

# **SOGAV™ Solenoid Operated Gas Admission Valve**

**SOGAV 43**

**Installation and Operation Manual**

## IMPORTANT



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

## DEFINITIONS

- **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

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.



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.



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[www.woodward.com/searchpublications.aspx](http://www.woodward.com/searchpublications.aspx)

The current revision and distribution restriction of all publications are shown in manual **26311**.

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

## NOTICE

To prevent damage to a control system that uses an alternator or battery-charging device, make sure the charging device is turned off before disconnecting the battery from the system.

## 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*.

Revisions—Text changes are indicated by a black line alongside the text.

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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# Regulatory Compliance

## European Compliance for CE Marking:

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

<b>ATEX – Potentially Explosive Atmospheres Directive:</b>	Declared to 94/9/EC COUNCIL DIRECTIVE of 23 March 1994 on the approximation of the laws of the Member States concerning equipment and protective systems intended for use in explosive atmospheres. Zone 2, Category 3, Group II G, EEx m II T4 X
<b>Low Voltage Directive:</b>	Declared to 2006/95/EC COUNCIL DIRECTIVE of 12 December 2006 on the harmonization of the laws of the Member States relating to electrical equipment designed for use within certain voltage limits.

## Other European Compliance:

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

<b>Machinery Directive:</b>	Compliant as partly completed machinery with Directive 2006/42/EC of the European Parliament and the Council of 17 May 2006 on Machinery.
<b>Pressure Equipment Directive:</b>	Exempt per Article 1-3.10
<b>EMC Directive:</b>	Not applicable to this product. Electromagnetically passive devices are excluded from the scope of the 2004/108/EC Directive.

## North American Compliance:

These listings are limited only to those units bearing the CSA identification.

<b>CSA:</b>	CSA Certified for Class I, Division 2, Groups A, B, C, D, T4 at 105 °C Ambient for use in Canada and the United States. Certificate 1514353
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The SOGAV 43 solenoid is certified as a component for on-engine use. The final assembly is subject to acceptance by the authority having jurisdiction.

## 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 105 °C.

Connect the ground terminal on the SOGAV 43 solenoid to earth ground.

SOGAV 43 solenoids are labeled with maximum rated values of input current and input power. These input ratings must not be exceeded during solenoid operation in order to prevent exceeding a prescribed coil temperature rise at the maximum rated ambient operating temperature. These solenoids must be driven by specially designed current-limiting drivers providing periodic, two-tier current waveforms. Refer to the Appendix for details on how to determine and interpret these input rating values.

**! 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 les emplacements de Classe I, Division 2 ou Zone 2.**

# Chapter 1.

## General Information

### Introduction



#### **WARNING**

The engine, turbine, or other type of prime mover should be equipped with an independent fuel shut-off device to protect against fuel leakage or damage to the prime mover with possible personal injury, loss of life, or property damage. The fuel shut off device must be totally independent of the prime mover control system.

This manual gives the end user with the information necessary to properly install, operate, maintain, and troubleshoot the Woodward SOGAV™ 43 (Solenoid Operated Gas Admission Valve).

Refer to Figure 1-2 for the SOGAV 43 Functional Diagram.

An exploded view of these valves is available in Chapter 5.

### Principles of Operation

#### Magnetic

All valve actuation forces are generated magnetically through an E-core solenoid device. Magnetic flux generated in the E-core solenoid assembly attracts a low carbon steel plate (the armature) that is attached to the valve mechanism. The E-core produces very high forces over short travels. The valve mechanism travels approximately 0.40 mm from full closed to full open. The short travel along with the high solenoid force results in fast and consistent opening and closing response.

#### Valve

The valve is similar to an air (or gas) compressor valve. It is a face type poppet with multiple concentric grooves. The moving metering plate is spring loaded and pressure loaded against the lower stop/metering plate and is pulled off the lower stop by the force generated on the attached armature by the E-core solenoid. When the plates are separated, gas flows from the grooves in the moving metering plate to the grooves in the lower stop/metering plate (View A). When the moving metering plate and the lower stop/metering plate are in contact, gas cannot pass from the grooves in the moving metering plate to the grooves in the lower stop/metering plate (View B).

The groove edges are the metering edges. Overlapped, flat lapped sealing surfaces, spring loading, and pressure imbalance across the moving metering plate provide excellent sealing while the valve is closed.

An array of springs, combined with pressure imbalance across the moving metering plate, rapidly close the valve once the E-core is de-energized. The same array of springs center the moving plate relative to the lower stop/metering plate. This centering technique eliminates sliding (wearing) motion.

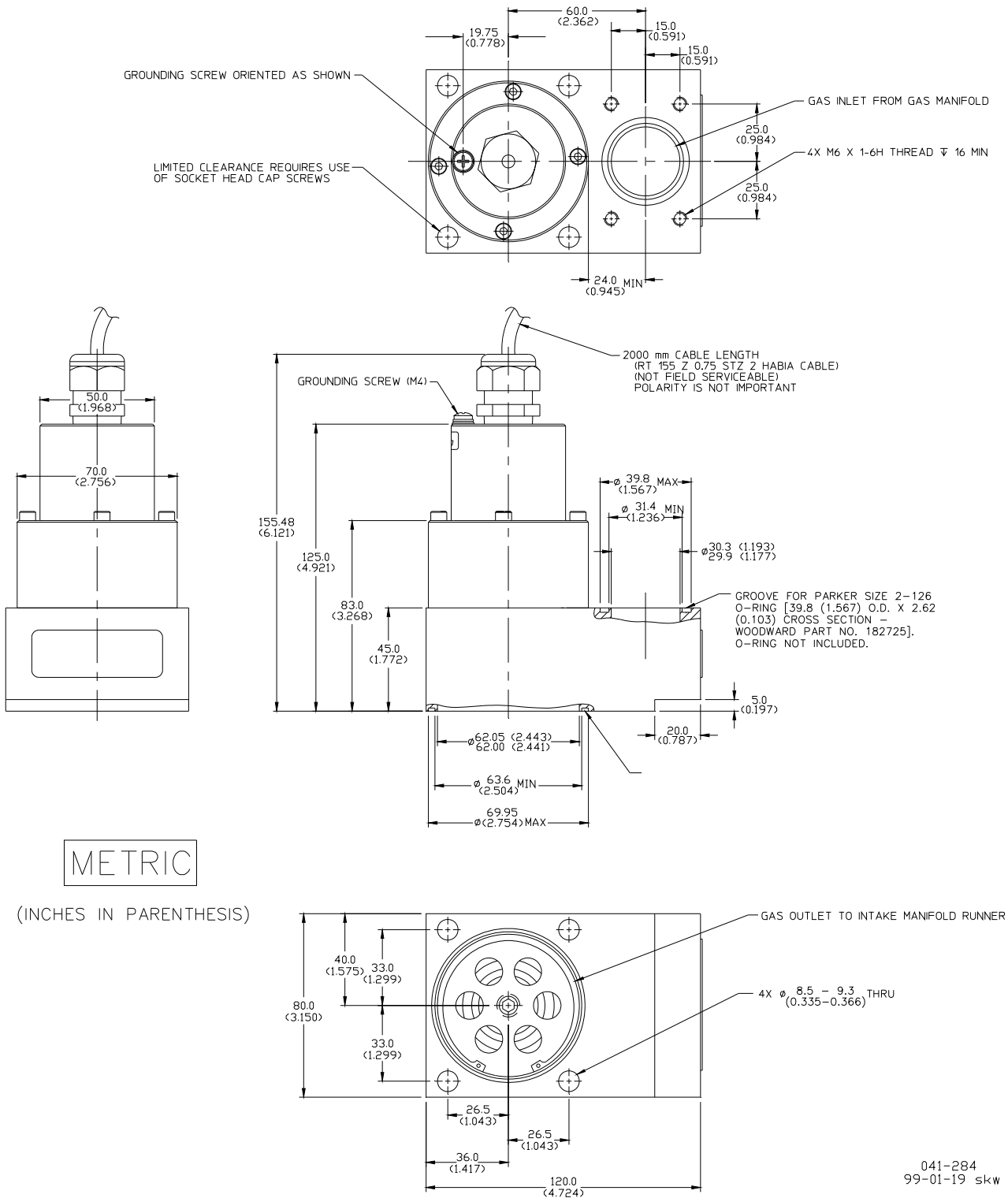


Figure 1-1a. SOGAV 43 Outline Drawing (Cable/Gland)  
(approved for use in hazardous locations)  
**NOTE**—Actual gland and cable length vary by part number.



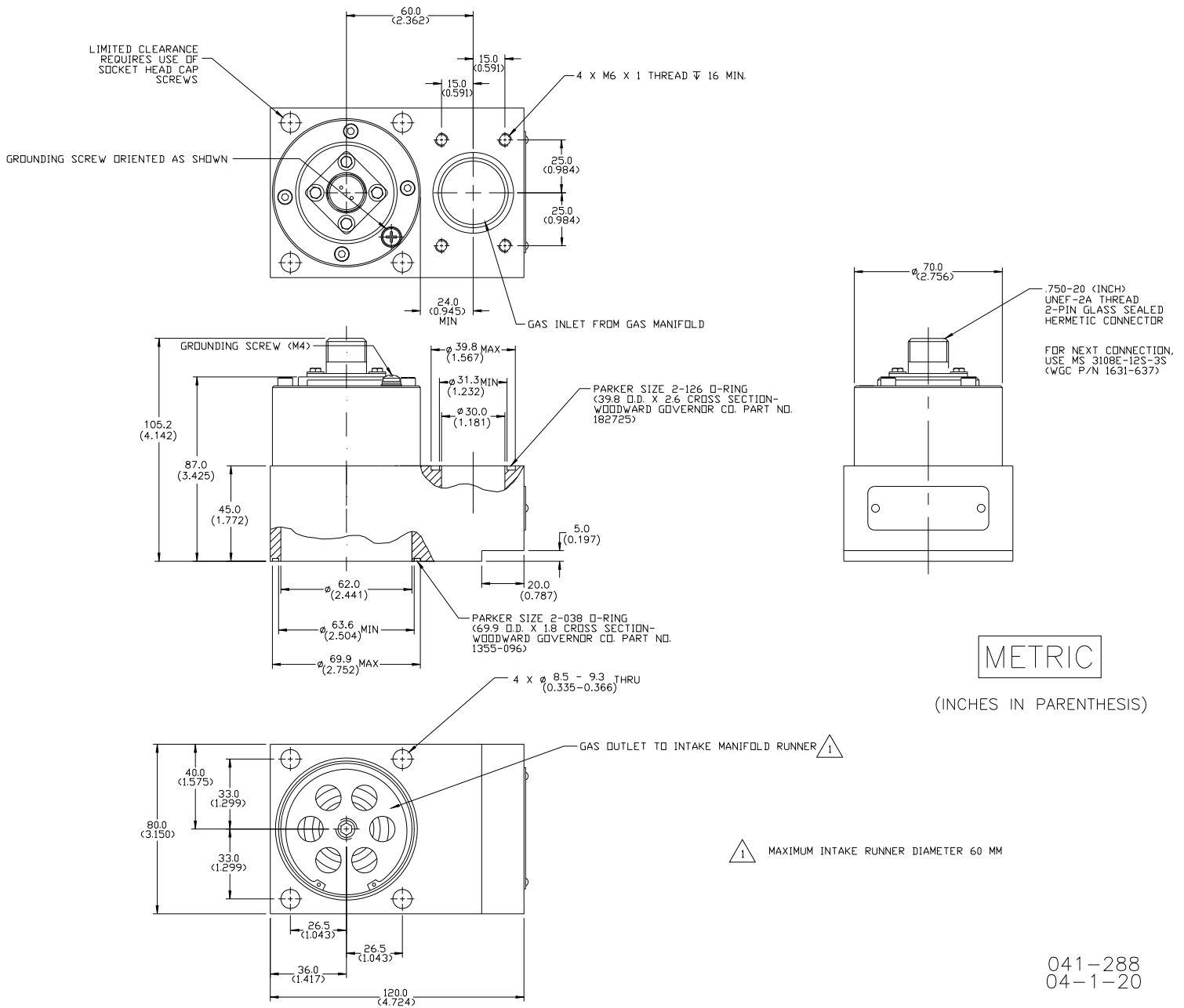
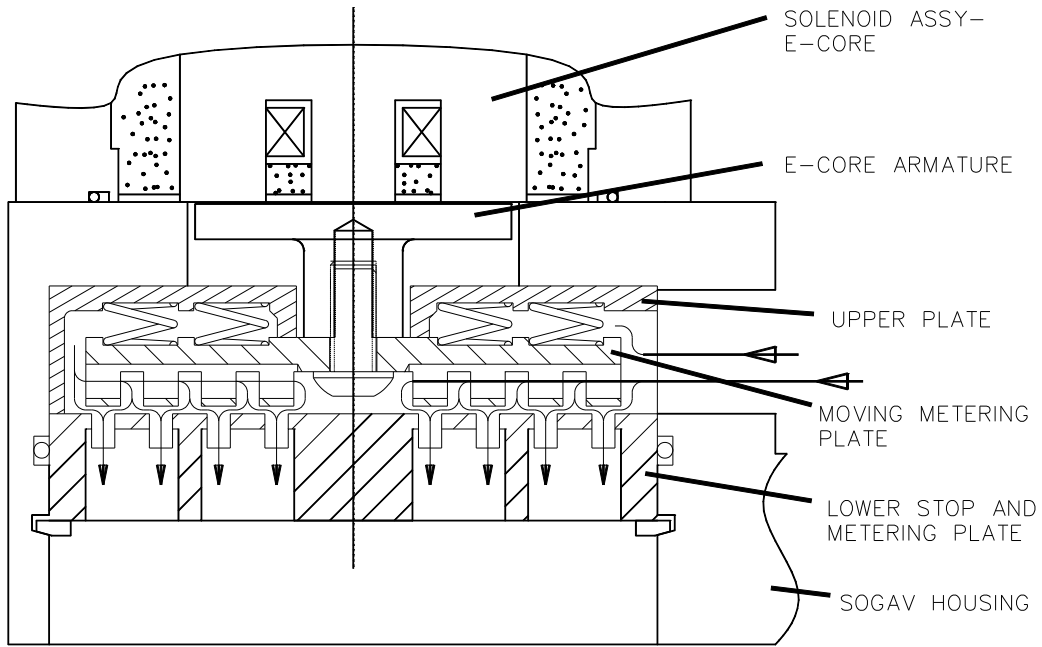
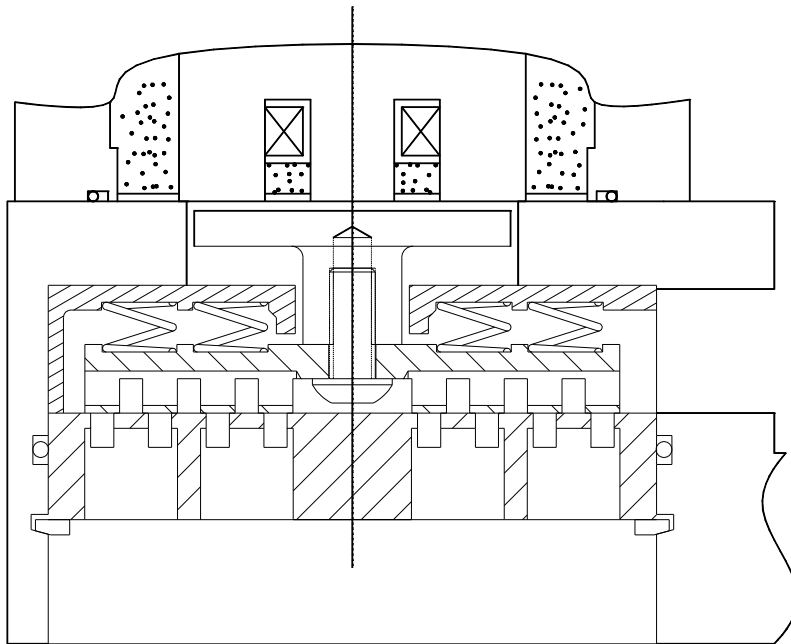


Figure 1-1b. SOGAV 43 Outline Drawing (MS Connector)

FUNCTIONAL DIAGRAM



COIL ENERGIZED  
VALVE OPEN VIEW A



COIL DE-ENERGIZED  
VALVE CLOSED VIEW B

041-148  
94-6-23 RAM

Figure 1-2. SOGAV 43 Functional Diagram

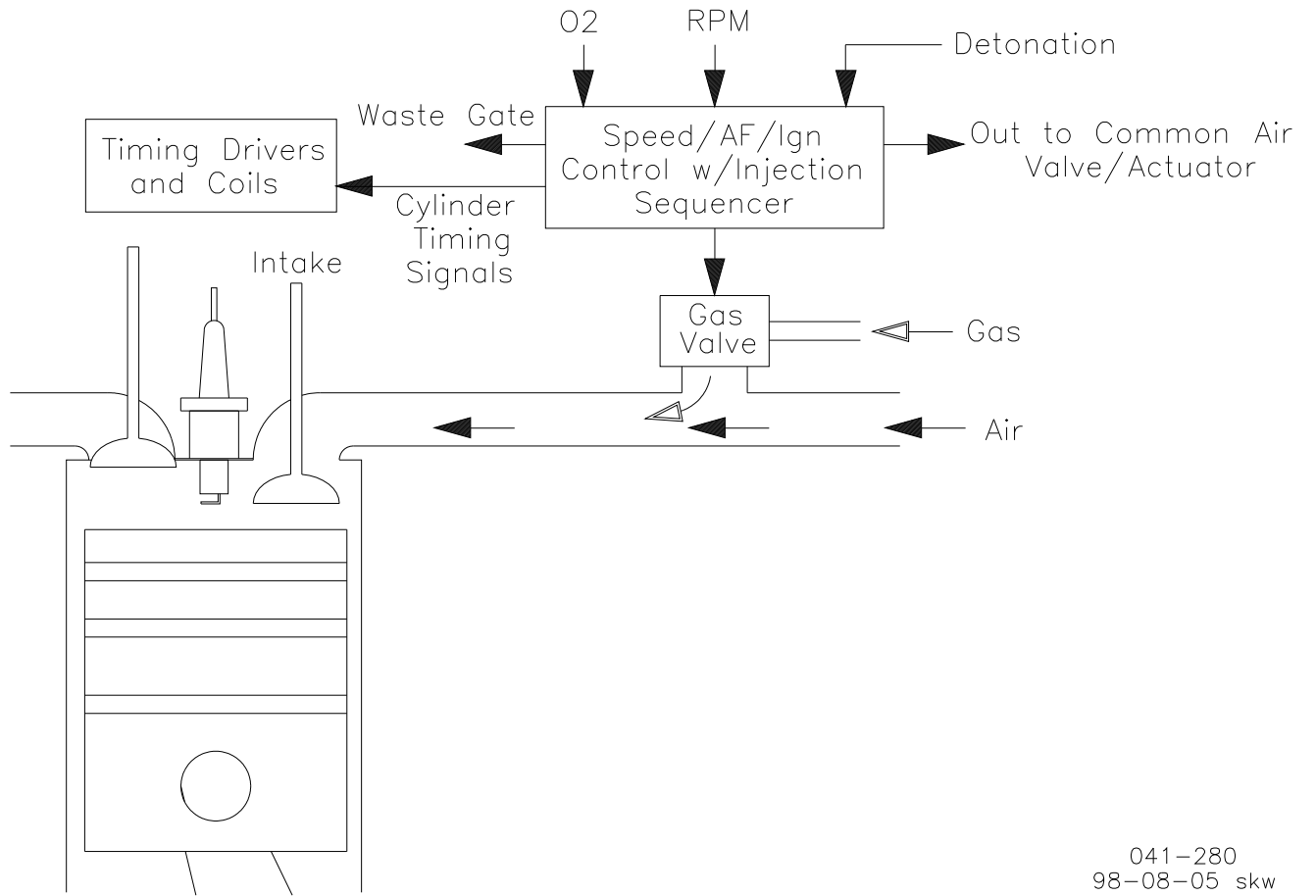


Figure 1-3. In-Manifold Electric Gas Admission

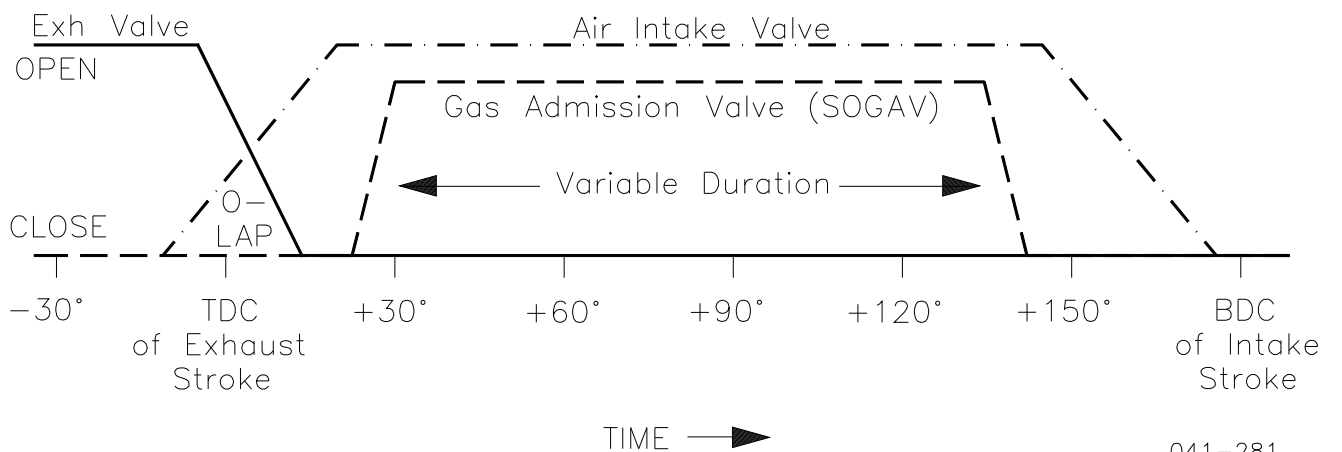


Figure 1-4. Timing: In-Manifold Gas Admission

## Chapter 2. Installation/Adjustment

### Installation

**! 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.**

**! WARNING**

**Due to typical noise levels in engine environments, hearing protection should be worn when working on or around the SOGAV 43.**

**! 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**

**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.**

Refer to the outline drawing, Figure 1-1 (wire treatment varies depending on model).

It is imperative that the interior of all gas manifolding be absolutely clean prior to SOGAV™ installation and engine start-up. There must be no dirt, weld slag, metal chips, etc., present. Contamination of this type can prevent the valve from operating properly and can damage the engine if it passes through the valve.

The region around the SOGAV installation pad must also be very clean so that no debris gets into the air manifold during SOGAV valve installation.

Locate the appropriate O-ring (specified on the outline drawing) in the groove on the base of the SOGAV valve.

Mount the SOGAV valve to the cylinder head or air intake manifold runner using either M8 or 5/16-inch socket head screws. Socket head screws are required for bolt head clearance. Tighten these screws evenly to a torque recommended by the manufacturer.

Install the gas inlet line to the inlet side of the SOGAV valve using the O-ring specified on the outline drawing. Use M6x1 screws with at least 12 threads of engagement. Lubricate the threads and torque evenly to 8 N·m (70 lb-in).

The cable connector should be installed last. Assure that the knurled locking nut is well snugged.

The hazardous location approved solenoid cable must be terminated at the engine mounted fuel injection driver. The cable connection at the solenoid is not field-serviceable.

## Initial Operation/Adjustment

There are no field adjustments to be made to either SOGAV valve.

After installation, pressurize the gas manifold system (preferably with air or inert gas) and check for leaks around all valves and all interface flanges, by brushing on a soap and water solution.

Refer to the overall control system documentation for start-up/operation procedures. These procedures will vary from application to application.

If background noise is minimal, basic valve operation can be confirmed by an audible ticking sound.

## Chapter 3.

# Application Guidelines

### Introduction

Figure 1-4 shows the general timing relationships between exhaust valve position, intake valve position, and SOGAV™ opening.

This method allows for fresh air scavenging of the combustion chamber during the overlap period around TDC (top dead center) of the exhaust stroke. After the overlap period (immediately after the exhaust valve closes), the SOGAV valve rapidly opens and admits gas into the air stream passing through the inlet runner. The gas is then carried into the combustion chamber with the air through the open air intake valve.

Governing is by duration. The SOGAV valve remains open for a duration necessary to keep the engine under speed or load control (by way of the electronic governor and In-Pulse™ unit).

The SOGAV valve must always close sufficiently before the air inlet valve closes in order to assure that all gas admitted into the inlet runner gets carried into the combustion chamber. If this time is not sufficient, gas will remain in the inlet runner after the intake valve closes and will pass through to the exhaust during the next overlap period (wasting fuel and emitting unburned hydrocarbons). It is the responsibility of the engineer applying the SOGAV system to determine the timing of SOGAV valve opening as well as the maximum allowable duration.

In the interest of maximizing the allowable duration and reducing the possibility of trapped gas in the runner after intake valve closing:

1. Locate the SOGAV valve as close as possible to the air intake valve, and
2. Minimize the length of the connecting passage between the SOGAV valve and the air manifold runner.

The SOGAV valve can be mounted in any orientation with the solenoid axis greater than horizontal, placing the solenoid higher than the metering plates. However, a vertical orientation (valve inlet facing upward) is preferred and will substantially increase valve life versus a horizontal orientation. Take care to keep the SOGAV valve and wiring from being exposed to extremely hot surfaces (such as exhaust systems).

The necessity for proper gas manifold design cannot be overstated. Ideally, the dynamic flow performance of the manifold design should be checked out using computer modeling before making hardware. After design and during developmental testing, the manifold should be instrumented and monitored in order to verify acceptability of the design.

The inside diameter of the gas feeder pipes connecting the SOGAV valves to the gas manifold must be the same size or greater than the gas inlet hole in the SOGAV valve. This diameter is 30 mm. This pipe must be as short as possible. The length of this pipe affects the acceleration of the gas immediately after the valve opens. Increased opening duration is required to compensate for long feeder pipe lengths.

All gas feeder pipes must be the same length.

The feeder pipes connecting the gas manifold to the SOGAV valves must not impart substantial stress into the SOGAV valve when installed. Flexible lines are preferred to rigid steel welded assemblies.

The gas manifold should be sufficiently large so that:

1. Local pressure drops at the entries to the feeder pipes are minor (while the valve is at full flow), and
2. Pulsations are damped such that flow through the gas pressure regulating device is essentially steady.

It is best if the gas manifold is fed at multiple locations. The engineer designing the gas manifold must consider the effects of multiple valves being open at the same time. For example, a V-16 engine will often have three SOGAV valves open and flowing at the same time. If that engine were equipped with a common manifold fed at one end only, the furthest of the three valves could be starved because of pressure drops caused by the other two open valves.

The surface to which the valve mounts must have an opening of approximately the same size as the SOGAV outlet (refer to the outline drawing). A smaller hole will restrict flow, and a larger hole must not be so large as to interfere with the O-ring seating surface. The O-ring seating surface finish must meet industry standards for O-ring sealing with gasses.

Gas distribution (dispersion) devices in the air manifold runner might help to increase the homogeneity of the mix entering the combustion chamber. Before designing such a device, the engineer must consider that:

1. These devices restrict gas flow and can easily be more restrictive than the (wide open) SOGAV valve itself, and
2. These devices might not get well purged of gas during the period after the SOGAV valve closes and before the air intake valve closes. During the SOGAV valve's closed period, this trapped gas may trickle out such that during the following overlap period, unburned gas passes through to the exhaust.

In addition to controlling gas admission events, the main engine controller must control air manifold pressure and gas manifold pressure.

Air manifold pressure control is required in order to achieve the desired air/fuel ratio. This can be done with an air throttle valve/actuator and/or a wastegate valve/actuator.

Gas manifold pressure regulation is necessary because:

1. Air manifold pressure varies significantly during operation,
2. The amount of fuel admitted per event varies significantly depending on speed and load, and
3. The SOGAV 43 is limited to 200 kPa (2.0 bar) of pressure drop across it. Pressure drops greater than these limits will prevent the valve from opening.

If operating at a low load condition, a relatively small pressure drop is required to prevent extremely short durations. Extremely short durations are not desirable because they can reduce mixture homogeneity. Also, small unit-to-unit SOGAV response variations result in substantial unit-to-unit fuel admission variations when operating at extremely short durations. These response variations have a very minor effect when duration is relatively long.

If operating at full speed and full load, a fairly high pressure drop (150 kPa/1.5 bar) is generally required to admit the required amount of fuel in the time permitted. If the engine's load were substantially reduced without reducing the gas manifold pressure, a pressure drop greater than the 200 kPa/2.0 bar limit would exist across the valve and the valve would not function.

Gas pressure regulation must be handled by the main engine controller and is discussed here to assist in understanding how the overall system works.

## Wiring

### **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.**

### **WARNING**

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

The wiring connecting the In-Pulse unit to the valves should be shielded, twin-lead wire with an insulation adequate for the on-engine environment. The shielding should be grounded through the In-Pulse connector, but not grounded on the SOGAV end.

The mating connectors are defined on the outline drawing (Figure 1-1).

Connect the ground terminal on the SOGAV solenoid to earth ground.

The cables do not need to all be the same length as long as each cable meets the electrical code requirements for the location of operation and the following length/wire gauge criteria:

- Up to 15 m cable length: 1 mm<sup>2</sup> (18 AWG) required
- 15 to 25 m cable length: 1.5 mm<sup>2</sup> (16 AWG) required
- 25 to 40 m cable length: 2 mm<sup>2</sup> (14 AWG) required

SOGAV applications utilizing the Woodward In-Pulse II controller or ECM3 controller should be set up such that the SOGAV cable shielding is not grounded to the SOGAV. The cable gland that holds and seals the cable relative to the SOGAV solenoid should therefore be the non-grounding style for these applications. Failure to comply with this requirement may cause controller and engine operational issues, and will invalidate the controller EMC certification(s). This requirement applies only to the controllers mentioned in this paragraph. Applications utilizing other controllers may be set up differently assuming they meet the necessary performance and EMC requirements.

## Sizing

Always consult a Woodward application engineer to determine the appropriate system and hardware for the specific application.

For an indication of which SOGAV valve is most appropriate for an application, follow these steps:

1. Assuming the full speed and full load condition, determine the air manifold pressure required to achieve the desired air/fuel ratio. Call this variable P2 and use units of bar (absolute; 1 bar = 100 kPa).



2. Determine the properties of the poorest quality gas expected to be used on this application. In addition to energy content, the following properties are required:
  - Specific gravity relative to air. Call this variable sg (unitless).
  - Ratio of specific heats (CP/CV). Call this variable k (unitless).
3. Assuming the full speed and full load condition and the fuel energy content, determine the mass (in grams) of fuel required per combustion event.
4. Determine the maximum allowable SOGAV valve admission time duration per combustion event (in seconds). Subtract 0.005 seconds to compensate for SOGAV valve opening and closing times and for gas acceleration delay in the gas manifold runner. Consider the timing and duration issues discussed in the previous section.
5. Using the data from steps 3 and 4 above, determine the required mass flow rate while the valve is in the open condition. Call this variable MR and use units of grams/second.
6. Calculate the available flow. Using a P1 (gas manifold pressure) of 2 bar greater than P2, perform the Available Flow Rate calculation. Determine if the available flow (MA) exceeds the required flow (MR) calculated in step 5.
7. If available flow calculated in step 6 was too low, a larger valve will be needed.

Available Flow Rate Equation (with valve in full open condition; this equation is set up for a scientific calculator, where \* indicates multiplication and ^ indicates raising to a power):

$$MA = Z * ((2 * k / (k - 1)) * sg * P1^2 * (293.15 / (273.15 + Tg)) * ((P2 / P1)^{(2/k)} - (P2 / P1)^{((k + 1)/k)}))^{.5}$$

where:

MA = available gas mass flow rate (g/s)

Z = valve constant (use 43 for SOGAV 43)

k = ratio of specific heats (CP/CV)

sg = gas specific gravity (relative to air)

P1 = gas absolute upstream pressure at valve entry (bar)

P2 = gas absolute downstream pressure at valve exit (bar)

Tg = gas temperature (°C)

The above equation is valid only for ratios of P2/P1 greater than 0.544. For P2/P1 ratios less than 0.544, flow is choked (sonic or critical). To make the equation valid for P2/P1 ratios less than 0.544, use P2/P1 = 0.544 instead.

## Input Power Limitations

Woodward solenoids are labeled with maximum rated values of input current and input power. These input ratings must not be exceeded during continuous solenoid operation, to prevent exceeding a prescribed coil temperature rise at the maximum rated ambient operating temperature. These solenoids must be driven by specially designed current limiting drivers, providing periodic, two-tier current waveforms. Details on how to determine and interpret these values are in the Appendix.

## Safety

In addition to normal safety systems used with gas engines, the gas manifold should be immediately de-pressurized and evacuated after engine shutdown. This is required to prevent possible leaks of gas into the air manifold (through the SOGAV valves) after shutdown. Gas leaks of this type can cause overfueling during the next start-up.

## Chapter 4. Servicing

SOGAV™ valve life is highly dependent on the following variables, which are beyond the control of the manufacturer:

- Engine speed
- Fuel quality/contaminants
- Fuel filtration
- Temperature
- Vibration
- Driver electronics used
- Oil/lubrication content of fuel (2 ppm minimum oil content is recommended. for oil content less than 2 ppm, the appropriate coated version of the SOGAV should be used.)
- Valve orientation (a vertical orientation [valve inlet facing upward] is preferred)

Therefore, SOGAV valve maintenance/reconditioning should be carried out at intervals determined by the engine manufacturer for the particular application.

For optimum service/reconditioning, return SOGAV valves to Woodward, where trained personnel and sophisticated reconditioning and test equipment is available.

If on-site maintenance or troubleshooting is required, refer to Chapter 5.

## Chapter 5. Maintenance/Troubleshooting

### Introduction

Some SOGAV™ valve troubleshooting and minor valve maintenance can be done in the field. However, the lack of flow and response testing facilities often limits the ability to analyze the problem and verify the solution. If time permits, it is always advisable to return the SOGAV valves to Woodward for service.

Refer to the Figure 5-1 (Exploded Assembly) for the SOGAV 43.

#### **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.

#### **WARNING**

To prevent possible serious personal injury or damage to equipment, be sure all electric power and gas pressure have been removed from the SOGAV 43 and solenoid before beginning any maintenance or troubleshooting.

#### **WARNING**

Maintenance and troubleshooting should only be attempted by properly trained personnel. Hazardous voltages are present during the troubleshooting procedure and present a risk of electric shock. Failure to observe these warnings could lead to injury or death.

#### **NOTICE**

Disassembly without prior Woodward authorization voids the manufacturer's warranty.

### Troubleshooting

If a SOGAV valve is suspected of having a problem, one of four tests will most likely isolate the problem. If the SOGAV valve passes the four tests, the problem is probably not with the SOGAV valve, and disassembly should not be required. The following tests assume that the valve has been removed from the engine. The tests should be done in the order listed.

#### **WARNING**

Prior to performing any maintenance on the SOGAV valve, remove all electrical power from the valve solenoid and relieve all gas pressure from the inlet and the outlet of the valve. Failure to remove all electrical power and relieve all inlet and outlet gas pressure before performing maintenance may result in equipment damage, personal injury, or death.

## Coil Integrity

1. Measure coil resistance from one connector pin to the other. At room temperature, the coil resistance should be within the following ranges:

High Voltage:

SOGAV 43/MS Connector      1.8–2.1  $\Omega$

Low Voltage:

SOGAV 43/Cable              1.35–1.55  $\Omega$

Because of the low resistance levels, make sure to compensate for the meter lead resistance. If outside of this tolerance, the E-core coil assembly should be replaced.

Additional indication of a coil problem can be observed by comparing coil resistance of a suspect SOGAV valve to one that is known to be good. This is particularly helpful if the meter's accuracy at low resistances is questionable.

2. Check for a ground fault. Measure resistance from either pin to the E-core solenoid assembly housing. If a low resistance is measured, a ground fault exists and the E-core solenoid assembly should be replaced.

Generally, a properly operating coil will measure infinite resistance to ground; however sometimes a high resistance will be measured at first ( $> 10 \text{ M}\Omega$ ) and the reading will gradually increase until the meter reads infinite. This is not a problem. This is a result of the meter's charging of the coil's natural capacitance.

## Valve Leakage

Install a pressurization adapter to the gas inlet using the appropriate O-ring. This can be easily made or ordered from Woodward (Woodward tool 8995-280).

Apply 200 kPa/2.0 bar (29 psig) of air pressure to the SOGAV inlet. In a quiet area, listen to the outlet of the SOGAV valve. If the leakage is inaudible or barely audible, the valve is OK. If the leakage is appreciable, either the valve plates are damaged or contamination is present between the valve plates. In either case, disassembly and corrective action is required.

If instrumentation is available, measure the leakage flow rate and compare to the specified maximum in Chapter 6 of this manual.

## Actuator Strength

Apply 200 kPa/2.0 bar (29 psig) of air pressure to the inlet of the SOGAV 43 valve as was done during the leakage test.



**WARNING**

**ELECTRIC SHOCK HAZARD—Exercise care in using the power supply below. The voltage and current are sufficient to cause death or serious injury.**

Using a power supply capable of 10 A at 24 Vdc, set up as follows:

- current limit: 10 A (Do not use the E-core to set up this current limit.)
- voltage limit:  $> 24 \text{ Vdc}$

Install a switch between the power supply and SOGAV E-core solenoid assembly. Turn off the switch and turn on the power supply.

Turn the switch ON and then immediately OFF.

**DO NOT LEAVE THE SOLENOID ASSEMBLY ENERGIZED WITH 10 A FOR MORE THAN 2 SECONDS.** The coil will overheat if left continually energized with 10 A for more than 2 seconds. Also, remember that two 1-second bursts in rapid succession are equivalent to one 2 second burst in terms of heat generation. Allow one minute cool down between bursts. (The coil does not overheat in operation because the In-Pulse™ driver limits the 10 A “on” time to a maximum of 0.001 seconds per event. This is not possible using the manual switch method.)

If a loud pop is heard (like a balloon bursting), the actuator strength is adequate.

If no loud pop is heard and the current was applied properly, the valve should be disassembled and evaluated. Most likely, one of three situations exist:

- The socket head cap screw connecting the armature to the moving metering plate is loose; or
- There is debris between the moving metering plate and the upper plate; or
- There is debris between the armature and the E-core solenoid assembly.

## Valve Travel

In the absence of elaborate flow test apparatus, a fair check of flow capacity can be inferred from valve travel.

Reset the power supply used in the previous test to a 5 A current limit.

With no pressure applied to the SOGAV valve, turn the switch ON and quickly reduce the current to 1 A (the valve can be continually operated at 1 A without overheating).

Using a depth micrometer or dial indicator, measure the distance from the SOGAV valve's base flange down to the face of the moving metering plate. Then de-energize the solenoid assembly (turn switch OFF) and repeat the measurement. The difference in measurements (travel) should be 0.38 to 0.43 mm (0.015 to 0.017 inch).

The depth micrometer or dial indicator should have a stem with a diameter less than 3 mm. The lapped face of the moving metering plate can be accessed by inserting the stem through one of the outlet holes in the lower stop/metering plate. The stem must also pass through a face groove in the lower stop/metering plate and contact the face of the moving metering plate.

If the travel is less than 0.38 mm, debris is probably present between the moving metering plate and the upper plate or between the armature and E-core solenoid assembly. If the travel is greater than 0.43 mm, some wear probably exists and the valve should be disassembled and the parts evaluated.

## Comments

If the SOGAV valve passes the tests above, there should be no reason to disassemble it. The problem most likely lies elsewhere. In addition to suspecting the electronic controls (outside the scope of this manual), the following possibilities should be considered:

- Does pressure difference ( $\Delta P$ ) across the valve exceed 200 kPa/2.0 bar? This will prevent valve pull-in.
- Are the cables and connectors in good condition? Each lead should have less than 0.4  $\Omega$  resistance. Have the cables been burnt? Are there intermittent connections at the connectors? Are the connectors tight?

## Disassembly

### **WARNING**

The beveled retaining ring (Ref 04144-10 below) is manufactured from beryllium copper. Do not machine, grind, cut, or physically modify in any way. Beryllium particulate (dust, mist, fume, fragments, particles, and/or powder) that could result from machining, grinding, cutting, or physically modifying the retaining ring can be a health hazard (see Material Safety Data Sheet). Beryllium copper in solid form and as contained in finished products (in this case, the unmodified retaining ring) presents no special health risks.

Refer to the appropriate SOGAV exploded assembly (Figures 5-1, 5-2, or 5-3).

Do not attempt to remove the receptacle from the E-core solenoid assembly. The back side of the receptacle is potted and attempts to remove the receptacle will damage the potting and coil lead wires.

1. Using a 3 mm Allen wrench, remove the E-core solenoid assembly from the main SOGAV housing.
2. Using the appropriate retaining ring pliers, remove the beveled retaining ring that holds the metering plates into the SOGAV housing. **If worn or damaged, discard and replace with new retaining ring. Do not machine, grind, cut, or physically modify the beveled retaining ring in any way.** Gently press on the armature to remove the metering plates out of their bore in the SOGAV housing. Some resistance will be felt due to the O-ring. Remove the O-ring after the lower stop/metering plate is removed, but before removing the upper plate. This will prevent damaging the O-ring with the upper plate.
3. Use extreme care to avoid damaging the critical valve face surfaces.
4. Use an 11 mm open end wrench and a 5 mm Allen wrench to remove the M6x16 stainless steel socket head cap screw holding the armature to the moving metering plate. The armature stem has flats for the wrench. Never apply torque to the screw without holding the armature with the 11 mm wrench. This can damage the springs. Never grip the large diameter of the armature with pliers.
5. Using a twisting motion, carefully remove the springs that are snapped into the seats in the moving metering plate.
6. Clean all parts using care to not to damage the critical valve (face) surfaces.

## Evaluation

1. Inspect the two O-rings. In particular, look for shearing of the O-ring used in the vicinity of the lower stop/metering plate. Discard if these are damaged.
2. Inspect the springs closely. Use a microscope or magnifying glass. Look for wear (flattening) of the wire between the two dead end coils on each end of the spring. If this wear appears to exceed approximately 10% of the wire's original diameter, the springs should be replaced.
3. A much better evaluation can be made using a spring checker (if available). Compress each spring to a length of 6.75 mm (0.266 inch). If the force is less than 8.32 N (1.87 lb), the spring should be replaced.
4. Generally speaking, if the valve is known to have several thousand hours of operation, the springs should be replaced.
5. Inspect the valve contact surfaces on both the moving metering plate and the lower stop/metering plate. The metering plates should be replaced (or factory reconditioned) if ridges exist in excess of 15  $\mu\text{m}$  (0.0006 inch) at the edges of the polished contact surfaces.
6. Before reassembly, gently lap the metering plate contact faces using a flat polishing stone. Concentrate only on removing nicks, local damage, and mineral deposits. Do not attempt to remove substantial material. Only machine lapping can correct out-of-flatness conditions to the precision level necessary for good sealing.
7. Inspect the SOGAV housing and upper plate for obvious damage. Note that the SOGAV housing, upper plate, and armature are a matched assembly. If any one of these parts requires replacement, the whole matched assembly must be replaced.
8. If the E-core solenoid assembly was found to be bad during the previous troubleshooting tests, discard and procure a replacement. This is a potted assembly and is not serviceable.
9. Inspect the beveled retaining ring for wear, cracks or other non-conformances. **If worn or damaged, discard and replace with new retaining ring. Do not machine, grind, cut, or physically modify the beveled retaining ring in any way.**

## Assembly

1. Discard any parts known to be defective and procure replacements.
2. Clean out the Loctite residue in the armature by using a wire brush. Also, clean any Loctite residue from the small end of the armature, and the spring seat side of the moving metering plate. The stainless steel socket head cap screw will be replaced later.

### NOTICE

Do not use a tap to clean the armature threads.

3. After all parts are thoroughly cleaned, carefully snap the springs into the seats in the moving metering plate using a twisting motion. Insert the non-colored end of the spring into the seat in the moving metering plate (if the blue color marking is missing from the spring, carefully measure end coil outside diameters on each end of the spring with a micrometer and insert the LARGER end of the spring into the seat in the moving metering plate). Assure that the springs sit thoroughly against the bottom of the seats.
4. After all springs are installed, double check that the blue end of every spring faces outward and that all springs are thoroughly seated in the bottom of the seats in moving metering plates.
5. Replace the stainless steel socket head cap screw with a new screw. Thoroughly clean and degrease the threads in the armature. No oily residue must be present.
6. Seat the upper plate over the moving metering plate so that the springs engage the spring seats in the upper plate. Apply high strength Loctite (#271) to the threads of the stainless steel socket head cap screw and use it to install the armature to the moving metering plate. Use an 11 mm open end wrench and a 5 mm Allen wrench socket to torque the M6 socket head cap screw to between 9.7 and 10.85 N·m (86 and 96 lb-in). **Do not use Loctite if bolt has patch lock.**
7. Insert the assembly (consisting of the armature, springs, moving metering plate, upper plate, and screw) into the housing making sure to align the pilot hole in the upper plate with the roll pin in the bottom of the bore in the SOGAV housing.
8. Install the O-ring into its groove in the bore in the housing. Lubricate well with petroleum jelly or a suitable O-ring lubricant.
9. Install the lower stop/metering plate and gently press through the O-ring, being careful not to damage the O-ring.
10. Using suitable retaining ring pliers, install the retaining ring with the beveled edge outward. Using a pin punch, tap the center of the retaining ring first (radially outward), then tap the ends (radially outward), in order to thoroughly seat the ring in the groove. Do not use excessive striking force when seating the retaining ring as valve performance can be adversely affected. **If worn or damaged, discard and replace with new retaining ring. Do not machine, grind, cut, or physically modify the beveled retaining ring in any way.**
11. Using a depth micrometer, measure the depth of the armature below the upper surface of the SOGAV housing. Measure in multiple locations. This depth should not vary by more than 25  $\mu\text{m}$  (0.001 inch). The depth should lie between 0.43 mm and 0.51 mm (0.017 and 0.020 inch).

If these dimensions are not within tolerance, there are three likely causes:

1. There is contamination either between:
  - the upper plate and the bottom of the bore in the SOGAV housing, or
  - the moving metering plate and the lower stop/metering plate.
2. The springs are not properly seated in their pockets.
3. The retaining ring is not properly installed.



12. Finally, install the E-core solenoid assembly using the O-ring and 45 mm long M4 screws. Using a 3 mm Allen wrench socket, torque the screws evenly to 3.4–3.6 N·m (30–32 lb-in).

## Final Comments

The final step is to repeat the Troubleshooting tests in order to verify SOGAV valve function prior to installing on the engine. Make sure to give the Loctite a minimum of one hour to cure before cycling the SOGAV valve.

## Parts List for SOGAV 43

(Figure 5-1)

04144-1	Socket Head Cap Screw (M4x45) .....	4
04144-2	Solenoid Assembly—E-core .....	1
04144-3	Preformed Packing (O-ring).....	1
04144-4	SOGAV Housing .....	1
04144-4A	E-core Armature .....	1
04144-4B	Upper Plate .....	1
04144-5	Metering Plate Loading Spring .....	6
04144-6	Moving Metering Plate .....	1
04144-7	Socket Head Cap Screw (M6x16) .....	1
04144-8	Preformed Packing (O-ring).....	1
04144-9	Lower Stop/Metering Plate .....	1
04144-10	Beveled Retaining Ring .....	1

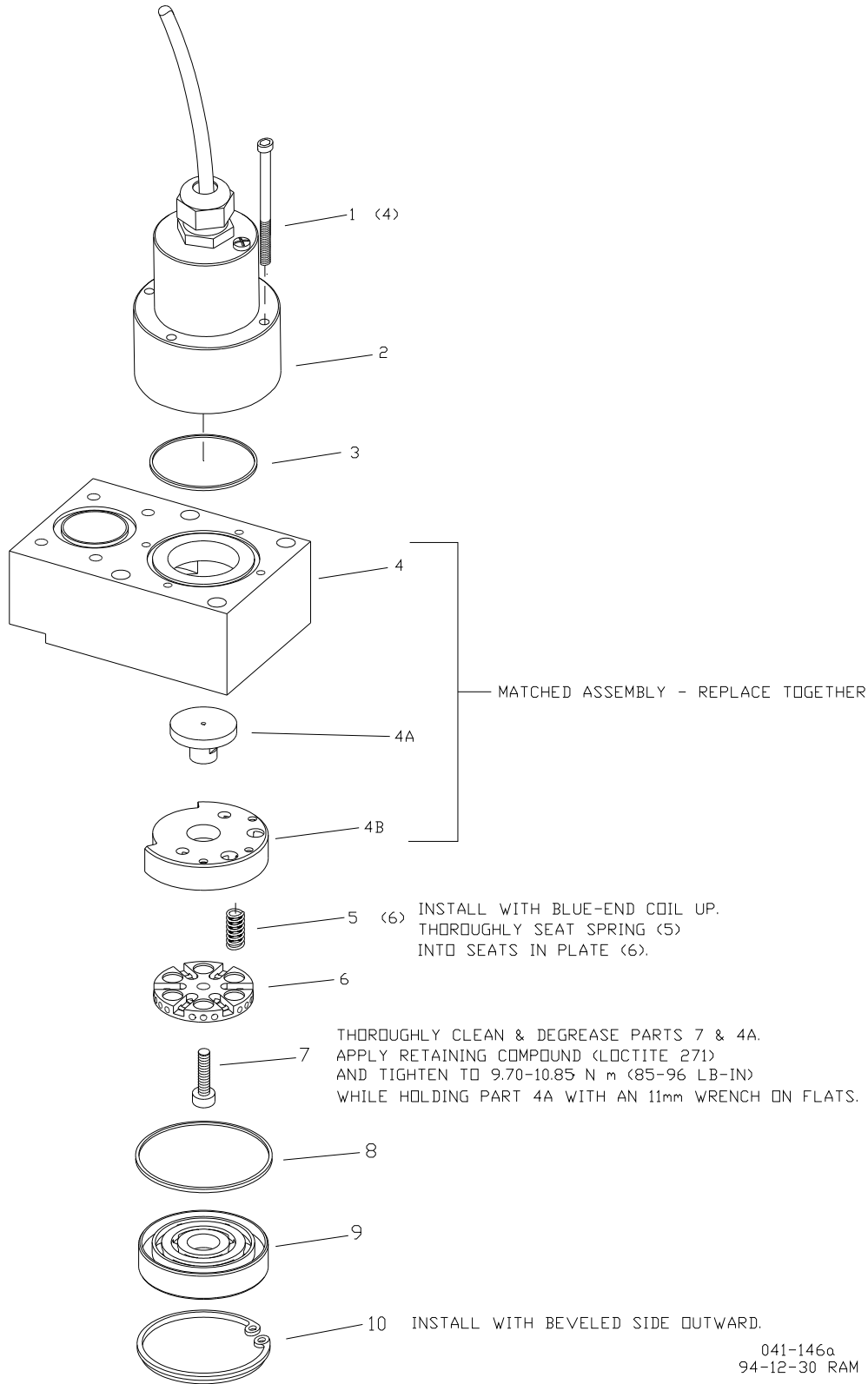


Figure 5-1. SOGAV 43 Exploded Assembly

# Chapter 6. Specification

## Construction

All parts exposed to the gas are resistant to corrosion and stress corrosion cracking (a problem associated with hydrogen sulfides, which are sometimes present in natural gas).

## Environment

Operating Temperature:

–20 to +105 °C (–4 to +221 °F)

–20 to +93 °C (–4 to +199 °F) for versions using AGRO EMC grounded cable glands

Storage Temperature:

–40 to +70 °C (–40 to +158 °F)

Vibration Qualification Test:

Test Method: MIL-STD-810C

Method: 514.2

Procedure: I

Curve: L (20 g – Figure 514.2-2)

Resonance Search: 5–2000 Hz

Dwell Endurance: 30 minutes at each major resonance in each axis

Sweep Endurance: 3 hours minus the dwell time in each axis

Operating Humidity:

≤ 85% relative humidity, non-condensing

Storage Humidity:

≤ 90% relative humidity, non-condensing

Humidity, Salt Spray, Pressure Wash Resistance, etc:

The unit withstands exposure to pressure washing, salt spray, etc., without adverse corrosion or infiltration.

Ingress Protection:

IP66

Maximum Altitude:

4000 m

Fuel Gas Specifications:

NG = Natural Gas

CMM = Coal Mine Ventilation Gas

CBM = Coal Bed Methane

**Fuel Gas Specifications**

		Gas				
		NG	CMM	CBM	Biogas	Associated gas
Lower heating value, min (LHV <sub>v</sub> )	MJ / Nm <sup>3</sup>	<b>24</b>	<b>17</b>	<b>24</b>	<b>17</b>	<b>24</b>
Methane number, min (MN)		<b>Engine specific</b>	<b>90</b>	<b>Engine specific</b>	<b>90</b>	<b>30</b>
Methane content, min CH <sub>4</sub>	Vol-%	60	50	60	50	40
Carbon dioxide, max	Vol-%	30	5	30	60	30
Carbon monoxide, max	Vol-%					
Hydrogen sulphide, max H <sub>2</sub> S	Vol-%	0,05	0,05	0,05	0,05	0,05
Hydrogen, max H <sub>2</sub>	Vol-%	5	5	5	5	5
Condensate / Moisture		Not allowed	Not allowed	Not allowed	Not allowed	Not allowed
Ammonia, max	Mg/Nm <sub>3</sub>	40	40	40	40	40
Chlorine + Fluorines, max	Mg/Nm <sub>3</sub>	60	60	60	60	60
Silicon, max	Mg/Nm <sub>3</sub>				50	
Particles or solids, max content	Mg/Nm <sub>3</sub>	50	50	50	50	50
Particles or solids, max size	µm	5	5	5	5	5

## Performance

**Response (assumes the use of a Woodward In-Pulse™ control)** is dependent on current wave form and the pressure differential. Typical 90 V In-Pulse II and current wave form results below:

Time to full open after signal on:  
0.0020 second max

Time to full closed after signal off:  
0.0020 second max

### **Steady State Flow Rate (with valve in full open condition)**

See the flow equation defined previously in the sizing section.

### **Maximum Leakage When Closed**

Less than 10 SCFH (0.17 SCFM) tested with 22 psia air at the inlet, 12.3 psia air at the outlet at 68 °F

Less than 0.28 m<sup>3</sup>/h (0.0048 m<sup>3</sup>/min) tested with 152 kPa air at the inlet, 84.8 kPa air at the outlet at 20 °F

### **Filtration Required**

5 µm absolute max particle size

### **Coil Heat Dissipation**

8 W (maximum)

### **Expected Maximum Gas Supply Pressure (P1)** (not a limiting specification)

500 kPa/5 bar absolute (72.5 psi absolute)

### **Expected Maximum Air Manifold Pressure (P2)** (not a limiting specification)

300 kPa/3.0 bar absolute (43.5 psi absolute)

### **Maximum Gas Manifold to Air Manifold Pressure Difference**

(the limiting specification: P1 – P2)

200 kPa/2.0 bar (29.0 psi)

### **Maximum Backfire Pressure Spike** (without back-flowing through valve)

50 kPa/0.5 bar (7 psi) above the current gas manifold pressure

Exceeding this by more than 2 bar (29 psi) may damage the valve.

### **Expected Maximum Gas Supply Temperature**

80 °C (176 °F)

# Chapter 7.

## Service Options

### Product Service 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 and 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 Engine Retrofitter (RER)** is an independent company that does retrofits and upgrades on reciprocating gas engines and dual-fuel conversions, and can provide the full line of Woodward systems and components for the retrofits and overhauls, emission compliance upgrades, long term service contracts, emergency repairs, etc.
- 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.

You can locate your nearest Woodward distributor, AISF, RER, or RTR on our website at:

[www.woodward.com/directory.aspx](http://www.woodward.com/directory.aspx)

## Woodward Factory Servicing 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).



## How to Contact Woodward

For assistance, call one of the following Woodward facilities to obtain the address and phone number of the facility nearest your location where you will be able to get information and service.

### Electrical Power Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany	+49 (0) 21 52 14 51
India	+91 (129) 4097100
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
Poland	+48 12 295 13 00
United States	+1 (970) 482-5811

### Engine Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany	+49 (711) 78954-0
India	+91 (129) 4097100
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
The Netherlands	+31 (23) 5661111
United States	+1 (970) 482-5811

### Turbine Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
India	+91 (129) 4097100
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

You can also locate your nearest Woodward distributor or service facility on our website at:

[www.woodward.com/directory.aspx](http://www.woodward.com/directory.aspx)

## Technical Assistance

If you need to telephone for technical assistance, you will need to provide the following information. Please write it down here before phoning:

Your Name \_\_\_\_\_

Site Location \_\_\_\_\_

Phone Number \_\_\_\_\_

Fax Number \_\_\_\_\_

---

Engine/Turbine Model Number \_\_\_\_\_

Manufacturer \_\_\_\_\_

Number of Cylinders (if applicable) \_\_\_\_\_

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

Rating \_\_\_\_\_

Application \_\_\_\_\_

---

**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 \_\_\_\_\_

*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.*

# Appendix.

## Interpreting Solenoid Ratings

### Procedure for interpreting the “Equivalent Average Direct Current” (EADC) and “Equivalent Average Power” (EAP) ratings of Woodward Solenoids

#### Introduction

Woodward solenoids are labeled with maximum rated values of input current and input power. These input ratings must not be exceeded during continuous solenoid operation, to prevent exceeding a prescribed coil temperature rise at the maximum rated ambient operating temperature. These solenoids must be driven by specially designed current limiting drivers, providing periodic, two-tier current waveforms (see example waveform in Figure A-1).

The first tier is the relatively large “pull-in” current pulse. The second tier is the lesser “hold-in” current pulse. Solenoid applications vary in regard to the current waveform required to achieve the desired solenoid performance, considering the device being actuated by the solenoid, the frequency of solenoid operation, etc. The parameters “Equivalent Average Direct Current” (EADC) and “Equivalent Average Power” (EAP) are used as ratings for these solenoids to achieve a rating procedure that can be applied to varying solenoid applications.

#### Equivalent Average Direct Current (EADC)

Equivalent Average Direct Current (EADC) equates to the equivalent dc current (I) that can be continuously applied to a solenoid, having the highest expected coil resistance and operating at the maximum rated ambient temperature, while not exceeding the rated solenoid coil temperature rise. The EADC rating can be related to various periodic, two-tier solenoid current waveforms used to drive the solenoids.

The average area under an “ $I^2$  vs. time” solenoid current waveform plot depicts the solenoid coil heating effect. If the area under the “ $I^2$  vs. time” waveform of a two-tier current waveform is equal to, or less than, the rated EADC of the solenoid, the two-tier waveform is acceptable (it will not overheat the coil) if the solenoid is operated at maximum rated ambient temperature. This approach is applied, in detail, as follows:

1. A solenoid application is established and a suitable, worst case, two-tier current waveform is defined, in terms of the parameters defined in Figure A-1, that achieve the desired solenoid dynamic performance.
2. The current waveform parameters are applied to the EADC equation as shown in the example calculation of Figure A-1. The resulting calculated EADC value must not exceed the solenoid’s rated EADC value, indicated on the solenoid nameplate.
3. The above analysis must include the “worst case” operating condition, which is the highest expected “duty cycle” waveform. The highest “duty cycle” waveform is a waveform whereby the duration of the current “ON” time, relative to the total time between periodic current waveform cycles, is the greatest.

## Equivalent Average Power (EAP)

While EADC, as discussed above, is the most accurate and preferred parameter for determining suitability of two-tier waveforms, Equivalent Average Power (EAP) is another parameter that defines solenoid input limitations.

Equivalent Average Power (EAP) equates to the equivalent input power that can be continuously applied to a respective solenoid, operating at the maximum rated ambient temperature, without overheating the solenoid coil. The EAP rating can be related to typical periodic two-tier solenoid current waveforms used to drive the solenoids.

The product of (average coil current)<sup>2</sup> and coil resistance ( $I^2R$ ) describes the solenoid coil heating effect (input power). For a given set of conditions, if the EADC (amps) of a two-tier current waveform is known, and if the associated solenoid coil resistance  $R_c$  (ohms) is known, the associated EAP can be calculated by the relationship:

$$\text{EAP} = \text{EADC}^2 * R_c \text{ (watts)}$$

If the calculated EAP of a two-tier current waveform is equal to, or less than, the rated EAP of the solenoid, the two-tier waveform is acceptable in that it will not overheat the solenoid coil when operating at maximum rated ambient temperature. This approach is applied, in detail, as follows:

1. The value of EADC is calculated for a given two-tier current waveform as described above.
2. The highest expected nominal solenoid coil resistance ( $R_c \text{ max}$ ), for the object solenoid, at the rated coil temperature (including temperature rise) is determined from Table A-1.
3. Entering the calculated EADC value and listed coil resistance into the above equation will result in the EAP value for a given solenoid part number.

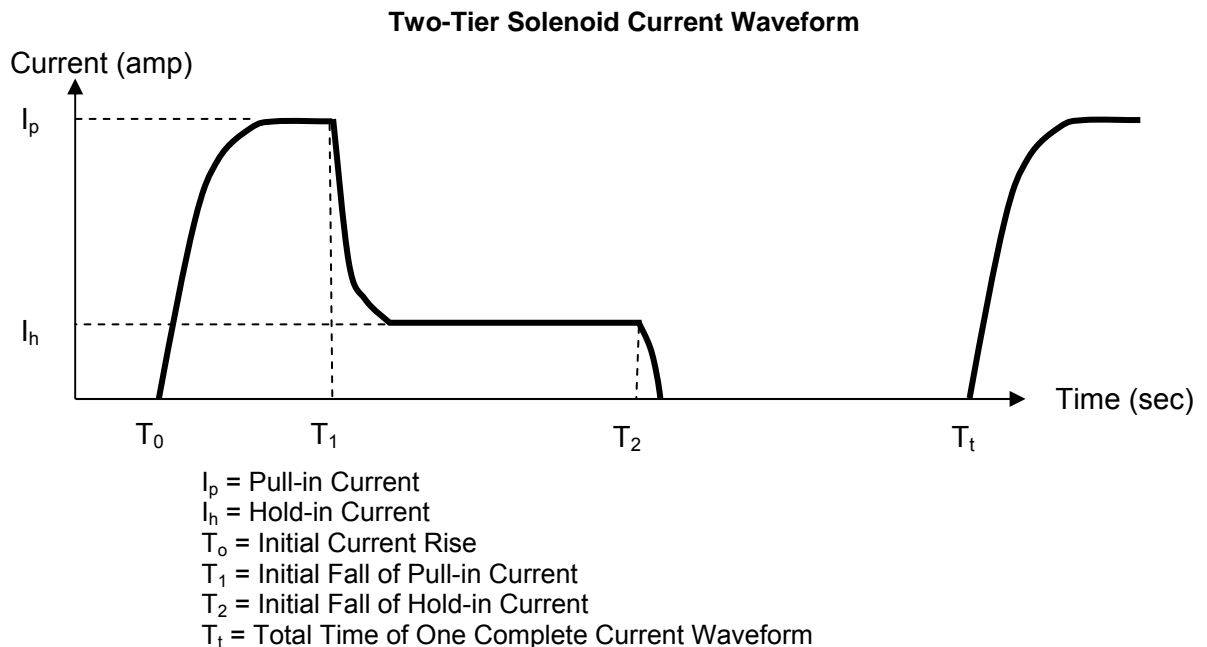


Figure A-1. Two Tier Current Waveform Parameters

**EXAMPLE CALCULATION**—Equivalent Average Direct Current (EADC)

Let:  $T_0 = 0.0 \text{ s}$   $I_p = 10 \text{ A}$   
 $T_1 = 0.002 \text{ s}$   $I_h = 2 \text{ A}$   
 $T_2 = 0.020 \text{ s}$   
 $T_t = 0.100 \text{ s}$

$$\text{EADC} = [ \{ (T_1 - T_0) * (I_p)^2 + (T_2 - T_1) * (I_h)^2 \} / (T_t - T_0) ]^{0.5} \text{ (amps)}$$

$$\text{EADC} = [ \{ (0.002 * (10)^2) + \{ 0.018 * (2)^2 \} / \{ 0.100 \} \} ]^{0.5} = [ (0.2 + 0.072) / (0.100) ]^{0.5}$$

$$\text{EADC} = 1.649 \text{ A}$$

**IMPORTANT** Due to assumptions of current waveform rise times, fall times, and other waveform parameters, the EADC value obtained from the equation shown above typically results in a conservative value. A more precise method may be used to calculate the EADC value of an application's current waveform if the method shown above results in an EADC value at or slightly over the solenoid's rated EADC value. Contact Woodward for more information or assistance if needed with EADC calculations for a particular application.


Solenoid Part No.	Coil Resistance (max) (ohms)
5852-115.....	2.27
5852-116.....	3.08
5852-148.....	2.27
5852-161.....	2.27
5852-201.....	2.27
5852-235.....	2.27

Table A-1. Maximum Solenoid Coil Resistance (Rc) Values for Woodward SOGAV 43 Solenoids

**IMPORTANT** Coil resistance values listed represent the expected coil resistance when the coil has reached its maximum allowed operating temperature. In each case, the resistance, at a coil temperature of 21 °C, is assumed to be the maximum value allowed by the coil design specification.




## DECLARATION OF CONFORMITY

**Manufacturer's Name:** WOODWARD GOVERNOR COMPANY (WGC)  
**Manufacturer's Address:** 1000 E. Drake Rd.  
Fort Collins, CO, USA, 80525  
**Model Name(s)/Number(s):** 110 Newton, 400 Newton, 800 Newton, and 1200 Newton Solenoids  
5852-118, 5852-116, 5852-173, 5852-125 and similar  
**Conformance to Directive(s):** 2006/95/EC COUNCIL DIRECTIVE of 12 December 2006 on the  
harmonization of the laws of Member States relating to electrical  
equipment designed for use within certain voltage limits.  
  
94/9/EC COUNCIL DIRECTIVE of 23 March 1994 on the  
approximation of the laws of the Member States concerning  
equipment and protective systems intended for use in potentially  
explosive atmospheres.  
**Marking(s):**  Category 3 Group II G, EEx m II T4 X  
**Applicable Standards:** EN61010-1, (2001): Safety requirements for electrical equipment for  
measurement, control, and laboratory use - Part 1: General  
Requirements  
EN50028, (1987): Electrical apparatus for potentially explosive  
atmospheres. Encapsulation 'm'

---

We, the undersigned, hereby declare that the equipment specified above conforms to the above Directive(s).

**MANUFACTURER**

  
\_\_\_\_\_  
**Signature**

**Suhail Horan**  
\_\_\_\_\_  
**Full Name**

**Quality Manager**  
\_\_\_\_\_  
**Position**

**WGC, Fort Collins, CO, USA**  
\_\_\_\_\_  
**Place**

**19 November 2009**  
\_\_\_\_\_  
**Date**

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

**Manufacturer's Name:** WOODWARD GOVERNOR COMPANY (WGC)

**Manufacturer's Address:** 1000 E. Drake Rd.                      3800 N. Wilson Ave.  
Fort Collins, CO, USA, 80525                      Loveland, CO, USA 80538

**Model Names:** SOGAV 2.2, 36, 43, 105, 245, and 250

**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.

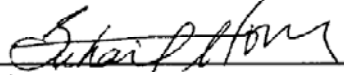
The person authorized to compile the technical documentation:

Name: Ralf Friedrich, Group Director, Quality, EPS  
Address: Woodward GmbH, Handwerkstraße 29, 70565 Stuttgart, Germany

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 Governor Company 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

Suhail Horan  
\_\_\_\_\_  
Full Name

Quality Manager  
\_\_\_\_\_  
Position

WGC, Fort Collins, CO, USA  
\_\_\_\_\_  
Place

21 - MAY - 2010  
\_\_\_\_\_  
Date

We appreciate your comments about the content of our publications.

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

Please reference publication **04144AB**.



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