



**Product Manual 26384**  
**(Revision L, 11/2019)**  
Original Instructions



## **SonicFlo™ Syngas Gas Fuel Control Valves with Electric Trip**

**Installation and Operation Manual**





### General Precautions

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

Practice all plant and safety instructions and precautions.

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



### Revisions

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### Proper Use

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



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 Out-of-date translations are marked with .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

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

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## Warnings and Notices

### Important Definitions



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

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

#### **WARNING**

**Overspeed /  
Overtemperature /  
Overpressure**

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

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

#### **WARNING**

**Personal Protective  
Equipment**

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

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

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

#### **WARNING**

**Start-up**

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



## Electrostatic Discharge Awareness

### NOTICE

#### Electrostatic Precautions

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

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

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

Follow these precautions when working with or near the control.

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



## Regulatory Compliance

### European Compliance for CE Marking:

These listings are limited only to those units bearing the CE Marking.

**EMC Directive** Declared to Directive 2014/30/EU of the European Parliament and of the Council of 26 February 2014 on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC). 2014/30/EU is met by evaluation of the physical nature to the EMC protection requirement. Electromagnetically passive or “benign” devices are excluded from the scope of the Directive 2014/30/EU however, they also meet the protection requirement and intent of the directive.

**Pressure Equipment Directive:** Directive 2014/68/EU on the harmonisation of the laws of the Member States relating to the making available on the market of pressure equipment.  
PED Category III  
PED Module H - Full Quality Assurance,  
CE-0062-PED-H-WDI 001-19-USA, Bureau Veritas SA (0062)

**ATEX – Potentially Explosive Atmospheres Directive:** Directive 2014/34/EU on the harmonization of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres  
Zone 2, Category 3, Group II G, Ex nA IIC T3 X Gc IP 54  
See below for special conditions for safe use.

### Other European Compliance:

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

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

**ATEX** Exempt from the non-electrical portion of the ATEX Directive 2014/34/EU due to no potential ignition sources per EN 13463-1.

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

### North American Compliance:

Suitability for use in North American Hazardous Locations is the result of compliance of the individual components:

**LVDT:** ETL Certified for Class I, Division 2, Groups A, B, C, D, T3, per ETL J98036083-003 for use in the United States and Canada.



**Servo Valve:** FM Certified for use in United States Class I, Division 2, Groups A, B, C, D per 4B9A6.AX. CSA certified for use in Canadian Class I, Division 2, Groups A, B, C, D as a component for use in other equipment subject to acceptance by CSA or Inspection Authority having jurisdiction, per CSA 1072373.

**Junction Box:** UL Certified for Class I, Zone 1: AEx e II, Ex e II, T6 for use in the United States and Canada per UL E203312.

**Electric Trip Solenoid:** CSA certified for Class I, Division 2, Groups A, B, C, D per CSA 1260548.

**SIL Compliance:**

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



SonicFlo™ Gas Fuel Control 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 5 – Safety Management – Safe Position Fuel Shutoff Function.

SIL Certificate WOO 17-04-071 C001

[Link to exida SIL 3 Certification](#)

**Special Conditions for Safe Use**

Wiring must be in accordance with North American Class I, Division 2 or European or other international Zone 2, Category 3 wiring methods as applicable, and in accordance with the authority having jurisdiction.

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

The wiring junction box provides earth ground terminals if needed for a separate earth ground to meet wiring requirements.

T3 reflects conditions without process fluid. 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.

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

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 Class I, Division 2 or Zone 2 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 des applications de Classe I, applications Division 2 ou Zone 2.



# Chapter 1.

## General Information

### Introduction

The SonicFlo™ valve controls the flow of gas fuel to the combustion system of an industrial or utility gas turbine.

This unique high recovery design yields a flow characteristic unaffected by discharge pressure at very low-pressure ratios ( $P1/P2$ ) [contact Woodward for specific recovery information]. The high recovery design has an approximate equal percentage flow characteristic from 0% to 15% stroke and a linear flow characteristic from 15% to 100% stroke. The design integrates the valve and actuator into a compact assembly.

The integral actuator is a single-acting spring-loaded design for failsafe operation. The actuator includes an onboard hydraulic filter for last chance filtration of the fluid to ensure reliability of the servo valve and actuator. The servo valve is electrically redundant with triple coil design. A triple coil LVDT (linear variable differential transformer) directly coupled to the hydraulic piston provides feedback for the actuator.



Figure 1-1. Syngas SonicFlo Gas Fuel Control Valves



Table 1-1. Control Valve Functional Characteristics

Valve Type	Two Way–Right Angle
Type of Operation	Run—Valve Open Trip—Valve Closed
Stroke Length	3 in (76.2 mm)
Fluid Ports	ASME B16.5-1996 Class 300 and 600 Size 8 (200 mm)
Flowing Media	Syngas
Valve Proof Pressure Level	SA-216 Grade WCC: Class 300 and 600 flanges - 1125 psig/7757 kPa SA-351 Grade CF8M: Class 300 flanges – 1100 psig/7584 kPa Class 600 flanges – 1325 psig/9136 kPa
Minimum Valve Burst Pressure	SA-216 Grade WCC: 300 lb flange—3700 psig/25 511 kPa 600 lb flange—7400 psig/51 021 kPa SA-351 Grade CF8M: 300 lb flange—3600 psig/24 821 kPa 600 lb flange—7200 psig/49 645 kPa
Gas Filtration	25 $\mu$ m absolute at 75 beta requirement
Ambient Temperature	–20 to +180 °F (–29 to +82 °C)
Shut-off Classification	Class IV per ASME B16.104/FCI 70-2 (0.01% of rated valve capacity at full travel measured with air at 50 psid/345 kPa)
External Leakage	T2
Inter-seal Vent Leakage	Max 10 cc/min
Position Accuracy	$\pm 1\%$ of full scale (Over $\pm 25$ °F/ $\pm 14$ °C deviation from calibration)
Position Repeatability	$\pm 0.5\%$ of point over range of 10% to 100%
Hydraulic Fluid Type	Petroleum based hydraulic fluids
Hydraulic Supply Pressure	1500 - 1800 psig (10342 - 12411 kPa) – Consult Woodward for use of pressures down to 1300 psig (8963 kPa). Design based on 1600 psig (11032 kPa).
Hydraulic Proof Test Fluid Pressure Level	Per SAE J214
Minimum Hydraulic Burst Fluid Pressure	Per SAE J214
Fluid Filtration Required	10–15 $\mu$ m absolute
Trip Time	Less than 0.300 s
Slew Time	1 $\pm$ 0.150 seconds (opening & closing)
Design Availability Objective	Better than 99.5% over an 8760 hour period
Hydraulic Fluid Connections	Supply pressure—0.750-14 UNF straight thread port (–8) Drain pressure—1.312-20 UNF straight thread port (–16)
Sound Level	<110 dB at max flow conditions for 6 inch valves <120 dB at max flow conditions for 8 inch valves
Vibration Test Level	0.5 gp 5–100 Hz sine wave Random 0.01500 gr <sup>2</sup> /Hz from 10 to 40 Hz ramping down to 0.00015 gr <sup>2</sup> /Hz at 500 Hz
Shock	Limited to 30 g by servo valve
Servo Input Current Rating	–7.2 to +8.8 mA (null bias 0.8 $\pm$ 0.32 mA)
Trip Solenoid Voltage	90-140 Vdc (125 Vdc nominal)
Hydraulic Fluid Contamination Level	Per ISO 4406 code 18/16/13 max Code 16/14/11 preferred
Trim Configuration	Exponential 0% to 15% Linear 15% to 100%



Materials	Valve Body: NACE MR0103 compatible A216 Grade WCB steel or A351 Grade CF8M stainless steel Trim Materials: ASTM A479 Type 316 or 304 stainless steel sleeve, ASTM A564 Type 630 (17-4) stainless steel plug and ASTM A479 Type 316 or Type 304 stainless steel bonnet.
Allowable Operating Gas Pressure & Temperature	SA216 Grade WCC Steel: 300 lb Flange—3.45 MPa (500 psig) at -29 to +260 °C (-20 to +500 °F) 600 lb Flange—4.00 MPa (580 psig) at -29 to +260 °C (-20 to +500 °F) SA351 Grade CF8M SST: 300 lb Flange—3.45 MPa (500 psig) at -29 to +228 °C (-20 to +443 °F) AND 3.31 MPa (480 psig) at 260 °C (500 °F) per ASME B16.34 600 lb Flange—4.00 MPa (580 psig) at -29 to +260 °C (-20 to +500 °F)
Max Valve Discharge Flange Temperature	530 °F (277 °C)
Valve Port Sizes	8" (200 mm)—Cg=9000, 13000, 15000, or 17000
Flow Characteristics	±3.0% Cg deviation of point from 15% to 100% stroke
Hydraulic Fluid Temperature	10 to 66 °C (50 to 150 °F)



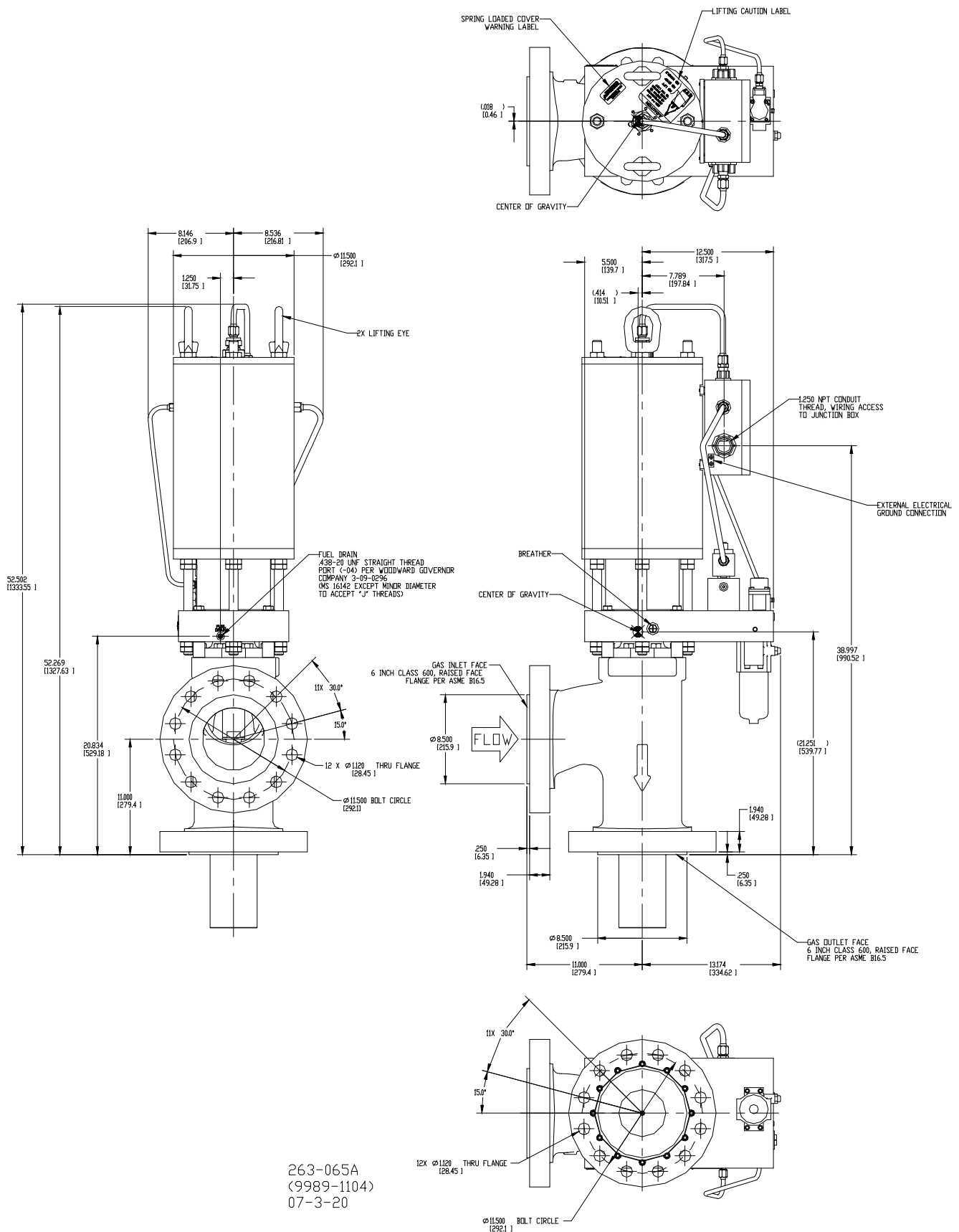


Figure 1-2a. SonicFlo Outline Drawing (6-inch, Class 600)



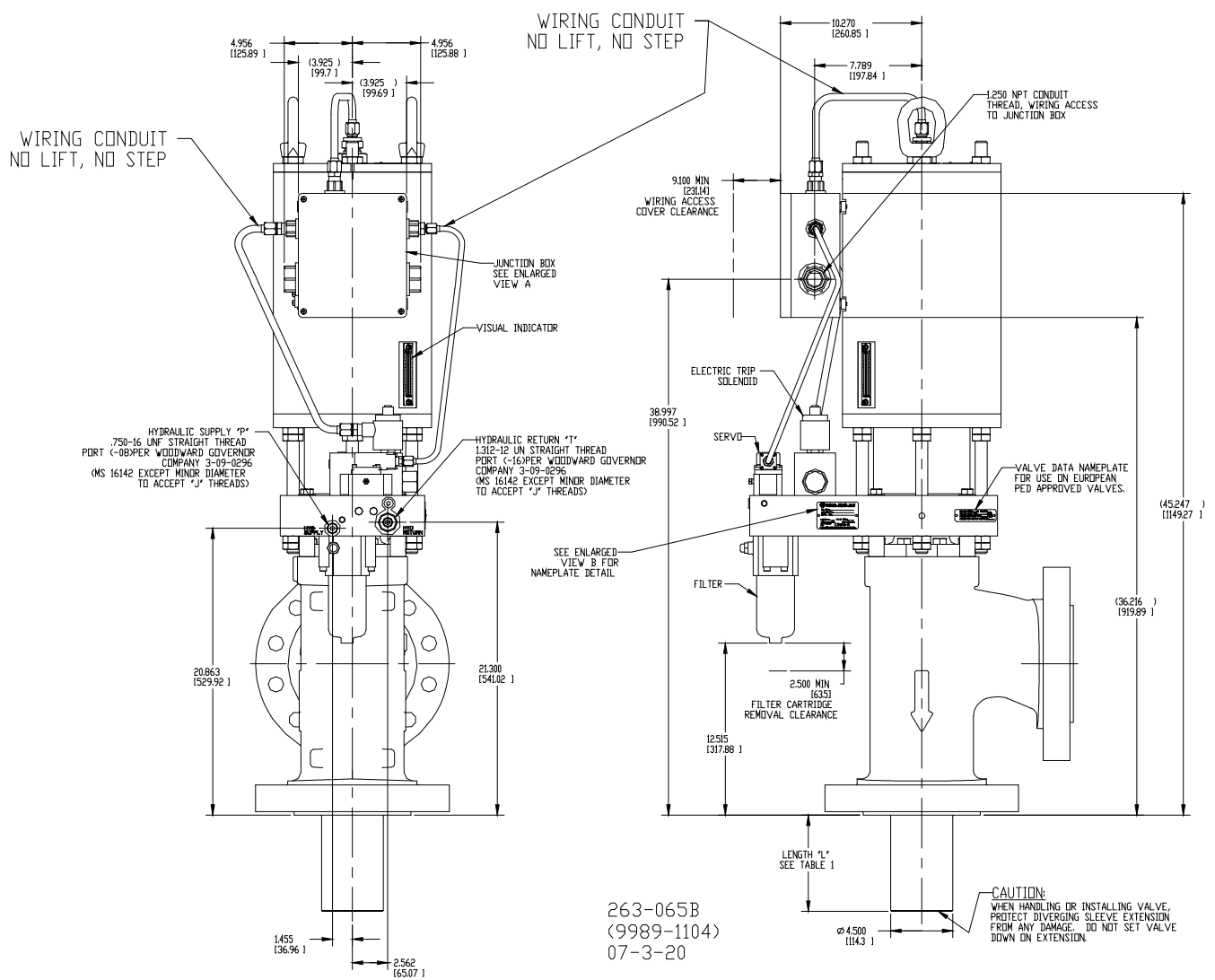


Figure 1-2b. SonicFlo Outline Drawing (6-inch, Class 600)



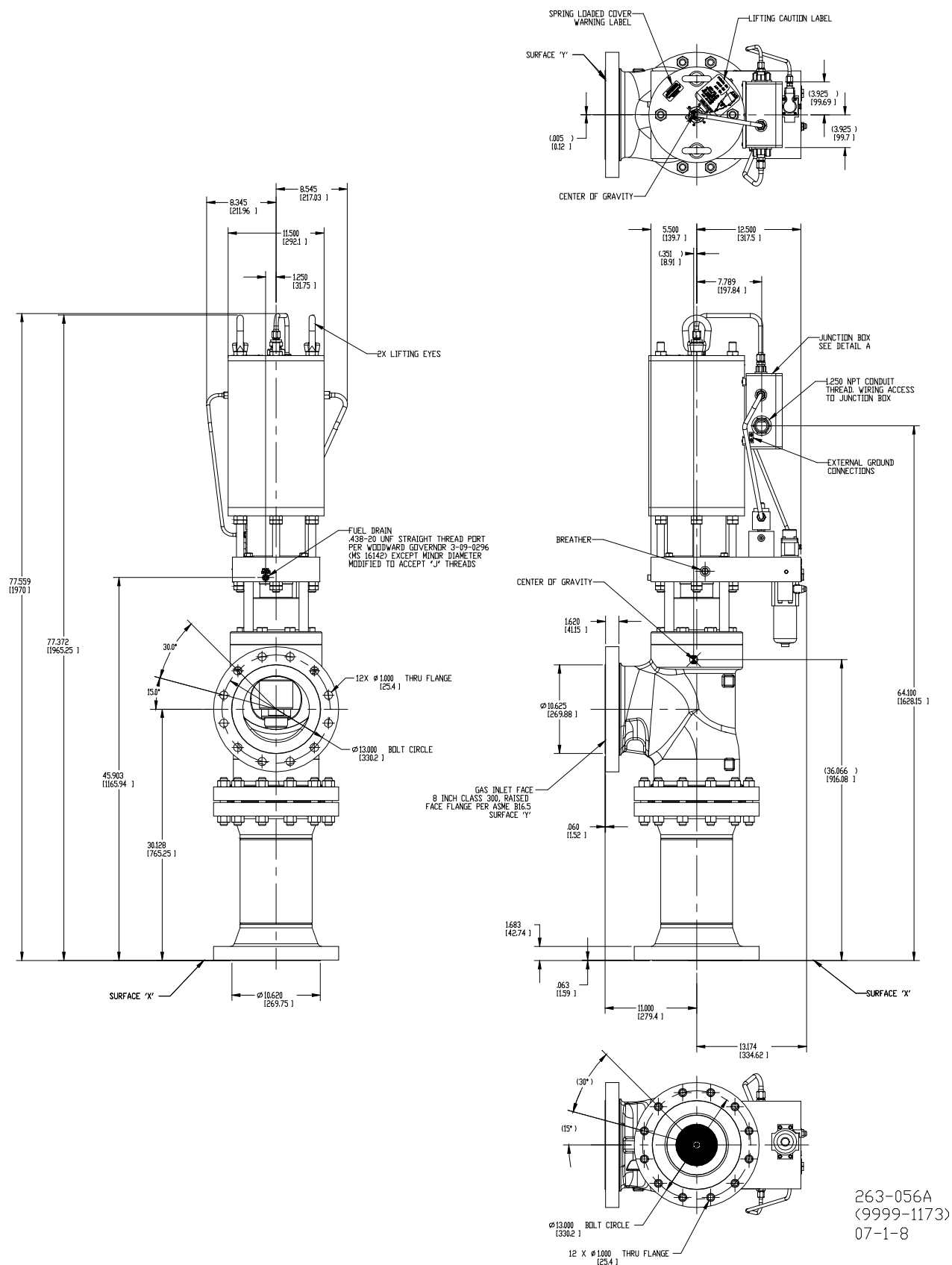


Figure 1-3a. SonicFlo Outline Drawing (8-inch, Class 300)



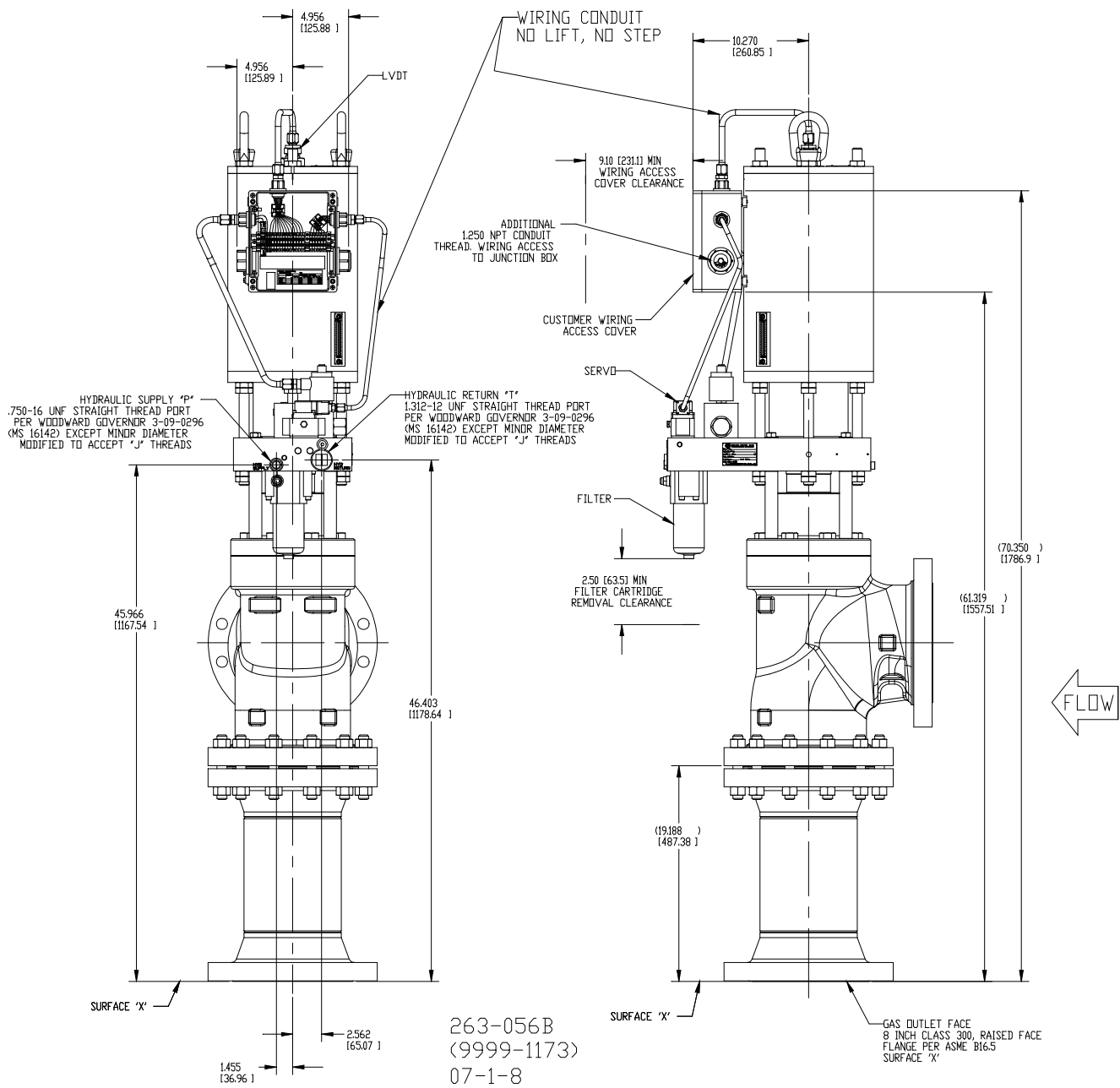


Figure 1-3b. SonicFlo Outline Drawing (8-inch, Class 300)



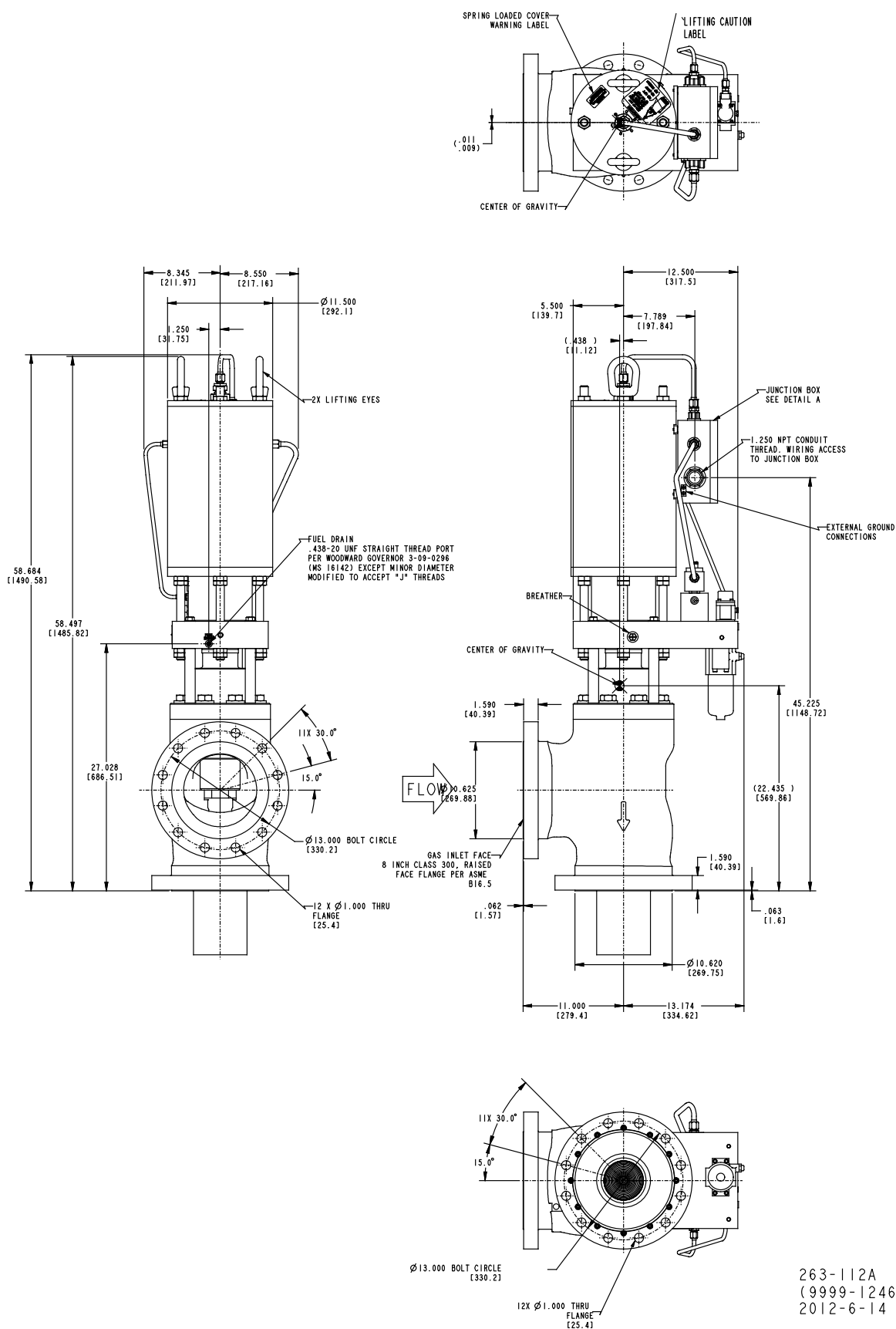


Figure 1-4a. SonicFlo Outline Drawing (8-inch, Class 300, No Spool)



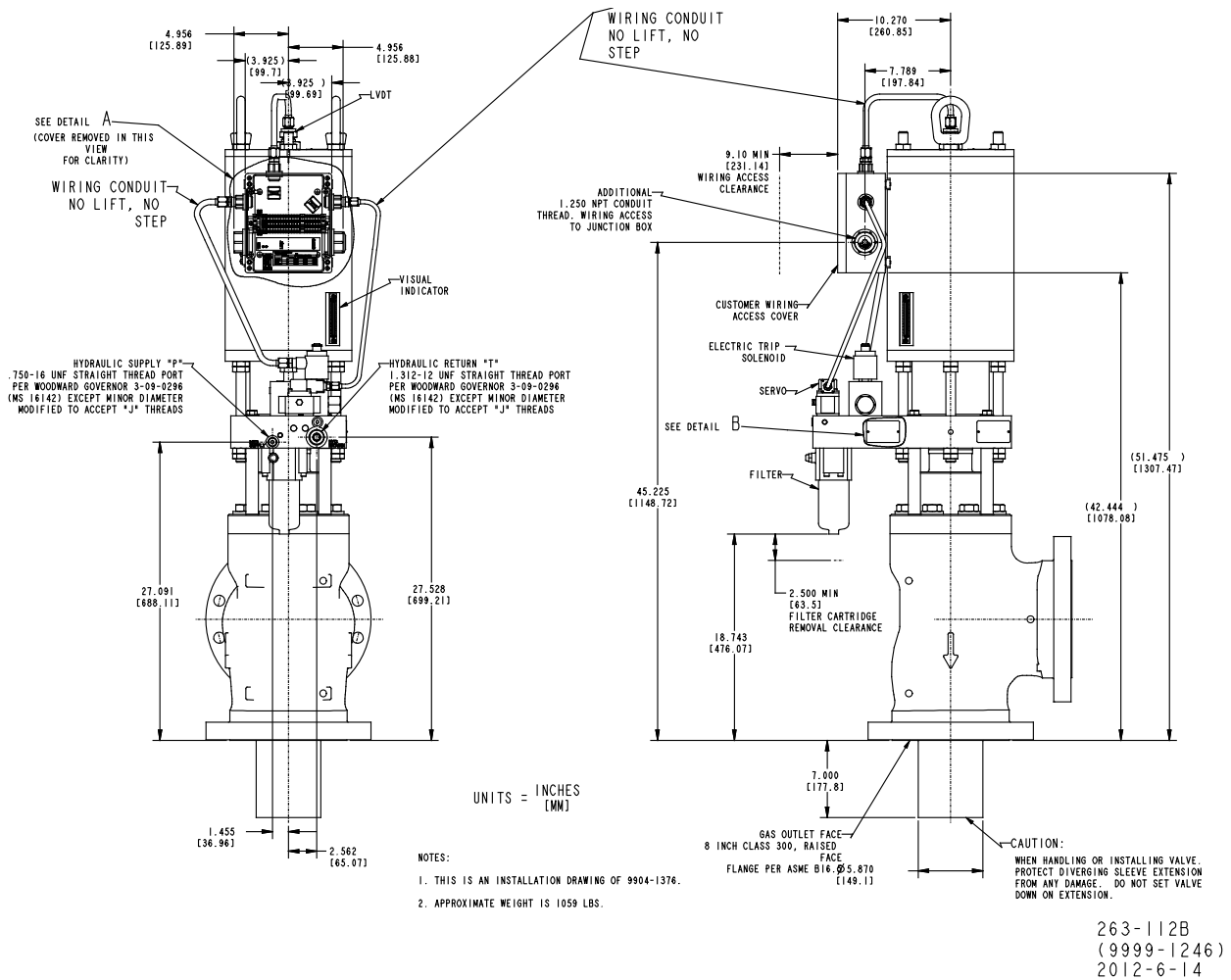
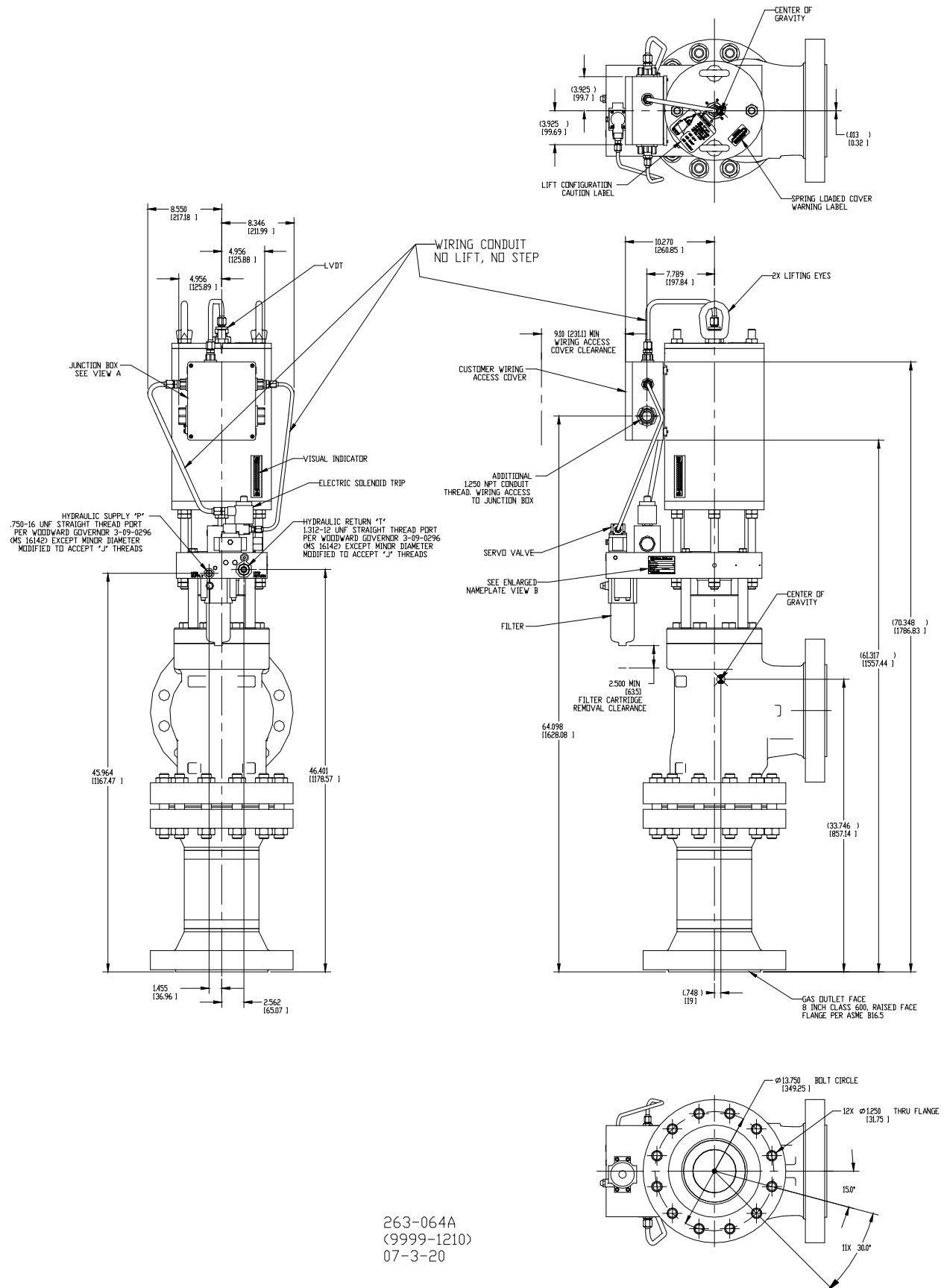


Figure 1-4b. SonicFlo Outline Drawing (8-inch, Class 300, No Spool)







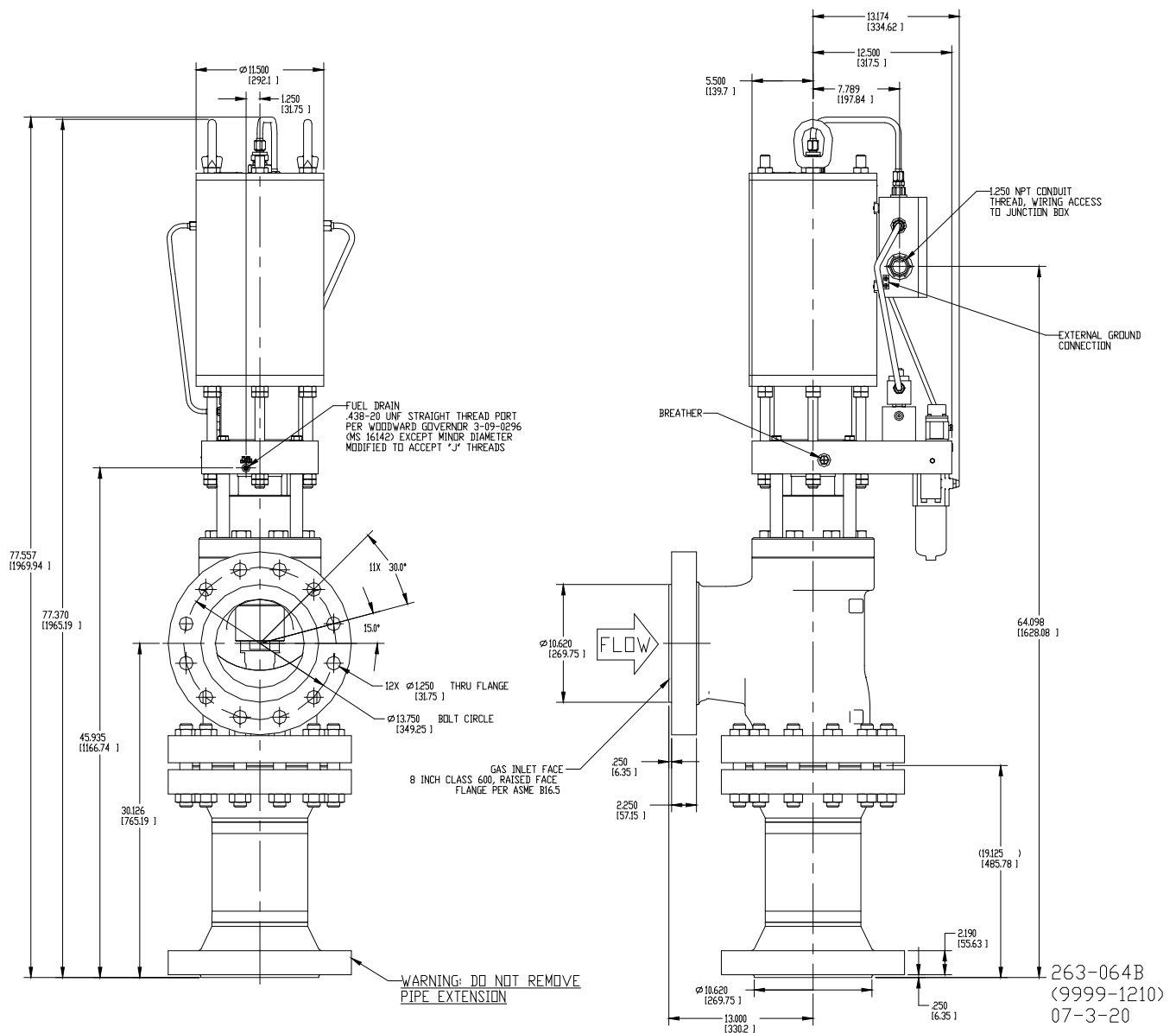


Figure 1-5b. SonicFlo Outline Drawing (8-inch, Class 600)



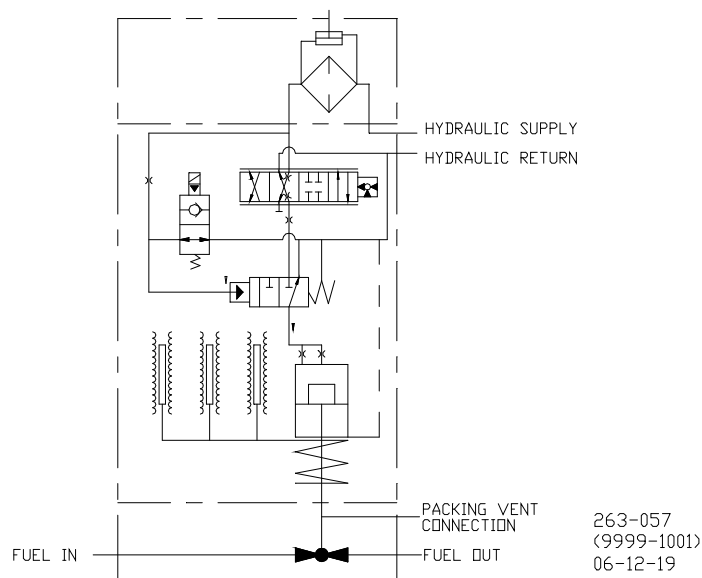


Figure 1-6. Hydraulic Schematic Circuit

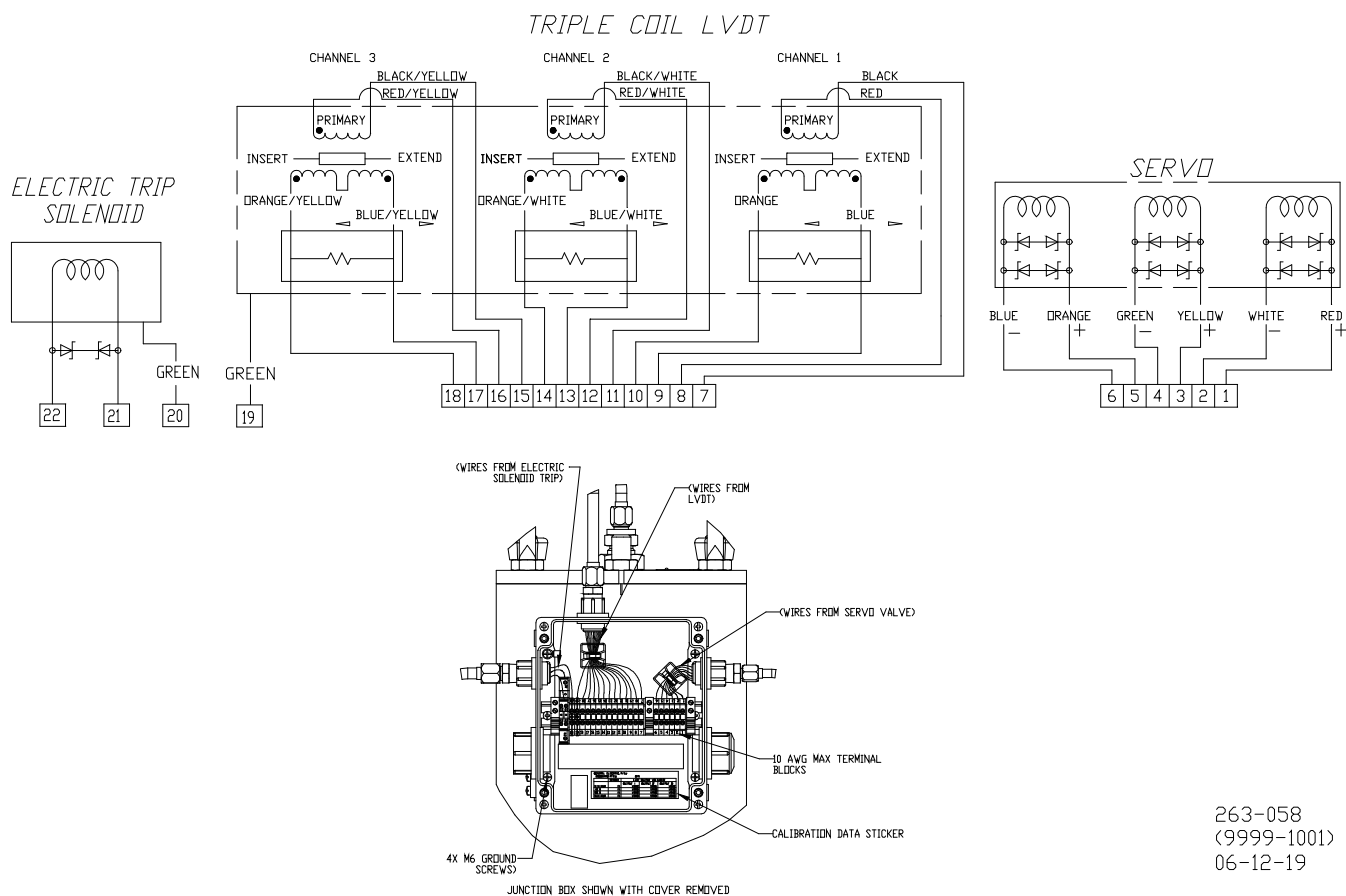


Figure 1-7. Wiring Diagram



## Chapter 2. Description

### Triple Coil Electrohydraulic Servo Valve Assembly

The hydraulic actuator assembly uses a two-stage hydraulic servo valve to modulate the position of the actuator output shaft and thereby control the gas fuel valves. 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 electric current applied to the three coils.

If the control system requires a rapid movement of the valve to send more fuel to the turbine, total current is increased well above the null current. In such a condition, control port PC1 is connected to supply pressure. The flow rate delivered to the piston cavity of the actuator is proportional to the total current applied to the three coils. Thus, the opening velocity is also proportional to the current (above null) supplied to the torque motor.

If the control system requires a rapid movement to close the gas fuel valve, the total current is reduced well below the null current. In such a condition, port PC1 is connected to the hydraulic drain circuit. The flow rate from the piston cavity to drain is proportional to the magnitude of the total current below the null value. Thus, the closing velocity is also proportional to the current (below null) supplied to the torque motor.

Near the null current, the four-landed valve isolates the control port from the hydraulic supply and drain, balancing the piston pressure against the spring 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 position of the valve.

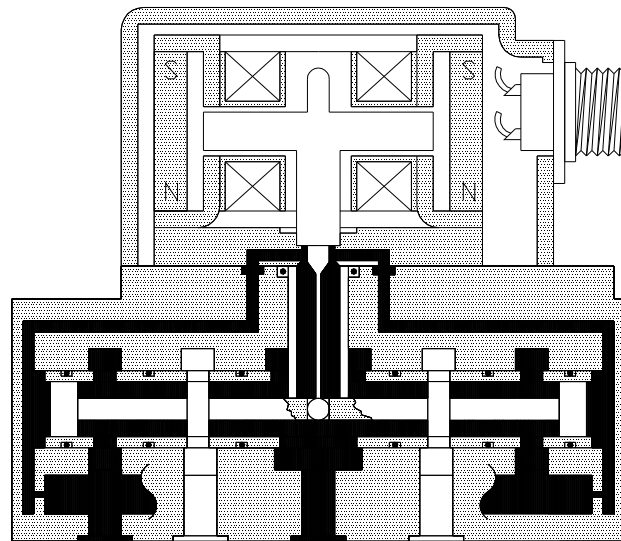


Figure 2-1. Servo Valve Cutaway



## Trip Relay Valve Assembly

The SonicFlo™ valve uses a solenoid-operated trip relay circuit to operate a high capacity, three-way, two-position, hydraulically operated valve. This trip relay circuit consists of four functional elements: the trip relay solenoid valve, the trip relay supply orifice, the hydraulically operated trip valve, and the trip relay volume.

In the normal run mode, the trip relay solenoid valve is closed, which prevents the trip relay volume from bleeding to the hydraulic return. As a result, high-pressure oil is fed into the trip relay circuit through the supply orifice, which quickly pressurizes the trip circuit to supply pressure. When the trip circuit pressure increases above 1100 kPa (160 psig), the three-way relay valve shifts position so that the common port connects the control port of the servo-valve to the lower piston cavity of the actuator, allowing the servo-valve to position the throttle valve.

The solenoid valve opens when it is de-energized. Opening the solenoid valve causes the trip circuit to be connected to drain. This in turn causes the three-way relay valve to shift position so that the common port is connected to the hydraulic drain circuit, and isolated from the hydraulic supply. As the pressure falls within the lower piston cavity, the return spring rapidly returns the valve plug to the downward position, closing the control valve and shutting off fuel to the engine.

## Hydraulic Filter Assembly

The valve is supplied with an integrated, high-capacity filter. The 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 shows when the recommended pressure differential has been exceeded and thus replacement of the element is necessary.

## LVDT Position Feedback Sensors

The SonicFlo high recovery control valves use a triple-coil LVDT for position feedback. The LVDT is factory set to give 0.7 Vrms feedback at minimum position and 3.5 Vrms feedback at maximum position, when supplied with 7 Vrms excitation at 3000 Hz.



## Chapter 3. Installation

### General

See the outline drawings (Figures 1-2 through 1-5) for:

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

Installation attitude does not affect actuator or fuel valve performance, but a vertical 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 gas fuel control valve is designed for support by the piping flanges alone; additional supports are neither needed nor recommended. Do not use this valve to provide support to any component other than the piping to which it is directly connected.

The orientation of the visual position indicator may be changed to accommodate surrounding obstructions, if any. See Chapter 4 for instructions to change the orientation.

#### **WARNING**

**EXPLOSION HAZARD**—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.

#### **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 operate the valve without proper support for the diverging sleeve. IF BENCH TESTING THE VALVE, ENSURE THAT ASME/ANSI RATED FLANGES ARE GASKETED AND INSTALLED OVER THE INLET AND DISCHARGE FLANGES WITH THE BOLTS PROPERLY TORQUED. The diverging sleeve screws by themselves are not designed to hold pressure loads. Failure to comply with this warning may result in personal injury. Do not place hands inside valve body during inspection, cleaning, or operation.





Figure 3-1. Illustration of Diverging Sleeve Screws

Diverging Sleeve assembly screws are not designed to hold pressure loads. If bench testing, do not apply pressure to the valve without ANSI flanges (see below figures).

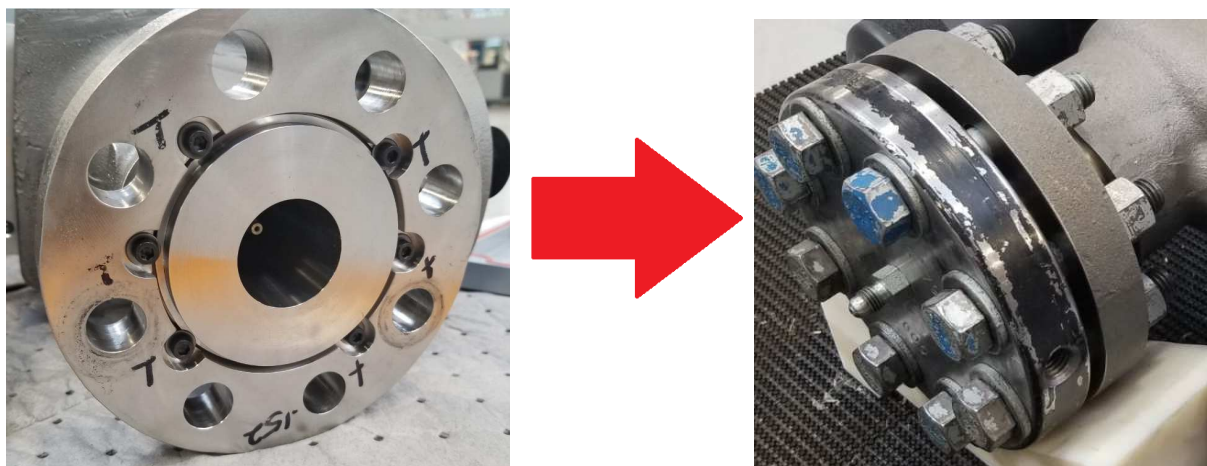


Figure 3-2. Illustration of Raised Face Style Diverging Sleeve

Raised Face style diverging sleeves should be secured with a blind flange when bench testing



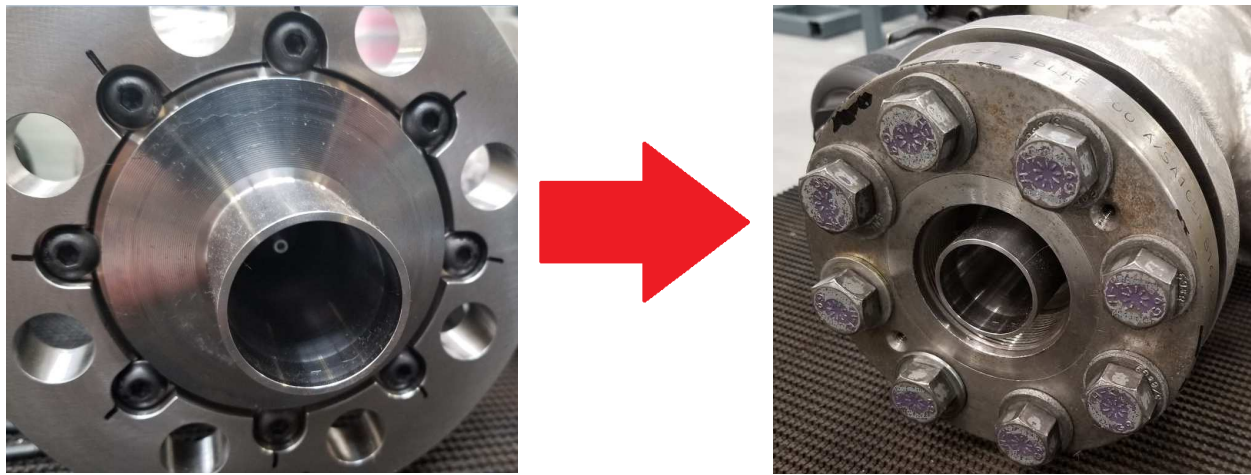


Figure 3-3. Illustration of Extension Style Diverging Sleeve

Extension style diverging sleeves should be secured with a threaded or weld neck style flange when bench testing



### **WARNING**

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



### **WARNING**

Do not lift or handle the valve by any conduit. Lift or handle the valve only by using the eyebolts. Use a “Y” type lifting configuration to prevent damage to the LVDT conduit.



### **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.



## 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 ASME B16.5 for details of flange, gasket, and bolt types and dimensions.

The gas fuel control valve is designed for support by the piping flanges alone; additional supports are neither needed nor recommended.

This is a 90° angle valve. Verify that the process piping centerline-to-flange-face dimensions meet the requirements of the outline drawings (Figures 1-2 through 1-5) 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.

ASTM/ASME grade bolts or studs should be used to install the valve into the process piping. The length and diameter for Class 300 flanges must conform to the following table according to the valve flange size.

Table 3-1. Class 300 Flange Specifications

Nominal Pipe Size	Number of Bolts	Diameter of Bolts	Stud Length
8 inch/ 203 mm	12	7/8 inch/ 22 mm	5.50 inch/ 139.7 mm

The length and diameter for Class 600 flanges must conform to the following table according to the valve flange size.

Table 3-2. Bolt Size and Torque Specifications

Nominal Pipe Size	Number of Bolts	Diameter of Bolts	Stud Length
6 inch/ 152 mm	12	1 inch/ 25 mm	6.75 inch/ 171.4 mm
8 inch/ 203 mm	12	1-1/8 inch/ 29 mm	7.75 inch/ 196.8 mm

Flange gasket materials should conform to ASME 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. Recommend a two-step torque method. Once the studs/bolts are hand tightened, torque the studs/bolts in a crossing pattern to half the required torque. Once all studs/bolts have been torqued to half the appropriate value, repeat the pattern until the rated torque value is obtained.

Do not insulate the valve or actuator. Insulation may be used on the inlet horizontal leg of the pipe. There should be no insulation around the outlet flange of the valve or the outlet riser pipe. If the outlet riser pipe is longer than 6 diameters, insulation may be used below the 6-diameter mark. The reason for this being the purge temperature is extremely hot and may damage the valve seals.



The valve discharge flange must not exceed 530 °F (277 °C) when the valve is closed and the downstream circuit is being purged.

## Hydraulic Connections

Two hydraulic connections must be made to each valve: supply and return. 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.

## Electrical Connections



### **WARNING**

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



### **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.**

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 68 dB.

### **Servo Valve Electrical Connection**

Servo valve cable should consist of three individually shielded twisted pairs. Each pair should be connected to one coil of the servo valve as indicated in Figure 1-7 (Wiring Diagram).

### **Electric Trip Solenoid Connection**

The electric trip solenoid valve must use wire suitable for at least 300 V.



### **WARNING**

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

### **NOTICE**

**Do not connect any cable grounds to “instrument ground”, “control ground”, or any non-earth ground system.**



## LVDT Electrical Connection

The LVDT cable must consist of six individually shielded twisted pairs. Three separate pairs should be used for each of the excitation voltages to the LVDT, and three separate pairs used for each of the feedback voltages from the LVDT.

## Fuel Vent Port

There is a fuel vent port that 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.

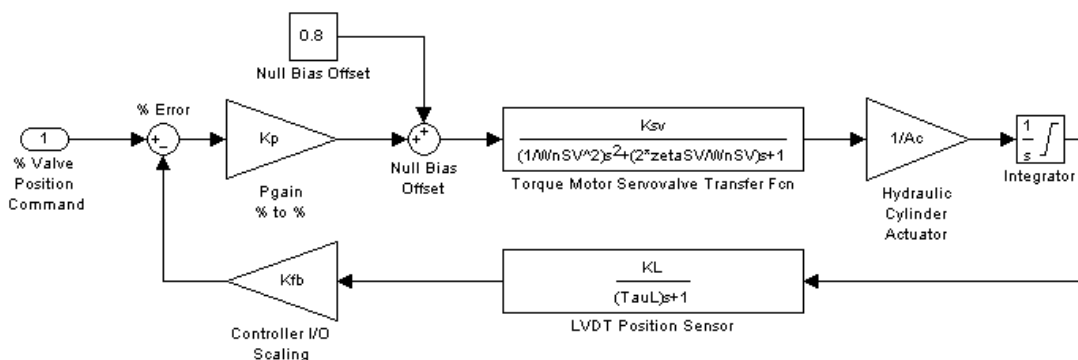


Figure 3-4. Gas Fuel Control Valve Block Diagram

### Syngas Valves

Ksv nominal =	6.1 in <sup>3</sup> /sec/mA at 1600 psi supply; Ksv is proportional to square root of supply, and constant with position.
Ksv =	8.1 in <sup>3</sup> /sec/mA in the opening direction
Ksv =	2.8 in <sup>3</sup> /sec/mA in the closing direction
ZetaSV =	0.7
WnSV =	502 rad/s (80 Hz); WnSV is proportional to square root of supply
Ac =	7.69 in <sup>2</sup>
KL =	0.93 Vrms/inch
Servo Travel =	3.0 inches
TauL =	0.005 seconds (depends on excitation/demodulation)

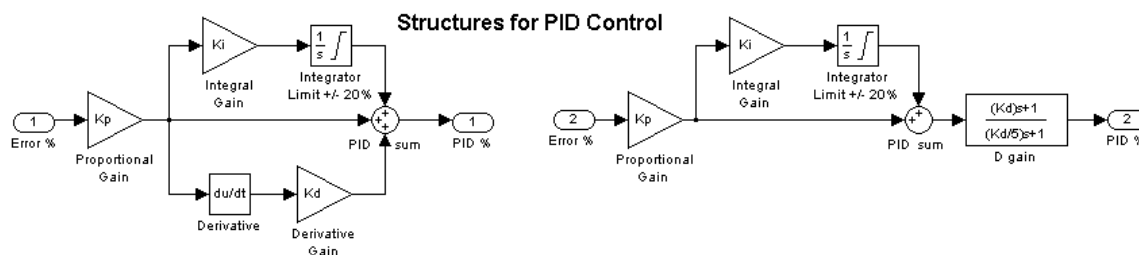


Figure 3-5. Structures for PID Control



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

Control Gain Settings	Proportional Control	Proportional Integral	Proportional Integral Derivative
	Kp=5;	Kp=3; Ki=5;	Kp=3; Ki=5; Kd=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

There are generally two possible rigging procedures for the high recovery gas fuel control valves.

#### Level 1 Calibration 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 10% 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 90% 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  $0.7 \pm 0.1$  Vrms. This process may have to be repeated to ensure the feedback voltages at both the 10% and 90% command positions match the documented values.

#### Level 2 Calibration Rigging Procedure

Once the control system is connected to the valve, drive the valve to the fully closed position and set this point as 0% stroke. Next, drive the valve to the fully open position and set this point as 100% stroke. Stroke versus Cg data will be provided with the valve for input into the control system. The control system will use this data to determine the valve position needed for a given Cg value.



## Chapter 4

# Maintenance and Hardware Replacement

### Maintenance



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 SonicFlo™ valve requires no maintenance or adjustment for 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 is possible. Contact a Woodward representative for assistance.

### Hardware Replacement



**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 applications.



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.



Do not lift or handle the valve by any conduit. Lift or handle the valve only by using the eyebolts. Use a “Y” type lifting configuration to prevent damage to the LVDT conduit.



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



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.

To facilitate field replacement of items, spare parts should be kept on-site. See the outline drawings (Figures 1-2 through 1-5) for the locations of items. Contact Woodward for a complete list of field-replaceable parts and additional instructions for their replacement.



## Hydraulic Filter Assembly/Cartridge

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

### Replacement of Filter Assembly:

1. Remove the four 0.312-18 socket head cap screws.
2. Remove the filter assembly from the manifold block. The filter will contain a large amount of hydraulic fluid. **Be cautious when handling.**
3. Verify that two O-rings are present in the interface between the filter and the manifold.
4. Obtain a new filter assembly from Woodward.
5. Verify that two new O-rings are present in the new filter assembly.
6. Install the filter assembly onto the manifold assembly. Be sure to place the filter in the correct orientation. See the outline drawings (Figures 1-2 through 1-5).
7. Install the four 0.312-18 cap screws through the filter and torque to 244–256 lb-in (27.6–28.9 N·m).
8. Check for external leakage upon pressurizing the hydraulic system.

### Replacement of Filter Cartridge:

1. Using a 1-5/16 wrench, loosen the bowl from the filter assembly.
2. The filter bowl will contain a large amount of hydraulic fluid. **Be cautious when handling.**
3. Remove the filter element by pulling straight down from the rest of the assembly.
4. Obtain a new filter element from Woodward.
5. Lubricate the O-ring on the inside diameter of the cartridge with hydraulic fluid.
6. Install the cartridge into the assembly by sliding the open end of the cartridge onto the nipple.
7. Install the filter bowl onto the assembly. Tighten only by hand. Do not torque the bowl.
8. Check for external leakage upon pressurizing the hydraulic system.

## Trip Relay Valve Cartridge

The trip relay valve cartridge is located in the trip relay block on top of the hydraulic manifold block, next to the servo valve. See the outline drawings (Figures 1-2 through 1-5).

1. Using a 1-1/2 inch wrench (~38+ mm), loosen the trip relay valve from the trip relay block.
2. Slowly remove the cartridge from the trip relay block. There could be a substantial amount of hydraulic fluid upon removal. **Be cautious when handling.**
3. Obtain a new trip relay valve cartridge from Woodward.
4. Verify that all O-rings are present on the new cartridge.
5. Lubricate the O-rings with hydraulic fluid or petroleum jelly.
6. Install the cartridge into the trip relay block.
7. Torque to 40–58 lb-ft (54–79 N·m).
8. Check for external leakage upon pressurizing the hydraulic system.

## Trip Relay Solenoid Valve

The trip relay solenoid valve is located on the side of the hydraulic manifold opposite the trip relay cartridge valve. See the outline drawings (Figures 1-2 through 1-5).

1. Remove the cover to the electrical junction box.
2. Disconnect the solenoid valve wires from the connector block labeled 11 and 12.
3. Loosen the conduit fittings from the electrical box, the solenoid valve, and the tee fitting in between.
4. Carefully remove the conduit from the solenoid valve and pull the wiring out of the conduit.
5. Using a 1-1/4 inch wrench (~32– mm), loosen the solenoid valve from the hydraulic manifold.
6. Slowly remove the solenoid valve from the manifold. **There could be some hydraulic fluid upon removal. Be cautious when handling.**
7. Obtain a new solenoid valve from Woodward.
8. Verify that both O-rings and back-up ring are present on the new valve.
9. Lubricate the O-rings with hydraulic fluid or petroleum jelly.
10. Install the new solenoid valve into the hydraulic manifold.
11. Torque the solenoid valve to 40–58 lb-ft (54–79 N·m).
12. Install wiring through the conduit and into the electrical box.
13. Connect the conduit to the solenoid valve and torque to 450–550 lb-in (51–62 N·m).
14. Torque the conduit to the electrical box and to the tee fitting to 450–550 lb-in (51–62 N·m).
15. Install wires into the solenoid valve connector blocks labeled 11 and 12. If it is necessary to cut the wires for installation, be sure to retain at least one service loop of wiring.



16. Replace the cover onto the junction box and tighten the screws.
17. Check for external leakage upon pressurizing the hydraulic system.

## Servo Valve

The servo valve is located on the hydraulic manifold directly above the filter assembly. See the outline drawings (Figures 1-2 through 1-5).

1. Remove the cover to the electrical junction box.
2. Disconnect the servo valve wires from the connector blocks labeled 1-6.
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 0.312-18 UNF socket head cap screws holding the servo valve to the manifold.
6. Verify that all four O-rings are removed from the interface between the manifold and the servo valve.  
On units with an intermediate orifice plate, verify that the four O-rings between the servo valve and plate are removed.
7. Obtain a replacement servo valve from Woodward and verify part number and revision with the existing unit.
8. Remove the protective plate from the replacement servo valve and verify that O-rings are on all four counter bores of the servo valve.
9. Place the replacement servo valve onto 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. On units with an intermediate orifice plate, verify that the three O-rings on the underside of the orifice plate are in their grooves. Verify that the plate is in the proper location by aligning the "P" and "T" on the side of the servo valve with the "P" and "T" etched into the plate. Be sure to orient the servo valve/orifice plate to match the original orientation. Be sure that all seven O-rings remain in their proper location during assembly.
10. Install four 0.312-18 UNF socket head cap screws and torque to 55–57 lb-in (6.2–6.4 N·m).
11. Install wiring through the conduit and into the electrical box.
12. Connect the conduit to the servo valve and torque to 270–300 lb-in (31–34 N·m).
13. Torque the conduit to the electrical box to 270–300 lb-in (31–34 N·m).
14. Install wires into the servo valve connector blocks labeled 1-6 as shown in the wiring diagram (Figure 1-7). If it is necessary to cut wires for installation, be sure to retain at least one service loop of wiring.
15. Replace the cover onto the junction box and tighten the screws.
16. Check for external leakage upon pressurizing the hydraulic system.

## LVDT

### **IMPORTANT**

**If the valve is characterized, the LVDT cannot be replaced in the field. The valve must be returned for factory calibration and testing.**

The LVDT is located on the top of the actuator. See the outline drawings (Figures 1-2 through 1-5).

1. Remove the cover to the electrical junction box.
2. Disconnect the servo valve wires from the connector blocks labeled 1-6, the LVDT wires from the connector block labeled 7-18, and the grounding wire.
3. Loosen the conduit fittings from the LVDT, the servo valve, and the electrical box.
4. Carefully remove the conduit from the LVDT and servo valve, and pull the wiring out of the conduit.
5. Remove the conduit from the electrical box.
6. Remove the four 0.625-11 jam nuts from the bottom end of the tie rods (on the underside of the hydraulic manifold). Next, remove the four remaining 0.625-11 nuts.
7. Carefully remove the entire actuator sub-assembly from the valve.
8. Remove the four 0.625-11 jam nuts from the tie rods just below the bottom cylinder plate.

### **WARNING**

**To prevent possible personal injury, do NOT completely remove the nuts in step 9 from the tie rods until you have verified that the preload has been removed from the springs.**



9. Slowly remove the four remaining 0.625-11 nuts from the bottom end of the tie rods, rotating each nut one turn at a time. This will keep the cover and LVDT square with the housing. Failure to remove the nuts in this manner can cause the cover and LVDT body to become misaligned with the LVDT core rods, potentially damaging them. This action will release the preload on the integral springs of the actuator. The tie rod studs are long enough to completely release the preload prior to coming off of the tie rods. Do NOT completely remove the nuts from the tie rods until you have verified that the preload has been removed from the springs; failure to comply could result in bodily injury.
10. The bottom plate and the spring seat should be free to be removed from the assembly. The LVDT core rods will be removed with the spring seat.
11. Using a 0.750 wrench, remove the core rod of the LVDT from the spring seat. Be sure not to mix the old LVDT core rod and body with the replacement parts.
12. Bend the tab down on the locking washer and loosen the 1.25-12 jam nut on the LVDT housing.
13. Remove the LVDT from the top plate.
14. Install the new core rod into the spring seat using the 0.750 wrench. Torque to 70–73 lb-in (7.9–8.2 N·m).
15. Notice on the base of the core rods that one of them is labeled with a “1”. Note its orientation for future reference.
16. Make sure that the springs are seated in the proper location.
17. Carefully install the spring seat and core rod sub-assembly onto the springs, with the core rods inserted into the center of the springs. Next, install the bottom cylinder plate and guide pin sub-assembly onto the tie rods with the guide pin towards the spring seat. Align the spring seat such that the guide pin is inserted into the corresponding spring seat hole.
18. Install four 0.625-11 nuts, one onto each stud. Slowly compress the springs into their cavity by rotating each nut one turn at a time. This will keep the cover and core rods square with the housing. Failure to install the nuts in this manner can possibly cause damage to the LVDT core rods.
19. Torque the 0.625 nuts to 150–188 lb-ft (203–255 N·m).
20. Install four additional 0.625 nuts onto the studs, and torque to 75–94 lb-ft (102–127 N·m).
21. Using a flashlight, confirm the location/orientation of the core rod labeled with a “1”. Making sure that the locking tab washer is in place, carefully install the new LVDT housing through the washer and into the top plate, oriented such that the core rod opening labeled with a “1” is aligned with the corresponding core rod. Once the LVDT housing is assembled onto the core rods, partially thread the LVDT housing into the top plate. Do not tighten the jam nut yet, as the LVDT will need to be adjusted prior to use.
22. Replace the conduit onto the electrical box.
23. Carefully replace the LVDT wires and servo valve wires through the conduits and into the electrical box.
24. Connect the conduit to the LVDT and servo valve. Do not tighten.
25. Connect the servo valve wires to the connector blocks labeled 1-6, the LVDT wires to the connector blocks labeled 7-18, and the ground wire to the ground screw as shown in the wiring diagram (Figure 1-7).
26. Replace the cover to the electrical box.
27. Verify that all hardware has been replaced onto the actuator and that all external fittings are torqued except for the lock nuts on the LVDT and the conduit on the LVDT.
28. Replace the actuator onto the valve, guiding the 4 tie rods through the mounting holes in the manifold. Make sure the electrical junction box is oriented on the same side as the servo valve.
29. Install four 0.625-11 nuts, one onto each stud. Torque the nuts to 150–188 lb-ft (203–255 N·m).
30. Install four additional 0.625 nuts onto the studs, and torque to 75–94 lb-ft (102–127 N·m).
31. Verify that the excitation voltage to each LVDT is  $7.00 \pm 0.10$  Vrms (measured across terminals 7 & 8 and 11 & 12 and 15 & 16).
32. Supply the actuator with hydraulics at 1300–1800 psig (8964–12411 kPa).
33. Measure the LVDT output voltage using a high-quality digital voltmeter (select AC measurement mode).
34. With the actuator at minimum position, the output of the LVDT (measured across terminals 9 & 10 and 13 & 14 and 17 & 18) should be  $0.700 \pm 0.100$  Vrms. If the readout is not within these specifications, adjust the LVDT in or out of the actuator by screwing the LVDT housing in or out of the top block. **NOTE—A small rotation of the LVDT will cause a substantial change in the readout.**
35. Once 0.700 Vrms is obtained, carefully torque the LVDT jam nut to 50–75 lb-ft (68–102 N·m). Then bend the tab on the locking washer up to prevent loosening of the jam nut.



36. Torque the LVDT conduit onto the LVDT and electrical box to 450–550 lb-in (51–62 N·m). Torque the servo valve conduit onto the servo valve and electrical box to 270–300 lb-in (31–34 N·m).
37. Adjust the control system to command the valve to 100% open.
38. The readout of the LVDT should now be  $3.50 \pm 0.50$  Vrms.
39. If the readout at 100% is not within tolerance, repeat steps 36–40.

## Clocking (Rotation) of Actuator to Valve



### WARNING

Be sure all electric power, hydraulic pressure, and gas pressure have been removed from the valve and actuator before maintenance or repairs begin.

See the outline drawings (Figures 1-2 through 1-5) for the location of items.

### Rotation of Actuator Relative to the Gas Valve

1. If the valve is contained within the piping, confirm there is no pressure in the valve and that the isolation valves have been appropriately locked out. Carefully support the valve using the two lifting lugs located on the top of the valve/actuator while the valve is supported from below.
2. The cap screws in the gas control valves cannot be fully removed. Loosen the cap screws fully. Lift the actuator only enough (approx. 1 inch/25 mm) so the screws can be lifted to the tops of the 4-1/4-inch (108 mm) long spacers. The screws will have to be pulled up into the manifold in order to clear the spacers. Remove the 4 spacers. Proceed to step 4.
3. Do not remove the actuator from the valve body, simply rotate the actuator while still in the valve body and while supporting the weight of the actuator from above. The actuator may only be rotated 90 degrees either way from the as-shipped configuration.
4. Replace the four spacers (one on each cap screw) and the four 0.625-11 cap screws and washers into the actuator, and thread into the valve body.
5. Torque the 0.625-11 cap screws to 116.0–132.5 lb-ft (157.3–179.7 N·m).
6. Verify that the spacers are all tightly held between the actuator and valve bodies.

## Inspections

Woodward recommends the following maintenance and inspection schedule for the SonicFlo valve:

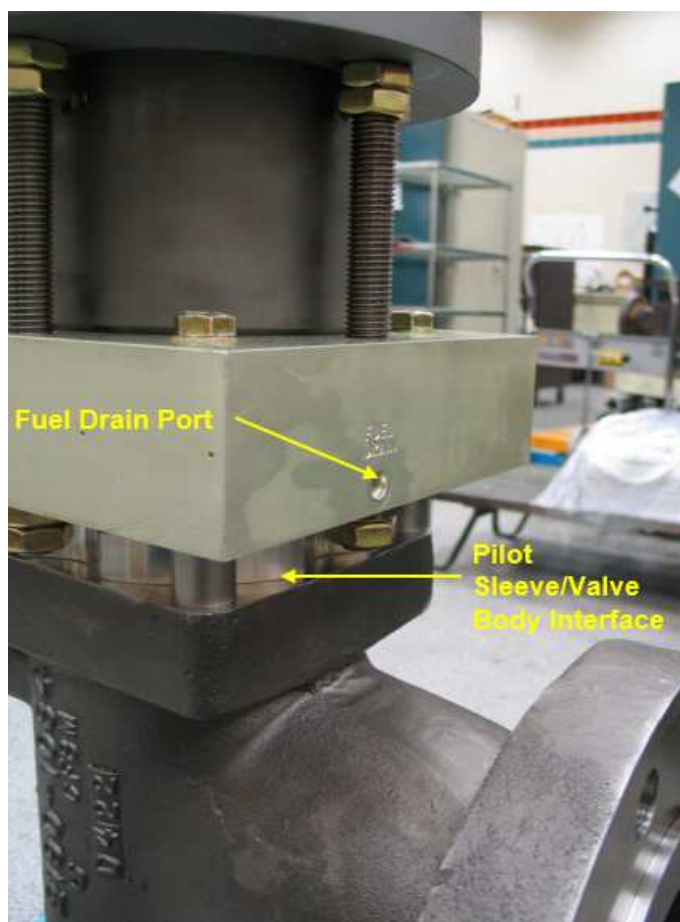
### Routine Inspections

- Routinely check 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.

### Annual Inspections

- Pressurize the valve section of the assembly to the rated pressure of 580 psig (4000 kPa) for class 600 valves or 500 psig (3447 kPa) for class 300 valves. Inspect external sealing surfaces for leakage using leak detect fluid. These locations include the inlet and discharge flange connections as well as the pilot sleeve/valve body interface. No leakage is permitted from these areas.
- Pressurize the valve section of the assembly to 50 psig (340 kPa) and inspect for excessive overboard vent leakage from the Fuel Drain Port on the valve. The leakage should be less than 100 cm<sup>3</sup>/minute.





Pressurize the actuator section of the assembly to the rated pressure of 1700 psig (11725 kPa) and perform the following inspections:

- Inspect all hydraulic sealing surfaces for external leakage.
- Remove hydraulic pressure.

### Overhaul / Replace Valve

- If there is any external leakage, or if either the gas leakage from the fuel drain port or the hydraulic leakage from the interseal fitting exceeds the limits stated above, the valve should be removed and returned to Woodward for overhaul.
- Otherwise, Woodward recommends valves be removed from service and returned to Woodward for overhaul every 48,000 hours of operation or at the nearest major turbine overhaul, whichever comes first.

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

## Troubleshooting

### Gas Fuel Control Valve not functioning correctly when using customer control system.

Perform steps 31 through 35 of the LVDT replacement procedure above. The troubleshooting tool (Woodward part number 1010-4982) can be installed in place of the visual indicator to assist in mechanically determining valve stroke (verify that the valve is at the minimum position).

1. Remove two socket head cap screws holding the visual indicator onto the control valve actuator. Save screws for replacement of visual indicator.
2. Remove the visual indicator.
3. Using two cap screws provided, attach tool 1010-4982 (available from Woodward) to the actuator. Be sure to place the pin of the sliding piece onto the top of the spring seat within the actuator housing.



4. Using a customer-supplied travel indicator with a total stroke greater than 3.10 inches (78.7 mm) placed on top of the sliding piece of the tool, attach the indicator to the actuator housing. Zero the indicator.
5. Raise the servo valve current to  $2 \pm 0.5$  mA. The valve should move fully open.
6. The maximum travel should match the value recorded within the electrical enclosure. If this value is not the same, contact Woodward for recommendations.
7. If this value matches the recorded value, check the feedback voltage of the LVDT (all three coils) vs the recorded values in the electrical enclosure.
8. If the feedback voltages do not match, verify that the excitation voltage is  $7.00 \pm 0.100$  Vdc at 3000 Hz. If the excitation voltage is correct, and the LVDT output voltage does not match the values listed on the calibration sticker, contact Woodward for a replacement LVDT and follow the steps listed within this document for replacement.
9. If the feedback and physical stroke values match the recorded values supplied with the valve, then the control system is not functioning properly. Refer to the control system manufacturer for troubleshooting assistance.

## 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 control valve.

Disassembly of the gas fuel control 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.
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 3.
	Piping flange bolts improperly torqued	Rework bolts as needed to achieve torque requirements detailed in Chapter 3.
	Packing missing or deteriorated	Return actuator to Woodward for service.



Symptom	Possible Causes	Remedies
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 (Figure 1-7) 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 solenoid valve failure	Replace solenoid valve.
Valve will not close	Filter element plugged	Check filter DP indicator. Replace element if the DP indicator shows red.
	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.)	Trace and verify that all wiring is in accordance with the electrical schematic (Figure 1-7) 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.
	LVDT failure	Replace LVDT. If characterized, return to Woodward for service.
	Springs broken	Return actuator to Woodward for service.
	Linkage broken	Return actuator to Woodward for service.
Valve will not respond smoothly	Hydraulic filter clogged	Check the differential pressure indicator on the filter housing.
	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.
	Piston seal worn out	Return actuator to Woodward for service.
	Control system instability	Contact control system supplier.
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. Possible causes include inlet pressure regulation, control system setup, and improper wiring practices. See Chapter 3 Installation section for wiring recommendations.



## Chapter 5

# Safety Management – Safe Position Fuel Shutoff Function

### Safety Function

The SonicFlo™ Gas Fuel Control 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 SonicFlo™ Gas Fuel Control 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 17-04-071 R001, and Certification: WOO 17-04-071 C001. The exida FMEDA report is available on a per request basis from Woodward.

The functional safety requirements in this chapter apply to all SonicFlo™ Gas Fuel Control Valve configurations listed in Table 5-1.

The SonicFlo™ Gas Fuel Control 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 SonicFlo™ Gas Fuel Control 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 the SonicFlo™ Gas Fuel Control Valve – Over Speed SIF

The SonicFlo™ Gas Fuel Control 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 the SonicFlo™ Gas Fuel Control 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:

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

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

The failure rates listed below, for only the SonicFlo™ Gas Fuel Control Valve, do not include failures due to wear-out of any components and are only valid for the useful lifetime of the SonicFlo™ Gas Fuel Control Valve. They reflect random failures and include failures due to external events such as unexpected use. Reference the exida FMEDA report: WOO 17-04-071 R001 for detailed information concerning the SFF and PFD.



Table 5-1. Failure Rates according to IEC 61508 in FIT

**Failure Rates for Static Applications<sup>[1]</sup> with Good Maintenance Assumptions in FIT @ SSI=2**

Application/Device/Configuration	$\lambda_{SD}$	$\lambda_{SU}^{[2]}$	$\lambda_{DD}$	$\lambda_{DU}$	#	E
Full Stroke, Clean Service, Hydraulic Trip	0	76	0	828	1879	477
Full Stroke, Clean Service, Electric Trip	0	454	0	948	2092	487
Full Stroke, Clean Service, Dual Trip - Hydraulic	0	116	0	1047	2474	577
Full Stroke, Clean Service, Dual Trip - Electric	0	454	0	948	2092	487
Full Stroke, Clean Service, Hydraulic Trip, with PVST	76	0	419	409	1879	477
Full Stroke, Clean Service, Electric Trip, with PVST	450	4	516	432	2092	487
Full Stroke, Clean Service, Dual Trip – Hydraulic, with PVST	116	0	616	431	2474	577
Full Stroke, Clean Service, Dual Trip – Electric, with PVST	450	4	516	432	2092	487

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 17-04-071 R001 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 SonicFlo™ Gas Fuel Control 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 SonicFlo™ Gas Fuel Control Valve is 250,000 hours of operation. Under “normal” operating conditions SonicFlo™ Gas Fuel Control 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 SonicFlo™ Gas Fuel Control 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.

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

<sup>[2]</sup> 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 SonicFlo™ Gas Fuel Control Valve after initial installation, and after any modification of the overall safety system. No modification shall be made to the SonicFlo™ Gas Fuel Control 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 SonicFlo™ Gas Fuel Control 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 SonicFlo™ Gas Fuel Control 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 SonicFlo™ Gas Fuel Control 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 SonicFlo™ Gas Fuel Control Valve must conform to the guidelines and restrictions included in this manual.

## Functional Testing after Initial Installation

A functional test of the SonicFlo™ Gas Fuel Control 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 SonicFlo™ Gas Fuel Control Valve. For guidance on the functional test, see the Proof Test procedure below.

## Functional Testing after Changes

A functional test of the SonicFlo™ Gas Fuel Control Valve is required after making any changes that affect the safety system. Although there are functions in the SonicFlo™ Gas Fuel Control 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 5-2. 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 SonicFlo™ Gas Fuel Control 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 SonicFlo™ Gas Fuel Control Valve is given in the table below.

Table 5-3. Proof Test Coverage

Device	$\lambda_{DUPT}$ (FIT)	Proof Test Coverage	
		No PVST	with PVST
Full Stroke, Clean Service, Hydraulic Trip	278	66.4%	32.0%
Full Stroke, Clean Service, Electric Trip	283	70.1%	34.5%
Full Stroke, Clean Service, Dual Trip - Hydraulic	280	73.3%	35.0%
Full Stroke, Clean Service, Dual Trip - Electric	283	70.1%	34.5%

The suggested proof test and proof test coverage is referenced in exida FMEDA report; WOO 17-04-071 R001.



## Chapter 6.

# Product Support and Service Options

### Product Support Options

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

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

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

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

- A **Full Service Distributor** has the primary responsibility for sales, service, system integration solutions, technical desk support, and aftermarket marketing of standard Woodward products within a specific geographic area and market segment.
- An **Authorized Independent Service Facility (AISF)** provides authorized service that includes repairs, repair parts, and warranty service on Woodward's behalf. Service (not new unit sales) is an AISF's primary mission.
- A **Recognized Turbine Retrofitter (RTR)** is an independent company that does both steam and gas turbine control retrofits and upgrades globally, and can provide the full line of Woodward systems and components for the retrofits and overhauls, long term service contracts, emergency repairs, etc.

A current list of Woodward Business Partners is available at [www.woodward.com/directory](http://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](http://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](http://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

<u>Facility</u>	<u>Phone Number</u>
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

<u>Facility</u>	<u>Phone Number</u>
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

<u>Facility</u>	<u>Phone Number</u>
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 \_\_\_\_\_

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### Prime Mover Information

Manufacturer \_\_\_\_\_

Turbine Model Number \_\_\_\_\_

Type of Fuel (gas, steam, etc.) \_\_\_\_\_

Power Output Rating \_\_\_\_\_

Application (power generation, marine,  
etc.) \_\_\_\_\_

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### Control/Governor Information

#### Control/Governor #1

Woodward Part Number & Rev. Letter \_\_\_\_\_

Control Description or Governor Type \_\_\_\_\_

Serial Number \_\_\_\_\_

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#### Control/Governor #2

Woodward Part Number & Rev. Letter \_\_\_\_\_

Control Description or Governor Type \_\_\_\_\_

Serial Number \_\_\_\_\_

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#### Control/Governor #3

Woodward Part Number & Rev. Letter \_\_\_\_\_

Control Description or Governor Type \_\_\_\_\_

Serial Number \_\_\_\_\_

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### 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 L—

- Revised ASME listing within Fluid Ports in Table 1-1
- Revised Valve Proof Pressure Levels in Table 1-1
- Revised Minimum Valve Burst Pressure listing in Table 1-1
- Revised Allowable Operating Gas Pressure & Temperature listing in Table 1-1

### Changes in Revision K—

- Added clarification to Hydraulic Supply Pressure in Table 1-1
- Revised PED Directive
- Added RoHS Directive
- Replaced DoC

### Changes in Revision J—

- Replaced Warning on Page 21 regarding Bench Testing
- Added Figures 3-1, 3-2, and 3-3 as examples to illustrate the warning on Bench Testing

### Changes in Revision H—

- Added SIL 3 Certification
- Added Chapter 5 Safety Management

### Changes in Revision G—

- Updated Certifications in Regulatory and Compliance Section
- Updated Declarations

### Changes in Revision F—

- Updated ATEX information (page 7)
- Updated Declaration

### Changes in Revision E—

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

### Changes in Revision D—

- Added Cg values to Valve Port Size (page 2)
- Updated Annual Inspections information (page 24)


### Changes in Revision C—

- Updated Regulatory Compliance section
- Updated Functional Characteristics
- Added outline drawing for 8-inch, Class 300, No Spool version
- Added new Declarations




# Declarations

## EU DECLARATION OF CONFORMITY

EU DoC No.:	00145-04-CE-02-03
Manufacturer's Name:	WOODWARD INC.
Manufacturer's Contact Address:	1041 Woodward Way Fort Collins, CO 80524 USA
Model Name(s)/Number(s):	Sonic Flo™ Gas Fuel Control Valves Sizes 2", 3", 4" and 6", Classes 300 and 600, Size 8" Class 300
The object of the declaration described above is in conformity with the following relevant Union harmonization legislation:	<p>Directive 2014/34/EU of the European Parliament and of the Council of 26 February 2014 on the harmonization of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres</p> <p>Directive 2014/68/EU of the European Parliament and of the Council of 15 May 2014 on the harmonization of the laws of the Member States relating to the making available on the market of pressure equipment 2", 3", 4": PED Category II 6", 8": PED Category III</p> <p>Directive 2014/30/EU of the European Parliament and of the Council of 26 February 2014 on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC). 2014/30/EU is met by evaluation of the physical nature to the EMC protection requirement. Electromagnetically passive or "benign" devices are excluded from the scope of the Directive 2014/30/EU, however, they also meet the protection requirement and intent of the directive.</p>
Markings in addition to CE marking:	 II 3 G, Ex nA IIC T3X Gc, IP54
Applicable Standards:	<p>ASME B16.34:2013</p> <p>ASME Boiler and Pressure Vessel Code Section VIII, Div. 2:2010</p> <p>EN 60079-0:2012 – Explosive atmospheres – Part 0 : Equipment – General Req'ts</p> <p>EN 60079-15:2010 – Explosive atmospheres – Part 15: Equip. protection by type of protection n</p> <p>EN 61000-6-4, 2007/A1:2011: EMC Part 6-4: Generic Standards - Emissions for Industrial Environments</p> <p>EN 61000-6-2, 2005: EMC Part 6-2: Generic Standards - Immunity for Industrial Environments</p>
Conformity Assessment:	PED Module H – Full Quality Assurance, CE-0062-PED-H-WDI 001-19-USA, Bureau Veritas SA (0062) 52 Boulevard du Parc, 92200 Neuilly-sur-Seine, France

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

### MANUFACTURER

Signature 

Full Name **Mike Row**

Position **Engineering Supervisor**

Place **Woodward, Fort Collins, CO, USA**

Date **29-July-2019**

5-09-1183 Rev 31



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

**File name:** 00145-04-CE-02-01  
**Manufacturer's Name:** WOODWARD INC.

**Contact Address:** 1041 Woodward Way  
Fort Collins, CO 80524 USA

**Model Names:** Sonic Flo™ Gas Fuel Control Valves  
Sizes 2", 3", 4" and 6", Class 300 and 600, Size 8" Class 300

**This product complies, where applicable, with the following Essential Requirements of Annex I:** 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7

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


The person authorized to compile the technical documentation:

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

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

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

**MANUFACTURER**



\_\_\_\_\_  
Signature

Christopher Perkins

\_\_\_\_\_  
Full Name

Engineering Manager

\_\_\_\_\_  
Position

Woodward Inc., Fort Collins, CO, USA

\_\_\_\_\_  
Place

12 - APR - 2016

\_\_\_\_\_  
Date

Document: 5-09-1182 (rev. 16)



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We appreciate your comments about the content of our publications.

Send comments to: [icinfo@woodward.com](mailto:icinfo@woodward.com)

Please reference publication **26384**.



PO Box 1519, Fort Collins CO 80522-1519, USA  
1041 Woodward Way, Fort Collins CO 80524, USA  
Phone +1 (970) 482-5811

Email and Website—[www.woodward.com](http://www.woodward.com)

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

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