

Product Manual 26727 (Revision AB, 4/2025) Original Instructions



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

Installation and Operation Manual



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.

General Precautions

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

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Revisions

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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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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.



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.



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 , <i>Guide for Handling and Protection of Electronic Controls, Printed Circuit Boards, and Modules</i> .

Follow these precautions when working with or near the control.

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



Regulatory Compliance

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

VariStroke Model Number Information Fail-Safe Compliance Specials Varistroke Valve Configuration Action Rod End Bore Stroke Product Line Size Direction V Х XX Х Х XX XX χ х XX Code Description 0 CE Marked for Ordinary Locations North American Div 1 & 2, ATEX/IECEx Zone 1 & 2 North American Div 2, ATEX/IECEx Zone 2 2 North American Div 1 & 2, ATEX/IECEx Zone 1 & 2, EAC 3 4 North American Div 2, ATEX/IECEx Zone 2, EAC 5 (Reserved for Future Use) 6 (Reserved for Future Use) North American Div 1 & 2, ATEX/IECEx Zone 1 & 2, TIIS 7 (Reserved for Future Use) 8 9 North American Div 1 & 2, ATEX/IECEx Zone 1 & 2, CCOE North American Div 2, ATEX/IECEx Zone 2, CCOE А в North American Div 1 & 2, ATEX/IECEx Zone 1 & 2, KCS MARK KOREA с North American Div 2, ATEX/IECEx Zone 2, KCS MARK KOREA

European Compliance for CE Marking:

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

EMC Directive	Declared to Directive 2014/30/EU of the European Parliament and of the Council of 26 February 2014 on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC).
ATEX Directive:	Directive 2014/34/EU on the harmonisation of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres. Zone 1: II 2 G Ex db IIB T4 Gb, Sira 14ATEX1028X Zone 2: II 3 G Ex nA IIC T4 Gc
	Note: ATEX EU-Type Certificate is limited to Category 2 (Zone 1). See Declaration of Conformity for clarification.

Manual 26727	VariStroke-I (VS-I) Electro-hydraulic Actuator	
Other European Compliance: Compliance with the following European Directives or standards does not qualify this product for application of the CE Marking.		
ATEX Directive:	Exempt from the non-electrical portion of the ATEX Directive 2014/34/EU due to no potential ignition sources per EN ISO 80079-36:2016 for Zone 1 installation.	
Machinery Directive:	Compliant as partly completed machinery with Directive 2006/42/EC of the European Parliament and the Council of 17 May 2006 on machinery.	
Pressure Equipment Directive:	Compliant as "SEP" per Article 4.3 to Pressure Equipment Directive 2014/68/EU on the harmonisation of the laws of the Member States relating to making pressure equipment available on the market.	
RoHS Directive:	Restriction of Hazardous Substances 2011/65/EU: Woodward Turbomachinery Systems products are intended exclusively for sale and use only as a part of Large-Scale Fixed Installations per the meaning of Art.2.4(e) of directive 2011/65/EU. This fulfills the requirements stated in Art.2.4(c) and as such the product is excluded from the scope of RoHS2.	

EAC Customs Union

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

EAC Customs Union	Certified to Technical Regulation CU 012/2011 for use in potentially	
(Marked):	explosive atmospheres per Certificate:	
	RU C-US.MЮ62.B00436	
	Zone 1: 1Ex d IIB T4 Gb X	
	Zone 2: 2Ex nA IIC T4 Gc X	

Other International Compliance

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

IECEx:	Certified for use in explosive atmospheres per Certificate: IECEx CSA 13.0041X Zone 1: Ex db IIB T4 Gb Zone 2: Ex nA IIC T4 Gc
CCOE (PESO) India:	Certified for explosive atmospheres under Petroleum Rules 2002. Zone 1 and Zone 2 per the IECEx certificate above.
TIIS Japan:	Code T – Integrated models are certified for use in explosive atmospheres per TIIS Certificate TC21468. Zone 1 and Zone 2 per the IECEx certificate above.
KCs Mark Korea	KTL Certified for use in explosive atmospheres. Zone 1, KTL 17-KA4BO-0458X as Ex db IIB T4 Gb Zone 2, KTL 17-KA4BO-0459X as Ex nA IIC T4 Gb

North American Compliance:

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

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

Special Conditions for Safe Use

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

A conduit seal must be installed within 457 mm (18 inches) of the conduit entry when the product is used in Zone 1 or Class I, Division 1 hazardous locations. When a VS-I Remote Cylinder is used in Zone 1 or Class I, Division 1 hazardous locations, conduit seals are also required at the cylinder and the servo for the feedback wiring so that they are separated flameproof / explosionproof enclosures. Conduit barriers are not required for Zone 2 or Class I, Division 2 installation.

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

The maximum hydraulic oil temperature is 70 °C continuous.

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

Connect external safety ground terminal to earth ground.

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

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

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

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

VS-I Remote Cylinders shall only be used with Woodward VariStroke servos (e.g., VS-I, VS-GI, or VS-DX).

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

2 or Zone 2 applications.

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



Chapter 1. General Information

Introduction

Table 1-1. Woodward Reference Literature

Manual 35148:	Customer Service Tool for VariStroke-I Electro-hydraulic Actuator (VS-I, VS-GI,
	and VS-DX)
Manual 25071:	Oils for Hydraulic Controls
Manual 35163:	VariStroke Power Cylinder
Manual 25075:	Commercial Preservation Packaging for Storage of Mechanical-Hydraulic Controls
CMM-03002:	VariStroke-I (VS-I) Family - Bronze Level Component Maintenance Manual
Manual 82715:	Guide for Handling and Protection of Electronic Controls, Printed Circuit Boards, &
	Modules
Manual 51629:	Observed Field Installation Issues with VariStroke-I
Customer	YouTube - Woodward Inc, Training and Products channel:
Service Tool	https://www.youtube.com/channel/UC0Ogv5ntWU2OXxshcYYt6Mg
Training Videos:	
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
Demand	This term describes the reference value for the position. Also, in cases the term
	position demand is used. This is synonymous to the industry term position
	setpoint.
Customer	The PC software providing capabilities to configure, monitor and diagnose the
Service Tool	VariStroke-I servo
PCBA / PCB	Printed Circuit Board Assembly
DI	Discrete Input
DO	Discrete Output
AISF	Authorized Independent Service Facility
OVBD	Overboard Drain

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

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

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

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

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

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



For info 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 to the user in comparison to other electro-hydraulic actuators:

Dirt Tolerance

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

Valve Rack Linearization

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

Side Load Capability

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

Chemically Resistant Versions

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

VS-I Integrated and Remote Construction

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

- 1. Hydraulic Power Cylinder
- 2. Rotary Servo Valve
- 3. Feedback Sensors: MLDT (Magnetostrictive Linear Displacement Transducer) for power cylinder position controlling
- 4. Integrated electronic driver module (PCBA) located in Electronic Driver Module Enclosure



Figure 1-2. VariStroke-I, Key Features

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

The VariStroke-I Remote Servo Kit (Figure 1-3) 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 1-3. VariStroke-I Remote, Key Features

Hydraulic Power Cylinder

The simple and robust design of the VS-I hydraulic cylinder is capable of consistent performance for extended periods in challenging environments. The hydraulic 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 in turbine shut down condition.



Figure 1-4. Hydraulic Power Cylinder - Stroke Adjustment Options

Rotary Servo Valve

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

Additionally, the remote servo has an overboard drain (OVBD) port, which is permanently connected to the drain. This port can (optionally) be connected to the OVBD connection on the hydraulic power cylinder to drain any leakage pass the primary rod seal.

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

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

Servo Valve Actuator

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

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

Electronic Driver Module Printed Circuit Board (PCB)

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

- Power supply
- Isolated input and outputs
- Dual redundant demand inputs
- Dual redundant inputs for final cylinder feedback
- Microprocessor based control
- Actuator H-Bridge drive
- Current limiting for thermal protection
- Advanced diagnostics
- Discrete outputs for fault, alarm, and shutdown enunciation



Figure 1-5. Application Example

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

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

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

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

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

Cylinder Position Control

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

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

VS-I Remote Servo Only Construction

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

- 1. Rotary servo valve
- 2. PCB (this information is available in the VS-I Integrated and Remote Construction section above)

Rotary Servo Valve

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

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

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





Figure 1-6. VariStroke-I Remote Servo, Key Features

Hydraulic Power Cylinder

The VariStroke Remote Servo can be connected to any hydraulic cylinder; however, proper operation requires that the VariStroke Performance Equation be satisfied (see Chapter 2, Performance Index). 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
- Update Rate: ≤1 ms
- Linearity: ±0.04% Full Stroke
- Current Drain: < 100 mA
- Sensor length must not exceed 2 times the cylinder stroke length

Chapter 2. Specifications

Physical Specifications

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

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

 Table 2-2. Available Springs for Spring Assist Cylinders

			Opinig			
Bore in (mm)	Stroke in (mm)	Spring force kgf (lbf)	S	т	U	v
4	4 (101 6)	MIN	25 (56)	52 (114)	102 (224)	-
(101.6)	4 (101.0)	MAX	51 (112)	103 (226)	217 (478)	-
	2 (76 2)	MIN	49 (108)	107 (235)	236 (520)	-
6	3 (70.2)	MAX	98 (216)	214 (471)	472 (1040)	-
(152.4)	4 (101 6)	MIN	49 (108)	107 (235)	236 (520)	-
	4 (101.6)	MAX	98 (216)	214 (471)	472 (1040)	-
3 (76.2		MIN	126 (276)	240(529)	477 (1052)	883 (1946)
	3 (76.2)	MAX	231 (510)	479 (1057)	954 (2104)	1835 (4046)
(203.2)		MIN	110 (242)	239 (528)	477 (1052)	918 (2023)
4 (101.6)	MAX	247 (544)	450 (1058)	954 (2104)	1836 (4047)	
3 (76.2)		MIN	201 (443)	364 (803)	744 (1640)	1156 (3430)
	3 (76.2)	MAX	321 (708)	583 (1286)	1190 (2624)	2489 (5488)
(254.0)		MIN	161 (354)	291 (642)	595 (1312)	1245 (2744)
	4 (101.6)	MAX	321 (708)	583 (1286)	1190 (2624)	2489 (5488)

Spring

External Force, Load

The max external load should be below 80% of the Stall Force of the VariStroke actuator. Stall force is defined as the supply pressure times the area of the active side of the actuator cylinder.

IMPORTANT Make sure that the external load value is within the appropriate range over the entire piston stroke. Too high load will decrease the unit performance.



Figure 2-1. Hydraulic Cylinder with Load

Load requirements:

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

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Stall Force (extending):	Extending stall force can be obtained from the following equation:
	Extend Stall = $\frac{\pi OD^2}{4}$ p (p - <i>supply pressure</i>) [in ² • psi = lbf] or [mm ² • MPa = N]
Stall Force (retracting):	Retracting stall force can be obtained from following equation:

Retract Stall = $\frac{\pi (OD^2 - ID^2)}{4}$ p (p - *supply pressure*) [in² • psi = lbf] or [mm² • MPa = N] The formulas above are valid for double acting cylinders. For spring-assist actuators, additional spring force and its direction must be considered.

Extending Slew Rate:	Configurable
Retracting Slew Rate:	Configurable

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



Performance Specifications

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

Additionally, for spring-assist actuators, the power cylinder internal spring installed in the cylinder generates force towards the fail-safe position.



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

WARNING Overspeed / Overpressure

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

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	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
Ingress Protection	IP66
(IEC 60529, IEC 60079-0):	
	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	(4 to 20) mA into 235 Ω . >70 dB CMRR. Common Mode Voltage
Signals #1, 2:	Range ±50 V (dc), Accuracy 0.1% of full scale @ 25 °C
Analog Output Signal:	(4 to 20) mA. Maximum load: 500 Ω. Accuracy 0.5% of full scale @ 25 °C
Discrete Output Signal:	Configurable NO or NC
	0.5 A at 24 V (dc), max 32 V (dc)
	0.5 A inductive at 28 (dc) 0.2 Henry
Discrete Input Signal:	Contact current 3.8 mA (typ.) @ input closed
	Max input voltage 32 V (dc), High signal threshold > 7 V; Low signal
Foodbook Dovice (interreted):	Inresnold < 3 V
Feedback Device (Integrated).	Perseveble terminal suitable for 0.14 to 2.5 mm ² or 12 to 24 AWC
Connections.	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	Position Sensor: 0.750"-14 NPT
Cylinder:	
Table 2-5. Cylir	nder Position Sensor Requirements (Remote Servo Only)
Output Sig	nal: Analog: 4–20 mA
Input Volta	de: 15 Vdc (power provided by VariStroke)
l inear	ity: ±0.04% Full Stroke
Current Dra	ain: <100 mA

 Sensor Length:
 ≤ 2 times the Cylinder Stroke Length

 Update Rate:
 ≤ 1 ms

 Sensor Cable Length Limit:
 3 m (10 feet) maximum between sensor and VariStroke

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	Slower update rates than the one shown in the above requirements

IMPORTANT	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 considers using Magnetostrictive position sensors and/or DCDTs.

Table 2-6. Hydraulic Specifications

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

IMPORTANT	It is recommended to set the hydraulic system pressure regulator to 110% or less of normal operating pressure to prevent over-
	pressure.

Proof Pressure:	51.7 bar (750 psig)
Burst Pressure:	86.2 bar (1250 psig)
Fluid Temperature:	(15 to 70) °C / (59 to 158) °F continuous
Fluid Cleanliness Level:	ISO 4406 code 20/18/16 or cleaner
Output Cylinder Action:	Double
Hydraulic Connections	Hydraulic Supply Port: 1.250 SAE Code 61 Flange
for	Hydraulic Drain Port: 1.500 SAE Code 61 Flange
Integrated Actuators:	
Hydraulic Connections	Hydraulic Supply Port: 1.250 SAE Code 61 Flange
for	Hydraulic Drain Port: 1.500 SAE Code 61 Flange
Remote Servo:	Control ports C1 and C2: 1.000 SAE Code 61 Flange
	Actuator and Servo OVBD: .438-20 UNF
Pipe Size Between	Diameter: 25.4 mm (1 inch) minimum
Remote Servo and	Length: 3 m (120 inch) maximum
Cylinder:	
Supply Fluid Flow:	Refer to the following figures for maximum transient flow rate and steady
	state flow rate requirements:



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

IMPORTANT

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



Figure 2-3. Steady State Flow Rate

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

IMPORTANT

Special Ambient Temperature Specifications / Allowances



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.

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

Table 2-7. Special Ambient Temperature Specifications/Allowances

Performance Index

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

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

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



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

Where:

 $P_{supply} = Supply Pressure in BAR$

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

*L*_{stroke} = Stroke Length in **Centimeters**

Note: This is the used maximum stop position. It may or may not equal the cylinder length.

 $VS_{Constant} = Varistroke Constant = 180$

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

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

Diagrams



Functional Block Diagram



VS-I Integrated Hydraulic Schematic





VS-I Remote Servo Hydraulic Schematic



Figure 2-7. VS-I Remote Hydraulic Schematic

VS-I Servo Only Hydraulic Schematic



Actuator not included - for reference only







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Figure 2-10. VS-I Spring Assist Remote Hydraulic Schematic

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

	Table 2-8.	VS-I	Installation	Drawings
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Woodward Model Number	Description	Appendix Number
V45TD-10XX	V45 Servo, 4-inch (100mm) Bore Integrated Servo- Cylinder	A
V45TD-12XX	V45 Servo, 5-inch (127mm) Bore Integrated Servo- Cylinder	В
V45TD-15XX	V45 Servo, 6-inch (150mm) Bore Integrated Servo- Cylinder	С
V45TD-20XX	V45 Servo, 8-inch (200mm) Bore Integrated Servo- Cylinder	D
V45TD-25XX	V45 Servo, 10-inch (250mm) Bore Integrated Servo- Cylinder	Е
V45RD-10XX	V45 Servo, 4-inch (100mm) Bore Remote Servo- Cylinder	F
V45RD-12XX	V45 Servo, 5-inch (127mm) Bore Remote Servo- Cylinder	G
V45RD-15XX	V45 Servo, 6-inch (150mm) Bore Remote Servo- Cylinder	Н
V45RD-20XX	V45 Servo, 8-inch (200mm) Bore Remote Servo- Cylinder	I
V45RD-25XX	V45 Servo, 10-inch (250mm) Bore Remote Servo- Cylinder	J
V45TX-1010	V45 Servo, 4-inch (100mm) Bore Integrated Spring Assist Servo-Cylinder	К
V45TX-15XX	V45 Servo, 6-inch (150mm) Bore Integrated Spring Assist Servo-Cylinder	L
V45TX-20XX	V45 Servo, 8-inch (200mm) Bore Integrated Spring Assist Servo-Cylinder	М
V45TX-2510	V45 Servo, 10-inch (250mm) Bore Integrated Spring Assist Servo-Cylinder	Ν
V45RX-1010	V45 Servo, 4-inch (100mm) Bore Remote Spring Assist Servo-Cylinder	0
V45RX-15XX	V45 Servo, 6-inch (150mm) Bore Remote Spring Assist Servo-Cylinder	Р
V45RX-20XX	V45 Servo, 8-inch (200mm) Bore Remote Spring Assist Servo-Cylinder	Q
V45RX-2510	V45 Servo, 10-inch (250mm) Bore Remote Spring Assist Servo-Cylinder	R
V45V	V45 Remote Servo Version	S

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Notes

- 1. These general reference outline drawings apply to Woodward VS-I only. Consult Woodward for the latest outline drawing.
- 2. Installation Orientation:
 - a. Cylinder any orientation is acceptable.
 - b. Servo Valve any orientation except upside down. Vertical orientation is recommended.
- 3. Service Manual Replacement Parts:
 - a. Servo Valve Refer to Chapter 4 for additional details
 - b. Hydraulic Power Cylinder Refer to Chapter 4 for additional details
 - c. Service Manual Refer to Chapter 4 for additional details
Chapter 3. Installation

Receiving Instructions

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

Unpacking Instructions

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



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.



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.



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 the figures in the installation chapter and drawings in the appendices for the correct torque procedure of all covers.



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





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.



A conduit seal must be installed within 457 mm (18 inches) of the conduit entry when the product is used in Zone 1 or Class I, Division 1 hazardous locations. When a VS-I Remote Cylinder is used in Zone 1 or Class I, Division 1 hazardous locations, conduit seals are also required at the cylinder and the servo for the feedback wiring so that they are separated flameproof / explosionproof enclosures.

Installation Instructions

General

See the outline drawings and specifications for:

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

A vertical actuator position is generally preferred to conserve floor space as well as ease of making electrical and hydraulic connections. However, the VS-I can be mounted in any attitude. 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 to remove the top cover for access to the terminal blocks and to see the status LEDs on the printed circuit board.

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

The integrated VS-I is designed to be supported by the hydraulic power cylinder mating bottom or top surface. For each individual VS-I actuator bolt pattern, bolts and bolting torque recommendations are to be followed per Table 3-1.

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.

The VariStroke-I is shipped with plastic thread protectors in the servo's four wiring entries. These plastic thread protectors are not environmentally rated and are for shipping purposes only. Each port must be sealed with a conduit, cable gland, or metal plug. Zone-1 applications require Zone-1 rated plugs. Woodward offers servo Zone-1 plug kit 8923-3203.

Refer to Installation Application Note 51629 for additional best practices.



Installation Dimensions for Integrated Actuator

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



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

Installation Dimensions for Remote Servo Kit



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





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

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





Figure 3-2c. Hydraulic Rod Position for Different Cylinders Versions

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

Cylinders without a spring will have the rod in the retract position despite the fail direction.

Installation Dimensions for Servo Only





NOTICE

Minimum Bolt Grade, Bolting Torque and Thread Engagement Recommendation 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.

Lifting

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



Figure 3-4. VS-I Lifting Positions

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



Figure 3-5. Incorrect Lifting Method



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

Manual 26727		VariSt	roke-I (VS-I) Electro	o-hydraulic Actuator
	NG Ensure that t shaft to the t stall force an	he linkages and cou urbine are appropria d dynamic loads.	plings connecting tely sized and able	the VS-I output to withstand the
WARNING The lifting eye located on the top of the VS-I servo valve is intended to lift ONLY the servo itself, not the integrated servo-cylinder configurations.				
WARNING Make sure that the crane, cables, straps, and all other lifting equipment used for VS-I lifting can support the VS-I weight. See outline drawings for VS-I weights.				
When transporting the hydraulic cylinder in an upside-down position, the cylinder rod must be properly secured against uncontrolled rod movement.				
Hydraulic Conne	ections			
	Table 3-2. Servo	Hydraulic Connection	ns for Integrated Ver	sion
		Ser	vo	
For the	Hydraulic Connections	Fitting	Bolt Size	Torque
Integrated VS-	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)
Note: SAE J518, JIS B 8363, ISO/DIS 6162 AND DIN 20066 are interchangeable, except for bolt sizes/threads. The VS-I uses metric bolt sizes.				

Table 3-3. Servo and Cylinder Hydraulic Connections for Remote Version

	Servo				
	Hydraulic Connections	Fitting	Bolt Size	Torque	
	Hydraulic Supply	1.250 SAE J518	4x M10x1.5	(34 to 48) N ⋅ m,	
	Port	Code 61 Flange	Screws	(25 to 35 lb-ft)	
	Hydraulic Drain	1.500 SAE J518	4x M12x1.75	(48 to 61) N·m,	
	Port	Code 61 Flange	Screws	(35 to 45 lb-ft)	
For Pomoto	Hydraulic Control	Hydraulic Control 1.000 SAE J518		(34 to 48) N⋅m,	
VS-I	Port C1 and C2 Code 61 Flan		Screws	(25 to 35 lb-ft)	
	Cylinder				
	Hydraulic Connections	Fitting	Bolt Size	Torque	
	OVBD	.438-20 UNF Straight Thread Port	N/A	(7 – 8) Nm, (65 - 69 lbf-in)	
	Hydraulic Control Port C1 and C2	1.000 SAE J518 Code 61 Flange	4x M10x1.5 Screws	(34 to 48) N·m, (25 to 35 lb-ft)	

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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 is 3 meters.



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

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

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

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

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

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

For remote servo-cylinder connection, use 25 mm (1 inch) tubing to minimize servo-actuator plumbing flow restrictions. Rigid/steel tubing is recommended for these connections.



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

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

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



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

Electrical Connections

Figure 3-7 shows an overall electrical wiring diagram. Detailed wiring requirements for these connections will follow in the remainder of the Electrical Connections section. The RS-232 connection is covered in manual 35148 *Customer Service Tool for VariStroke-I Electro-hydraulic Actuator*.



Figure 3-7. 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 counter clockwise (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 the

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



Figure 3-8. Servo Cover

Connect the control wiring to the terminal blocks, then insert the terminal block plugs in the headers. Then tighten the header retaining screws.



Figure 3-9. Electrical Adapters

When 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 a torque wrench if available. The recommended torque is from 90 to 100 LB-FT. As a last

step, tighten the locking setscrew until flush with the top surface of the cover (recommended torque 5.5 to 6.2 lb-in).

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 3-4.

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

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

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.

Temperature range	-40°C to +85°C
Valtaga Banga	18 VDC to 32 VDC
voltage Range	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

Table 3-4. Recommended Fuse Ratings or Circuit Breakers.

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



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 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.

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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 3-10. Power Supply Input Connections

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

Table 3-5. Terminal Assignment for this Option Usage.

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



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



Figure 3-11. Correct Wiring to Power Supply Input





Figure 3-12. 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 3-6 to assist the cable selection.

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

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

Table 3-6. Voltage Drop Using American Wire Gauge (AWG)

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 maximum performance.

Wire Cross-Sectional Area Voltage Drop

A standard wire cross-sectional area voltage drop at maximum ambient temperature is provided in Table 3-7 to assist the cable selection.

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

- -			o //	()
Table 3-7. Vol	tage Drop Usi	ng Wire Cross	-Sectional Area	(mm ²)

Example of Voltage Drop Calculation Using Wire Cross-Sectional Area

A 2.5mm² 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 $30 \times 0.174 = 5.22$ V. It is 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 3-13 below gives a possible solution for installations required to run at longer distances.



Figure 3-13. 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).



Wiring Strain Relief

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



Figure 3-14. 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 maximize the diameter 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 where permitted by the control-wiring diagram.

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



Strip wires away from the PCBA chamber to avoid 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 the dedicated demand input. For application where reliability is critical, the Demand Input #2 can be configured for a redundant demand input.



Figure 3-15. Analog Input Connections

Table 3-8.	Demand	Analog	Input
------------	--------	--------	-------

0.1% of full range
(0 to 25) mA, the recommended maximum range is (2 to
22) mA
200 ppm/°C
200 Ω ±10%
±50 V(dc)
70 db @ 50 Hz & 60 Hz
400 k Ω 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 35148 for information on configuring these inputs.



Figure 3-16. Final Cylinder Position Feedback Analog Input Connections

Table 3-9.	Cvlinder	Position	Feedback	Analog	Input

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

NOTICE

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.



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

The following drawings illustrate correct and incorrect wiring methods to the cylinder position feedback analog inputs.







Figure 3-18. Cylinder Position Sensor Wiring Diagram When Using External Power Supply



Figure 3-19. Example of Incorrect Cylinder Position Sensor Connection When Using External Power Supply



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



Figure 3-20. Cylinder Position Connectors







Cylinder Position Feedback Analog Input Wiring Requirements:

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



Analog Output

The analog output of the VS-I is in the form of a (4 to 20) mA output and can drive load resistance from 0 up to 500 Ω . This output can be configured. Refer to the Customer Service Tool manual 35148 for configuration information. The design of this output is for monitoring and diagnostic purposes only, and not intended for any type of closed loop feedback.



Figure 3-22. Analog Output Connection

Table 3-10. 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-I has four discrete inputs. External power is not necessary for these inputs as the isolation is provided internally. The discrete inputs have an internal pull-up resistor and are inverted at the processor, such that an open circuit is the passive low state. The high state is achieved when the input is pulled low by an external contact to the isolated ground terminal provided. There are four inputs and one ground terminal (DI GND) provided, so it is necessary to share the one ground if more than one input is used.



Figure 3-23. Discrete Inputs Connections

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

Trip Points:

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

Isolation: 500 V (ac) from digital common and chassis.

Wiring Requirements

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

Discrete Outputs

There are four discrete outputs on the VS-I. Configuration of the outputs is normally open / normally closed. Refer to the Customer Service Tool manual 35148 for configuration information. Wire the outputs to switch load from positive supply or switch load to ground. Woodward recommends that the output be used as a high side driver as shown in the diagram below. This configuration makes some common wiring faults to ground more detectable in the user system. The user must supply the external 24 V supply for the output to function properly.



Figure 3-24. 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.

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

Table 3-11. Discrete Outputs

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

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

The VS-I has (2) CAN ports.

NOTICE



Figure 3-25. CAN Ports Connections

Table 3-12. 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 the 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.



Wiring

The VS-I has four NPT wiring entries: two ³/₄ inch (19.05 mm), two ¹/₂ 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. Unused wiring entry ports must be plugged.

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 $0.5 \text{ N} \cdot \text{m}$ (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 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 Electro-hydraulic 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.

Several features can be setup by using the Customer Service Tool:

- 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



	Application Statistics tokes Device Analog Demand Input 1	Analog Demand Input 2	Feedback Thresholds
Buccountry	Carnel Readers 0.00 PA	Darant Baulton 0.00 Mé	
INPUT CONFIGURATION			
Itatus Overview	Analog Input 1 Scaling	Analog Input 2 Scaling	Position Readback Senior 1 Fault Detection Thresholds
🕒 Shutdown 🕓 Alam	Minimum Analog Demond In 4.00 wA = 0% of Stroke	Minimum Analog Demand In 4.00 w4 = 0% of Strake	Low Unit 2.00
	Maximum Analog Demand In 2000 mA = 100% of Stroke	Missimum Acalog Demand In 20.00 IgA = 100% of Stroke	Hightimit 21.00
easting Media CONF GURATION	Anales Input 1 haut Detection Thresholds	Analysis insul 2 Fault Detectors Thresholds	Broking Easthark Searce 2 Ex it Paterting Three balls
enend 0.00 %	Low Link 2.00 mi	Low tint 2.00 mA	Invitet 2.00
redback 0.00 %	15x8 (mit	the line and at	
	11/2 (COT) 11	ngn 5m; 22.07] W	High Unit. 2100
ickon Buttorn			1
Demand Input Configuration		Run Enable	Position Feedback Configuration
	Incidential Continuous	Caution : If the Ran Enable is loggled to USED while the circuit is open, the arbuster will remediately statisticsen.	And American Inc.
	internet for internet		input inside
	Denand Inputs	Ran Enable Not Lived	Feedbacks in Control
lavigation Buttons	Demand laput 1 0.00 %		Position Feedback 1 🕥 0.00 % 4.01 mA
System	Domand Input 2 0.00 %	Current Run Enable Status Circuit Open	Position Feedback 2 Q 0.00 % 4.02 mA
Information	Denand 0.00 %		Fredback 0.00 %
Calbrate Dvonis Mos	Dual input Configuration	Reset	Duai Peedback Cooliguadion
Manual Durner Value	Spread Alarm Limit 5.00 %	Reset	Spread Alam Linit 5.00 %
operation	Actual Spread 0.00 %	Current Reset Elisarete Input Status Circuit Open	Actual Spread B20 S
Configuration	Spread Foult Mode Low Signal Select		Spread Fault Mode High Signal Scient
Output			
Configuration	10xxxxxxx		Wanter
			AND DESCRIPTION OF A DE

Figure 3-26. Customer Service Tool Example Pages



Chapter 4. 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.



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

General

The VariStroke-I is warranted to be free from defects in materials and workmanship when installed and used in the manner for which it was intended, for a period defined in Woodward's Terms and Conditions.

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

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

The VariStroke-I is shipped with plastic thread protectors in the servo's four wiring entries. These plastic thread protectors are not environmentally rated and are for shipping purposes only. Each port must be sealed with a conduit, cable gland, or metal plug. Zone-1 applications require Zone-1 rated plugs. Woodward offers servo Zone-1 plug kit 8923-3203.

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 center (AISF)
- Bronze Level can be performed by Woodward or service center (AISF)

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The tables below show the common spare parts:

Table 4-1. Servo, Integrated – Replacement Kits for Cylinders 6, 8, and 10 Bore

Replacement Kit Number	Replacement Kit Description	Components Maintenance Manual (CMM)	Installation Drawing Number	Servo Type	Level of Service
9907-1335 9907-2360 (CR)	Integrated			V45 INTEGRATED, Fail Extend	Gold
9907-1336 9907-2361 (CR)	servo V45 for cylinders 6, 8 and 10 bore	CMM-03002	9999-1590-1	V45 INTEGRATED, Fail Retract	Silver, Bronze

Servo - Integrated

Table 4-2. Servo, Integrated – Replacement Kits for Cylinders 4 and 5 Bore

Servo - Integrated

Replacement Kit Number	Replacement Kit Description	Components Maintenance Manual (CMM)	Installation Drawing Number	Servo Type	Level of Service
9907-1452 9907-1473 (TOP LEVEL 9907- 1468 ONLY)	Integrated servo V45 for cylinders 4 and 5 bore		9999-1590-1	V45 INTEGRATED, Fail Extend	Gold, Silver, Bronze
9907-1453		CMM-03002		V45 INTEGRATED, Fail Retract	

Table 4-3. Servo, Remote – Replacement Kits

Servo - Remote

Replacement Kit number	Replacement Kit description	Components Maintenance Manual (CMM)	Installation Drawing number	Servo type	Level of Service
9907-1256 907-2113 (CR)	Pomoto corvo			V45 Remote, Fail Extend	Gold,
9907-1333 9907-2112 (CR)	V45	CMM-03002	9999-3189	V45 Remote, Fail Retract	Silver, Bronze

Table 4-4. 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
8935-1216-10	Cylinder Rod			4 inch bore	Gold.
8935-1216-12				5 inch bore	
8935-1216-15		CMM-03002	9999-1590-7	6 inch bore	Silver,
8935-1216-20	Ocais			8 inch bore	Bronze
8935-1216-25				10 inch bore	

Table 4-5. Cylinder Seals- Replacement Kits

Cylinder (No Spring Assist Version)

Replacement Kit Number	Replacement Kit description	Components Maintenance Manual (CMM)	Installation Drawing Number	Cylinder Size	Level of Service
8935-1215-10	Seal Kits (soft components) Standard Version	CMM-02003	9999-1590-7	4 inch bore	
8935-1215-12				5 inch bore	
8935-1215-15 935-1380-15 (CR)				6 inch bore	Gold,
8935-1215-20 8935-1380-20 (CR)				8 inch bore	Silver
8935-1215-25 8935-1380-25 (CR)				10 inch bore	

Table 4-6. Cylinder Seals, Spring Assist – Replacement Kits

Cylinder (Spring Assist Version)

Replacement Kit Number	Replacement Kit Description	Components Maintenance Manual (CMM)	Installation Drawing Number	Cylinder Size	Level of Service
8935-1215-10	Seal Kits (soft components) – Spring Assist	CMM-02003	9999-1590-14	4 inch bore	Gold,
8935-1215-15				6 inch bore	
8935-1215-20				8 inch bore	Silver
8935-1215-25	Versions			10 inch bore	

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Table 4-7. Position Sensor – Replacement Kits

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	

Cylinder (All Bores)

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.

VARNING 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.



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.



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



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.

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determine the cause and solution to the fault.

Problem	Cause	Remedy	
	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-I 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 VS-I has a valid demand signal.	
Shut down	Unexpected command from digital communication.	Take away command and reset VS-I for normal operation.	
Shut down	Discrete input wiring problem.	Fix wiring problem.	
Detection: Shut down command sent by Customer Service Tool, Analog Demand out of range, digital communication protocols (CAN open), Run Enable, or diagnostic.	Run Enable configuration problem.	Ensure the Used / Not Used settings inside the VS-I match the Active/Inactive settings of the controller. Settings can be modified using the 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 3: Cylinder Position Feedback Analog Inputs	
Alarm		Using the Customer Service Tool, view the	

Table 4-8. VS-I General Troubleshooting Guide

Detection: Alarm or Shut down is detected. Diagnostic triggered an Alarm and/or shut down Alarms / Shutdowns page to determine the fault. Use the remainder of this chapter to

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Table 4-9. VS-I Demand Faults Guide						
Problem / Alarm	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-I 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.				
	Wiring is disconnected or loose.	Check terminals and connections.				
Domand 1 or 2 Input Low	Short in wiring.	Check wiring for shorts to positive voltages. Check wiring insulation.				
Detection:	Control system 4 to 20 mA output has failed low.	Check the current to the analog input to the VS-I. Fix control system.				
threshold. This is a user configurable parameter. Typically, 2 mA.	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-I Customer Service Tool.				
	VS-I internal electronics failure.	Contact Woodward Technical Support for further assistance.				
Demand 1 or 2 Input High	Short in wiring to external voltage.	Check wiring for shorts to positive voltages.				
Detection: The analog demand input is above the	Control system 4 to 20 mA output has failed high.	Check the current to the analog input to the VS-I. Fix control system.				
diagnostic threshold. This is a user configurable parameter. Typically, 22 mA.	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-I Customer Service Tool.				
	VS-I internal electronics failure.	Contact Woodward Technical Support for further assistance.				
Demand Spread Alarm		If dual demand signals are not				
Detection: Demand Inputs are configured to Dual Mode and 1 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.	being connected and used, set mode to Single Channel. When using dual demand signals, check source hardware and connections.				
Demand Linearization Table Order Incorrect	Demand Linearization is not monotonically increasing.	Correct the table OR disable linearization.				

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Problem	Cause	Remedy		
Bower up Boost	It is normal for the Power Up Reset diagnostic to occur upon power up of the VS-I.	Issue a reset to the VS-I.		
Detection: CPU reset by a power up event.	If this occurs while the VS-I 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-I 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		
Input Voltage High	Input Power level detected above reasonable limit.	down, Input Voltage Low flag may be set.		
(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 3: Cylinder Position Feedback Analog Inputs.		

Table 4-10. VS-I Power Supply Faults

Table 4-11. VS-I Feedback Faults

Problem	Cause	Remedy
Position 1 or 2 Feedback Low		
Detection: Power cylinder feedback 1 or 2 below Low threshold Typically, 2 mA. Position 1 or 2 Feedback High Detection: Power cylinder feedback 1 or 2 above High threshold Typically, 21 mA. Position Feedback Spread Alarm	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.
•		
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.
are out of usable range.		!
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:	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.
Compare actual measurements (using external measurement device) with % feedback as shown in the VariStroke Customer Service Tool.	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.

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

Table 4-12. VS-I Temperature Faults

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1	Fable 4-13. Performance Fault	S					
Problem	Cause	Remedy					
	Weak power supply						
Spring Check Failed Detection:	Broken return spring	 Verify the power supply has sufficient current capability. 					
Startup test showed a detected failure of the servo valve safety return spring.	Servo valve seizure	Service is required.					
Servo Tracking Alarm Detection: The Servo Valve is unable to maintain position within the tracking error alarm	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.					
limits. This will trigger an Alarm Servo Tracking Fault	Excessive valve/actuator Wear	Service is required.					
Detection: The Servo Valve is unable to position within the tracking error fault limits. This will trigger a shut down.	VS-I electronics failure.	Contact Woodward Technical Support for assistance.					
	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 2: External Force, Load.					
Cylinder Tracking Alarm Detection: The Power Cylinder is unable to position	Excessive thermal growth in control valve linkage	Lower the ambient temperature of the VariStroke and/or linkage. If this is not possible, consider disabling this diagnostic.					
within the tracking error alarm limits. This will trigger an Alarm.	Contamination in the	Ensure oil supply meets cleanliness requirements. Replace / filter the oil and flush					

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Cylinder Tracking Fault Detection:	Contamination in the valve/actuator system.	Replace / filter the oil and flush the valve with clean oil. If problem persists, service may be required.			
within the tracking error fault limits. This will trigger a shut down.	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		Ensure that calibrated maximum stop position is greater than			
Detection: The maximum stop position has been se	Incorrect cylinder or position sensor configuration OR	40% of the physical cylinder length and sensor length.			
length.	incorrect calibration limits	Check that the settings in the Remote Cylinder Setup are			

Remote Cylinder Setup are correct.

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Problem	Cause	Remedy		
Performance Index Warning	Incorrect configuration and calibration settings.			
The settings for Supply Pressure, Offset at Minimum Position, and Maximum Stop Position result in a violation of the performance relationship.	The VS-I servo valve is too large for the set cylinder volume.	See Chapter 2: Performance Index for the details of this alarm.		
	Loss or reduction in hydraulic supply pressure	Ensure that hydraulic pressure does not drop more than 10% during a full slew. Consider adding		
Slow Slew Rates	Applied load on the actuator is too high.	a high-volume hydraulic accumulator to the supply line. See Chapter 2 : Hydraulic		
	Excessive wear of actuator/linkage/valve	Specifications Verify mechanical condition of actuator/linkage/valve.		
	Table 4-15. Internal Faults			
Problem	Cause	Remedy		
Electronics Fault	An internal error has occurred in the driver.	Service required.		

Table 4-14. Performance Faults (continued)

Maintenance

To maximize the life of the VS-I, please refer to the maintenance recommendation in Chapter 7: Asset Management and Refurbishment Scheduling Period.

Chapter 5. Ordering Code





Chapter 6. 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

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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



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 <u>https://www.woodward.com/support</u>, 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	Products Used in	Products Used in Industrial			
Electrical Power Systems	Engine Systems	Turbomachinery Systems			
Facility Phone Number	FacilityPhone Number	FacilityPhone Number			
Brazil +55 (19) 3708 4800	Brazil +55 (19) 3708 4800	Brazil +55 (19) 3708 4800			
China +86 (512) 8818 5515	China +86 (512) 8818 5515	China +86 (512) 8818 5515			
Germany+49 (711) 78954-510	Germany +49 (711) 78954-510	India+91 (124) 4399500			
India+91 (124) 4399500	India +91 (124) 4399500	Japan+81 (43) 213-2191			
Japan+81 (43) 213-2191	Japan+81 (43) 213-2191	Korea+ 82 (51) 636-7080			
Korea+82 (51) 636-7080	Korea+82 (51) 636-7080	The Netherlands+31 (23) 5661111			
Poland+48 (12) 295 13 00	The Netherlands+31 (23) 5661111	Poland+48 (12) 295 13 00			
United States+1 (970) 482-5811	United States+1 (970) 482-5811	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 7. Asset Management and Refurbishment Scheduling Period

The following recommendations regarding the Woodward designed and manufactured VS-I actuator are to assist in properly managing the reliability, availability, and "safety of operation" expectations established for turbines. While there are electronic control systems designed to monitor and diagnose the operational performance of these components, control monitoring cannot replace normal preventative maintenance practices. It is important to follow these recommendations in order to avoid unnecessary and unscheduled shutdowns.

This product is designed for continuous operation under normal industrial operating conditions. Periodic service is not required on any components. Recommend performing service during major turnarounds, scheduled every five to eight years depending on the site and application. During major outages, Woodward recommends the VS-I be sent back to Woodward or a Woodward Authorized Service Facility (AISF) for inspection, component servicing 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 right maintenance cycles 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-I product.
- **Bronze**: Service to be performed by a Woodward authorized service center. Bronze service typically involves limited disassembly, 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 6 for Product Support.

For maintenance and service replacement kits are available. 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.

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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:

- 1) Carefully inspect the piston rod surface for significant scratches, corrosion, or damage.
- 2) 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.
- 3) Evaluate the source of any external leakage.

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

Chapter 8. Long-Term Storage Requirements

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

Appendices Outline Drawings and Installation Features

Appendix A – V45 Servo, 4-inch (100mm) Bore Integrated Servo-Cylinder (V45TD-10XX)







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W OOD W ARD P/N:	ORDER_NUMBER	STROKE [INCH]	FAIL-SAFE MODE	HEIGHT 'A'	HEIGHT 'B' / INCH [mm] / 3	HEIGHT 'C'	HEIGHT 'D' INCH (mm)	DIMENSION 'E' INCH (mm)	DIMENSION 'F' INCH (mm)	DIMENSION 'G' INCH [mm]	APPROXIMATE WEIGHT LBS [kg]								
4X3_MALE_E_VS1	V45TD-1007-MUE		EXTEND					(1, 21 [104 03])	(07 [4 79])	(7. 27. (49.1. 441)	402 (97)								
4X3_MALE_R_VS1	V45TD-1007-MUR		RETRACT	45 43 (39/ 30)	19 13 1/ 60 501	43 47 (33/ 53)	(46 47 1/40 70))	(4.21 [100.73])	(.07 (1.70))	(7.27 [104.00])	172 [07]								
4X3_FEMALE_E_VS1	V45TD-1007-FUE	2	EXTEND	10.10 (004.00)	10.13 [400.30]	13-17 (334-32)	(10.17 [410.72])	(1. 21. [407. 70])	(07 [4 79])	17 22 1492 411	404 (97)								
4X3_FEMALE_R_VS1	V45TD-1007-FUR		RETRACT	1				(4.24 [107.70])	(.07 [1.70])	(7.23 [103.04])	191 1073								
4X4_MALE_E_VS1	V45TD-1010-MUE		EXTEND		70] 20.13 [511.30]			(/ 17 [105 02])	(07 (4 79))	(7 / 7 1490 7/1)	100 (001								
9907-1350	V45TD-1010-MUR	, I	RETRACT	44 43 14 40 701		20.13 [511.30] 1	20.13 [511.30] 14.17 [359.	4/ 47 1350 001	2 (250 02) (47 47 (12(42))	(4.17 [105.92])	(.07 (1.70))	(7.47 (109.74))	193 [00]						
4X4_FEMALE_E_VS1	V45TD-1010-FUE	4	EXTEND	10.15 [409.70]				20.13 [311.30] 14.17 [3	14.17 [337.92] (17.17 [430.12])	(/ 10 [104 / 3])	(07 (4 70))	(7 10 (400 / 7))	400 (07)						
4X4_FEMALE_R_VS1	V45TD-1010-FUR		RETRACT					(4.19 [100.43])	(.07 (1.76))	(7.42 [100.47])	192 [07]								
4X6_MALE_E_VS1	V45TD-1015-MUE		EXTEND					(1 00 5403 803)	(07 (4 70))	(7.00.1000.141)	407. (00)								
4X6_MALE_R_VSI	V45TD-1015-MUR	, í	RETRACT	18.13 [460.50] 24.13 [612.90]	40.40.11/0.501	40 40 1/ (0 50)	40 40 11/0 501	40 40 1/ (0 50) 0/ 40 1/40 00)	01 43 1140 003	01 43 1140 003				(4.09 [103.09])	(.07 [1.76])	(7.69 [200.4])	197 [09]		
4X6_FEMALE_E_VS1	V45TD-1015-FUE	°	EXTEND		24.13 [612.90]	24.13 [612.90]	24.13 [612.90]	30.301 24.13 [012.90]	24-13 [612-90] 16-17 [410-72]	(19.17 (400.92))	(1 44 1401 200)	/ 07 /4 703	(7.0) (400.4(1))	407 [00]					
4X6_FEMALE_R_VS1	V45TD-1015-FUR		RETRACT														(4.11 [104.39])	(.0/ [1./0])	(/.04 [199.14])



Figure A-1b. V45TD-10XX Integrated Installation Dimensions

Appendix B – V45 Servo, 5-inch (127mm) Bore Integrated Servo-Cylinder (V45TD-12XX)





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

	TABLE												
W OOD W ARD P/N:	ORDER_NUMBER	STROKE [INCH]	FAILSAFE DIRECTION	HEIGHT 'A' INCH [mm] Z	/AN€IGHT 'B' <u>ANS</u> H (mm) ∠	AFEIGHT 'C' ANCH (mm) Z	HEIGHT 'D' INCH (mm)	DIMENSION 'E' INCH (mm)	DIMENSION 'F' INCH (mm)	DIMENSION 'G' INCH (mm)	APPROXIMATE WEIGHT LBS [kg]		
9907-1748	V45TD-1207-MUE	3	EXTEND					(1 02 (102 241)	(04 (4 52))	(7. 20. (195. 171)	240 (05)		
9907-1752	V45TD-1207-MUR		RETRAC T	15 13 (30) 301 10 13 (740 50)	12 17 122/ 521	(1E 07 (LO3 10))		(.00 [1.52])	(7.27 [105.17])	210 [33]			
9907-1756	V45TD-1207-FUE		EXTEND	10.13 (304.30)	1041301 10113 (400130)	(3117 (354132)	(15.67 (403.10))	// OF (102 07))	(04 (4 52))	(7. DE (10/ 1E))	200 (05)		
9907-1760	V45TD-1207-FUR		RETRACT					(4.05 [102.07])	(.00 [1.52])	(7.25 [104.15])	209 [95]		
9907-1749	V45TD-1210-MUE	4	EXTEND		1] 20.13 (511.30)	14.17 [359.92]	(16.87.(1.28.50))	(1. 00. [101.40])	(04 (1 52))	(7 51 (100 75))	212 (04)		
9907-1753	V45TD-1210-MUR		RETRAC T	16.13 [409.70]				(4.00 (101.00))	(.00 [1.52])	(7.51 (190.75))	212 (70)		
9907-1757	V45TD-1210-FUE		EXTEND				(10.07 [420.30])	(/ 01 [101 9E])	1 04 14 520	17 17 1490 7/1	241 (04)		
9907-1761	V45TD-1210-FUR		RETRAC T					(4.01 [101.05])	(.00 [1.52])	(7.47 [109.74])	211 [90]		
9907-1750	V45TD-1215-MUE		EXTEND	18.13 [460.50]	2/ 12 (612 00)	44 47 4440 701	(40.07.1/70.20)	(3.02.100.571)	(06 (1.52))	(7.06.1202.18))	216 (08)		
9907-1754	V45TD-1215-MUR	4	RETRAC T					(3.72 (77.37))	(.00 [1.52])	(7.70 (202.10))	210 (90)		
9907-1758	V45TD-1215-FUE] °	EXTEND		24.13 [012.70]	10.17 [410.72]	(10.07 [477.30])	(2.0/ (100.09))	(04 (1 52))	(7.01.(200.04))	245 (0.0)		
9907-1762	V45TD-1215-FUR	1	RETRAC T	1				(3.54 (100.00))	(.00 [1.52])	(7.91 (200.91))	213 (70)		
9907-1751	V45TD-1220-MUE		EXTEND					(3.97.107.571)	(04 (4 52))	(0 / 2 / 24/ 42)	220 (400)		
9907-1755	V45TD-1220-MUR	8	RETRACT	0. 43 (544.30)	26 12 1662 701	10 17 1/ 41 521	(20.97.1520.401)	(3.04 (97.34))	(.00 [1.52])	(0.45 (214.12))	220 [100]		
9907-1759	V45TD-1220-FUE		EXTEND	20.13 [311.30]	20.13 [511.30] 26.13 [663.70]	10.17 [401.32]	(20.07 [330.10])	(3.96.109.041)	(04 (1 52))	(0.30.1212.051)	220 (100)		
9907-1763	V45TD-1220-FUR		RETRACT	1				(3:00 (90:04))	(.06 [1.52])	(0.30 [212.05])	220 (100)		



Figure B-1b. V45TD-12XX Integrated Installation Dimensions

Appendix C – V45 Servo, 6-inch (150mm) Bore Integrated Servo-Cylinder (V45TD-15XX)











Manual 26727

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

TABL											
W OOD W ARD P/N:	ORDER_NUMBER	STROKE [INCH]	FAIL-SAFE MODE	HEIGHT 'A'	HEIGHT 'B' /3	HEIGHT 'C'	HEIGHT 'D' INCH (mm)	DIMENSION 'E' INCH (mm)	DIMENSION 'F' INCH (mm)	DIMENSION 'G' INCH [mm]	APPROXIMATE WEIGHT LBS [kg]
6X2_MALE_E_VS1_V45	V45TD-1505-MUE		EXTEND					(3 39 (86 11))	(050 (1 27))	(7 25 (18/ 15))	253 (115)
6X2_MALE_R_VS1_V45	V45TD-1505-MUR	2	RETRACT	16.33 [414.78]	18.33 [465.85]	12 07 1320 111	(15.47 [392.94])	(3.37 [00.11])	(1050 [1127])	(7.25 [104.15])	200 (110)
6X2_FEMALE_E_VS1_V45	V45TD-1505-FUE		EXTEND			12177 (327144)		(3 /// (87 381)	(056 (1.62))	(7 12 (180 851)	26.9 (113)
6X2_FEMALE_R_VS1_V45	V 45TD-1505-FUR		RETRACT					13144 1071303	(1050 (1142))	(7.12 (100.05))	247 (10)
6X3_MALE_E_VS1_V45	V45TD-1507-MUE	- 3	EXTEND				(16.47 [418.34])	(3 35 (58 (9))	(053 (1 351)	(7 50 (190 50))	257 (117)
6X3_MALE_R_VS1_V45	V45TD-1507-MUR		RETRACT	17.33 [440.18]	20.33 [516.38]	13.97 [354.84]		(3.33 (30.07))	(1055 (1155))	(7.50 (170.50)	257 (117)
6X3_FEMALE_E_VS1_V45	V45TD-1507-FUE		EXTEND		20.33 [310.30]			(3.39 (86.11))	(.053 (1.351)	(7.36 [186.94])	253 (115)
6X3_FEMALE_R_VS1_V45	V45TD-1507-FUR		RETRACT					13137 1001113			255 (115)
6X4_MALE_E_VS1_V45	V45TD-1510-MUE	4	EXTEND			14.97 [380.24]	(17.47 [443.74])	(3.30 (83.82))	(.052 [1.32])	(7.76 [167.10])	260 (118)
6X4_MALE_R_VS1_V45	V45TD-1510-MUR		RETRACT	18.33 [465.85] 22.33	22.33 [567.18]						
6X4_FEMALE_E_VS1_V45	V4510-1510-FUE		EXTENU					(3.35 [85.09])	(.053 [1.35])	(7.61 [193.29])	257 (117)
6X4_FEMALE_R_VS1_V45	V 45 I D - 1510 - FUR		RETRACT								
6X6_MALE_E_VS1_V45	V4510-1515-MUE	-	EXTENU	20.33 [516.38]	26.33 [668.78]			(3.22 [81.79])	(.051 [1.29])	(8.29 [210.57])	267 (121)
OXO_HALE_R_V31_V43		6	RETRACT			16.97 [431.04]	(19.47 [494.54])				
6X6_FEMALE_D_VS1_V45	V45TD 1515-FUE	1	DETDACT					(3.26 [82.80])	(.051 [1.29])	(8.13 [206.50])	264 (120)
	V4510-1515-10K		EVTEND								
6Y8 MALE D VSL VAS	V45TD-1520-HUL	1	DETDACT			18.97 [481.84]		(3.14 [79.76])	(.049 [1.25])	(8.85 [224.79])	275 (125)
AV8 FEMALE E VSL VAS	V/STD_1520_FUE	8	EYTEND	22.33 (567.18)	30.33 [770.38]		(21.47 [545.34])				
6X8 FEMALE R VSL V45	V45TD-1520-FUR	1	RETRACT					(3.18 [80.77])	(.050 [1.27])	(8.67 [220.22])	271 (123)
6X10 MALE E VSL V45	V45TD-1525-MUE		EXTEND							1	
6X10_MALE_R_VS1_V45	V45TD-1525-MUR	1	RETRACT					(3.06 [77.72])	(.049 [1.25])	(9.43 (239.52))	282 (128)
6X10_FEMALE_E_VS1_V45	V45TD-1525-FUE	1 10	EXTEND	24.33 [617.98]	34.33 [871.98]	20.97 [532.64]	(23.47 [596.14])	12 40 100 100	1 010 11 053	10.01.0001.000	070 (101)
6X10_FEMALE_R_VSI_V45	V45TD-1525-FUR	1	RETRACT					(3.09 [78.49])	(.049 [1.25])	(9.24 (234.69))	278 (126)
6X12_MALE_E_VS1_V45	V45TD-1530-MUE		EXTEND					(0.00.075.053)	1 0/7 14 401	(40.03.1051.R(1)	000 (434)
6X12_MALE_R_VS1_V45	V45TD-1530-MUR	1 10	RETRACT	24 33 1440 701	20 22 1072 501	22 07 (592 //)	125 17 1414 010	(2.99 [75.95])	(.047 [1.19])	(10.03 [254.76])	209 (131)
6X12_FEMALE_E_VS1_V45	V45TD-1530-FUE] 12	EXTEND	20.33 (000./0)	30.33 (9/3.50)	22.7/ [303.44]	(23.47 (040.94))	(2.02.174.74))	(0/8 (4 22))	(0.93 (2) 0.491)	294 (120)
6X12 FEMALE R VSL V45	V45TD-1530-FUR		RETRACT					(3.02 (76.71))	(.040 [1.22])	(7.03 (249.00))	200 (130)



4 INCH STROKE ACTUATOR UNITS = INCHES [MM]

0

2



SECTION A-A

Appendix D – V45 Servo, 8-inch (200mm) Bore Integrated Servo-Cylinder (V45TD-20XX)



Figure D-1a. V45TD-20XX Integrated Installation Dimensions

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

						ABLE					
W 000 W ARD P/N:	ORDER_NUMBER	STROKE [INCH]	FAIL-SAFE MODE	HEIGHT 'A' A	HEIGHT 'B' A	HEIGHT 'C' 🔬	HEIGHT 'D' INCH (mm)	DIMENSION 'E' INCH (mm)	DIMENSION 'F' INCH (mm)	DIMENSION 'G' INCH (mm)	APPROXIMATE WEIGHT LBS [kg]
9907-1318	V45TD-2010-MUE		EXTEND					(2.02.174.041)	(02 (0 74))	(0.04 (220.00))	287 (420)
9907-1324	V45TD-2010-MUR	,	RETRACT	18.52 [470.41] 2:	00 50 1580 041	14.97 [380.24]	(17.47 [443.74])	(3.03 (70.91))	(.03 (0.70))	(9.00 [230.00])	204 [127]
9907-1365	V45TD-2010-FUE	-	EXTEND		22.32 (3/2.01)			(3.11.(70.10))	(03 (0 76))	(8 76 (222 50))	277 (126)
9907-1366	V45TD-2010-FUR		RETRACT					(3.11 (79.10))	(.03 [0.76])	(0.76 [222.50])	277 [120]
9907-1321	V45TD-2015-MUE		EXTEND			16.97 [431.04]	(19.47 [494.54])	(2.00.172.741)	(02 (0.74))	(0.94 (2/.0.051)	207 (425)
9907-1325	V45TD-2015-MUR	6	RETRACT	20 52 (521 24)	1.21] 26.52 [673.61]			(2.90 (73.74))	(.03 (0.70))	(9.01 (249.03))	277 [133]
9907-1338	V45TD-2015-FUE		EXTEND	20.52 (521.21)				(2 08 (75 60))	(03 (0 761)	(9 49 (241 05))	280 (131)
9907-1339	V45TD-2015-FUR		RETRACT					(2.90 (75.09))	(.05 (0.70))	(9.47 [241.05])	207 [131]
9907-1322	V45TD-2020-MUE		EXTEND	22.52 (572.01)	30.52 (775.21)	18.97 [481.84]		(2 79 (70 841)	(03 (0 76))	(10 58 (268 61))	309 [160]
9907-1319	V45TD-2020-MUR		RETRACT				(21 47 (545 341)	(2.17) (10:04)	(105 (0170))	(10.50 (200.01)	507 [140]
9907-1326	V45TD-2020-FUE	Ň	EXTEND				(2007) (303)(30)	(2.86 (72.641)	(03 (0 761)	(10.24, [260, 10])	302 (137)
9907-1367	V45TD-2020-FUR		RETRACT					(2.00 (72.04))	(.03 (0.70))	(10.24 (200.10))	502 (157)
9907-1368	V45TD-2025-MUE		EXTEND					(2 68 (68 071)	(03 (0 76))	(11 36 (288 541)	322 [166]
9907-1320	V45TD-2025-MUR	10	RETRACT	26 52 622 01	34 52 (876 81)	20.97 (532.64)	(23.47.1596.141)	(2100 [00107])	1103 101703	(11:30 [200134])	JEE (140)
9907-1369	V45TD-2025-FUE		EXTEND	24.52 (022.01)	34.52 1070.013	20177 [332:04]	(23.47 (370.14))	(2 75 (69 851)	(03 (0 761)	(11 01 (279 67))	314 [14:2]
9907-1370	V45TD-2025-FUR		RETRACT					(2.75 (07.05))	1.05 (0.70)	(11.01 (277.075	514 (142)
9907-1371	V45TD-2030-MUE		EXTEND					(2 50 (65 661)	(03 (0 761)	(12 17 (309 02))	33/ [151]
9907-1323	V45TD-2030-MUR	12	RETRACT	26 52 (673 61)	38 52 (978 / 1)	22 97 (583 441	(25 47 1646 941)	(2.57 (05.00)/	(105 (0170))	(1211) (307102))	334 (101)
9907-1372	V45TD-2030-FUE	[*]	EXTEND	20.52 (075.01)	10.52 (770.41)	22.77 [303.44]	(123.47 [040.74])	(2.65.167.23))	(03 (0 76))	(11 80 (299 69))	327 [168]
9907-1373	V45TD-2030-FUR		RETRACT					(2:05 (07:25))	(105 (0.70))	(11.00 (277.07))	JE7 [140]



Figure D-1b. V45TD-20XX Integrated Installation Dimensions

Appendix E – V45 Servo, 10-inch (250mm) Bore Integrated Servo-Cylinder (V45TD-25XX)



Figure E-1a. V45TD-25XX Integrated Installation Dimensions

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

TABLE											
W OOD W ARD P/N:	ORDER_NUMBER	STROKE [INCH]	FAILSAFE MODE	HEIGHT 'A' /	HEIGHT 'B'	HEIGHT 'C'	HEIGHT 'D' INCH (mm)	DIMENSION 'E' INCH (mm)	DIMENSION 'F' INCH (mm)	DIMENSION 'G' INCH (mm)	APPROXIMATE WEIGHT LBS [kg]
9907-1330	V45TD-2510-MUE		EXTEND	47.02.02.02.03.03.02.0572.031			(4.93.114.191)	(02 (54))	(7.30 (407.(5))	E30 (0/4)	
9907-1331	V45TD-2510-MUR		RETRACT		24 02 (557 02)	14.97 [380.24]	(17.47 [443.74])	(1.03 (40.40))	(.02 (.51))	(7.30 (107.43))	JJZ (241)
9907-1353	V45TD-2510-FUE	4	EXTEND	[17.75 [455.42]	21.93 [557.02]			(4.94 (17.4(1))	(02 [54))	(19.04 (19.00))	E0/ (000)
9907-1354	V45TD-2510-FUR		RETRACT					(1.00 [47.14])	(.02 [.31])	(7.21 [103.00])	524 [230]
9907-1329	V45TD-2515-MUE		EXTEND		25.93 [658.62]		(19.47 [494.54])	(1.76 [44, 80])	(02 [54])	(8.06.1204.701)	552 (250)
9907-1327	V45TD-2515-MUR	6	RETRACT	10 03 1506 221		16.97 [431.04]		(1170 [44100])	(102 (101))	(0.00 [204.70])	552 (250)
9907-1355	V45TD-2515-FUE		EXTEND	17.75 (500.22)				(1 79 [45 44])	(02 [51])	(7 87 (200 01))	544 (247)
9907-1356	V45TD-2515-FUR		RETRACT					(1.77 [45.44])	(.02 (.51))	(7.07 (200.01))	544 (247)
9907-1342	V45TD-2520-MUE		EXTEND	21.93 [557.02]				(1 70 (63 261)	(02 [51])	(8 76 (222 50))	572 (259)
9907-1328	V45TD-2520-MUR	8	RETRACT		29.93 [760.22]	18.97 [481.84]	(21 47 (545 341)	(1.70 [43.20])	(102 (151))	(0.70 (222.50))	512 (257)
9907-1332	V45TD-2520-FUE	, v	EXTEND				(21147 (345134))	(1 73 [63 86])	(02 [51])	(8 56 (217 52))	565 (256)
9907-1357	V45TD-2520-FUR		RETRACT					(1.75 [45:00])	1.02 (1.5 1)/	(0.50 (217.52))	505 (250)
9907-1343	V45TD-2525-MUE		EXTEND					(1.65 [41.83])	(02 [54])	10 18 1240 821	503 (260)
9907-1358	V45TD-2525-MUR	10	RETRACT	23 93 (607 82)	120 1381 FP FF	20 97 1532 641	(23 47 1596 141)	(1.05 [41.05])	(.02 (.51))	(7.40 [240.02])	575 [207]
9907-1359	V45TD-2525-FUE		EXTEND	23.75 (007.02)	55.75 (001.72)	20.77 (552.04)	(23.47 (370.14))	(1.67 [/.2 30])	(02 [51])	(0.27 (235 571)	585 (269)
9907-1360	V45TD-2525-FUR		RETRACT					(1.07 [42.37])	(.02 (.51))	(7.27 (255.57))	505 (207)
9907-1361	V45TD-2530-MUE		EXTEND					(1.59 (40 50))	(02 [51])	(10 22 (259 601)	613 (278)
9907-1362	V45TD-2530-MUR	12	RETRACT	25 03 1458 421	37 93 (963 / 21	22 07 (583 //1	(25 47 1646 941)	(1.57 [40.50])	(.02 (.31))	(10.22 (239.00))	013 [2/0]
9907-1363	V45TD-2530-FUE	· "	EXTEND] 37.93 [963.42]	22.97 [505.44]	(23.47 [040.74])	(1.62 [41.02])	(02 [54))	(10 00 [254 12])	605 (27/1
9907-1364	V45TD-2530-FUR		RETRACT					(1.02 [41.02])	(.02 (.5 0)	(10.00 (2)4.12)	005 (274)



Figure E-1b. V45TD-25XX Integrated Installation Dimensions

Appendix F – V45 Servo, 4-inch (100mm) Bore Remote Servo-Cylinder (V45RD-10XX)





Manual 26727



Figure F-1b. V45RD-10XX Remote Installation Dimensions

Manual 26727

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

	TABLE										
W OOD W ARD P/N:	STROKE [INCH]	HEIGHT 'A' /]	HEIGHT 'B'	HEIGHT 'C'	HEIGHT 'D' INCH (mm) 3	HEIGHT 'E' INCH (mm)	DIMENSION 'F' INCH [mm]	DIMENSION 'G' INCH (mm)	DIMENSION 'H' INCH (mm)	APPROXIMATE WEIGHT LBS [kg]	
1328-5140-07M		45 43 (30) 301	10 12 1/40 501	13.17 [334.52]	11.32 [287.53]	(16.17 [410.72])	(.23 [5.84])	(.03 [.76])	(5.90 [149.86])	108 [49]	
1328-5140-07F	-	13.13 [304.30]	10.13 [400.30]				(.23 [5.84])	(.03 [.76])	(5.82 [147.83])	107 [49]	
1328-5140-10M	4	16.13 [409.70]	20.13 [511.30]	14.17 [359.92]	12.32 [312.93]	(17.17 [436.12])	(.23 [5.84])	(.03 [.76])	(6.25 [158.75])	110 [50]	
1328-5140-10F	4						(.23 [5.84])	(.03 [.76])	(6.17 [156.72])	109 [49]	
1328-5140-15M		19 13 1/40 501	42 1/ (0 50) 0/ 42 1/(40 00)	44 45 440 501	44 30 5363 531	(40, 47, (1, 0, 0, 0, 0))	(.23 [5.84])	(.03 [.76])	(6.98 [177.29])	113 [51]	
1328-5140-15F	0	10.13 [400.30]	24.13 [012.90]	10.17 [410.72]	14.32 [303.73]	(19.17 [400.92])	(.23 [5.84])	(.03 [.76])	(6.88 [174.75])	112 [51]	



9. FOR ANY FURTHER INFORMATION PLEASE SEE MANUAL B26727.



Appendix G – V45 Servo, 5-inch (127mm) Bore Remote Servo-Cylinder (V45RD-12XX)



Figure G-1a. VS-I Remote Maximum Allowable Distance between Actuator and Servo

Manual 26727

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



Figure G-1b. V45RD-12XX Remote Installation Dimensions



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

IABLE										
₩ 00D W ARD P ⁄ N:	STROKE [INCH]	HEIGHT 'A'	HEIGHT 'B'	HEIGHT 'C'	HEIGHT 'D' INCH [mm] 3	HEIGHT 'E' INCH [mm]	DIMENSION 'F' INCH [mm]	DIMENSION 'G' INCH [mm]	DIMENSION 'H' INCH [mm]	APPROXIMATE WEIGHT LBS [kg]
1328-5153-07M	2	45 43 (39/ 30)	19 13 1/ 40 501	42 47 122/ 521	44 30 (007 53)	(45 97 (/ 02 401)	(.24 [6.096])	(.04 [1.016])	(5.89 [149.61]	122 [55]
1328-5153-07F	2	15.13 [304.30]	10.13 [400.50]	13.17 [334.32]	11.32 [207.33]	(13.07 [403.10])	(.24 [6.096])	(.04 [1.016])	(5.81 [147.57])	121 [55]
1328-5153-10M	4	16 13 [400 70]	20 13 (511 30)	1/ 17 (350 02)	12 32 1312 031	(16 97 [/.29 50])	(.24 [6.096])	(.04 [1.016])	(6.23 [158.24])	124 [56]
1328-5153-10F	4	10.13 [409.70]	20.13 [511.30]	14.17 [339.92]	[[[2+2]]]	(10.07 [420.30])	(.24 [6.096])	(.04 [1.016])	(6.15 [156.21])	123 [56]
1328-5153-15M	4	10 12 1/ 40 501	2/ 12 [612 00]	16 17 1/ 10 721	1/ 20 (24)	(40 07 1/70 201)	(.23 [5.84])	(.04 [1.016])	(6.94 [176.28])	129 [59]
1328-5153-15F	0	10.13 [400.50]	24.13 [012.90]	10.1/ [410./2]	14.32 [303./3]	(10.07 [479.30])	(.23 [5.84])	(.04 [1.016])	(6.85 [173.99])	128 [58]
1328-5153-20M	- 8	20 13 (511 30)	13 [511.30] 26.13 [663.70]	18.17 [461.52]	16.23 [412.24]	(20.87 (530.101)	(.22 [5.59])	(.04 [1.016])	(7.66 [194.56])	133 [60]
1328-5153-20F		20.13 [511.30]				(20.07 [330.10])	(.22 [5.59])	(.04 [1.016])	(7.57 [192.28])	132 [60]



Figure G-1c. V45RD-12XX Remote Installation Dimensions

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Appendix H – V45 Servo, 6-inch (150mm) Bore Remote Servo-Cylinder (V45RD-15XX)



THE SPACING BETWEEN SERVO VALVE AND ACTUATOR IS LIMITED BY THE POSITION SENSOR WIRINGS. ALLOWED MAXIMUM LENGTH OF THE CABLE FROM THE TERMINAL IN ACTUATOR TO TERMINAL ON PCB PLATE EQUALS 112 INCH [2850 mm].



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Figure H-1b. V45RD-15XX Remote Installation Dimensions

Manual 26727

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

TABLE													
W OOD W ARD P/N:	STROKE [INCH]	HEIGHT 'A' A	HEIGHT 'B' 🔏 INCH (mm)	HEIGHT 'C'	HEIGHT 'D'	HEIGHT 'E' INCH (mm)	DIMENSION 'F' INCH (mm)	DIMENSION 'G' INCH (mm)	DIMENSION 'H' INCH [mm]	APPROXIMATE WEIGHT LBS [kg]			
1328-5135-05M	2	46 33 (/ 4/ 70)	10 33 1/45 501	12.97 [329.44]	44.00 (00)	(45 / 7 (202 0/1)	(.083 [2.11])	(.036 [.91])	(6.55 [166.37])	155 [70]			
1328-5135-05F	2	10.33 [414.70]	10.33 [403.30]		11.22 [204.99]	(13.47 [372.74])	(.085 [2.16])	(.037 [.94])	(6.32 [160.53])	151 [68]			
1328-5135-07M	э	17 33 (440 18)	20 33 (516 38)	13 07 (35/ 8/)	12.22 [310.39]	(16.47 [418.34])	(.081 [2.06])	(.036 [.91])	(6.93 [176.02])	158 [72]			
1328-5135-07F	L	17.33 [440.10]	20.01 [0.010]	13.97 [354.04]			(.083 [2.11])	(.036 [.91])	(6.69 [169.93])	155 [70]			
1328-5135-10M	1	/ 10 22 [/45 05]	10 22 1/45 051	10 22 1/45 051	10 22 1/45 051	22 22 1547 101	44 07 1200 241	43 22 1335 701	(17 47 1443 741)	(.079 [2.00])	(.035 [.889])	(7.32 [185.93])	162 [74]
1328-5135-10F	4	10.33 [403.03]	22.33 [307.10]	14.97 [300.24]	13.22 [333.77]	(17.47 [44].74])	(.081 [2.06])	(.035 [.889])	(7.08 [179.83])	158 [72]			
1328-5135-15M	4	20 22 (544 201	24 22 1440 701	16.97 [431.04]	15.22 [386.59]	(19.47 [494.54])	(.076 [1.93])	(.033 [.838])	(8.12 [206.25])	168 [76]			
1328-5135-15F	0	20.33 [310.30]	20.33 [000.70]				(.078 [1.98])	(.034 [.864])	(7.86 [199.64])	165 [75]			
1328-5135-20M	0	22 22 1547 101	20 22 1770 201	19 07 [/.91 9/]	17 22 [127 20]	(21 / 7 (5/ 5 3/ 1)	(.073 [1.85])	(.032 [.813])	(8.94 [227.08])	175 [79]			
1328-5135-20F	0	22.33 [307.10]	10111 [11010]	10.77 [401.04]	17.22 [437.37]	(21.47 (343.34))	(.075 [1.91])	(.033 [.838])	(8.66 [219.96])	172 [78]			
1328-5135-25M	10	2/ 22 (447.00)	2/ 22 (074 00)	20.07 (522.4/1	10 22 1/ 00 101	(22 /7 (504 4/1)	(.070 [1.78])	(.031 [.787])	(9.76 [247.90])	182 [83]			
1328-5135-25F	10 24.33 [617.98]	24.55 [017.90]	J4.JJ [0/1.70]	20.97 [532.64]	17.22 [400.17]	(23.47 (370.14))	(.079 [2.00])	(.031 [.787])	(9.48 [240.79])	179 [81]			
1328-5135-30M	12	12 26.33 [668.78]	38 33 (073 58)	22 07 (583 441	21.22 [538.99]	(25 17 [616 01])	(.068 [1.73])	(.030 [.762])	(10.60 [269.24])	189 [86]			
1328-5135-30F	12		10.11 (9/3.30)	22.77 [303.44]		(23.47 [040.94])	(.068 [1.73])	(.030 [.762])	(10.30 [261.62])	186 [84]			



NOTES:

1. THIS IS AN INSTALLATION DRAWING FOR REMOTE VARISTROKE I ACTUATORS WITH 6 INCH BORE AND DIFFERENT STROKES. SEE TABLE FOR ACTUATOR PART NUMBERS.

2 LIFTING BRACKETS CAN BE REMOVED AFTER VARISTROKE INSTALLATION. 3 FOR FIRST ARTICLE INSEPCTION (FAI) REQUIREMENTS SEE 4-09-2704.

4. ACTUATOR APPEARANCE MAY VARY FROM THE SHOWN AND MAY NOT REFLECT CURRENT HARDWARE.

AND USING BOTH OF THE LIFTING BRACKETS. SUPPORT VERTICAL POSITION DURING HANGING TRANSPORTATION.

FOR HORIZONTAL TRANSPORTATION USE ADDITIONAL LIFTING EYES (M16X2 THREAD) - NOT INCLUDED IN THE ASSEMBLY.

6. FINISH: PRIMED AND PAINTED "LIGHT GRAY" COLOR, GLOSS FINISH, TWO - PART EPOXY.

7. WHEN MOUNTING, MATING SURFACE SHALL BE FLAT TO .020 INCH. NO PAINT OR OTHER CONTAMINANTS ALLOWED ON EITHER MATING SURFACE.

ACTUATOR OVBD (OVER BOARD DRAIN) CAN BE CONNECTED EITHER TO OPTIONAL OVBD PLACED ON THE SERVO VALVE OR DIRECTLY TO THE SYSTEM DRAIN LINE. (PLEASE SEE HYDRAULIC SCHEMATIC - SHEET 1)

9. FOR ANY FURTHER INFORMATION PLEASE SEE MANUAL B26727.



MALE ROD END



DETAIL K SCALE 0.800

> UNITS = INCHES [MM]

Figure H-1c. V45RD-15XX Remote Installation Dimensions

Appendix I – V45 Servo, 8-inch (200mm) Bore Remote Servo-Cylinder (V45RD-20XX)



NOTES:

ALLOWED MAXIMUM LENGTH OF THE CABLE FROM THE TERMINAL IN ACTUATOR TO TERMINAL ON PCB PLATE EQUALS 112 INCH [2850 mm]. UNITS = INCHES [MM]





Figure I-1b. V45RD-20XX Remote Installation Dimensions
Manual 26727

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

W OOD W ARD P/N:	STROKE [INCH]	HEIGHT 'A' /3	HEIGHT 'B' /3	HEIGHT 'C' /	HEIGHT 'D' INCH (mm) 3	HEIGHT 'E' INCH (mm)	DIMENSION 'F' INCH [mm]	DIMENSION 'G' INCH [mm]	DIMENSION 'H' INCH [mm]	APPROXIMATE WEIGHT LBS [kg]
1328-5136-10M	1	19 52 (470 44)	22 52 (572 04)	4/ 07 [200 2/]	43 22 (335 70)	(47 17 (112 71))	(.088 [2.24])	(.037 [.940])	(7.71 [195.83])	263 [119]
1328-5136-10F	4	10.32 [470.41]	22.32 [372.01]	14.97 [300.24]	13.22 [333.79]		(.091 [2.31])	(.039 [.991])	(7.34 [186.44])	255 [116]
1328-5136-15M	4	20 52 (521 24)	24 52 5472 441	14 07 [121 0/]	45 22 1204 501	(40 17 (101 51))	(.084 [2.13])	(.036 [.914])	(8.54 [216.92])	275 [125]
1328-5136-15F	0	20.32 [321.21]	20.32 [0/3.01]	10.97 [431.04]	13+22 [300+37]	(17.47 [474.34])	(.087 [2.21])	(.037 [.940])	(8.16 [207.26])	267 [121]
1328-5136-20M	0	22 52 (572 04)	20 52 1775 241	19 07 [/.91 9/]	10 22 14 27 201	(24 / 7 (5/5 3/1)	(.081 [2.06])	(.034 [.864])	(9.38 [238.25])	288 [131]
1328-5136-20F	U	22.02 (072.01)	70.72 [112.21]	10.77 [401.04]	1/+22 [4]/+37]	(21.47 [343.34])	(.083 [2.11])	(.035 [.889])	(8.98 [228.09])	279 [127]
1328-5136-25M	10	2/ 52 5622 041	3/ 53 1074 041	20.07 (522.4/1	40 22 (199 40)	(22 / 7 (504 4/1)	(.077 [1.96])	(.033 [.838])	(10.24 [260.09])	300 [136]
1328-5136-25F	10	24.52 [022.01]	34.32 [0/0.0]	20.97 [332.04]	19.22 [400.19]	(23.47 [390.14])	(.079 [2.01])	(.034 [.864])	(9.83 [249.68])	292 [133]
1328-5136-30M	12	26 52 1673 641	38 52 1078 / 41	22 07 (583 //)	21 22 (538 00)	(25 17 1616 01))	(.074 [1.88])	(.031 [.787])	(11.10 [281.94])	312 [142]
1328-5136-30F	1Z	20.02 [0/0.01]	10.02 [9/0.4]]	22.7/ [303.44]	21.22 (530.99)	(20.47 [040.94])	(.076 [1.93])	(.032 [.813])	(10.68 [271.27])	304 [138]



NOTES:

1. THIS IS AN INSTALLATION DRAWING FOR REMOTE VARISTROKE I ACTUATORS WITH 8 INCH BORE AND DIFFERENT STROKES. SEE TABLE FOR ACTUATOR PART NUMBERS.

2 LIFTING BRACKETS CAN BE REMOVED AFTER VARISTROKE INSTALLATION. FOR FIRST ARTICLE INSEPCTION (FAI) REQUIREMENTS

4. ACTUATOR APPEARANCE MAY VARY FROM THE SHOWN AND MAY NOT REFLECT CURRENT HARDWARE.

Anging using both of the lifting brackets. Support vertical position during hanging transportation.

- FOR HORIZONTAL TRANSPORTATION USE ADDITIONAL LIFTING EYES (M16X2 THREAD) NOT INCLUDED IN THE ASSEMBLY.
- 6. FINISH: PRIMED AND PAINTED "LIGHT GRAY" COLOR, GLOSS FINISH, TWO PART EPOXY.

7. WHEN MOUNTING, MATING SURFACE SHALL BE FLAT TO .020 INCH. NO PAINT OR OTHER CONTAMINANTS ALLOWED ON EITHER MATING SURFACE.

ACTUATOR OVBD (OVER BOARD DRAIN) CAN BE CONNECTED EITHER TO OPTIONAL OVBD PLACED ON THE SERVO VALVE OR DIRECTLY TO THE SYSTEM DRAIN LINE. (PLEASE SEE HYDRAULIC SCHEMATIC - SHEET 1)

9. FOR ANY FURTHER INFORMATION PLEASE SEE MANUAL B26727.





DETAIL K SCALE 0.800

UNITS = INCHES [MM]

Figure I-1c. V45RD-20XX Remote Installation Dimensions

Appendix J – V45 Servo, 10-inch (250mm) Bore Remote Servo-Cylinder (V45RD-25XX)



UNITS = INCHES [MM]







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

					TABLE					
W OOD W ARD P/N:	STROKE [INCH]	HEIGHT 'A' /	HEIGHT 'B'	HEIGHT 'C' INCH (mm) 3	HEIGHT 'D'	HEIGHT 'E' INCH (mm)	DIMENSION 'F' INCH [mm]	DIMENSION 'G' INCH [mm]	DIMENSION 'H' INCH (mm)	APPROXIMATE WEIGHT LBS [kg]
1328-5137-10M	1	47.02 (/ 55./ 2)	24.02 (557.02)	4/ 07 (200 2/1	12 22 1225 701	(47 17 11 2 70))	(.094 [2.39])	(.045 [1.143])	(7.30 [185.42])	436 [198]
1328-5137-10F	4	17.95 [455.42]	21.93 [557.02]	14.97 [300.24]	13.22 [333.79]	(1/.4/ [443./9])	(.096 [2.44])	(.046 [1.168])	(7.09 [180.09])	428 [194]
1328-5137-15M	4	10 03 (E04 22)	25 03 1459 421	16 07 [134 0/1	45 22 1204 501	(10 17 1101 51)	(.089 [2.26])	(.043 [1.092])	(8.11 [205.99])	456 [207]
1328-5137-15F	0	19.93 [300.22]	23.93 [030.02]	10.97 [431.04]	13.22 [300.39]	(19.47 [494.34])	(.091 [2.31])	(.044 [1.118])	(7.88 [200.15])	448 [203]
1328-5137-20M	0	24 02 (557 02)	20 02 1740 221	10 07 (/ 04 0/)	10 22 12 20 10	(24 /7 (6/6 2/1)	(.086 [2.18])	(.042 [1.067])	(8.92 [226.57])	476 [216]
1328-5137-20F	0	21.93 [337.02]	29.93 [/00.22]	10.97 [401.04]	1/.22 [43/.37]	(21.47 [343.34])	(.087 [2.21])	(.042 [1.067])	(8.69 [220.73])	468 [212]
1328-5137-25M	40	22 02 (207 02)	22 02 10/4 021	20.07.07.0	40.00.1/00.401	(22) / 7. (50/ 4/3)	(.083 [2.11])	(.040 [1.016])	(9.76 [247.90])	496 [225]
1328-5137-25F	10	23.93 [007.02]	33.93 [001.02]	20.97 [532.04]	19.22 [400.19]	(23.47 [390.14])	(.084 [2.13])	(.041 [1.041])	(9.51 [241.55])	488 [221]
1328-5137-30M	10	25 03 (450 42)	27 02 (0/2 /2)	22.07.07.0	24 22 (528 00)		(.079 [2.01])	(.038 [.965])	(10.60 [269.24])	516 [234]
1328-5137-30F	IZ	23.93 [030.02]	37.93 [903.42]	22.97 [303.44]	21.22 [330.99]	(23.4/ [040.94])	(.081 [2.06])	(.040 [1.016])	(10.35 [262.89])	508 [230]







NOTES:

- 1. THIS IS AN INSTALLATION DRAWING FOR REMOTE VARISTROKE I ACTUATORS WITH 10 INCH BORE AND DIFFERENT STROKES. SEE TABLE FOR ACTUATOR PART NUMBERS.
- 2 LIFTING BRACKETS CAN BE REMOVED AFTER VARISTROKE INSTALLATION. 3 FOR FIRST ARTICLE INSEPCTION (FAI) REQUIREMENTS SEE 4-09-2704.
- 4. ACTUATOR APPEARANCE MAY VARY FROM THE SHOWN AND MAY NOT REFLECT CURRENT HARDWARE.
- ANGING USING BOTH OF THE LIFTING BRACKETS. SUPPORT VERTICAL POSITION DURING HANGING TRANSPORTATION.
 - FOR HORIZONTAL TRANSPORTATION USE ADDITIONAL LIFTING EYES (M16X2 THREAD) - NOT INCLUDED IN THE ASSEMBLY.
- 6. FINISH: PRIMED AND PAINTED "LIGHT GRAY" COLOR, GLOSS FINISH, TWO - PART EPOXY.
- 7. WHEN MOUNTING, MATING SURFACE SHALL BE FLAT TO .020 INCH. NO PAINT OR OTHER CONTAMINANTS ALLOWED ON EITHER MATING SURFACE.
- ACTUATOR OVBD (OVER BOARD DRAIN) CAN BE CONNECTED EITHER TO OPTIONAL OVBD PLACED ON THE SERVO VALVE OR DIRECTLY TO THE SYSTEM DRAIN LINE. (PLEASE SEE HYDRAULIC SCHEMATIC - SHEET 1)
- 9. FOR ANY FURTHER INFORMATION PLEASE SEE MANUAL B26727.

Figure J-1c. V45RD-25XX Remote Installation Dimensions



UNITS = INCHES [MM]



Appendix K – V45 Servo, 4-inch (100mm) Bore Integrated Spring Assist Servo-Cylinder (V45TX-1010)

Figure K-1a. V45TX-1010 Integrated Spring Assist Installation Dimensions

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					I ABL	E .					1
W OOD W ARD P/N:	ORDER_NUMBER	STROKE [INCH]	FAIL-SAFE MODE	HEIGHT 'A'	HEIGHT 'B' A	HEIGHT 'C'	HEIGHT 'D' INCH (mm)	DIMENSION 'E' INCH (mm)	DIMENSION 'F' INCH (mm)	DIMENSION 'G' INCH (mm)	APPROXIMATE WEIGHT LBS [kg]
9907-1552	V45TS-1010-MUE		EVTEND					(4.28 [108.71])	(.06 [1.52])	(8.42 [213.87])	209 [95]
9907-1607	V45TS-1010-FUE		LATENO	18.13 [460.50]	22 43 (5(2 40)	46 47 1140 701	(40 47 1/04 00)	(4.30 [109.22])	(.06 [1.52])	(8.36 [212.34])	208 [94]
9907-1608	V45TS-1010-MUR		DETDACT		22.13 [302.10]	10.17 [410.72]	(19.17 [400.92])	(4.24 [107.70])	(.06 [1.52])	(8.23 [209.04])	210 [95]
9907-1609	V45TS-1010-FUR		RETRACT					(4.26 [108.20])	(.06 [1.52])	(8.18 [207.77])	210 [95]
9907-1610	V45TT-1010-MUE		EVTEND	20 12 (511 20)	.30] 24.13 [612.90]	18.17 [461.52]	(21.17 [537.72])	(4.19 [106.43])	(.06 [1.52])	(8.89 [225.81])	213 [97]
9907-1612	V45TT-1010-FUE	,	EXTENU					(4.21 [106.93])	(.06 [1.52])	(8.82 [224.03])	212 [96]
9907-1614	V45TT-1010-MUR	+	DETDACT	20.13 (511.30)				(4.13 [104.90])	(.06 [1.52])	(8.70 [220.98])	216 [98]
9907-1616	V45TT-1010-FUR		RETRACT					(4.15 [105.41])	(.06 [1.52])	(8.65 [219.71])	215 [98]
9907-1611	V45TU-1010-MUE		EVIEND					(4.01 [101.85])	(.06 [1.52])	(9.41 [239.01])	223 [101]
9907-1613	V45TU-1010-FUE		EXTEND	22 43 (542 40)	26 43 1663 701	20 47 (542 22)	(03.47.1500.50))	(4.02 [102.19])	(.06 [1.52])	(9.34 [237.24])	222 [101]
9907-1615	V45TU-1010-MUR			22.13 (302.10)	26.13 [003.70]	26.13 [663.70] 20.17 [512.32]	(23.17 (500.52))	(3.94 [100.08])	(.06 [1.52])	(9.28 [235.71])	227 [103]
9907-1617	V45TU-1010-FUR	1	RETRACT					(3.96 [100.58])	(.06 [1.52])	(9.22 [234.19])	226 [103]



Figure K-1b. V45TX-1010 Integrated Spring Assist Installation Dimensions

Appendix L – V45 Servo, 6-inch (150mm) Bore Integrated Spring Assist Servo-Cylinder (V45TX-15XX)



Figure L-1a. V45TX-15XX Integrated Spring Assist Installation Dimensions





Appendix M – V45 Servo, 8-inch (200mm) Bore Integrated Spring Assist Servo-Cylinder (V45TX-20XX)



Figure M-1a. V45TX-20XX Integrated Spring Assist Installation Dimensions

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Appendix N – V45 Servo, 10-inch (250mm) Bore Integrated Spring

Figure N-1a. V45TX-2510 Integrated Spring Assist Installation Dimensions

Manual 26727

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



Figure N-1b. V45TX-2510 Integrated Spring Assist Installation Dimensions

Appendix O – V45 Servo, 4-inch (100mm) Bore Remote Spring Assist Servo-Cylinder (V45RX-1010)

		OPTIONS CHART		
W OOD W ARD P/N:	1328-5157	6300-1350	W ISE_EXT_DESC	ORDER_NUMBER
9907-1618	1328-5157-10-1EM	6300-1350-E	4X4_STR_MALE_E_SPRING1REM_ASSIST_VSI	V45RS-1010-MUE
9907-1621	1328-5157-10-1EF	6300-1350-E	4X4_STR_FEMALE_E_SPRING1REM_ASSIST_VSI	V45RS-1010-FUE
9907-1624	1328-5157-10-1RM	6300-1350-R	4X4_STR_MALE_R_SPRING1REM_ASSIST_VSI	V45RS-1010-MUR
9907-1627	1328-5157-10-1RF	6300-1350-R	4X4_STR_FEMALE_R_SPRING1REM_ASSIST_VSI	V45RS-1010-FUR
9907-1619	1328-5157-10-2EM	6300-1350-E	4X4_STR_MALE_E_SPRING2REM_ASSIST_VSI	V45RT-1010-MUE
9907-1622	1328-5157-10-2EF	6300-1350-E	4X4_STR_FEMALE_E_SPRING2REM_ASSIST_VSI	V45RT-1010-FUE
9907-1625	1328-5157-10-2RM	6300-1350-R	4X4_STR_MALE_R_SPRING2REM_ASSIST_VSI	V45RT-1010-MUR
9907-1628	1328-5157-10-2RF	6300-1350-R	4X4_STR_FEMALE_R_SPRING2REM_ASSIST_VSI	V45RT-1010-FUR
9907-1620	1328-5157-10-3EM	6300-1350-E	4X4_STR_MALE_E_SPRING3REM_ASSIST_VSI	V45RU-1010-MUE
9907-1623	1328-5157-10-3EF	6300-1350-E	4X4_STR_FEMALE_E_SPRING3REM_ASSIST_VSI	V45RU-1010-FUE
9907-1626	1328-5157-10-3RM	6300-1350-R	4X4_STR_MALE_R_SPRING3REM_ASSIST_VSI	V45RU-1010-MUR
9907-1629	1328-5157-10-3RF	6300-1350-R	4X4_STR_FEMALE_R_SPRING3REM_ASSIST_VSI	V45RU-1010-FUR





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VariStroke-I (VS-I) Electro-hydraulic Actuator <u>3</u> 4.500 -3 2.250 4X M14X2-6H ▼ 1.3 (33.02) MAX THREAD TOP MOUNTING 2.200 1.100 TOP MOUNTING SURFACE 1.650 [41.91] 3 2.400 [60.96] <u>/3</u> 3.300 [83.82] € Ô Ø1.630 DIMENSION 'F' POSITION OF CENTER OF GRAVITY SEE TABLE 4.800 4X Ø1.062 [26.97] CENTER OF GRAVITY -1.398 (35.5) 3 WRENCH FLATS 3 3.779 3.721 [95.98 94.52] SECTION A-A DIMENSION 'G' POSITION OF CENTER OF GRAVITY SEE TABLE (6.000 [152.4] 3 1.000 [25.4] -HEIGHT 'B' EXTENDED POSITION SEE TABLE 2X LIFTING EYE А A -.830 [21.08] he .312-24 UNF STRAIGHT TH PER WOODW/ (MS 16142 EXCEPT TO ACCEF PORT (-04) PORT (-04) DIAMETER THREADS -1.270 ____ -0-17 ₽₽ φ **\$** 0 0 HEIGHT 'C' SEE TABLE 1.000 SAE CODE 61 FLANGE PORT CONNECTION 4X M10X1.5 THREAD CENTER OF GRAVITY HEIGHT 'E' SEE TABLE





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W OOD W ARD P / N:	CYLINDER_FAIL_VERSION	STROKE [INCH]	HEIGHT 'A' /	HEIGHT 'B'	HEIGHT 'C'	HEIGHT 'D' INCH [mm] /3	HEIGHT 'E' INCH [mm]	DIMENSION 'F' INCH [mm]	DIMENSION 'G' INCH [mm]	DIMENSION 'H' INCH [mm]	APPROXIMATE WEIGHT LBS [kg]
1328-5157-10-1EM	EXTEND							(.20 [5.08])	(.03 [.76])	(7.57 [192.28])	114 [52]
1328-5157-10-1EF	EXTEND	-	19 13 1/ 40 501	22.13 [562.10]	16.17 [410.72]	14.32 [363.73]	(19.17 [486.92])	(.20 [5.08])	(.03 [.76])	(7.44 [188.98])	113 (51)
1328-5157-10-1RM	RETRACT		10.13 [400.30]					(.20 [5.08])	(.03 [.76])	(7.22 [183.39])	116 [53]
1328-5157-10-1RF	RETRACT							(.20 [5.08])	(.03 [.76])	(7.13 [181.10])	115 [52]
1328-5157-10-2EM	EXTEND		20.43 (544.30)	24.13 [612.90] 18		16.32 [414.53]	(21.17 [537.72])	(.20 [5.08])	(.03 [.76])	(8.37 [212.60])	118 [54]
1328-5157-10-2EF	EXTEND	,			18.17 [461.52]			(.20 [5.08])	(.03 [.76])	(8.23 [209.04])	117 [53]
1328-5157-10-2RM	RETRACT	4	20.13 [511.30]					(.20 [5.08])	(.03 [.76])	(8.03 [203.96])	121 [55]
1328-5157-10-2RF	RETRACT							(.20 [5.08])	(.03 [.76])	(7.93 [201.42])	120 [54]
1328-5157-10-3EM	EXTEND							(.19 [4.83])	(.03 [.76])	(9.24 [234.70])	128 [58]
1328-5157-10-3EF	EXTEND		00 43 (540 40)	04 43 1443 701	20 47 (542 20)	49 30 ((45 33)	(03.47.1500.50))	(.19 [4.83])	(.03 [.76])	(9.11 [231.39])	127 [58]
1328-5157-10-3RM	RETRACT		22.13 [562.10]	26.13 [663.70]	20.17 [513.32]	18.32 [465.33]	(23.1/ [588.52])	(.19 [4.83])	(.03 [.76])	(9.00 [228.60])	132 [60]
1328-5157-10-3RF	RETRACT							(.19 [4.83])	(.03 [.76])	(8.90 [226.06])	131 [59]



Figure O-1c. V45RX-1010 Remote Spring Assist Installation Dimensions

Appendix P – V45 Servo, 6-inch (150mm) Bore Remote Spring Assist Servo-Cylinder (V45RX-15XX)

	OPTIONS CHART							
W OOD W ARD P / N:	1328-5159	6300-1350	DESCRIPTION	ORDER_NUMBER				
9907-1702	1328-5159-07-1EM	6300-1350-E	6X3_STR_MALE_E_SPRING1_ASSIST_REM_VSI	V45RS-1507-MUE				
9907-1708	1328-5159-07-1EF	6300-1350-E	6X3_STR_FEMALE_E_SPRING1_ASSIST_REM_VSI	V45RS-1507-FUE				
9907-1714	1328-5159-07-1RM	6300-1350-R	6X3_STR_MALE_R_SPRING1_ASSIST_REM_VSI	V45RS-1507-MUR				
9907-1720	1328-5159-07-1RF	6300-1350-R	6X3_STR_FEMALE_R_SPRING1_ASSIST_REM_VSI	V45RS-1507-FUR				
9907-1703	1328-5159-07-2EM	6300-1350-E	6X3_STR_MALE_E_SPRING2_ASSIST_REM_VSI	V45RT-1507-MUE				
9907-1709	1328-5159-07-2EF	6300-1350-E	6X3_STR_FEMALE_E_SPRING2_ASSIST_REM_VSI	V45RT-1507-FUE				
9907-1715	1328-5159-07-2RM	6300-1350-R	6X3_STR_MALE_R_SPRING2_ASSIST_REM_VSI	V45RT-1507-MUR				
9907-1721	1328-5159-07-2RF	6300-1350-R	6X3_STR_FEMALE_R_SPRING2_ASSIST_REM_VSI	V45RT-1507-FUR				
9907-1704	1328-5159-07-3EM	6300-1350-E	6X3_STR_MALE_E_SPRING3_ASSIST_REM_VSI	V45RU-1507-MUE				
9907-1710	1328-5159-07-3EF	6300-1350-E	6X3_STR_FEMALE_E_SPRING3_ASSIST_REM_VSI	V45RU-1507-FUE				
9907-1716	1328-5159-07-3RM	6300-1350-R	6X3_STR_MALE_R_SPRING3_ASSIST_REM_VSI	V45RU-1507-MUR				
9907-1722	1328-5159-07-3RF	6300-1350-R	6X3_STR_FEMALE_R_SPRING3_ASSIST_REM_VSI	V45RU-1507-FUR				
9907-1705	1328-5159-10-1EM	6300-1350-E	6X4_STR_MALE_E_SPRING1_ASSIST_REM_VSI	V45RS-1510-MUE				
9907-1711	1328-5159-10-1EF	6300-1350-E	6X4_STR_FEMALE_E_SPRING1_ASSIST_REM_VSI	V45RS-1510-FUE				
9907-1717	1328-5159-10-1RM	6300-1350-R	6X4_STR_MALE_R_SPRING1_ASSIST_REM_VSI	V45RS-1510-MUR				
9907-1723	1328-5159-10-1RF	6300-1350-R	6X4_STR_FEMALE_R_SPRING1_ASSIST_REM_VSI	V45RS-1510-FUR				
9907-1706	1328-5159-10-2EM	6300-1350-E	6X4_STR_MALE_E_SPRING2_ASSIST_REM_VSI	V45RT-1510-MUE				
9907-1712	1328-5159-10-2EF	6300-1350-E	6X4_STR_FEMALE_E_SPRING2_ASSIST_REM_VSI	V45RT-1510-FUE				
9907-1718	1328-5159-10-2RM	6300-1350-R	6X4_STR_MALE_R_SPRING2_ASSIST_REM_VSI	V45RT-1510-MUR				
9907-1724	1328-5159-10-2RF	6300-1350-R	6X4_STR_FEMALE_R_SPRING2_ASSIST_REM_VSI	V45RT-1510-FUR				
9907-1707	1328-5159-10-3EM	6300-1350-E	6X4_STR_MALE_E_SPRING3_ASSIST_REM_VSI	V45RU-1510-MUE				
9907-1713	1328-5159-10-3EF	6300-1350-E	6X4_STR_FEMALE_E_SPRING3_ASSIST_REM_VSI	V45RU-1510-FUE				
9907-1719	1328-5159-10-3RM	6300-1350-R	6X4_STR_MALE_R_SPRING3_ASSIST_REM_VSI	V45RU-1510-MUR				
9907-1725	1328-5159-10-3RF	6300-1350-R	6X4_STR_FEMALE_R_SPRING3_ASSIST_REM_VSI	V45RU-1510-FUR				



AT THE SPACING BETWEEN SERVO VALVE AND ACTUATOR IS LIMITED BY THE POSITION SENSOR WIRINGS. ALLOWED MAXIMUM LENGTH OF THE CABLE FROM THE TERMINAL IN ACTUATOR TO TERMINAL ON PCB PLATE EQUALS 112 INCH (2850 mm).

Figure P-1a. VS-I Remote Maximum Allowable Distance Between Actuator and Servo

Manual 26727





Manual 26727

W OOD W ARD P/N:	CYLINDER_FAIL_VERSION	STROKE	HEIGHT 'A' /3	HEIGHT 'B'	HEIGHT 'C'	HEIGHT 'D'	HEIGHT 'E' INCH [mm]	DIMENSION 'F' INCH [mm]	DIMENSION 'G' INCH [mm]	DIMENSION 'H' INCH [mm]	APPROXIMATE WEIGHT LBS [kg]
1328-5159-07-1EM	EXTEND	3						(.07 [1.78])	(.03 [.76])	(7.96 [202.18])	160 [73]
1328-5159-07-1EF	EXTEND	3	40 33 1/45 051	24 22 (5/4 70)	44.07 1390 241	43 22 1335 701	147 17 1113 711	(.08 [2.03])	(.03 [.76])	(7.66 [194.56])	157 [71]
1328-5159-07-1RM	RETRACT	3	[10.33 [403.03]	21.33 (341.70)	14.97 [300.24]	13.22 [335.79]	(1/.4/ [443./4])	(.08 [2.03])	(.04 [1.02])	(7.35 [186.69])	161 [73]
1328-5159-07-1RF	RETRACT	3						(.08 [2.03])	(.04 [1.02])	(7.11 [180.59])	158 [72]
1328-5159-07-2EM	EXTEND	3						(.08 [2.03])	(.03 [.76])	(8.87 [225.30])	169 [77]
1328-5159-07-2EF	EXTEND	3	20 33 (544 30)	22 22 (502 50)	44 07 1/24 0/1	45 00 1394 501	110 17 1101 FUN	(.08 [2.03])	(.03 [.76])	(8.56 [217.42])	166 [75]
1328-5159-07-2RM	RETRACT	3	20.33 [310.30]	23.33 [392.30]	10.97 [431.04]	13.22 [300.39]	(17.4/ [474.34])	(.08 [2.03])	(.03 [.76])	(8.24 [209.30])	173 [79]
1328-5159-07-2RF	RETRACT	3						(.08 [2.03])	(.03 [.76])	(7.99 [202.95])	169 [77]
1328-5159-07-3EM	EXTEND	3						(.07 [1.78])	(.03 [.76])	(9.79 [248.67])	183 [83]
1328-5159-07-3EF	EXTEND	3	00 00 1047 401	25 22 14/2 201	49 07 14 94 941	47 00 (107 00)	(04 / 7 (E/E 3/1))	(.07 [1.78])	(.03 [.76])	(9.48 [240.79])	180 [82]
1328-5159-07-3RM	RETRACT	3	22.33 [307.10]	23.33 [043.30]	10.97 [401.04]	1/.22 [43/.39]	(21.47 [343.34])	(.07 [1.78])	(.03 [.76])	(9.21 [233.93])	189 [86]
1328-5159-07-3RF	RETRACT	3						(.07 [1.78])	(.03 [.76])	(8.96 [227.58])	186 [84]
1328-5159-10-1EM	EXTEND	4						(.08 [2.03])	(.03 [.76])	(9.01 [228.85])	168 [76]
1328-5159-10-1EF	EXTEND	4	20 33 (516 38)	24 33 (668 78)	16 07 (431 041	15 22 (386 50)	(10 17 (101 51))	(.08 [2.03])	(.03 [.76])	(8.68 [220.47])	164 [74]
1328-5159-10-1RM	RETRACT	4	20.00 (010.00)	24.00 [000.70]	10.97 [431.04]	13.22 (300.37)	(17.47 [474.34])	(.08 [2.03])	(.03 [.76])	(8.20 [208.28])	170 [77]
1328-5159-10-1RF	RETRACT	4						(.08 [2.03])	(.03 [.76])	(7.97 [202.44])	168 [76]
1328-5159-10-2EM	EXTEND	4						(.07 [1.78])	(.03 [.76])	(9.92 [251.97])	178 [81]
1328-5159-10-2EF	EXTEND	4	00 00 1047 401	24 22 1440 701	49 07 1494 941	47 00 (107 00)	(04 / 7 (E/E 3/1))	(.07 [1.78])	(.03 [.76])	(9.59 [243.59])	175 [79]
1328-5159-10-2RM	RETRACT	4	22.33 [307.10]	20.33 [000.70]	10.77 [401.04]	1/.22 [43/.37]	(21.47 [343.34])	(.07 [1.78])	(.03 [.76])	(9.14 [232.16])	183 [83]
1328-5159-10-2RF	RETRACT	4						(.07 [1.78])	(.03 [.76])	(8.88 [225.55])	180 [82]
1328-5159-10-3EM	EXTEND	4						(.07 [1.78])	(.03 [.76])	(10.83 [275.08])	197 [89]
1328-5159-10-3EF	EXTEND	4	2/ 22 1449 701	20 22 1740 501	20.07 (522.4/1	40 22 1/ 00 401	.19] (23.47 [596.14])	(.07 [1.78])	(.03 [.76])	(10.52 [267.21])	193 [88]
1328-5159-10-3RM	RETRACT	4	24.33 [000./0]] 28.33 [719.58] :	8] 20.97 [532.64]	/ [532.64] 19.22 [488.19] (2		(.07 [1.78])	(.03 [.76])	(10.17 [258.32])	203 [92]
1328-5159-10-3RF	RETRACT	4]					(.07 [1.78])	(.03 [.76])	(9.92 [251.97])	200 [91]





Appendix Q – V45 Servo, 8-inch (200mm) Bore Remote Spring Assist Servo-Cylinder (V45RX-20XX)

	OPTIONS CHART								
W OOD W ARD P/N:	1328-5147	6300-1350	DESCRIPTION	ORDER_NUMBER					
9907-1566	1328-5147-07-1EM	6300-1350-E	8X3_STR_MALE_E_SPRING1_ASSIST_REM_VSI	V45RS-2007-MUE					
9907-1573	1328-5147-07-1EF	6300-1350-E	8X3_STR_FEMALE_E_SPRING1_ASSIST_REM_VSI	V45RS-2007-FUE					
9907-1581	1328-5147-07-1RM	6300-1350-R	8X3_STR_MALE_R_SPRING1_ASSIST_REM_VSI	V45RS-2007-MUR					
9907-1589	1328-5147-07-1RF	6300-1350-R	8X3_STR_FEMALE_R_SPRING1_ASSIST_REM_VSI	V45RS-2007-FUR					
9907-1603	1328-5147-07-2EM	6300-1350-E	8X3_STR_MALE_E_SPRING2_ASSIST_REM_VSI	V45RT-2007-MUE					
9907-1574	1328-5147-07-2EF	6300-1350-E	8X3_STR_FEMALE_E_SPRING2_ASSIST_REM_VSI	V45RT-2007-FUE					
9907-1582	1328-5147-07-2RM	6300-1350-R	8X3_STR_MALE_R_SPRING2_ASSIST_REM_VSI	V45RT-2007-MUR					
9907-1590	1328-5147-07-2RF	6300-1350-R	8X3_STR_FEMALE_R_SPRING2_ASSIST_REM_VSI	V45RT-2007-FUR					
9907-1567	1328-5147-07-3EM	6300-1350-E	8X3_STR_MALE_E_SPRING3_ASSIST_REM_VSI	V45RU-2007-MUE					
9907-1575	1328-5147-07-3EF	6300-1350-E	8X3_STR_FEMALE_E_SPRING3_ASSIST_REM_VSI	V45RU-2007-FUE					
9907-1583	1328-5147-07-3RM	6300-1350-R	8X3_STR_MALE_R_SPRING3_ASSIST_REM_VSI	V45RU-2007-MUR					
9907-1591	1328-5147-07-3RF	6300-1350-R	8X3_STR_FEMALE_R_SPRING3_ASSIST_REM_VSI	V45RU-2007-FUR					
9907-1568	1328-5147-07-4EM	6300-1350-E	8X3_STR_MALE_E_SPRING4_ASSIST_REM_VSI	V45RV-2007-MUE					
9907-1576	1328-5147-07-4EF	6300-1350-E	8X3_STR_FEMALE_E_SPRING4_ASSIST_REM_VSI	V45RV-2007-FUE					
9907-1584	1328-5147-07-4RM	6300-1350-R	8X3_STR_MALE_R_SPRING4_ASSIST_REM_VSI	V45RV-2007-MUR					
9907-1592	1328-5147-07-4RF	6300-1350-R	8X3_STR_FEMALE_R_SPRING4_ASSIST_REM_VSI	V45RV-2007-FUR					
9907-1569	1328-5147-10-1EM	6300-1350-E	8X4_STR_MALE_E_SPRING1_ASSIST_REM_VSI	V45RS-2010-MUE					
9907-1577	1328-5147-10-1EF	6300-1350-E	8X4_STR_FEMALE_E_SPRING1_ASSIST_REM_VSI	V45RS-2010-FUE					
9907-1585	1328-5147-10-1RM	6300-1350-R	8X4_STR_MALE_R_SPRING1_ASSIST_REM_VSI	V45RS-2010-MUR					
9907-1593	1328-5147-10-1RF	6300-1350-R	8X4_STR_FEMALE_R_SPRING1_ASSIST_REM_VSI	V45RS-2010-FUR					
9907-1570	1328-5147-10-2EM	6300-1350-E	8X4_STR_MALE_E_SPRING2_ASSIST_REM_VSI	V45RT-2010-MUE					
9907-1578	1328-5147-10-2EF	6300-1350-E	8X4_STR_FEMALE_E_SPRING2_ASSIST_REM_VSI	V45RT-2010-FUE					
9907-1586	1328-5147-10-2RM	6300-1350-R	8X4_STR_MALE_R_SPRING2_ASSIST_REM_VSI	V45RT-2010-MUR					
9907-1594	1328-5147-10-2RF	6300-1350-R	8X4_STR_FEMALE_R_SPRING2_ASSIST_REM_VSI	V45RT-2010-FUR					
9907-1571	1328-5147-10-3EM	6300-1350-E	8X4_STR_MALE_E_SPRING3_ASSIST_REM_VSI	V45RU-2010-MUE					
9907-1579	1328-5147-10-3EF	6300-1350-E	8X4_STR_FEMALE_E_SPRING3_ASSIST_REM_VSI	V45RU-2010-FUE					
9907-1587	1328-5147-10-3RM	6300-1350-R	8X4_STR_MALE_R_SPRING3_ASSIST_REM_VSI	V45RU-2010-MUR					
9907-1595	1328-5147-10-3RF	6300-1350-R	8X4_STR_FEMALE_R_SPRING3_ASSIST_REM_VSI	V45RU-2010-FUR					
9907-1572	1328-5147-10-4EM	6300-1350-E	8X4_STR_MALE_E_SPRING4_ASSIST_REM_VSI	V45RV-2010-MUE					
9907-1580	1328-5147-10-4EF	6300-1350-E	8X4_STR_FEMALE_E_SPRING4_ASSIST_REM_VSI	V45RV-2010-FUE					
9907-1588	1328-5147-10-4RM	6300-1350-R	8X4_STR_MALE_R_SPRING4_ASSIST_REM_VSI	V45RV-2010-MUR					
9907-1596	1328-5147-10-4RF	6300-1350-R	BX4 STR FEMALE R SPRING4 ASSIST REM VSL	V45RV-2010-FUR					







AULES: THE SPACING RETWEEN SERVO VALVE AND ACTUATOR IS LIMITED BY THE POSITION SENSOR W IRINGS. ALLOWED MAXIMUM LENGTH OF THE CABLE FROM THE TERMINAL IN ACTUATOR TO TERMINAL OM PCE PLATE EQUALST 12 UNEI (2250 mm).

Figure Q-1a. VS-I Remote Maximum Allowable Distance between Actuator and Servo

UNITS = INCHES [MM]





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

W OOD W ARD P/N:	STROKE [INCH]	HEIGHT 'A'	HEIGHT 'B' 3	HEIGHT 'C'	HEIGHT 'D'	HEIGHT 'E' INCH (mm)	DIMENSION 'F' INCH (mm)	DIMENSION 'G' INCH [mm]	DIMENSION 'H' INCH [mm]	APPROXIMATE WEIGHT LBS [kg]
1328-5147-07-1EM							(.08 [2.03])	(.04 [1.02])	(9.47 [240.54])	270 [123]
1328-5147-07-1EF		20 54 (522 22)	22 54 1500 / 21	46 07 11 24 011	45 00 1007 501	(40.17.1101.51)	(.08 [2.03])	(.04 [1.02])	(9.03 [229.36])	263 [119]
1328-5147-07-1RM		20.30 [322.22]	23.30 [390.42]	10.97 [431.04]	12.22 [200.29]	(19.4/ [494.04])	(.08 [2.03])	(.04 [1.02])	(8.58 [217.93])	277 [126]
1328-5147-07-1RF							(.08 [2.03])	(.04 [1.02])	(8.20 [208.28])	270 [123]
1328-5147-07-2EM							(.08 [2.03])	(.04 [1.02])	(9.46 [240.28])	275 [125]
1328-5147-07-2EF		20 54 (522 22)	22 54 1509 / 21	46 07 1/34 0/1	45 00 1394 501	(40.17.1101.51)	(.08 [2.03])	(.04 [1.02])	(9.02 [229.11])	267 [121]
1328-5147-07-2RM		20.30 [322.22]	23.30 [390.42]	10.97 [431.04]	13.22 [300.39]	(19.4/ [494.04])	(.08 [2.03])	(.04 [1.02])	(8.61 [218.69])	282 [128]
1328-5147-07-2RF							(.08 [2.03])	(.04 [1.02])	(8.25 [209.55])	274 [124]
1328-5147-07-3EM	2						(.08 [2.03])	(.04 [1.02])	(10.41 [264.41])	293 [133]
1328-5147-07-3EF		22 54 1572 021	25 54 14/0 221	40.07 [/ 04.0/]	10 20 12 20 10	(04.17.15/5.2/1)	(.08 [2.03])	(.04 [1.02])	(9.97 [253.24])	285 [129]
1328-5147-07-3RM		22.30 [3/3.02]	23.30 [049.22]	10.9/ [401.04]	1/.22 [43/.39]	(21.47 [343.34])	(.08 [2.03])	(.04 [1.02])	(9.56 [242.82])	305 [138]
1328-5147-07-3RF							(.08 [2.03])	(.04 [1.02])	(9.19 [233.43])	297 [135]
1328-5147-07-4EM							(.07 [1.78])	(.03 [.76])	(11.32 [287.53])	331 [150]
1328-5147-07-4EF		2/ 54 (422 02)	27 54 1700 021	20.07 (522.4/1	10 22 1/ 99 101	(22 / 7 (504 4/ 1)	(.07 [1.78])	(.03 [.76]) (10	(10.90 [276.86])	323 [147]
1328-5147-07-4RM		24.30 [023.02]	27.56 [700.02]	20.97 [332.04] [9.22 [486.19] [23.47 [396.14]] (.07 [1.78]) (.03 [.76]) (10.64 [270.26])	347 [157]					
1328-5147-07-4RF							(.07 [1.78])	(.03 [.76])	(10.30 [261.62])	339 [154]
1328-5147-10-1EM							(.08 [2.03])	(.04 [1.02])	(9.64 [244.86])	272 [123]
1328-5147-10-1EF		20 54 (522 22)	2/ 54 1422 021	46 07 1/24 0/1	45 00 1394 501	(40 /7 //0/ 5/1)	(.08 [2.03])	(.04 [1.02])	(9.17 [232.92])	264 [120]
1328-5147-10-1RM		20.30 [322.22]	24.30 [023.02]	10.97 [431.04]	13.22 [300.39]	(19.4/ [494.34])	(.08 [2.03])	(.04 [1.02])	(8.57 [217.68])	277 [126]
1328-5147-10-1RF							(.08 [2.03])	(.04 [1.02])	(8.19 [208.03])	269 [122]
1328-5147-10-2EM							(.08 [2.03])	(.03 [.76])	(10.58 [268.73])	291 [132]
1328-5147-10-2EF		22 54 1572 021	24 54 1471 421	10 07 1/01 0/1	17 22 1/27 201	(24 / 7 (5/5 2/1)	(.08 [2.03])	(.03 [.76])	(10.12 [257.05])	283 [128]
1328-5147-10-2RM		22.30 [3/3.02]	20.30 [074.02]	10.77 [401.04]	1/.22 [43/.37]	(21.47 [343.34])	(.08 [2.03])	(.03 [.76])	(9.53 [242.06])	300 [136]
1328-5147-10-2RF	,						(.08 [2.03])	(.03 [.76])	(9.16 [232.66])	293 [133]
1328-5147-10-3EM	4						(.07 [1.78])	(.03 [.76])	(11.51 [292.35])	318 [144]
1328-5147-10-3EF		21 54 1422 021	20 57 1725 121	20.07 (522.77)	40 00 1/ 00 401	(22.17.1507.41)	(.07 [1.78])	(.03 [.76])	(11.05 [280.67])	310 [141]
1328-5147-10-3RM		24.30 [023.02]	20.30 [/23.42]	20.97 [552.04]	19.22 [400.19]	(23.47 [390.14])	(.07 [1.78])	(.03 [.76])	(10.55 [267.97])	332 [151]
1328-5147-10-3RF							(.07 [1.78])	(.03 [.76])	(10.19 [258.83])	325 [147]
1328-5147-10-4EM							(.06 [1.52])	(.03 [.76])	(13.34 [338.84])	391 [177]
1328-5147-10-4EF		20 54 1725 421	22 54 1927 021		0 00 00 000 001 //		(.06 [1.52])	(.03 [.76])	(12.93 [328.42])	384 [174]
1328-5147-10-4RM		20.30 [/25.42]	1 12.10 [027.02]	24.7/ [034.24]	23.22 [309.79]	(21.4/ [09/./4])	(.06 [1.52])	(.03 [.76])	(12.69 [322.33])	415 [188]
1328-5147-10-4RF							(.06 [1.52])	(.03 [.76])	(12.37 [314.20])	407 [185]



NOTES:



detail K scale 0.8

1. THIS IS AN INSTALLATION DRAWING FOR REMOTE VARISTROKE I ACTUATORS SPRING ASSIST, WITH 8 INCH BORE AND DIFFERENT STROKES. SEE TABLE FOR ACTUATOR PART NUMBERS ON 3RD SHEET.

2 LIFTING BRACKETS CAN BE REMOVED AFTER VARISTROKE INSTALLATION. 3 FOR FIRST ARTICLE INSEPCTION (FAI) REQUIREMENTS SEE 4-09-2704.

- ACTUATOR APPEARANCE MAY VARY FROM THE SHOWN AND MAY NOT REFLECT CURRENT HARDWARE.
- AND HANGING USING BOTH OF THE LIFTING BRACKETS. SUPPORT VERTICAL POSITION DURING HANGING TRANSPORTATION.

FOR HORIZONTAL POSITION SUPPORT DURING TRANSPORTATION USE ADDITIONAL LIFTING EYES (MM4X2 THREAD) - NOT INCLUDED IN THE ASSEMBLY.

- 6. FINISH: PRIMED AND PAINTED "LIGHT GRAY" COLOR, GLOSS FINISH, TWO - PART EPOXY.
- WHEN MOUNTING, MATING SURFACE SHALL BE FLAT TO .020 INCH. NO PAINT OR OTHER CONTAMINANTS ALLOWED ON EITHER MATING SURFACE.

ACTUATOR OVBD (OVER BOARD DRAIN) CAN BE CONNECTED EITHER TO OPTIONAL OVBD PLACED ON THE SERVO VALVE OR DIRECTLY TO THE SYSTEM DRAIN LINE. (PLASE SEE HYDRAULIC SCHEMATIC - SHEET 1)

9. FOR ANY FURTHER INFORMATION PLEASE SEE MANUAL B26727.

10. INTERPRET DRAWING PER ASME Y14.5-2009.



Figure Q-1c. V45RX-20XX Remote Spring Assist Installation Dimensions

Appendix R – V45 Servo, 10-inch (250mm) Bore Remote Spring Assist Servo-Cylinder (V45RX-2510)

		OPTIONS CHART		
W OOD W ARD P/N:	1328-5155	6300-1350	DESCRIPTION	ORDER_NUMBER
9907-1646	1328-5155-10-1EM	6300-1350-E	10X4_STR_MALE_E_SPRING1_ASSIST_REMOTE_VSI	V45RS-2510-MUE
9907-1554	1328-5155-10-1EF	6300-1350-E	10X4_STR_FEMALE_E_SPRING1_ASSIST_REMOTE_VSI	V45RS-2510-FUE
9907-1558	1328-5155-10-1RM	6300-1350-R	10X4_STR_MALE_R_SPRING1_ASSIST_REMOTE_VSI	V45RS-2510-MUR
9907-1562	1328-5155-10-1RF	6300-1350-R	10X4_STR_FEMALE_R_SPRING1_ASSIST_REMOTE_VSI	V45RS-2510-FUR
9907-1647	1328-5155-10-2EM	6300-1350-E	10X4_STR_MALE_E_SPRING2_ASSIST_REMOTE_VSI	V45RT-2510-MUE
9907-1555	1328-5155-10-2EF	6300-1350-E	10X4_STR_FEMALE_E_SPRING2_ASSIST_REMOTE_VSI	V45RT-2510-FUE
9907-1559	1328-5155-10-2RM	6300-1350-R	10X4_STR_MALE_R_SPRING2_ASSIST_REMOTE_VSI	V45RT-2510-MUR
9907-1563	1328-5155-10-2RF	6300-1350-R	10X4_STR_FEMALE_R_SPRING2_ASSIST_REMOTE_VSI	V45RT-2510-FUR
9907-1648	1328-5155-10-3EM	6300-1350-E	10X4_STR_MALE_E_SPRING3_ASSIST_REMOTE_VSI	V45RU-2510-MUE
9907-1556	1328-5155-10-3EF	6300-1350-E	10X4_STR_FEMALE_E_SPRING3_ASSIST_REMOTE_VSI	V45RU-2510-FUE
9907-1560	1328-5155-10-3RM	6300-1350-R	10X4_STR_MALE_R_SPRING3_ASSIST_REMOTE_VSI	V45RU-2510-MUR
9907-1564	1328-5155-10-3RF	6300-1350-R	10X4_STR_FEMALE_R_SPRING3_ASSIST_REMOTE_VSI	V45RU-2510-FUR
9907-1553	1328-5155-10-4EM	6300-1350-E	10X4_STR_MALE_E_SPRING4_ASSIST_REMOTE_VSI	V45RV-2510-MUE
9907-1557	1328-5155-10-4EF	6300-1350-E	10X4_STR_FEMALE_E_SPRING4_ASSIST_REMOTE_VSI	V45RV-2510-FUE
9907-1561	1328-5155-10-4RM	6300-1350-R	10X4_STR_MALE_R_SPRING4_ASSIST_REMOTE_VSI	V45RV-2510-MUR
9907-1565	1328-5155-10-4RE	6300-1350-R	10X4 STR FEMALE & SPRING4 ASSIST REMOTE VSL	V45RV-2510-EUR



Figure R-1a. VS-I Remote Maximum Allowable Distance between Actuator and Servo



Figure R-1b. V45RX-2510 Remote Spring Assist Installation Dimensions

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

W OOD W ARD P/N:	FAIL-SAFE DIRECTION	STROKE	HEIGHT 'A' A	HEIGHT 'B' A	HEIGHT 'C'	HEIGHT 'D' A	HEIGHT 'E' INCH (mm)	DIMENSION 'F' INCH [mm]	DIMENSION 'G' INCH [mm]	DIMENSION 'H' INCH [mm]	APPROXIMATE WEIGHT LBS [kg]
*1328-5155-10-1EM	EXTEND							(.09 [2.29])	(.04 [1.02])	(9.10 [231.14])	461 [209]
1328-5155-10-1EF	EXTEND]	10 03 (504 22)	22 02 (407 02)	14 07 1/24 0/1	45 00 1004 501	(10 /7 //0/ 5/1)	(.09 [2.29])	(.04 [1.02])	(8.82 [224.03])	454 [206]
1328-5155-10-1RM	RETRACT]	19.93 (300.22)	23.93 [007.02]	10.97 [431.04]	13+22 [300+39]	(19.47 [494.34])	(.08 [2.03])	(.05 [1.27])	(8.34 [211.84])	475 [215]
1328-5155-10-1RF	RETRACT]						(.09 [2.29])	(.04 [1.02])	(8.82 [224.03])	454 [206]
1328-5155-10-2EM	EXTEND]						(.09 [2.29])	(.04 [1.02])	(8.82 [224.03])	454 [206]
1328-5155-10-2EF	EXTEND	1	24 02 (557 02)	25 03 ((50 (20)	40.07.0.04.0.1	47 00 (107 00)	(04.17.1515.20)	(.08 [2.03])	(.04 [1.02])	(9.72 [246.89])	487 [221]
1328-5155-10-2RM	RETRACT	1	21.75 [557.02]	25.93 [050.02])	10.77 [401.04]	17.22 [437.37]	(21.4/ [343.34])	(.08 [2.03])	(.04 [1.02])	(9.34 [237.24])	517 [234]
1328-5155-10-2RF	RETRACT	1,						(.08 [2.03])	(.04 [1.02])	(9.72 [246.89])	487 [221]
1328-5155-10-3EM	EXTEND	4			00.05 (520.771	40,00,7/00,401	(0) (7 (50) 4(1)	(.07 [1.78])	(.04 [1.02])	(10.88 [276.35])	542 [246]
1328-5155-10-3EF	EXTEND	1	22 02 (407 02)	27 03 1700 / 21				(.07 [1.78])	(.04 [1.02])	(10.62 [269.75])	534 [242]
1328-5155-10-3RM	RETRACT]	23.93 [007.02]	27.93 [709.42]	20.97 [552.04]	19.22 [400.19]	(23.47 [390.14])	(.07 [1.78])	(.04 [1.02])	(10.41 [264.41])	572 [259]
1328-5155-10-3RF	RETRACT]						(.07 [1.78])	(.04 [1.02])	(10.41 [264.41])	572 [259]
1328-5155-10-4EM	EXTEND	1						(.06 [1.52])	(.04 [1.02])	(12.71 [322.83])	662 [300]
1328-5155-10-4EF	EXTEND	1	27.02.02.020.020	24 02 (044 02)	21 07 1621 201	22 22 1500 701	(27.47 [697.74])	(.06 [1.52])	(.04 [1.02])	(12.47 [316.74])	654 [297]
1328-5155-10-4RM	RETRACT	1	27.95 [/09.42]	31.93 [811.02]	24.97 [634.24]	23.22 [589.79]		(.06 [1.52])	(.04 [1.02])	(12.60 [320.04])	709 [322]
1328-5155-10-4RE	RETRACT	1						(.06 [1.52])	(.04 [1.02])	(12.41 [315.21])	701 [318]





NOTES:

1. THIS IS AN INSTALLATION DRAWING FOR REMOTE VARISTROKE I ACTUATORS WITH 10 INCH BORE AND DIFFERENT STROKES. SEE TABLE FOR ACTUATOR PART NUMBERS ON 3RD SHEET.

2 LIFTING BRACKETS CAN BE REMOVED AFTER VARISTROKE INSTALLATION.

FOR FIRST ARTICLE INSEPCTION (FAI) REQUIREMENTS SEE 4-09-2704.

4. ACTUATOR APPEARANCE MAY VARY FROM THE SHOWN AND MAY NOT REFLECT CURRENT HARDWARE.

ANGING USING BOTH OF THE LIFTING BRACKETS. SUPPORT VERTICAL POSITION DURING HANGING TRANSPORTATION.

FOR HORIZONTAL POSITION SUPPORT DURING TRANSPORTATION USE ADDITIONAL LIFTING EYES (M16X2 THREAD) - NOT INCLUDED IN THE ASSEMBLY.

6. FINISH: PRIMED AND PAINTED "LIGHT GRAY" COLOR, GLOSS FINISH, TWO - PART EPOXY.

7. WHEN MOUNTING, MATING SURFACE SHALL BE FLAT TO .020 INCH. NO PAINT OR OTHER CONTAMINANTS ALLOWED ON EITHER MATING SURFACE.

ACTUATOR OVBD (OVER BOARD DRAIN) CAN BE CONNECTED EITHER TO OPTIONAL OVBD PLACED ON THE SERVO VALVE OR DIRECTLY TO THE SYSTEM DRAIN LINE. (PLEASE SEE HYDRAULIC SCHEMATIC - SHEET 1)

9. FOR ANY FURTHER INFORMATION PLEASE SEE MANUAL B26727.

10. INTERPRET DRAWING PER ASME Y14.5-2009



UNITS = INCHES [MM]

Figure R-1c. V45RX-2510 Remote Spring Assist Installation Dimensions



Appendix S – Remote Servo Version (V45V)

Figure S-1a. Typical VS-I Remote Servo Installation Dimensions



Figure S-1b. Typical VS-I Remote Servo Installation Dimensions

Revision History

Changes in Revision AB—

• Removed references to end user in Bronze Level service description (chapters 4 and 5)

Changes in Revision AA—

- Revised Installation Instructions in Chapter 3 to include information about plastic thread protectors
- Revised Wiring section in Chapter 3

• Revised Repair and Troubleshooting section in Chapter 4 to include information about plastic thread protectors

Changes in Revision Y—

• Replaced Model Number Information in Chapter 5

Changes in Revision W-

- Removed Customer Service Tool software section
- Replaced DoC/Dol
- Updated Regulatory Compliance section
- Updated section on Special Conditions for Safe Use
- New Tables 1-1, 1-2, 3-2, 3-3, 3-8, 3-9, 3-10, 3-11, 3-12, 4-1, 4-2, 4-3, 4-4, 4-5, 4-6, 4-7
- Revised Tables 2-2, 3-9
- New Figures 1-1, 2-2, 3-20, 3-26
- Revised Figures 3-13, 3-21, 3-23, M-1b
- Revised Warning box pg. 25 and 33
- New Warning box pg. 34 and 56
- New Notice box pg. 56
- Revised Notes section in Chapter 2
- Chapter 3 revisions:
 - Added Servo Cover section
 - Revised Input Power section
 - Added American Wire Gauge Voltage Drop section
 - Added Configuration and Calibration section
- New Chapter 5: Ordering Code
- Revised "Replacement/Exchange" section in Chapter 6
- Revised "Levels of Service Capability available at Factory or Select Service Locations" in Chapter 7

Changes in Revision V—

- Added reference to Applications Note 51629 above Fig. 3-1a on pg. 34
- Added step #6 to the procedure on pg. 62

Changes in Revision U—

- Added content to upper left block in Figure 1-6
- Added a note under Figure 1-6

Changes in Revision T—

• Replaced Figure B-1b

Changes in Revision R—

- Replaced most of the declarations in the Regulatory Compliance section
- Edited content within the Special Conditions for Safe Use section
- Replaced both warnings at the end of the Regulatory Compliance section
- Added Ingress Protection to Table 2-3
- Updated Warning in Special Ambient Temperature Specifications/Allowances section in Chapter 2
- Replaced the DoC

Changes in Revision P—

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

- Removed contaminant examples from Dirt Tolerance paragraph in Chapter 1
- Add Chemically Resistant Versions paragraph to Chapter 1
- Added new spring size references to Code 20 and Code 25 in Figure 1-6
- Added a note regarding chemically resistant versions immediately beneath Figure 1-6

Changes in Revision N—

- Added 6" Stroke Options to table 2-2
- Updated Options Chart in Figures M-1b and N-1b
- Added Kit contents and text to Chapter 4, pg. 56
- Replaced DOI

Changes in Revision M—

- Added 6" Stroke Options to table 2-2
- Updated Options Chart in Figures M-1b and N-1b

Changes in Revision L—

- Edited content of Note 3d on pg. 31
- Added Shaft Seal Replacement section to Chapter 7
- Added Figure 7-1

Changes in Revision K—

- Important Box added to bottom of page 47
- Figure L-1a updated Note text

Changes in Revision J—

- Added System Requirements to Chapter 4
- New EU Declaration
- Removed GOST-TR certification and installed EAC Ex certification

Changes in Revision H—

- Updated Regulatory and Compliance Section
- Removed Appendix F and added new Appendix M-S
- Replaced Figures B-1a, C-1a, D-1a, E-1a, and E-1b
- Updated Hydraulic Supply Tubing spec on pg. 33
- Updated Figures 1-4 and 1-6
- Updated Tables 2-2, 2-8, and 3-1

Changes in Revision G—

- Removed all references, figures, and tables pertaining to V25
- Replaced references to Stability Specifications with Performance Index
- Renamed all appendices
- Replaced Figure 1-7
- Replaced Figure 2-2
- Replaced Figure 2-3
- Added V45TD-10XX and V45RD-10XX to Table 2-3
- Replaced Figure 4-7
- Added V45 Servo, 4-inch (100mm) Bore Integrated Servo-Cylinder (V45TD-10XX)
- Replaced Figure B-1b
- Added V45 Servo, 4-inch (100mm) Bore Remote Servo-Cylinder (V45RD-10XX)
- Replaced Figure G-1c
- Added V45 Servo, 5-inch (127mm) Bore Remote Servo-Cylinder (V45TD-12XX) information in body and Appendices.
- Added V45 Servo, 5-inch (127mm) Bore Remote Servo-Cylinder (V45RD-12XX) information in body and Appendices.

Changes in Revision F—

Miscellaneous updates as marked with change bars

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• Appendices A through M and associated figures

Changes in Revision E—

• Miscellaneous updates as marked with change bars

Changes in Revision D—

- Updated Compliance information & Declarations
- Updated Figures 2-3 & 2-4
- Expanded explanation of Cylinder Configuration (Chapter 5)
- Updated Hardware Replacement instructions (Chapter 7)

Changes in Revision C—

• Major updates throughout

Changes in Revision B-

• Major updates throughout

Changes in Revision A—

- Updated product photo
- Added information to Hydraulic Specifications
- Updated Figures 1-3 & 2-1

Declarations

EU	DECLARATION OF CONFORMITY
EU DoC No.: Manufacturer's Name:	00420-04-EU-02-01 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)
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 Ant") 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 60079-1:2014, which is 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).

Signature	Contract offices
	Annette Lynch
Full Name	
	Engineering Manager
Position	
	Woodward, Fort Collins, CO, USA
Place	
	NI AL 2121

5-09-1183 Rev 33

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

File name: Manufacturer's Name:	00420-04-EU-MD-02-01 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		
	Connetter Lon ch	
Signature	Carto	
	Annette Lynch	
Full Name		
	Engineering Manager	
Position		
	Woodward Inc., Fort Collins, CO, USA	
Place		
	March 18, 2022	
Date	, , , , , , , , , , , , , , , , , , , ,	

Document: 5-09-1182 (rev. 17)

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We appreciate your comments about the content of our publications. Send comments to: <u>industrial.support@woodward.com</u>

Please reference publication **26727**.





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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.