if a loss of power occurs, the servo valve return spring forces the servo valve to connect the control pressure to the drain, causing the cylinder to move to the fail-safe position.

Servo Valve Actuator

The VS-GI 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 an integrated circuit on the PCB which detects the orientation of the sensing magnet on the shaft. The H-bridge drive, which controls the position of the LAT, 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 the upper compartment of the servo-valve housing and performs the following tasks:

- Connections to simple or redundant power supplies
- Model-based control of the servo valve and the power cylinder
  - Actuator H-bridge drive of the servo valve
  - Servo valve drive current limiting for thermal protection
- Isolated control setpoint input and position feedback outputs
  - Dual redundant demand inputs
  - Dual redundant inputs for final cylinder feedback
- Advanced diagnostics
- Discrete outputs for fault, alarm, shutdown annunciation, MIN and MAX position indication, and dump valve control

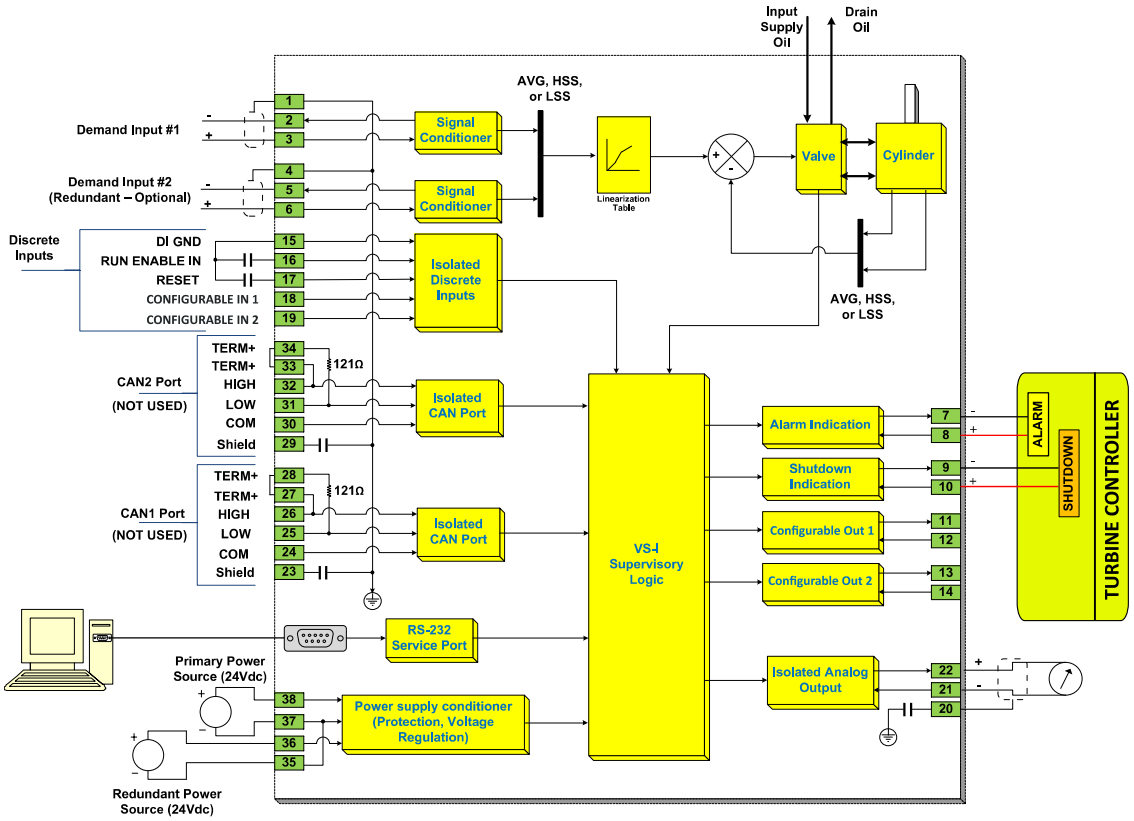


Figure 1-4. Application Example

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

The power supply system performs EMI filtering on the (18 to 32) V (dc) input voltage, as well as generating controlled voltages for several electronic sub-systems of the driver module. Each power supply is monitored for proper operation. If input voltage or internal power systems are detected outside of allowable operating ranges, a diagnostic alarm will be announced. Calibration and configuration of alarms, shut down, dump valve, and redundancy functions are configurable via the Customer Service Tool.

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

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

Cylinder Position Control

The inner control loop of the position controller regulates a pulse width modulated (PWM) drive signal to the servo valve 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.

The outer loop of the position controller adjusts the hydraulic power cylinder position to match the feedback signal to the demand. The model-based algorithm that synchronizes both the servo position controller and cylinder position controller ensures accurate tracking, stability, and highly predictable dynamic performance with minimal overshoot or undershoot during rapid control setpoint changes.

VS-GI Remote Servo Only Construction

The remote servo (Figure 1-5) requires the following major components:

1. Rotary servo valve
2. Hydraulic power cylinder

Rotary Servo Valve

The servo valve has three ports: supply, control port, and drain/tank. With the hydraulic valve in its middle position, all ports are blocked. As the valve rotates, either the supply is connected to a control port, or the control port is drained. The combined action of the servo position controller and cylinder position controller modulates the power cylinder position as necessary to match the input demand. OVBD is permanently connected to the drain.

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 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 the detected diagnostic condition prevents reliable control, or 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.

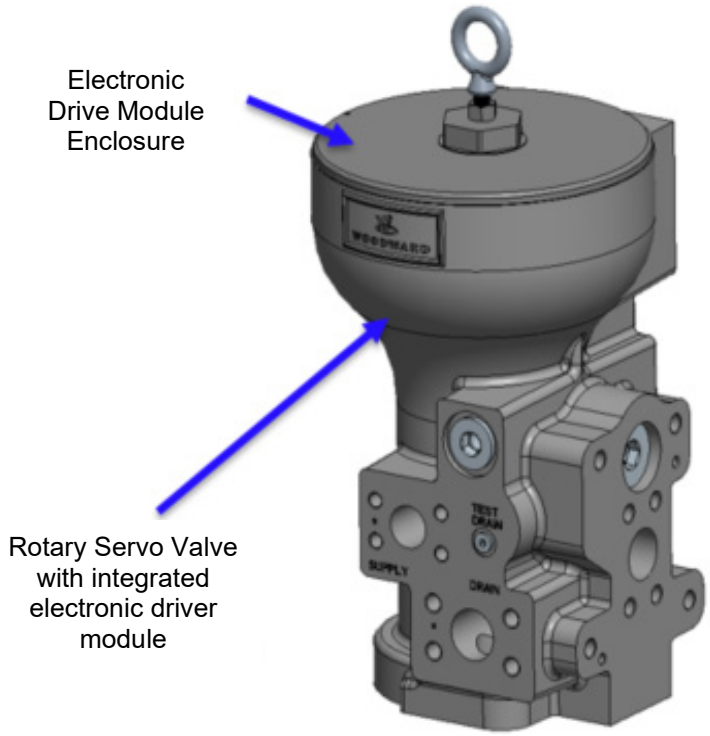


Figure 1-5. VariStroke-I Remote Servo, Key Features

Hydraulic Power Cylinder

The VariStroke-GI remote servo can be connected to any hydraulic cylinder; however, proper operation requires the VariStroke performance equation be satisfied (see Chapter 2, Performance Index). To control the 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
- Time constant: ≤1 ms
- Linearity: ±0.04% full stroke
- Maximum current draw: < 100 mA
- Sensor length must not exceed 2-times the cylinder stroke length

IMPORTANT

The VariStroke will always interpret the cylinder position feedback signal the same, regardless of the fail direction. Small current (~4mA) position signal always designates a retracted position. Larger current (~20mA) position signal always designates an extended position.

VariStroke-GI Accessories

The VariStroke-GI can be equipped or configured with the following features:
1. DV – Dump Valve
2. T&TV – Trip and Throttle Functionality
3. DX Skid – Redundant servo for critical applications (see VariStroke DX manual 35132)

DV – Dump Valve

The dump valve accessory is provided to significantly improve the actuator slew rate in the closing direction. This is often desirable for long stroke applications when closing time is critical for load rejection, and to prevent turbine overspeed. The dump valve is installed directly onto the cylinder and can be controlled via the VS1 by the electronic driver module, or via an external 24VDC signal. For installation of the dump valve, additional ports and mounting holes are provided on the cylinder. When using the dump valve, the electronic driver module must be configured correctly. See the VariStroke Customer Service Tool manual 35148 for proper instructions.

T&TV – Trip and Throttle Valve

The VariStroke-GI may be used in Trip & Throttle Valve (T&TV) applications. The unit can be configured using the Customer Service Tool to accept raise/lower commands from the discrete inputs, and single or dual analog inputs for the position setpoint. The valve opening and closing rates and partial stroke test values are also configurable. See the VariStroke Customer Service Tool manual 35148 for configuration instructions.

DX Skid

VS-DX duplex hydraulic servo skid is a dual redundant servo valve system. The system offers redundant operation of a single hydraulic power cylinder to control the steam control valve in applications where it is critical to limit the potential failures of the turbine actuation system that could interrupt the operation of the turbine.

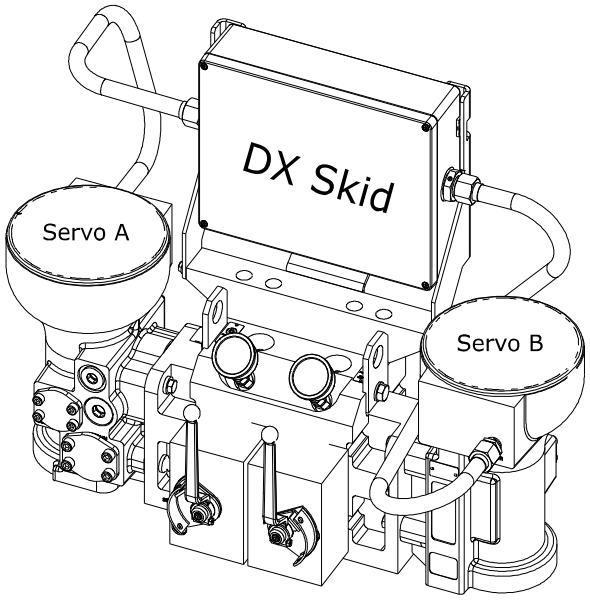


Figure 1-6. VS-DX Duplex Hydraulic Servo Skid

Chapter 2. Specifications

Physical and Performance Specifications

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

Bore Diameter (OD)	Rod Diameter (ID)
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

			Spring			
Bore in (mm)	**Stroke in (mm)**	**Spring force kgf (lbf)**	**K**	**L**	**M**	**N**
6 (152.4)	3 (76.2)	MIN	49 (108)	107 (235)	236 (520)	-
		MAX	98 (216)	214 (471)	472 (1040)	-
	4 (101.6)	MIN	49 (108)	107 (235)	236 (520)	-
		MAX	98 (216)	214 (471)	472 (1040)	-
8 (203.2)	3 (76.2)	MIN	126 (276)	240(529)	477 (1052)	883 (1946)
		MAX	231 (510)	479 (1057)	954 (2104)	1835 (4046)
	4 (101.6)	MIN	110 (242)	239 (528)	477 (1052)	918 (2023)
		MAX	247 (544)	450 (1058)	954 (2104)	1836 (4047)
10 (254.0)	3 (76.2)	MIN	201 (443)	364 (803)	744 (1640)	1156 (3430)
		MAX	321 (708)	583 (1286)	1190 (2624)	2489 (5488)
	4 (101.6)	MIN	161 (354)	291 (642)	595 (1312)	1245 (2744)
		MAX	321 (708)	583 (1286)	1190 (2624)	2489 (5488)

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

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

[in² • psi = lbf] or [mm² • MPa = N]

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

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

[in² • psi = lbf] or [mm² • MPa = N]

The formulas above are valid for single acting cylinders. For spring-assist actuators, additional spring force must be considered.

Extending Slew Rate [1]
Retracting Slew Rate [1]

[1]Configurable by selection of the actuator bore, stroke, supply pressure, and external load. It is recommended that the VariStroke sizing tool be used to select the desired actuator configuration.

Both retracting and extending slew rate depends on the supply pressure vs the external load balance. To achieve the highest slew rate available, it's recommended to use the dump valve option.

Note: Slew rates for remote servo applications may be 10–15% slower due to pressure drop within the servo-cylinder piping.

IMPORTANT

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

Position Accuracy:	±2% of full stroke
Position Repeatability:	±1% of full stroke
MLDT Temperature Drift:	0.04% /°C
Fail-safe Operation:	The internal return spring within the servo valve will result in the hydraulic power cylinder to extend or retract (part number dependent) in case of a critical electronic fault or loss of power. Additionally, for spring-assist power cylinders, the internal spring installed in the cylinder generates force toward the fail-safe position.

⚠WARNING

Ensure the VS-GI 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 might expect it to be.

⚠WARNING

Overspeed / Overpressure

Never close the drain line when supply pressure is present on the VS-GI unit, otherwise the control output pressure can increase suddenly and cannot be controlled by the input setpoint. This could cause the actuator to move to the fully open position, causing 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 G^2/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.

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 @ 24V nominal 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 as Normally Open (NO) - default or Normally Closed (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):	Dual Signal MLDT
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
Response Time Constant:	≤ 1 ms
Sensor Cable Length Limit:	3 m (10 feet) maximum between sensor and VariStroke

IMPORTANT

Slower position feedback response characteristics as compared to the requirements shown above could result in excessive limit cycle, wear, and poor position accuracy.

For this reason, 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.

IMPORTANT

The VariStroke will always interpret the cylinder position feedback signal the same, regardless of the fail direction. Small current (~4mA) position signal always designates a retracted position. Larger current (~20mA) position signal always designates an extended position.

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:	3.44 bar (50 psig)
Maximum Supply Pressure:	34.5 bar (500 psig)
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:	Single
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 Hydraulic Control Port: 1.500 SAE Code 61 Flange
Recommended Line Size Between Remote Servo and Cylinder:	Diameter: 38.1 mm (1.5 inch) minimum Length: 3 m (120 inch) maximum
Supply Fluid Flow:	Refer to the following figures for maximum transient flow rate and steady state flow rate requirements:

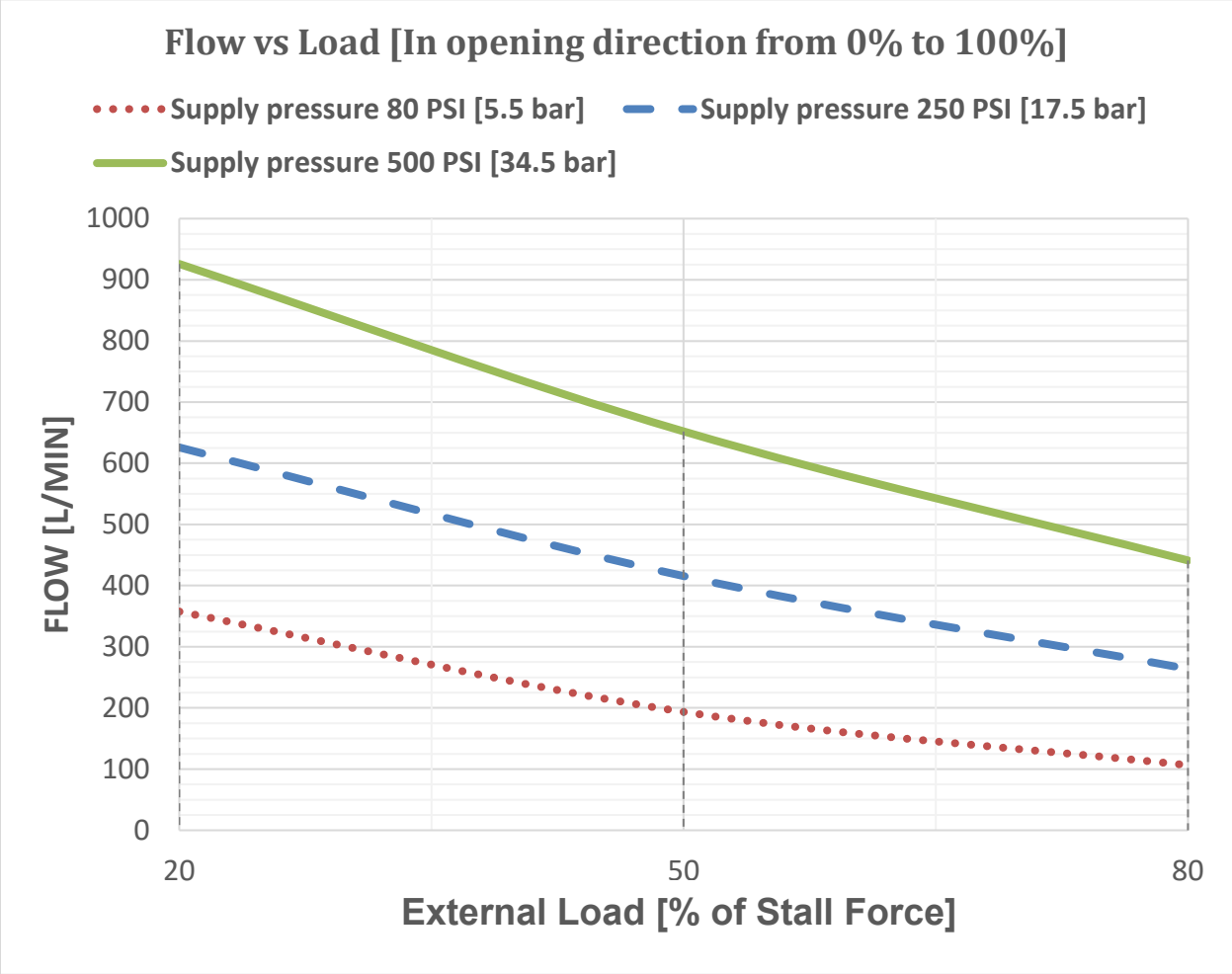


Figure 2-1. VS-GI Maximum Transient Flow Rates (During Full Slew in Opening Direction)

IMPORTANT

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

IMPORTANT

The figure above shows the estimated hydraulic flow for supply pressures 34.5, 17.5, and 5.5 bar. The flow is shown in relation to the load. For the single acting cylinder, the load should be between 20% to 80% of stall force.

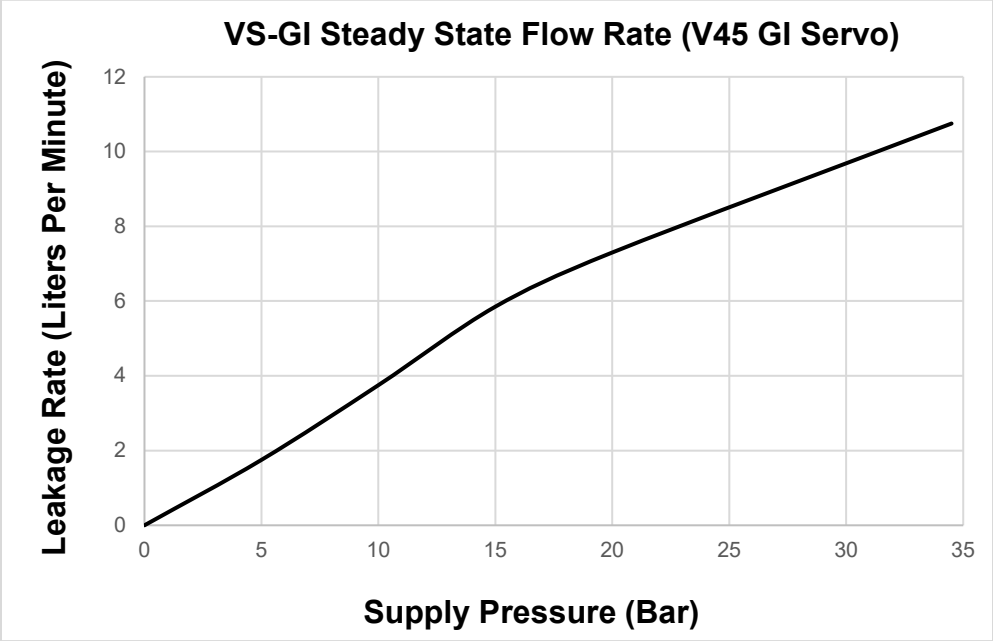


Figure 2-2. Steady State Internal Flow Rate Consumption

IMPORTANT

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

Special Ambient Temperature Specifications / Allowances

WARNING

The following information applies only to a VariStroke-GI installed in a non-hazardous location. If the VariStroke-GI is installed into a Zone 1, Zone 2, Division 1, or Division 2 environment, the special ambient temperature allowances do NOT apply.

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-GI product line is designed to bring a multitude of benefits to the actuation marketplace. One of the primary benefits is the VariStroke's ability to combine high-speed actuation with low-pressure hydraulic systems. To accomplish this, the VariStroke-GI provides one of the largest, commercially available servo valves in the world. This large servo valve allows the VariStroke-GI 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 to actuate their steam valve actuators much faster than they have in the past but with superior small signal and steady state response. This combination of performance (fast slew speed, high quality small signal response, and stable steady state positioning) is a primary feature of the VariStroke-GI. However, there are limitations when paring a large servo valve with a relatively small cylinder volume, which should be evaluated during product sizing and selection.

Before purchasing or installing a VS-GI actuator, the user should verify that the actuator will operate properly. As determined by the equation below, the performance of the VS-GI is dependent on servo valve size, supply pressure, and the power cylinder maximum 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 to notify the user.

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

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.

$VS_{Constant} = Varistroke\ Constant$ = 360

Figure 2-3 shows a graphical representation of the minimum available stroke for different cylinder diameters and working pressures.

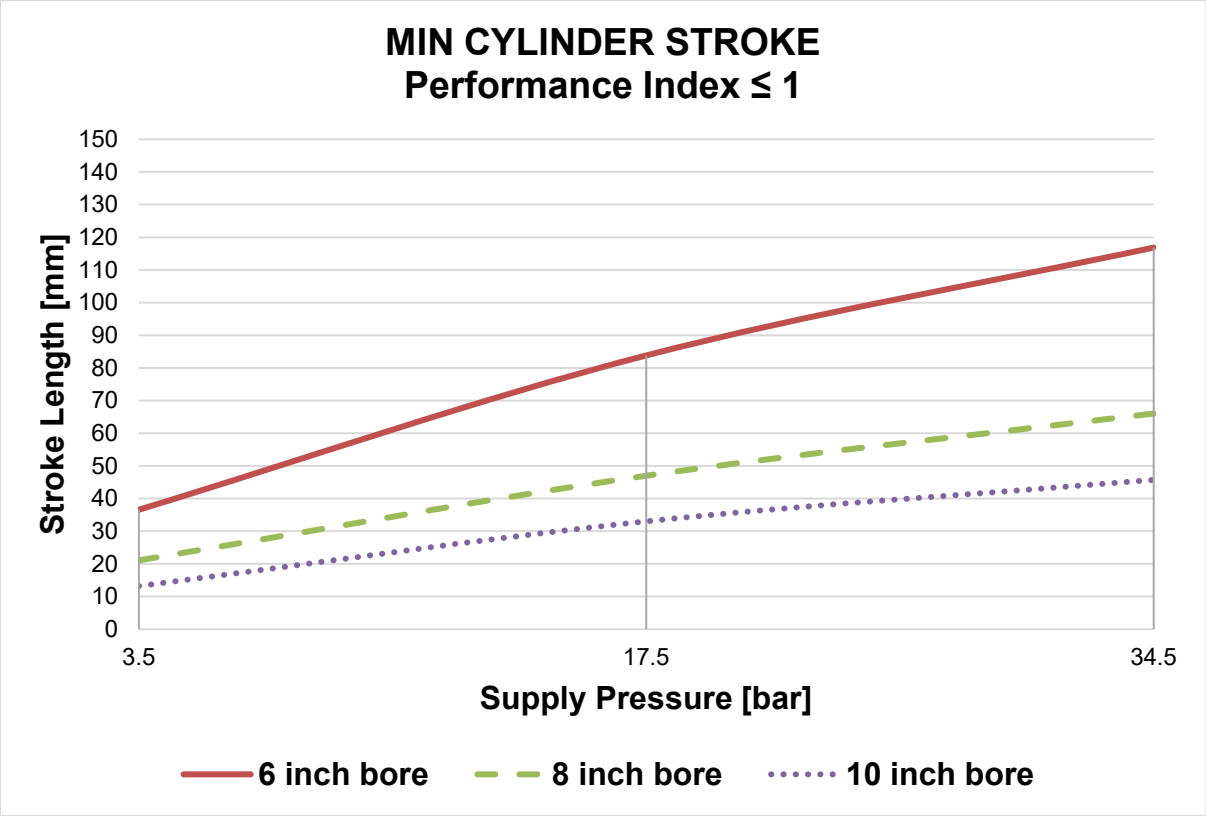


Figure 2-3. Performance Chart for 6”, 8”, and 10” Bore Actuators

Representative System Diagrams

Functional Block Diagrams

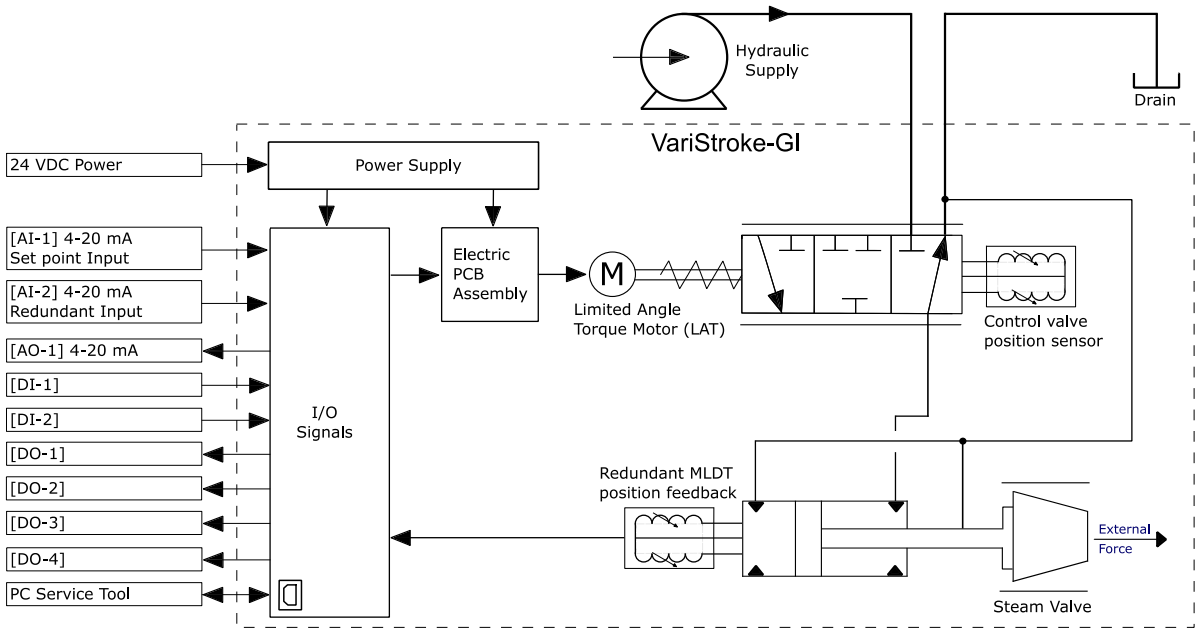


Figure 2-4. Basic Device Block Diagram

VS-GI Integrated Hydraulic Schematic – Fail Retract Option

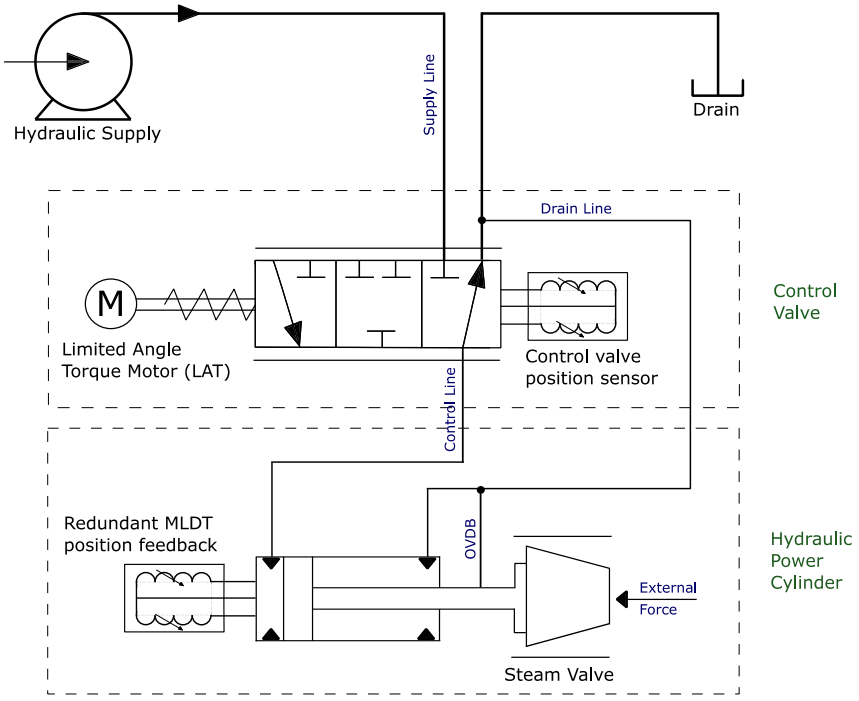


Figure 2-5. VS-GI Integrated Hydraulic Schematic – Fail Retract

VS-GI Integrated Hydraulic Schematic – Fail Extend Option

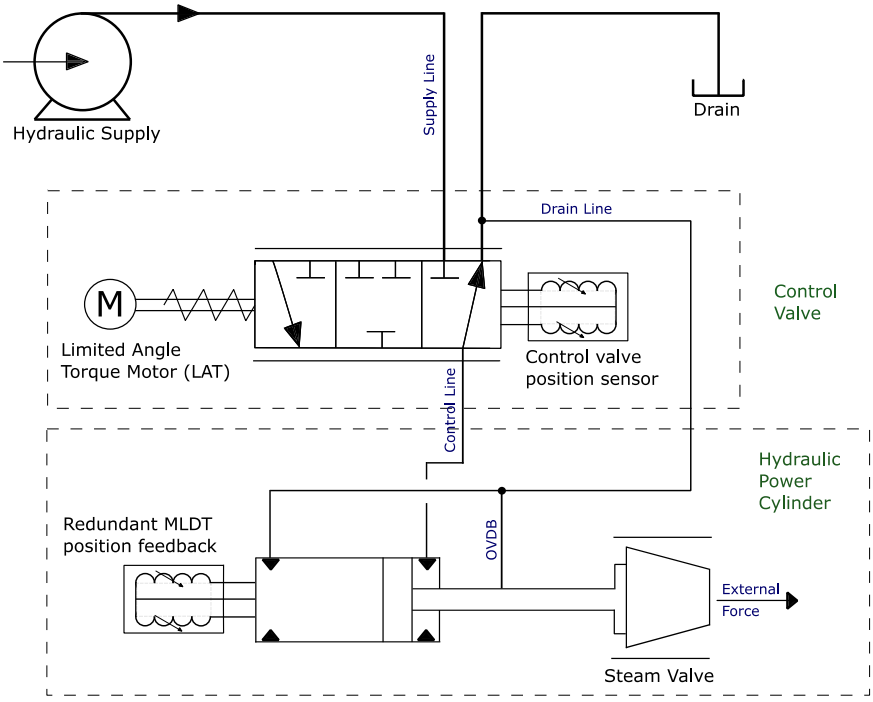


Figure 2-6. VS-GI Integrated Hydraulic Schematic – Fail Extend

VS-GI Spring Assist Integrated Hydraulic Schematic – Fail Retract Option

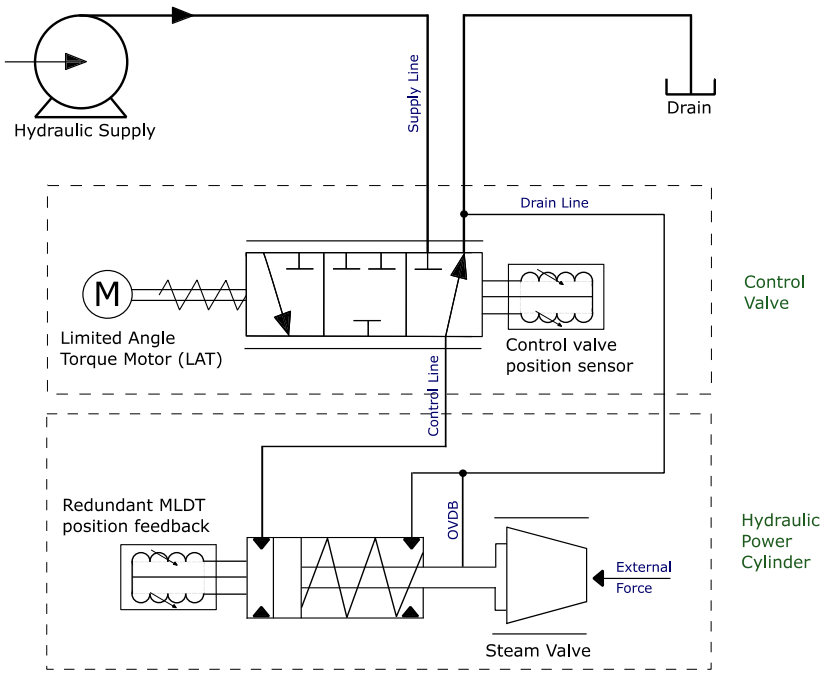


Figure 2-7. VS-GI Integrated Hydraulic Schematic – Fail Retract with Spring

VS-GI Spring Assist Integrated Hydraulic Schematic – Fail Extend Option

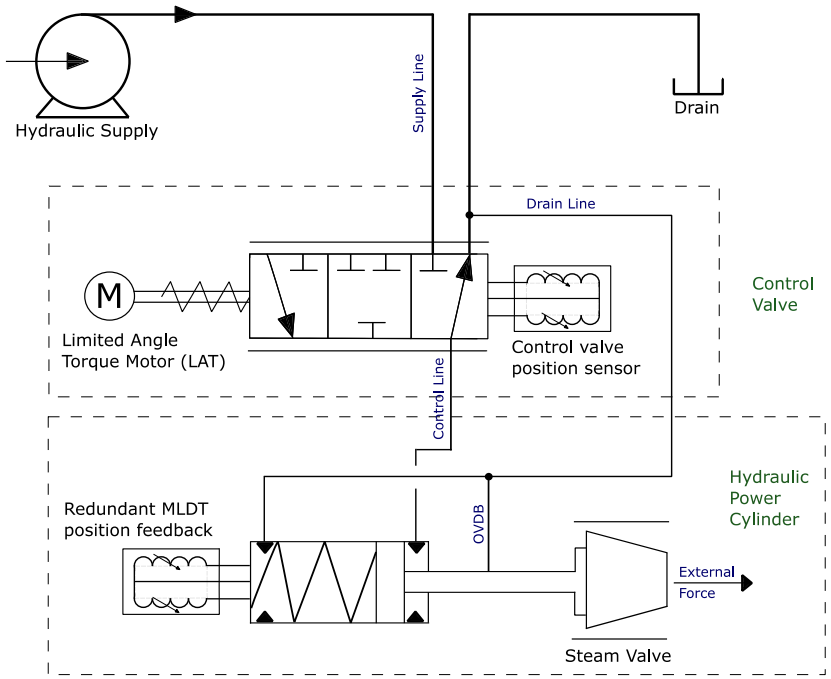


Figure 2-8. VS-GI Integrated Hydraulic Schematic – Fail Extend with Spring

VS-GI Remote Hydraulic Schematic – Fail Retract with Externally Provided Closing Load

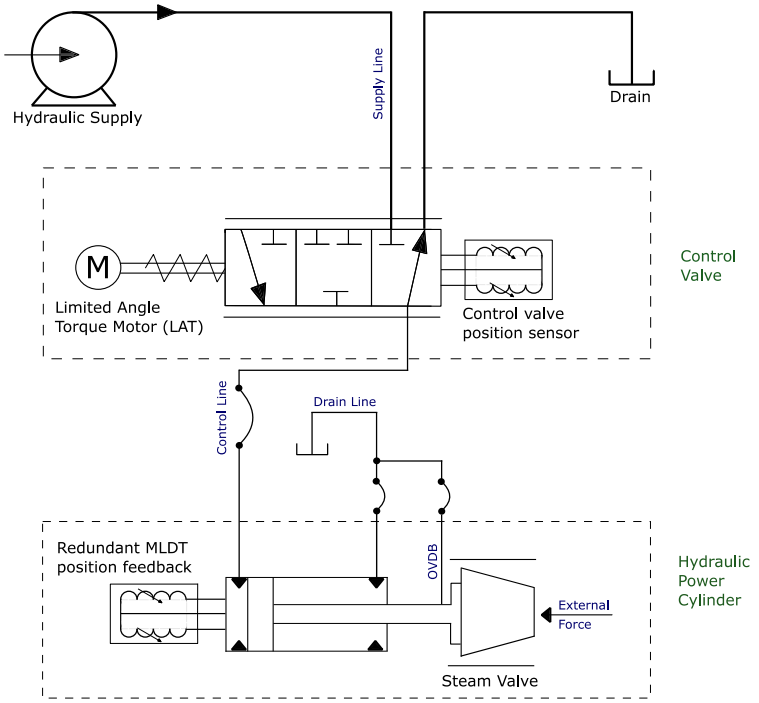


Figure 2-9. VS-GI Remote Hydraulic Schematic – Fail Retract with Externally Provided Closing Load

VS-GI Remote Hydraulic Schematic – Fail Extend with Externally Provided Closing Load

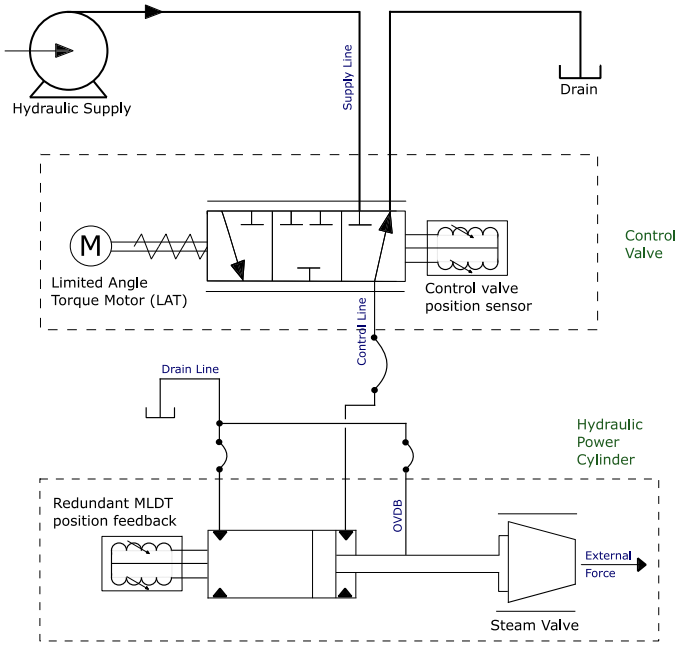


Figure 2-10. VS-GI Remote Hydraulic Schematic – Fail Extend with Externally Provided Closing Load

Chapter 3.
Dump Valves

General Overview

The dump valve feature is provided to significantly improve the slew rate in the fail-safe direction. This is often desirable for long stroke applications, when closing time is critical for load rejection, and to prevent turbine overspeed. The dump valve is installed directly onto the cylinder and can be controlled via the VS1 by servo control board or an external 24VDC signal. For installation of the dump valve, additional ports and mounting holes are incorporated on the cylinder.

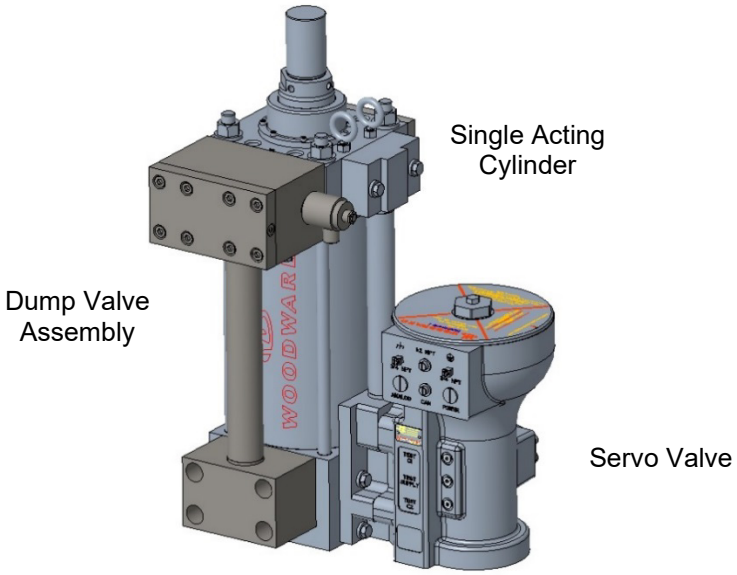


Figure 3-1. VS-GI Remote Hydraulic Schematic – Fail Retract

Table 3-1. Environmental Specifications – Dump Valve

Ambient Temperature:	–40 to +80 °C / (–40 to +176) °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.

Table 3-2. Electrical Specifications – Dump Valve

Supply Voltage:	(18 to 32) V (dc), 24 V (dc) nominal
Current Consumption:	0.4 A steady state @ 24 V Max: 1 A (transient current)
Cable/Entries:	Solenoid: 0.500”-14 NPT Conduit entry, 3X 18 AWG wires, 10 ft min length.

Table 3-3. Hydraulic Specifications – Dump Valve

Fluid Type:	Petroleum-based hydraulic fluids as well as fire resistant hydraulic fluids such as Fyrquel EHC
Minimum DV Control Pressure:	3.44 bar (50 psig)
Maximum DV Control Pressure:	34.5 bar (500 psig)
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
Internal Control Pressure Leakage (when closed):	0.015 l/min (liter per minute) at 34.5 bar 0.004 gal/min at 500 psig
Control Pressure Flow Through Orifices (when opened):	12 l/min (liter per minute) at 34.5 bar 3.2 gal/min at 500 psig
Hydraulic Connections:	DV Control Port: 0.562-18 UNF STP
Dump Valve Dead Time:	0.015 to 0.075 seconds (depending on load level)
Dump Valve Opening Time (full stroke):	1.5-inch DV: 0.04 to 0.2 seconds (depending on load level) 2.0-inch DV: 0.07 to 0.38 seconds (depending on load level)
Dump Valve Capacity:	1.5-inch DV: Effective Cv of the Dump Valve and fittings = 27.0 2.0-inch DV: Effective Cv of the Dump Valve and fittings = 47.9

IMPORTANT **The dump valve control pressure should be equal to the VS-GI supply pressure. This will provide optimum performance.**

Table 3-4. Recommended Dump Valve Size for Each VariStroke-GI Model

6 inch bore cylinder	1.5-inch dump valve (all strokes)
8 inch bore cylinder	2.0-inch dump valve (all strokes)
10 inch bore cylinder	2.0-inch dump valve (all strokes)

Note: VS-GI can be ordered with dump valve ports only. If faster slew time is required, the dump valve can be installed. See the outline drawing for dump valve kit part number.

Working Principles

The dump valve has the following major components:

- Solenoid valve
- 2 x 2-way slip-in cartridge valves

The dump valve system is opened when the solenoid voltage is removed from the coils. Once de-energized, the solenoid opens and the control pressure holding the two cartridge valves closed is released to drain pressure. When the last stage of the dump valve opens, it connects the two chambers of the actuator to each other. The hydraulic oil is transferred from the active chamber being controlled by the VS-1 servo to the inactive chamber, allowing the return spring in the actuator or the external return spring to force the cylinder to the closed position. The displaced fluid is then drained to the hydraulic return system. The short transfer path minimizes the closing time. Recirculating the oil from the active side of the cylinder to the inactive side also reduces the resulting drain flow rate. When the dump valve is open (solenoid de-energized), the DV control pressure applied is constant to the hydraulic return and it is proportional to the supply pressure (12 l/min at 34.5 bar).

To run, the solenoid must be energized, which will close the solenoid valve and allow the control pressure to act on the cartridge valves, closing them. Once the dump valve is closed, the active side of the actuator can be pressurized by the VariStroke servo valve for proper position control.

For optimum performance, the DV control pressure should be equal to the VS-GI supply pressure. An excessively high DV control pressure can extend the opening time, and increase the time required to reach the fail-safe position. Too low of a DV control pressure may not allow the dump valve to close properly and may prohibit the servo from controlling properly.

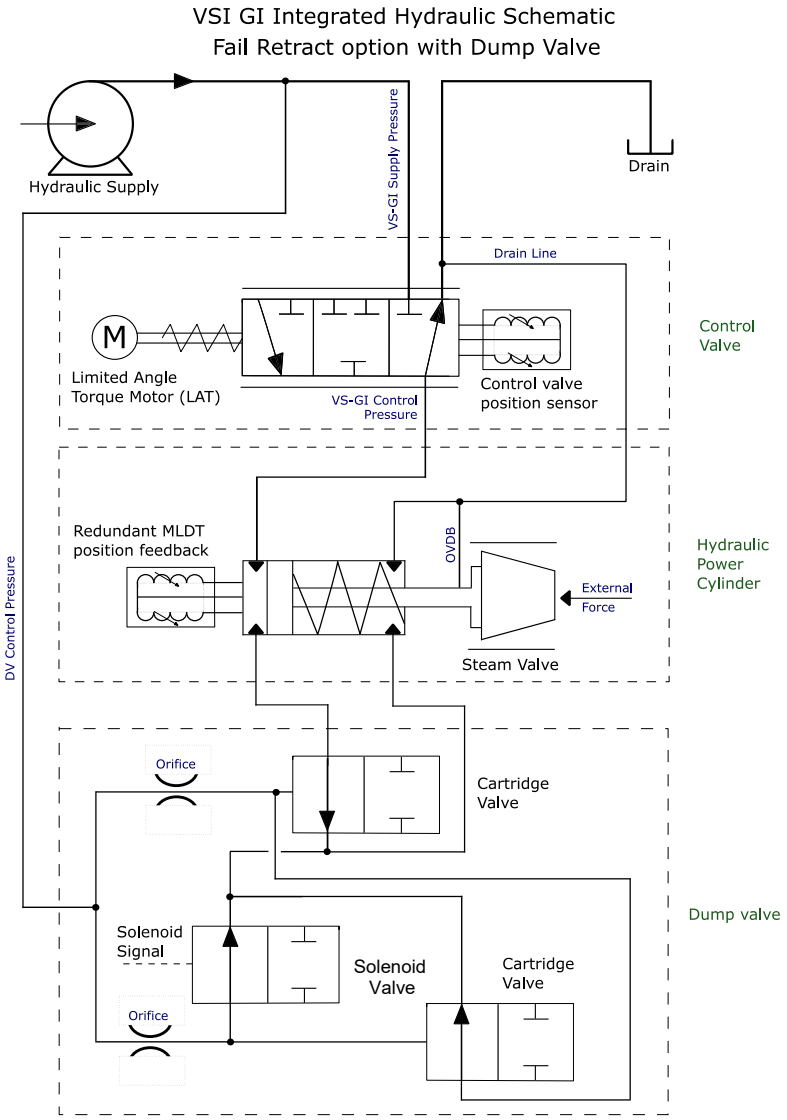


Figure 3-2. Hydraulic Schematic – Spring Return Actuator with Dump Valve

IMPORTANT

The dump valve was designed to operate with the same supply and drain levels as the VS-GI. If the supply or drain pressures deviate significantly as a result of the system installation or transient conditions, this could result in incorrect operation.

IMPORTANT **It is highly recommended that the inlet supply pressure (DV control pressure) does not decrease by more than 10% of nominal value during slew/step.**

The VariStroke drain pressure should be as low as possible to maximize performance in the closing direction.

The drain pressure must not exceed 5% of supply pressure or 1.7 bar (25 psig), whichever is less, under any condition.

IMPORTANT **For single acting actuators, the closing time is heavily dependent on the externally provided load and drain pressure. Keep the drain pressure as low as possible to maximize performance in the closing direction.**

For the VariStroke-GI single acting actuators, the slew time is highly dependent on the externally provided load since the servo is only controlling the active side of the cylinder.

IMPORTANT **For the VS-GI single acting actuator, the closing time is highly dependent on the externally provided load and drain pressure. It is the user's responsibility to test the system performance to ensure that the required closing slew time is achieved**

The dump valve can be controlled in two ways:

- The signal from external control system
- The signal from VS-GI interface (digital output signal), see manual 35148

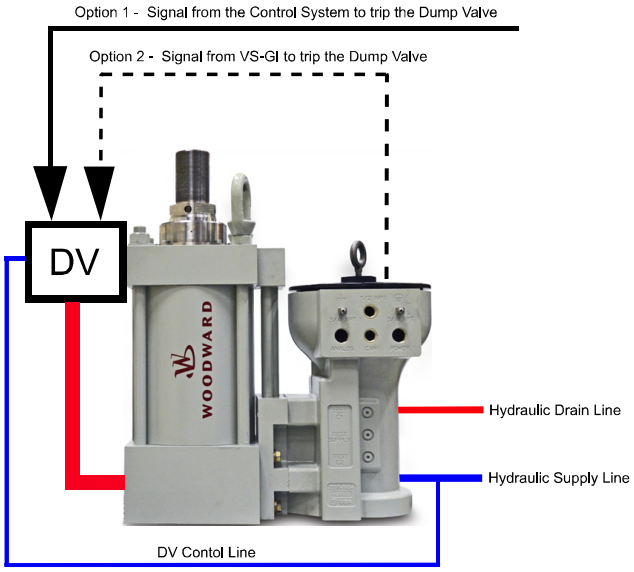


Figure 3-3. Dump Valve Schematic

Figure 3-4 shows an example of the recommended electrical control circuit. The power source and relay module are not provided as part of the VariStroke-GI assembly. A representative relay module is the Phoenix Contact Model RIF-1-RSC-LDP-24DC/2X21/FG – 2909848. Refer to the VariStroke-I Customer Service Tool manual 35148 to review how to configure the digital output signal for control of the dump valve.

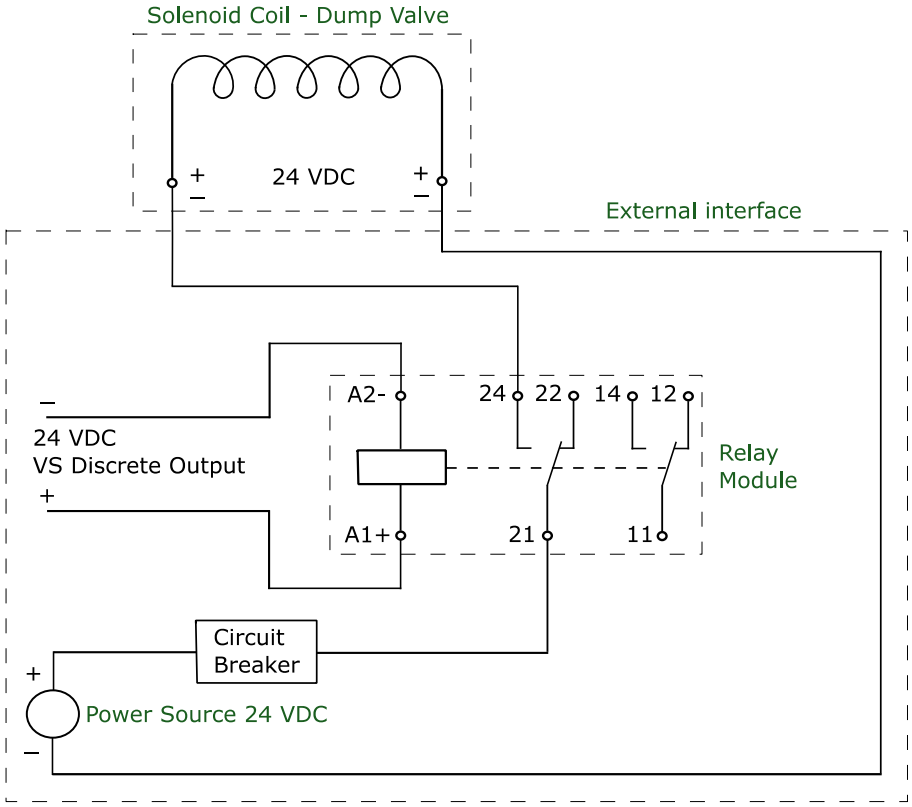


Figure 3-4. Electric Diagram

IMPORTANT

The VariStroke discrete output signal cannot be directly connected to the solenoid. Use of an interposing relay is required. The solenoid consumes a maximum current of 1 A @ 24 VDC.

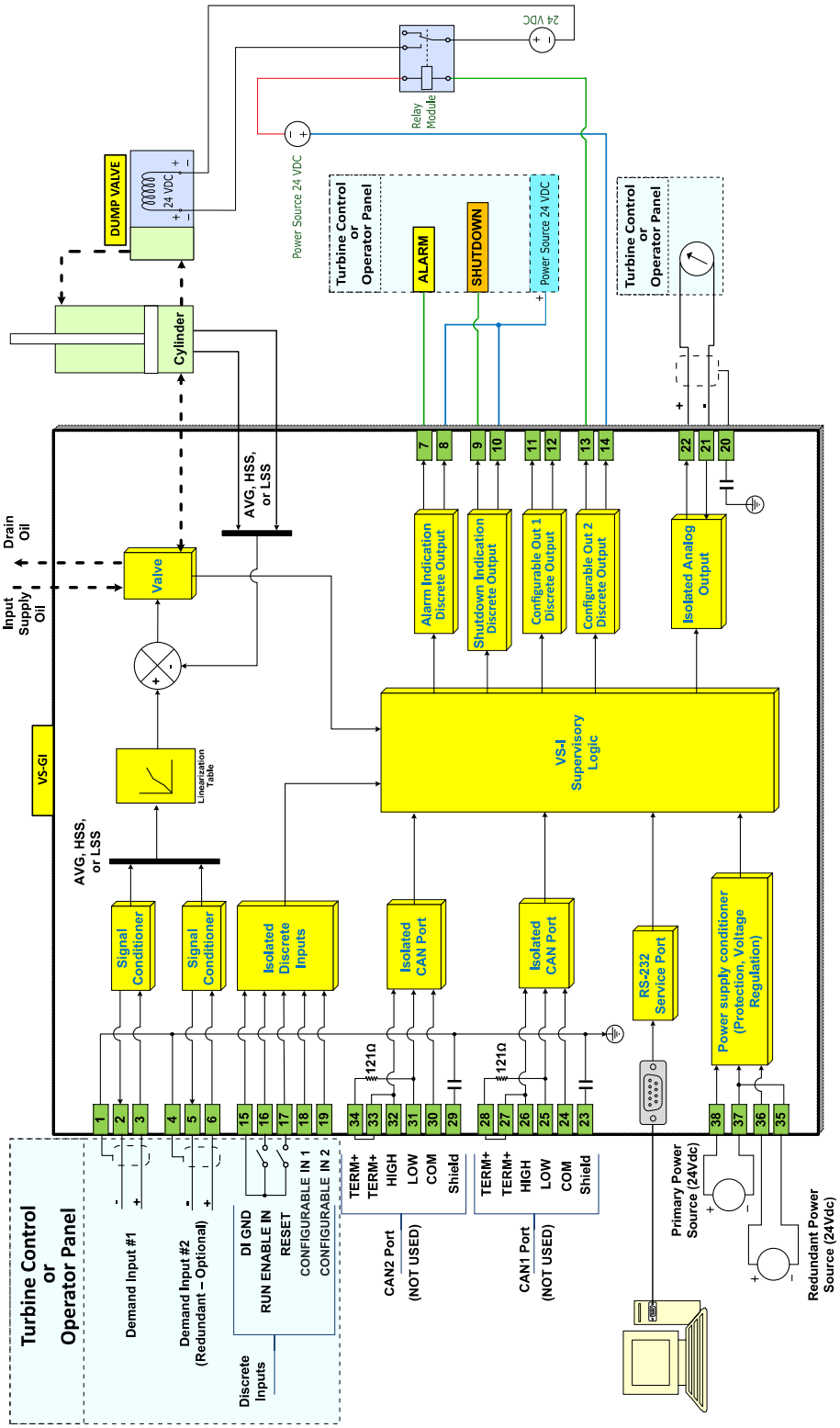


Figure 3-5. Example Wiring Diagram for Use of the VS-GI Discrete Output Signal to Control the Dump Valve

Chapter 4.
VariStroke-TTV (Trip & Throttle Valve) Functionality

General Overview

VariStroke-TTV (VS-TTV) actuators are designed to be used on stream turbine trip & throttle valves (T&TV) for replacement of old problematic hand valve operated actuators, which have the tendency to stick and are difficult to accurately adjust during turbine starts.

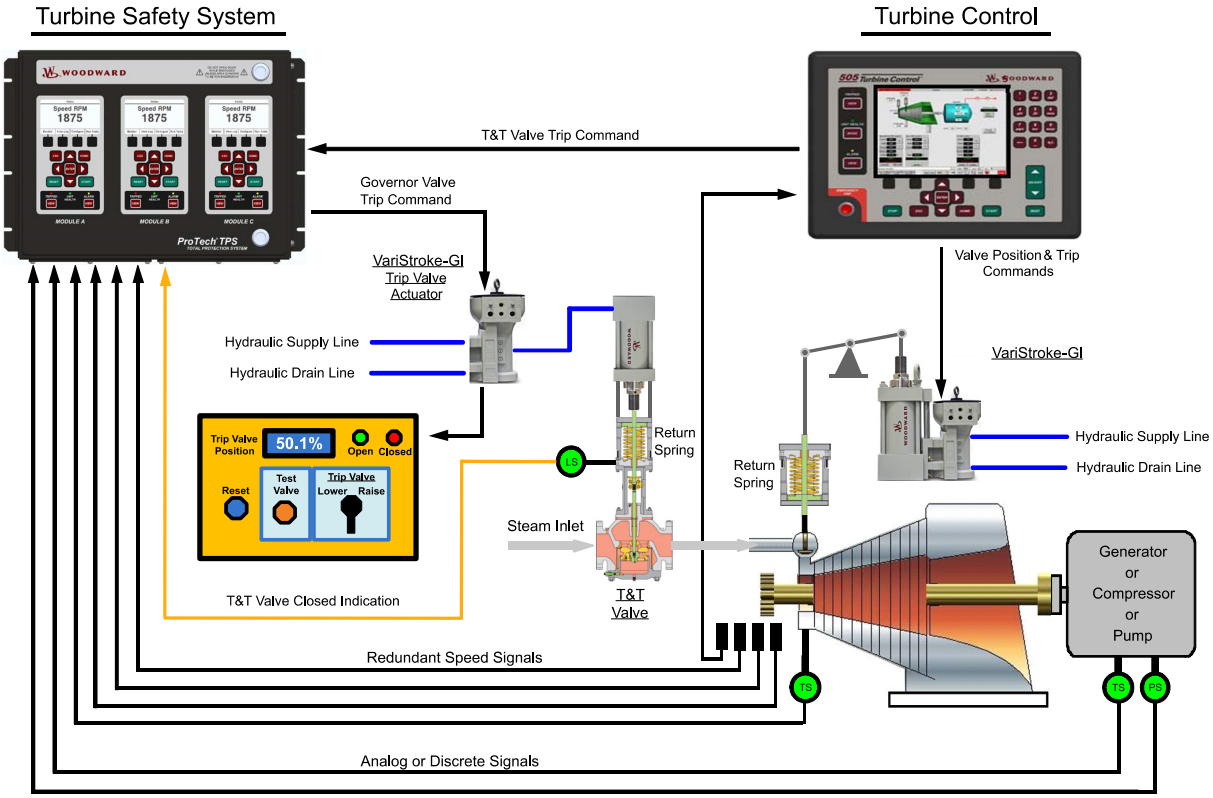


Figure 4-1. Example VS-T&TV Actuator Application

Depending on the turbine safety system, the VariStroke-TTV can be controlled in several ways, either by using the analog inputs, discrete inputs, or a combination of both. These command signals allow the T&TV position to be safely controlled by operators from a local operator panel near the device or remotely by the turbine or plant control system. Optionally, the VS-TTV actuator can also be configured to accept a 4-20mA input demand signal to open and close the T&TV as well. To verify valve position and health, the VS-TTV actuator includes an internal Magnetostrictive Linear Displacement Transducer (MLDT) position sensor as well as min & max discrete output position indication signals.

An integrated safety feature for Partial Stroke Testing (PST) allows remote testing of the T&TV actuator's ability to move the valve from a remote-control panel during normal operation. The test can verify the movability of the cylinder piston ,which is critical for turbine safety. This test can be initiated by activating both discrete input signals (open and close signal) at the same time.

Additionally, the VS-TTV actuator can utilize a fast-acting dump valve connected to the hydraulic cylinder to quickly drain oil from one side of the power piston to the other side, forcing the actuator's piston to quickly close upon receiving a valve trip command. For redundancy purposes, the VS-TTV servo also drains oil from one side of the power piston to the other side upon receiving a valve trip command.

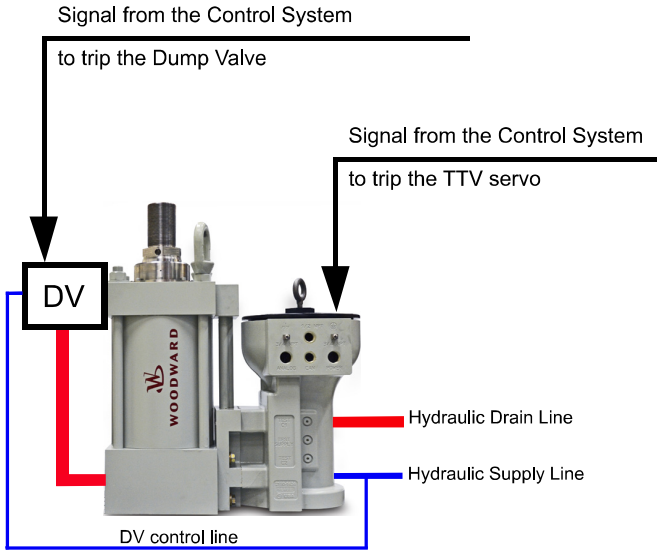


Figure 4-2. VS-TTV Actuator with Dump Valve

T&TV Based Functions:

Open Valve & Close Valve Discrete Input Commands:

The VariStroke-TTV actuator's discrete input #4 (configurable in 2) functions as an open valve command. Once the valve is in operation mode, it allows the user to command the T&TV to open at the configured ramp rate.

The VariStroke-TTV actuator's discrete input #3 (configurable in 1) functions as a close valve command and once the T&TV is open, it can be used to ramp the T&TV closed at a configured ramp rate. Open/close valve ramp rates are configurable within the VariStroke Customer Service Tool.

Partial Stroke Test

The VS-TTV actuator's Partial Stroke Test (PST) is designed to allow verification of T&TV health during normal turbine operation. This test can be initiated by closing both the open valve discrete input command and the close valve discrete input command at the same time. The PST conditions are configured within the VariStroke Customer Service Tool. See manual 35148 for more info.

Example PST scenario: The T&TV position is 100%, the user configured PST demand position is set at 80%, the user configured PST ramp slew rate is set at 2.5%/second, no T&TV alarm condition exists. When a start PST command is given (open and close valve commands given at the same time). When the PST command is given, the VS-TTV actuator will ramp the valve position from 100% to 80% at the user configured ramp slew rate and hold at 80% until the PST command is removed (open and close valve commands removed) then the VS-TTV actuator will ramp valve position from 80% to 100% at the user configured ramp slew rate.

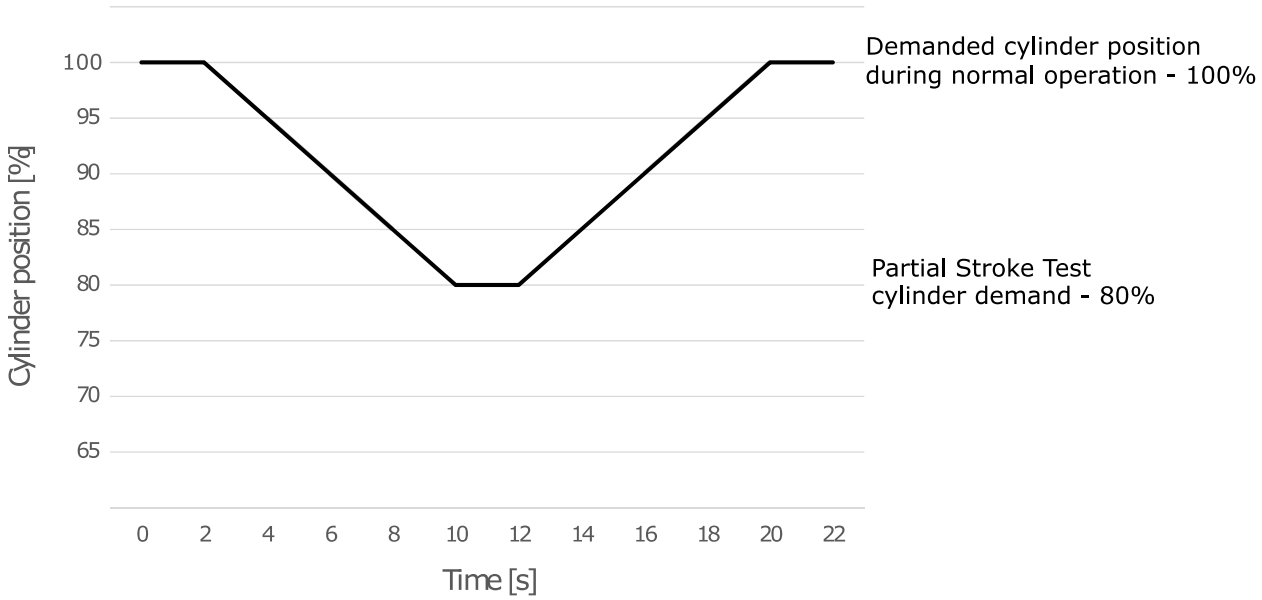


Figure 4-3. Example Partial Stroke Test

Installation Recommendations

Since the VS-TTV is a single-acting hydraulic actuator, it utilizes pressurized hydraulic oil as the force to open the valve. The combination of the external T&TV load and return spring force must be sufficient to close the valve. Thus, for proper VS-TTV actuator performance, it is recommended that the applied VS-TTV actuator be sized such that the external TTV load and return spring force is within 50%-80% of the VS-TTV actuator's calculated stall force. Higher external loads will reduce the closing slew times as well as the risk of sticking which is critical for T&TV applications.

IMPORTANT

Make sure that the external load value is within the appropriate range over the entire piston stroke. Too low of a load will decrease the unit performance in the fail-safe direction.

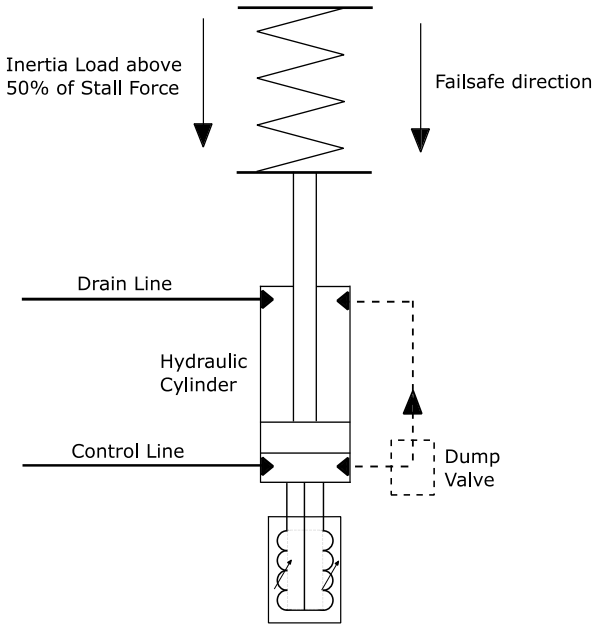


Figure 4-4. VS-TTV Actuator with T&TV and Return Spring Load

IMPORTANT

The dump valve cannot be tested during normal operation. The partial stroke test should not be used in conjunction with the dump valve.

Depending on the application, the VS-TTV can be integrated with the turbine control in many ways. For example, the partial stroke test can be activated from the local control cabinet using the open/close discrete input signals. The analog position demand signal position demand (analog 4-20mA) as well as the indication signals (alarm/shutdown discrete outputs) may be controlled by the turbine controller. Additionally, the turbine safety system can be connected directly to VS-TTV servo's run enable discrete input signal and the dump valve solenoid. This allows for fast and reliable turbine shutdown. See the figure below. For more application examples, contact Woodward.

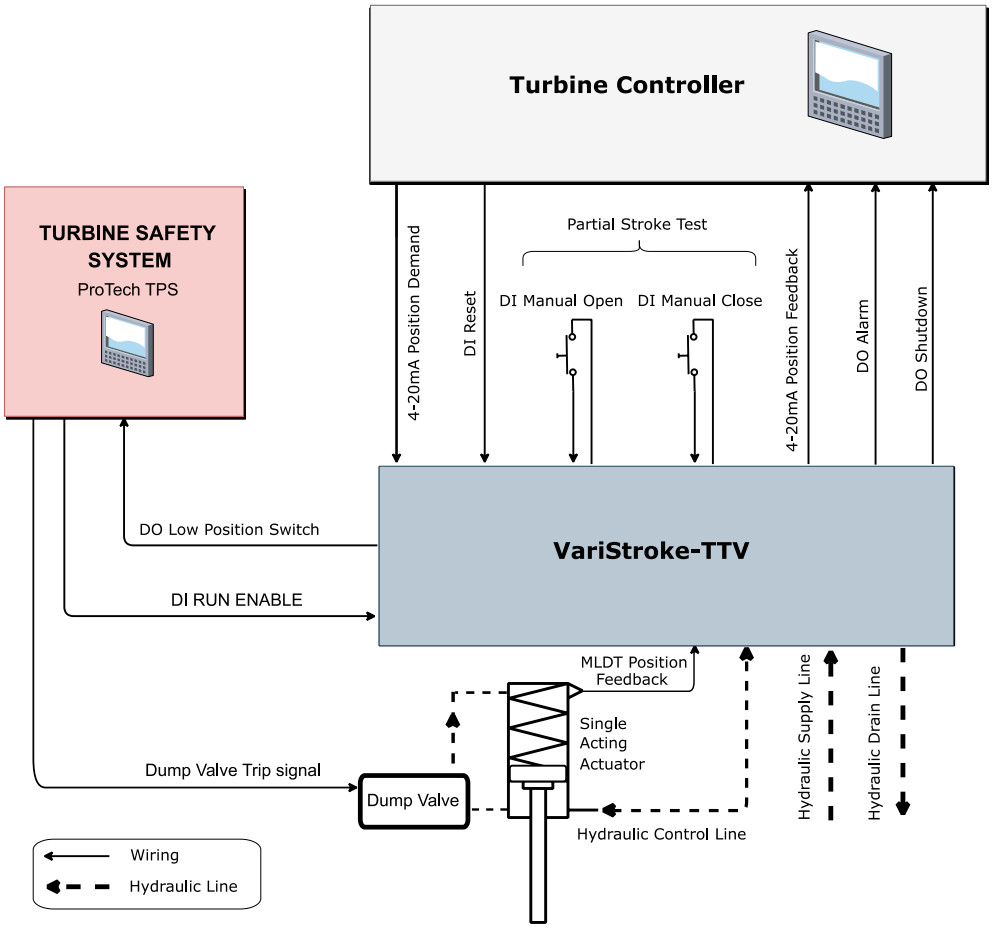


Figure 4-5. VS-TTV Actuator with T&TV and Return Spring Load

The VS-T&TV actuator can be controlled in several ways (input demand options):

- **Discrete Only:** The VariStroke-TTV actuator's discrete input #4 (configurable in 2) functions as an open valve command. Once the valve is in operation mode, it allows the user to command the T&TV to open at the configured ramp rate.

  The VariStroke-TTV actuator's discrete input #3 (configurable in 1) functions as a close valve command and once the T&TV is open, it can be used to ramp the T&TV closed at a configured ramp rate.

  Open/close valve ramp rates are configurable within the VariStroke Customer Service Tool. Refer to Figure 4-6: VariStroke-TTV Interface Diagram.

  The VS-TTV can be commanded to step to its shutdown state by opening the RUN ENABLE discrete input.

- **Discrete with Analog Demand 1 (Low Signal Select):** Two discrete inputs (open valve, close valve) and analog 4-20mA demand input #1 are used to set the TTV actuator position. With this configuration, the lower of the two demand signals (lower signal value) will determine the position. Refer to Figure 4-6: VariStroke-TTV Interface Diagram.

  The VS-TTV can be commanded to step to its shutdown state by opening the RUN ENABLE discrete input or be decreasing analog input signals below 2 mA (see manual 35148 for analog inputs configuration).

- **Discrete with Dual Analog (Low Signal Select):** Two discrete inputs (open valve, close valve) and two analog 4-20mA demand inputs #1 & #2 are used to set the TTV actuator position. With this configuration, the lower of the three demand signals (lower signal value) will determine the position. Refer to Figure 4-6: VariStroke-TTV Interface Diagram.

The VS-TTV can be commanded to step to its shutdown state by opening the RUN ENABLE discrete input or by decreasing analog input signals below 2 mA (see manual 35148 for analog inputs configuration).

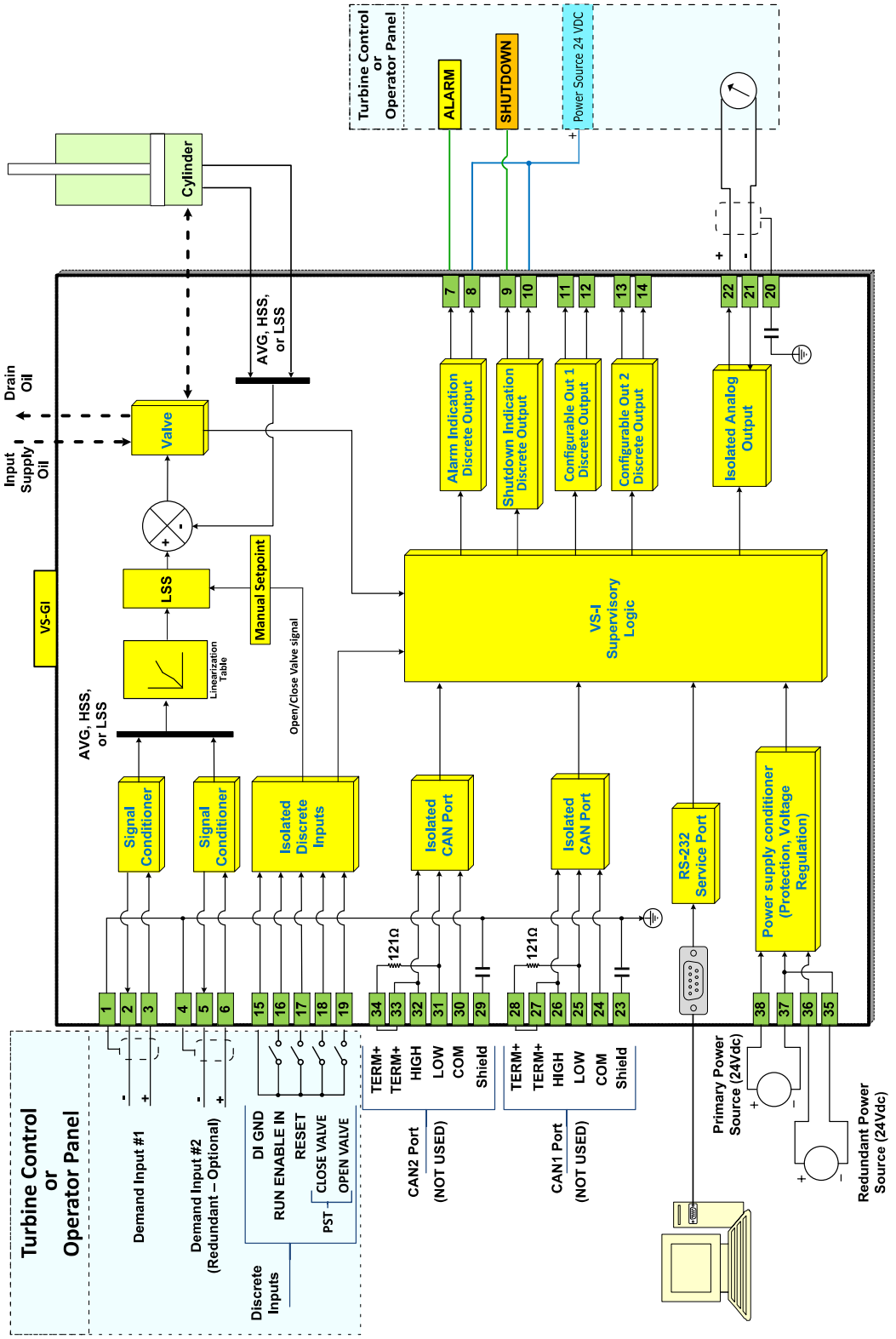


Figure 4-6. VariStroke-TTV Interface Diagram

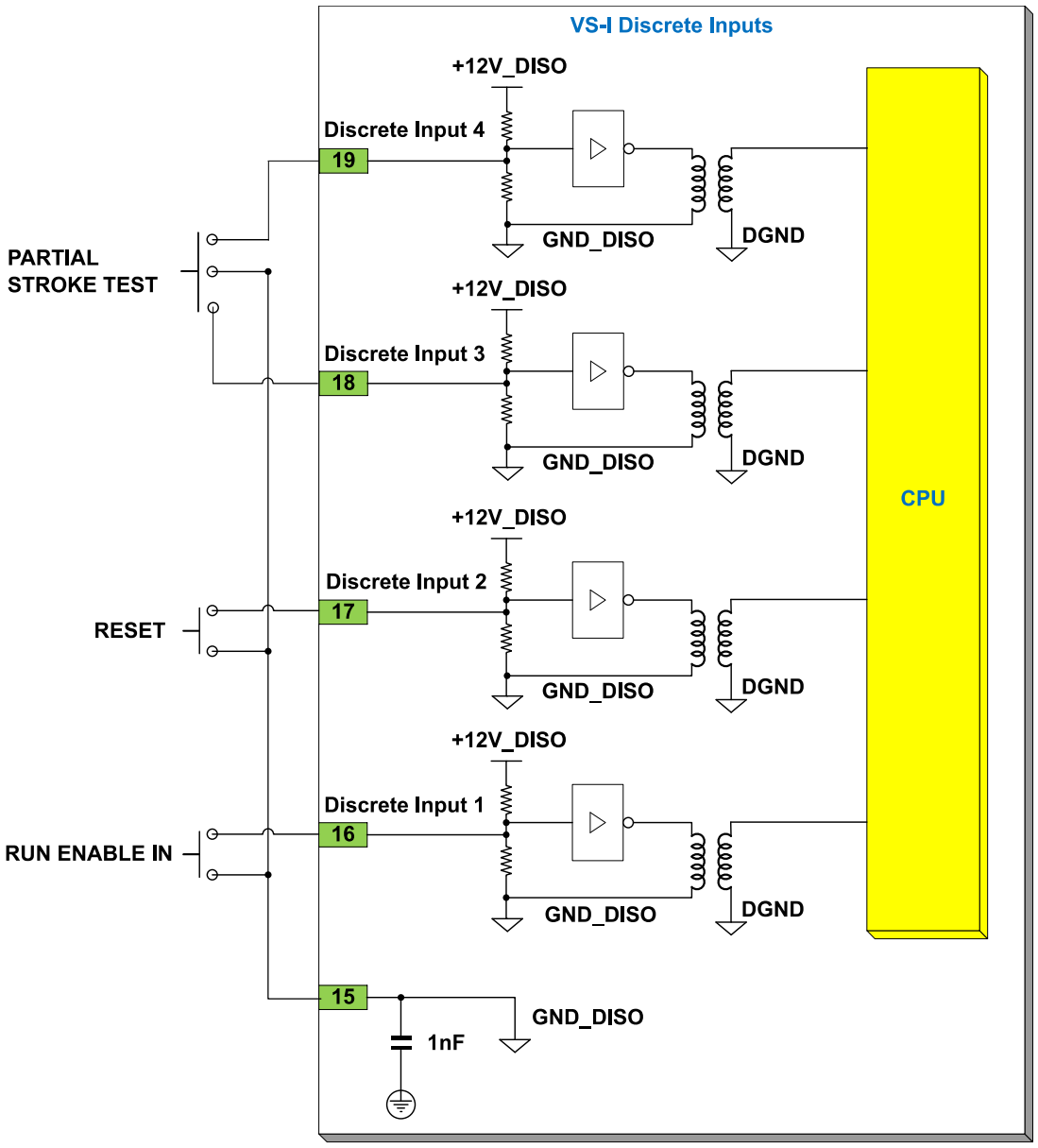


Figure 4-7. T&TV – Example Partial Stroke Test Functionality Wiring

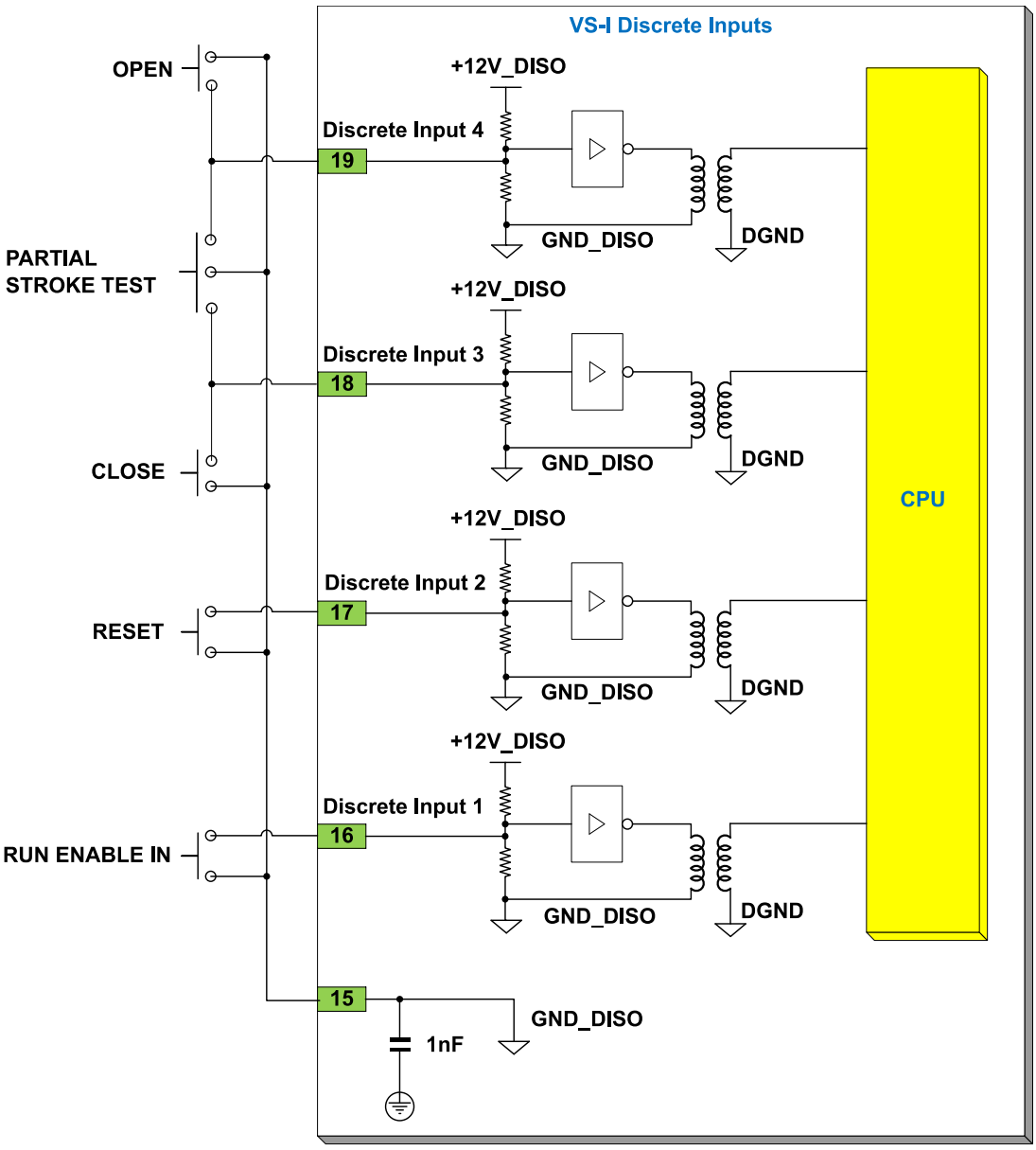


Figure 4-8. T&TV – Example Partial Stroke Test and Open/Close Signal Wiring

Chapter 5.
Installation

Receiving Instructions

The VS-GI 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-GI is discovered, immediately notify both the shipping agent and Woodward.

Unpacking Instructions

Carefully unpack the VS-GI 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, cover surface, threads, or the VS-GI housing mating surface while removing or replacing the cover.

⚠WARNING

For Division 1/Zone 1 products: Proper torque on all joints is critical 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-GI 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-GI.

⚠CAUTION

The surface of this product can become hot 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
- Dump valve kit (for the units with dump valve ports; DV0)

A vertical actuator position is generally preferred to conserve floor space as well as ease of making electrical and hydraulic connections. However, the VS-GI can be mounted in any aptitude. It is recommended 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-GI actuator is to be installed near uninsulated/unshielded steam valves or piping, radiation heat shields should be installed between the actuator and these hot surfaces.

The integrated VS-GI is designed for support by the hydraulic power cylinder mating bottom or top surface.

For remote servo kit installation, both the 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.

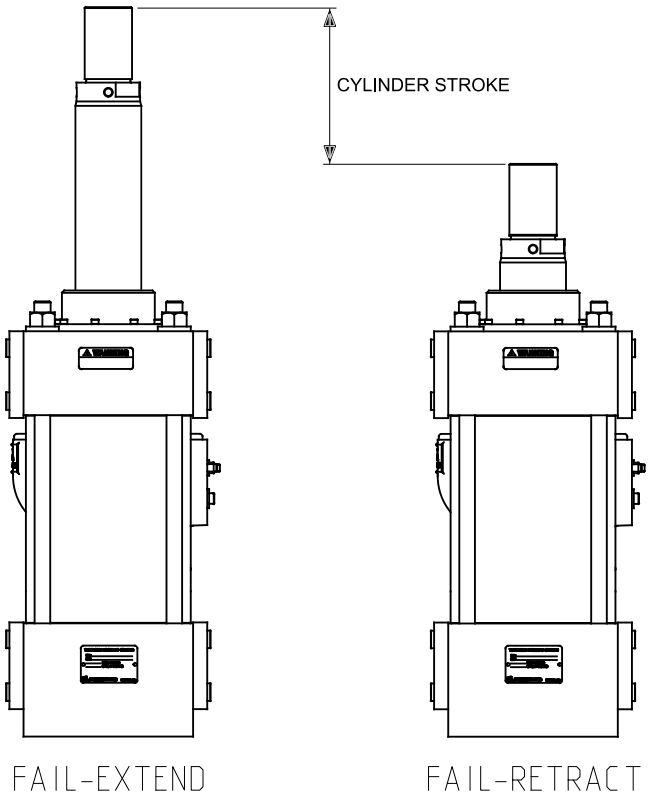


Figure 5-1. Hydraulic Rod Position for Different Cylinder Versions

Fail extend, spring assist cylinders will arrive with the cylinder rod in the fully extended position, until hydraulic pressure is supplied, and the controls are properly connected. For all fail retract spring assist cylinders, the hydraulic rod is in the retracted position without hydraulic pressure.

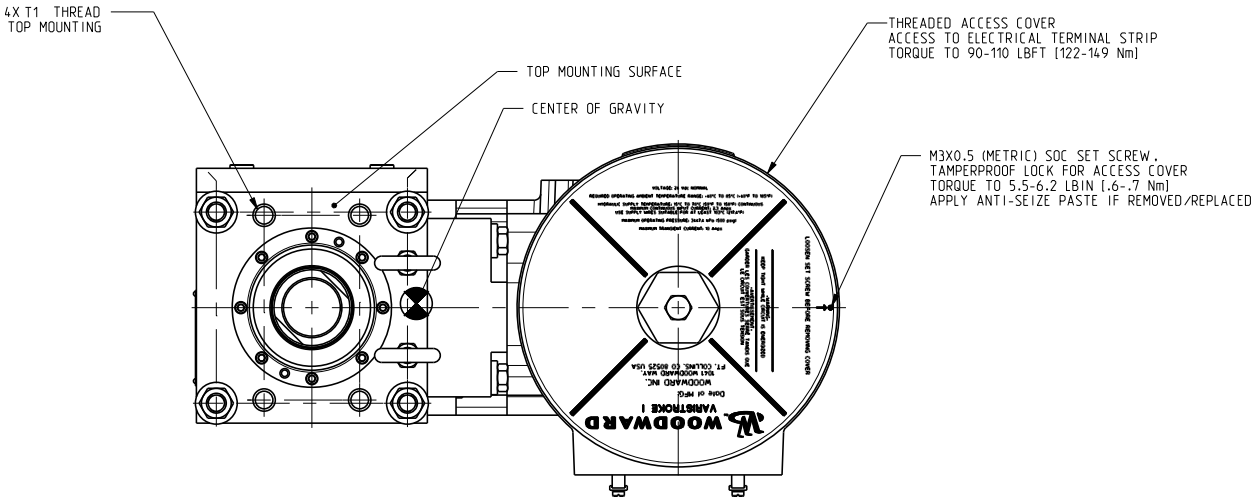


Figure 5-2a. VS-GI Integrated Product Installation Interface - Bolting Pattern and Installation Features – Top View

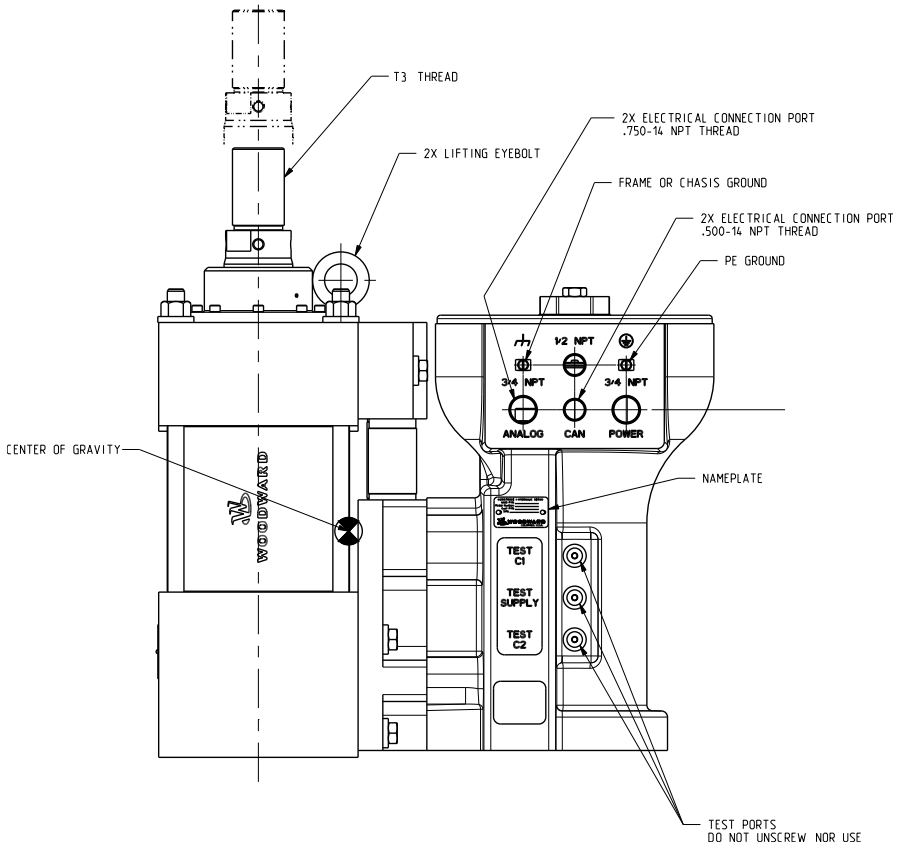


Figure 5-2b. VS-GI Integrated Product Installation Interface - Bolting Pattern and Installation Features – Side View

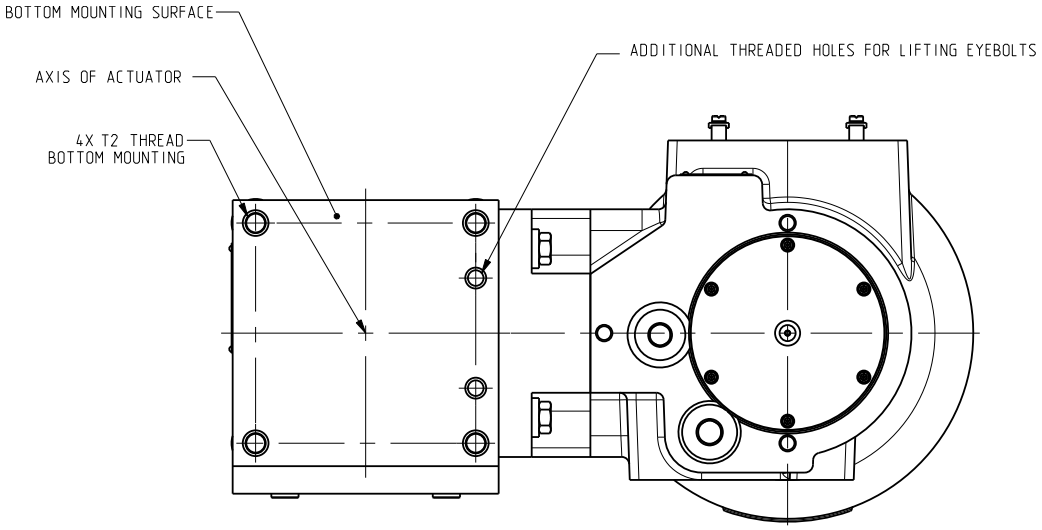


Figure 5-2c. VS-GI Integrated Product Installation Interface - Bolting Pattern and Installation Features – Bottom View

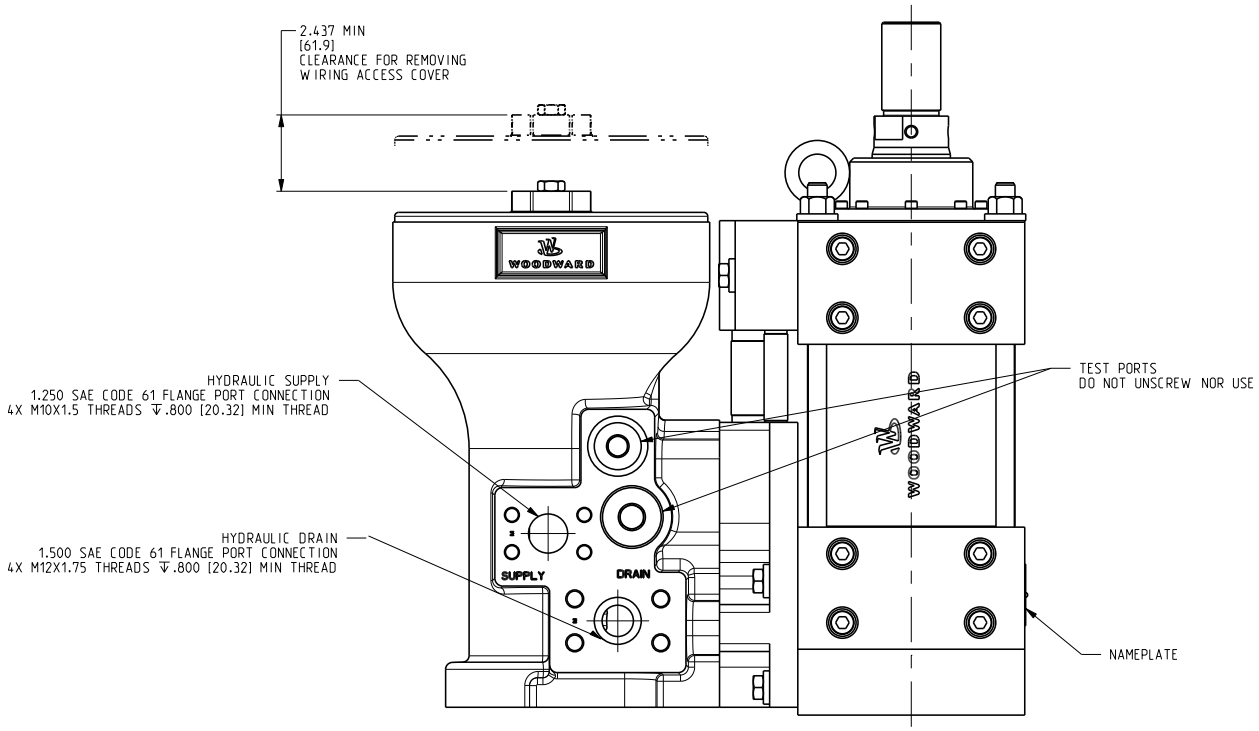


Figure 5-2d. VS-GI Integrated Product Installation Interface - Bolting Pattern and Installation Features – Side View

NOTICE

Recommended minimum bolt grade, bolting torque, and thread engagement is valid for low carbon steel mounting surface to which the product is bolted. For a different configuration, please consult Woodward for torque and bolt grade recommendations.

Table 5-1. VS-GI Installation Bolts and Bolting Torque Recommendation

Thread **"T1"** (See Figure 5-2a) and **"T2"** (See Figure 5-2c)

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
6 (152)	M16x2	1.60 (40.6)	10.9	110-120 (149-163)	6H
8 (203)	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"** (See Figure 5-2b)

6 (152)	M-M48x2 F-M33x2	1.80 (45.7)	N/A	N/A	6g/6H
8 (203)	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

Installation Dimensions for Servo Only

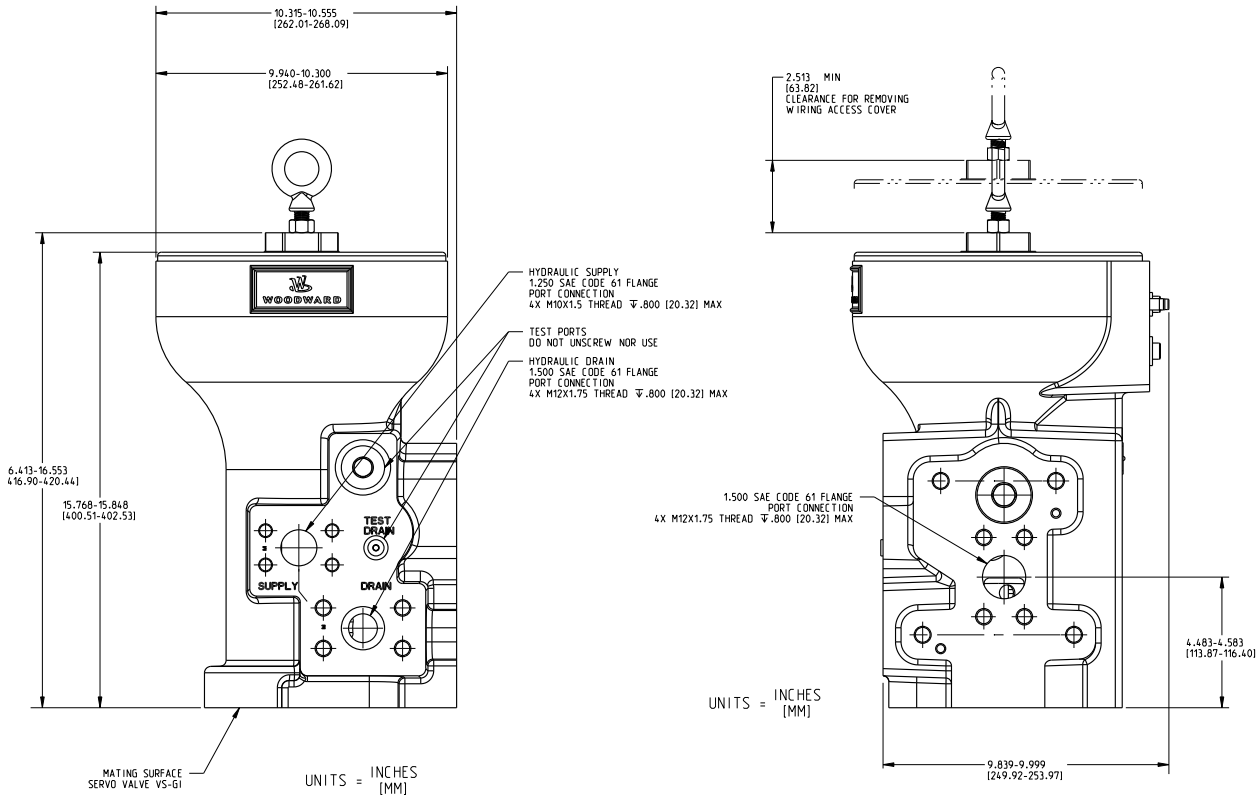


Figure 5-3a. VS-GI Remote Servo - Bolting Pattern and Installation Features – Side View

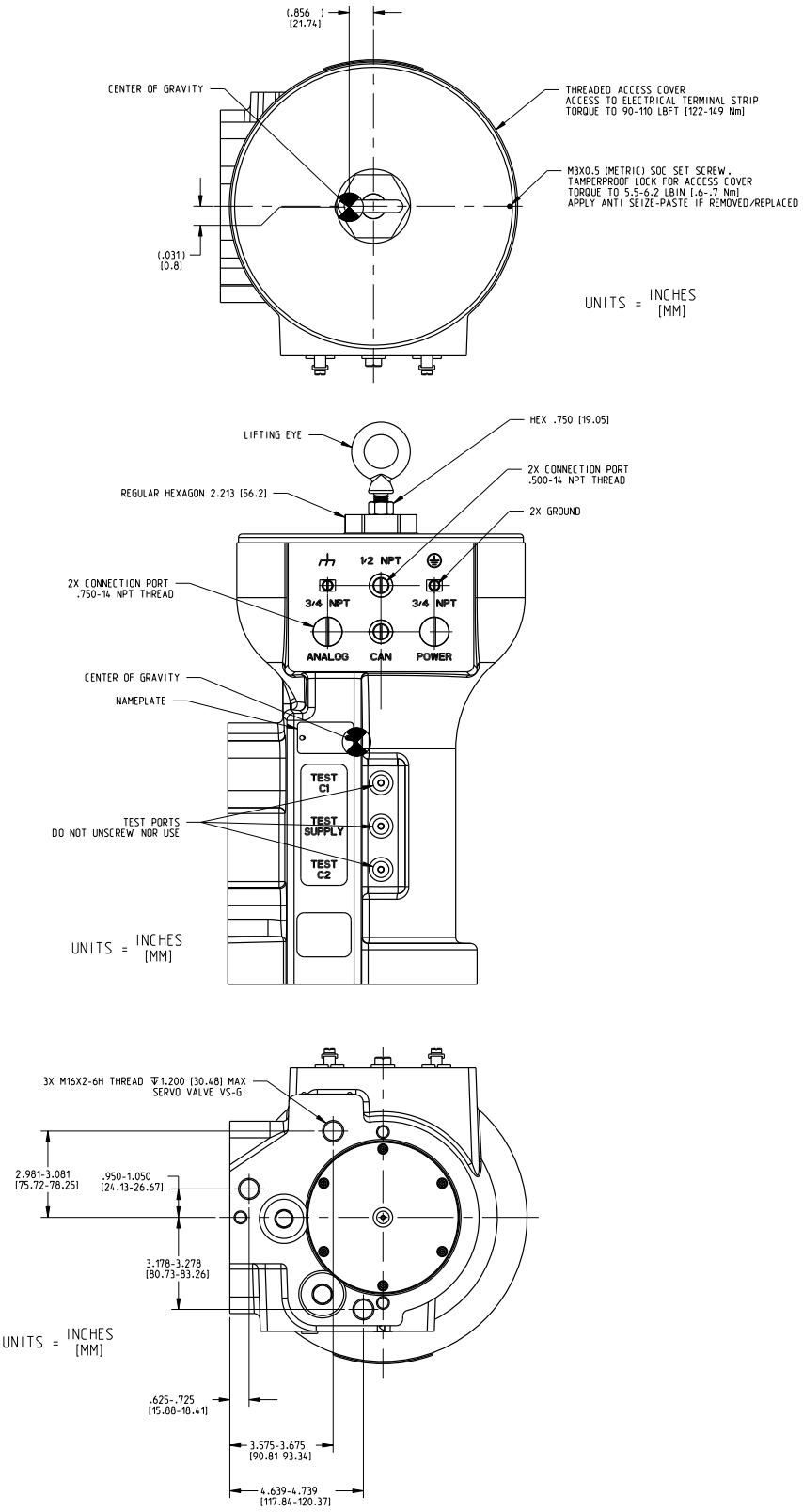


Figure 5-3b. VS-GI Remote Servo - Bolting Pattern and Installation Features – Side, Top, and Bottom View

Installation Dimensions for Dump Valve

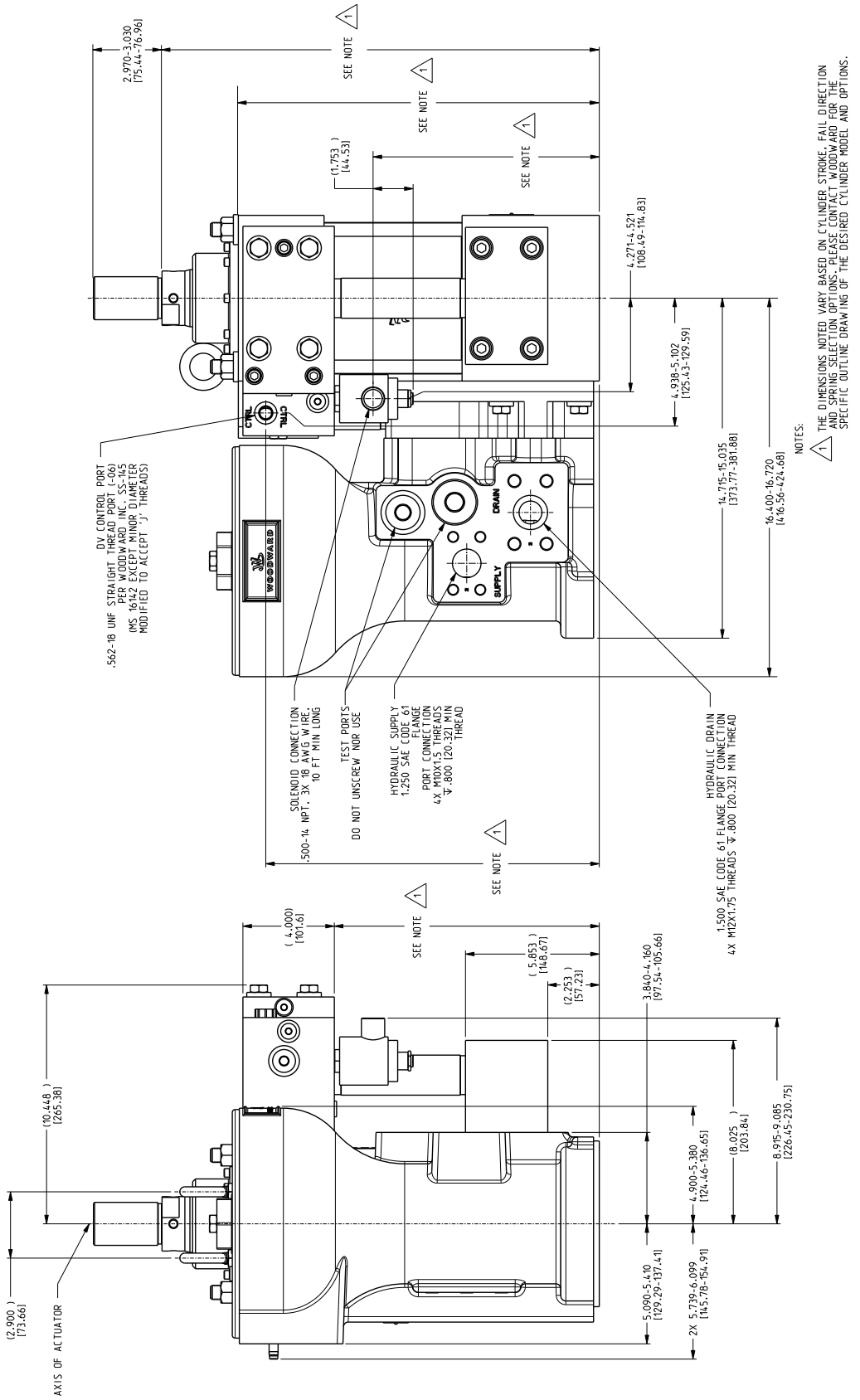


Figure 5-3c. VS-GI, 6-inch Bore, Fail Extend Version with Dump Valve

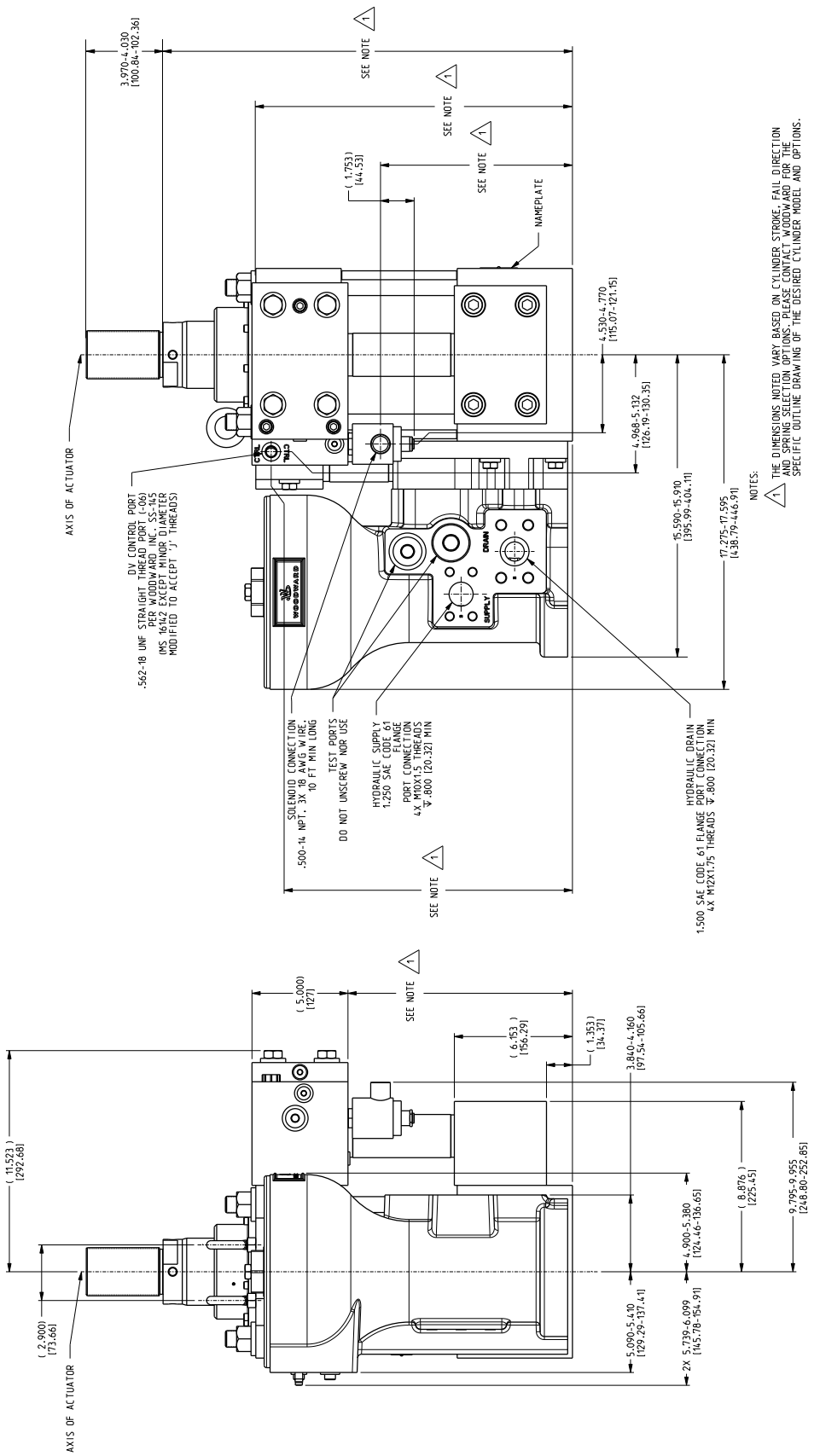


Figure 5-3d. VS-GI, 8-inch Bore, Fail Extend Version with Dump Valve

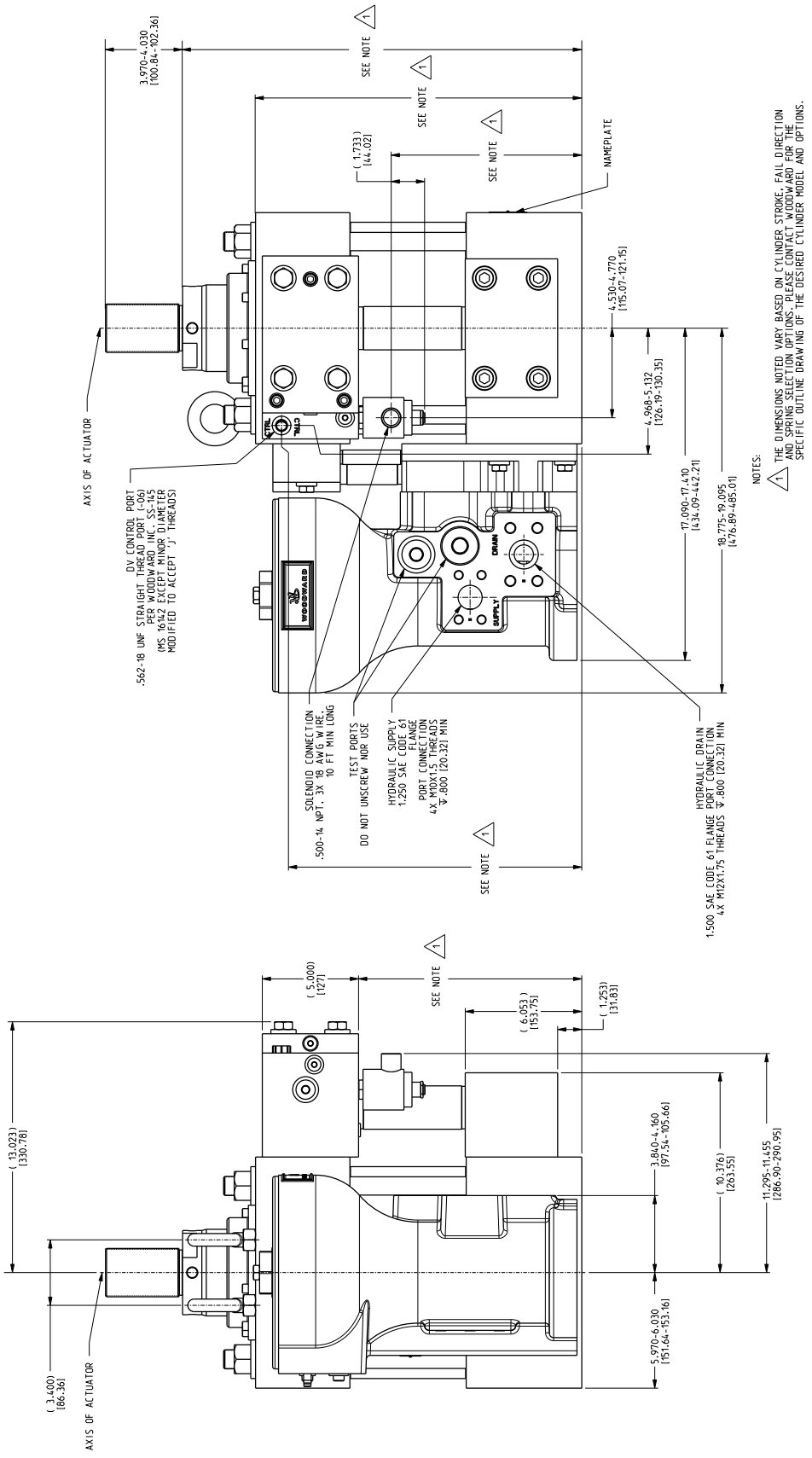


Figure 5-3e. VS-GI, 10-inch Bore, Fail Extend Version with Dump Valve

Lifting

VariStroke comes equipped with lifting eyebolts for vertical lifting. When transporting, use both eyebolts as shown below. **Use two separate lifting belts with the same length.**

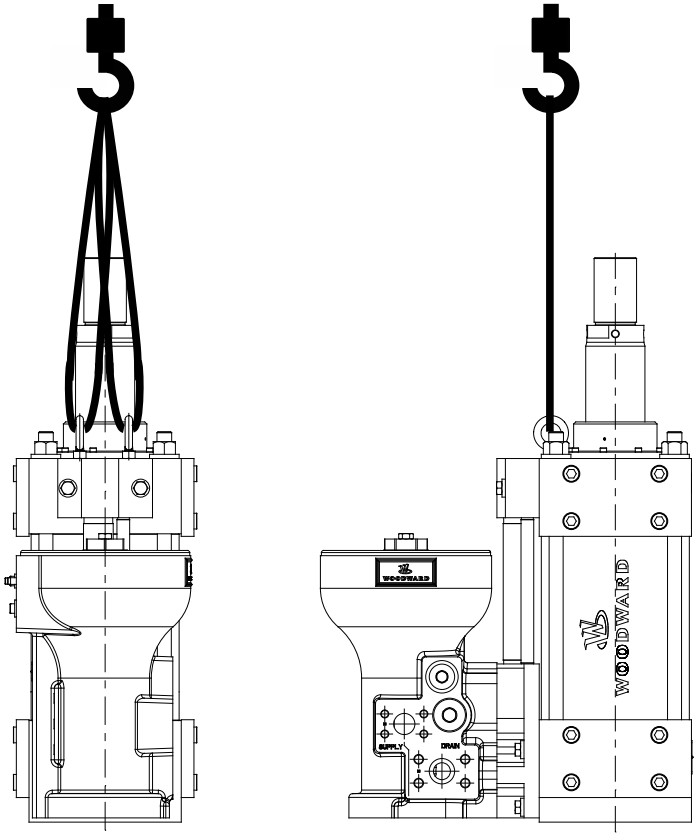


Figure 5-4. VS-GI Lifting Positions

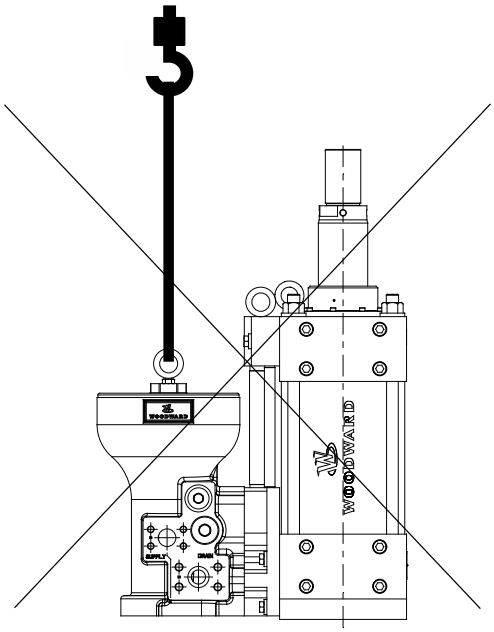


Figure 5-5. Incorrect Lifting Method

⚠WARNING

The VS-GI 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-GI integrated, the user is obligated to maintain the minimum required gap between servo valve and the actuator installation surface.

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

Improper mounting may be considered a violation of warranty conditions.

⚠WARNING

Maximum allowable linkage misalignment is 5°. It is highly recommended that the customer strictly warns the installer of this.

⚠WARNING

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

⚠WARNING

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

⚠WARNING

Ensure the crane, cables, straps, and all other lifting equipment used for VS-GI lifting is able to support the VS-GI weight. See outline drawings for VS-GI 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

Table 5-2. Servo and Dump Valve Hydraulic Connections for Integrated Version

For the Integrated VS-GI

Servo			
Hydraulic Connections	**Fitting**	**Bolt Size**	**Torque**
Hydraulic Supply Port	1.250 SAE J518 Code 61 Flange	4x M10x1.5 Screws	(34 to 48) N·m, (25 to 35 lb-ft)
Hydraulic Drain Port	1.500 SAE J518 Code 61 Flange	4x M12x1.75 Screws	(48 to 61) N·m, (35 to 45 lb-ft)
Dump Valve			
Hydraulic Connections	**Fitting**	**Bolt Size**	**Torque**
Hydraulic Control/Supply Port	.562-18 UNF-2B	N/A	(8 – 14) Nm, (75 - 125 lbf-in)

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

Table 5-3. Servo and Dump Valve Hydraulic Connections for Remote Version

For Remote VS-GI

Servo			
Hydraulic Connections	**Fitting**	**Bolt Size**	**Torque**
Hydraulic Supply Port	1.250 SAE J518 Code 61 Flange	4x M10x1.5 Screws	(34 to 48) N·m, (25 to 35 lb-ft)
Hydraulic Drain Port	1.500 SAE J518 Code 61 Flange	4x M12x1.75 Screws	(48 to 61) N·m, (35 to 45 lb-ft)
Hydraulic Control Port	1.500 SAE J518 Code 61 Flange	4x M12x1.75 Screws	(48 to 61) N·m, (35 to 45 lb-ft)
Dump Valve			
Hydraulic Connections	**Fitting**	**Bolt Size**	**Torque**
Hydraulic Control/Supply Port	.562-18 UNF-2B	N/A	(8 – 14) Nm, (75 - 125 lbf-in)

Note: SAE J518, JIS B 8363, ISO/DIS 6162 AND DIN 20066 are interchangeable, except for bolt sizes/threads. The VS-GI uses metric bolt sizes.
Note: Maximum pipe length between remote servo and cylinder: 3 meters

⚠CAUTION **Before installing the VS-GI, 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 should be 32 mm (1.25 inches) of tubing capable of supplying 925 L/min (244 US gal/min) at 34.5 bar (500 psig).

The hydraulic supply to the dump valve should be 13 mm (0.5 inches) of tubing capable of supplying 12 L/min (3.2 US gal/min) at 34.5 bar (500) psig.

The hydraulic drain should be 38 mm (1.5 inches) of tubing or larger and must not restrict the flow of fluid from the actuator. The drain pressure must not exceed 5% of supply pressure or 1.7 bar (25 psig), whichever is less, under any condition.

IMPORTANT

For the single acting actuator, closing time is strongly related with load and drain pressure. Keep the drain pressure as low as possible to maximize performance in the closing direction.

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 38 mm (1.5 inches) tubing to minimize servo-actuator plumbing flow restrictions. Recommend rigid/steel tubing for these connections.

IMPORTANT

It is highly recommended that inlet supply pressure does not 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). The VS-GI design enables closure of the cylinder without hydraulic supply pressure. This enables the flow capacity to be minimized for operation in the direction opposite the fail-safe direction. Ensure that the supply pressure (measured at the servo inlet) does not deviate from the steady-state pressure setting by more than +/- 10% even during the largest anticipated step in position opposite the fail-safe direction.

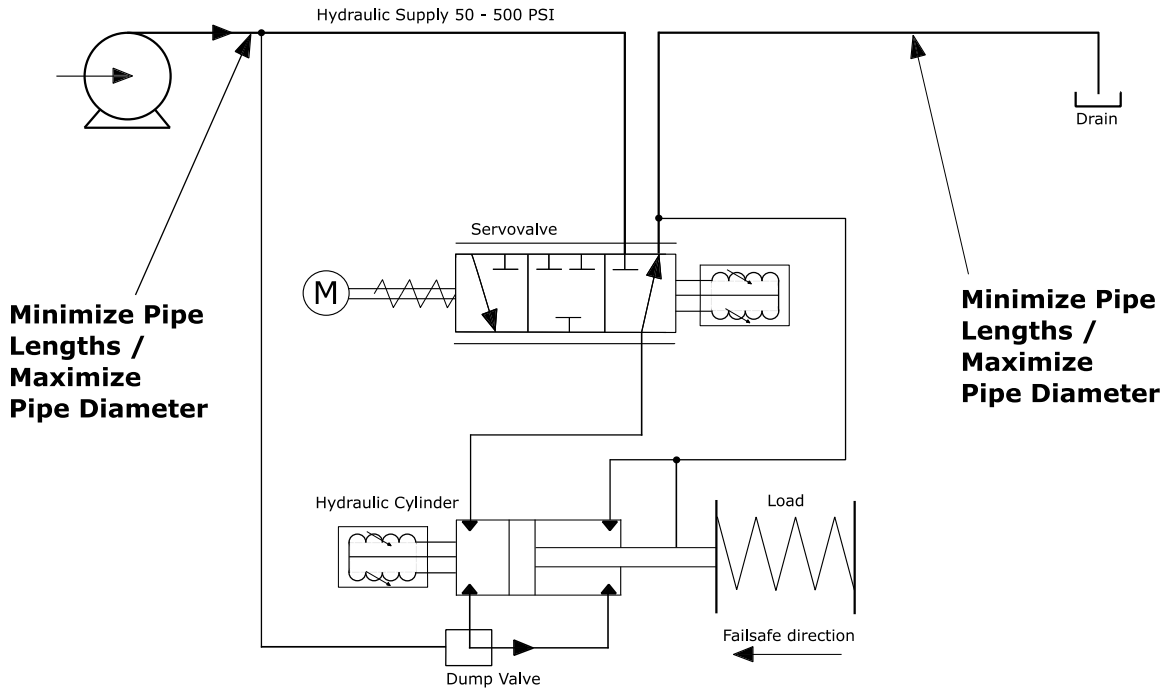


Figure 5-6. Suggested Configuration

WARNING

Do not remove any test port connection plugs when the 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 in the fail-safe direction, the actuator may generate pressure spikes in the supply line due to an effect similar to a water hammer. A hydraulic accumulator in the supply line installed close to the VariStroke can considerably reduce or eliminate this effect.

External Force, Load

For proper function of the VS-GI, an appropriately sized external load is required. The magnitude of this external load should be within 20% to 80% of the stall force of the VariStroke actuator. Stall force is defined as the supply pressure x the area of the active side of the actuator cylinder.

IMPORTANT

Ensure that the external load value is within the appropriate range over the entire piston stroke. Too low or too high of a load will increase control overshoot and decrease the unit performance.

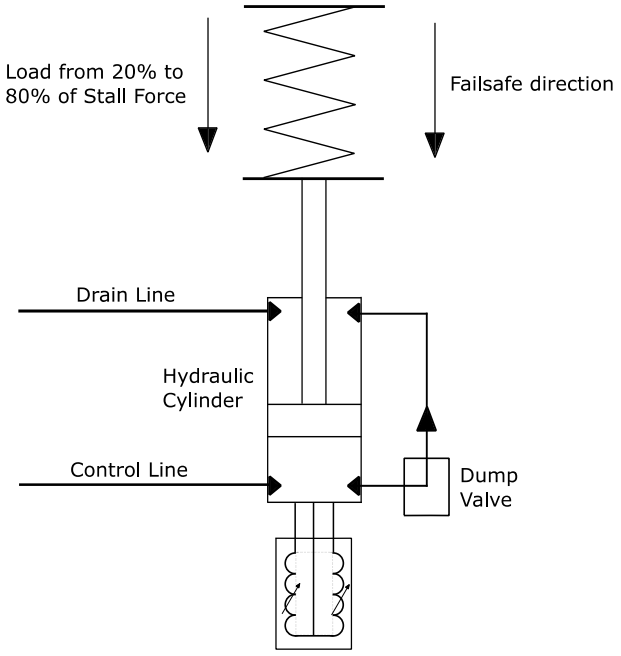


Figure 5-7. Hydraulic Cylinder with Load

Load requirements:

$Load_{min} = Stall\ Force * 20\%$

$Load_{max} = Stall\ Force * 80\%$

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

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

[in² • psi = lbf] or [mm² • MPa = N]

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

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

[in² • psi = lbf] or [mm² • MPa = N]

Maximum Allowable Actuator Velocity and Inertial Load without External Hard Stop

To protect against damage due to high velocity impact, the actuated system must be sized such that the maximum piston velocity and inertial load is maintained within the design limits of the VariStroke actuator. If the inertial load or velocity is higher than the rated design limits (see Figures 5-8, 5-9, and 5-10 below for applications without dump valve), an external hard stop must be incorporated such that the VariStroke actuator cylinder does not impact the internal end plates at high speeds during operation (particularly in the fail-safe direction).

For the Applications with Dump Valve the External Hard Stop is Always Required.

The figures shown below describe the relation between velocity and max inertia load. If the installed inertial load (mass) is higher, an external hard stop is required.

Required Return Force = The force needed to achieve proper piston velocity (for the applications without dump valve).

Max Allowable Inertia Load = The maximum installed mass of the driven load including the VariStroke piston rod, linkage, springs, valve, etc.

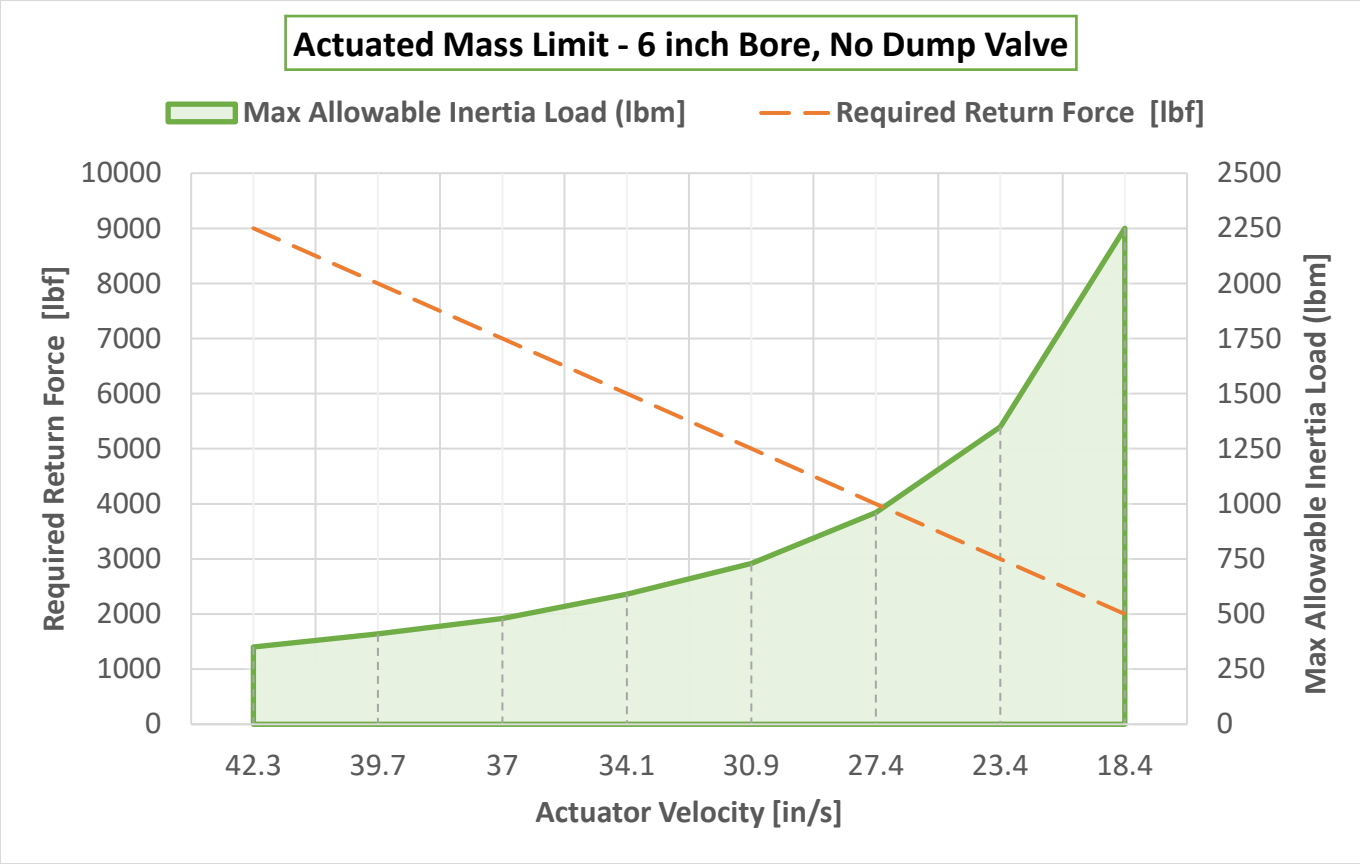


Figure 5-8. Actuated Mass Limit - 6-inch Bore, No Dump Valve

NOTICE

For a 6-inch bore, if the velocity is below 18.4 in/s the entire load may be provided as inertial load (mass).

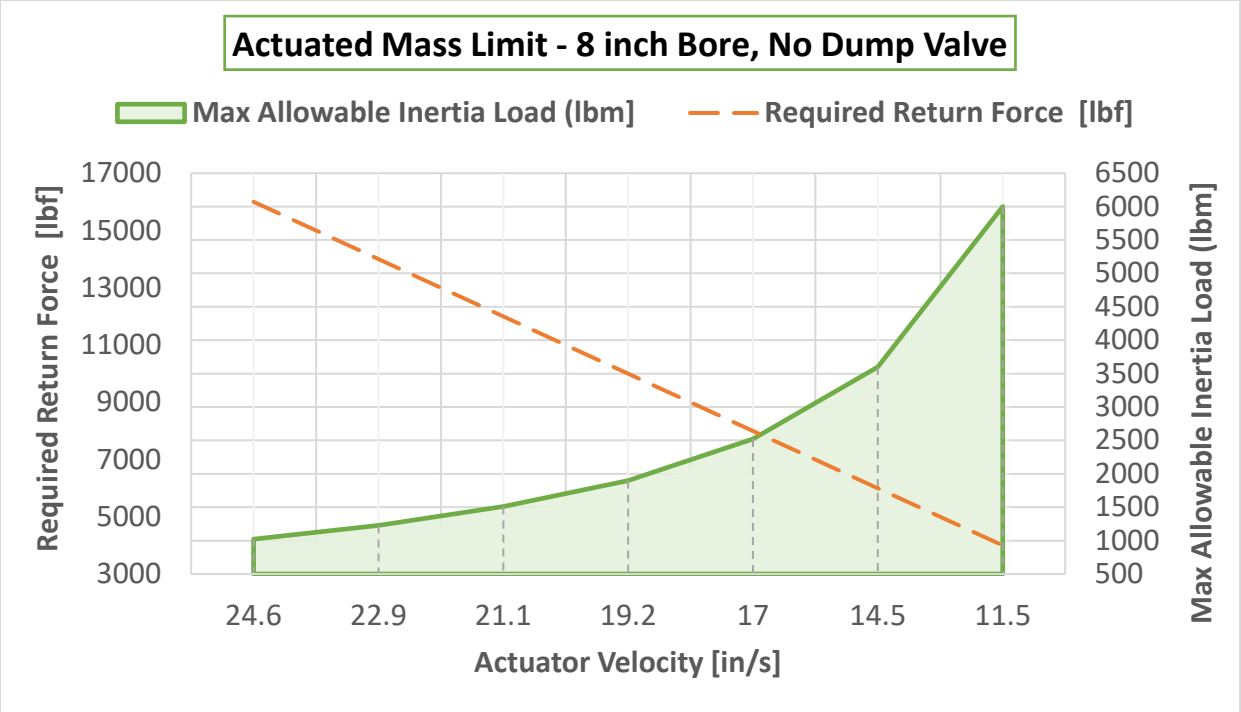


Figure 5-9. Actuated Mass Limit – 8-inch Bore, No Dump Valve

NOTICE

For an 8-inch bore, if velocity is below 11.5 in/s the entire load may be provided as inertial load (mass).

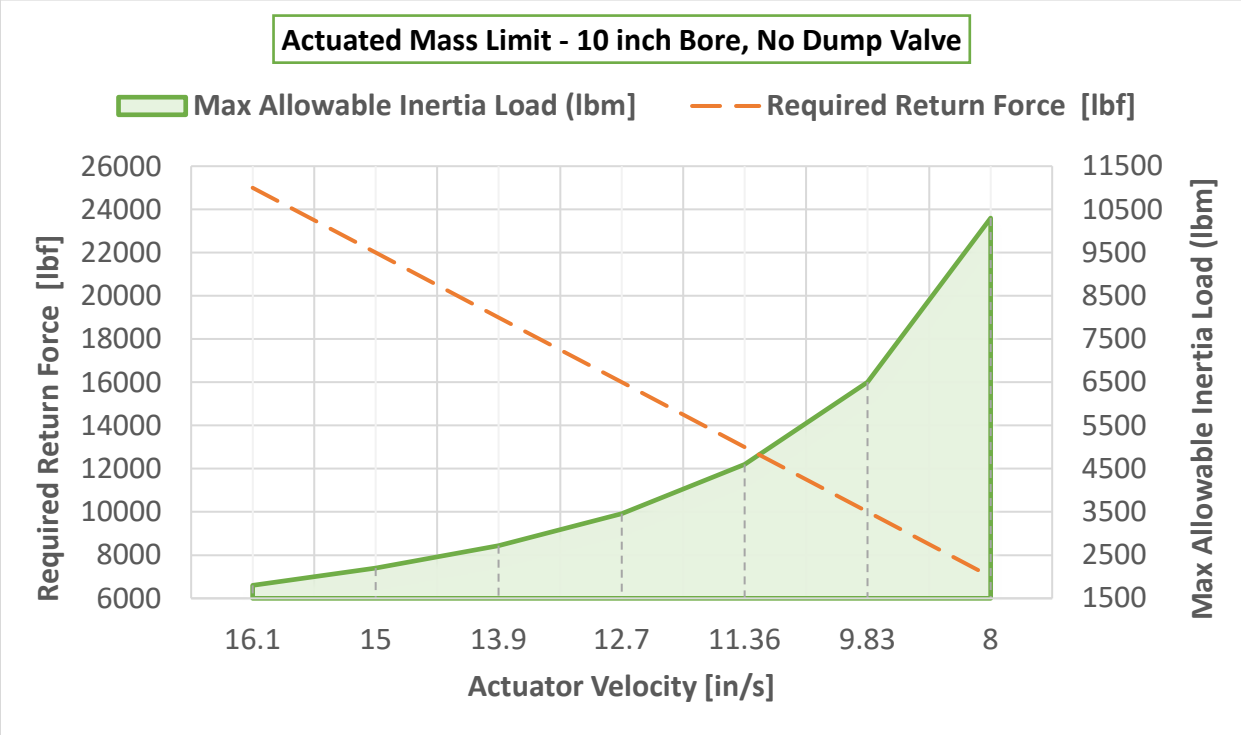


Figure 5-10. Actuated Mass Limit - 10-inch Bore, No Dump Valve

NOTICE

For a 10-inch bore, if velocity is below 8 in/s the entire load may be provided as inertial load (mass).

⚠WARNING

Due to very wide variety of cylinder applications and cylinder operating conditions, it is the user's responsibility to provide an external hard stop to prevent damage to the VariStroke actuator due to impact.

⚠WARNING

Excessive velocity or inertia load without inclusion of an external hard stop in the linkage can cause cylinder damage, loss of fluid containment, and loss of prime mover control. Woodward is not responsible for loss or damage resulting from such use.

External Hard Stop Location

If high velocity or a high inertial load is expected in the application, the placement of the external hard stop location is also critical for longevity. If the inertial load or velocity exceeds the design limits, the position of the external hard stop location must be offset from the internal cylinder stop (zero-cylinder position) according to the values listed in the following section.

If the inertial load exceeds the values presented on graphs above, the external hard stop must be installed at a position no closer than the minimum distances shown in the tables 5-4a through 5-4f depending on cylinder size below.

For the applications with dump valve, the external hard stop is always required.

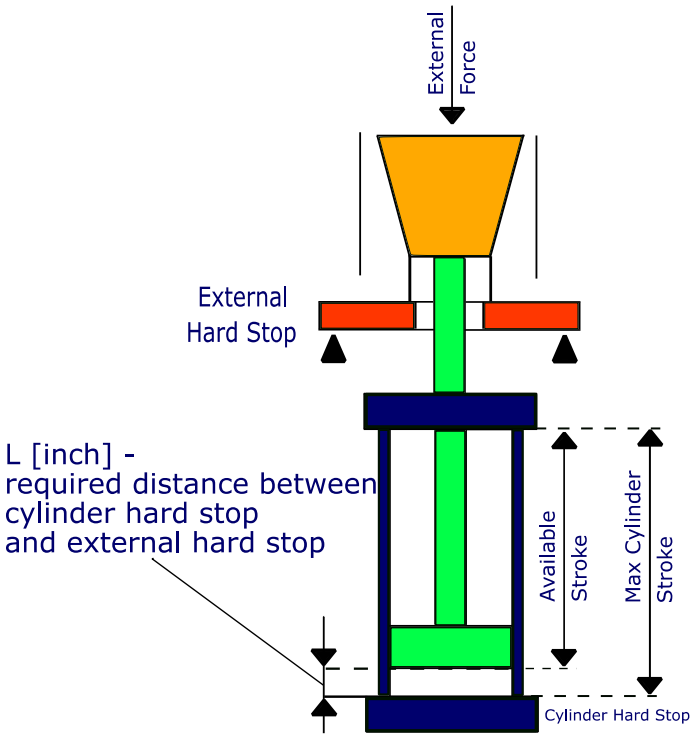


Figure 5-11. External Hard Stop

WARNING

Incorrect calculation or lack of testing of the final actuator velocity and/or inertia load without inclusion of an external hard stop can cause cylinder damage. Woodward is not responsible for loss or damage resulting from such use.

Table 5-4a. Minimum External Hard Stop Distance for 6 inch Bore Cylinder (Without Dump Valve)
Without Dump Valve 6-inch Bore

Inertial Load Range kgf (lbf)	Piston Velocity Range m/s (in/s)	"L" Minimum Hard Stop Distance mm (inch)
5126 – 2722 (11300 – 6000)	0.79 (31) or higher*	8.9 (0.35)
2721 – 1020 (5999– 2250)*	0.78 – 0.46 (30.9 - 18.4)*	6.1 (0.24)*

*For more info see Figure 5-8

Table 5-4b. Min. External Hard Stop Distance for 6 inch Bore Cylinder (With Dump Valve)
With Dump Valve 6-inch Bore

Inertial Load Range kgf (lbf)	Piston Velocity Range m/s (in/s)	"L" Minimum Hard Stop Distance mm (inch)
5126 – 2722 (11300 – 6000)	1.73 (68) or higher	14.0 (0.55)
2721 – 1474 (5999 – 3250)	1.72 - 1.50 (67.9 - 59)	12.4 (0.49)
1473 – 818 (3249 – 1804)	1.49 - 1.02 (58.9 - 40)	11.4 (0.45)
817 – 0 (1803 – 0)	1.01 - 0 (39.9 - 0)	7.8 (0.31)

Table 5-4c. Min. External Hard Stop Distance for 8 inch Bore Cylinder (Without Dump Valve)
Without Dump Valve 8-inch Bore

Inertial Load Range kgf (lbf)	Piston Velocity Range m/s (in/s)	"L" Minimum Hard Stop Distance mm (inch)
9126 - 4763 (20120 - 10500)	0.54 (21) or higher*	4.3 (0.168)
4762 -2721 (10499 – 6000)*	0.54 – 0.29 (20.9 – 11.5)*	3.5 (0.137)*

*For more info see Figure 5-9

Table 5-4d. Min. External Hard Stop Distance for 8 inch Bore Cylinder (With Dump Valve)
With Dump Valve 8-inch Bore

Inertial Load range kgf (lbf)	Piston Velocity Range m/s (in/s)	"L" Minimum Hard Stop Distance mm (inch)
9126 - 4672 (20120 - 10300)	1.50 (59) or higher	12.4 (0.49)
4671 - 2268 (10299 - 5000)	1.49 - 1.02 (58.9 - 40)	11.4 (0.45)
2267 - 1134 (4999 - 2500)	1.01 - 0.66 (39.9 - 26)	7.8 (0.31)
1133 - 0 (2499 - 0)	0.65 - 0 (25.9 - 0)	4.3 (0.168)

Table 5-4e. Min. External Hard Stop Distance for 10 inch Bore Cylinder (Without Dump Valve)
Without Dump Valve 10-inch Bore

Inertial Load Range kgf (lbf)	Piston Velocity Range m/s (in/s)	"L" Minimum Hard Stop Distance mm (inch)
14515 - 7682 (32000 - 16935)	0.33 (13.02) or higher*	4.1 (0.162)
7681 - 4672 (16934 - 10300)*	0.32 – 0.2 (13.01 - 8)*	3.5 (0.137)*

*For more info see Figure 5-10

Table 5-4f. Min. External Hard Stop Distance for 10 inch Bore Cylinder (With Dump Valve)
With Dump Valve 10-inch Bore

Inertial Load Range kgf (lbf)	Piston Velocity Range m/s (in/s)	"L" Minimum Hard Stop Distance mm (inch)
14515 - 7535 (32000 - 16613)	0.93 (36.6) or higher	8.9 (0.35)
7534 - 3685 (16612 - 8065)	0.92 - 0.63 (36.5 - 24.8)	7.9 (0.31)
3684 - 1829 (8064 - 4032)	0.62 - 0.41 (24.7 - 16.2)	4.9 (0.192)
1828 - 0 (4031 - 0)	0.4 - 0 (16.1 - 0)	4.3 (0.168)

IMPORTANT

See tables "Min External Hard Stop distance" for proper "L" distance between cylinder hard stop and external hard stop.

⚠WARNING

Incorrect calculation or lack of testing of the final actuator velocity and/or inertia load, without inclusion of an external hard stop can cause cylinder damage. Woodward is not responsible for loss or damage resulting from such use.

Minimum Load Requirements for Cylinder Calibration

To perform proper cylinder calibration, an external assisting load sufficient to overcome the actuator friction is required. The minimum recommended external assisting load for calibration is listed in Table 5-5 below:

Table 5-5. Min Calibration Inertia Load

		Cylinder Bore Size mm (inch)		
		152 (6)	**203.2 (8)**	**254.0 (10)**
Min assisting load kgf (lbf)	Fail Extend	108 (240)	185 (410)	290 (640)
	Fail Retract	131 (290)	231 (510)	362 (800)

The VariStroke minimum and maximum stroke positions should be calibrated within the range allowed by the external end stops and including the recommended minimum hard stop distance to prevent controller saturation. See instructions in the VariStroke Customer Service Tool manual 35148 for instructions on calibration.

Electrical Connections

The figure below shows an overall electrical wiring diagram.

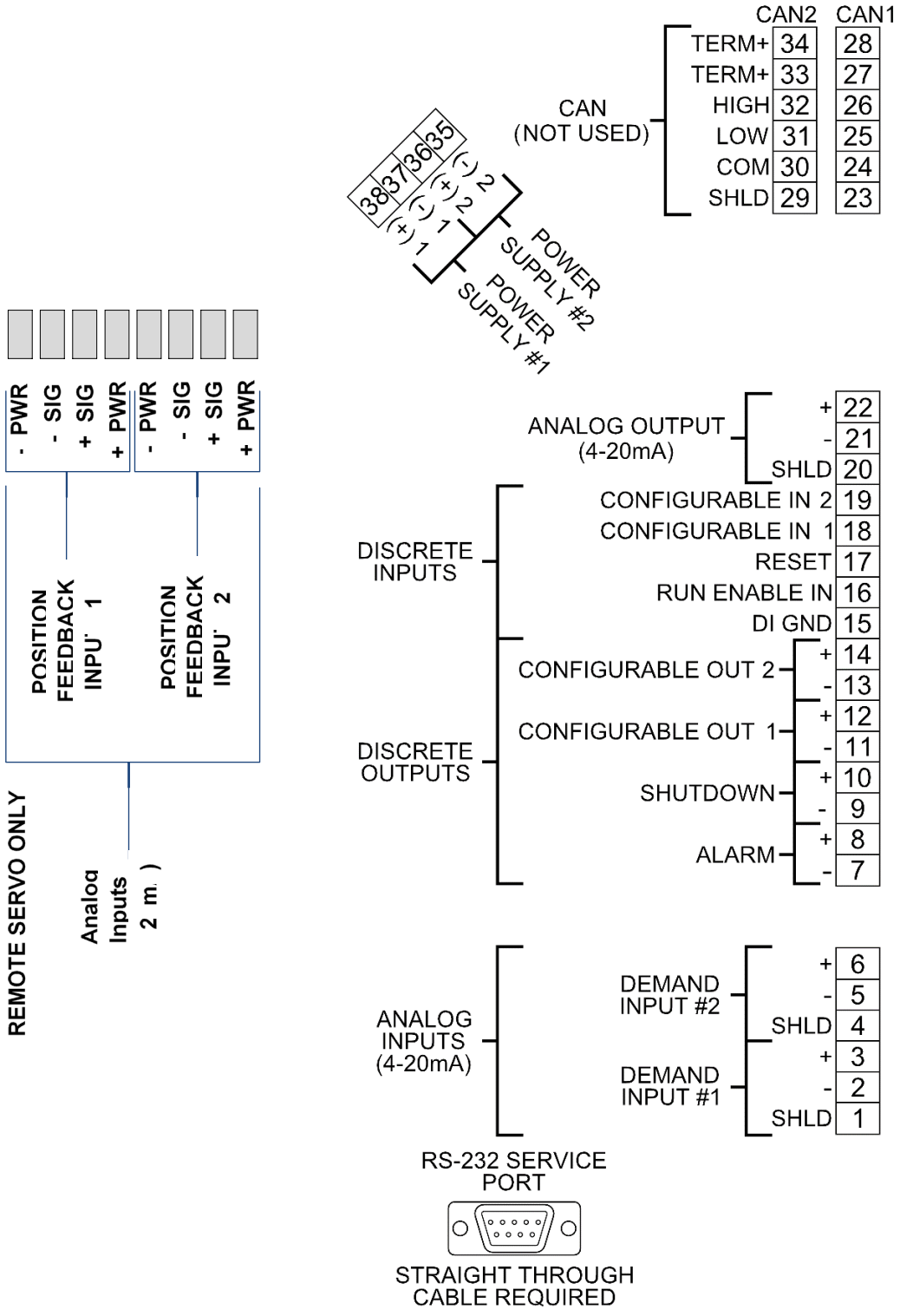


Figure 5-12. Electrical Wiring Diagram

Servo Cover

To access the PCBA and wiring terminals, remove the servo cover. Loosen the locking setscrew first by rotating counterclockwise (Hex key; size 1.5 mm). Remove the cover from the servo valve by rotating counterclockwise (flat wrench; size 2.25 inch).

⚠WARNING

Take care not to damage cover sealing surfaces or threads during removal or installation. Damage to these joints may compromise the ingress or explosion protection ratings of the product. Prior to replacing the cover(s), inspect the seal and mating faces on each part. Clean the surfaces with rubbing alcohol if necessary.

Proper torque is critical for the function of these joints. Refer to figures in the installation chapter and drawings in the Appendices for the correct torque procedure for all covers.

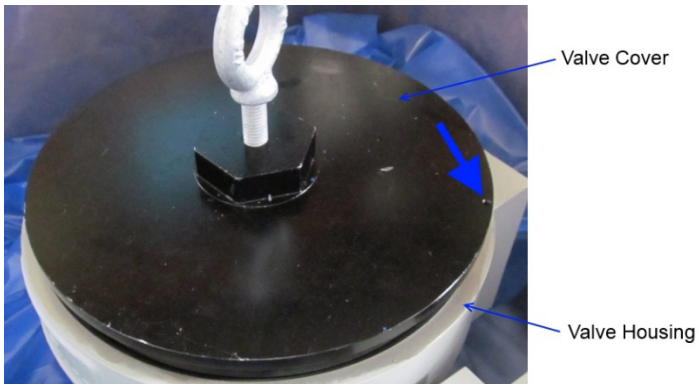


Figure 5-13. Servo Cover

Connect the control wiring to the terminal blocks, then insert the terminal block plugs in the headers, and tighten the header retaining screws. For REMOTE SERVO ONLY, see the page below for position sensor wires installation.

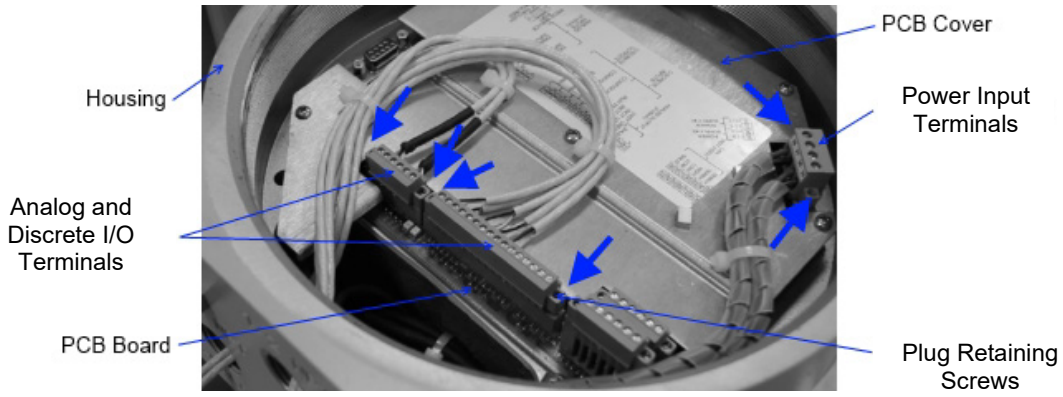


Figure 5-14. Electrical Adapters

Once the wires are connected, install the electronics cover onto the valve housing. Note: Use caution to not cross thread the cover. Turn the cover until the threads engage to align the cover with the threads of the housing. Turn the cover by hand to thread onto the housing until the O-ring is compressed against the housing. Use torque wrench if available; recommended torque setting is 90 to 100 LB-FT. As a last step, tighten the locking setscrew until flush with the top surface of the cover; the recommended torque setting is 5.5 to 6.2 lb-in.

To install the position sensor wires for REMOTE SERVO ONLY, disassembling the PCBA cover is required.

For PCBA cover disassembly/assembly see steps below:

Disassembly:

- Using the PH2 screwdriver, remove the seven screws from the PCB cover.

Note: There are two different screw lengths (L – long, S – short); see picture below.

WARNING

Do not touch the components or conductors on a printed circuit board (PCBA) with your hands or with conductive devices. Make sure that no contamination or debris is left on the PCBA surface.

Assembly:

- Using the 2.5 X 0.4 mm screwdriver, connect the cylinder position sensor wires to the PCB. The order of the sensor's installation is unimportant. Sensors are equivalent. After tightening screws, tug on the wires to verify they are firmly connected.
- Install the seven screws into the PCB cover. Torque to 12 ±1 lb-in (1.2 to 1.5 N·m).

Note: There are two different screw lengths (L – long, S – short); see picture below.

- Install all electrical wires. Ensure that power and signal wires use separate conduit entrances.

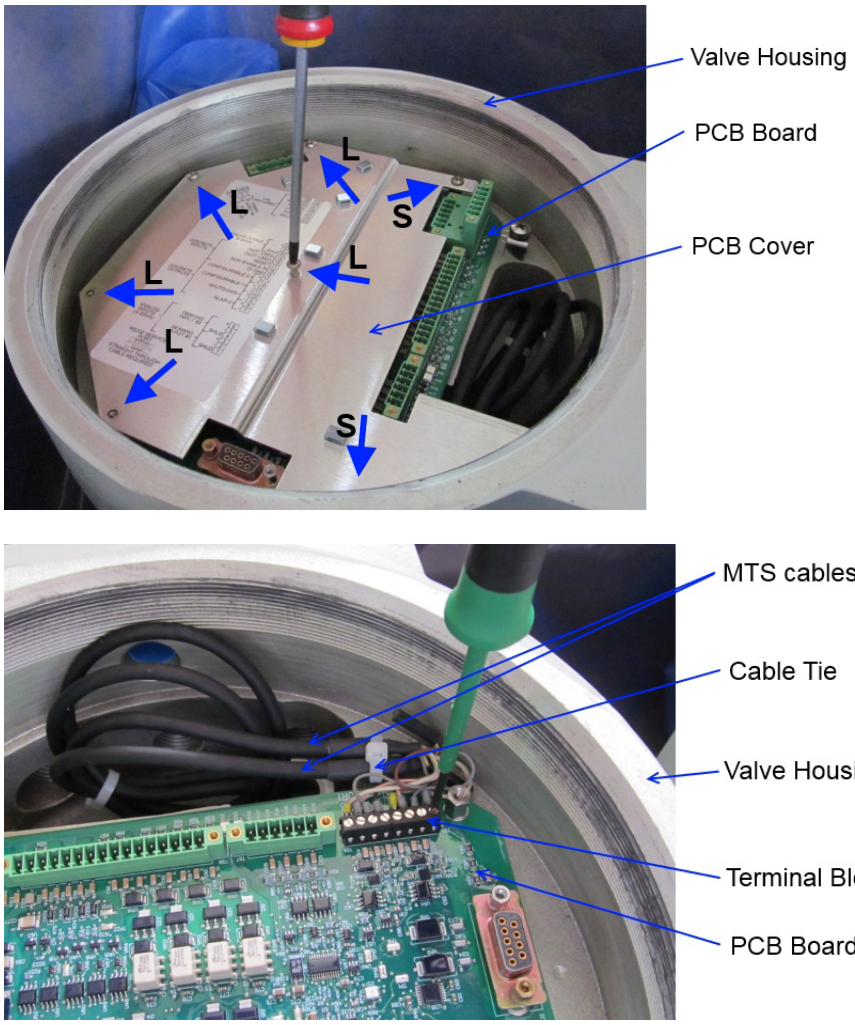


Figure 5-15. Remote Servo Only, PCBA Cover Removal

Input Power

The VS-I requires a power source capable of supplying the necessary output voltage and current at full transient conditions. The electrical power supply should be able to support current requirements listed in Table 5-6.

High input current transients can be drawn during rapid movement. The recommendations below include the transient nature of the electrically driven actuator system.

Correct cable selection and sizing are critical 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.

IMPORTANT

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 5-6. Recommended Fuse Ratings or Circuit Breakers.

Temperature Range	-40°C to +85°C
Voltage Range	18 VDC to 32 VDC 24 VDC Nominal
Continuous Input Current	3.1 A
Transient Input Current [1]	10 A, 100 ms
Current limit mode	8A, 3s
Fuse	10 A Slow Blow
Circuit Breaker	10 A minimum

Note: [1] - These numbers represent the maximum possible VariStroke current draw under worst case operating conditions.

⚠CAUTION

The circuit breaker must be suitably located and easily reached and must be marked as the disconnecting device for the equipment.

Recommendations for Dual and Simplex Power Wiring:

The VariStroke is provided with power terminals suitable for the required voltage and current level. Two positive and two negative terminals are each sized for up to 12 AWG.

Provisions for separate, redundant power supplies are provided by dual inputs. Each of the inputs is diode isolated from the main input bus. If one of the power supplies fails, the VariStroke will continue to operate normally using the functioning power supply.

If a single power source is used to supply power to the VS-I, jumpers should be used to apply power to both sets of input power terminals. The purpose of these jumpers is to ensure that the power supplied from the source is distributed equally to the two driver inputs. This minimizes the power dissipated in each of the driver input diodes for reduced heat load and improved reliability.

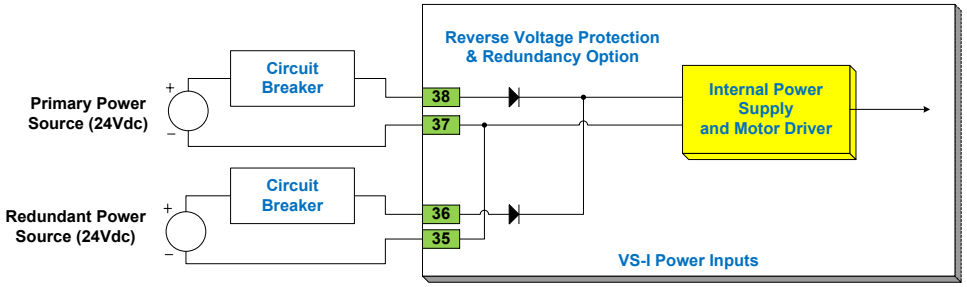


Figure 5-16. Power Supply Input Connections

The VS-I can connect to two redundant power supplies.

Table 5-7. 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 on the terminal.

Additionally, both (-) signals (terminal #35 and terminal #37) should be connected 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.

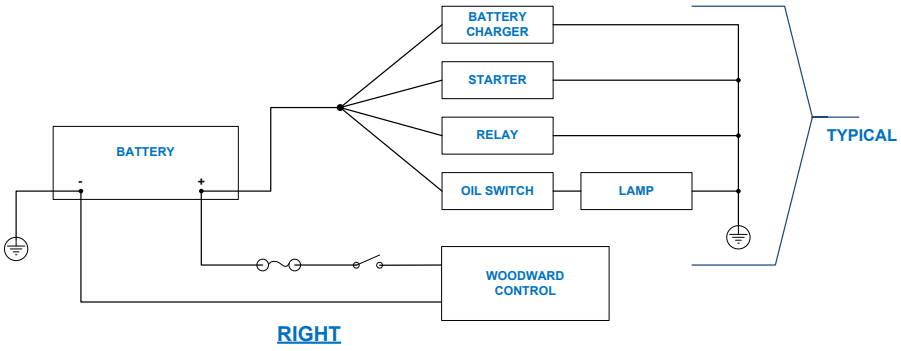


Figure 5-17. Correct Wiring to Power Supply Input

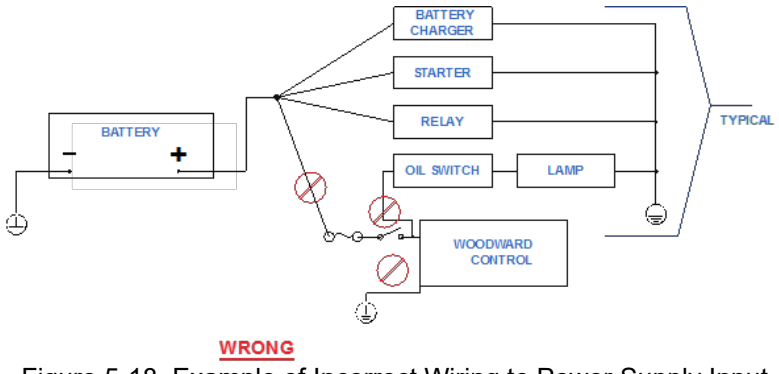


Figure 5-18. Example of Incorrect Wiring to Power Supply Input

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

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

American Wire Gauge Voltage Drop

A standard wire gauge voltage drop at maximum ambient temperature is provided in Table 5-8 to assist with cable selection.
A guideline for allowable voltage drop is to size the wire for <10% of the nominal voltage under maximum transient conditions.

Table 5-8. Voltage Drop Using American Wire Gauge (AWG)

Wire Gauge (AWG)	Voltage Drop per Meter @ 10 A Round-Trip (V)	Voltage Drop Per Foot @ 10 A Round-Trip (V)
12	0.131	0.040
14	0.208	0.063
16	0.331	0.101

Voltage Drop Calculation Using American Wire Gauge
Example: A 12 AWG wire will drop 0.040 V/ft at 10 A at maximum ambient temperature. Using 100 feet between the VariStroke and the power supply would provide a voltage drop of 100x0.040 = 4.0V. It is very important to ensure the voltage at the VS-I's input terminal is within the product power input specification to achieve the maximum performance.

Wire Cross-Sectional Area Voltage Drop
A standard wire cross-sectional area voltage drop at maximum ambient temperature is provided in Table 5-9 to assist the cable selection.

Table 5-9. Voltage Drop Using Wire Cross-Sectional Area (mm^2)

Wire Gauge (mm^2)	Voltage Drop per Meter @ 10 A Round-Trip (V)	Voltage Drop Per Foot @ 10 A Round-Trip (V)
4	0.108	0.033
2.5	0.174	0.053
1.5	0.289	0.088

Example of Voltage Drop Calculation Using Wire Cross-Sectional Area
A 2.5mm^2 wires will drop 0.174 V/m at 10 A at maximum ambient temperature. Using 30m between the VariStroke and the power supply would provide a voltage drop of 30 x 0.174 = 5.22V.

It is very important to ensure the voltage at the VS-I's input terminal is within the product power input specification to achieve the maximum performance.

A guideline for allowable voltage drop is to size wire for <10% of the nominal voltage under maximum transient conditions.

Extended Power Input

The Power Wiring Requirements section above specifies the maximum length of 30 meters between the power source and the VS-I. Installations that require a longer power cable run also require a much larger wire gauge for most of the run to account for voltage drop. A voltage stabilizing capacitor near the VS-I may also be required to help under transient conditions. Figure 5-19 below gives a possible solution for installations required to run at longer distances.

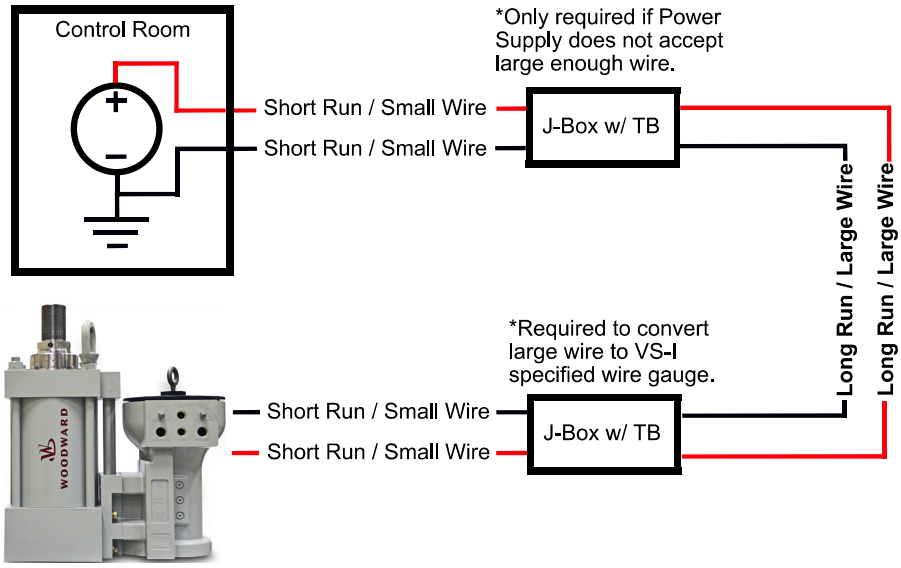


Figure 5-19. Example of wire gauge step-up, step-down to achieve longer runs

The total voltage drop is the sum of the voltage drops across the power cable and extension cable(s). Ensure the wire gauge of the extension cable is selected to comply with power input voltage range requirements.

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.

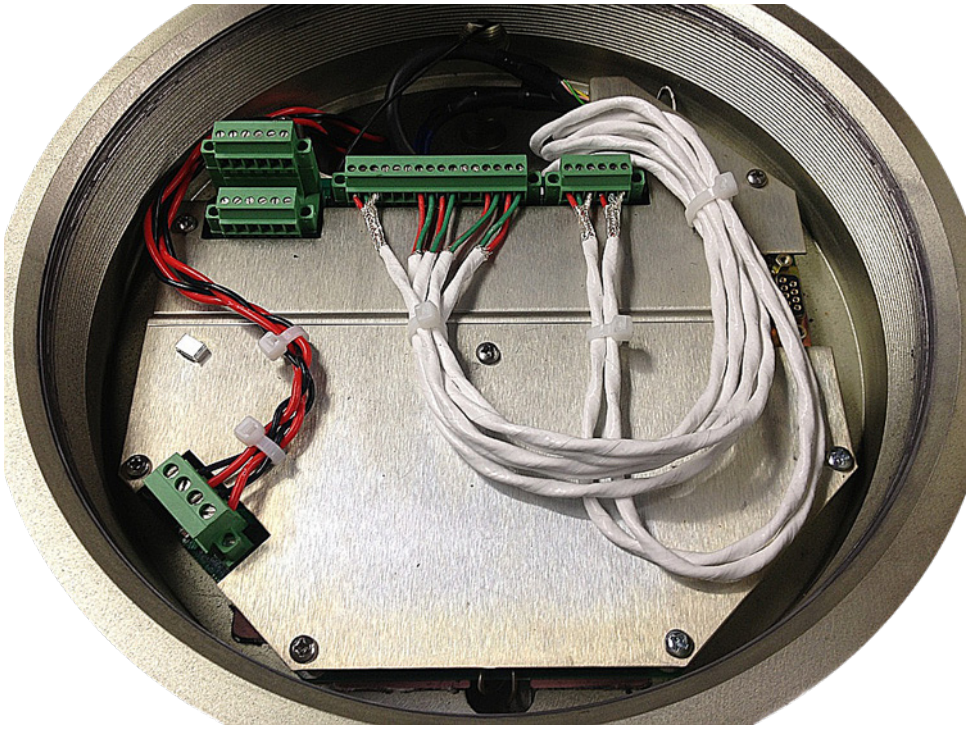


Figure 5-20. Recommended Wiring Strain Relief

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 the diameter should be maximized where possible.
- Installations with severe electromagnetic interference (EMI) may require additional shielding precautions. Contact Woodward for more information.
- Do not ground shield on both ends, except when 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.

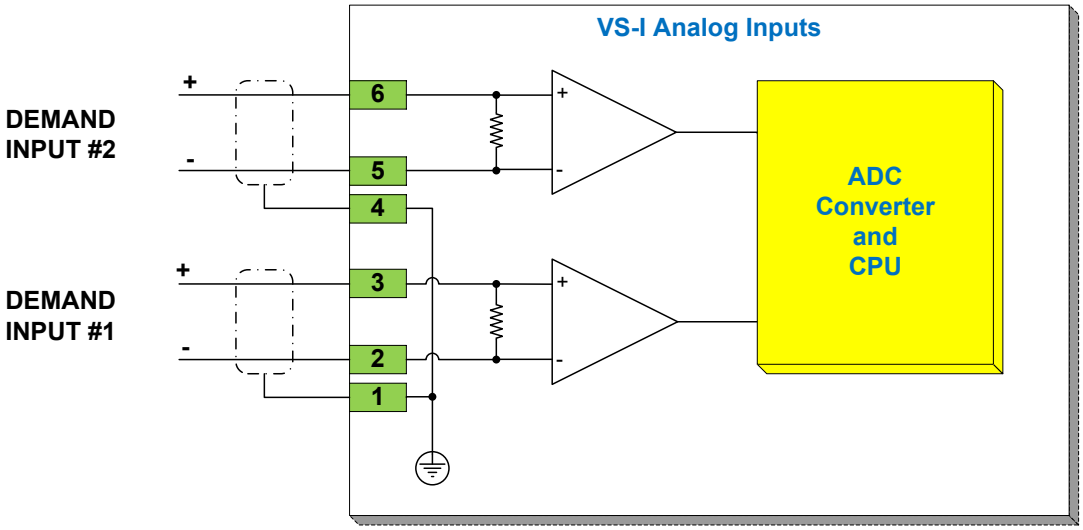


Figure 5-21. Analog Input Connections

Table 5-10. Demand Analog Inputs

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
- Recommended analog input maximum distance is 100m due to the criticality of the signal positioning the VS-I. Cable length may be increased if appropriate actions are taken to verify signal integrity and reduce noise at longer distances.
- 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 Customer Service Tool manual for information on configuring these inputs.

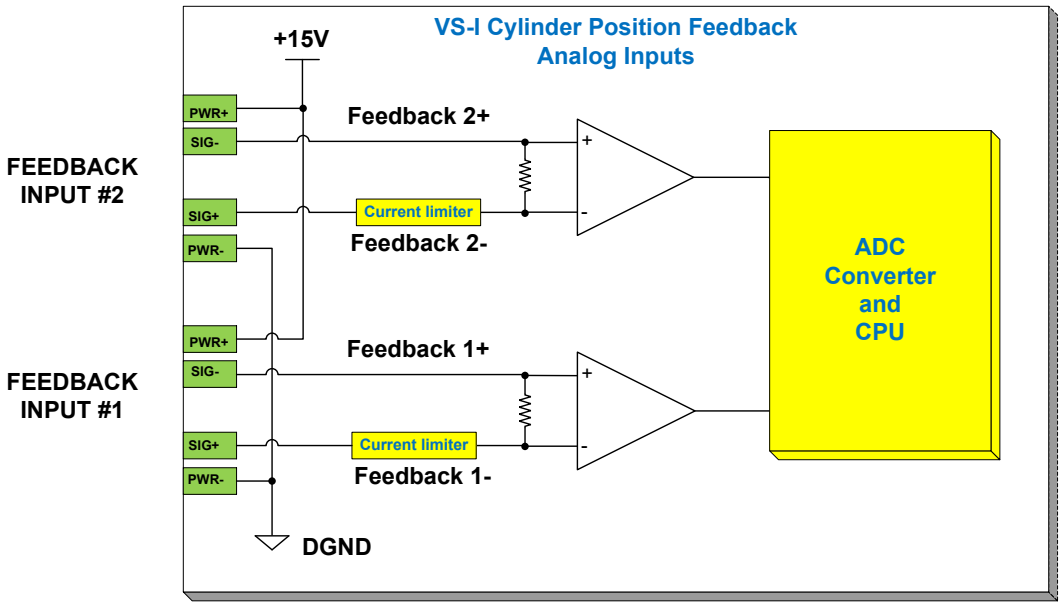


Figure 5-22. Final Cylinder Position Feedback Analog Input Connections

Table 5-11. Analog Inputs (Remote Servo)

Input Range:	(0 to 25) mA. The recommended maximum range is (2 to 21) mA, where ~4mA means piston retracted and ~20mA piston extended (this is valid for both fail direction variants).
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

IMPORTANT

The VariStroke will always interpret the Cylinder Position Feedback signal the same, regardless of the fail direction. Small current (~4mA) position signal always designates a retracted position. Larger current (~20mA) position signal always designates an extended position.

⚠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.

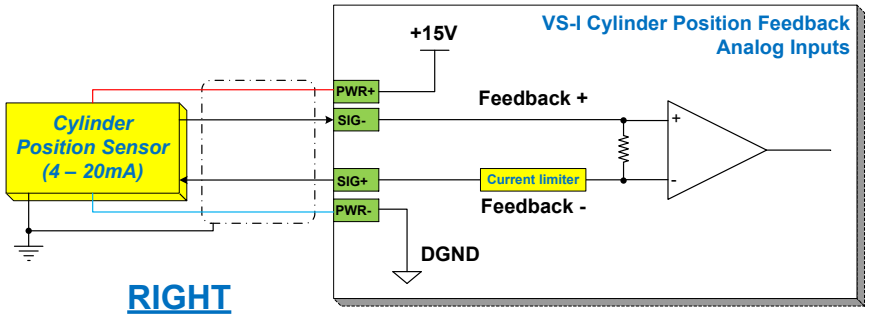


Figure 5-23. Cylinder Position Sensor Wiring Diagram When Using Vs-1 Internal Power

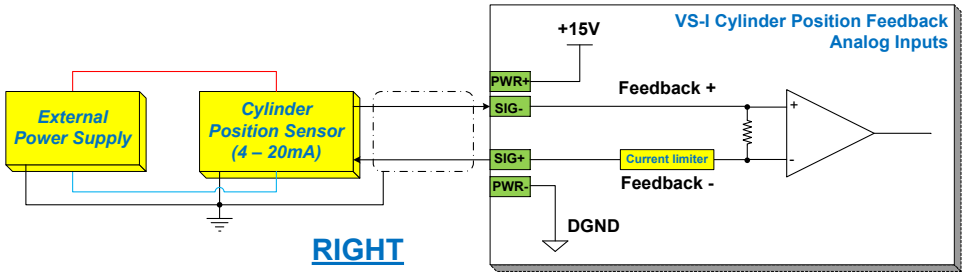


Figure 5-24. Cylinder Position Sensor Wiring Diagram When Using External Power Supply

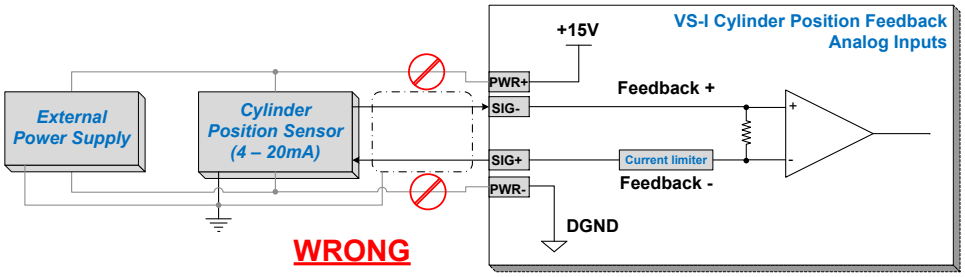


Figure 5-25. Example of Incorrect Cylinder Position Sensor Connection When Using External Power Supply

⚠WARNING

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

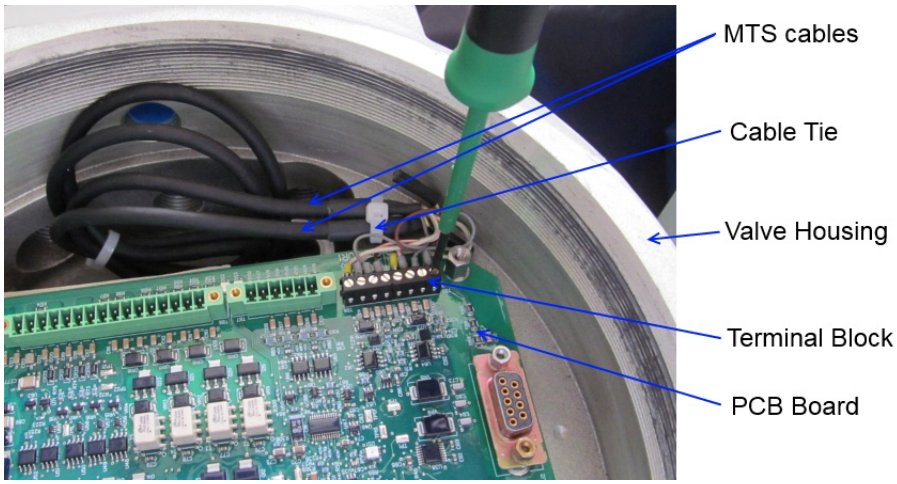


Figure 5-26. Cylinder Position Connectors

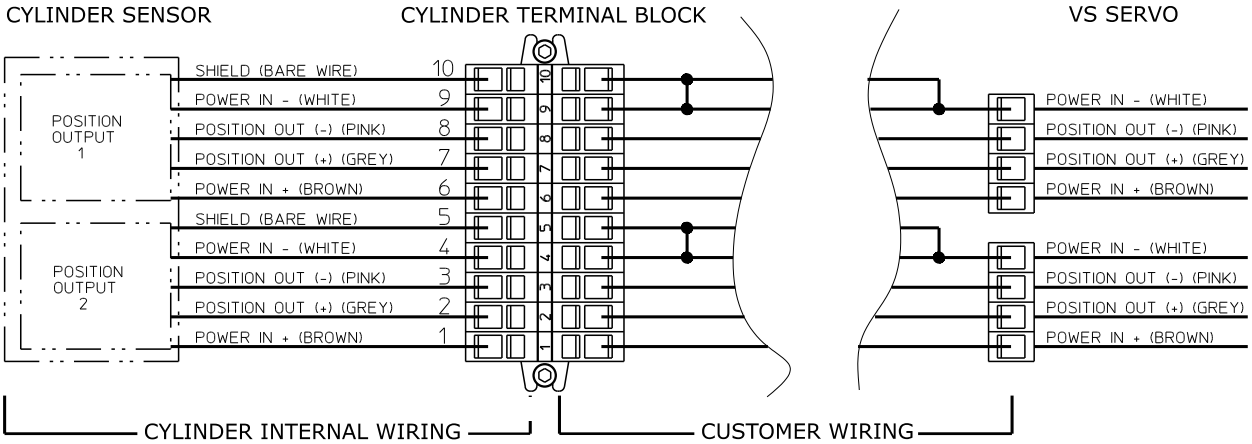


Figure 5-27. Cylinder Position Sensor Connection Scheme with MTS Sensor

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-GI is in the form of a 4 to 20 mA output and can drive load resistance from 0 up to 500 Ω. This output is configurable. Refer to the Customer Service Tool manual 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.

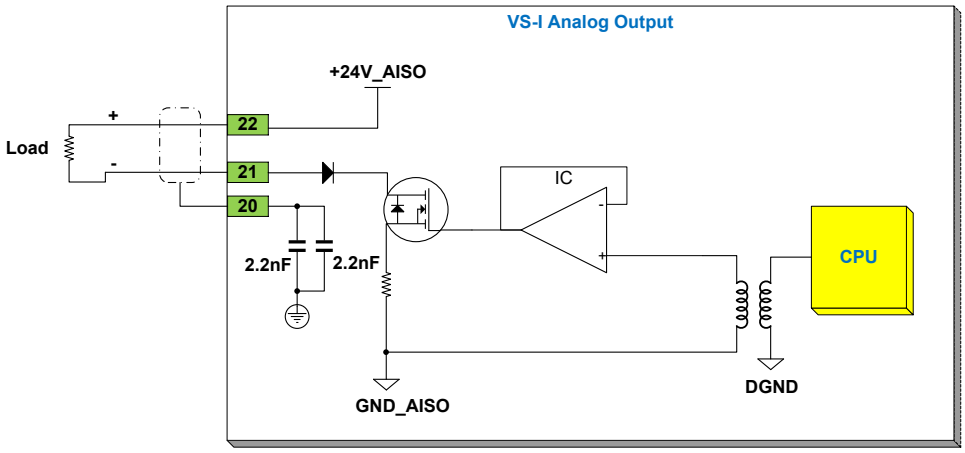


Figure 5-28. Analog Output Connection

Table 5-12. Analog Outputs

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-GI 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 ground terminal if more than one input is used.

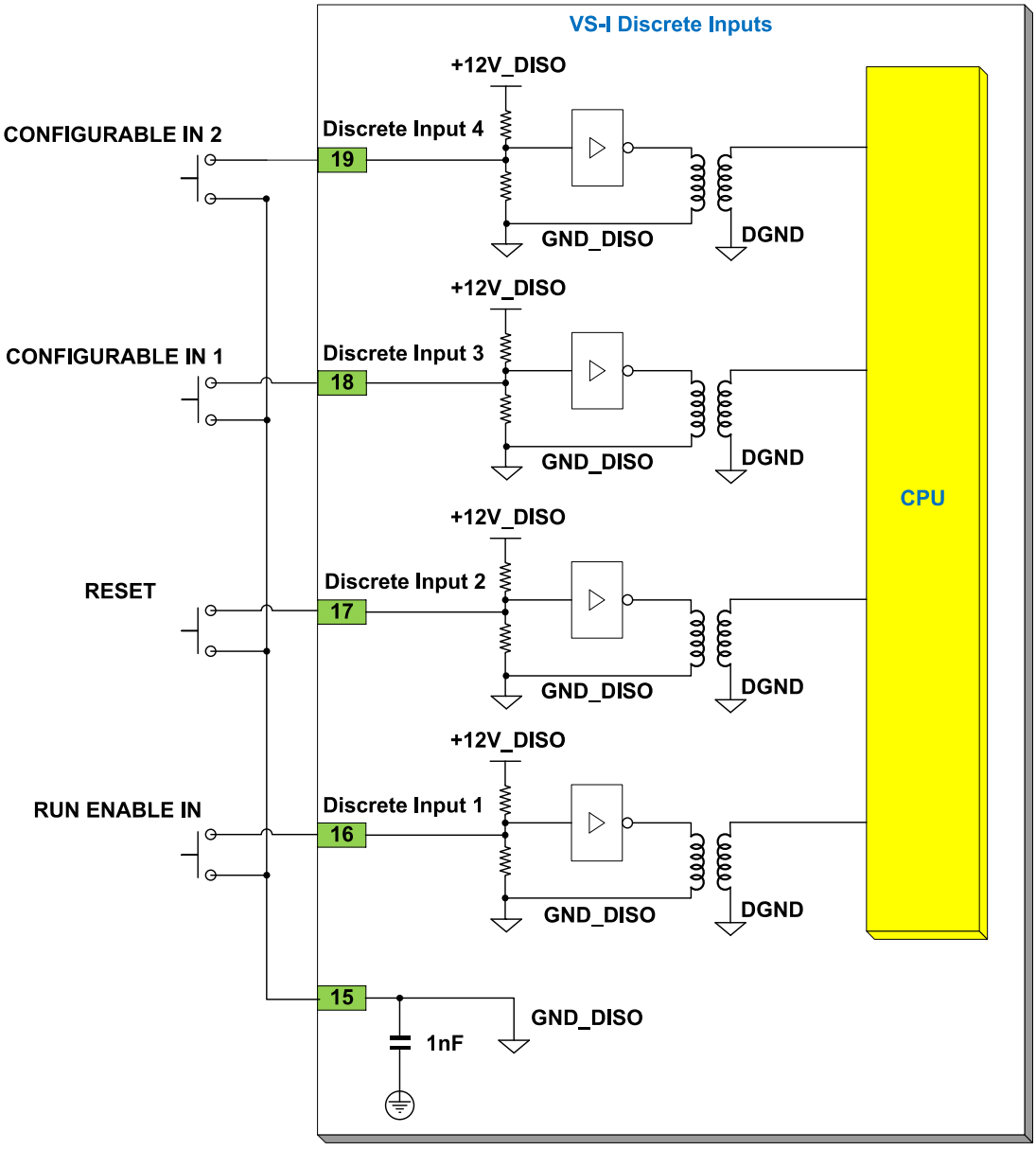


Figure 5-29. Discrete Inputs Connections

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 a 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 the VS-I. Configuration of the outputs is normally open/normally closed. Refer to the Customer Service Tool manual for configuration information. Wire the outputs to switch load from positive supply or to the 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 the ground more detectable in the user system. The user must supply the external 24 V supply for the output to function properly.

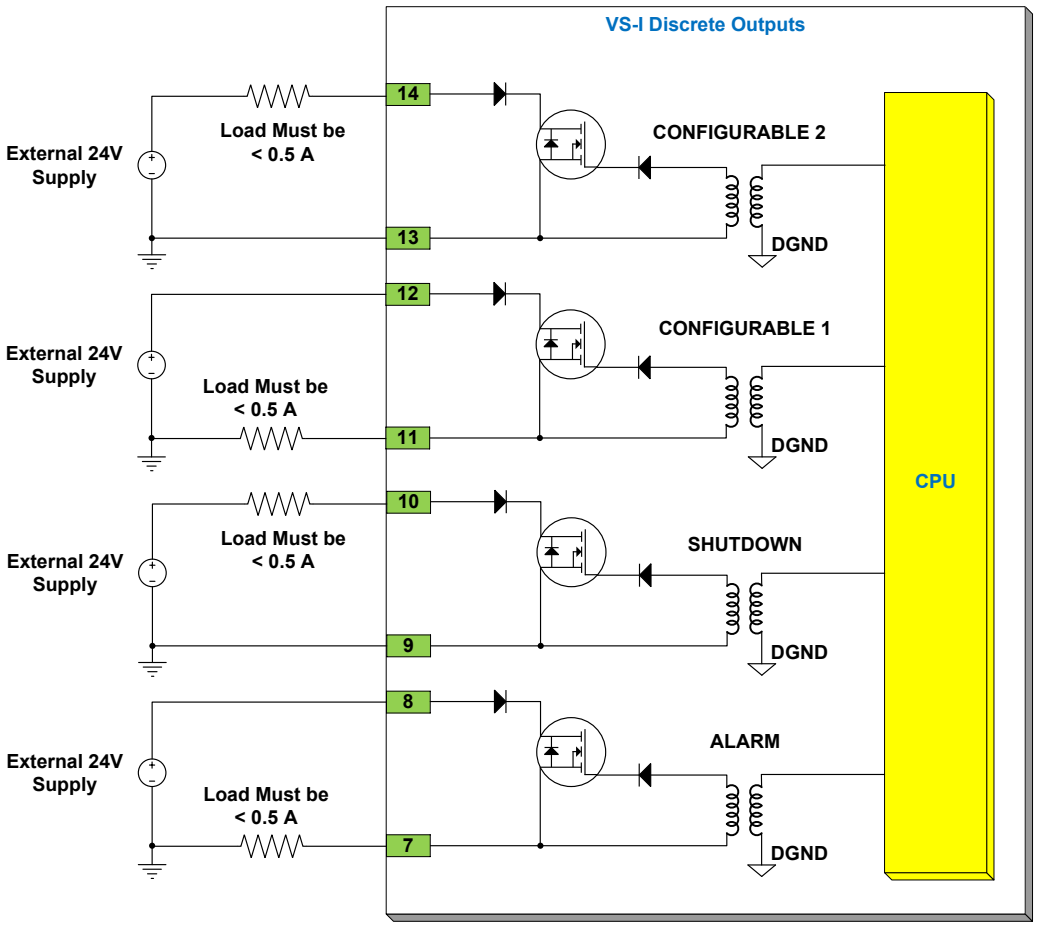


Figure 5-30. Discrete Output Connections

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.

Table 5-13. Discrete Outputs

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-GI models.

The VS-GI has two terminal blocks to support the connections to redundant CAN control networks. However, the PCB firmware currently does not support CAN communication functionality.

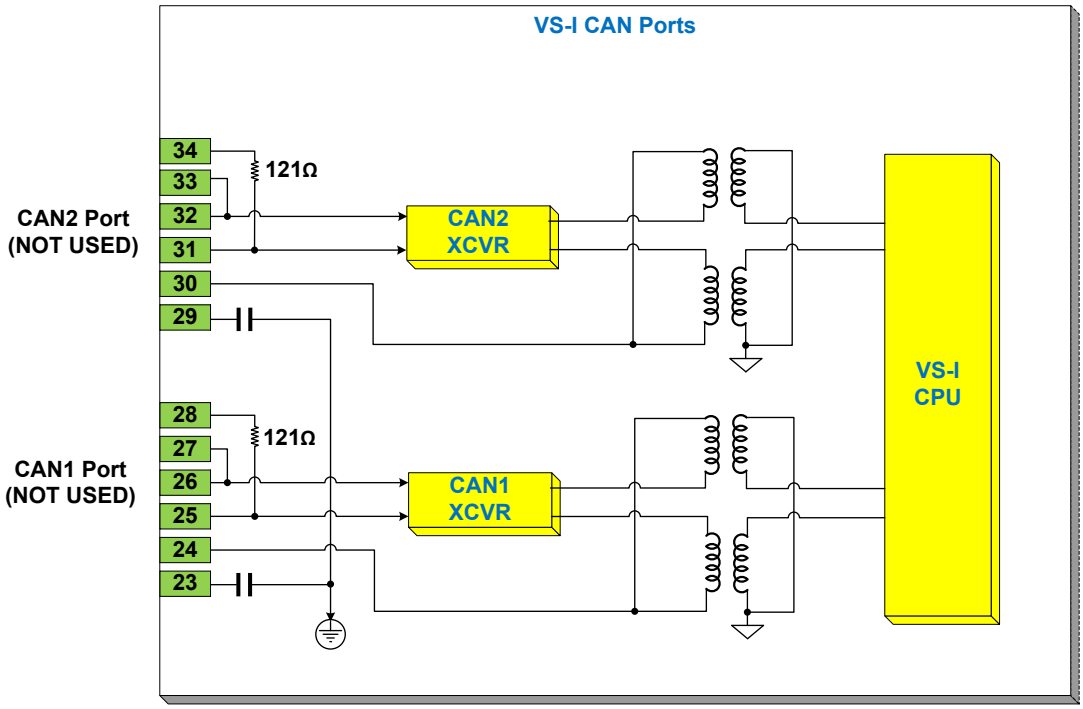


Figure 5-31. CAN Ports Connections

Table 5-14. CAN Specifications

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 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-GI 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.

Configuration and Calibration

The VariStroke-I configuration and calibration process is covered by the Customer Service Tool, which communicates with VS-I electronics via a serial connection to RS-232. Detailed instructions are provided in manual 35148 *Customer Service Tool for VariStroke-I Electrohydraulic Actuator.* The manual provides initial setup instructions, in addition to detailed descriptions of how to enable and/or configure various features and functions of the VariStroke-I actuator family using the Customer Service Tool.

Using the Customer Service Tool, several features can be setup:

- Input/Output configuration
- Demand linearization
- Hydraulic cylinder setup
- Automatic cylinder stroke calibration
- Dynamics settings
- Dither, silt buster features activation
- Alarms/shutdowns details and configuration
- Detailed diagnostics and data trending
- Manual operation

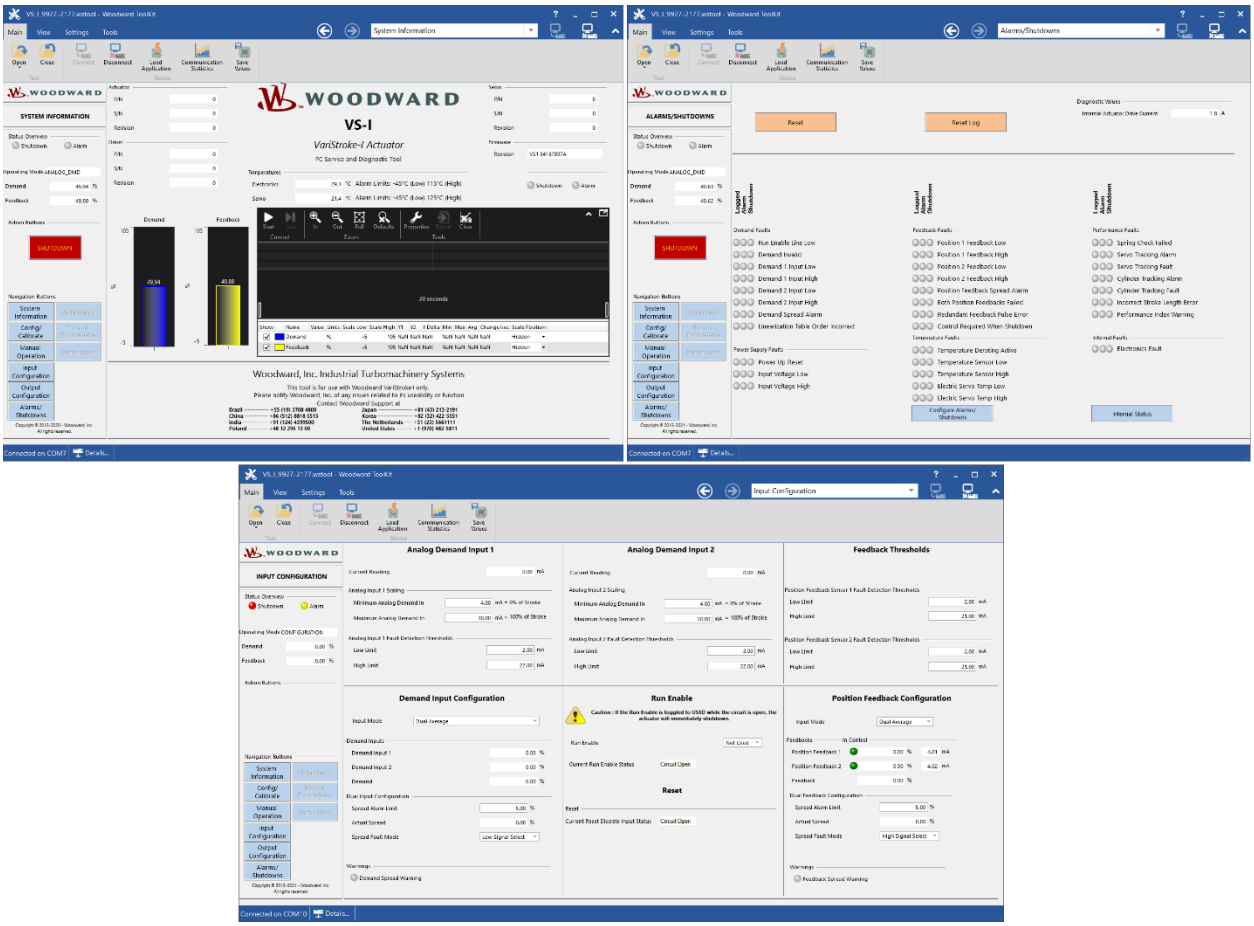


Figure 5-32. Customer Service Tool Example Pages

Chapter 6.
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-GI actuator.

General

The VariStroke-GI 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-GI 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.

Plugs Kit for ZONE 1:
8923-3203 SERVO PLUGS, ZONE 1, KIT

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

Spare Parts

Before performing any repairs or replacement procedures to the VS-I, all product support options listed in Chapter 7 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 Components Maintenance Manual CMM-03002.

Level of Service (review each kit for available service level, see tables below):

- Gold Level – can be performed only by Woodward
- Silver Level – can be performed only by Woodward or Service Centre (AISF)
- **Bronze Level** - can be performed by Woodward, Service Centre (AISF), and **End User (customer)**

The tables below show the common spare parts:

Table 6-1. Servo, Integrated – Replacement Kits

Servo, Integrated

Replacement Kit Number	Replacement Kit Description	Components Maintenance Manual (CMM)	Installation Drawing Number	Servo Type	Level of Service
9907-2340	Integrated Servo V45	CMM-03002	9999-1590-20	V45 GI INTEGRATED, Fail Extend	Gold, Silver, Bronze
9907-2341				V45 GI INTEGRATED, Fail Retract	
9907-2342				V45 GI INTEGRATED, Fail Extend, TTV	
9907-2343				V45 GI INTEGRATED, Fail Retract, TTV	

Table 6-2. Servo, Remote – Replacement Kits

Servo, Remote

Replacement Kit Number	Replacement Kit Description	Components Maintenance Manual (CMM)	Installation Drawing Number	Servo Type	Level of Service
9907-2117	Remote Servo V45	CMM-03002	9999-1895	V45 GI Remote, Fail Extend	Gold, Silver, Bronze
9907-2116				V45 GI Remote, Fail Retract	
9907-2130				V45 GI Remote, Fail Extend, TTV	
9907-2131				V45 GI Remote, Fail Retract, TTV	

Table 6-3. Cylinder Rod Seals – Replacement Kits

Cylinder Rod Seals

Replacement Kit Number	Replacement Kit Description	Components Maintenance Manual (CMM)	Installation Drawing Number	Cylinder Size	Level of Service
8935-1216-15	Cylinder Rod Seals	CMM-03002	9999-1590-7	6-inch bore	Gold, Silver, Bronze
8935-1216-20				8-inch bore	
8935-1216-25				10-inch bore	

Table 6-4. Cylinder Seals – Replacement Kits

Cylinder Seals (No Spring Assist Version)

Replacement Kit Number	Replacement Kit Description	Components Maintenance Manual (CMM)	Installation Drawing Number	Cylinder Size	Level of Service
8935-1215-15	Seal Kits (soft components) standard version	CMM-02003	9999-1590-7	6-inch bore	Gold, Silver
8935-1215-20				8-inch bore	
8935-1215-25				10-inch bore	

Table 6-5. Cylinder Seals, Spring Assist – Replacement Kits

Cylinder Seals, Spring Assist

Replacement Kit Number	Replacement Kit Description	Components Maintenance Manual (CMM)	Installation Drawing Number	Cylinder Size	Level of Service
8935-1215-15	Seal Kits (soft components) – spring assist versions	CMM-02003	9999-1590-14	6-inch bore	Gold, Silver
8935-1215-20				8-inch bore	
8935-1215-25				10-inch bore	

Table 6-6. Position Sensor – Replacement Kits

Position Sensor

Replacement Kit Number	Replacement Kit Description	Components Maintenance Manual (CMM)	Installation Drawing Number	Cylinder Stroke	Level of Service
8935-1211-05	CYLINDER MTS REPLACEMENT KIT (position sensor)	CMM-02003	9999-1590-8	2-inch	Gold, Silver
8935-1211-07				3-inch	
8935-1211-10				4-inch	
8935-1211-15				6-inch	
8935-1211-20				8-inch	
8935-1211-25				10-inch	
8935-1211-30				12-inch	

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. Troubleshooting beyond this level is recommended 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-GI 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 6-7. VS-GI General Troubleshooting Guide

Problem	Cause	Remedy
Shut down Detection: Shut down command sent by Customer 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 shutdown position has been commanded from an external source, i.e., Customer 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-GI for normal operation. Shut down the analog input(s) and restore them to a range within the normal 4-20 mA control range to initiate a reset. Ensure the VS-I has a valid demand signal.
	Unexpected command from digital communication.	Take away command and reset VS-GI for normal operation.
	Discrete input wiring problem.	Fix wiring problem.
	Run enable configuration problem.	Ensure the used/not used settings inside the VS-GI match the active/inactive settings of the controller. Settings can be modified using the Customer Service Tool. If the Run Enable is not used, disable this function using the Customer Service Tool.
	Critical alarm/diagnostic triggered a shut down.	Using the Customer 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 5 “Cylinder Position Feedback Analog Inputs”.
Alarm Detection: Alarm or shut down is detected.	Diagnostic triggered an alarm and/or shut down	Using the Customer 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.

Table 6-8. VS-GI Demand Faults Guide

Problem	Cause	Remedy
Run Enable Line Low	Run Enable circuit is open or Run Enable configured incorrectly.	Ensure the used/not used settings inside the VS-GI match the active/inactive settings of the controller. Modify settings using the Customer Service Tool. If the Run Enable is not used, disable this function using the Customer Service Tool.
Demand Invalid	All selected analog inputs are outside the specified range.	Check input source and connections.
Demand 1 or 2 Input Low Detection: The analog input is below the diagnostic threshold. This is a user configurable parameter (typically 2 mA).	Wiring is disconnected or loose.	Check terminals and connections.
	Short in wiring.	Check wiring for shorts to external voltages. Check wiring insulation.
	Control system 4 to 20 mA output has failed low.	Check the current to the analog input to the VS-GI. Fix control system.
	Incorrect user configurable parameter in the electronics module for the min input diagnostic.	Verify the 4–20 mA diagnostic range— low limit value using the VS-GI Customer Service Tool.
	VS-GI internal electronics failure.	Contact Woodward technical support for further assistance.
Demand 1 or 2 Input High Detection: The analog demand input is above the diagnostic threshold. This is a user configurable parameter (typically 22 mA).	Short in wiring to external voltage.	Check wiring for shorts to positive voltages.
	Control system 4 to 20 mA output has failed high.	Check the current to the analog input to the VS-GI. Fix control system.
	Incorrect user configurable parameter in the electronics module for the max input diagnostic.	Verify the 4–20 mA diagnostic range—high limit value using the VS-GI Customer Service Tool.
	VS-GI internal electronics failure.	Contact Woodward technical support for further assistance.
Demand Spread Alarm Detection: Demand inputs are configured to dual mode and one or both analog inputs in range; however, the difference between the two signals is greater than the spread warning limit.	Incorrect input configuration and/or spread alarm limits	If dual demand signals are not being connected and used, set mode to single channel. When using dual demand signals, check source hardware and connections.
Linearization Table Order Incorrect	Demand linearization is not monotonically increasing.	Correct the table OR disable linearization.

Table 6-9. VS-GI Power Supply Faults

Problem	Cause	Remedy
Power-up Reset Detection: CPU reset by a power up event.	It is normal for the Power Up Reset diagnostic to occur upon power up of the VS-GI.	Issue a reset to the VS-GI.
	If this occurs while the VS-GI is powered, and the diagnostic is set during a fast position transient, most likely the power infrastructure is not delivering the power needed.	During transient: Check terminal voltage at the VS-GI during a 0-100% position transient, check wire gauge, fuses, or other resistive components in the power supply system.
Input Voltage Low	Input power level detected below reasonable limit.	Check power source and connections. If the battery voltage decreases slowly during power down, Input Voltage Low flag may be set.
Input Voltage High	Input power level detected above reasonable limit.	
(Remote Servo Only) Shut down	Position sensor loop power overloaded due to wiring fault or failed sensor.	Check sensor current draw and ensure position sensor wiring and power supply are connected correctly. See Chapter 5 “Cylinder Position Feedback Analog Inputs”.

Table 6-10. VS-GI Feedback Faults

Problem	Cause	Remedy
Position 1 or 2 Feedback Low Detection: Power cylinder feedback 1 or 2 below low threshold, typically 2 mA.	Feedback sensor wiring fault or failed sensor channel.	Check all connections to the final cylinder, check for any impediment to motion. If problem persists, service will be required.
Position 1 or 2 Feedback High Detection: Power cylinder feedback 1 or 2 above high threshold, typically 21 mA.		
Position Feedback Spread Alarm Detection: The difference between the redundant power cylinder feedback signals is greater than the set limits.	Sensors incorrectly calibrated.	Complete one of the calibration procedures described in Customer Service Tool manual 35148.
Both Position Feedbacks Failed Detection: Both power cylinder feedback signals are out of usable range.	Feedback sensor wiring fault or failed sensor channel(s).	Check all connections to the final cylinder, check for any impediment to motion. If problem persists, service will be required.
Position Feedback 1 or 2 Readings are Negative or Much Greater 100% Detection: Customer Service Tool readings of Position Feedback 1 or 2.	Sensor temperature is too high. **Note:** This fault will typically clear after the actuator has cooled.	Ensure that the environment AND the mounting location are within the environmental specifications listed in Chapter 2.
Stroke / Position in Customer Service Tool Does Not Match Actual Stroke / Position Detection: Compare actual measurements (using external measurement device) with % feedback as shown in the VariStroke Customer Service Tool.	Incorrect “Position Sensor Length” input into Customer Service Tool.	Ensure that the “Position Sensor Length” input into the Customer Service Tool equals the full, 4–20 mA range of the position sensor.
	Position sensor requirements for accuracy and linearity are not fulfilled.	If greater accuracy is desired, consider replacing the cylinder position sensor with a more accurate sensor.

Table 6-11. VS-GI Temperature Faults

Problem	Cause	Remedy
Temperature Derating Active	Current limits reduced because of high temperature. Limits will automatically reset.	Reduce ambient temperature to within specification limits.
Temperature Sensor High Detection: The control board temperature sensor indicates a temperature above operational limit.	The ambient temperature of the electronics module is higher than allowed by specification.	
	The temperature sensor is defective.	Contact Woodward technical support for further assistance.
Temperature Sensor Low Detection: The control board temperature sensor indicates a temperature below operational limit.	The ambient temperature of the electronics module is lower than allowed by specification.	Increase ambient temperature to within specification limits.
	The temperature sensor is defective.	Contact Woodward technical support for further assistance.
Electric Servo Temp High Detection: The servo electric motor temperature sensor indicates a temperature above operational limit.	The ambient temperature of the electronics module is higher than allowed by specification.	Reduce ambient temperature to within specification limits.
	The temperature sensor is defective.	Contact Woodward technical support for further assistance.
Electric Servo Temp Low Detection: The servo electric motor temperature sensor indicates a temperature below operational limit.	The ambient temperature of the electronics module is lower than allowed by specification.	Increase ambient temperature to within specification limits.
	The temperature sensor is defective.	Contact Woodward technical support for further assistance.

Table 6-12. Performance Faults

Problem	Cause	Remedy
Spring Check Failed Detection: Startup test showed a detected failure of the servo valve safety return spring.	Weak power supply	Verify the power supply has sufficient current capability.
	Broken return spring	Service is required.
	Servo valve seizure	
Servo Tracking Alarm Detection: The servo valve is unable to maintain position within the tracking error alarm limits. This will trigger an alarm. **Servo Tracking Fault** Detection: The servo valve is unable to position within the tracking error fault limits. This will trigger a shut down.	Contamination in the valve/actuator system	Ensure oil supply meets cleanliness requirements. Replace/filter the oil and flush the valve with clean oil. If problem persists, service may be required.
	Excessive valve/actuator wear	Service is required.
	VS-GI electronics failure	Contact Woodward technical support for assistance.
Cylinder Tracking Alarm Detection: The power cylinder is unable to position within the tracking error alarm limits. This will trigger an alarm **Cylinder Tracking Fault** Detection: The power cylinder is unable to position within the tracking error fault limits. This will trigger a shut down	Seized control valve/linkage	Ensure that the force required to move the valve and linkage does not exceed the VariStroke force limits at the operating hydraulic pressure level. See Chapter 5: External Force, Load.
	Excessive thermal growth in control valve linkage	Lower the ambient temperature of the VariStroke and/or linkage. If this is not possible, consider extending tracking limits or disabling this diagnostic.
	Contamination in the valve/actuator system.	Ensure oil supply meets cleanliness requirements. Replace/filter the oil and flush the valve with clean oil. If problem persists, service may be required.
	Excessive valve/actuator wear	Service is required.
	Faulty/erratic position sensor feedback	Check all connections to the final cylinder, check for any impediment to motion. If problem persists, service will be required.
Incorrect Stroke Length Error Detection: The maximum stop position has been set to less than 40% of the physical cylinder length.	Incorrect cylinder or position sensor configuration OR incorrect calibration limits	Ensure that calibrated maximum stop position is greater than 40% of the physical cylinder length and sensor length. Check that the settings in the remote cylinder setup are correct.

Performance Index Warning Detection: The settings for supply pressure, offset at minimum position, and maximum stop position result in a violation of the performance relationship.	Incorrect configuration and calibration settings.	See Chapter 2 “Performance Index for the details of this alarm”.
	The VS-GI servo valve is too large for the set cylinder volume.	
Slow Slew Rates	Loss or reduction in hydraulic supply pressure.	Ensure that the hydraulic pressure does not drop more than 10% during a full slew. Consider adding a high-volume hydraulic accumulator to the supply line. See Chapter 2 “Hydraulic Specifications”.
	External load level	Check if the load is in proper range, see Chapter 5 “External Force, Load”.
	Excessive wear of actuator/linkage/valve	Verify mechanical condition of actuator/linkage/valve.
Cylinder Position Oscillation Detection: Unstable output cylinder shaft control with constant input demand setting	Hydraulic fluid flow not sufficient.	Verify hydraulic supply system capability. See Chapter 5 “Hydraulic Connections”.
	Oil filter restricting flow	Clean and replace the hydraulic system filter.
	Air present in hydraulic system	Purge air from the system by cycling the demand signal up and down several times when turbine is shutdown. Check hydraulic supply and control line piping for areas where air could be trapped and change piping to correct if needed. Install syphon in drain line if needed (to be considered for remote cylinder applications).
	Drain line under pressure	Remove all flow restrictions from drain line, install larger drain pipe if needed; see Chapter 5 “Hydraulic Connections”.
	Single Acting Actuators only – Spring/valve closing load/force too weak	Check if the return spring and valve force is in proper range to close actuator/valve effectively. See Chapter 5 “External Force, Load”.

Table 6-13. Internal Faults

Problem	Cause	Remedy
Electronics Fault	An internal error has occurred in the driver.	Service required.

Maintenance

To maximize the life of the VS-GI, please refer to the maintenance recommendation in Chapter 9: Asset Management and Refurbishment Scheduling Period.

Chapter 7.
Ordering Code

Boxes to order Servo Only or DX Skid

Boxes to order Assembly (servo + cylinder) or Cylinder Only

VS-GI / VS-DX Single Acting Model Number Information

WOODWARD

Varistroke Product Line	Valve Size	Configuration	Action	–	Bore	Stroke	–	Rod End	Mounting Option	Fail-Safe Direction	Compliance	Position sensor	–	Specials: Dump valve & TTV	–	Specials: Seals	–	Specials: Special Requirements
V	XX	X	X	–	XX	XX	–	X	X	X	X	X	–	X	–	X	–	X

Valve Size

Code	Description
45	VS-GI / Port 6x .453"

Configuration

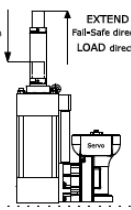
Code	Description
T	Integrated
W	DX Skid
J	DX Skid with Junction Box [1]

[1] only available for Zone 2

Action

Code	Description
G	Single Acting Configuration
K, L, M	Single Acting Configuration – Additionally Cylinder equipped with Internal Spring (Spring Assist)

RETRACT Fail-Safe direction LOAD direction — EXTEND Fail-Safe direction LOAD direction



Bore / Stroke / Rod End

Code	Description	Code	Description	Available Action
15	152,4mm (6in) / Rod Dia 2,50"	07	76,2mm (3in)	G, M
		10	101,6mm (4in)	G, M
		15	152,4mm (6in)	G
		20	203,2mm (8in)	G
		25	254,0mm (10in)	G
		30	304,8mm (12in)	G
20	203,2mm (8in) / Rod Dia 3,50"	07	76,2mm (3in)	G, L, M
		15	152,4mm (6in)	G
		20	203,2mm (8in)	G
		25	254,0mm (10in)	G
		30	304,8mm (12in)	G
25	254mm (10in) / Rod Dia 4,50"	07	76,2mm (3in)	G, M
		10	101,6mm (4in)	G, M
		25	254,0mm (10in)	G

For more info see drawing with spring force. Contact Woodward if spring is needed for other stroke.

Mounting Option

Code	Description
U	VS I Universal Mount

Rod End

Code	Description
M	Male Thread
F	Female Thread

Fail-Safe Direction

Code	Description
E	Extend
R	Retract

Compliance

Code	Description
S	Zone 2 Self Declared
0	CE Mark for Ordianry Location
2	Zone 2 / Division 2
4	Zone 2 / Division 2 / EAC
6	Zone 2 / Division 2 / INMETRO
8	Zone 2 / Division 2 / TIIS
A	Zone 2 / Division 2 / CCOE
C	Zone 2 / Division 2 / KCs Mark

Not all options are available for each configuration. Please contact Woodward for more details.

Position sensor

Code	Description
M	with cylinder position sensor position sensor [2]

[2] option available only for the Cylinder Only

Specials: Dump valve & TTV

Code	Description
X	No Dump Valve and TTV function
T	TTV function activated [3 4 7]
P	Dump Valve Ports only [4 6]
D	Dump Valve installed [4 6]
U	Dump Valve Ports only and TTV function [4 6 7]
W	Dump Valve installed and TTV function [4 6 7]

[3] option available also for the Servo Only
[4] options not available for the DX Skid
[6] options not available for the Servo Only
[7] options not available for the Cylinder Only

Specials: Seals

Code	Description
S	Standard Seals
C	Chemically Resistant Seals [5]

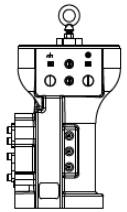
[5] option not available for DX Skid

Specials: Special Requirements

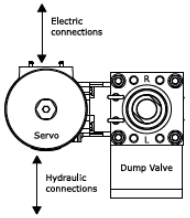
Code	Description
X	No Special Requirements
G	Special User Parameters
	Access Cover [8]

[8] option available only for VHPC Zone 2

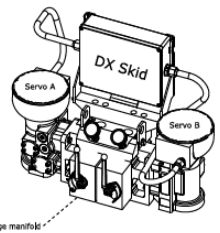
Servo Only



TOP VIEW
Dump valve position (on the LEFT side only)

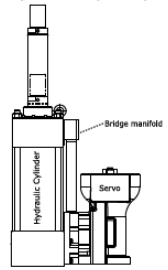


DX Skid with Junction Box



The DX Skid can operate with Cylinder Only (Remote). Order Cylinder Only separately.

Assembly - Integrated version (Servo + Cylinder)



The components can be ordered separately as Servo Only and Cylinder Only.

VS-GI -VariStroke-I Single Acting
VS-DX -DX Skid - Redundant servo for critical applications

Note:
1. For ordering examples see sheet 2.
2. The Model Number Information covers the Cylinder Only and Servo Only with 1.5 inch control ports.

Bore [in]	Stroke [in]	Spring force	Spring K	Spring L	Spring M	Spring N
6	3	MIN	108	235	520	-
		MAX	216	471	1040	-
	4	MIN	108	235	520	-
		MAX	216	471	1040	-
8	3	MIN	276	529	1052	1946
		MAX	510	1057	2104	4046
	4	MIN	242	528	1052	2023
		MAX	544	1058	2104	4047
10	4	MIN	354	642	1312	2744
		MAX	708	1286	2624	5488

For other spring sizes contact with Woodward.

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Boxes to order Servo Only or DX Skid

Boxes to order Assembly (servo + cylinder) or Cylinder Only

VS-GI / VS-DX Single Acting Model Number Information

WOODWARD

Varistroke Product Line	Valve Size	Configuration	Action		Bore	Stroke		Rod End	Mounting Option	Fail-Safe Direction	Compliance	Position sensor		Specials: Dump valve & TTV	Specials: Seals	Specials: Special Requirements
V	xx	x	x	–	xx	xx	–	x	x	x	x	x	–	x	x	x

Ordering examples

Boxes to order Servo Only or DX Skid

Servo only V

Model Number Example = Servo only (Remote)

V45RG-R1-X-S-X

- Varistroke
- VS-GI /6x,453"
- Remote
- Single Acting Cylinder
- Fail Retract
- Zone 1&2 / Division 1&2
- No Dump Valve and TTV function
- Standard Seals
- No Special Requirements

Servo only V

Model Number Example = Servo only (Remote)

V45RG-E2-T-C-X

- Varistroke
- VS-GI /6x,453"
- Remote
- Single Acting Cylinder
- Fail Extend
- Zone 2 / Division 2
- TTV function activated
- Chemically Resistant Seals
- No Special Requirements

Servo only V

Model Number Example = Servo only (Integrated)

V45TG-R1-X-S-X

- Varistroke
- VS-GI /6x,453"
- Integrated
- Single Acting Cylinder
- Fail Retract
- Zone 1&2 / Division 1&2
- No Dump Valve and TTV function
- Standard Seals
- No Special Requirements

Boxes to order Assembly (servo + cylinder) or Cylinder Only

Assembly (servo + cylinder) V

Model Number Example = Assembly (Integrated)

V45TK-2010-MUE1M-W-S-X

- Varistroke
- VS-GI /6x,453"
- Integrated
- Single Acting Cylinder with internal spring
- 203.2 mm Bore
- 101.4 mm Stroke
- Male Thread Rod End
- VS | Universal Mount Cylinder
- Fail Extend
- Zone 1&2 / Division 1&2
- with cylinder position sensor
- Dump Valve installed and TTV function
- Standard Seals
- No Special Requirements

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SINGLE ACTING MODELS AVAILABLE, IN ANY COMPLIANCE PREFIX

Model Number	Item Number
V45TG-1507-MUEXM-D-S-X	9907-2212
V45TG-1507-MUEXM-P-S-X	9907-2211
V45TG-1507-MUEXM-T-S-X	9907-2301
V45TG-1507-MUEXM-U-S-X	9907-2302
V45TG-1507-MUEXM-W-S-X	9907-2303
V45TG-1507-MUEXM-X-S-X	9907-2210
V45TG-1507-MURXM-D-S-X	9907-2215
V45TG-1507-MURXM-P-S-X	9907-2214
V45TG-1507-MURXM-X-S-X	9907-2213
V45TG-1510-MUEXM-T-S-X	9907-2307
V45TG-1510-MUEXM-X-S-X	9907-2222
V45TG-1510-MURXM-X-S-X	9907-2223
V45TG-1515-MUEXM-T-S-X	9907-2309
V45TG-1515-MUEXM-X-S-X	9907-2226
V45TG-1515-MURXM-X-S-X	9907-2227
V45TG-1520-MUEXM-D-S-X	9907-2228
V45TG-1520-MUEXM-X-S-X	9907-2269
V45TG-1520-MURXM-P-S-X	9907-2236
V45TG-1520-MURXM-X-S-X	9907-2234
V45TG-1525-MUEXM-D-S-X	9907-2230
V45TG-1525-MURXM-D-S-X	9907-2229
V45TG-1525-MURXM-D-S-X	9907-2231
V45TG-1530-MUEXM-D-S-X	9907-2232
V45TG-1530-MURXM-D-S-X	9907-2233
V45TG-1530-MURXM-X-S-X	9907-2238
V45TG-2007-MUEXM-D-S-X	9907-2245
V45TG-2007-MUEXM-P-S-X	9907-2247
V45TG-2007-MUEXM-T-S-X	9907-2310
V45TG-2007-MUEXM-U-S-X	9907-2311
V45TG-2007-MUEXM-W-S-X	9907-2312

Model Number	Item Number
V45TG-2007-MUEXM-X-S-X	9907-2246
V45TG-2007-MURXM-D-S-X	9907-2250
V45TG-2007-MURXM-P-S-X	9907-2249
V45TG-2007-MURXM-X-S-X	9907-2248
V45TG-2015-MUEXM-D-S-X	9907-2257
V45TG-2015-MUEXM-W-S-X	9907-2313
V45TG-2015-MUR-DVL	9907-2258
V45TG-2015-MURXM-W-S-X	9907-2314
V45TG-2020-MUEXM-D-S-X	9907-2261
V45TG-2025-MUEXM-D-S-X	9907-2263
V45TG-2025-MURXM-D-S-X	9907-2264
V45TG-2030-MUEXM-D-S-X	9907-2266
V45TG-2030-MURXM-D-S-X	9907-2268
V45TG-2507-MUEXM-D-S-X	9907-2273
V45TG-2507-MUEXM-T-S-X	9907-2315
V45TG-2507-MUEXM-U-S-X	9907-2316
V45TG-2507-MUEXM-W-S-X	9907-2317
V45TG-2507-MUEXM-X-S-X	9907-2271
V45TG-2507-MUR-DVLXM-X-S-X	9907-2276
V45TG-2507-MURXM-X-S-X	9907-2274
V45TG-2510-MUEXM-T-S-X	9907-2321
V45TG-2525-MUR-DVL	9907-2287
V45TL-1515-FUEXM-P-X	9907-2442
V45TL-2007-MUEXM-X-S-X	9907-2291
V45TM-1507-MUEXM-D-S-X	9907-2218
V45TM-1507-MUEXM-D-S-X	9907-2262
V45TM-1507-MUEXM-P-S-X	9907-2217
V45TM-1507-MUEXM-T-S-X	9907-2304
V45TM-1507-MUEXM-U-S-X	9907-2305
V45TM-1507-MUEXM-W-S-X	9907-2306
V45TM-1507-MUEXM-X-S-X	9907-2216

Model Number	Item Number
V45TM-1507-MURXM-D-S-X	9907-1992
V45TM-1507-MURXM-D-S-X	9907-2221
V45TM-1507-MURXM-P-S-X	9907-2220
V45TM-1507-MURXM-X-S-X	9907-2219
V45TM-1510-MUEXM-T-S-X	9907-2308
V45TM-1510-MUEXM-X-S-X	9907-2224
V45TM-1510-MURXM-X-S-X	9907-2225
V45TM-1515-FUEXM-P-X	9907-2441
V45TM-1520-MUEXM-D-S-X	9907-2235
V45TM-1520-MURXM-D-S-X	9907-2237
V45TM-1520-MURXM-D-S-X	9907-2272
V45TM-2007-MUEXM-D-S-X	9907-2253
V45TM-2007-MUEXM-D-S-X	9907-2275
V45TM-2007-MUEXM-P-S-X	9907-2252
V45TM-2007-MUEXM-P-S-X	9907-2351
V45TM-2007-MUEXM-X-S-X	9907-2251
V45TM-2007-MUR-DV0XM-X-S-X	9907-2255
V45TM-2007-MUR-DVLXM-X-S-X	9907-2256
V45TM-2007-MURXM-D-S-X	9907-2286
V45TM-2007-MURXM-P-S-X	9907-2283
V45TM-2007-MURXM-X-S-X	9907-2254
V45TM-2507-MUE-DVLXM-X-S-X	9907-2279
V45TM-2507-MUEXM-P-S-X	9907-2278
V45TM-2507-MUEXM-T-S-X	9907-2290
V45TM-2507-MUEXM-T-S-X	9907-2318
V45TM-2507-MUEXM-U-S-X	9907-2319
V45TM-2507-MUEXM-W-S-X	9907-2320
V45TM-2507-MUEXM-X-S-X	9907-2277
V45TM-2507-MUR-DV0XM-X-S-X	9907-2281
V45TM-2507-MUR-DVLXM-X-S-X	9907-2282
V45TM-2507-MURXM-X-S-X	9907-2280

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Chapter 8.
Product Support and Service Options

Product Support Options

If you are experiencing problems with the installation, or unsatisfactory performance of a Woodward product, the following options are available:

- Consult the troubleshooting guide in the manual.
- Contact the manufacturer or packager of your system.
- Contact the Woodward Full Service Distributor serving your area.
- Contact Woodward technical assistance (see “How to Contact Woodward” later in this chapter) and discuss your problem. In many cases, your problem can be resolved over the phone. If not, you can select which course of action to pursue based on the available services listed in this chapter.

OEM or Packager Support: Many Woodward controls and control devices are installed into the equipment system and programmed by an Original Equipment Manufacturer (OEM) or Equipment Packager at their factory. In some cases, the programming is password-protected by the OEM or packager, and they are the best source for product service and support. Warranty service for Woodward products shipped with an equipment system should also be handled through the OEM or Packager. Please review your equipment system documentation for details.

Woodward Business Partner Support: Woodward works with and supports a global network of independent business partners whose mission is to serve the users of Woodward controls, as described here:

- A **Full Service Distributor** has the primary responsibility for sales, service, system integration solutions, technical desk support, and aftermarket marketing of standard Woodward products within a specific geographic area and market segment.
- An **Authorized Independent Service Facility (AISF)** provides authorized service that includes repairs, repair parts, and warranty service on Woodward's behalf. Service (not new unit sales) is an AISF's primary mission.

A current list of Woodward Business Partners is available at:
https://www.woodward.com/en/support/industrial/service-and-spare-parts/find-a-local-partner

Product Service Options

The following factory options for servicing Woodward products are available through your local Full-Service Distributor or the OEM or Packager of the equipment system, based on the standard Woodward Product and Service Warranty (Woodward North American Terms and Conditions of Sale 5-09-0690) that is in effect at the time the product is originally shipped from Woodward or a service is performed:

- Replacement/Exchange (24-hour service)
- Flat Rate Repair
- Flat Rate Remanufacture

Replacement/Exchange: Replacement/Exchange is a premium program designed for the user who is in need of immediate service. It allows you to request and receive a like-new replacement unit in minimum time (usually within 24 hours of the request), providing a suitable unit is available at the time of the request, thereby minimizing costly downtime. This is a flat-rate program and includes the full standard Woodward product warranty (Woodward North American Terms and Conditions of Sale 5-09-0690).

This option allows you to call your Full-Service Distributor in the event of an unexpected outage, or in advance of a scheduled outage, to request a replacement control unit. If the unit is available at the time of the call, it can usually be shipped out within 24 hours. You replace your field control unit with the like-new replacement and return the field unit to the Full-Service Distributor.

Charges for the Replacement/Exchange service are based on a flat rate plus shipping expenses. You are invoiced the flat rate replacement/exchange charge plus a core charge at the time the replacement unit is shipped. If the core (field unit) is returned within 60 days, a credit for the core charge will be issued.

Flat Rate Repair: Flat Rate Repair is available for the majority of standard products in the field. This program offers you repair service for your products with the advantage of knowing in advance what the cost will be. All repair work carries the standard Woodward service warranty (Woodward North American Terms and Conditions of Sale 5-09-0690) on replaced parts and labor.

Flat Rate Remanufacture: Flat Rate Remanufacture is very similar to the Flat Rate Repair option with the exception that the unit will be returned to you in “like-new” condition and carry with it the full standard Woodward product warranty (Woodward North American Terms and Conditions of Sale 5-09-0690). This option is applicable to mechanical products only.

Returning Equipment for Repair

If a control (or any part of an electronic control) is to be returned for repair, please contact your Full-Service Distributor in advance to obtain Return Authorization and shipping instructions.

When shipping the item(s), attach a tag with the following information:
- Return authorization number
- Name and location where the control is installed
- Name and phone number of contact person
- Complete Woodward part number(s) and serial number(s)
- Description of the problem
- Instructions describing the desired type of repair

Packing a Control

Use the following materials when returning a complete control:
- Protective caps on any connectors
- Antistatic protective bags on all electronic modules
- Packing materials that will not damage the surface of the unit
- At least 100 mm (4 inches) of tightly packed, industry-approved packing material
- A packing carton with double walls
- A strong tape around the outside of the carton for increased strength

NOTICE

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*.

Replacement Parts

When ordering replacement parts for controls, include the following information:

- The part number(s) (XXXX-XXXX) that is on the enclosure nameplate
- The unit serial number, which is also on the nameplate

Engineering Services

Woodward offers various Engineering Services for our products. For these services, you can contact us by telephone, by email, or through the Woodward website.

- Technical Support
- Product Training
- Field Service

Technical Support is available from your equipment system supplier, your local Full-Service Distributor, or from many of Woodward's worldwide locations, depending upon the product and application. This service can assist you with technical questions or problem solving during the normal business hours of the Woodward location you contact. Emergency assistance is also available during non-business hours by phoning Woodward and stating the urgency of your problem.

Product Training is available as standard classes at many of our worldwide locations. We also offer customized classes, which can be tailored to your needs and can be held at one of our locations or at your site. This training, conducted by experienced personnel, will assure that you will be able to maintain system reliability and availability.

Field Service engineering on-site support is available, depending on the product and location, from many of our worldwide locations or from one of our Full-Service Distributors. The field engineers are experienced both on Woodward products as well as on much of the non-Woodward equipment with which our products interface.

For information on these services, please contact one of the Full-Service Distributors listed at **https://www.woodward.com/en/support/industrial/service-and-spare-parts/find-a-local-partner**

Contacting Woodward's Support Organization

For the name of your nearest Woodward Full-Service Distributor or service facility, please consult our worldwide directory at **https://www.woodward.com/support**, which also contains the most current product support and contact information.

You can also contact the Woodward Customer Service Department at one of the following Woodward facilities to obtain the address and phone number of the nearest facility at which you can obtain information and service.

Products Used in Electrical Power Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 8818 5515
Germany	+49 (711) 78954-510
India	+91 (124) 4399500
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
Poland	+48 (12) 295 13 00
United States	+1 (970) 482-5811

Products Used in Engine Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 8818 5515
Germany	+49 (711) 78954-510
India	+91 (124) 4399500
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
The Netherlands	+31 (23) 5661111
United States	+1 (970) 482-5811

Products Used in Industrial Turbomachinery Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 8818 5515
India	+91 (124) 4399500
Japan	+81 (43) 213-2191
Korea	+ 82 (51) 636-7080
The Netherlands	+31 (23) 5661111
Poland	+48 (12) 295 13 00
United States	+1 (970) 482-5811

Technical Assistance

If you need to contact technical assistance, you will need to provide the following information. Please write it down here before contacting the Engine OEM, the Packager, a Woodward Business Partner, or the Woodward factory:

General

Your Name _____

Site Location _____

Phone Number _____

Fax Number

Prime Mover Information

Manufacturer _____

Turbine Model Number _____

Type of Fuel (gas, steam, etc.) _____

Power Output Rating _____

Application (power generation, marine, etc.) _____

Control/Governor Information

Control/Governor #1

Woodward Part Number & Rev. Letter _____

Control Description or Governor Type _____

Serial Number

Control/Governor #2

Woodward Part Number & Rev. Letter _____

Control Description or Governor Type _____

Serial Number

Control/Governor #3

Woodward Part Number & Rev. Letter _____

Control Description or Governor Type _____

Serial Number

Symptoms

Description _____

_____

If you have an electronic or programmable control, please have the adjustment setting positions or the menu settings written down and with you at the time of the call.

Chapter 9.
Asset Management, Schedule Maintenance Intervals and Refurbishment Kits

The following recommendations for the Woodward VS-GI actuator are to assist in properly maintaining the reliability, availability, and “safety of operation” critical for steam turbines. Despite the monitoring and diagnostics capabilities of advanced electronic control systems, practicing preventative maintenance is critical to ensure control components maintain their ability to perform required functions, and equally important, to ensure system safety. It is important to follow recommendations for service and repair in order to avoid unnecessary unscheduled shutdowns, and potentially dangerous failures.

This product is designed for continuous operation under normal industrial operating conditions. Periodic service is not required on any components. However, it is recommended that the control device is inspected and overhauled during major service intervals, typically scheduled every five to eight years depending on the site and application service conditions. During major outages, Woodward recommends the VS-GI be sent back to Woodward or a Woodward Authorized Service Facility (AISF) for inspection, component service, or replacement and to take advantage of related product software and hardware improvements.

Installations that do not meet “normal” industrial operating conditions may require customized maintenance cycles to maximize reliability, performance, and asset life. Contact your local Woodward representative for a detailed evaluation of your site conditions to determine the appropriate maintenance cycle recommendations for your installation.

Levels of service capability available at factory or select service locations:

- **Gold**: Factory repaired and warranted to “like new” performance condition, via exchange (new or refurbished) units. Repair or overhaul is performed using production test processes, and production test equipment. Verified performance within new unit specifications for controls and actuation devices. For Gold service, the unit must be sent back to the Woodward facility of manufacture.
- **Silver**: Repair, exchange, or service from an authorized service center and covered under their warranty. Repair or overhaul with Woodward authorized service tools, and Woodward parts kits. Tested on Woodward approved functional test equipment to verify performance to repair specifications for controls and actuation devices. The unit must be sent to a Woodward authorized service center approved for the VS-GI product.
- **Bronze**: Service to be performed by the end user or Woodward authorized service center. Bronze service typically involves limited disassembly, and limited component replacement or refurbishment, maintenance and/or repair. This may include cleaning and/or functional testing (OK/Not OK determination) on approved bench test equipment based on Woodward specifications for controls and actuation.

Woodward’s Gold level overhaul services will return the unit to “like new” condition ready for another full operating cycle, lasting until the next planned maintenance outage. Prior to reaching the recommended maintenance cycle of the auxiliary component, please contact either the sites turbine OEM service representative, local Woodward Distributor, or Woodward Authorized Independent Service Facility to facilitate services. See Chapter 8 for product support.

Replacement kits are available for maintenance and service. The replacement kits are categorized by service level, servo type, cylinder size, and auxiliaries. Refer to Woodward tabulation drawing 9999-1590 which lists all available kits for the VS-I product.

Depending on the site and application, Woodward recommends full overhaul and maintenance every five to eight years.

Inspect all components to be sure that required kits and replacement components are ordered and

received before starting maintenance and service. Perform the following inspections to ensure that the primary parts are suitable for replacement after the soft goods are replaced:

- Carefully inspect the piston rod surface for significant scratches, corrosion, or damage.
- Inspect the PCBA (servo electronic board) condition for any evidence of heat related damage, corrosion, loss of conformal coat, exposure to hydraulic fluid, or water damage.
- Evaluate the source of any external leakage.

For any questions or concerns, please contact Woodward or a local service center.

Chapter 10.
Long-Term Storage Requirements

Units that will not be put into service within 12 months should be packaged for long-term storage as described in Woodward manual 25075, *Commercial Preservation Packaging for Storage of Mechanical-Hydraulic Controls*.

Appendices

PENDING

Revision History

Revision C—
- Replaced Chapter 7 Ordering Code documents

Revision B—
- Updated Model Number Information in Chapter 7

Revision A—
- Updated Table 1-1
- Added Table 1-2
- Added Figure 1-1a
- Updated Figure 1-4
- Added Important box on page 18
- Updated “Current Consumption” description, Table 2-4
- Added Important box on page 22
- New definitions under T&TV Based Functions (page 37) and Discrete Only (page 40)
- Updated Figures 4-7, 4-8, 5-12, 5-26, 5-28, 5-31
- Updated “Servo Cover” section
- Updated “Input Power” section
- Added Important box on page 73
- Updated Analog Input Wiring Requirements (page 74)
- Updated Chapter 6
- Updated “Troubleshooting” section
- Updated Chapter 9
- Replaced DoI

Rev —
- New manual

Declarations

DECLARATION OF INCORPORATION
Of Partly Completed Machinery
2006/42/EC

File name: 00420-04-EU-MD-02-01
Manufacturer's Name: WOODWARD INC.

Manufacturer's Address: 1041 Woodward Way
Fort Collins, CO 80524 USA

Model Names: Varistroke Electro Hydraulic Actuators: VS-I, VS-II, VS-GI

This product complies, where applicable, with the following Essential Requirements of Annex I: 1.1, 1.2, 1.3, 1.5, 1.6, 1.7

The relevant technical documentation is compiled in accordance with part B of Annex VII. Woodward shall transmit relevant information if required by a reasoned request by the national authorities. The method of transmittal shall be agreed upon by the applicable parties.

The person authorized to compile the technical documentation:

Name: Dominik Kania, Managing Director
Address: Woodward Poland Sp. z o.o., ul. Skarbowa 32, 32-005 Niepolomice, Poland

This product must not be put into service until the final machinery into which it is to be incorporated has been declared in conformity with the provisions of this Directive, where appropriate.

The undersigned hereby declares, on behalf of Woodward Inc. of Loveland and Fort Collins, Colorado that the above referenced product is in conformity with Directive 2006/42/EC as partly completed machinery:

MANUFACTURER

Signature: Annette Lynch

Full Name: Annette Lynch

Position: Engineering Manager

Place: Woodward Inc., Fort Collins, CO, USA

Date: March 18, 2022

Document: 5-09-1182 (rev. 17) **PAGE** 1 of 1

EU DECLARATION OF CONFORMITY

EU DoC No.:	00420-04-EU-02-01
Manufacturer's Name:	WOODWARD INC.
Manufacturer's Contact Address:	1041 Woodward Way Fort Collins, CO 80524 USA
Model Name(s)/Number(s):	Varistroke Electro Hydraulic Actuators: VS-I, VS-II, VS-GI, VS-DX
The object of the declaration described above is in conformity with the following relevant Union harmonization legislation:	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 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)
Markings in addition to CE marking: (Marking depends on model code. See Product Manual)	(no additional marking for Ordinary Location code 0 models) Ⓔx Category 2 Group II G, Ex db IIB T4 Gb Ⓔx Category 3 Group II G, Ex nA IIC T4 Gc
Applicable Standards:	EN 61000-6-4, 2007/A1:2011: EMC Part 6-4: Generic Standards – Emissions for Industrial Environments EN 61000-6-2, 2005: EMC Part 6-2: Generic Standards – Immunity for Industrial Environments EN IEC 60079-0:2018 - Explosive Atmospheres - Part 0: Equipment – General requirements (A review against EN IEC 60079-0:2018, which is harmonized, shows no significant changes relevant to this equipment so EN 60079-0 :2012/A11 : 2013 continues to represent "State of the Art") EN 60079-1:2014 - Explosive Atmospheres – Part 1 : Equipment protection by flameproof enclosures "d" (A review against EN IEC 60079-1:2014, which is harmonized, shows no significant changes relevant to this equipment so EN 60079-1:2007 continues to represent "State of the Art") EN 60079-15: 2010 - Explosive Atmospheres - Part 15: Equipment protection by type of protection "n"
Third Party Certification: (VS-I, VS-II only)	Zone 1: SIRA 14ATEX1028X CSA Group Netherlands B.V. (NB 2562) Utrechseweg 310, 6812 AR, Arnhem, Netherlands
Conformity Assessment: (VS-I, VS-II only)	Zone 1: ATEX Annex IV - Production Quality Assessment, 01 220 113542 TUV Rheinland Industrie Service GmbH (0035) Am Grauen Stein, D51105 Cologne

This declaration of conformity is issued under the sole responsibility of the manufacturer
We, the undersigned, hereby declare that the equipment specified above conforms to the above Directive(s).

MANUFACTURER

Signature	Annette Lynch
Full Name	**Annette Lynch**
Position	**Engineering Manager**
Place	**Woodward, Fort Collins, CO, USA**
Date	04-Oct-2021

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Released

We appreciate your comments about the content of our publications.

Send comments to: industrial.support@woodward.com

Please reference publication 35119.

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1041 Woodward Way, Fort Collins CO 80524, USA
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Email and Website—www.woodward.com

Woodward has company-owned plants, subsidiaries, and branches, as well as authorized distributors and other authorized service and sales facilities throughout the world.

Complete address / phone / fax / email information for all locations is available on our website.