



Product Manual 26570
(Revision D, 12/2020)
Original Instructions



Gas Stop/Ratio Valve for IECEx Intrinsically Safe Installation

Installation and Operation Manual

	<p>Read this entire manual and all other publications pertaining to the work to be performed before installing, operating, or servicing this equipment.</p> <p>Practice all plant and safety instructions and precautions.</p> <p>Failure to follow instructions can cause personal injury and/or property damage.</p>
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**General
Precautions**

	<p>This publication may have been revised or updated since this copy was produced. To verify that you have the latest revision, check manual 26455, <i>Customer Publication Cross Reference and Revision Status & Distribution Restrictions</i>, on the <i>publications page</i> of the Woodward website:</p> <p style="text-align: center;">http://www.woodward.com/</p> <p>The latest version of most publications is available on the <i>publications page</i>. If your publication is not there, please contact your customer service representative to get the latest copy.</p>
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Revisions

	<p>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.</p>
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Proper Use

	<p>If the cover of this publication states "Translation of the Original Instructions" please note:</p> <p>The original source of this publication may have been updated since this translation was made. Be sure to check manual 26455, <i>Customer Publication Cross Reference and Revision Status & Distribution Restrictions</i>, to verify whether this translation is up to date. Out-of-date translations are marked with . Always compare with the original for technical specifications and for proper and safe installation and operation procedures.</p>
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**Translated
Publications**

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

Woodward reserves the right to update any portion of this publication at any time. Information provided by Woodward is believed to be correct and reliable. However, no responsibility is assumed by Woodward unless otherwise expressly undertaken.

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Warnings and Notices

Important Definitions



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

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

! WARNING	<p>The engine, turbine, or other type of prime mover should be equipped with an overspeed shutdown device to protect against runaway or damage to the prime mover with possible personal injury, loss of life, or property damage.</p>
<p>Overspeed / Overtemperature / Overpressure</p>	<p>The overspeed shutdown device must be totally independent of the prime mover control system. An overtemperature or overpressure shutdown device may also be needed for safety, as appropriate.</p>

! WARNING	<p>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:</p>
<p>Personal Protective Equipment</p>	<ul style="list-style-type: none"> • Eye Protection • Hearing Protection • Hard Hat • Gloves • Safety Boots • Respirator <p>Always read the proper Material Safety Data Sheet (MSDS) for any working fluid(s) and comply with recommended safety equipment.</p>

! WARNING	<p>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.</p>
<p>Start-up</p>	

Electrostatic Discharge Awareness

NOTICE

Electrostatic Precautions

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

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

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

Follow these precautions when working with or near the control.

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

Regulatory Compliance

International Compliance

IECEX Suitability is the result of IECEx compliance of the individual components as follows:

Servo valve per IECEx KEM 10.0041X for Ex ia IIB/IIC T4 Ga, Ex ia IIB/IIC T3 or T4 Gb,
Ex nA IIC T3 or T4 Gc

LVDT per IECEx ITS 10.0031X for Ex ia IIC T3 Ga and IECEx ITS 10.0032X for
Ex nA IIC T3 Gc

Junction Box per IECEx PTB 08.0006X for Ex db eb ia [ia] IIC T4, T5, T6 Gb

SIL Compliance:

SIL certification is available for specific Woodward item numbers. Please contact a Woodward representative for assistance.



Gas Stop/Ratio Valve – Certified SIL 3 Capable for safe position fuel shutoff function in safety instrumented systems. Evaluated to IEC 61508 Parts 1-7. Refer to the instructions of this Installation and Operation Manual, Chapter 6 – Safety Management – Safe Position Fuel Shutoff Function. SIL Certificate WOO 1905012 C001

Special Conditions for Safe Use

Wiring must be in accordance with Zone 1, Category 2 wiring methods as applicable, and in accordance with the authority having jurisdiction.

Special Conditions for IECEx compliance:

- If the servo valve has been used in a nA application, it cannot be subsequently safely used in an ia application.
- When installed in Zone 1 application, wires to the servo valve and LVDT must be installed with barriers per instructions in this manual.

Field wiring must be suitable for at least 100 °C.

The ambient temperature range for this valve is –29 to +82 °C.

The risk of electrostatic discharge is reduced by permanent installation of the valve, proper connection to the protective earth (PE) terminals, and care when cleaning. The valve should not be cleaned unless the area is known to be non-hazardous.

**WARNING**

EXPLOSION HAZARD—Do not connect or disconnect while circuit is live unless area is known to be non-hazardous.

Substitution of components may impair suitability for Zone 1 applications.

**AVERTISSEMENT**

RISQUE D'EXPLOSION—Ne pas raccorder ni débrancher tant que l'installation est sous tension, sauf en cas l'ambiance est décidément non dangereuse.

La substitution de composants peut rendre ce matériel inacceptable pour les emplacements de Zone 1.

Chapter 1.

General Information

The Woodward Gas Stop/Ratio Valve performs a dual function for industrial or utility gas turbines. One function rapidly shuts off fuel to the turbine fuel control system. Another function provides accurate control of gas fuel pressure at the outlet of the stop/ratio valve. This pressure is applied to the inlets of the gas fuel control valve.

The Gas Stop/Ratio Valve features a modular design, and meets critical control characteristics while allowing the same valve design to accommodate a variety of stroke, force output, and mechanical interface arrangements. The electrical and mechanical interfaces have been designed for quick and easy assembly or removal of the valve, at the factory or in the field. The components include an on-board hydraulic filter, electrohydraulic servo valve, trip valve, single-acting hydraulic cylinder, and dual LVDTs (the 6" and 8" valves also have the option for triple LVDTs).

Optimum control of the gas turbine requires that the actuator and valve accurately and quickly track the demand signals transmitted by the control. The stop/ratio valve has been designed to provide output forces that exceed the opening and closing requirements with some margin. The additional margin helps ensure that the system moves rapidly even under service conditions where the valve has been contaminated or worn. The hydraulic trip relay valve has been selected to provide high operating force margins, high flow capacity, and to ensure the desired closure rate of the valve under trip conditions.

By using a long actuation rod between the hydraulic cylinder and the valve lever arm, the side-loading forces on the actuator shaft and seals are greatly reduced, decreasing the wear between sliding parts, and increasing the useful service life of the system. The ample distance between the wetted heavy-duty linear slide rings within the stop/ratio valve accommodates any remaining side load. These provisions provide extended service life even in severe service conditions.

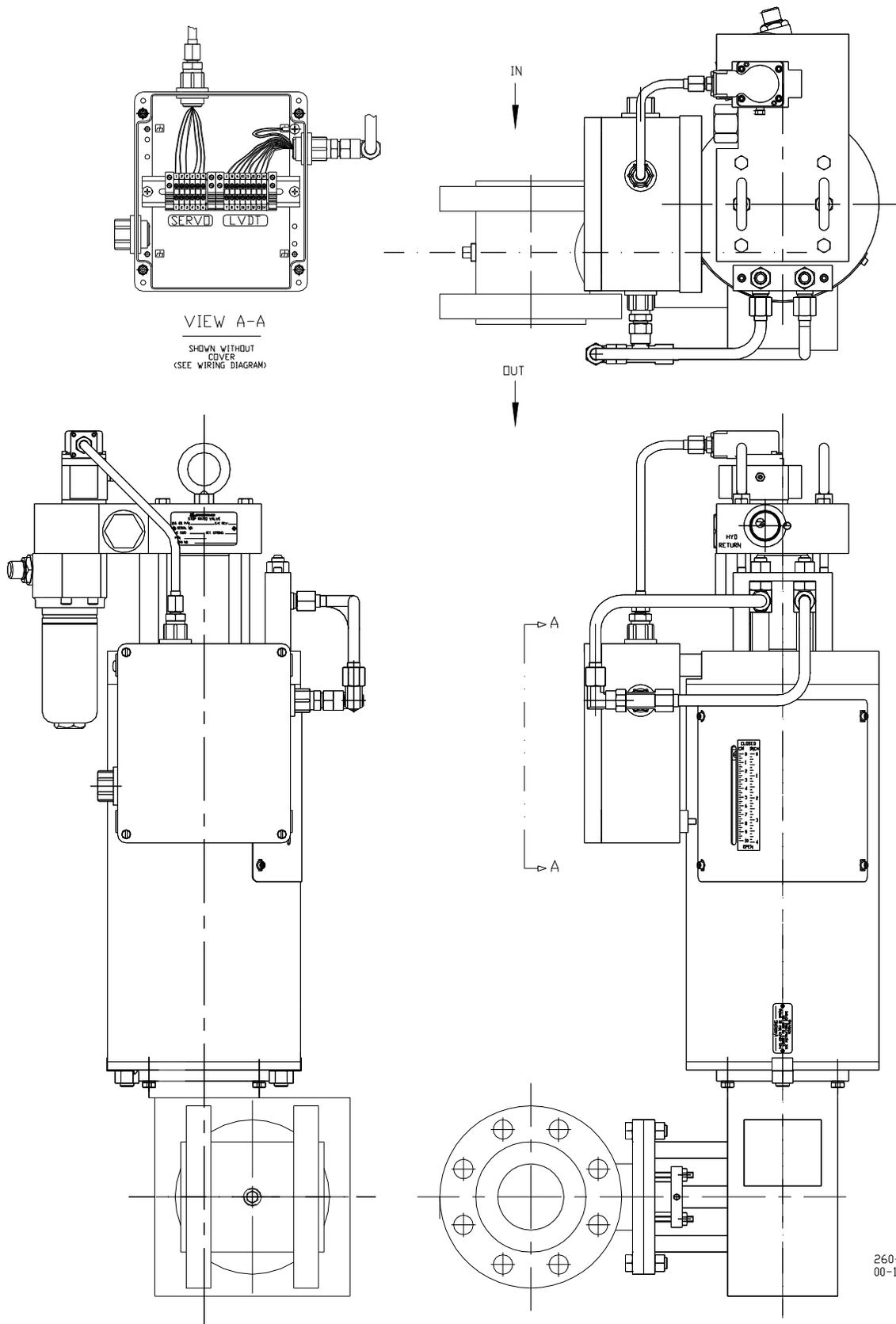
Table 1-1. Gas Stop/Ratio Valve Functional Characteristics

Functional Requirement	Gas Stop/Ratio Valve																								
Valve Type	Fisher Type Vee-Ball® Design V300 or V300 Series B or V200 Series B Flangeless HD Metal, TCM-Ultra, or SS-260 seals																								
Position Accuracy	±1% full scale (over ±25 °F/±14 °C deviation from calibration)																								
Position Repeatability	±0.5% of point over the range of 10 to 100%																								
Hydraulic Fluid Type	Petroleum Based hydraulic fluids as well as fire resistant hydraulic fluids such as Fyrquel EHC																								
Maximum Operating Hydraulic Supply Pressure	1200 to 1700 psig (8274 to 11 722 kPa) (design at 1600 psig/11 032 kPa)																								
Proof Test Fluid Pressure Level	2550 psig (20 685 kPa) minimum per SAE J214 (Prod Test)																								
Minimum Burst Fluid Pressure	4250 psig (34 475 kPa) minimum per SAE J214																								
Fluid Filtration Required	10–15 µm at 75 Beta																								
Hydraulic Fluid Contamination Level	Per ISO 4406 code 18/16/13 max, code 16/14/11 preferred																								
Hydraulic Fluid Temperature	+80 to +170 °F (+27 to +77 °C)																								
Actuator Ambient Temperature	–20 to +180 °F (–29 to +82 °C)																								
Vibration Test Level	Random 0.01500 gr ² /Hz from 10 to 40 Hz ramping down to 0.00015 gr ² /Hz at 500 Hz (1.04 Grms)																								
Shock	Limited to 30 g by servo valve																								
Trip Time	Less than 0.200 seconds (100–0% stroke)																								
Open Slew Time	5 to 95% in 0.500 ±0.15 seconds																								
Close Slew Time	95 to 5% in 0.500 ± 0.15 seconds																								
Trip Pressure (relative to hydraulic return)	Pick up 24 ±6 psid (165 ±41 kPa) Drop out 22 ±6 psid (152 ±41 kPa)																								
Hydraulic Fluid Connections	Trip Relay Pressure–1.062-12 UNF straight thread port (–12) Supply Pressure–0.750-16 UNF straight thread port (–8) Return Port–1.312-20 UNF straight thread port (–16)																								
Servo Input Current Rating	–7.2 to +8.8 mA (null bias 0.8 ±0.32 mA)																								
Paint	Two part Epoxy																								
Actuation Forces (opening at 1200 psig/8274 kPa) (closing via spring)	<table border="0"> <tr> <td></td> <td>3, 4, & 6" valves</td> <td>6 & 8" valves</td> </tr> <tr> <td></td> <td>(small actuator¹)</td> <td>(large actuator²)</td> </tr> <tr> <td>Opening Force</td> <td></td> <td></td> </tr> <tr> <td> Fully Extended</td> <td>811 lb/3607 N</td> <td>1200 lb/5338 N</td> </tr> <tr> <td> Fully Retracted</td> <td>1581 lb/7032 N</td> <td>3085 lb/13 722 N</td> </tr> <tr> <td>Closing Force</td> <td></td> <td></td> </tr> <tr> <td> Fully Extended</td> <td>2075 lb/9230 N</td> <td>4690 lb/20 861 N</td> </tr> <tr> <td> Fully Retracted</td> <td>1305 lb/5805 N</td> <td>2805 lb/12 477 N</td> </tr> </table>		3, 4, & 6" valves	6 & 8" valves		(small actuator ¹)	(large actuator ²)	Opening Force			Fully Extended	811 lb/3607 N	1200 lb/5338 N	Fully Retracted	1581 lb/7032 N	3085 lb/13 722 N	Closing Force			Fully Extended	2075 lb/9230 N	4690 lb/20 861 N	Fully Retracted	1305 lb/5805 N	2805 lb/12 477 N
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Closing Force																									
Fully Extended	2075 lb/9230 N	4690 lb/20 861 N																							
Fully Retracted	1305 lb/5805 N	2805 lb/12 477 N																							
Design Availability Objective	Better than 99.5% over an 8760 hour period																								
Sound Level	Per Fisher-Rosemount Catalog 12																								

¹Small actuator used on 3", 4", and 6" valves with HD Metal or TCM-Ultra seals

²Large actuator used on 6" valves with SS-260 seals, as well as on 8" valves with HD Metal or TCM-Ultra seals

Note: Vee-Ball® is a trademark of Fisher-Rosemount.



260-072
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Figure 1-1. Gas Stop/Ratio Valve (typical; 3-inch shown)

Notes for Figures 1-2 through 1-9

1. These general reference outline drawings apply to various Woodward Gas Fuel Stop/Ratio valves. Consult Woodward for the latest outline drawing for your particular stop/ratio valve.
2. Installation Orientation
Pipe supported only
Orientation vertical approximately as shown
See elsewhere in this manual for other installation recommendations
3. Approximate Weight
3" Valve—255 lbs/116 kg
4" Valve—280 lbs/127 kg,
6" Valve (except SS-260)—332 lbs/151 kg
6" Valve (SS-260)—447 lbs/203 kg
8" Valve—540 lbs/245 kg
4. Service Manual Replacement Parts
Servo Valve—consult Woodward for part number
O-rings for servo valve—consult Woodward for part number
Filter element—consult Woodward for part number
Manual—consult Woodward for part number
LVDT—consult Woodward for part number
Trip relay valve—consult Woodward for part number
Seal kit for trip relay valve—consult Woodward for part number
5. Description of Stop/Ratio Valve
Process fluid natural gas
Temperature range natural gas 50 to 300 °F/10 to 149 °C (unheated fuel)
 natural gas 50 to 450 °F/10 to 232 °C (heated fuel)
 ambient -20 to +180 °F/-29 to +82 °C
External leakage (2 cm³/min maximum to overboard drain)
6. Actuation
Cylinder bore Small Actuator¹: 1.750 inch diameter (44.45 mm)
 Large Actuator²: 2.500 inch diameter (63.50 mm)
Stroke 3.500 inch (88.90 mm)
Static seals Elastomer per US MIL-R-83248 (Viton)
Operating fluid Petroleum-based hydraulic fluid as well as fire resistant hydraulic fluids such as Fyrquel EHC
Rated hydraulic pressure 1600 psig/11 032 kPa
Operating hydraulic pressure 1200 to 1700 psig/8274 to 11 722 kPa
Ambient temperature -20 to +180 °F/-29 to +82 °C
Hydraulic fluid temperature 80 to 170 °F/27 to 77 °C
7. Servo Valve
Flow rating Small Actuator¹: 5.0 US gal/min (18.9 L/min) at 1000 psid (6895 kPa) valve drop, 4-way
 Large Actuator²: 10.0 US gal/min (37.8 L/min) at 1000 psid (6895 kPa) valve drop, 4-way
Electrical input rating ±8 mA (sum of three coils)
Null bias 10% of rated flow to close stop/ratio valve
 (= 10 ± 4% rated current at hydraulic null)
Electrical connection 0.375 O.D. tube fitting. 0.562-18 UNF-2A thread per MS 33656-6

¹Small actuator used on 3", 4", and 6" valves with HD Metal or TCM-Ultra seals

²Large actuator used on 6" valves with SS-260 seals, as well as on 8" valves with HD Metal or TCM-Ultra seals

IMPORTANT

These general reference outline drawings apply to various Woodward Gas Fuel Stop/Ratio valves. Consult Woodward for the latest outline drawing for your particular stop/ratio valve.

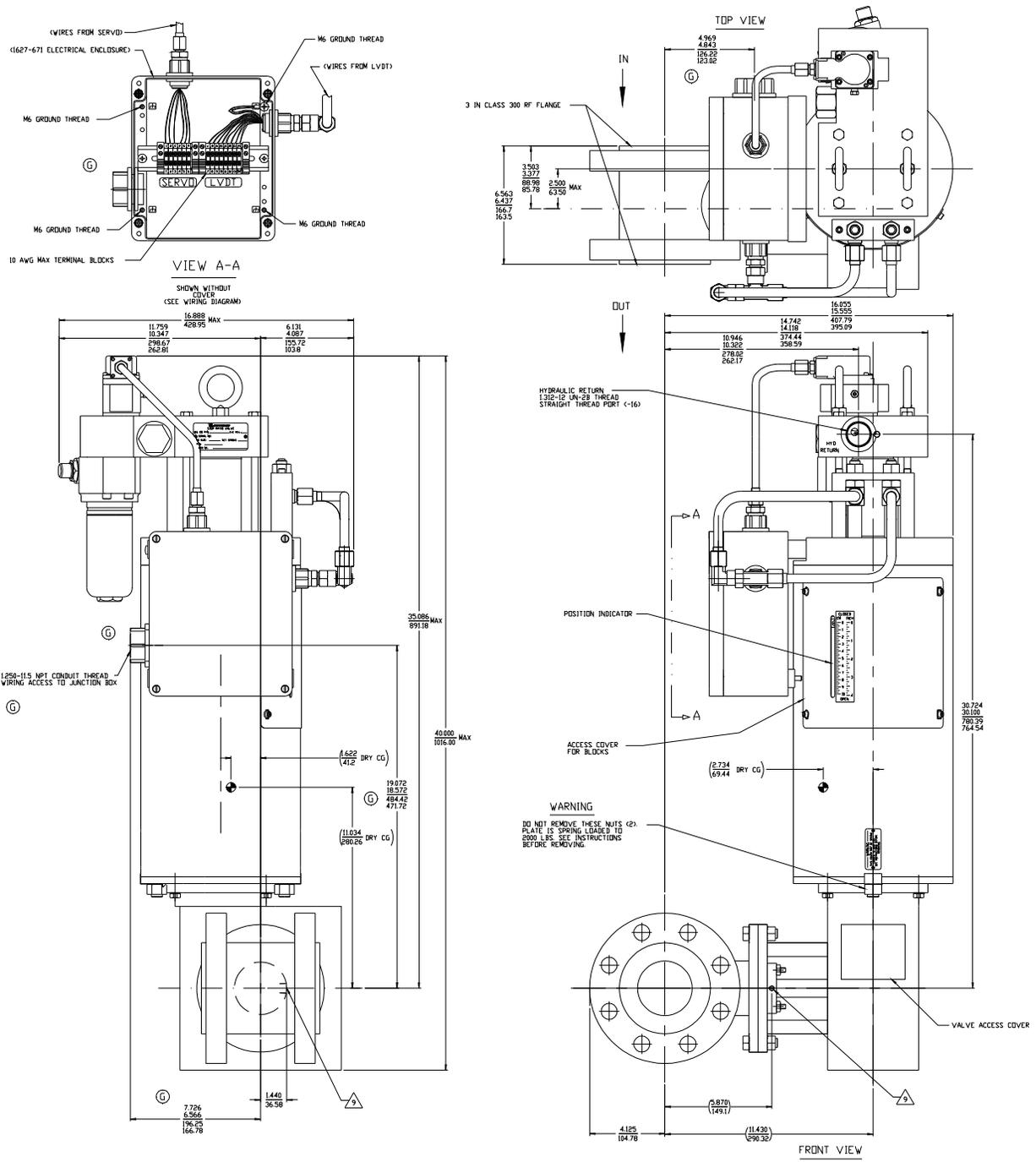


Figure 1-2a. Gas Stop/Ratio Valve Outline Drawing (3-inch)

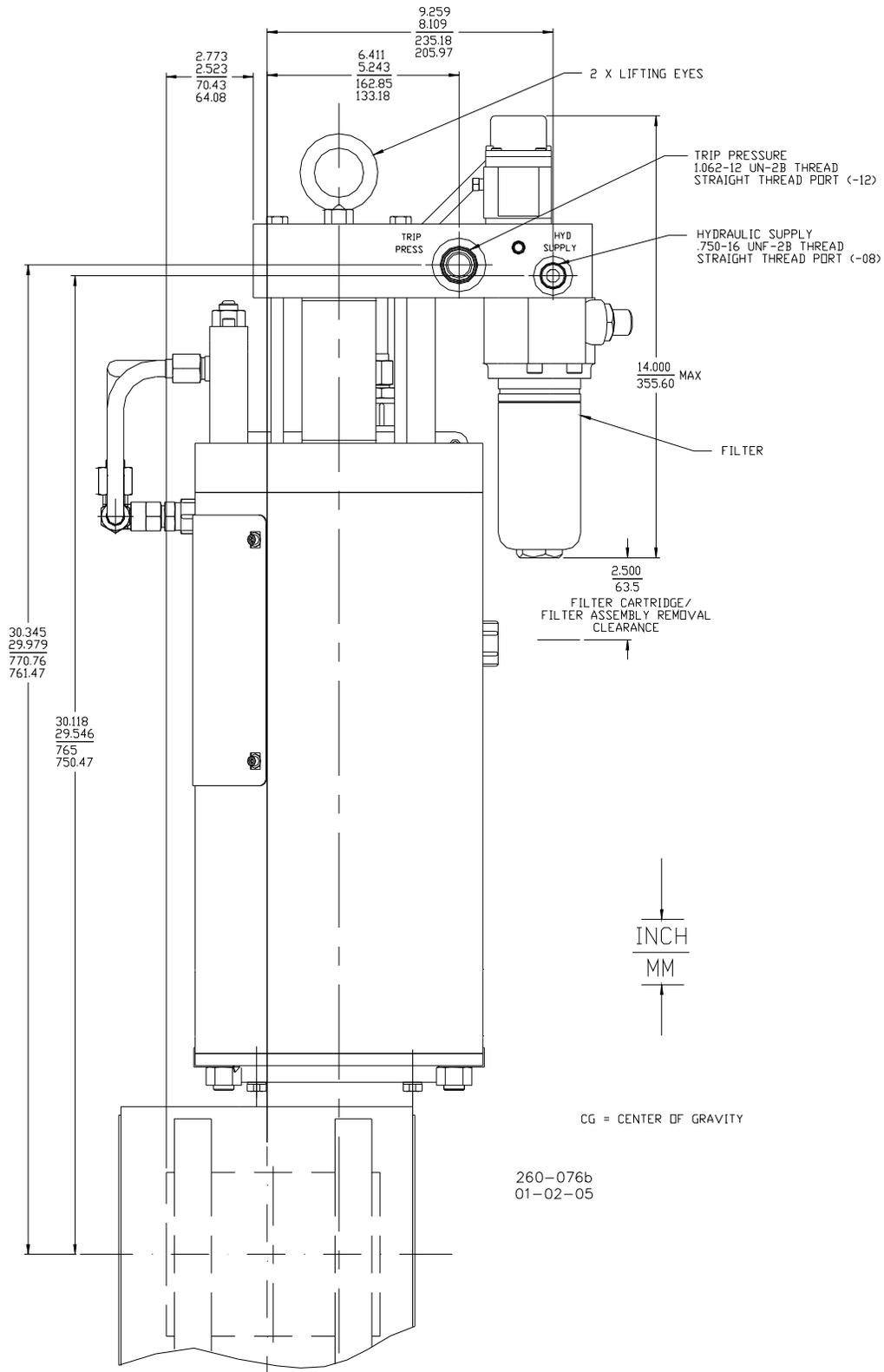


Figure 1-2b. Gas Stop/Ratio Valve Outline Drawing (3-inch)

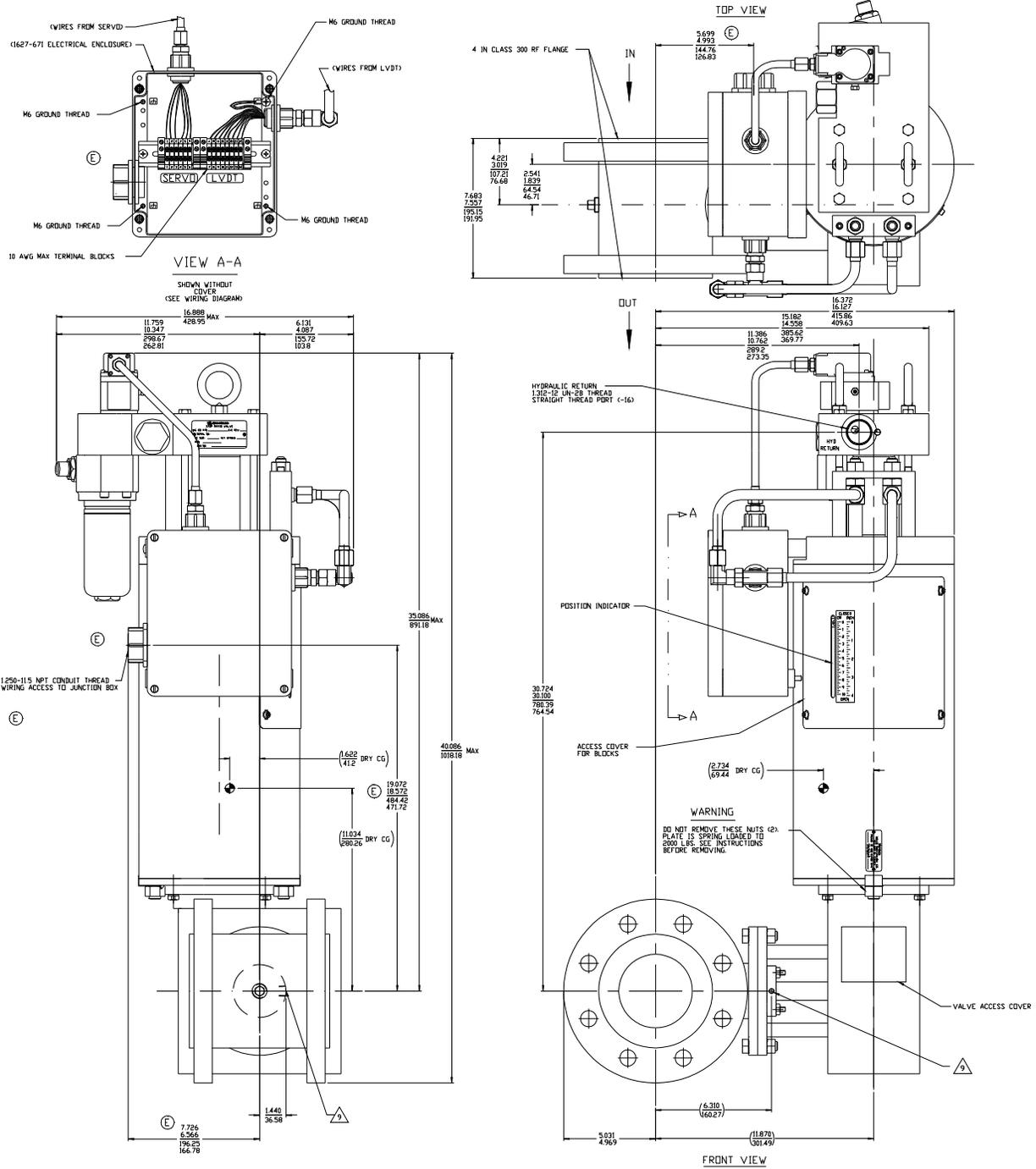


Figure 1-3a. Gas Stop/Ratio Valve Outline Drawing (4-inch)

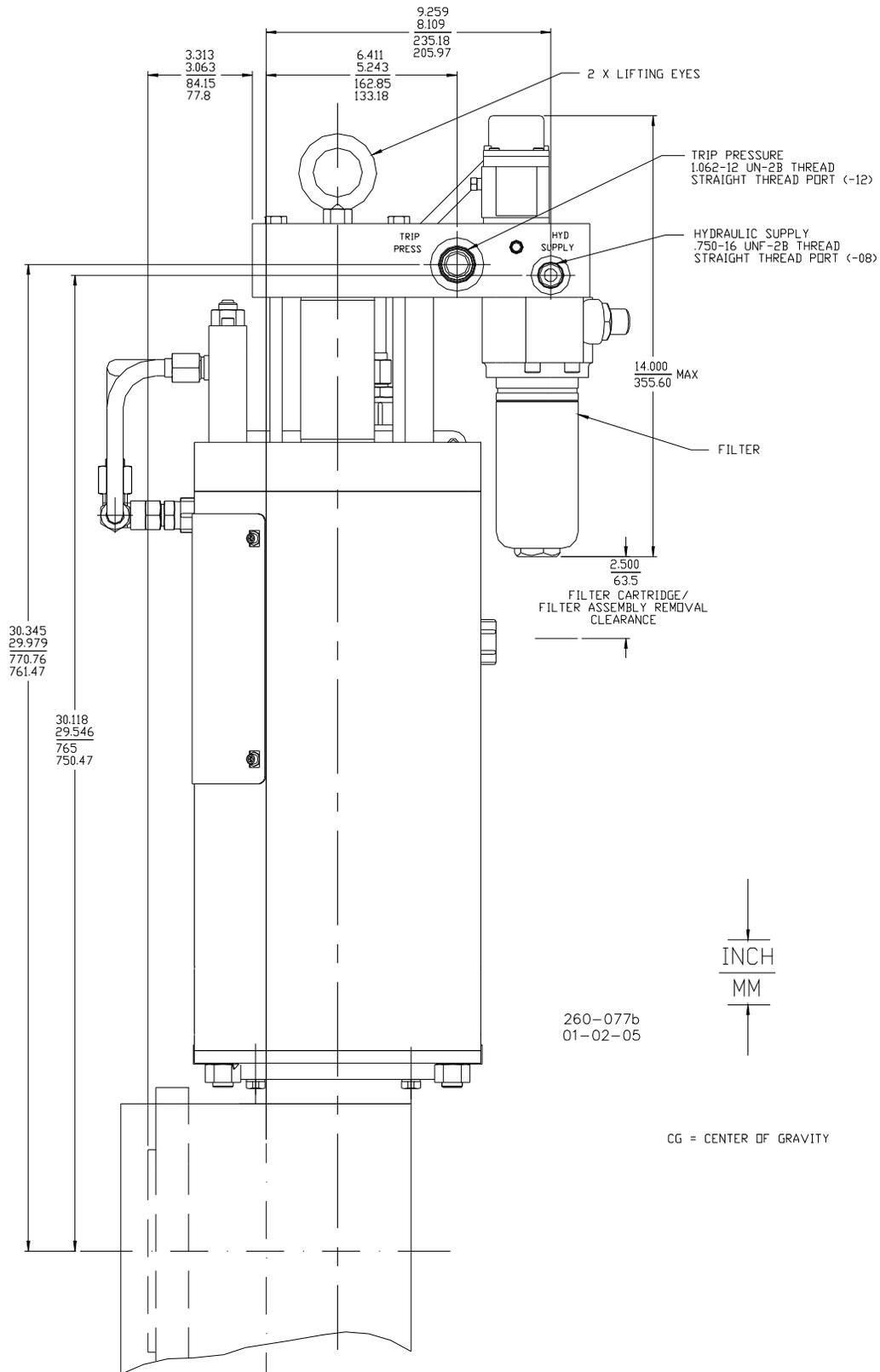
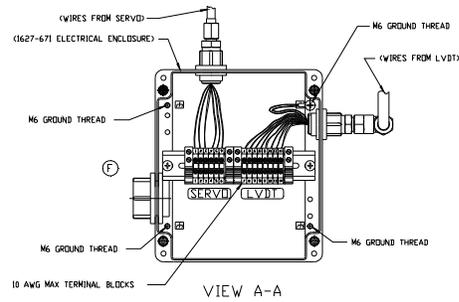
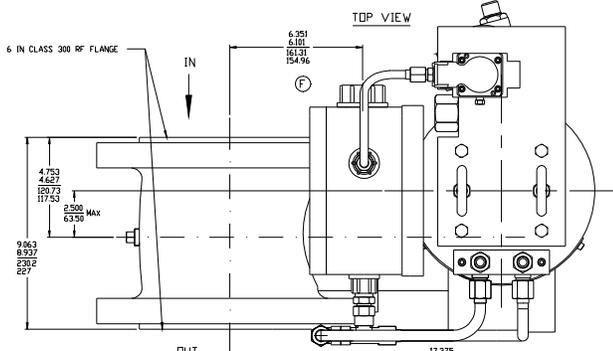
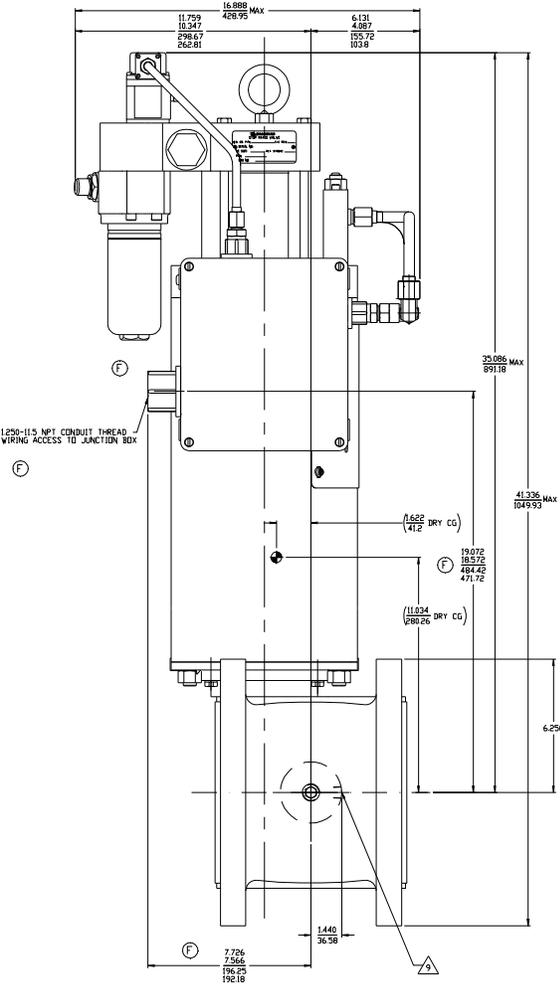


Figure 1-3b. Gas Stop/Ratio Valve Outline Drawing (4-inch)

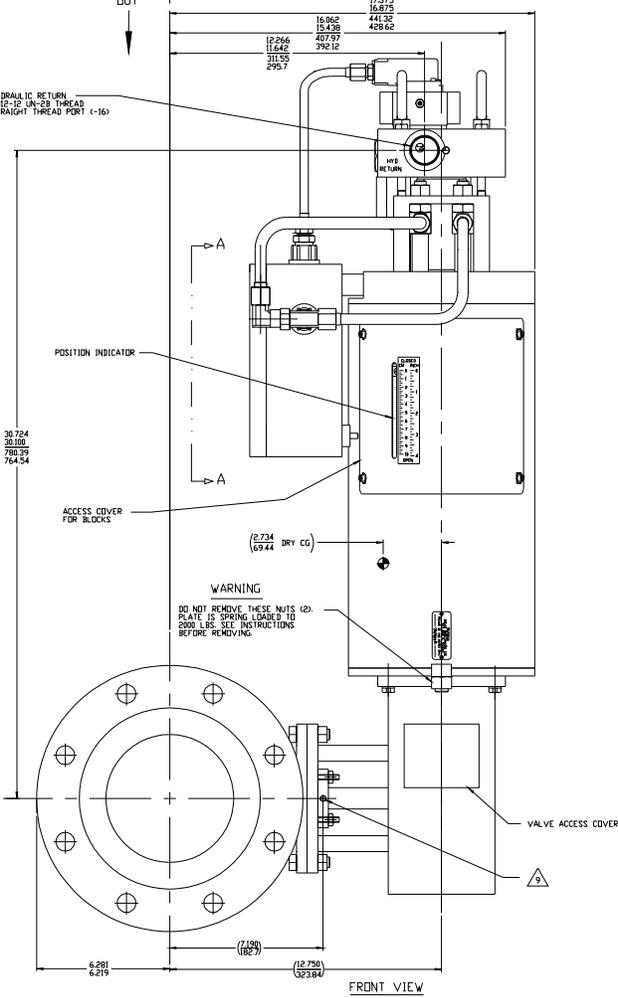


VIEW A-A

SHOWN WITHOUT COVER (SEE WIRING DIAGRAM)



TOP VIEW



FRONT VIEW

Figure 1-4a. Gas Stop/Ratio Valve Outline Drawing (6-inch, except SS-260)

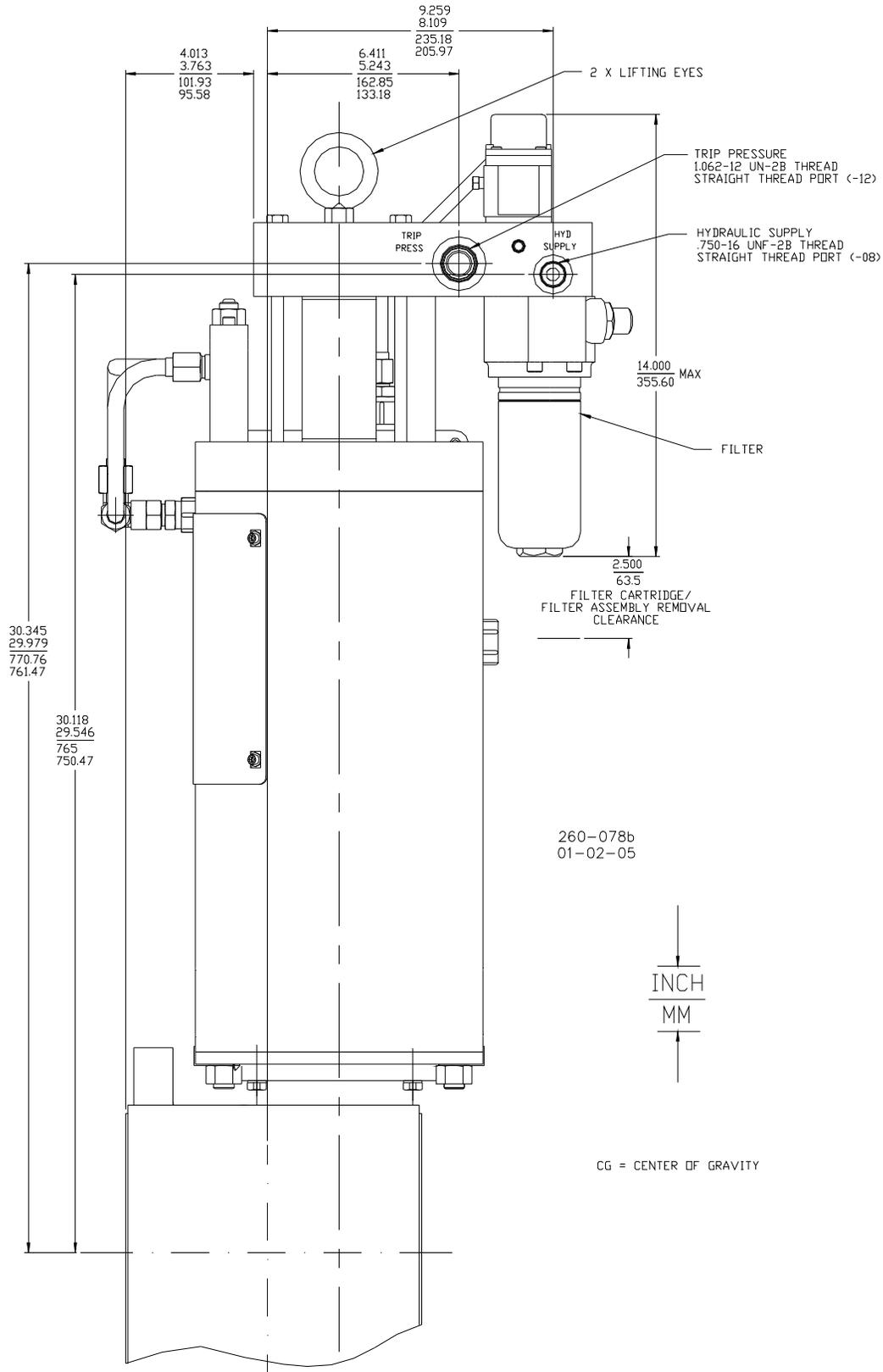


Figure 1-4b. Gas Stop/Ratio Valve Outline Drawing (6-inch, except SS-260)

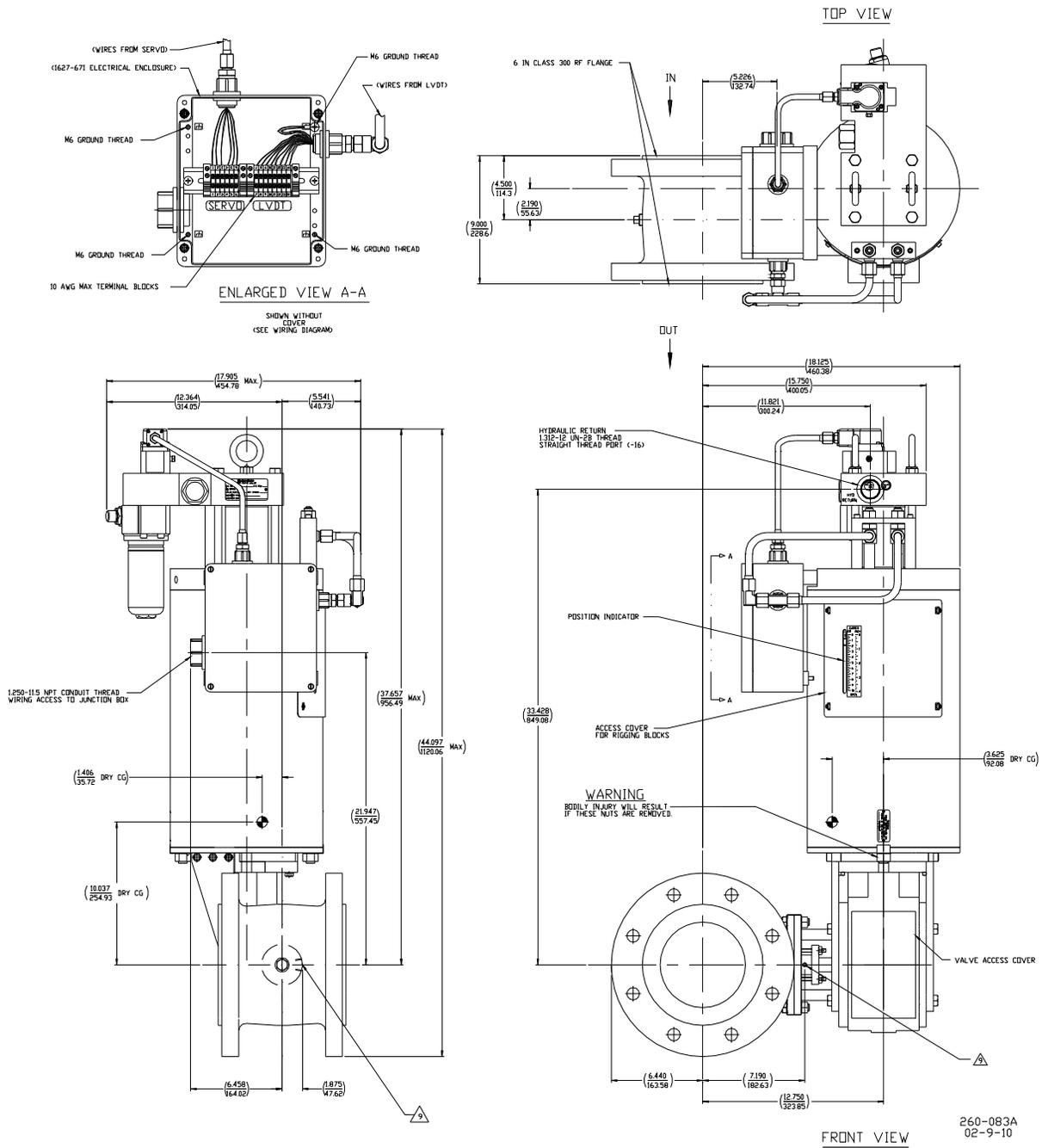


Figure 1-5a. Gas Stop/Ratio Valve Outline Drawing (6-inch, SS-260)

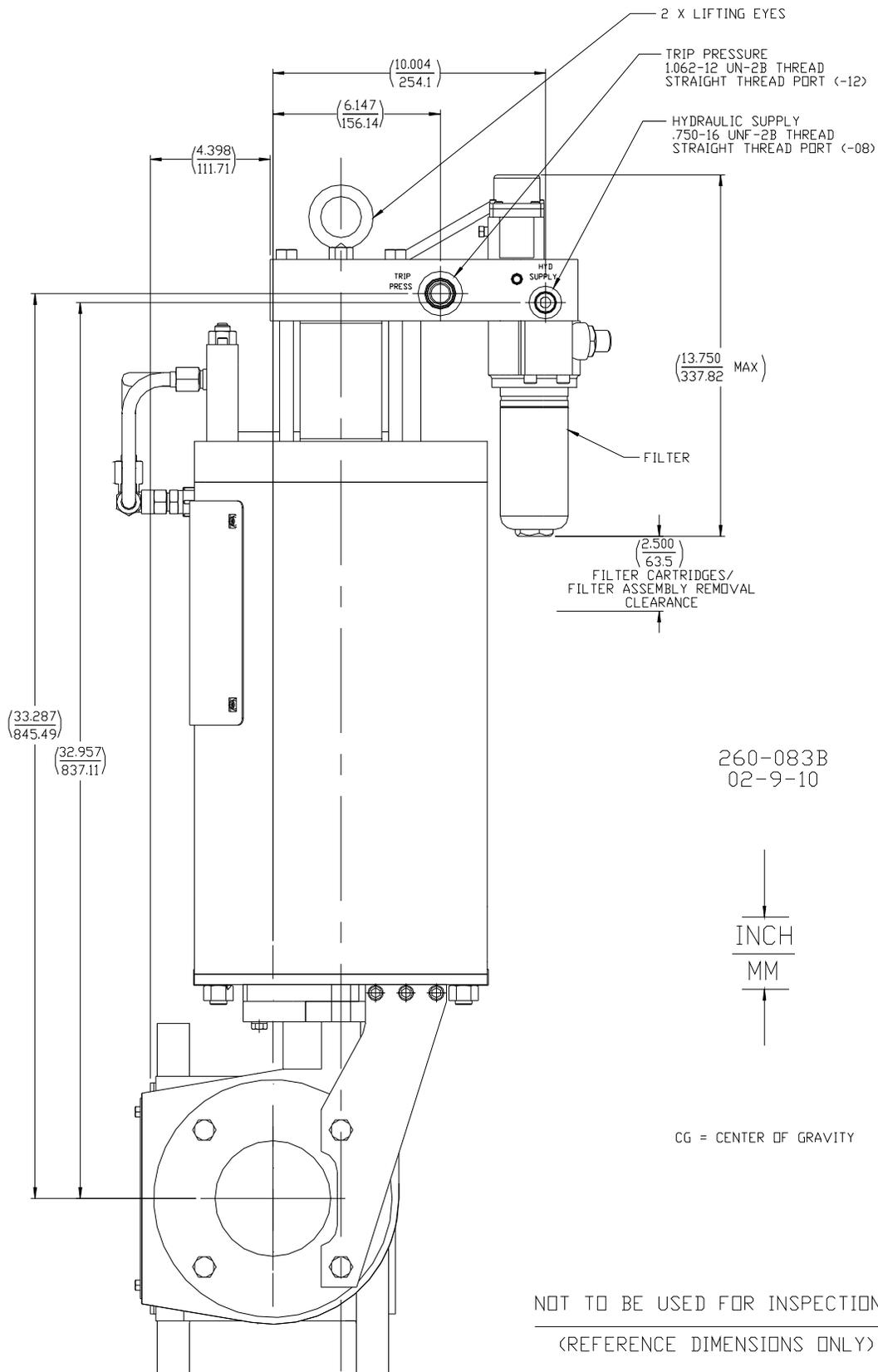


Figure 1-5b. Gas Stop/Ratio Valve Outline Drawing (6-inch, SS-260)

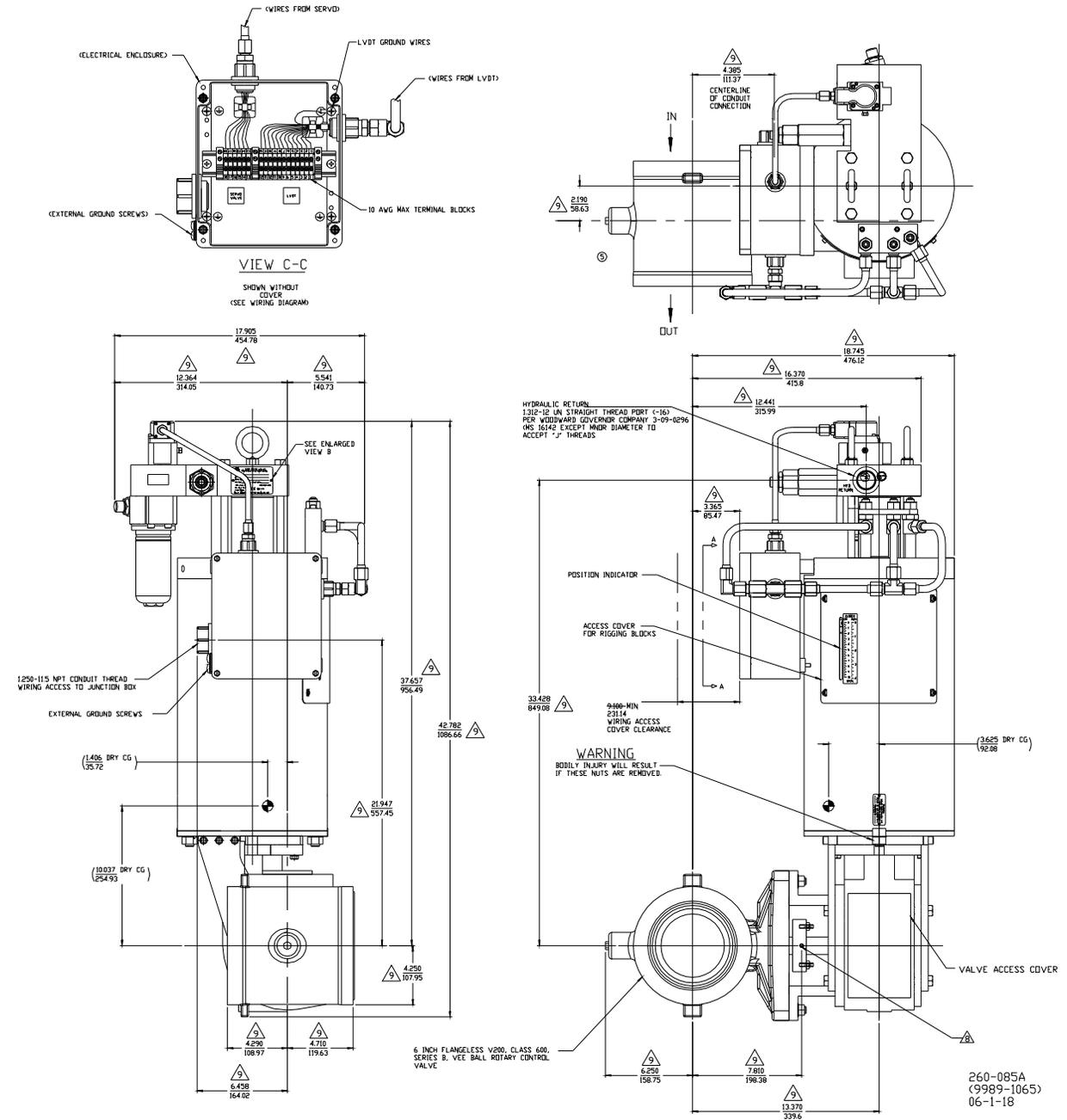


Figure 1-6a. Gas Stop/Ratio Valve Outline Drawing (6-inch, with 3 LVDTs, SS-260)

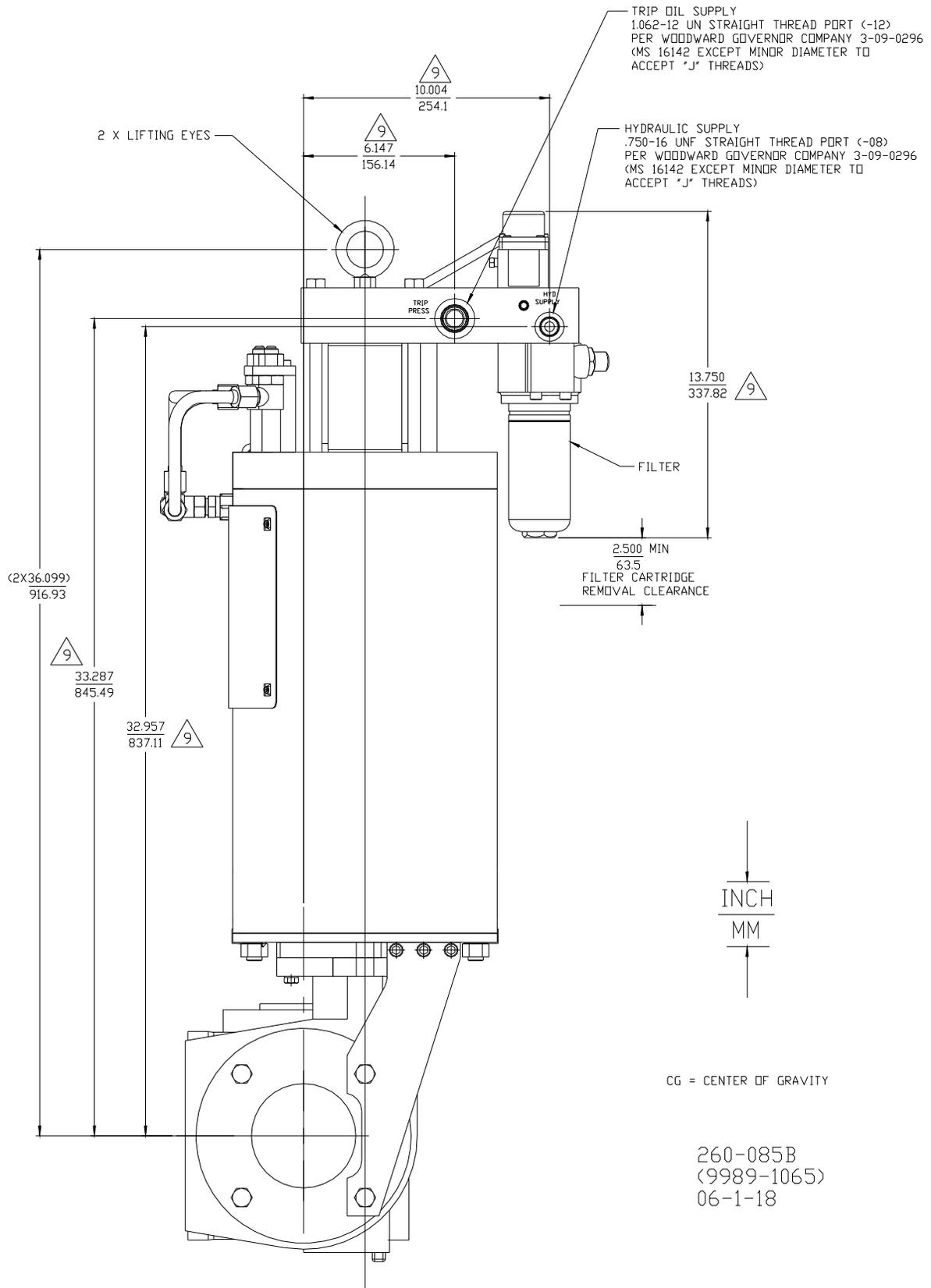


Figure 1-6b. Gas Stop/Ratio Valve Outline Drawing (6-inch, with 3 LVDTs, SS-260)

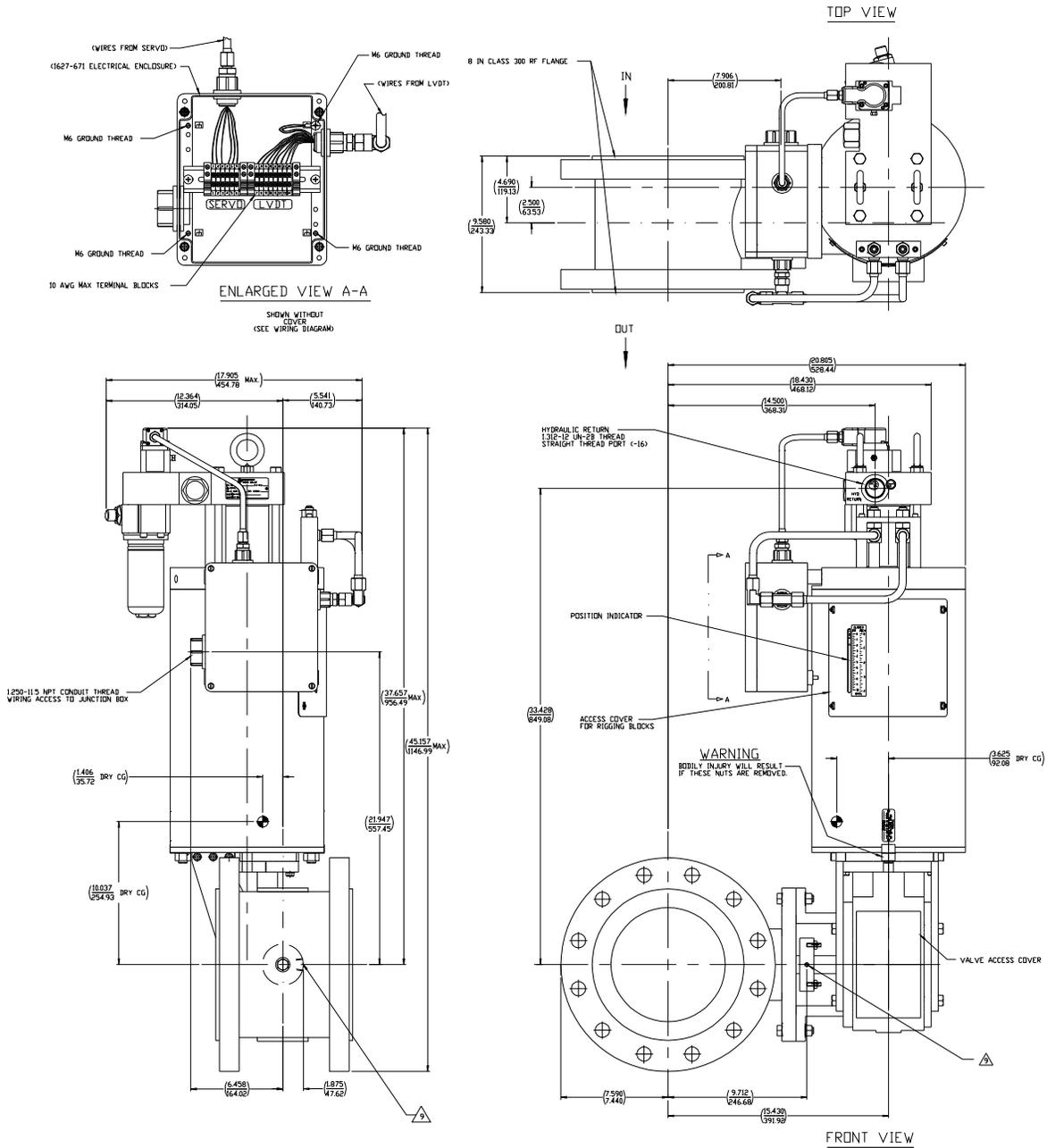


Figure 1-7a. Gas Stop/Ratio Valve Outline Drawing (8-inch, with 2 LVDTs)

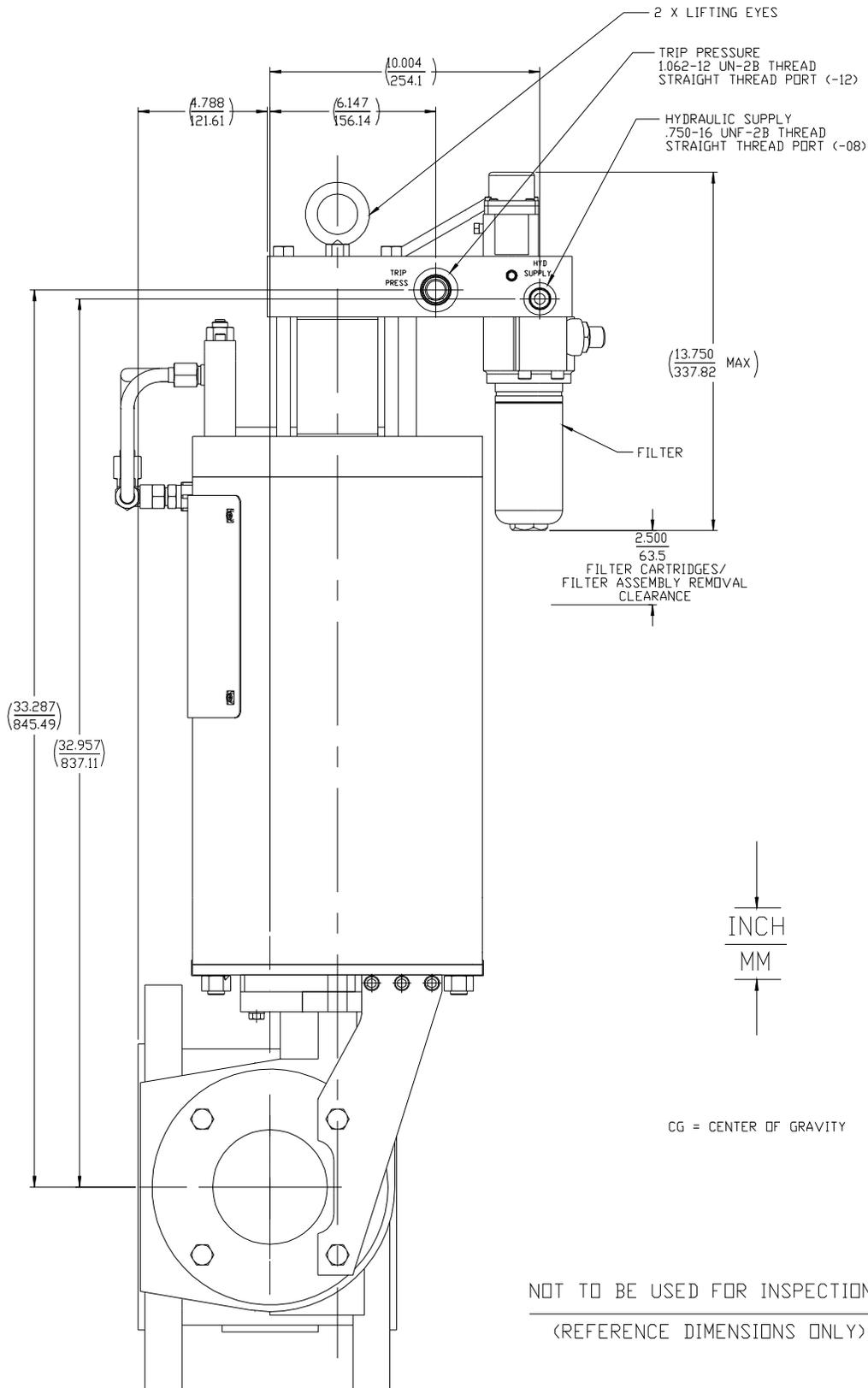


Figure 1-7b. Gas Stop/Ratio Valve Outline Drawing (8-inch, with 2 LVDTs)

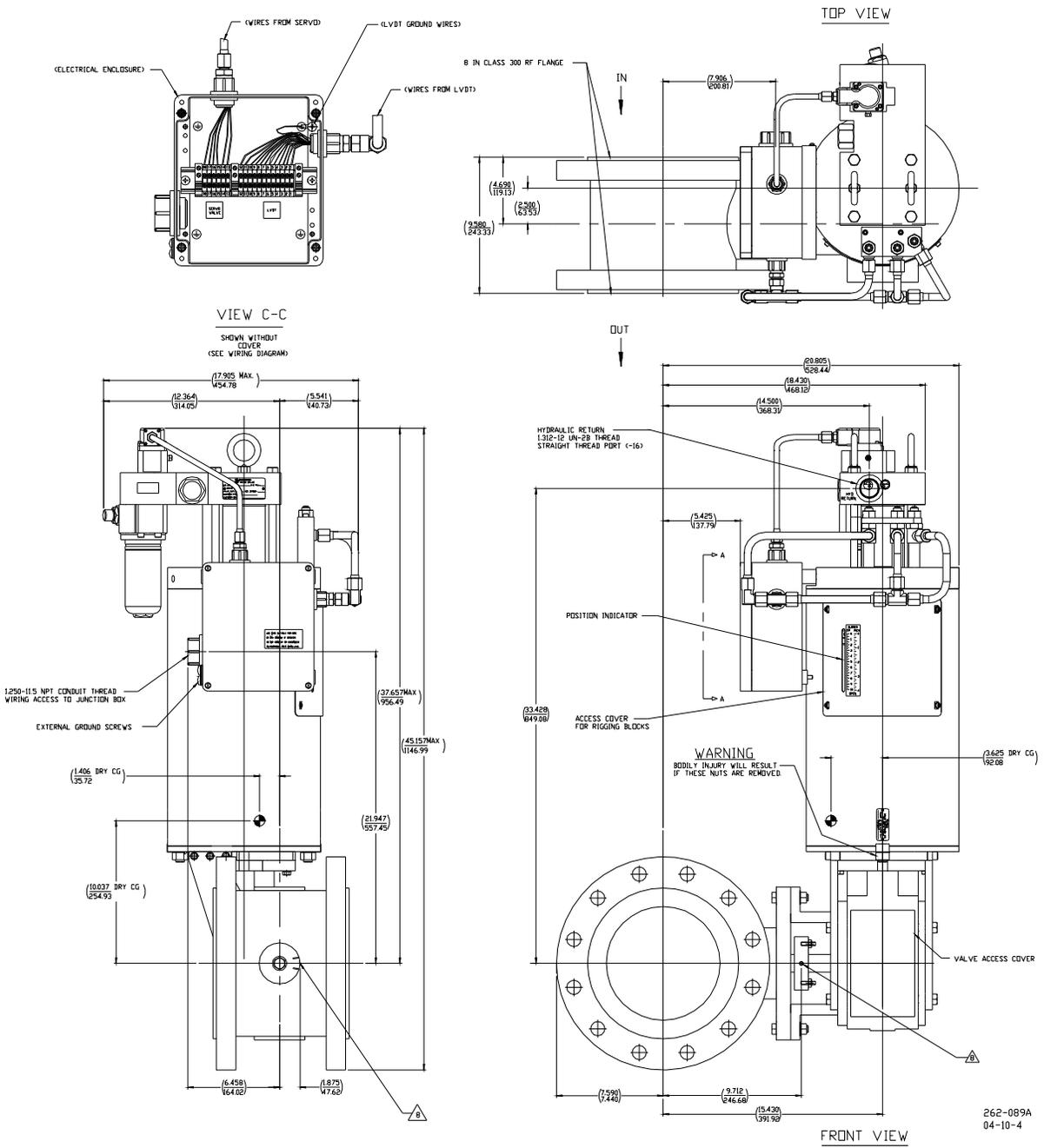


Figure 1-8a. Gas Stop/Ratio Valve Outline Drawing (8-inch, with 3 LVDTs)

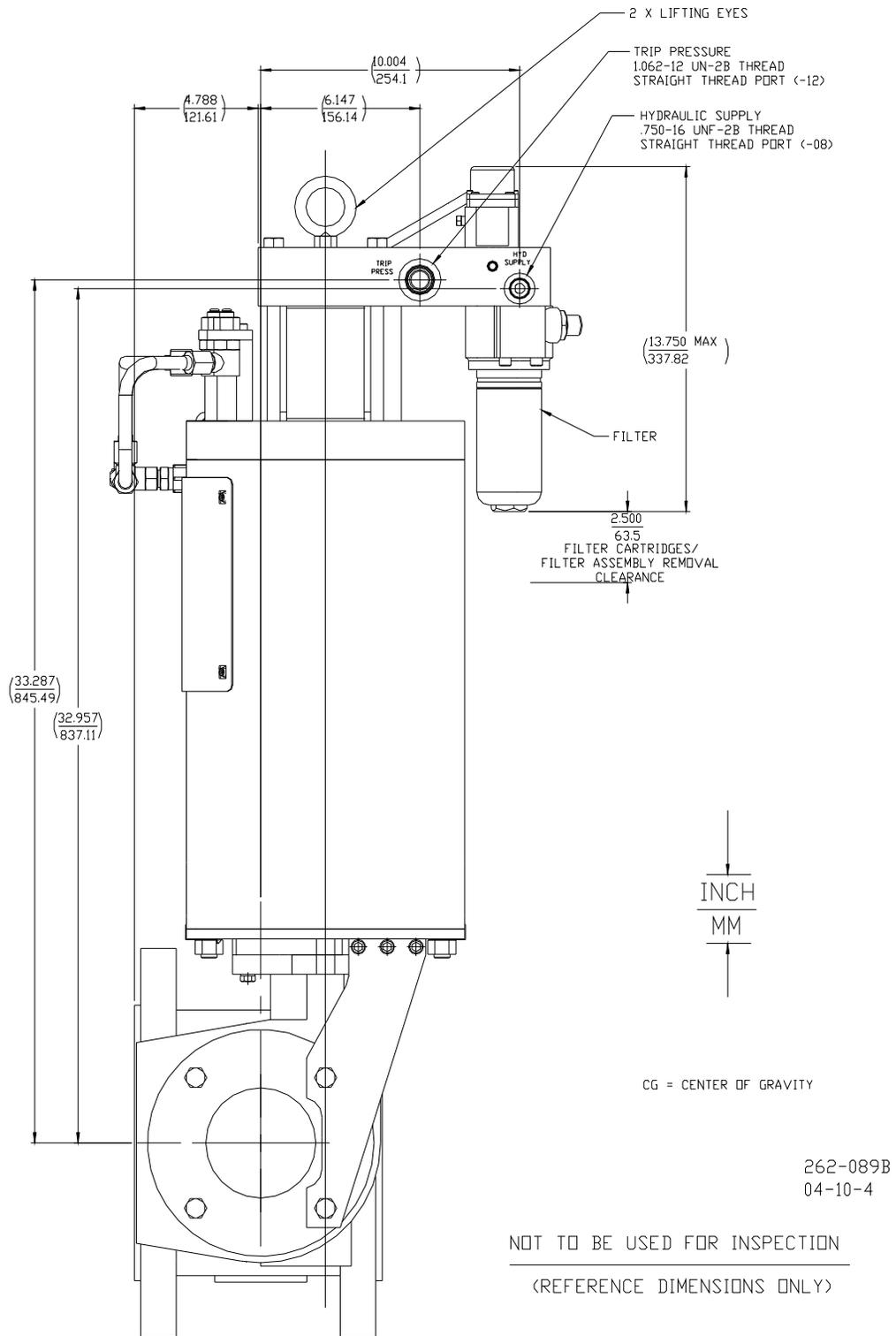


Figure 1-8b. Gas Stop/Ratio Valve Outline Drawing (8-inch, with 3 LVDTs)

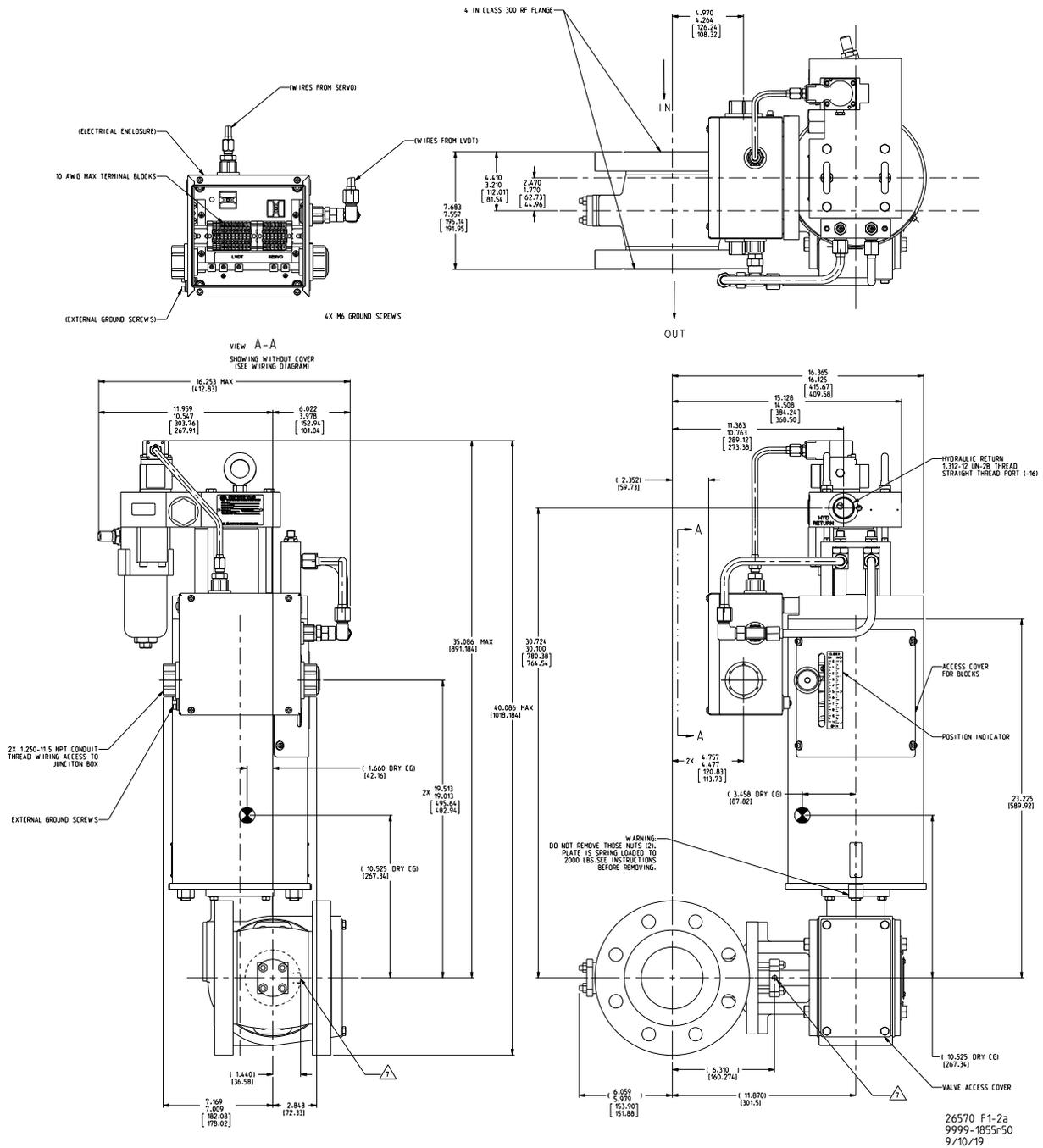


Figure 1-9a. Gas Stop/Ratio Valve Outline Drawing (4-inch with SST Junction Box)

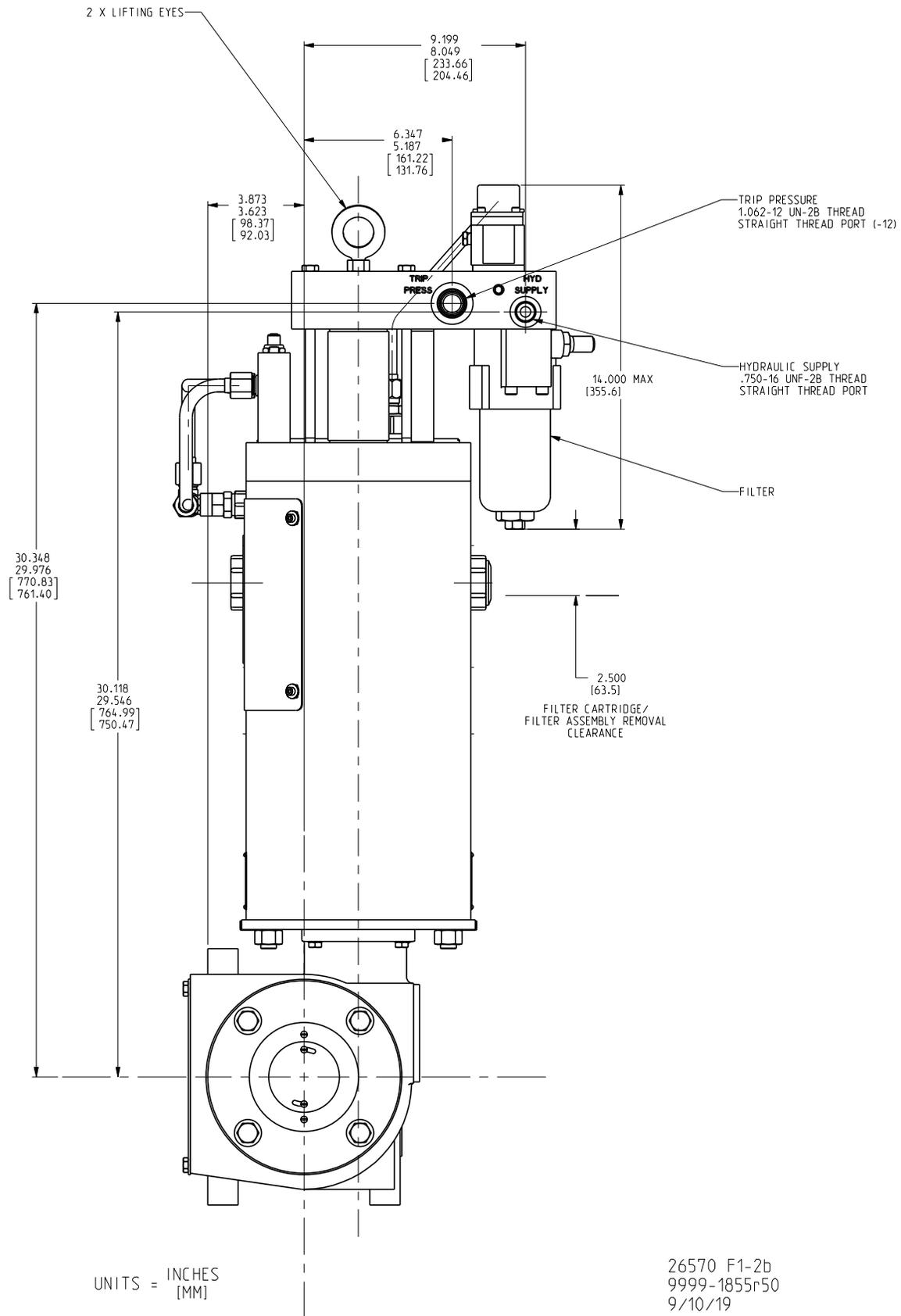
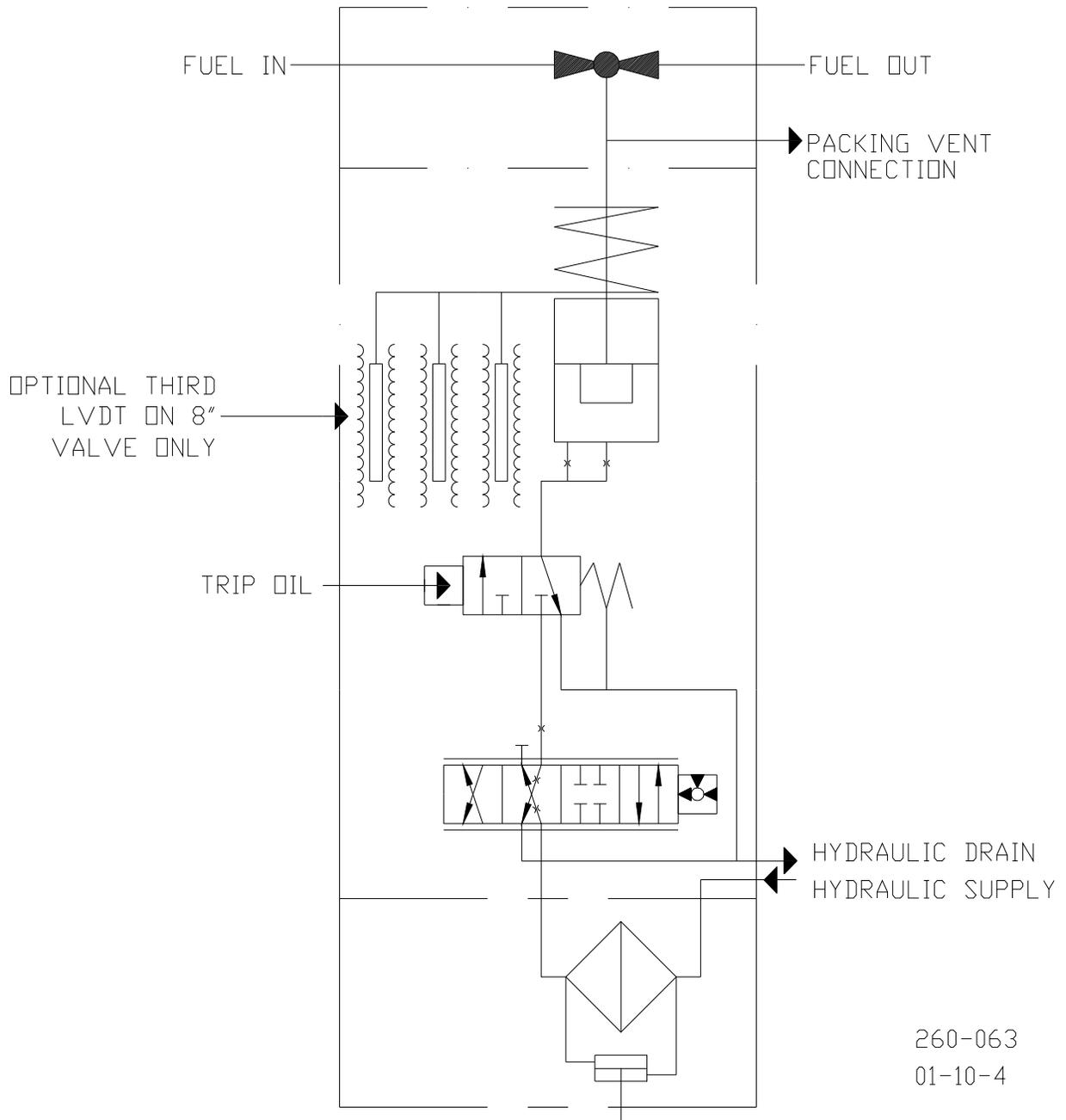
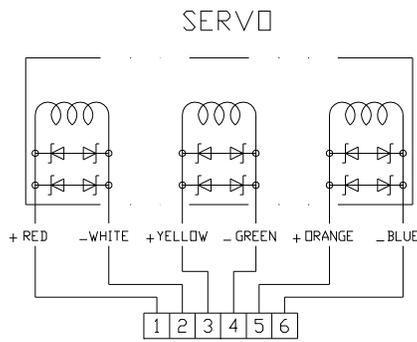


Figure 1-9b. Gas Stop/Ratio Valve Outline Drawing (4-inch with SST Junction Box)

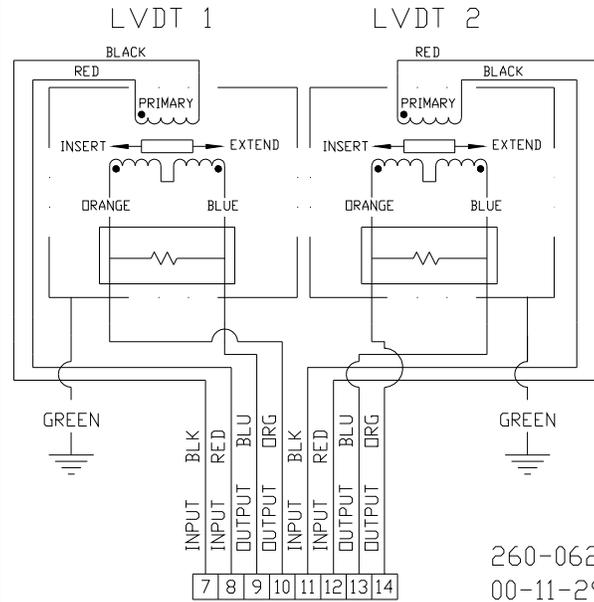


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Figure 1-10. Single Acting Hydraulic Schematic



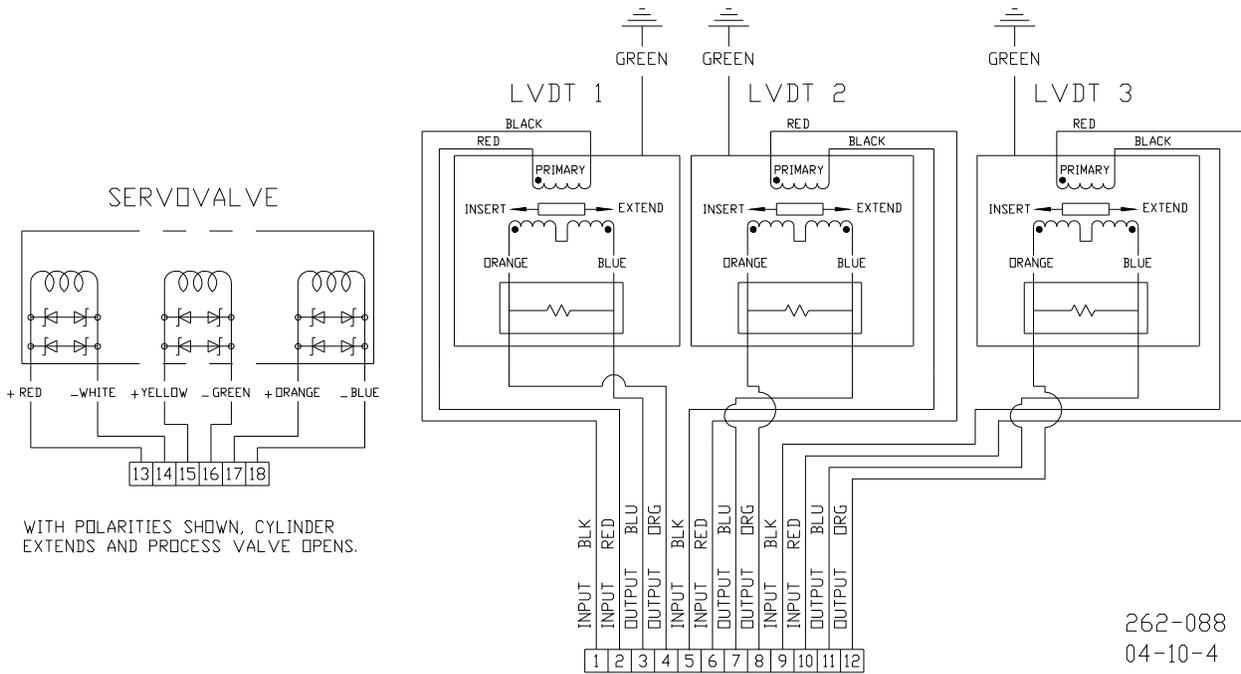
WITH POLARITIES SHOWN, CYLINDER EXTENDS AND PROCESS VALVE OPENS.



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LVDT VOLTAGE INCREASES WHEN CYLINDER EXTENDS AND PROCESS VALVE OPENS.

Figure 1-11a. Electrical Schematic and Wiring Diagram (Dual LVDT)



WITH POLARITIES SHOWN, CYLINDER EXTENDS AND PROCESS VALVE OPENS.

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Figure 1-11b. Electrical Schematic and Wiring Diagram (Triple LVDT, 6" and 8" valves only)

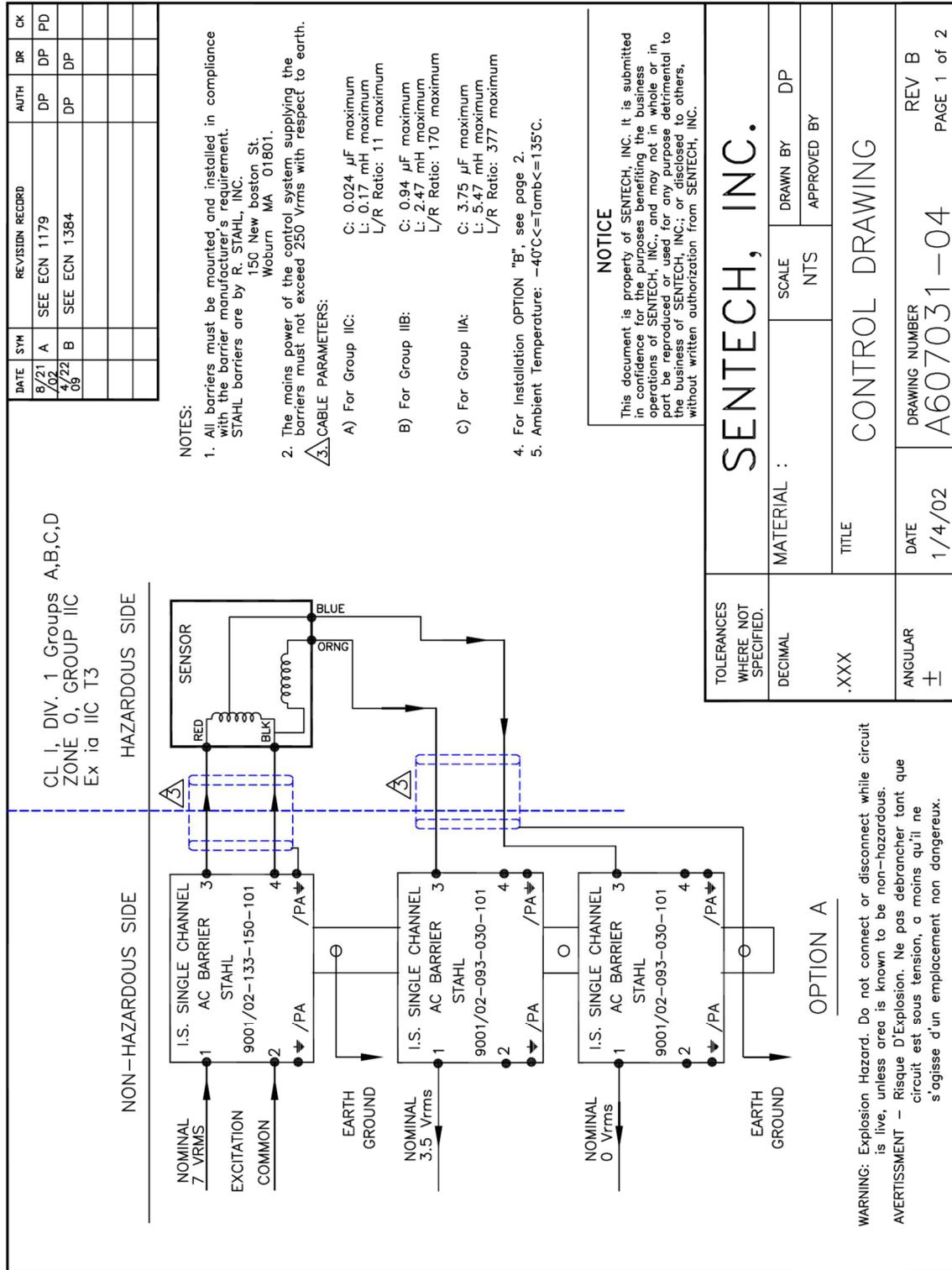


Figure 1-12a. Sentech Control Drawing

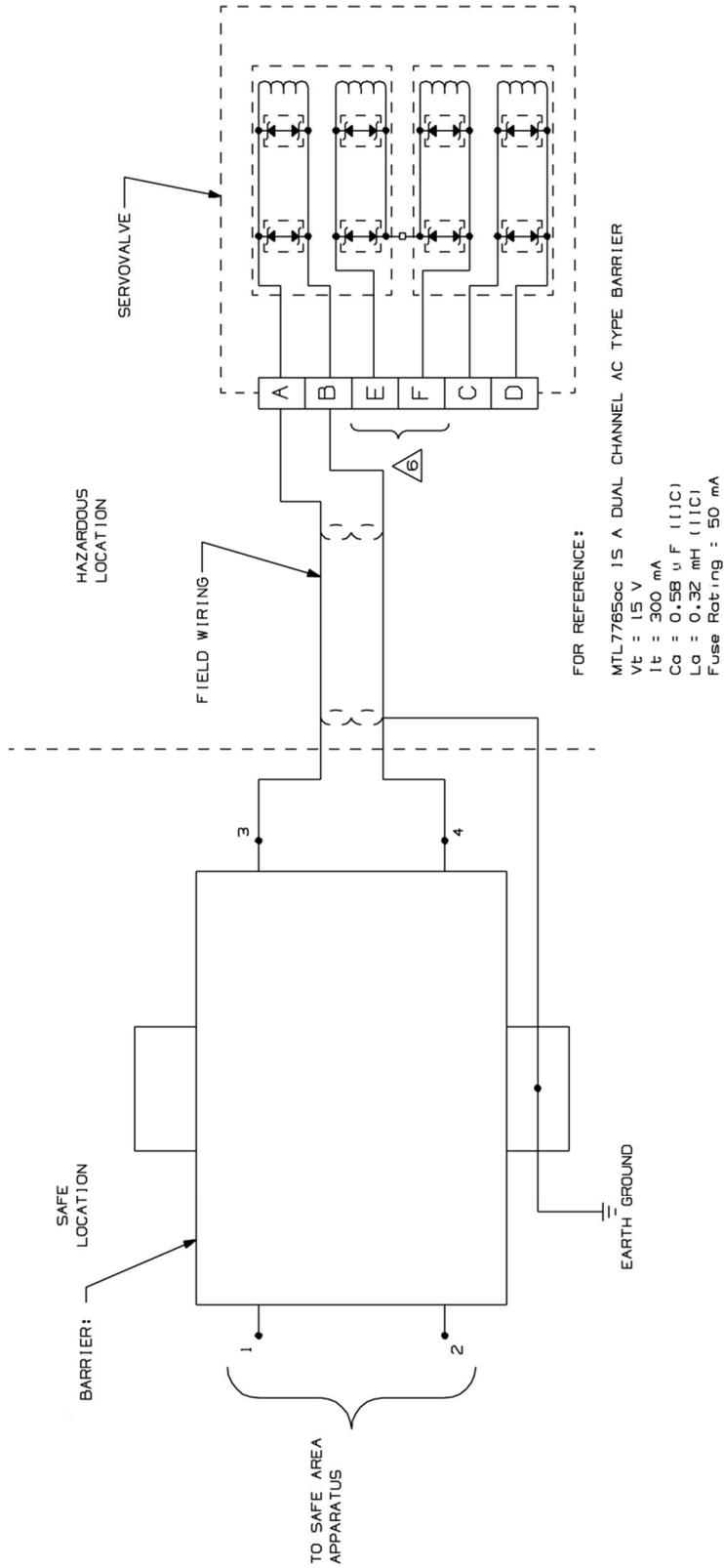


Figure 1-12b. Moog Drawing G4400 Configuration 4

Chapter 2.

Stop/Ratio Valve Operation

The Gas Stop/Ratio Valve actuator is controlled by an electronic servo-control system (not included), which compares the demanded and actual valve positions. The control system modulates the input current signal to the electrohydraulic servo valve to minimize the positioning system error. See Figure 1-2 for a functional schematic of the single acting actuator.

Hydraulic oil enters the actuator via a removable element filter with integral high ΔP indicator and is directed to a four way, electrohydraulic servo valve used in a three-way configuration. The PC1 control pressure output from the servo valve is directed to the top of the hydraulic piston. When the force exerted by the hydraulic pressure exceeds the force of the opposing loading springs, the output piston extends, rotating the valve in the opening direction.

A trip relay valve assembly is interposed between the electrohydraulic servo control valve and the servo output stage. Loss or reduction of the externally supplied trip signal pressure causes the trip relay valve to shift position. This connects the upper cavity of the actuator piston to the hydraulic drain. The force supplied by the return springs pushes the actuation rod up, rotating the valve to the closed position.

Two redundant LVDT position feedback transducers are also mounted within each actuator. An optional third LVDT is available on the 6" and 8" stop/ratio actuators only. The LVDT sensor cores and support rods are connected to the main actuator output rod by a coupling arrangement guided on a bushing. This guide bushing maintains LVDT alignment to minimize core damage due to sliding wear and the associated loss of sensing accuracy.

Chapter 3.

Standard Component Details

Triple Coil Electrohydraulic Servo Valve Assembly

The stop/ratio valve actuator utilizes a two stage hydraulic servo valve to modulate the position of the output shaft and thereby control the stop ratio valve. The first stage torque motor utilizes a triple wound coil, which controls the position of the first and second stage valves in proportion to the total electrical current applied to the three coils.

If the control system requires a rapid movement of the valve to increase fuel pressure to the control valves, the total current is increased well above the null current. In such a condition, supply oil is admitted to the cavity above the actuator piston. The flow rate delivered to the upper piston cavity is proportional to the total current applied to the three coils. Thus, the actuator stroke velocity and the valve opening are also proportional to the current (above null) supplied to the torque motor above the null point.

If the control system requires a rapid movement to reduce fuel pressure downstream of the stop/ratio valve, the total current is reduced well below the null current. In such a condition, the actuator piston cavity is connected to the hydraulic drain circuit. The flow rate returning from the upper piston cavity of the valve is proportional to the magnitude of the total current below the null value. The flow rate and closing velocity of the valve are in this case proportional to the total current below the null point.

Near the null current, the servo valve essentially isolates the upper piston cavity from the hydraulic supply and drain, and the upper piston pressure and spring load are balanced to maintain a constant position. The control system, which regulates the amount of current delivered to the coils, modulates the current supplied to the coil to obtain proper closed loop operation of the system.

Trip Relay Valve Assembly

The stop/ratio valve utilizes a three-way, two position, and hydraulically operated valve to switch the position of the gas stop/ratio valve. When the trip circuit pressure increases above 24 ± 6 psid (165 ± 41 kPa) relative to hydraulic drain pressure, the three-way relay valve shifts position. The servo valve control port is then connected to the actuator upper piston cavity, and this interconnecting route is isolated from the drain passage. Actuation pressure is routed to the upper piston cavity of the valve, allowing the gas stop/ratio actuator to function.

As the trip circuit supply pressure reduces below 22 ± 6 psid (152 ± 41 kPa) relative to hydraulic drain pressure, the three-way relay valve shifts position such that the upper piston cavity is connected to the hydraulic drain circuit, and isolated from the hydraulic supply. As the pressure falls within the upper piston cavity, the return spring rapidly returns the actuator piston to the upward position, closing the stop ratio valve and shutting off fuel to the engine.

Hydraulic Filter Assembly

The stop/ratio actuator is supplied with an integrated, high capacity filter. This broad range filter protects the internal hydraulic control components from large oil-borne contaminants that might cause the hydraulic components to stick or operate erratically. The filter is supplied with a visual indicator which indicates when the pressure differential exceeds the recommended value, indicating that replacement of the element is necessary.

LVDT Position Feedback Sensors

The stop/ratio actuator uses dual LVDTs for position feedback. An optional third LVDT is available on the 6" and 8" stop/ratio actuators only. The LVDTs are factory set to give 0.7 ± 0.1 Vrms feedback at minimum position and 3.5 ± 0.5 Vrms feedback at maximum position. The actual voltage values for each LVDT are recorded on a label placed inside the actuator electrical box, for reference during field calibration.

Chapter 4. Installation

General

See the outline drawings (Figures 1-5 through 1-11) for:

- Overall dimensions
- Process piping flange locations
- Hydraulic fitting sizes
- Electrical connections
- Lift points and center of gravity
- Weight of the valve

The design of the Vee-Ball® valve requires that the rotary drive shaft be mounted horizontally. Additionally, a vertical actuator position is generally preferred to conserve floor space as well as ease of making electrical, fuel, and hydraulic connections and changing the hydraulic filter element.

The stop/ratio valve is designed for support by the piping flanges alone. Additional supports are neither needed nor recommended.

The standard stop/ratio valve is supplied with a left-hand orientation as shown in the outline drawing. The valve can be configured with a right-hand orientation; however, this request must be on the purchase order at the time the order is placed for this change to take place.

**WARNING**

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

**WARNING**

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

**WARNING**

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

**WARNING**

Do not lift or handle the valve by any conduit. Lift or handle the valve only by using the eyebolts.

**WARNING**

The surface temperature of this valve approaches the maximum temperature of the applied process media. It is the responsibility of the user to ensure that the external environment contains no hazardous gases capable of ignition in the range of the process media temperatures.

Unpacking

The valve is shipped in an airtight bag with desiccant to ensure a non-corrosive environment. We recommend that the valve be kept in its shipping container until installation. If the valve is to be stored for extended periods of time, encase the valve in an airtight container with desiccant.

Piping Installation

Refer to ANSI B16.5 for details of flange, gasket, and bolt types and dimensions.

Verify that the process piping flange-to-flange-face dimensions meet the requirements of the outline drawings (Figures 1-5 through 1-11) within standard piping tolerances. The valve should mount between the piping interfaces such that the flange bolts can be installed with only manual pressure applied to align the flanges. Mechanical devices such as hydraulic or mechanical jacks, pulleys, chain-falls, or similar should never be used to force the piping system to align with the valve flanges.

The stop/ratio valve is designed for support by the piping flanges alone; additional supports are neither needed nor recommended.

Grade 5 (metric class 8.8) bolts or studs should be used to install the valve into the process piping. The length and diameter for Class 300 flanges shall conform to the following table according to the valve flange size.

Table 4-1. Class 300 Pipe and Fixture Specifications

Nominal Pipe Size	Number of Bolts	Diameter of Bolts	Stud Length	Machine Bolt Length
1 inch/ 25 mm	4	5/8 inch/ 16 mm	3.00 inch/ 76.2 mm	2.50 inch/ 63.5 mm
2 inch/ 51 mm	8	3/4 inch/ 19 mm	3.50 inch/ 88.9 mm	3.00 inch/ 76.2 mm
3 inch/ 76 mm	8	3/4 inch/ 19 mm	4.25 inch/ 108.0 mm	3.50 inch/ 88.9 mm
4 inch/ 102 mm	8	3/4 inch/ 19 mm	4.50 inch/ 114.3 mm	3.75 inch/ 95.2 mm
6 inch/ 152 mm	8	3/4 inch/ 19 mm	4.75 inch/ 120.6 mm	4.25 inch/ 108.0 mm
8 inch/ 203 mm	12	7/8 inch/ 22 mm	5.50 inch/ 139.7 mm	4.75 inch/ 120.6 mm

Flange gasket materials should conform to ANSI B16.20. The user should select a gasket material which will withstand the expected bolt loading without injurious crushing, and which is suitable for the service conditions.

When installing the valve into the process piping, it is important to properly torque the stud/bolts in the appropriate sequence in order to keep the flanges of the mating hardware parallel to each other. A two-step torque method is recommended. Once the studs/bolts are hand tightened, torque the studs/bolts in a crossing pattern to half the torque value listed in the following table. Once all studs/bolts have been torqued to half the appropriate value, repeat the pattern until the rated torque value is obtained.

Table 4-2. Bolt Size and Torque Specifications

Bolt Size	Torque
5/8 inch/16 mm	150–155 lb-ft/203–210 N·m
3/4 inch/19 mm	250–260 lb-ft/339–353 N·m
7/8 inch/22 mm	375–390 lb-ft/508–529 N·m

Hydraulic Connections

There are three hydraulic connections that must be made to each valve: supply, return, and trip oil. The connections to the valve are straight-thread O-ring style ports per SAE J514. The tubing up to the valve must be constructed to eliminate any transfer of vibration or other forces into the valve.

Make provisions for proper filtration of the hydraulic fluid that will supply the actuator. The system filtration should be designed to assure a supply of hydraulic oil with a maximum ISO 4406 contamination level of 18/16/13 and a preferred level of 16/14/11. The filter element included with the actuator is not intended to provide adequate filtration over the entire life of the actuator.

The hydraulic supply to the actuator is to be 0.500 inch (12.70 mm) tubing capable of supplying 10 US gallons/min (18 L/min) at 1200–1700 psig (8274–11 722 kPa).

The hydraulic drain should be 1.00 inch (25.4 mm) tubing and must not restrict the flow of fluid from the valve. The drain pressure must not exceed 30 psig (207 kPa) under any condition.

The trip relay valve supply should be 0.750 inch (19.05 mm) tubing. The Trip Relay Pressure should be above 40 psig (276 kPa) to enable the valve to function.

Electrical Connections



WARNING

EXPLOSION HAZARD—Do not connect or disconnect while circuit is live unless area is known to be non-hazardous.



WARNING

Due to the hazardous location listings associated with this valve, proper wire type and wiring practices are critical to operation.



WARNING

Protective earth (PE) ground must be connected on the junction box per the installation drawing to reduce the risk of electrostatic discharge in a hazardous atmosphere.

NOTICE

Do not connect any cable grounds to “instrument ground”, “control ground”, or any non-earth ground system. Make all required electrical connections based on the wiring diagram (Figures 1-3 & 1-4).

The use of cable with individually-shielded twisted pairs is recommended. All signal lines should be shielded to prevent picking up stray signals from nearby equipment. Installations with severe electromagnetic interference (EMI) may require shielded cable run in conduit, double-shielded wire, or other precautions. Connect the shields at the control system side or as indicated by the control system wiring practices, but never at both ends of the shield such that a ground loop is created. Wires exposed beyond the shield must be less than 2 inches (51 mm). The wiring should provide signal attenuation to greater than 60 dB.

Servo Valve Electrical Connection

When installed in Zone 1 application, using intrinsically safe method of protection, barriers must be installed in a safe area per the wiring diagram Figure 1-4b (Moog Drawing G4400 Configuration 4). All barriers which are part of the approved system configurations must be mounted and installed in compliance with the barrier manufacturer's requirements. Barriers supplied for the servo valve circuit are dual-channel AC-type barrier, manufactured by MTL Instruments, Ltd.

Hazard area (field) wiring must meet the requirements of the barrier manufacturer or ISA (Instrument Society of America) RP 12.6. Field wiring must be constructed using twisted, shielded pairs of at least 18 AWG (0.8 mm²) wire. Shield must be connected to earth ground only at the barrier strip.

LVDT Electrical Connection

When installing in a Zone 1 application using intrinsically safe method of protection, barriers must be installed in a safe area per the wiring diagram Figure 1-4a (Sentech Drawing A607031-04). All barriers must be mounted and installed in compliance with the barrier manufacturer's requirement. Barriers supplied for the LVDT circuit are manufactured by R. Stahl, Inc. The mains power of the control system supplying the barriers must not exceed 250 Vrms with respect to earth.

Cable parameters for the hazard area (field) wiring:

For Group IIC:

C: 0.024 μ F max

L: 0.17 mH max

L/R Ratio 11 max

Fuel Vent Port

The fuel vent port must be vented to a safe location. In normal operation, this vent should have zero leakage. However, if excessive leakage is detected from this vent port, contact a Woodward representative for assistance.

Electronic Settings

Dynamic Tuning Parameters

It is imperative that the correct dynamic characteristics of this valve be input into the control system to ensure that the operation of the valve/control system is within acceptable limits.

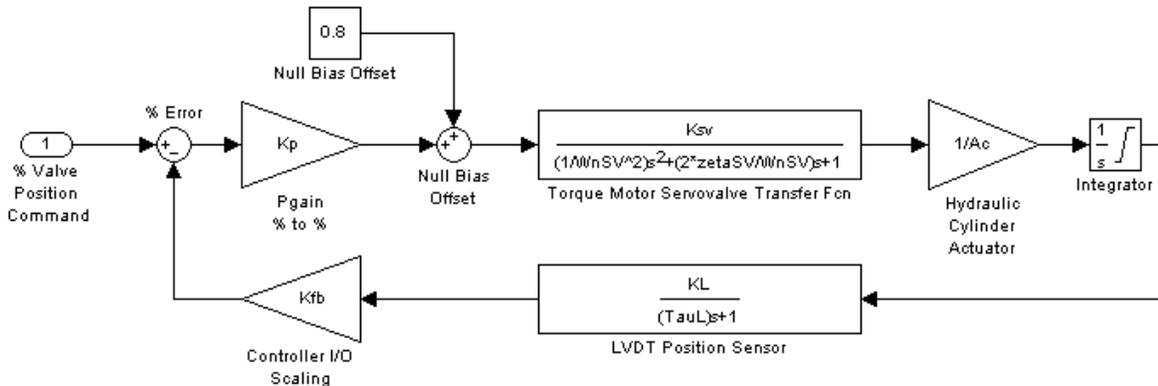


Figure 4-1. Stop/Ratio Valve Block Diagram

- K_{sv} nominal = 3.0 in³/sec/mA at 1600 psi supply (small actuator¹);
 6.0 in²/sec/mA at 1600 psi supply (large actuator¹);
 K_{sv} is proportional to square root of supply, and constant with position.
 $Zeta_{SV}$ = 0.7
 Wn_{SV} = 680 rad/sec (108 Hz); Wn_{SV} is proportional to square root of supply
 A_c = 2.4 in² (small actuator¹); 4.9 in² (large actuator¹)
 K_L = 0.80 Vrms/inch
 Servo Travel = 3.5 inches
 Tau_L = 0.005 seconds (depends on excitation/demodulation)

¹See page 2 for usage of small and large actuators

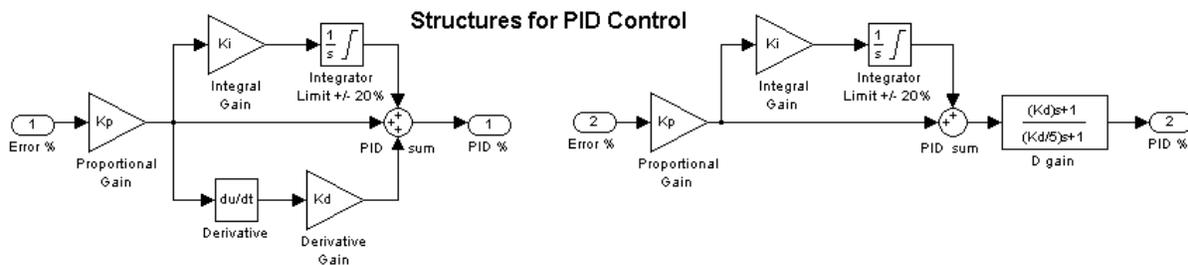


Figure 4-2. Structures for PID Control

Table 4-3. Recommended Control Gain Values for Different Control Types

Control Gain Settings	Proportional Control	Proportional Integral	Proportional Integral Derivative
	$K_p=5$;	$K_p=3$; $K_i=5$;	$K_p=3$; $K_i=5$; $K_d=0.01$ or $Tau\ Lead = 0.01$

Null Current Adjustment

Every valve shipped contains documentation that gives the actual Null Current as measured by Woodward. It is imperative that the control system null current match the as-measured current for each valve in the system. Incorrect null current setting, with proportional control only, will result in position error.

Rigging Procedure

Inside the electrical enclosure of the valve, there is an adhesive label that contains the appropriate valve position (as a percent of full stroke), the physical stroke (inches), and the corresponding LVDT feedback signals for each LVDT (assuming 7.0 Vrms excitation at 3000 Hz).

Once the control system is connected to the valve and control of the valve is established, set the valve command position to 0% of full stroke. Measure the feedback voltage from each LVDT. Adjust the Offset in the feedback loop until the feedback voltage matches the documented values (see the label inside the electrical enclosure) for that position. Adjust the command position to 100% of full stroke. Adjust the Gain of the feedback loop until the LVDT feedback voltage matches the documented values. Set the command position to close the valve. Verify that the valve is closed visually and that the feedback voltage from the LVDT is 0.7 ± 0.1 Vrms. This process may have to be repeated to ensure the feedback voltages at both the 0% and 100% command positions match the documented values.

Chapter 5. Maintenance and Hardware Replacement

Maintenance

WARNING

Any cleaning by hand or with water spray must be performed while the area is known to be non-hazardous to prevent an electrostatic discharge in an explosive atmosphere.

The Gas Stop/Ratio Valve requires no maintenance or adjustment in preparation for or during normal operation.

Woodward recommends routine checks of the DP gauge on the filter assembly to verify that the filter is not partially clogged. If the DP indicator shows red, the filter element needs to be replaced.

In the event that any of the standard components of the valve become inoperative, field replacement of certain components is possible. Contact a Woodward representative for assistance.

Hardware Replacement

WARNING

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

WARNING

EXPLOSION HAZARD—Do not connect or disconnect while circuit is live unless area is known to be non-hazardous.

Substitution of components may impair suitability for Class I, Division 2 or Zone 2.

WARNING

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

WARNING

Do not lift or handle the valve by any conduit. Lift or handle the valve only by using the eyebolts.

WARNING

Due to typical noise levels in turbine environments, hearing protection should be worn when working on or around the Gas Stop/Ratio valve.

WARNING

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

See the outline drawings (Figures 1-5 through 1-11) for the location of items.

Hydraulic Filter Assembly/Cartridge

The hydraulic filter is located on the hydraulic manifold, hanging directly under the servo valve.

Replacement of Filter Assembly

1. Remove four 0.312-18 UNC socket head cap screws.
2. Remove the filter assembly from manifold block.

IMPORTANT

The filter contains a large amount of hydraulic fluid that may be spilled during filter removal.

3. Remove the two O-rings present in the interface between the filter and the manifold.
4. Obtain a new filter assembly.
5. Place two new O-rings in the new filter assembly.
6. Install filter onto manifold assembly. Be sure to place the filter in the correct orientation. See the outline drawings (Figures 1-5 through 1-11).
7. Install four 0.312-18 cap screws through filter and torque into manifold to 106–146 lb-in (12.0–16.5 N·m).

Replacement of Filter Cartridge

IMPORTANT

The filter contains a large amount of hydraulic fluid that may be spilled during filter removal.

1. Using a 1-5/16 inch (~33+ mm) wrench, loosen the bowl from the filter assembly.
2. Remove the filter element by pulling it downward.
3. Obtain a new filter element.
4. Lubricate the O-ring on the ID of the cartridge with hydraulic fluid.
5. Install the cartridge into the assembly by sliding the open end of the cartridge upward onto the nipple.
6. Install the filter bowl. Tighten only by hand.

Trip Relay Valve Cartridge

The trip relay valve cartridge is located in the hydraulic manifold block.

IMPORTANT

Hydraulic fluid may spill during cartridge removal.

1. Using a 1.5 inch (~38+ mm) wrench, loosen the trip relay valve from the hydraulic manifold.
2. Slowly remove the cartridge from the manifold.
3. Obtain new trip relay valve cartridge and verify part number and revision with existing unit.
4. Verify that all O-rings and backup rings are present on new cartridge.
5. Lubricate O-rings with hydraulic fluid or petroleum jelly.
6. Install cartridge into manifold housing.
7. Torque to 80–90 lb-ft (108–122 N·m).

Servo Valve

The servo valve is located on the hydraulic manifold directly above the filter assembly. Refer to the outline drawings (Figures 1-5 through 1-11).

IMPORTANT

There could be a substantial amount of hydraulic fluid upon removal.

1. Remove the cover to the electrical junction box.
2. Disconnect the servo valve wires from the connector blocks, as shown in the wiring diagram (Figure 1-3a or 1-3b).
3. Loosen the conduit fittings from the electrical box and the servo valve.
4. Carefully remove the conduit from the servo valve and pull the wiring out of the conduit.
5. Remove the four #10-32 UNF socket head cap screws holding the servo valve to the manifold.
6. Discard the eight O-rings between the servo valve, the adapter plate, and the manifold.
7. Obtain replacement servo valve and verify part number and revision with existing unit.
8. Place four new O-rings on the adapter plate.
9. Reposition adapter plate onto hydraulic manifold ensuring hydraulic passages and bolt holes are aligned correctly. Be sure that all four O-rings remain in their proper location during assembly on the lower side of the adaptor plate facing the manifold.
10. Remove protective plate from replacement servo valve and verify that O-rings are on all four counter bores of the servo valve.
11. Place the servo valve onto the adapter plate that has been positioned on the hydraulic manifold. Be sure to orient the servo valve to match the original orientation. Be sure that all four O-rings remain in their proper location during assembly.
12. Install four #10-32 UNF socket head cap screws and torque to 55-57 lb-in (6.2-6.4 N·m).
13. Install the servo valve wiring through conduit and into electrical box.
14. Connect conduit to servo valve and torque to 450–550 lb-in (51–62 N·m).
15. Torque conduit to electrical box to 450–550 lb-in (51–62 N·m).
16. Install wires into servo valve connector blocks as shown in the wiring diagram (Figure 1-3a or 1-3b). If it is necessary to cut wires for installation, be sure to retain at least one service loop of wiring.
17. Replace cover onto junction box and tighten screws.

LVDT Replacement

WARNING

To prevent possible personal injury, do NOT remove the spring cover (which is spring-loaded to over 1000 lbs/4448 N).

The LVDTs are located on the upper mounting plate located on the top of the large spring cylinder and below the hydraulic manifold. Refer to the outline drawings (Figures 1-5 through 1-11).

1. Remove the cover to the electrical junction box.
2. Disconnect each set of LVDT wires from the connector blocks.
3. Loosen the conduit fittings from the electrical box and from each LVDT.
4. Carefully remove the conduit from the LVDTs and pull the wiring out of the conduit.
5. Disconnect the hydraulic drain connection for improved working space.

IMPORTANT

There could be a substantial amount of hydraulic fluid upon removal.

6. Remove the 0.500-20 UNF mounting nut from the defective LVDT only.
7. Remove the two 0.250-20 UNC socket head cap screws holding the LVDT bracket to the upper mounting plate.
8. Carefully remove the LVDT assembly from the valve by lifting vertically upwards. Take care not to damage the good LVDT housing and rod.

9. Remove the four #10-32 UNF screws holding the access cover on the side of the spring cylinder to gain access to the LVDT rods.
10. Remove 0.375-24 UNF jam nut from defective LVDT rod.
11. Remove the defective LVDT rod using the 0.250 inch flats at the top of the threads. The rod will be difficult to unscrew due to the thread-locking feature incorporated into the spring plate.
12. Obtain replacement LVDT and verify part number and revision with existing unit.
13. Install replacement LVDT rod into spring plate, positioning the rod height to approximately match the other LVDT rod height.
14. Install the 0.375-24 UNF jam nut onto the LVDT rod but do not torque nut at this time.
15. Carefully slide replacement LVDT through upper mounting plate and over the LVDT rod. Be very careful not to force the LVDT at any time since this could damage the LVDT rod.
16. Carefully reinstall the good LVDT and bracket assembly through upper mounting plate and over the LVDT rod. Be very careful not to force the LVDT at any time since this could damage the LVDT rod.
17. Install the two 0.250-20 UNC socket head cap screws holding the LVDT bracket to the upper mounting plate and torque to 58–78 lb-in (6.6–8.8 N·m).
18. Install replacement LVDT into mounting bracket and torque 0.500-20 UNF mounting nut to 400–500 lb-in (45–56 N·m).
19. Mark the LVDT wire sets so that each set of LVDT wires is distinct. Once the LVDT wires are installed into the electrical box, it will be difficult to distinguish the sets if they are not marked.
20. Install wiring through conduit and into electrical box.
21. Connect conduit to LVDTs and torque to 450–550 lb-in (51–62 N·m).
22. Torque conduit to electrical box to 450–550 lb-in (51–62 N·m).
23. Install wires into LVDT connector blocks as shown in the wiring diagram (Figure 1-3a or 1-3b). If it is necessary to cut wires for installation, be sure to retain at least one service loop of wiring.
24. Reattach the hydraulic drain connection.
25. Once the LVDT is installed, it must then be calibrated as described below.

LVDT Calibration

1. Whenever an LVDT is replaced, or whenever its core rod adjustment is disturbed, the LVDT output voltage must be calibrated in the following way.



WARNING

Use care and follow all instructions after removal of the spring access cover. Internal components can potentially crush fingers, and some components are held under significant force.

2. Shut off the hydraulic supply to the stop/ratio actuator.
3. Remove the access cover from the side of the stop/ratio actuator housing by removing the four #10-32 UNF screws and washers, exposing the LVDT core rod adjustment.
4. Adjust the LVDT rod so that the output of the replaced LVDT is 0.7 ± 0.1 Vrms with the stop/ratio actuator fully retracted (gas valve fully closed).
5. Tighten the 1.375-24 UNF LVDT rod jam nut to 270–320 lb-in (31–36 N·m).
6. Install the stroke measurement attachment bar (Woodward part number 1327-945 provided with the stop/ratio actuator) to the moving plate of the actuator as shown in Figure 5-1.
7. Attach an accurate stroke measurement device (dial indicator or equivalent), capable of measuring 4 inches (100 mm) of stroke, to the stop/ratio actuator body. Position the indicator plunger tip on the measurement bar, as shown in Figure 5-1.
8. Apply hydraulic pressure to the stop/ratio actuator and manually command the actuator to stroke 3.500 ± 0.005 inches (88.90 ± 0.13 mm) by manipulating the electronic controller.
9. Note and record the LVDT output voltages at this 3.5 inch stroke position.
10. Remove the actuator control command, returning the actuator to its rest (gas valve closed) position.
11. Shut off the stop/ratio actuator hydraulic supply.
12. Update the stop/ratio control logic with the new LVDT output voltage value.
13. Remove the cover on the stop/ratio actuator electrical junction box.
14. Replace the original LVDT max output voltage value on the label in the stop/ratio actuator electrical junction box with the newly measured value.
15. Replace the cover on the junction box and tighten the screws.
16. Remove the dial indicator and measurement bar.



Figure 5-1. Stroke Measurement Attachment Bar

17. Reinstall the access cover with four #10-32 UNF screws, adjusting the closed indicator mark to align with the position indicator screw slot. Tighten the four cover attaching screws to 30–40 lb-in (3.4–4.5 N·m).

Troubleshooting Charts

Faults in the fuel control or governing system are often associated with speed variations of the prime mover, but such speed variations do not always indicate fuel control or governing system faults. Therefore, when improper speed variations occur, check all components including the engine or turbine for proper operation. Refer to applicable electronic control manuals for assistance in isolating the trouble. The following steps describe troubleshooting for the gas fuel stop/ratio valve.

Disassembly of the gas fuel stop/ratio valve in the field is not recommended due to the dangerous forces contained in the springs. Under unusual circumstances where disassembly becomes necessary, all work and adjustments should be made by personnel thoroughly trained in the proper procedures.

When requesting information or service help from Woodward, it is important to include the part number and serial number of the valve assembly in your communication.

Symptom	Possible Causes	Remedies
External hydraulic leakage	Static O-ring seal(s) missing or deteriorated	Replace O-rings fitted to user-serviceable components (filter, servo valve, trip relay valve) as needed. Otherwise, return actuator to Woodward for service.
	Dynamic O-ring seal missing or deteriorated	Return actuator to Woodward for service.
Internal hydraulic leakage	Servo valve internal O-ring seal(s) missing or deteriorated	Replace servo valve.
	Servo valve metering edges worn	Replace servo valve.
	Piston seal missing or deteriorated	Return actuator to Woodward for service.

Symptom	Possible Causes	Remedies
External gas fuel leakage	Piping flange gaskets missing or deteriorated	Replace gaskets.
	Piping flanges improperly aligned	Rework piping as needed to achieve alignment requirements detailed in Chapter 4.
	Piping flange bolts improperly torqued	Rework bolts as needed to achieve torque requirements detailed in Chapter 4.
	Packing follower needs adjustment	Adjust follower per Fisher manual Form 5290, Type Vee-Ball.
Internal gas fuel leakage	Packing missing or deteriorated	Service packing per Fisher manual Form 5290, Type Vee-Ball.
	Vee-Ball seal missing or deteriorated	Service seal per Fisher manual Form 5290, Type Vee-Ball, and Fisher Errata Sheet Type Vee-Ball SS-260.
Valve will not open	Servo valve command current incorrect. (The sum of the current through the three coils of the servo valve must be greater than the null bias of the servo valve for the gas valve to open.)	Trace and verify that all wiring is in accordance with the electrical schematic (Figures 1-3a, 1-3b, or 1-4b) and the GE system wiring schematic(s). Pay special attention to the polarity of the wiring to the servo valve and LVDT.
	Servo valve failure	Replace servo valve.
	Hydraulic supply pressure inadequate	Supply pressure must be greater than 1200 psig/8274 kPa (1600 psig/11 032 kPa preferred).
	Trip relay pressure inadequate	Trip pressure must be greater than 40 psig (276 kPa).
	Vee-Ball jammed	Service Vee-Ball per Fisher manual Form 5290, Type Vee-Ball.
	Valve will not close	Servo valve command current incorrect. (The sum of the current through the three coils of the servo valve must be less than the null bias of the servo valve for the gas valve to close.)
Servo valve failure		Replace servo valve.
LVDT failure		Replace LVDT.
Springs broken		Return actuator to Woodward for service.
Linkage broken		Return actuator to Woodward for service.
Vee-Ball jammed		Service Vee-Ball per Fisher manual Form 5290, Type Vee-Ball.
Valve will not respond smoothly		Hydraulic filter clogged
	Servo valve spool sticking	Verify hydraulic contamination levels are within recommendations of Chapter 1. The use of dither may improve performance in contaminated systems.
	Servo valve internal pilot filter clogged	Replace servo valve.
	Excessive friction in Vee-Ball assembly	Service Vee-Ball per Fisher manual Form 5290, Type Vee-Ball, and Fisher Errata Sheet Type Vee-Ball SS-260.
	Rod-end(s) worn out	Return actuator to Woodward for service.
	Piston seal worn out	Return actuator to Woodward for service.
Actuator seals wear out prematurely	Hydraulic contamination level is excessive	Verify hydraulic contamination levels are within recommendations of Chapter 1. The use of excessive dither may reduce life in contaminated systems.
	System is oscillating (seal life is proportional to distance traveled). Even small oscillations (on the order of $\pm 1\%$) at slow frequencies (on the order of 0.1 Hz) cause wear to accumulate rapidly.	Determine and eliminate the root cause of oscillation.

Chapter 6. Safety Management – Safe Position Fuel Shutoff Function

Safety Function

The Gas Stop/Ratio Valve will move to the closed position within the full stroke trip time listed in this manual.

Product Variations Certified

The SIL (Safety Integrity Level) rated Gas Stop/Ratio Valves for fuel shutoff are designed and certified to the functional safety standards according to IEC 61508, Parts 1 through 7. Reference the exida FMEDA report: WOO 19/05-012 R002, and Certification: WOO 1905012 C001. The exida FMEDA report is available on a per request basis from Woodward.

The functional safety requirements in this chapter apply to all Gas Stop/Ratio Valve configurations listed in Table 6-1.

The Gas Stop/Ratio Valve configurations listed in Table 5-1 are certified for use in applications up to SIL 3 according to IEC 61508. The SIL of an entire SIF (Safety Instrumented Function) must be verified via calculation of Average PFD (Probability of Failure on Demand) considering redundant architectures, proof test interval, proof test effectiveness, any automatic diagnostics, average repair and the specific failure rates of all products included in the SIF. Each element must be checked to assure compliance with the minimum HFT (Hardware Fault Tolerance) requirements.

The SonicFlo™ Gas Fuel Control Valves are classified as a device that is part Type A element according to IEC 61508, having a HFT of 0.

The Gas Stop/Ratio Valves are designed and verified to withstand the worst-case (or greater) expected environmental conditions as listed in other sections of this manual.

SFF (Safe Failure Fraction) for Gas Stop/Ratio Valve – Over Speed SIF

The Gas Stop/Ratio Valve is only one part of a shutoff system that supports an over-speed shutdown SIF. This system consists of a speed sensor, a processing unit and a fuel shutoff actuation subsystem of which Gas Stop/Ratio Valve is a component.

The SFF (Safe Failure Fraction) for each subsystem should be calculated. The SFF summarizes the fraction of failures which lead to a safe state plus the fraction of failures which will be detected by diagnostic measures and lead to a defined safety action. This is reflected in the following formulas for SFF:

$$\text{SFF} = \lambda_{SD} + \lambda_{SU} + \lambda_{DD} / \lambda_{TOTAL}$$

Where $\lambda_{TOTAL} = \lambda_{SD} + \lambda_{SU} + \lambda_{DD} + \lambda_{DU}$

The failure rates listed below, for only the Gas Stop/Ratio Valve, do not include failures due to wear-out of any components and are only valid for the useful lifetime of the Gas Stop/Ratio Valve. They reflect random failures and include failures due to external events such as unexpected use. Reference the exida FMEDA report: WOO 19/05-012 R002 for detailed information concerning the SFF and PFD.

Failure Rates for Static Applications[1] with Good Maintenance Assumptions in FIT @ SSI=2

Table 6-1. Failure Rates according to IEC 61508 in FIT

Application/Device/Configuration	λ SD	λ SU [2]	λ DD	λ DU	#	E
Full Stroke, Clean Service, Hydraulic Trip	0	197	0	803	2088	575
Full Stroke, Clean Service, Electric Trip	0	575	0	923	2301	585
Full Stroke, Clean Service, Hydraulic Trip, with PVST	69	128	429	374	2088	575
Full Stroke, Clean Service, Electric Trip, with PVST	443	132	526	397	2301	585

According to IEC 61508 the architectural constraints of an element must be determined. This can be done by following the 1H approach according to 7.4.4.2 of IEC 61508 or the 2H approach according to 7.4.4.3 of IEC 61508. Reference the exida FMEDA report: WOO 19/05-012 R002 for additional information, including the assumptions used for the calculated FIT (Failure in Time) values in Table 5-1.

To claim diagnostic coverage for Partial Valve Stroke Testing (PVST), the PVST must be automatically performed at a rate at least ten times faster than the demand frequency with inclusions of position detection from the actuator's LVDT(s). Additionally, the PVST of the safety instrumented function must provide a full cycle test of the solenoid and/or hydraulic pilot valve depending on the device configuration. In cases where this is not true, another method must be used to perform a full solenoid/pilot valve cycle during automated diagnostics in order to use the PVST numbers.

Response Time Data

The Gas Stop/Ratio Valve full stroke trip time is as listed in this manual.

Limitations

When proper installation, maintenance, proof testing, and environmental limitations are observed, the design life of the Gas Stop/Ratio Valve is 250,000 hours of operation. Under "normal" operating conditions Gas Stop/Ratio Valves should be serviced with a factory or authorized service center overhaul every 50,000 hours not to exceed 6 years in service. Refer to service bulletin 01614 for additional service guidelines.

Management of Functional Safety

The Gas Stop/Ratio Valve is intended for use according to the requirements of a safety lifecycle management process such as IEC 61508 or IEC 61511. The safety performance numbers in this chapter can be used for the evaluation of the overall safety lifecycle.

[1] Static Application failure rates are applicable if the device is static for a period of more than 200 hours.

[2] It is important to realize that the No Effect failures are no longer included in the Safe Undetected failure category according to IEC 61508, ed2, 2010.

Restrictions

The user must complete a full functional check of the Gas Stop/Ratio Valve after initial installation, and after any modification of the overall safety system. No modification shall be made to the Gas Stop/Ratio Valve unless directed by Woodward. This functional check should include as much of the safety system as possible, such as sensors, transmitters, actuators, and trip blocks. The results of any functional check shall be recorded for future review.

Competence of Personnel

All personnel involved in the installation and maintenance of the Gas Stop/Ratio Valve must have appropriate training. Training and guidance materials are included in this manual.

These personnel shall report back to Woodward any failures detected during operation that may impact functional safety.

Operation and Maintenance Practice

A periodic proof (functional) test of the Gas Stop/Ratio Valve is required to verify that any dangerous faults not detected by safety controller internal run-time diagnostics are detected. More information is in the "Proof Test" section below. The frequency of the proof test is determined by the overall safety system design, of which the Gas Stop/Ratio Valve is part of the safety system. The safety numbers are given in the following sections to help the system integrator determine the appropriate test interval.

No special tools are required for operation or maintenance of the SonicFlo™ Gas Fuel Control Valve.

Installation and Site Acceptance Testing

Installation and use of the Gas Stop/Ratio Valve must conform to the guidelines and restrictions included in this manual.

Functional Testing after Initial Installation

A functional test of Gas Stop/Ratio Valve is required prior to use in a safety system. This should be done as part of the overall safety system installation check and should include all I/O interfaces to and from the Gas Stop/Ratio Valve. For guidance on the functional test, see the Proof Test procedure below.

Functional Testing after Changes

A functional test of the Gas Stop/Ratio Valve is required after making any changes that affect the safety system. Although there are functions in the Gas Stop/Ratio Valve that are not directly safety related, it is recommended that a functional test be performed after any change.

Proof Test (Functional Test)

The SonicFlo™ Gas Fuel Control Valve must be periodically proof tested to ensure there are no dangerous faults present that are not detected by on-line diagnostics. This proof test should be performed at least once per year.

Suggested Proof Test

The suggested proof test consists of a full stroke of the valve, shown in the table below.

Table 6-2. Suggested Proof Test

Step	Action
1	Bypass the safety function and take appropriate action to avoid a false trip.
2	Issue a trip command to the Gas Stop/Ratio Valve to force the actuator/valve assembly to the Fail-Safe state and confirm that the Safe State was achieved and within the correct time.
Note: This tests for all failures that could prevent the functioning of the control valve as well as the rest of the final control element.	
3	Inspect the actuator and valve for any leaks, visible damage or contamination.
4	Re-store the original supply/input to the actuator and confirm that the normal operating state was achieved.
5	Remove the bypass and otherwise restore normal operation.

For the test to be effective the movement of the valve must be confirmed. To confirm the effectiveness of the test both the travel of the valve and slew rate must be monitored and compared to expected results to validate the testing.

Proof Test Coverage

The Proof Test Coverage for the Gas Stop/Ratio Valve is given in the table below.

Table 6-3. Proof Test Coverage

Device	ADUPT5F (FIT)	Proof Test Coverage	
		No PVST	with PVST
Full Stroke, Clean Service, Hydraulic Trip	247	69%	34%
Full Stroke, Clean Service, Electric Trip	252	73%	37%

The suggested proof test and proof test coverage is referenced in exida FMEDA report; WOO 19/05-012 R002.

Terms and Definitions

Safety Freedom	Freedom from unacceptable risk of harm
Basic Safety	The equipment must be designed and manufactured such that it protects against risk of damage to persons by electrical shock and other hazards and against resulting fire and explosion. The protection must be effective under all conditions of the nominal operation and under single fault condition
Functional Safety	The ability of a system to carry out the actions necessary to achieve or to maintain a defined safe state for the equipment / machinery / plant / apparatus under control of the system
Safety Assessment	The investigation to arrive at a judgment - based on evidence - of the safety achieved by safety-related systems
Element	Part of a subsystem comprising a single component or any group of components that performs one or more element safety functions
Fail-Safe State	State of the process when safety is achieved; A loss or significant decrease of inlet supply pressure establish high volume reverse flow exhaust
Fail Safe	Failure that causes the hydraulic interface valve to go to the defined fail-safe state without a demand from the process
Fail Dangerous	Failure that does not permit the SIF to respond to a demand from the process (i.e. being unable to go to the defined fail-safe state)
Fail Dangerous Undetected	Failure that is dangerous and that is not being diagnosed by automatic testing
Fail Dangerous Detected	Failure that is dangerous but is detected by automatic testing
Fail Annunciation Undetected	Failure that does not cause a false trip or prevent the safety function but does cause loss of an automatic diagnostic and is not detected by another diagnostic
Fail Annunciation Detected	Failure that does not cause a false trip or prevent the safety function but does cause loss of an automatic diagnostic or false diagnostic indication
Fail No Effect	Failure of a component that is part of the safety function but that has no effect on the safety function
Low Demand Mode	Mode where the safety function is only performed on demand, to transfer the EUC into a specified safe state, and where the frequency of demands is no greater than one per year and no greater than twice the proof test frequency
High Demand Mode	Mode where the safety function is only performed on demand, to transfer the EUC into a specified safe state, and where the frequency of demands is greater than one per year or greater than twice the proof test frequency
Continuous Mode	Mode where the safety function maintains the EUC in a safe state as part of normal operation

Acronyms

EUC	Equipment Under Control
FMEDA	Failure Modes, Effects and Diagnostic Analysis
HFT	Hardware Fault Tolerance
MOC	Management of Change. These are specific procedures to follow for any work activities in compliance with government regulatory authorities or requirements of a standard
PFDavg	Average Probability of Failure on Demand
PFH	Probability of Failure per Hour
SFF	Safe Failure Fraction, the fraction of the overall failure rate of an element that results in either a safe fault or a diagnosed dangerous fault
SIF	Safety Instrumented Function, a set of equipment intended to reduce the risk due to a specific hazard (a safety loop)
SIL	Safety Integrity Level, discrete level (one out of a possible four) for specifying the safety integrity requirements of the safety functions to be allocated to the E/E/PE safety-related systems where Safety Integrity Level 4 is the highest level and Safety Integrity Level 1 is the lowest
SIS	Safety Instrumented System – Implementation of one or more Safety Instrumented Functions. A SIS is composed of any combination of sensor(s), logic solver(s), and final element(s)

Chapter 7.

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 www.woodward.com/directory.

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 (5-01-1205) that is in effect at the time the product is originally shipped from Woodward or a service is performed:

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

Replacement/Exchange: Replacement/Exchange is a premium program designed for the user who is in need of immediate service. It allows you to request and receive a like-new replacement unit in minimum time (usually within 24 hours of the request), providing a suitable unit is available at the time of the request, thereby minimizing costly downtime. This is a flat-rate program and includes the full standard Woodward product warranty (Woodward Product and Service Warranty 5-01-1205).

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 Product and Service Warranty 5-01-1205) 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 Product and Service Warranty 5-01-1205). This option is applicable to mechanical products only.

Returning Equipment for Repair

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

When shipping the item(s), attach a tag with the following information:

- Return authorization number
- Name and location where the control is installed
- Name and phone number of contact person
- Complete Woodward part number(s) and serial number(s)
- Description of the problem
- Instructions describing the desired type of repair

Packing a Control

Use the following materials when returning a complete control:

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

NOTICE

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

Replacement Parts

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

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

Engineering Services

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

- Technical Support
- Product Training
- Field Service

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

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

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

For information on these services, please contact us via telephone, email us, or use our website: www.woodward.com.

Contacting Woodward's Support Organization

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

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

Products Used in Electrical Power Systems	
Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany:	
Kempen	+49 (0) 21 52 14 51
Stuttgart	+49 (711) 78954-510
India	+91 (124) 4399500
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
Poland	+48 12 295 13 00
United States	+1 (970) 482-5811

Products Used in Engine Systems	
Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany	+49 (711) 78954-510
India	+91 (124) 4399500
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
The Netherlands	+31 (23) 5661111
United States	+1 (970) 482-5811

Products Used in Industrial Turbomachinery Systems	
Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
India	+91 (124) 4399500
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
The Netherlands	+31 (23) 5661111
Poland	+48 12 295 13 00
United States	+1 (970) 482-5811

Technical Assistance

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

General

Your Name _____

Site Location _____

Phone Number _____

Fax Number _____

Prime Mover Information

Manufacturer _____

Turbine Model Number _____

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

Power Output Rating _____

Application (power generation, marine,
etc.) _____

Control/Governor Information

Control/Governor #1

Woodward Part Number & Rev. Letter _____

Control Description or Governor Type _____

Serial Number _____

Control/Governor #2

Woodward Part Number & Rev. Letter _____

Control Description or Governor Type _____

Serial Number _____

Control/Governor #3

Woodward Part Number & Rev. Letter _____

Control Description or Governor Type _____

Serial Number _____

Symptoms

Description _____

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

Revision History

Changes in Revision D—

- Revised torque value in Servo Valve Section, line 12 on pg. 42.
- Added Chapter 6 Safety Management – Safe Position Fuel Shutoff Function

Changes in Revision C—

- Added SIL certification information to Regulatory Compliance section.
- Added Chapter 6 Safety Management – Safe Position Fuel Shutoff Function

Changes in Revision B—

- Updated IECEx Certifications in Regulatory Compliance Section
- Added Figures 1-9a and 1-9b
- Deleted IECEx Certifications

Changes in Revision A—

- Updated Regulatory Compliance information
- Added warning to Chapter 3 about proper grounding of junction box
- Added cleaning warning to Chapter 4

We appreciate your comments about the content of our publications.

Send comments to: icinfo@woodward.com

Please reference publication **26570**.



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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.