

VariStroke-I

Electro-hydraulic Actuator

Applications

The VariStroke-I is a linear electro-hydraulic actuator that is designed to provide the linear actuation force to operate steam turbine control valves or valve racks. This integrated actuator is intended for use on mechanical-driven or generator-driven steam turbines and uses a low-pressure hydraulic oil source (typically turbine lube oil) to provide its output shaft force.

The VariStroke-I's superb accuracy and resolution make it ideal for steam turbine valve control and related turbine speed and load control. The VariStroke-I electronics module accepts one or two (redundant) 4–20 mA position demand signals to position steam control valves. Precise and stable steam valve control directly relates to improved steam turbine speed and load control and reduced system mechanical wear. The actuator's fast slew rates (up to 762 mm/s for normal operation and even faster for trip event) allows applied generator or compressor-driven turbines to quickly respond to loss-of-load or emergency shutdown events.

The VariStroke-I actuator's robust design (corrosion resistant materials, single moving rotary valve, 50 lbf chip shear force, and self-cleaning port design) make it ideal for challenging applications where dirty or contaminated oil may be present.

This actuator can be purchased in the configuration that best meets the specific application's requirements (Integrated, Remote, Integrated Spring Assist, Remote Spring Assist or Servo Only models are available). Refer to Figures 1 through 5 below.

The VariStroke-I has redundant features which make it ideal for critical steam turbine applications, where turbine up-time and availability are essential. This linear actuator can be configured to accept simplex or dual-redundant position demand inputs, and then select the correct input to follow. This linear actuator's dual-redundant 4–20 mA demand inputs and dual-redundant MLDT (magnetostrictive linear displacement transducer) shaft position sensors allow it to continue to operate even with demand input or feedback sensor failures, ensuring extended run-times between forced outages.

In turbine retrofit applications, the VariStroke-I can be used to directly replace the existing servo system. This saves costly repairs to existing and aging servos, eliminates the difficulty of obtaining spare parts for obsolete equipment, and reduces calibration time and difficulty.



- Dirt-tolerant design
 - Two moving parts
 - 50 lbf chip shear force
 - Self-cleaning valve design
- Variable / configurable shaft stroke lengths
- Fast slew rates/times
 - Application dependent
 - Slew rate up to 762 mm/s (30 inches/second) @ 500 psig supply pressure and no load
- Precise position control
- Side-load tolerant
 - Shaft bearings
 - Triple seal technology
- Integrated driver
 - Two 4–20 mA demand inputs
 - Included valve flow linearization table
- Redundant MLDT position sensors
- Certified for Hazardous Locations

Description

The VariStroke-I is a linear electro-hydraulic actuator that utilizes a double-acting or spring assist double acting power cylinder (part number dependent) with integrated electronic driver module, servo valve, and MLDT-based position feedback sensors to precisely control steam turbine valves. The actuator's driver module accepts one or two (redundant) 4–20 mA demand set points and compares these set points 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 special digital controller architecture allows it to perform very stable position control during normal conditions and responds in milliseconds to desired valve step changes during system or plant transients. As a means of protecting the turbine, an internal 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.).

The VariStroke-I actuator is a product family with different models available for purchase depending on the force, stroke, and redundancy required. This actuator is available with standard bore diameters, standard stroke ranges, and with double acting (pressure return) or double-acting spring assist (pressure and spring return) operation. The VariStroke's unique "variable stroke" capability also allows users to customize/set the actuator's exact stroke length (no less than 50% of mechanical stroke) in the field to meet the required application.

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

The total cost to install this fully integrated actuator is low because complete assembly and extensive testing is performed at the factory. This greatly reduces OEM and end-user fabrication time, testing time, and site assembly time.

Features

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 (babbitt, ammonia, etc.) are common in such oil systems. Also due to the high temperatures at which steam turbines operate, turbine oil breakdown is common, resulting in the creation of a sludge-type substance and 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, 50 lbf of chip shear force, and self-cleaning port design allow it to operate in such applications without experiencing undesirable sticking or dragging actions.

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

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

Soft Stop Capability—Turbine valve seat life is always a concern among turbine OEMs and owners. To assist with extending the life of turbine control valves (or valve racks) and their valve seats, the VariStroke-I actuator includes a "Soft Stop" feature. This "Soft Stop" feature allows users to optionally configure a point above the valve seat (mechanical stop) to slow the valve's rate of travel, thus softening how hard the valve rack strikes its valve seat (minimum mechanical stop) and lengthening the life of both the valve and the valve seat.

Specifications

Performance

Position Accuracy:	±1% of full range
Position Repeatability:	±0.5% of full range
Temperature Drift:	0.04%/°C
Failsafe Operation:	Internal return spring on servo valve
Open Slew Rate:	Configurable
Close/Trip Slew Rate:	Up to 762 mm/s for close / up to 1104 mm/s for trip
Configuration:	Computer based Service Tool (RS-232 communications port) Linearization table allows valve rack flow linearization.

Physical

Available Model Stroke Range:	50.8-76.2-101.6-152.4-203.2-254-304.8 mm / 2-3-4-6-8-10-12 inches
Max Stall Force:	Determined by model number (cylinder bore size & direction dependent) Retract direction = 2300—14 200 kgf @ 34.5 bar / 5080—31 300 lbf @ 500 psig Extend direction = 2850—17 800 kgf @ 34.5 bar / 6280—39 200 lbf @ 500 psig
Cylinder Dimensions:	Determined by model number; available bore sizes (101.4-127-152.4-203.2-254 mm / 4-5-6-8-10 inches)
Cylinder Types:	Double-acting and double-acting spring assist (double acting with spring inside cylinder)
Failsafe Direction:	Extend or Retract (determined by model number)
Actuator Dimensions:	Determined by configuration
Weight:	Determined by model number
Mounting:	Any attitude except upside down (bolt patterns & sizes are determined by model number)

Environmental

Operating Temperature Range:	–40 to +85 °C (–40 to +185 °F)
Operating Oil Temperature Range:	+15 to +70 °C (+59 to +158 °F)
Shock:	US MIL-STD-810C method 516.2, procedure 1 (10 G peak, 11 ms duration, saw tooth waveform)
Vibration:	US MIL-STD-810F, M514.5A, Cat. 4 (0.015 G ² /Hz, 10–500 Hz, 1.04 Grms)
Ingress Protection:	IP66 per IEC/EN 60529

Electrical

Input Supply:	18–32 Vdc, 2.3 A (Max) at steady state @ 24Vdc, 10 A peak (100 ms maximum)
Analog Input Signals:	Isolated 4–20 mA (200 Ω input impedance)
Analog Output Signal:	4–20 mA – maximum external load: 500 Ω
Discrete Inputs:	Optically isolated (requires 24 Vdc wetting voltage)
Discrete Outputs Rating:	0.5 A @ 24 Vdc
Service Tool Port:	RS-232 communications

Hydraulic

Supply Pressure Range:	5.5 to 34.5 bar (80 to 500 psig)
Fluid Types:	Mineral or synthetic or Fyrquel EHC-based oils may be used
Recommended Oil Cleanliness:	24 to 40 μm nominal, β ₇₅ (ISO 4406 code 20/18/16 Class) max
Recommended Viscosity:	20 to 100 centistokes
Fluid Ports:	SAE J518 Code 61
Steady State Oil Consumption Max:	9.5 L/min @ 34.5 bar (2.5 US gal/min @ 500 psig)
V45 Servo Max Flow Rate:	237 L/min @ 7 bar / 62.6 US gal/min @ 100 psig 530 L/min @ 34.5 bar / 140 US gal/min @ 500 psig
Return/Drain Pressure:	Maximum: 2 bar (29 psig)

Regulatory Compliance

European Compliance for CE Marking:

EMC Directive:	2014/30/EU
ATEX Directive:	2014/34/EU, Zone 1: II 2 G, Ex db IIB T4 Gb Zone 2: II 3 G, Ex nA IIC T4 Gc

North American Compliance:

CSA:	Class I, Div. 1, Groups C & D and Class I, Div. 2, Groups A, B, C, & D, T4 at 85 °C For use in Canada and the United States
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Other European/International Compliance:

IECEX:	Zone 1: Ex db IIB T4 Gb Zone 2: Ex nA IIC T4 Gc
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Models available with additional certifications: EAC Customs Union, CCOE (PESO) India, TIIS Japan, KCs Mark Korea



Double Acting VS-I Model Number Information

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

Varistroke Product Line	V	Valve Size	XX	Configuration	X	Action	X	Bore	XX	Stroke	XX	Rod End	X	Mounting Option	X	Fat-Safe Direction	X	Compliance	X	Position sensor	X	Dump valve & TTV	X	Specials	X
Code	45 VS-I / Port 3 x .463" No Servo (Cylinder Only)	Code	S, T, U, V	Description	Integrated Remote	Code	T, R	Description	Double Acting Configuration - Additionally Cylinder equipped with Internal Spring (Spring Assist)	Code	M, F	Description	Male Thread Female Thread	Code	U	Description	Extend Retract	Code	S, E, R	Description	With cylinder position sensor	Code	X	Description	Standard Seals Chemically Resistant Seals
Code	XX	Description	S, T, U, V	Description	Double Acting Configuration - Additionally Cylinder equipped with Internal Spring (Spring Assist)	Code	U	Description	VS I Universal Mount	Code	X	Description	No Dump Valve and TTV function	Code	X	Description	No Special Requirements Special User Parameters	Code	X	Description	No Special Requirements Special User Parameters	Code	X	Description	No Special Requirements Special User Parameters

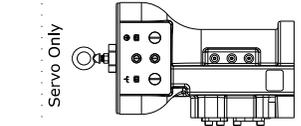
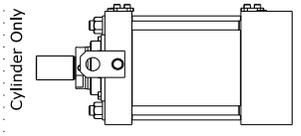
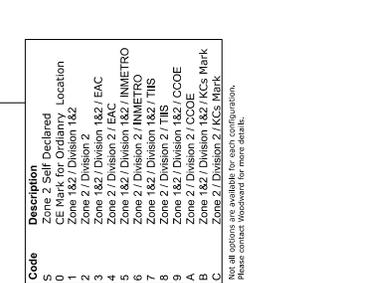
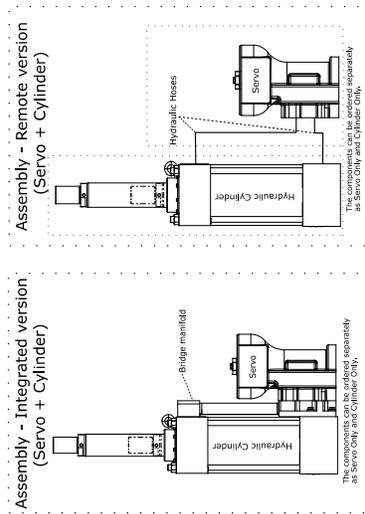
Code	Description	Available Action
07	76.2mm (3in) / Rod Dia 1.75"	D, S, T, U
10	101.6mm (4in) / Rod Dia 1.75"	D, S, T, U
15	152.4mm (6in) / Rod Dia 1.75"	D, S, T, U
20	203.2mm (8in) / Rod Dia 1.75"	D, S, T, U
05	50.8mm (2in)	D, S, T, U
07	76.2mm (3in)	D, S, T, U
10	101.6mm (4in)	D, S, T, U
15	152.4mm (6in)	D, S, T, U
20	203.2mm (8in)	D, S, T, U
25	254.0mm (10in)	D, S, T, U
30	304.8mm (12in)	D, S, T, U
07	76.2mm (3in)	D, S, T, U, V
10	101.6mm (4in)	D, S, T, U, V
15	152.4mm (6in)	D, S, T, U, V
20	203.2mm (8in)	D, S, T, U, V
25	254.0mm (10in)	D, S, T, U, V
30	304.8mm (12in)	D, S, T, U, V

Code	Description	Available Action
10	101.6mm (4in) / Rod Dia 1.75"	D, S, T, U
12	127mm (5in) / Rod Dia 1.75"	D, S, T, U
15	152.4mm (6in) / Rod Dia 2.50"	D, S, T, U
20	203.2mm (8in) / Rod Dia 3.50"	D, S, T, U, V
25	254mm (10in) / Rod Dia 4.50"	D, S, T, U, V

For more info see drawing with spring force. Contact Woodward T-Forms is needed for other risks.

Bore [in]	Stroke [in]	Spring force [lbf]		
		S	T	U
6	3	MIN 108	235	520
	4	MIN 108	235	520
8	3	MIN 276	529	1052
	4	MIN 242	538	1052
10	4	MIN 354	642	1312
	4	MIN 708	1268	2624

For other spring sizes contact with Woodward.



Note:
 1. For ordering examples see sheet 2.
 2. The Model Number Information covers the Cylinder Only and Servo Only with 1.0 inch control ports.

TITLE	MODEL NUMBER INFORMATION VS-I
DWG NO	9943-2374
Sheet	1/2
Rev	1

Figure 1. VariStroke-I Available Models / Ordering Number Encoder (page 1)



Double Acting VS-I Model Number Information

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

Varistroke Product Line	Valve Size	Configuration	Action	Bore	Stroke	Rod End	Mounting Option	Fail-Safe Direction	Compliance	Position sensor	Dump valve & TTV	Seals	Specials
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>				

Ordering examples

Boxes to order Servo Only

Servo only

Model Number Example = Servo only (Remote) **V45 RD-R1-X-S-X**

Model Number Example = Servo only (Integrated) **V45 TD-R1-X-S-X**

Model Number Example = Servo only (Remote) **V45 RD-E2-X-C-X**

Model Number Example = Servo only (Integrated) **V45 TD-E2-X-C-X**

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

Assembly (servo + cylinder)

Cylinder Only

Model Number Example = Assembly (Remote) **V45 RD-1520-FUR1M-X-S-X**

Model Number Example = Assembly (Integrated) **V45 TD-2010-FUR2M-X-S-X**

Model Number Example = Assembly (Remote) **V45 RD-1520-MUE1M-X-S-X**

Model Number Example = Cylinder Only (Remote) **V45 RV-2010-MUE2M-X-C-X**

Model Number Example = Cylinder Only (Integrated) **V45 TD-2010-FUR2M-X-S-X**

Model Number Example = Servo only (Remote) **V45 RD-R1-X-S-X**

Model Number Example = Servo only (Integrated) **V45 TD-R1-X-S-X**

Model Number Example = Servo only (Remote) **V45 RD-E2-X-C-X**

Model Number Example = Servo only (Integrated) **V45 TD-E2-X-C-X**

Model Number Example = Assembly (Remote) **V45 RD-1520-FUR1M-X-S-X**

Model Number Example = Assembly (Integrated) **V45 TD-2010-FUR2M-X-S-X**

Model Number Example = Assembly (Remote) **V45 RD-1520-MUE1M-X-S-X**

Model Number Example = Cylinder Only (Remote) **V45 RV-2010-MUE2M-X-C-X**

Model Number Example = Cylinder Only (Integrated) **V45 TD-2010-FUR2M-X-S-X**

Varistroke Product Line: VS-I / 3x.453°

Valve Size: XX

Configuration: X

Action: X

Bore: XX

Stroke: XX

Rod End: X

Mounting Option: X

Fail-Safe Direction: X

Compliance: X

Position sensor: X

Dump valve & TTV: X

Seals: X

Specials: X

Special Requirements:

- Zone 182 / Division 182
- No Dump Valve and TTV function
- Standard Seals
- No Special Requirements

Figure 2. VariStroke-I Available Models / Ordering Number Encoder (page 2)

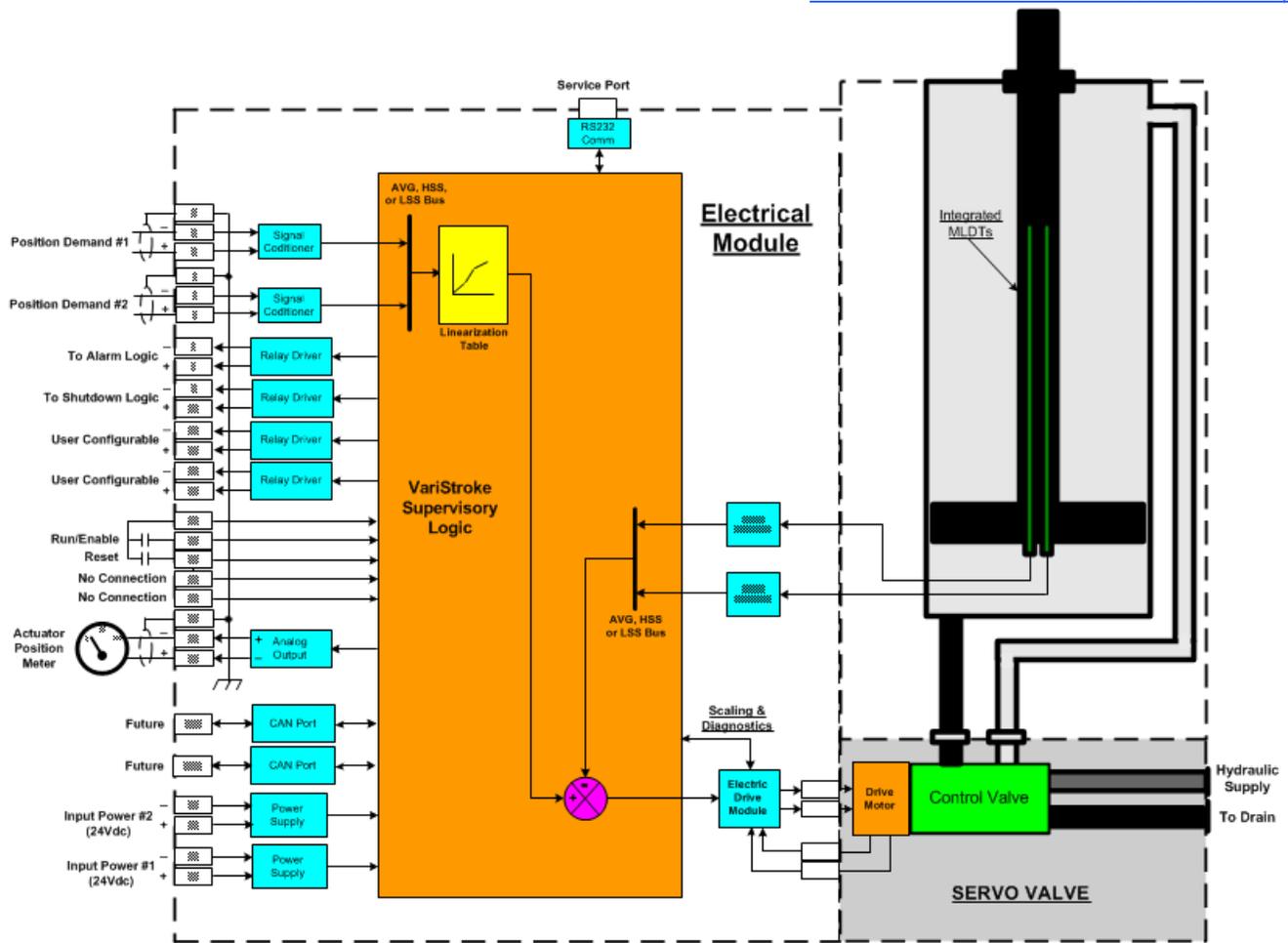


Figure 3. VariStroke-I Interface Schematic

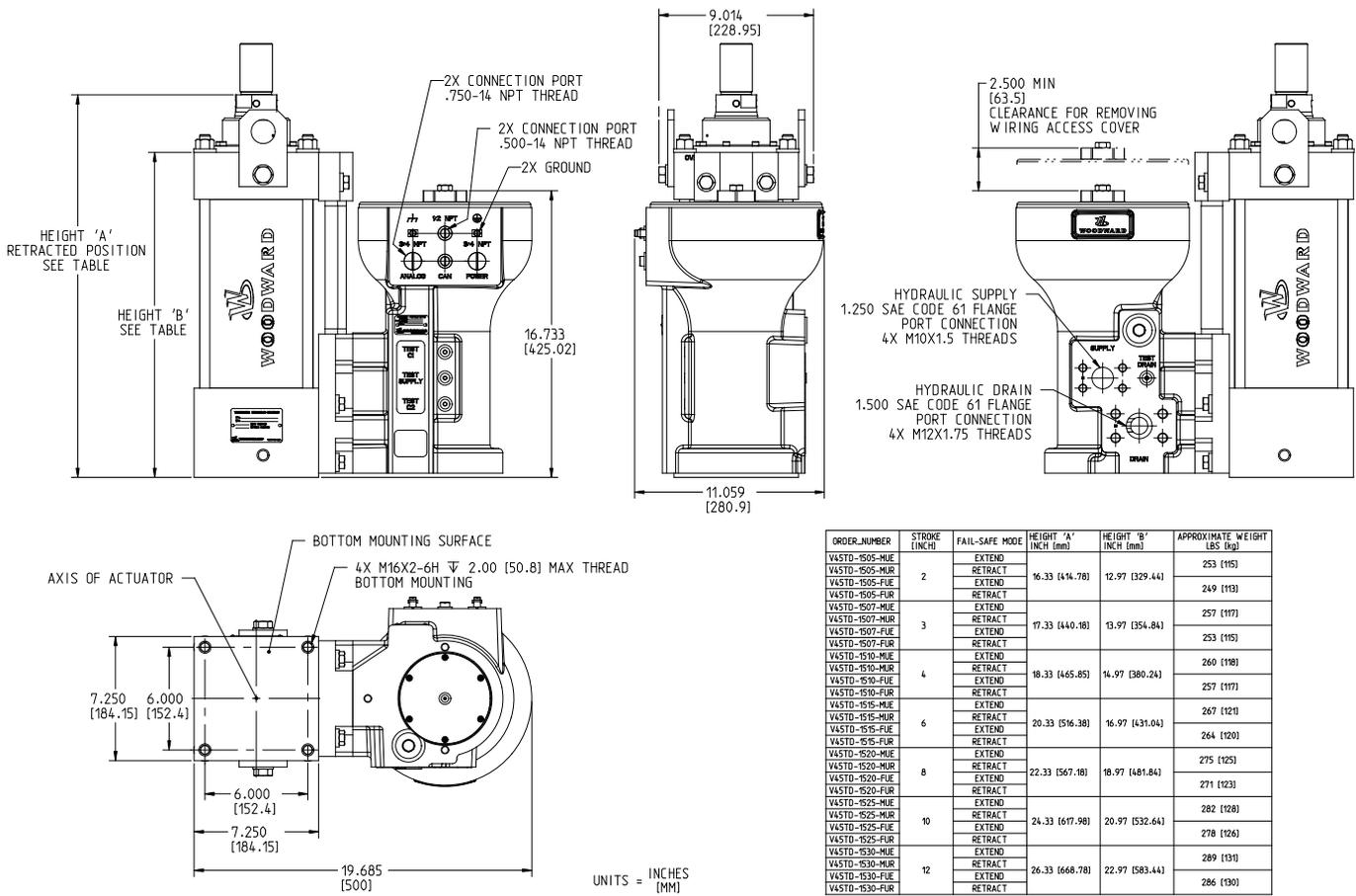


Figure 4. V45TD-15xx (Integrated, 6" Bore, Double Acting Cylinder) Outline Drawing

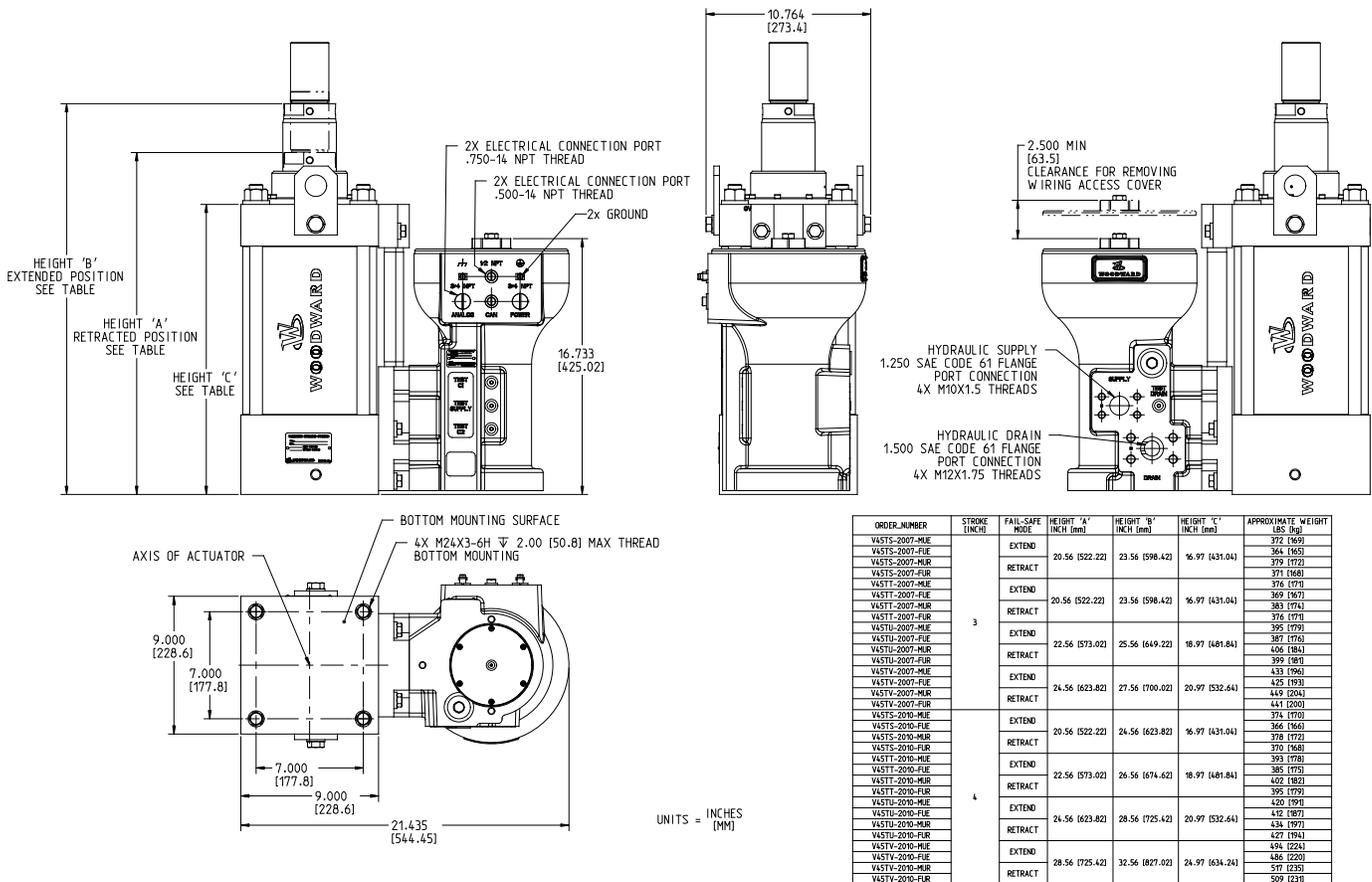


Figure 5. V45Tx-20xx (Integrated, 8" Bore, Spring Assist Cylinder) Outline Drawing

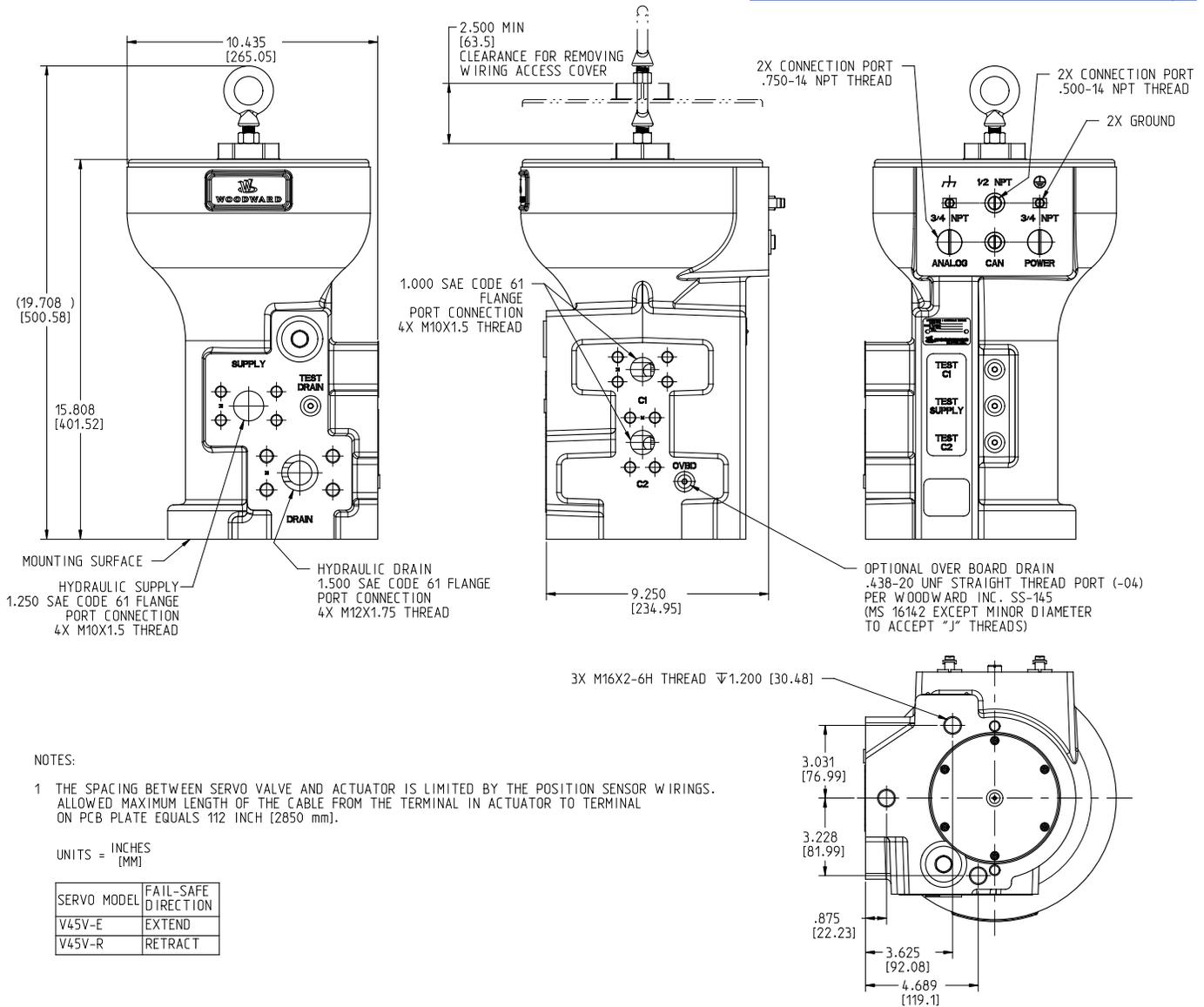


Figure 6. V45V Servo Only Outline Drawing

Table 1. Available Springs for Spring Assist Cylinders

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

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



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