8402

Rotary Fuel Valve and Position Controller for Gas Turbines

Installation and Operation Manual

Doc No: OMM840200032
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Section 1

Introduction

Contents

1.1 Document Conventions

The header of each page contains the Section or Appendix title and the page number. The footers contain the document number (OMM840200032), revision and date (Rev 8 – Aug 2012).

Acronyms are defined in the sections of this manual that discuss the corresponding subjects, by placing them in parentheses following the spelled-out terms they represent. As an example, a three-letter acronym (TLA) is a way to represent a three-word subject by combining and capitalizing the initial letters of those three words. Most are also listed under Symbols and Acronyms on page 10.

1.2 Safety

Attention may be drawn to information of special importance by using one of the following structures:

WARNING

A Warning identifies a step in a procedure that can cause injury to people. The warning identifies the hazard and lists the precautions that must be taken before the next step of the procedure is done.

CAUTION

A Caution identifies a step in a procedure that can cause damage to equipment. The caution identifies the hazard and lists the precautions that must be taken before the next step of the procedure is done.

Note

A Note contains more information that may be useful to the Operator and can appear before or after a procedure step.

1.2.1 Warning Symbols

The appearance of this electrical hazard warning symbol on AMOT equipment or the word Warning appearing in this manual indicates dangerously-high voltages are present inside its enclosure. To reduce the risk of fire or electrical shock, do not open the enclosure or attempt to access areas where you are not instructed to do so. Refer all servicing to qualified service personnel.

The appearance of this user caution symbol on AMOT equipment or the word Caution appearing in this manual indicates damage to the equipment or injury to the operator could occur if operational procedures are not followed. To reduce such risks, follow all procedures or steps as instructed.

1.3 Document Scope

This manual contains the information to install, configure and maintain the 8402 Rotary Fuel Valve System. It is divided into Sections as follows:

CAUTION

The configuration and operation of the Rotary Fuel Valve and Controller depends on the specific application and installation. This manual does not reflect specific configuration and operational settings for any particular application.

Refer to job-specific documentation for configuration and operational information, settings, and notes on a particular application.

Section 1	Introduction
Section 2	Product Description
Section 3	Product Information
Section 4	Installation
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Appendix A	Specifications and Approvals
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Appendix D	Component Identification
Appendix E	Mounting Details
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1.4 Product Support

All necessary settings are described in this manual. If any difficulties arise during start-up, you are asked not to carry out any unauthorised actions on the unit. You could endanger your rights under the equipment warranty.

For rapid spares and service support, call the telephone number listed on the back cover of this manual.

1.5 Symbols and Acronyms

A	amperes
ACT	action
ANSI	American National Standards Institute
API	American Petroleum Institute
Assy.	assembly
AUTO	automatic
AWG	American Wire Gage
B.C.	between centres
BCD	binary coded decimal
° C	degrees Celsius
CE	compliant with European Union Safety Directive
CHGND	chassis ground
CHK	check
CL	closed
CONFIG	configure
CSA	Canadian Standards Association
CTRL	control
Cv	flow coefficient
DC	direct current
dc	direct current
DEG	degrees
°	degrees (angle or temperature)
DGND	digital ground
Dia	diameter
ø	diameter
DIP	dual inline package
DIR	direction
E	encoder
EEPROM	electrically-erasable programmable read-only memory

ER	error
ERR	error
ESC	Escape
° F	degrees Fahrenheit
ft	feet
GND	ground
hz	hertz
I.D.	inside diameter
IEC	International Electrotechnical Commission
in	inches
kg	kilograms
lb	pounds
LCD	liquid crystal display
LED	light emitting diode
lbf ft	pounds force feet
m	meters
M	motor
mA	milliamperes
MAN	manual
MAX	maximum
MIN	minimum
ms	milliseconds
MTBF	mean time between failures
MTR	motor
N/C	no connection
NEMA	National Electrical Manufacturers Association
Nm	Newton-meters
NO.	number
NPT	National Standard Pipe (thread) Taper
O.D.	outside diameter

OP	open
PC	personal computer
PCB	printed circuit board
PID	Proportional-Integral-Derivative control algorithm
POS	position
ppm	parts per million
psi	pounds per square inch
PTFE	polytetrafluoroethylene (Teflon ®)
PWR	power
RET	return
Rev	revision
RF	raised face
RHF	revision level
RMA	Returned Material Authorization
SEL	Select
SER.	serial
SP	set point
SS	stainless steel
Std	standard
TYP	typical

Section 2

Product Description

Contents

This section describes the Rotary Fuel Valve system.

The Rotary Fuel Valve system precisely controls the flow of fuel gas to the combustion chamber of a gas turbine. A single fuel valve may be used to control start-up, ignition flow, idle flows, and for limiting control. This allows for considerable simplification when retrofitting existing fuel skids where two control valves were previously used.

WARNING

AMOT requires the use of a traditional skid design that uses two independent block/shutoff valves ("double block and bleed") in series with the AMOT gas control valve. The 4280 fuel valve will flow (leak) up to 0.5% of rated flow in the closed position.

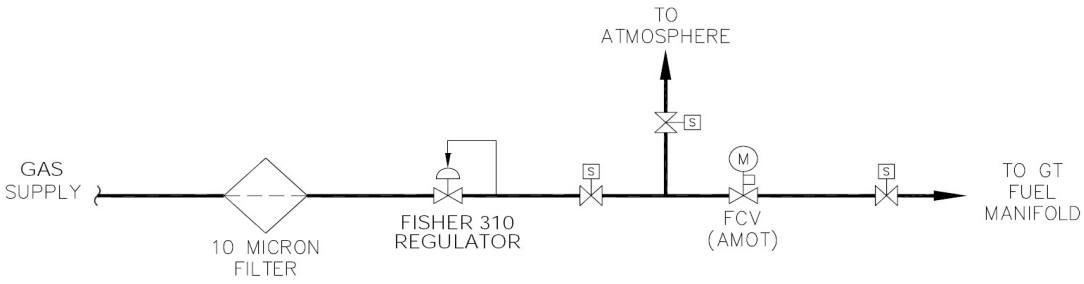


Fig 1 Typical Double Block and Bleed Fuel Skid Design

The fuel valve is available in 2-inch (50 mm) and 3-inch (75 mm) ANSI flange sizes to provide precise control for a range of gas turbine applications. Selection of the fuel valve size and flow coefficient (Cv) is based on the specific site, and on turbine gas flows and pressures. The flow coefficients for each fuel valve size are listed in Table 1.

Table 1 Flow Coefficients (Cv) for 2 in and 3 in Fuel Valves

Fuel Valve Size	Flow Coefficient
2-inch	12 Cv
2-inch	25 Cv
2-inch	30 Cv
3-inch	60 Cv
3-inch	90 Cv

The fuel flow characteristics of the valves are approximately linear, as shown in Fig 2. Table 2 gives the numerical data for each Cv curve plotted in Fig 2.

Note

These fuel valves are not designed for tight shut-off, as can be seen in Table 2.

Table 2 Flow Coefficient (Cv) Data

Percent open	Cv = 12	Cv = 25	Cv = 30	Cv = 60
0%	0.1	0.1	0.2	0.2
5%	0.1	0.2	0.3	1.2
11%	0.3	0.4	0.6	3.4
22%	1.0	1.7	2.2	8.5
33%	2.1	3.5	4.6	14.8
44%	3.5	5.8	7.7	22.0
55%	5.4	8.9	11.9	29.9
66%	7.5	12.4	16.5	38.2
77%	10.1	16.7	22.2	45.7
88%	12.5	20.6	27.5	53.0
100%	14.8	24.4	32.6	59.0

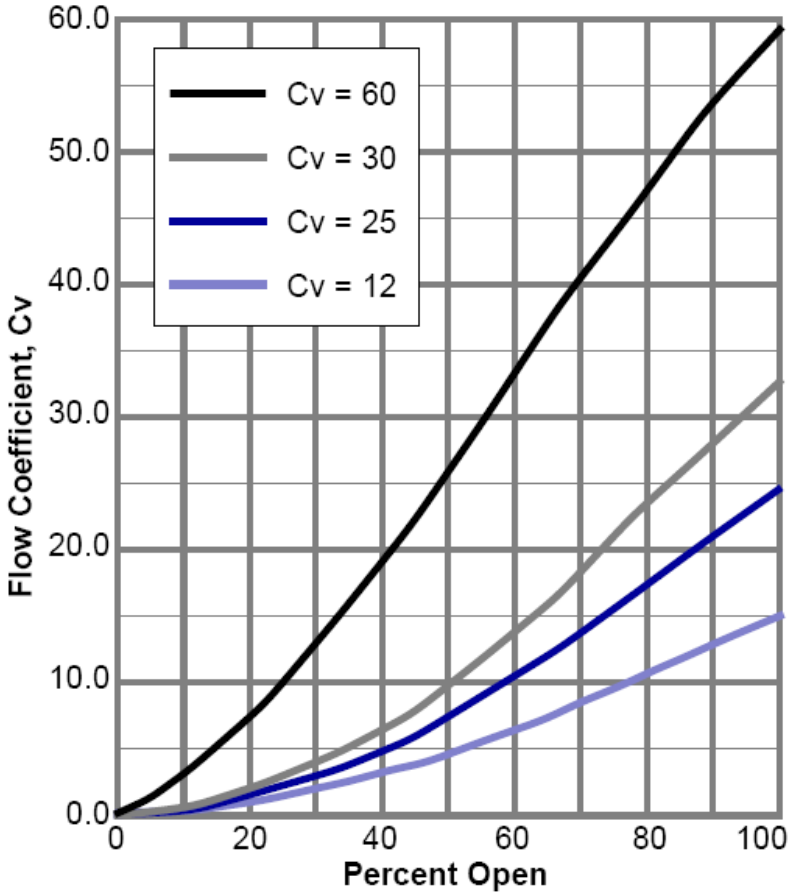


Fig 2 Fuel Valve Flow Characteristic, Model 4280

The Rotary Fuel Valve system consists of the fuel valve (model 4280), the valve actuator, and the controller (model 8412).

2.1 Mechanical Description

The model 4280 fuel valve includes the Rotary Fuel Gas Valve and the Rotary Actuator, as shown in Fig 3. The actuator, yoke, and coupling assemblies are identical for the 2-inch and 3-inch valve sizes.

The fuel valve is a balanced rotary design with precise resolution and flow control across a wide range of turbine operation, from ignition to full power.

The fuel valve body is rated for applications with 1000 psig supply pressure and is designed with standard ANSI Class 600 raised-face (RF) flanges.

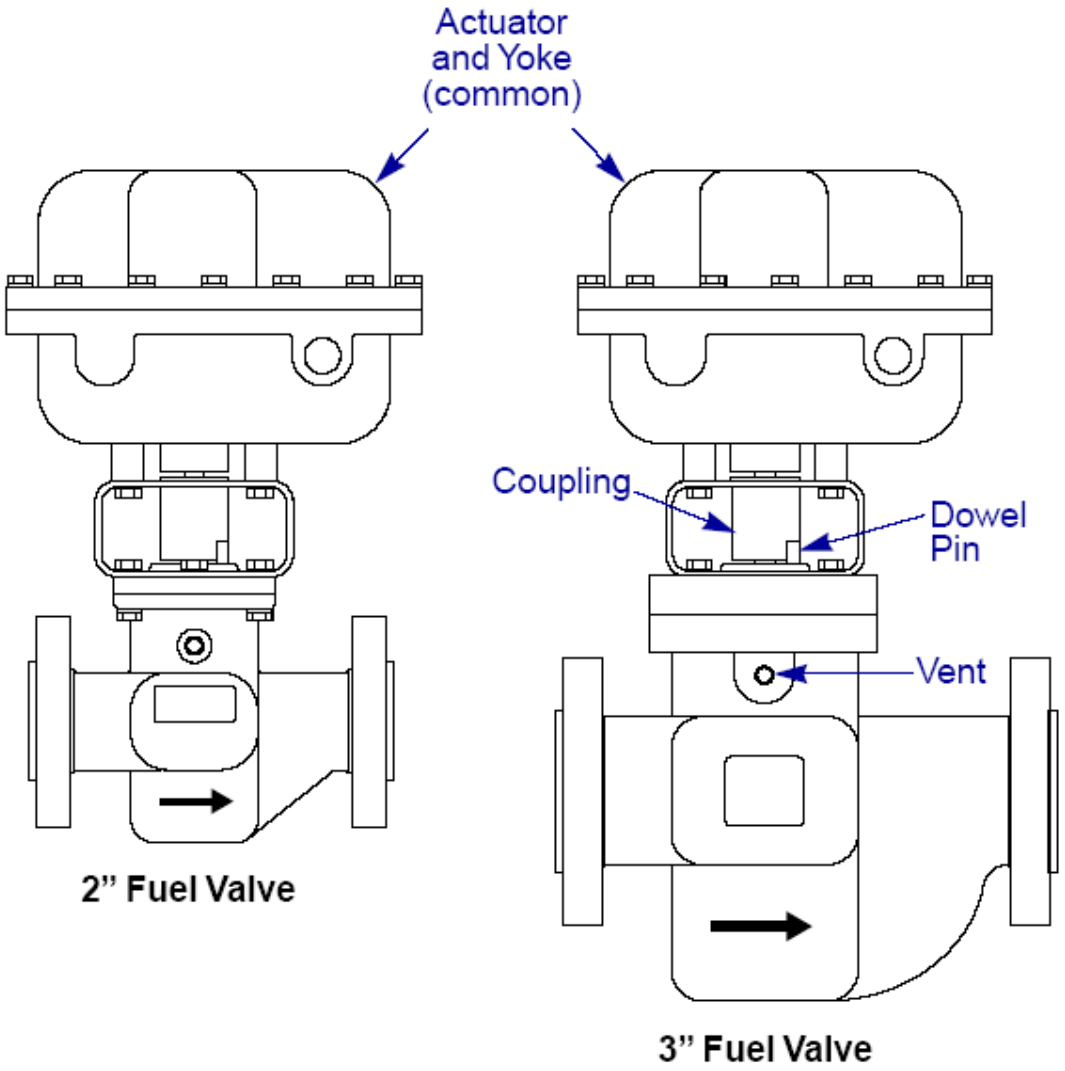


Fig 3 2 in and 3 in Rotary Fuel Valves and Actuator

The common actuator has a digitally controlled stepper motor and drives through a precision spur gear. Position feedback is provided by a digital encoder. The actuator can produce up to 50 Newton metres of torque, and can travel its full rotation of 60° in 250 ms. A specially-configured (non-standard) controller can provide faster operation, if required.

The actuator mechanical stops are located within the actuator head. The fully open position of the fuel valve is reached when the valve actuator is rotated in the clockwise direction to the mechanical stop (while looking down onto the top of the actuator). The fully closed position is reached when the valve actuator is rotated in the counter clockwise direction to the mechanical stop. A position indicator is provided on the coupling to show the approximate position of the fuel valve. Refer to Fuel Valve Position Indicator on page 43 for more information.

The positions of the mechanical stops in the actuator are checked relative to a dowel pin and either a machined slot in the actuator coupling, or an adjustable guide attached to the coupling, depending on the design level of the Fuel Valve (see Product Identification on page 21). Refer to Actuator Mechanical Stop Setup on page 40 for more information.

The actuator enclosure is designed for use in hazardous environments (Class I Division 1, Groups C & D, explosion-proof), and has been certified by CSA.

CAUTION

To prevent ignition of hazardous atmospheres, disconnect from the supply circuit before opening enclosure. Keep tightly closed while circuits are alive.

The actuator is O-ring gasketed and suitable for NEMA Type 4 indoor and outdoor use.

2.2 Electronic Control System

The Model 8412 Controller uses a high-speed microprocessor to control the fuel valve actuator. Each fuel valve size uses the same electronic control system. An EEPROM is provided for storage of the configured parameters.

The controller enclosure is a NEMA 4 design with a sealed door. The enclosure is not intended for outdoor service and must be located in an area classified as safe.

Fig 4 shows the functional control diagram for the fuel valve closed-loop control system.

The control system receives its demand position set point through a 4-20 mA input. This signal is converted to a 12-bit digital value using an analogue-to-digital converter.

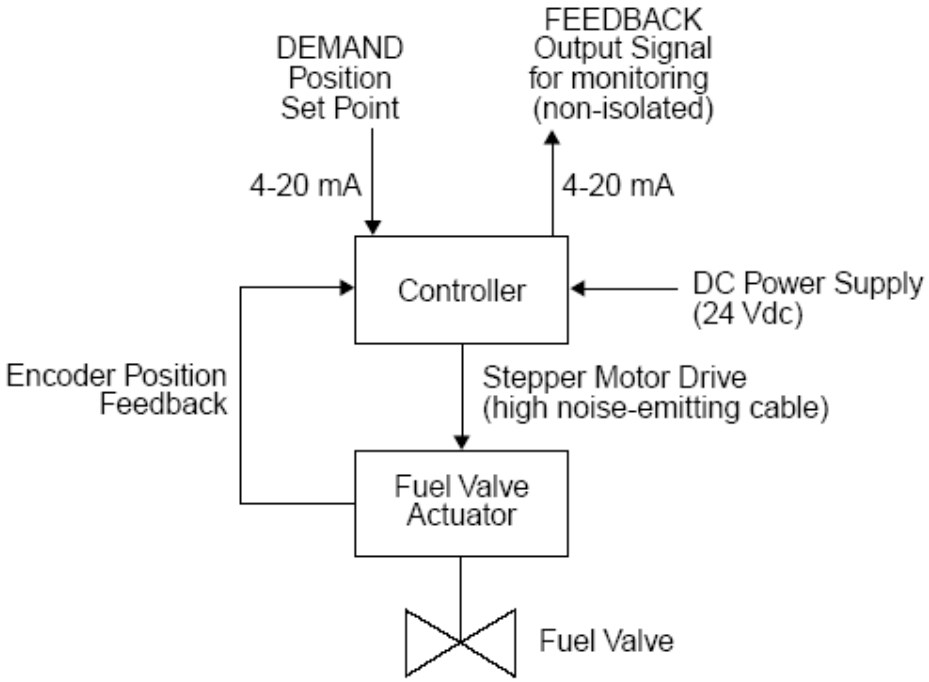


Fig 4 Functional Control Diagram for Fuel Valve System

The control system also receives the current position of the fuel valve signal from a 12-bit absolute optical encoder within the valve actuator, which gives an absolute angular position with a resolution of 0.022°.

Note

Fuel valves with a design level of G or higher (see Product Identification on page 21) may use a new encoder. This new encoder requires the use of a new encoder interface PCB within the Actuator.

The new encoder can be retrofitted into older design levels of the fuel valve. However, this would also require the installation of the new encoder interface PCB into the Actuator.

The new encoder interface PCB can be used with either the old or new encoder.

The controller compares the demand position set point to the current position of the actuator received from the encoder. Using a PID control algorithm, the controller calculates an error signal, and determines the direction and number of motor steps required to move the fuel valve from the current position to the demand set point position. The controller uses an acceleration/deceleration profile that optimizes speed and torque.

The output of the controller (direction and number of motor steps) is passed to the stepper motor drive within the valve actuator, which moves the fuel valve to the commanded position.

A 4-20 mA output feedback signal is also provided by the controller to monitor the fuel valve position.

Note

This output feedback loop is powered by the controller (24 V dc) and is not isolated. It is recommended that the user provide in-line fuses and electrical isolation when using this signal.

The control system is designed to freeze the fuel valve in place if there is a failure of the DC power supply, a failure of the encoder position feedback signal, or if the difference between the demand position set point and the encoder position feedback exceeds 5% for 5 seconds (see RUN Mode on page 60).

A failure of the demand position set point will cause the controller to respond in one of two configurable ways (see Set Point Fail on page 58).

2.3 Controller Status Relays

A SYSTEM FAULT relay is provided to indicate a complete system failure. A SYSTEM ERROR relay is provided to indicate an unusual operating condition. Refer to Controller Status Relays on page 63 for more information.

WARNING

The relay contacts are only suitable for dc voltage. Do not exceed the ratings of the relay contacts, as specified on page 63.

2.4 Specifications

The specifications for all the Rotary Fuel Valve sizes and the Controller are listed in Appendix A.

Section 3

Product Information

Contents

This section provides general information on the Rotary Fuel Valve system, including product identification information, and receiving, inspection, and storage information.

3.1 Product Identification

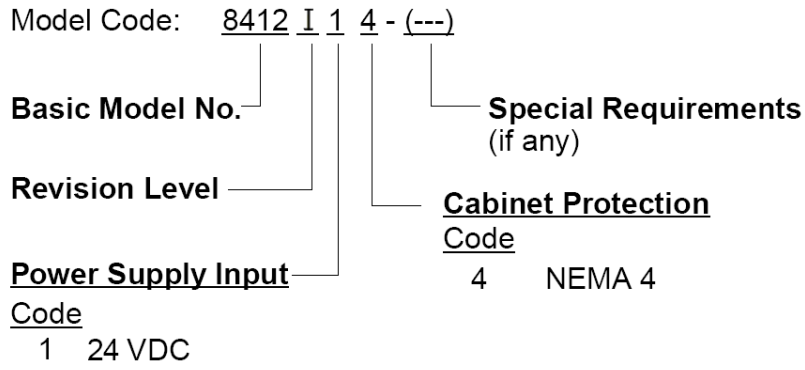
Each component of the Rotary Fuel Valve System, the controller, the actuator, and the valve, includes a product identification label, as described in the following sections.

Note

When ordering parts or requesting information or service assistance, please provide all nameplate and label information.

3.1.1 Controller

A product identification label for the model 8412 Rotary Fuel Valve Controller is affixed to the inside cover of the controller housing. This label provides the model and serial number for the controller:

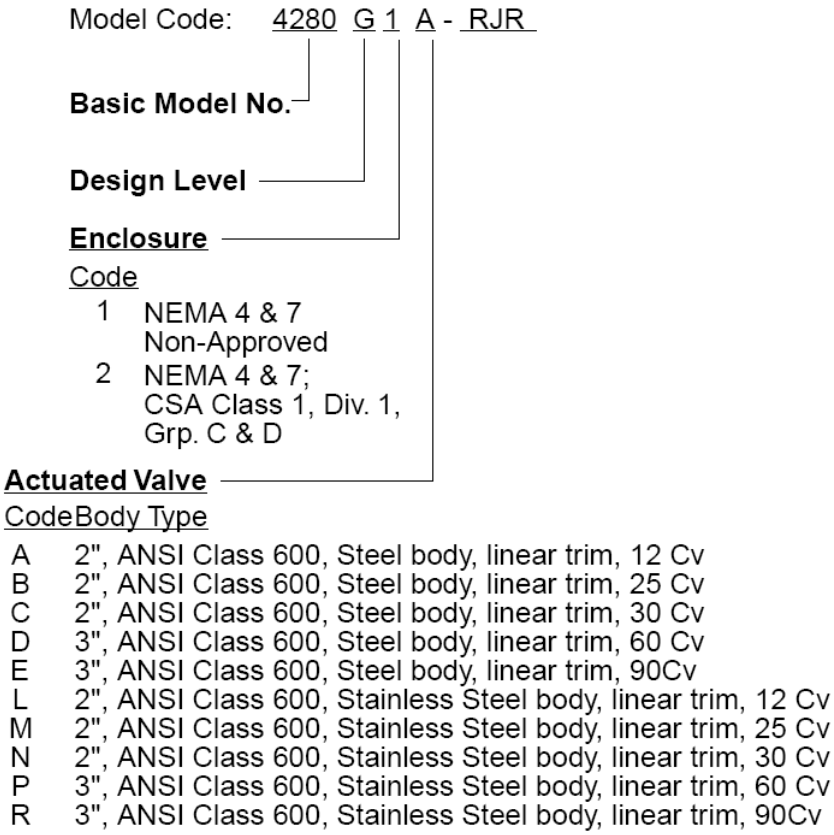


3.1.2 Actuator

A product identification nameplate for the model 4280 Rotary Fuel Valve Actuator is attached to the top of the actuator housing. This plate, bearing the CSA certification mark (see Third-Party Approvals on page 78), provides the model and serial number for the actuator.

3.1.3 Fuel Valve

A product identification nameplate for the model 4280 Rotary Fuel Valve is attached to the valve body. This plate provides the flow coefficient (Cv) for the valve, as well as the model and serial numbers:



3.2 Receiving

Upon receipt, the equipment should be carefully inspected for damage which may have occurred during shipping. Any damage should be immediately reported to the freight carrier and to AMOT.

The fuel valve/actuator and controller are packed in separate crates.

3.3 Inspection

Carefully unpack the equipment taking care to save the shipping carton and any packing material, should it be necessary to return the unit to AMOT. Verify that the items on the packing list agree with the order.

The flow coefficient (Cv) of the fuel valve is specified on the nameplate and should be marked on the outside of the crate.

3.4 Storage

If the actuator will not be installed immediately, it should be stored in a clean, dry, non corrosive environment. The storage temperature for the fuel valve and actuator must not be less than -40° C (-40° F) and not more than 100° C (212° F). The storage temperature for the controller must not be less than -20° C (-4° F) and not more than 70° C (158° F).

3.5 Returning Equipment to AMOT

In the event the fuel valve or controller requires service, contact AMOT at the address on the back page before returning any equipment for repair.

3.6 Ordering Information

Table 3 provides ordering information and part numbers for the components of the Rotary Fuel Valve system.

Table 3 Ordering information

Item	Part No.	Description
Controller	8412I14	24 V dc, NEMA4, export packing
Fuel Valve, 12 Cv	4280G2A-RJR	2 in fuel valve with flange & accessories kit in export packing, CSA
Fuel Valve, 25 Cv	4280G2B-RJR	2 in fuel valve with flange & accessories kit in export packing, CSA
Fuel Valve, 30 Cv	4280G2C-RJR	2 in fuel valve with flange & accessories kit in export packing, CSA
Fuel Valve, 60 Cv	4280G2D-RJR	3 in fuel valve & accessories kit in export packing, CSA
Fuel Valve, 90 Cv	4280G2E-RJR	3 in fuel valve & accessories kit in export packing, CSA
Spare Fuse and Connector Kit	10435X	See Table 4 below.

Table 4 Spare Fuse and Connector Kit (10435X)

Qty	Description
Fuses	
1	100 mA, fast acting, IEC type
1	10 A, fast acting, CSA/UL type
1	2 A, fast acting, CSA/UL type
1	600 mA, Slo-Blo, CSA/UL type
1	8 A, fast acting, CSA/UL type
Field Connectors	
1	Plug for connector, 2-pin, Weidmuller
1	Plug for connector, 3-pin, Weidmuller
1	Plug for connector, 4-pin, Weidmuller
2	Plug for connector, 5-pin, Weidmuller
1	Plug for connector, 6-pin, Weidmuller
1	Plug for connector, 7-pin, Weidmuller
8	Mounting block BB2 for Weidmuller connectors
4	Mounting block BB6R for Weidmuller connectors
7	Label strip for Weidmuller connectors
Fuel Valve Cable Entry	
1	Cable entry gland (CG5075)
1	Cable entry locking nut
1	Neoprene Gasket
Relay	
1	Relay, 1 Form A, 5V

Table 5 lists the parts included in the RJR flange and accessories kit for the 2-inch fuel valve.

Table 6 lists the parts included in the RJR flange and accessories kit for the 3-inch fuel valve.

The accessories kits for the 3-inch fuel valve does not include companion flanges.

These kits are normally shipped with the fuel valves.

Table 7 accessories kit for the 3-inch fuel valve complete with companion flanges is part number 20350X001.

Table 5 RJR Flange and Accessories Kit for 2 in Fuel Valve (20190X003)

Qty	Description
2	2 in x ANSI Class 600 RF weld neck flanges, A105 carbon steel with schedule 80 weld preparation
17	5/8–11 (UNC) x 4 1/4 in long studs
34	5/8–11 (UNC) hex nut
2	CG5075 Appleton cable grip (3/4 in NPT x 1/2 in grip)
4	2CG3G Flexitallic gaskets with flexite super fill and carbon steel centering ring
2	U-bolt, 1/2–13 UNC x 7in long
5	1/2–13 UNC hex nut
5	lock washer for 1/2 in U bolt

Table 6 RJR Flange and Accessories Kit for 3 in Fuel Valve (20350X003)

Qty	Description
17	3/4-10 (UNC) x 5 in long studs
34	3/4–10 (UNC) hex nut
34	3/4 lock washer
2	CG5075 Appleton cable grip (3/4 in NPT x 1/2 in grip)
4	3 in size Flexitallic gaskets with flexite super fill and carbon steel centering ring
2	U-bolt, 1/2–13 UNC x 10in long
5	1/2–13 UNC hex nut
5	lock washer for 1/2 in U bolt

Table 7 Flange and Accessories Kit for 3 in Fuel Valve (20350X001)

Qty	Description
2	3 in x ANSI Class 600 RF weld neck flanges, A015 carbon steel with schedule 80 weld preparation
17	3/4-10 (UNC) x 5 in long studs
34	3/4–10 (UNC) hex nut
34	3/4 lock washer
2	CG5075 Appleton cable grip (3/4 in NPT x 1/2 in grip)
4	3 in size Flexitallic gaskets with flexite super fill and carbon steel centering ring
2	U-bolt, 1/2–13 UNC x 10in long
5	1/2–13 UNC hex nut
5	lock washer for 1/2 in U bolt

Table 8 Replacement O-Ring Kit for 2-inch Fuel Valve (21338X001)

Qty	Description	Part Number
1	O-ring (Actuator Cover)	10050
4	O-ring (Cartridge/Body Seal)	837L001
1	O-ring (Shaft/Cover)	625
2	Key	11829L150
1	Grease	911L004

Table 9 Replacement O-Ring Kit for 3-inch Fuel Valve (21338X002)

Qty	Description	Part Number
1	O-ring (Actuator Cover)	10050
4	O-ring (Cartridge/Body Seal)	756L001
1	O-ring (Shaft/Cover)	625
2	Key	11829L150
1	Grease	911L004

Section 4

Installation

Contents

This section provides information on installing the Rotary Fuel Valve system.

4.1 Precautions

AMOT designs, manufactures, and tests its products to meet many national and international standards. However, for these products to operate within their normal specifications, they must be properly installed, used, and maintained.

WARNING

The following instructions must be adhered to and integrated with the user's safety program when installing, using, and maintaining AMOT products.

- **Read and save all instructions prior to installing, operating, and servicing this product.**
- **Follow all warnings, cautions, and instructions marked on and supplied with the product, including those within this manual.**

- **Inform and educate your personnel in the proper installation, operation, and maintenance of the product.**

- **Install the equipment as specified within the installation instructions provided by AMOT, and by the applicable local and national codes.**

- **Connect all products to the proper electrical source.**

WARNING

To avoid a shock hazard or gas explosion, installation and servicing must be performed only by qualified personnel. De-energize all sources of power BEFORE removing the actuator cover. KEEP THE ACTUATOR COVER TIGHT WHEN CIRCUITS ARE LIVE. Failure to follow these precautions may result in serious injury or death.

- **Handle, move, and install each product using the appropriate number of personnel and the appropriate moving devices and equipment (dolly, forklift, crane). Failure to do so could cause serious personal injury.**

- **To ensure proper performance, use qualified personnel to install, operate, update, tune, and maintain this product.**

- **When replacement parts are required, ensure that the qualified service technician uses only replacement parts specified by AMOT. Unauthorized substitutions may result in fire, electrical shock, other hazards, or improper equipment operation.**

- **Ensure that all actuator protective covers are in place (except when maintenance is being performed by qualified personnel) to prevent electrical shock, personal injury, or damage to the actuator.**

- **Remove protective covers only when explosion-proof standards permit.**

CAUTION

Take care not to trap wiring between the actuator body and top cover faces when installing the actuator top cover. Grounding the high power motor drive cabling to the actuator case could damage the electronic controller circuits.

- **Hermetically seal all open and used conduit glands on the fuel valve and controller to prevent the ingress of dirt and corrosive products.**

- **If you do not fully understand the instructions, contact your local AMOT representative for clarification.**

4.2 Power and Input Requirements

- Power to the controller (8412) must be 24 V dc (18-32 V dc), 8A, fused.
- Power consumption is 125 watts (VA) maximum.
- There are no 24 V dc power supply connections to the fuel valve.
- The demand position signal must be within the range of 4-20 mA.

CAUTION

Before power is applied to the unit, make sure that the voltage polarity is correct. Failure to do so will result in a blown fuse.

4.3 Fuel Valve Installation

Note that the gas flow direction is indicated by an arrow on the fuel valve bodies.

Note

Before installing the fuel valve, make sure that it is correctly sized (Cv) and is suitable for the intended application with respect to environmental conditions and the voltage and frequency of available line power. If you are unsure of the suitability of this equipment for your installation, consult AMOT before proceeding.

WARNING

AMOT requires the use of a traditional skid design that uses two independent block/shutoff valves ("double block and bleed") in series with the gas control valve. The 4280 fuel valve will flow (leak) up to 0.5% of rated flow in the closed position.

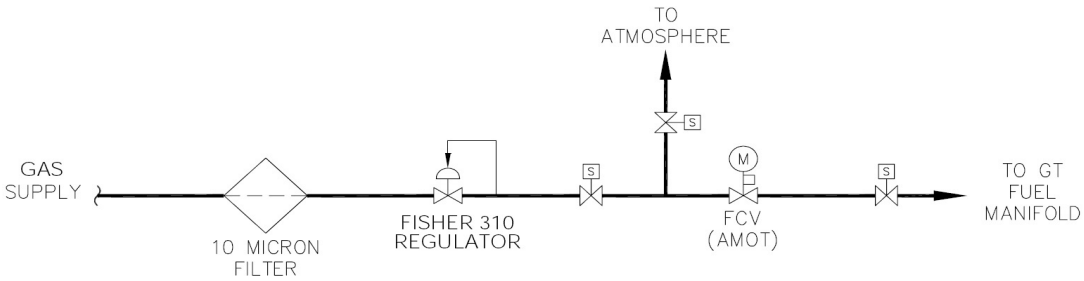


Fig 5 Typical Double Block and Bleed Fuel Skid Design

The fuel valve/actuator may be installed in either the vertical or horizontal plane and should normally be supported so that its weight is not transferred to the connecting piping.

If possible, the fuel valve/actuator assembly should be installed with the actuator head directly above the valve. To ensure adequate maintenance access, be sure to leave enough space above and around the actuator to allow removal of the actuator cover.

If the fuel valve is anchored to a solid skid surface, movement and expansion of any fixed piping connected to the valve must be considered. It is recommended that flexible piping be used whenever possible.

WARNING

The fuel valve MUST BE REMOVED FROM ITS INSTALLED LOCATION IN THE PIPING before any attempt is made to disassemble the actuator from the valve.

U-bolts are supplied to clamp the 2-inch and 3-inch valves to the skid. Appendix E provides mounting details for each fuel valve size.

Flexitallic gaskets are recommended for flange seals. Check that the flange faces are clean during final assembly. Torque all flange bolts evenly to the values listed in Table 10.

Table 10 Flange Bolt Torque Values

Fuel Valve Size	Number of Bolts	Bolt Size	Torque Nm (lbf ft)
2 inch	8	5/8 in – 11	142 (105)
3 inch	8	3/4 in - 10	264 (195)

4.3.1 Actuator Mounting Alignment

When an actuator is mounted onto a fuel valve in the field, care must be taken to properly align the actuator with the valve shaft. Explosion-proof requirements necessitate a tight fit between the valve shaft and its corresponding bushing within the actuator. Improper alignment of the bushing and shaft could cause the shaft to seize during operation.

When the yoke and actuator are mounted onto the fuel valve (see Fig 6), all the fuel valve and actuator mounting bolts should be installed, and the actuator aligned with the valve shaft, before any of the bolts are torqued. The mounting bolts should then be torqued in an alternating pattern on opposing sides of the unit.

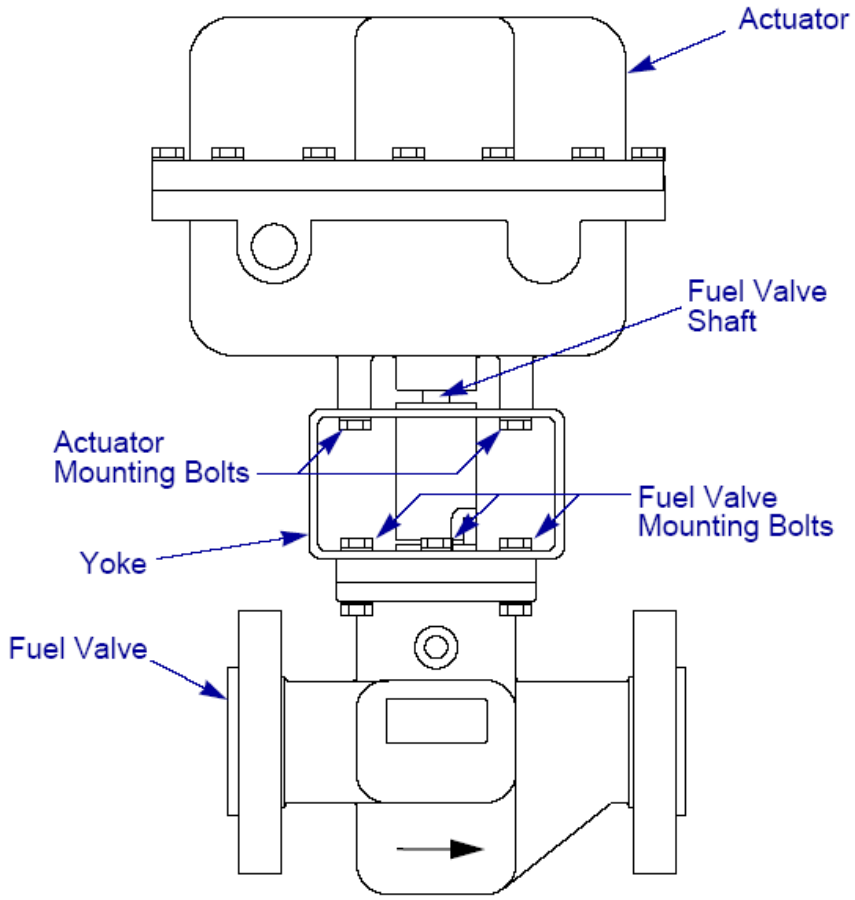


Fig 6 Fuel Valve and Actuator Assembly (2 in Fuel Valve Shown)

4.3.2 Fuel Valve Vent Connection

If the fuel valve is not to be vented to another area, fit a short length of stainless steel pipe to the vent outlet, turned down to prevent the ingress of dirt or foreign bodies.

When possible, the fuel valve should be mounted such that the vent line flows down and away from the valve. This will allow the use of gravity to prevent a build-up of condensation fluids in the vent line over time.

WARNING

If a cartridge O-ring seal or the primary rotor seal fails, fuel will leak out of the vent. Therefore, the vent must discharge into an area classified as hazardous (Class I Division 1, or Class I Division 2), or to the outside air if local codes permit.

4.3.3 Cable Entry Gland

If the fuel valve is installed in an explosion-proof area, an approved flameproof entry device (not provided by AMOT) must be used. The explosion-proof conduit must also be sealed within 0.5 m (19 in) of the actuator.

Otherwise, the 3/4 in NPT cable grip gland supplied with the fuel valve may be used.

WARNING

Any unused openings must be closed with wrench tight conduit plugs Certified for the Hazardous Locations.

4.4 Fuel Gas Preparation and Filters

A gas filter is not included in the model 4280 fuel valve. Because of the tight clearances within the valve, a 10-micron full-flow filter should be installed by the user upstream of the fuel valve. It is also recommended that a "last chance" 200-micron filter be installed at the inlet flange of the fuel valve.

CAUTION

It is critical that liquid condensates be removed from the fuel gas. Significant cooling which occurs as the gas expands through the fuel valve can result in the formation of solid hydrates and ice particles, which may erode the cartridge.

It is strongly recommended that the fuel gas supply temperature be maintained high enough to prevent ice formation in the fuel valve. Ice formation is most likely to occur when the turbine is operated at idle conditions.

In applications where the quality of the fuel gas is poor, and the fuel gas has not been processed to remove any particles, sand, debris, and liquids from the fuel supply, the fuel valve cartridge may develop significant wear (see Fuel Valve Wear on page 67). In such applications, the fuel valve cartridge assembly should be considered a Parts Class 1 spare (see Appendix F).

4.5 Hydrogen Sulphide

For standard carbon steel 4280 fuel valves (housing codes A through G, see Product Identification on page 21), the concentration of hydrogen sulphide (H_2S) in the fuel gas should not exceed 100 ppm.

A stainless steel fuel valve body is available for applications with high concentrations of H_2S.

4.6 Model 8412 Controller Installation

For optimum dissipation of excess heat, the control box should be mounted in a vertical position with a minimum 12 mm (0.5 inch) clearance at the rear of the enclosure, as shown in Fig 9.

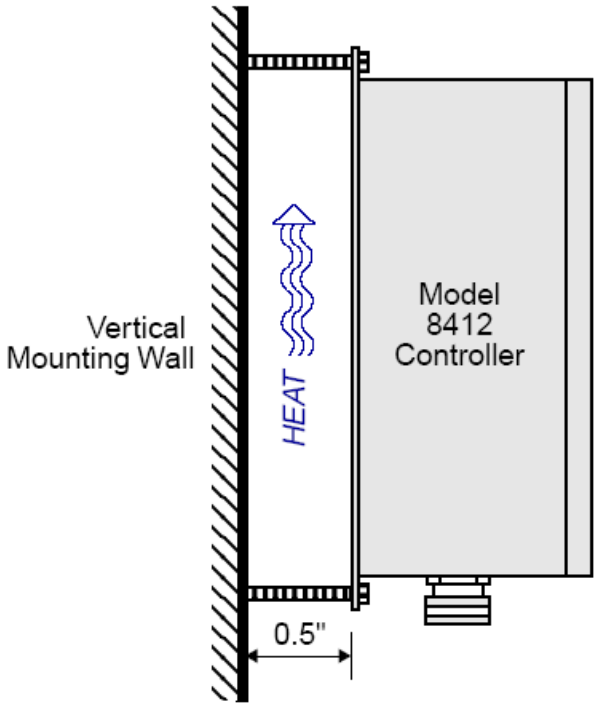


Fig 7 Mounting of 8412 Controller Housing

4.7 Cabling Requirements

Fig 8 identifies the locations and functions of the cables required for the Rotary Fuel Valve and Controller.

Fig C- 2 on page 88 and Fig C- 3 on page 89 also show the locations of the cables and provide further details.

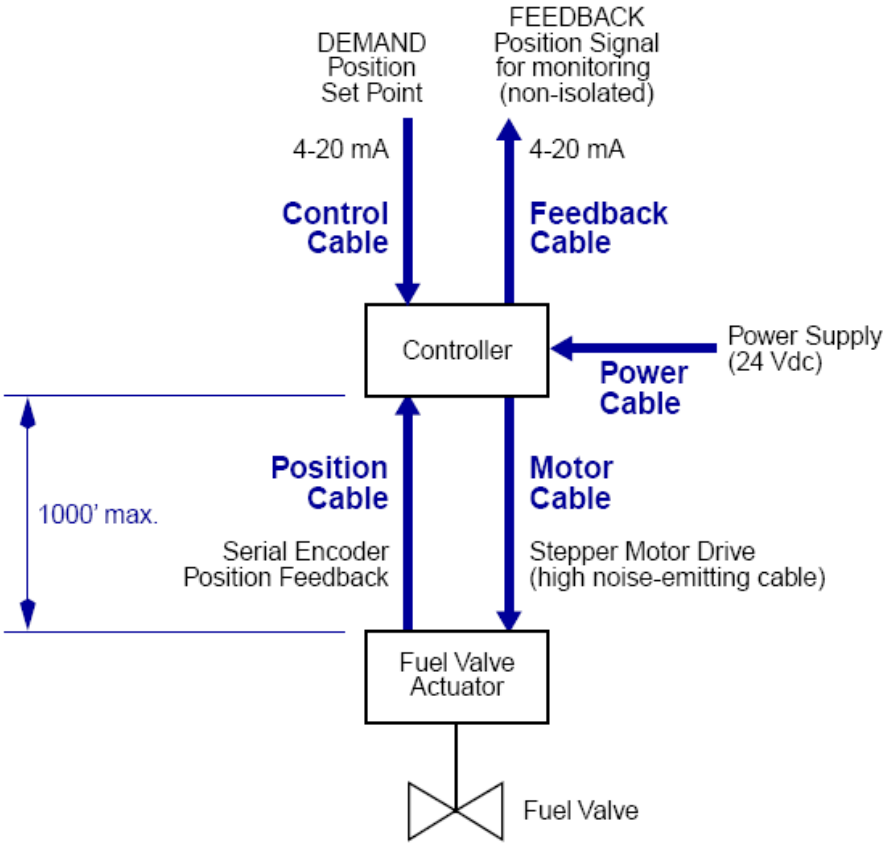


Fig 8 System Cabling Requirements

The following sections give the specifications and requirements for each cable.

4.7.1 Control and Feedback Cable

The control/feedback cable is a critical cable. It is strongly recommended that a dedicated cable be used for this purpose. There is no restriction on cable length.

Either of the following cable configurations should be used for the feedback cable:

- One Belden 8723 cable, or equivalent:
  This cable has five (5) conductors: 2 twisted, shielded 22-AWG pairs with individually shielded foil wrap, and 1 separate shield drain.

  or

- Two Belden 8723 cables, or equivalent:
  Each cable has three (3) conductors: 1 twisted, shielded 22- AWG pair with individually shielded foil wrap, and 1 separate shield drain.

Shielded cabling is used to reduce the effects of emissions and improve immunity to externally applied electrical phenomena.

4.7.2 Motor Cable

The motor cable is a high current, pulsing 5-amp power line. The cable run is limited to 305 metres (1000 feet. Table 11 lists the minimum American Wire Gauge (AWG) requirements for various motor cable lengths.

Table 11 Motor Cable Length vs. Minimum AWG

Motor Cable Length	Minimum AWG	Measured Field Resistance for Maximum Total Loop	Belden Cable Number Used (5-conductor)
up to 20 m (66 ft.)	18	1 Ω	8465
up to 50 m (164 ft.)	16	2 Ω	9620
up to 100 m (328 ft.)	14	2 Ω	9623
up to 305 m (1000 ft.)	10	3 Ω	27141A
up to 305 m (1000 ft.)	10	3 Ω	27281 (metal clad)

Either of the following cable configurations should be used for the motor cable:

- One cable with five (5) conductors.
  or
- Five cables with one (1) conductor in each cable.

The motor cable is unshielded since the use of a shielded cable would add distributed capacitance and adversely affect the actuator stepper motor performance. It is recommended that this cable be run in a separate conduit (to reduce noise emissions), and separated from all other cables.

For 8412 controller revision level G and subsequent, the cabling for the stepper motor drive (6410) is wired directly to a Weidmuller heavy-duty field interface connector located within the controller, as shown in Fig 9.

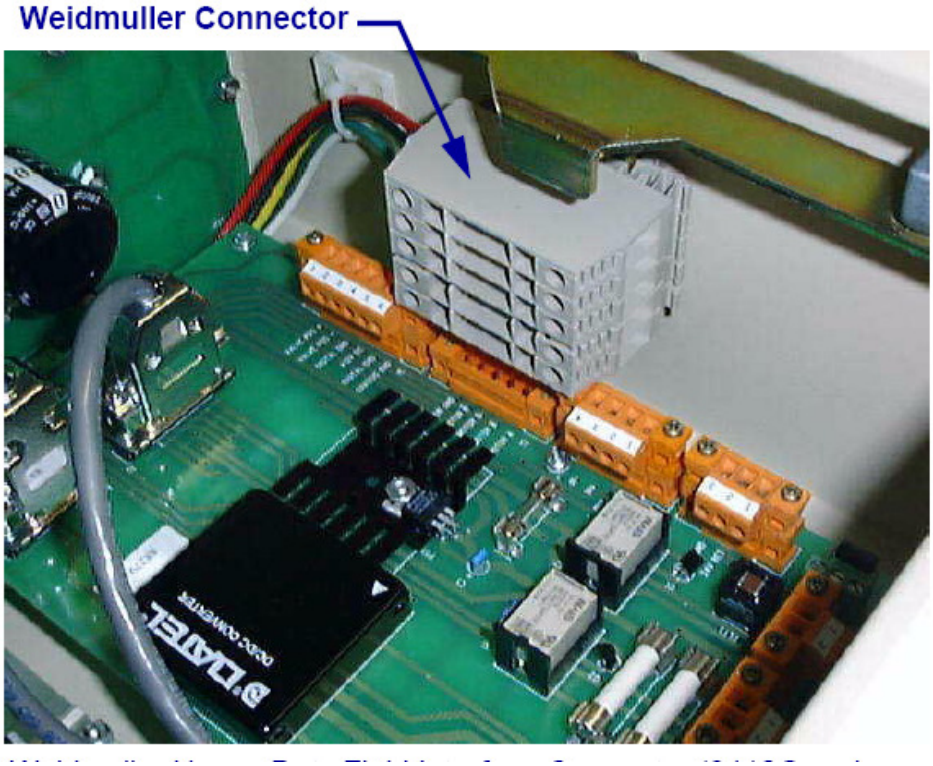


Fig 9 Weidmuller Heavy-Duty Field Interface Connector (8412G and Subsequent)

A connector end stop (not shown) is installed atop the connector after the field wiring is complete to hold the connector in the proper position. The end stop and connector should be placed low enough to keep the connector from interfering with the latching mechanism on the controller cover.

The cable terminations on the stepper motor drive connector are labelled, from top to bottom, as shown in Table 12.

Table 12 Cable Termination Labels on the Weidmuller Connector

Location	Label
TOP	A
	A BAR
	B
	B BAR
BOTTOM	GND

4.7.3 Position Cable

The position cable shall be Alpha 5610B1802 or equivalent. Shielded cabling is used to reduce the effects of emissions and improve immunity to externally applied electrical phenomena.

This cable is an RS422 serial line and is limited to 305 m (1000 feet). At a length of 305 m and a gage of 18 AWG, the field resistance for the total loop would measure about 12 Ω.

The position cable should not be combined with the motor cable.

Additional requirements for this cable are as follows:

- 5 conductor
- 2 twisted pairs + drain wire
- Overall shield
- 18 AWG

4.7.4 Power Cable

The 24 V dc power supply cable must be rated for 20 Amps. A dedicated circuit breaker should be used for this power supply.

4.8 Fuses

The 8412 controller contains nine (9) fuses, which are described in Table 13. The locations of the fuses are shown in the referenced figures.

Table 13 8412 Controller Fuses

Location	Fuse ID	Part No.	Description
Rotary Actuator PCB Assembly, 66275X (see Figure C-1 on page 89)			
	F1	51019L010	100 mA, 5x20 mm, fast acting, IEC type, glass
	F2	51019L010	100 mA, 5x20 mm, fast acting, IEC type, glass
	F3	51019L010	100 mA, 5x20 mm, fast acting, IEC type, glass
	F5	51019L010	100 mA, 5x20 mm, fast acting, IEC type, glass
PSU/Interconnect PCB Assembly, 66281X (see Figure C-4 on page 92)			
	F1	51098L110	10 A, fast acting, CSA/UL type, ceramic
	F2	51098L200	2 A, fast acting, CSA/UL type, ceramic
	F3	51023L060	600 mA, Slo-Blo, CSA/UL type, glass
Power Supply PCB Assembly, 66259X (see Figure C-6 on page 94)			
	F2	51098L800	8 A, fast acting, CSA/UL type, ceramic
	F3	51098L800	8 A, fast acting, CSA/UL type, ceramic

The fuses included in the Spare Fuse and Connector Kit (10435X) are listed in Table 4, page 31.

4.9 Chassis Grounding Terminals

The 8412 controller housing provides one or more threaded terminals which can be used to connect the controller chassis to an earth (safety) ground. (Fig

C- 2 on page 88 and Fig C- 3 on page 89 show the grounding connections within the controller.)

4.9.1 8412 Revisions G and H

For 8412 controller revisions G and H, a threaded terminal is located on the inside of the housing cover, near one of the cover hinges, as shown in Fig 10. To ensure a good chassis ground connection, a grounding strap is attached to the terminal with a washer and nut. The other end of the strap is connected to a mounting screw on the PSU/Interconnect PCB assembly located within the controller box. The location of this screw is highlighted in Fig C- 4 on page 90.

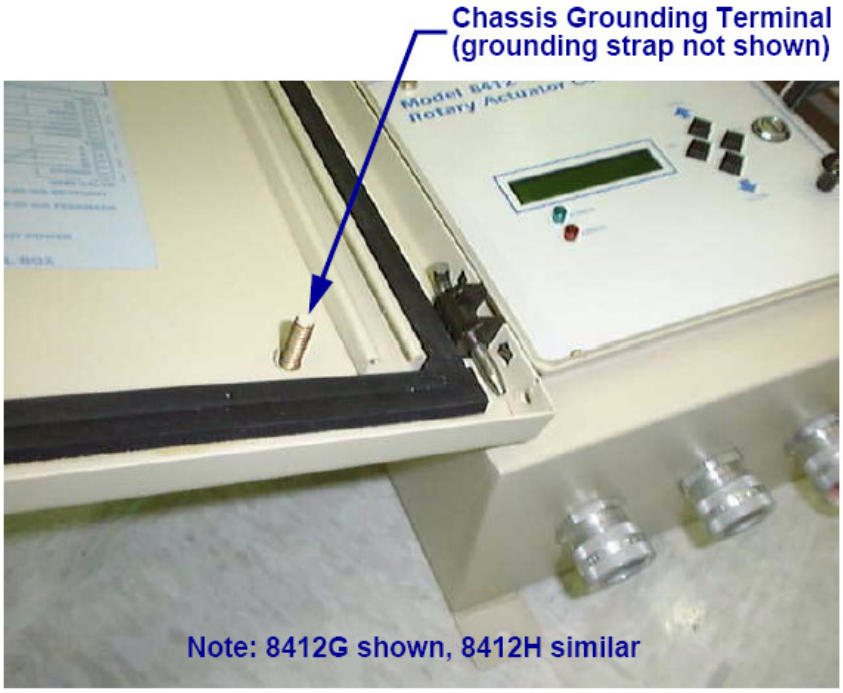


Fig 10 Location of Chassis Grounding Terminal, Revs. G and H Only

4.9.2 8412 Revision I

For 8412 controller revision I, a grounding terminal is provided within the enclosure box, on the side wall below the cover hinges.

Section 5

Configuration and Operation

Contents

This section provides information on configuring and operating the Rotary Fuel Valve system.

5.1 Actuator Mechanical Stop Setup

The actuator mechanical bottom and top stops located within the actuator head are set at the factory for the maximum stroke of the fuel valve. Controller setup and calibration at 4 and 20 mA is made relative to the actuator mechanical stops.

CAUTION

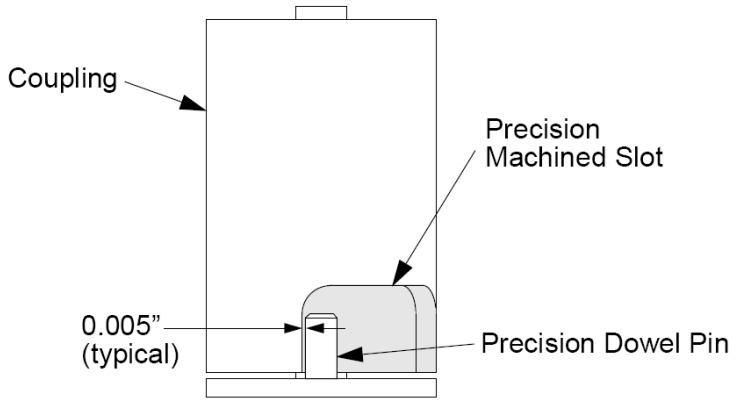
Check the actuator mechanical stop positions prior to Controller setup and calibration. Any adjustments of the mechanical stops should be done with the controller power off.

The position of the mechanical bottom stop is checked relative to a dowel pin and either a machined slot in the actuator coupling, or an adjustable guide attached to the coupling, depending on the design level of the Fuel Valve (see Product Identification on page 21):

- Models up to and including design level F use a slot machined into the actuator coupling (see Fig 11).
- Models with design level G and subsequent use an adjustable guide attached to the actuator coupling (see Fig 12).

5.1.1 Machined Slot (Model 4280F and Previous)

The distance between the dowel pin and the end of the slot when the fuel valve is at the bottom stop is initially set at 0.127 mm (0.005 inch). The closed position datum for the valve is shown in Fig 11.



Note: Dowel pin and slot shown in closed-flow position.

Fig 11 Precision Dowel Pin and Machined Slot (4280F and Previous)

Note

The precision dowel pin is intended only as a position datum for the fuel valve. It should not be used as a mechanical stop for the valve at the coupling. The open and closed mechanical stops for the valve are located in the actuator head.

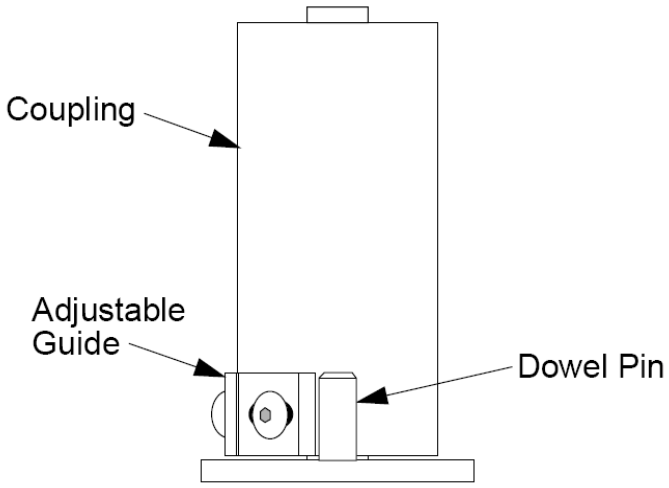
If it is necessary to reposition the actuator mechanical stops, a small clearance 0.127 mm (0.005 inch) is required between the precision dowel pin and the end of the machined slot to ensure that the actuator cannot apply load to the dowel pin.

The dowel pin is NOT intended for precise positioning of the fully open mechanical top stop. The fully open position is set electronically during the configuration procedure.

5.1.2 Adjustable Guide (Model 4280G and Subsequent)

Fuel valves with a design level of G or subsequent (see Product Identification on page 21) use an adjustable guide attached to the actuator coupling to indicate the fuel valve position, as shown in Fig 12 and Fig 15.

This design allows the guide to be adjusted at the factory to accurately indicate the -2° setting from the flow crack point (which is determined using a flow test). The guide stop should be against the dowel pin when the fuel valve is at -2° from the flow crack point. The scale plate (see Fig 15) should be adjusted to the proper -2° indicated position when the guide is against the dowel pin.



Note: Dowel pin and guide shown in closed-flow position.

Fig 12 Precision Dowel Pin and Adjustable Guide (4280G and Subs.)

5.2 Fuel Valve Position

The maximum stroke of the fuel valve actuator is approximately 64°, but depends on the exact settings of the mechanical stops. The operational range of the valve stroke from minimum to maximum flow is 60°. The mechanical top stop should be positioned at 62°. Fig 13 shows a typical flow characteristic curve for the fuel valve and the corresponding valve trim orifice positions at reference points 1 through 5 on the curve.

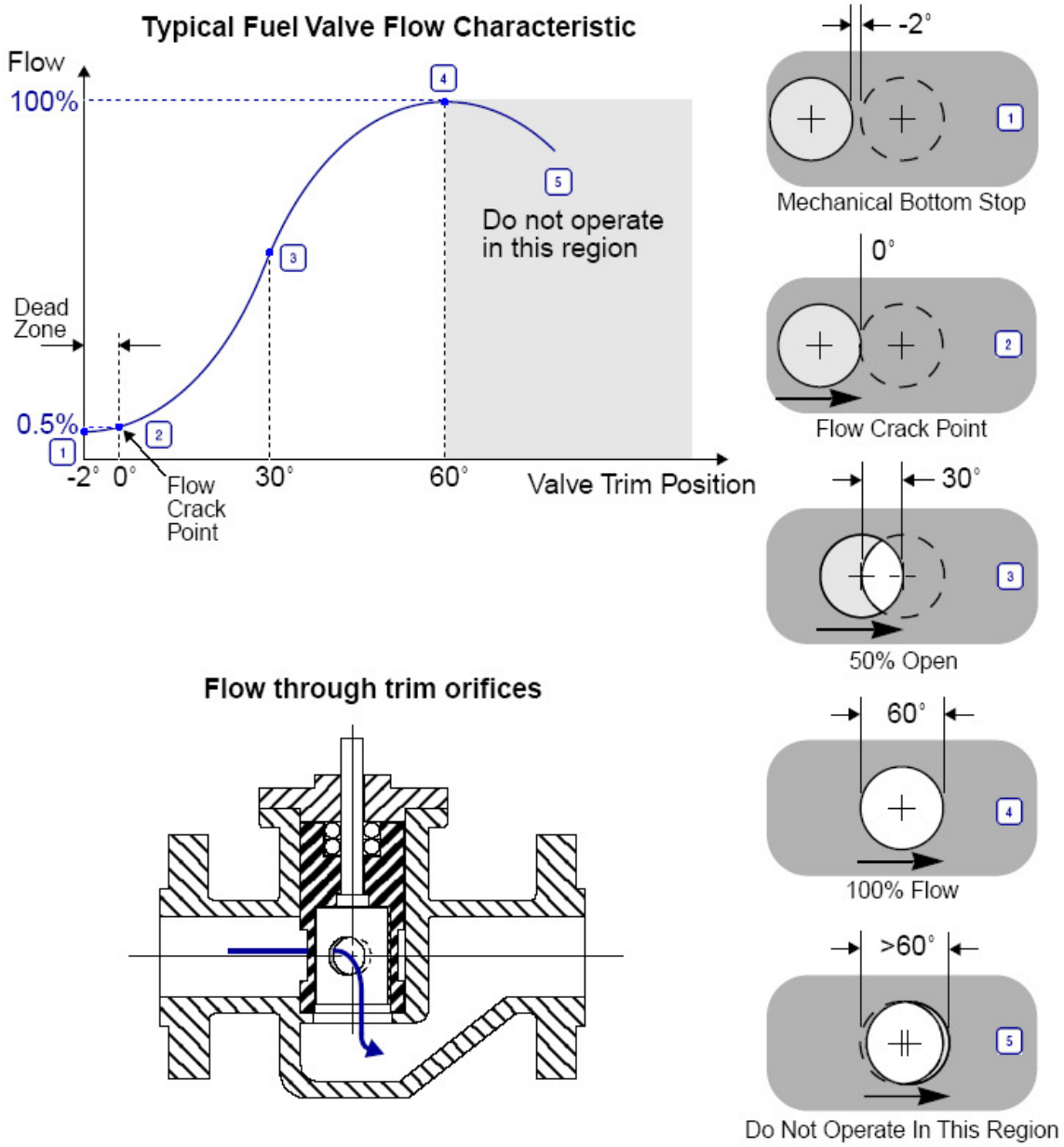


Fig 13 Typ Flow Characteristic and Corresponding Fuel Valve Trim Orifice Positions

There is a dead zone in the fuel valve flow characteristic at the closed position where the trim flow path is at a minimum (reference point 1). The actual fuel flow through the valve in this region is essentially trim leakage. During setup and calibration, this region is identified as a negative degree position (such as –1.1°).

The flow crack point (reference point 2) is the point at which the fuel valve begins to open. The exact absolute encoder count at the flow crack point is normally identified at the factory and written on a label inside the actuator. When provided, this count value may be used to help calibrate the 0%, 4 mA, low actuator position relative to the flow crack point (see Auto Setup on page 56). If this value is not provided, it may be necessary to find the flow crack point by flowing air through the fuel valve.

Note

The absolute encoder position values are fixed with respect to the fuel valve trim position, and are independent of the set point calibration. The only time that the absolute encoder values change with respect to the flow crack point is if the encoder is removed from the actuator.

Reference point 3 corresponds to a fuel valve position of 30° and a stroke of 50%.

The 100% flow condition is reached at a fuel valve position of 60° (reference point 4). Do not calibrate the fully open position at a valve stroke greater than 60°. At strokes above 60°, the flow characteristic decreases and provides for less flow (reference point 5). The mechanical top stop should be positioned at 62°.

5.3 Fuel Valve Position Indicator

Each actuator coupling configuration (machined slot and adjustable guide) provide a fuel valve position indicator, as described in the following sections.

5.3.1 Machined Slot (Model 4280F and Previous)

A position indicator on the coupling gives the approximate position of the fuel valve, as shown in Fig 14. The approximate degrees of valve rotation for each graduation on the indicator are given in the figure and listed in Table 14. (These values are not shown on the valve.) The approximate location of the fully open, 100% flow position (60°) is shown in the figure.

Note

There is not a graduation which corresponds to the fully open, 100% flow position (60°).

The fuel valve opens in the clockwise direction (while looking down onto the top of the actuator).

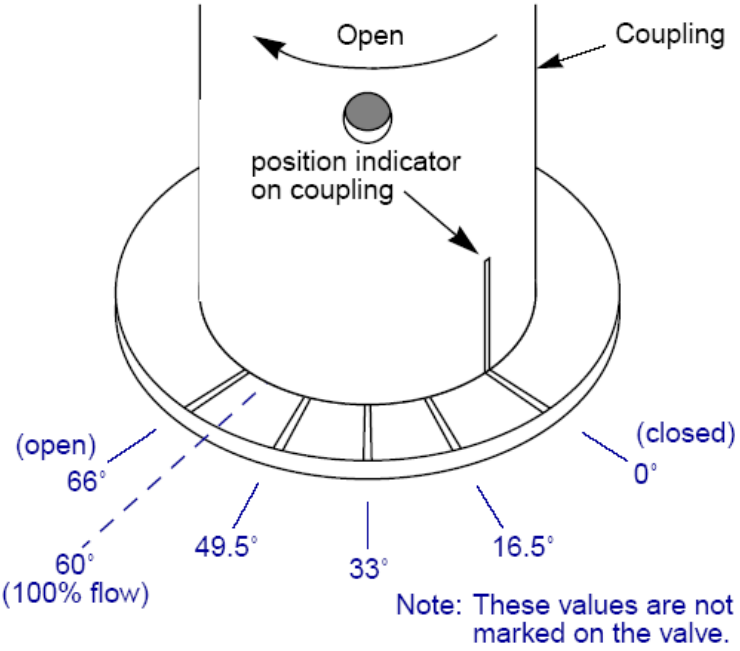


Fig 14 Fuel Valve Position Indicator Graduations (4280F and Previous)

For a calibrated fuel valve, the valve position indicator graduations correspond approximately to the valve stroke percentages listed in Table 14.

Table 14 Approximate Fuel Valve Position for each Graduation

Degrees of Rotation	Calibrated Stroke %	Notes
0°	0%	closed
16.5°	27.5%	
33°	55%	
49.5°	82.5%	
60°	100%	no graduation
66°	Over Range	

5.3.2 Adjustable Guide (Model 4280G and Subsequent)

A position indicator on the adjustable guide gives the approximate position of the fuel valve, as shown in Fig 15.

The fuel valve opens in the clockwise direction (while looking down onto the top of the actuator).

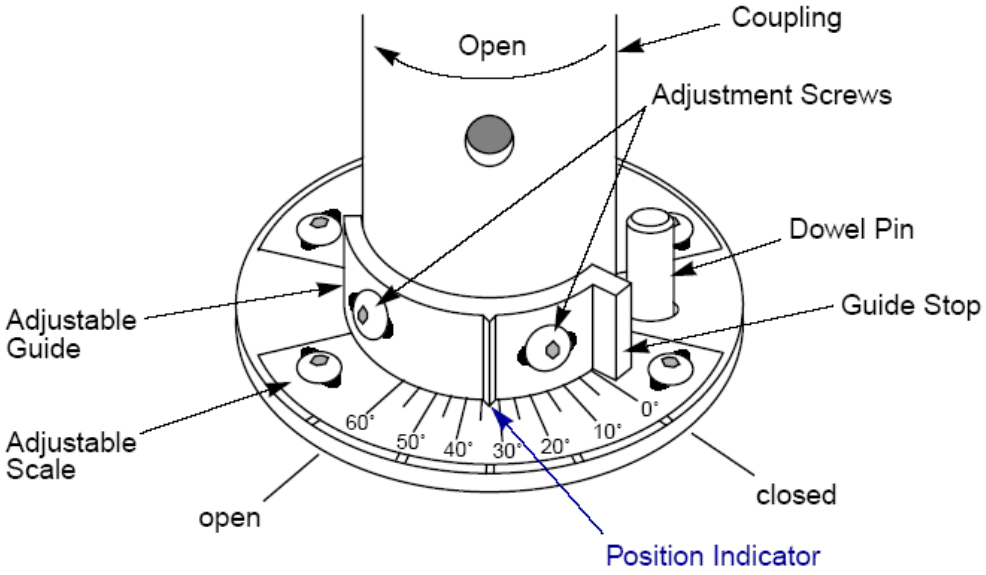


Fig 15 Fuel Valve Position Indicator (4280G and Subsequent)

The guide is adjusted at the factory using a flow test to determine the flow crack point. The guide stop should be against the dowel pin when the fuel valve is at -2° from the flow crack point. The scale should be adjusted to the -2° indicated position with the guide against the dowel pin.

Note

The position of the fuel valve is read at the indicator point between the adjustment screws on the guide, as noted in blue on Fig 15. The valve position is NOT read at the stop on the end of the guide.

5.4 DIP Switch Settings

To configure and operate the controller, DIP switch S1 on the stepper motor drive printed circuit board (PCB) within in the 8412 controller must be set. There are two stepper motor drive PCB configurations used, depending on the revision level of the controller (see Product Identification on page 21):

- Actuator controllers up to and including revision level E use the 5410 stepper motor drive PCB. The six positions on DIP switch S1 must be set as shown in Table 15. This is the only valid configuration for the DIP switch.

Table 15 Settings for DIP Switch S1 (8412E and Previous)

DIP Switch Position	Setting
1	Off
2	On
3	On
4	Off
5	Off
6	Off

- Actuator controllers of revision level F and subsequent use the 6410 stepper motor drive PCB shown in Fig C- 5 on page 91. The eight positions on DIP switch S1 shown in Fig C- 5 must be set as shown in Table 16.

Table 16 Settings for DIP Switch S1 (8412F and Subsequent)

DIP Switch Position	Setting
1	down/closed
2	up/open
3	down/closed
4	up/open
5	down/closed
6	down/closed
7	up/open
8	down/closed

DIP switch position 5 is placed in the down/closed position to reduce the time delay between the last step command and current reduction to 0.05 seconds, which reduces the motor temperature.

In addition, two jumpers must be installed at jumper location J6 next to DIP switch S1 on the 6410 stepper motor drive PCB, as shown in Fig C- 5 on page 91. Jumpers must be installed across pins 1 & 2 (pins closest to DIP switch S1), and across pins 3 & 4.

5.5 User Interface Panel

The user interface panel (Fig 16) for the Rotary Fuel Valve is located within the Model 8412 Rotary Actuator Controller housing. The panel consists of four push buttons, an LCD display, and two LED indicator lights (red and green).

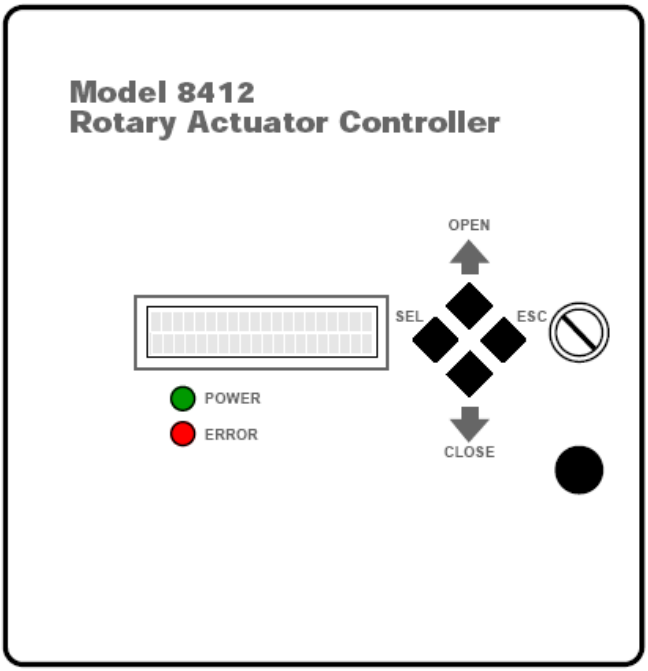


Fig 16 Fuel Valve Controller 8412 User Interface Panel

5.5.1 Push Buttons

The four push buttons on the user interface panel are labelled:

- **OPEN** (up arrow)
- **CLOSE** (down arrow)
- **SEL**(ECT)
- **ESC**(APE)

The function of each button depends on the configuration or operating mode of the controller, as discussed in subsequent sections.

5.5.2 LCD Display

The 2-line by 20-character LCD display on the user interface panel is used to monitor the current operation of the controller, to review the past operation of the controller recorded in the event log, and for the configuration of the controller.

When the controller is switched to the SETUP mode (switch S1 placed in CONFIG position, see Fig C- 1 on page 87), the main menu of the SETUP sequence will appear on the LCD display, as shown in Fig 17.

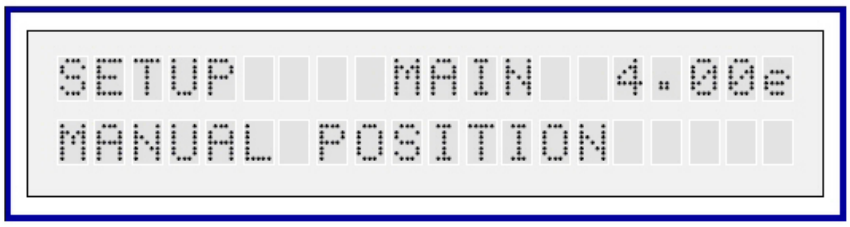


Fig 17 SETUP Mode LCD Display

The entire SETUP menu and the corresponding LCD displays are shown in Fig 21 on page 54 and described starting on page 52.

When the controller is in the RUN mode (see RUN Mode on page 60), the LCD display will show the current RUN status of the controller on the top line, and the current valve set point (**S**) and position (**V**) on the bottom line. During normal operation the display would appear as shown in Fig 18.

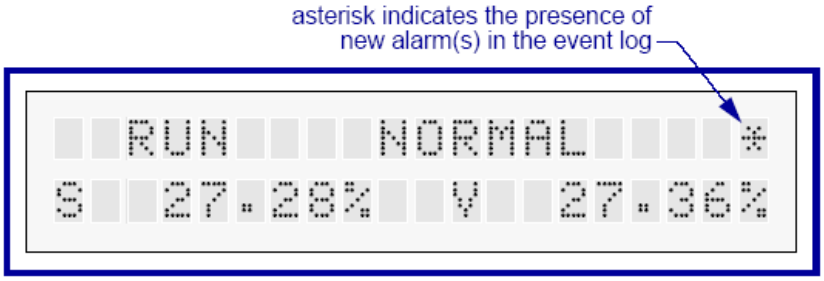


Fig 18 Normal RUN Mode LCD Display

An asterisk (*) in the right-most character of the top line indicates the presence of one or more new alarms in the event log (see Event Log on page 49).

If an error occurs during RUN mode operation, the top line of the LCD display will indicate the cause of the error, such as the example shown in Fig 19 for an encoder error.

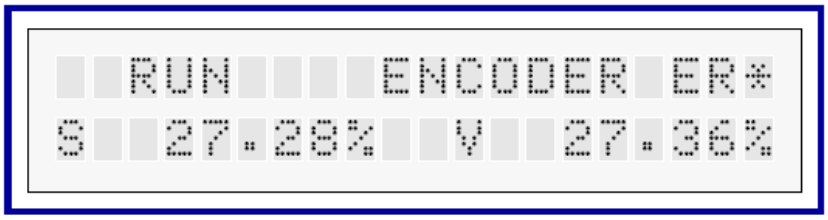


Fig 19 Example Error Message on LCD Display

Table 17 gives the complete list of the error messages which could appear on the top line of the LCD display during the RUN mode.

Table 17 RUN Mode Error Messages

RUN Error	Description	Green (POWER) LED Condition	Red (ERROR) LED Condition
SP LOW	set point signal below minimum (see Set Point Failure on page 62)	ON	FLASHING
SP HIGH	set point signal below minimum (see Set Point Failure on page 62)	ON	FLASHING
OPEN LOOP	open loop control selected (see Control Mode on page 59)	ON	no change
ENCODER ER	encoder comm. loss or error (see Encoder Error on page 63)	ON	ON
TRACKING E	diff. between output and position (see Tracking Error on page 61)	ON	ON
VALVE ERROR	fuel valve position out of range (see Fuel Valve Error on page 62)	ON	ON
DATA ERROR	unrecoverable data corruption (see Data Error on page 63)	ON	ON

While an error condition is present and an error message displayed, the push buttons on the user interface panel (see Push Buttons on page 47) will not be functional. The error condition must be corrected and the normal RUN display restored before the push buttons will function again.

The Controller Status Relays (see page 63) open in response to controller errors or failures to initiate the proper application-specific control action within the companion fuel control system.

5.5.3 Event Log

The controller records the last 19 events and alarms which have occurred in the controller and stores them in an event log, which can be viewed on the LCD display.

An asterisk (*) in the right-most character of the top line of the LCD display (see Fig 18 on page 48) indicates the presence of one or more new alarms in the event log. When the event log has been opened and the new alarm(s) displayed, the asterisk will be removed from the normal RUN display.

With the controller in the RUN mode, the event log can be viewed by pressing the **SEL**(ECT) push button **three times within one second**. The most recent event will then be displayed, such as the example shown in Fig 20 for a low set point error.

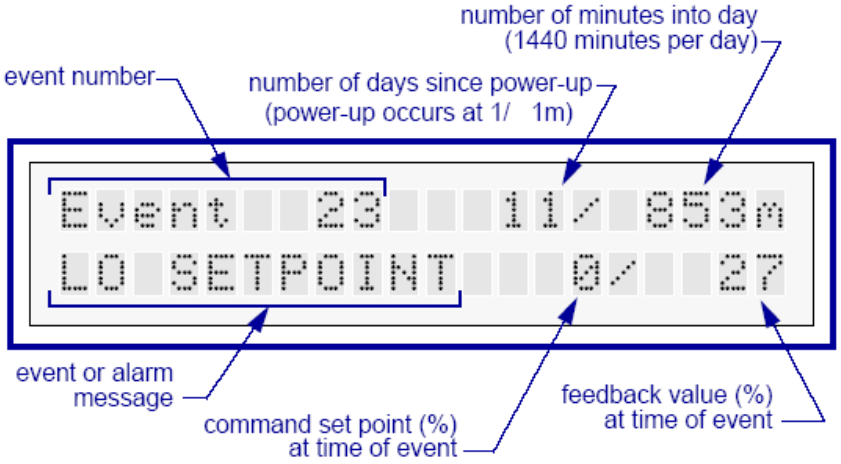


Fig 20 Example Event Log Display

In the example shown, the set point signal dropped below a configured minimum value (or the signal was lost) on the 853rd minute of the eleventh day since the controller was powered up. The command set point was zero at the time of the error, indicating that the signal was lost. The fuel valve was positioned at 27% at the time of the error.

The event log gives a sequential record of events and alarms, and tags each event with a time stamp which is relative to the power-up of the controller. The power-up event, which is always Event 1, will have a time stamp of 1/ 1m (minute one of day one). The time stamps are accurate to within 10 minutes per day.

An absolute day and minute time stamp capability is not available.

The most recent event or alarm always has the highest event number, with the oldest event having the lowest number. If the event log becomes full, the oldest event is dropped out of the log as each new event is added.

Note

The event log is cleared whenever the controller is powered down or a CPU reset occurs. Event messages are not saved and are not recoverable after a power-down or CPU reset.

Starting from the most recent event or alarm, displayed when the event log is opened, the operator can scroll forward or backward through the events using the up-arrow (OPEN) and down-arrow (CLOSE) push buttons.

Pressing the ESC(APE) button at any time will exit the event log and return the operator to the normal RUN display.

The complete list of possible event and alarm messages is given in Table 18.

Table 18 Event Log Messages

Event Message	Classification	Description
LO SETPOINT	Alarm	set point signal below minimum
HI SETPOINT	Alarm	set point signal above maximum
OPEN LOOP	Alarm	open loop control selected
ENCDR ERROR	Alarm	encoder communication loss or error
TRACK ERROR	Alarm	difference between output and position
VALVE ERROR	Alarm	fuel valve position out of range
DATA ERROR	Alarm	unrecoverable data corruption
ENTER CFG	Event	controller switched to SETUP mode
POWER UP	Event	controller powered up (or CPU reset)
24 HOURS	Event	24 hours passed since power-up of controller; a new log entry will be posted every 24 hours since power-up

The event log cannot be displayed during the presence of an error (alarm) condition. If an error occurs during RUN mode operation, the top line of the LCD display will indicate the cause of the error (see Fig 19 on page 48). The error condition must be corrected and the normal RUN display restored before the event log can be accessed.

A one minute timer is used in the event log to prevent the continuous occurrence of a singe event from rapidly filling up the log with identical entries. After a certain event or alarm message is logged, the controller will not allow the same event or alarm message to be logged again for a period of one minute. However, other event or alarm messages can continue to be logged during that time.

5.5.4 LED Indicators

The green (POWER) and red (ERROR) LED indicators on the user interface panel are used to confirm the current mode of operation and to indicate any errors.

The green LED will flash while the controller in the SETUP mode. It will be on continuously when the controller is in the RUN mode. The red LED will respond to various conditions within the controller as summarized in Table 19.

Table 19 LED Indications

Controller Mode	Green (POWER) LED Condition	Red (ERROR) LED Condition	Indication
SETUP	FLASHING	OFF	SETUP mode
SETUP	FLASHING	FLASHING	SETUP mode; tracking error
RUN	ON	OFF	automatic operation; no errors
RUN	ON	FLASHING	automatic operation; set point error
RUN	ON	ON	automatic operation; valve error; encoder error; tracking error; or data error

5.6 Configuration and Operation

The controller has two modes: SETUP and RUN. The SETUP mode is used to configure the system, as discussed in SETUP Mode on page 52. The RUN mode is used to operate the system, as discussed in RUN Mode on page 60.

The operating mode is selected using switch 1 (S1) on the Rotary Actuator printed circuit board (PCB) assembly shown in Fig C- 1 on page 87. This PCB is located on the back of the User Interface panel within the controller housing. Switch 1 can be placed in either the RUN or CONFIG position.

WARNING

Switching S1 from the RUN position to the CONFIG position will freeze the position of the fuel valve. Therefore, the fuel valve should be taken out of service before S1 is placed in the CONFIG position.

The current operating mode of the system is indicated by the LCD display and LED indicator lights described in User Interface Panel on page 46.

5.7 SETUP Mode

The Rotary Fuel Valve Control System is configured with the controller in the SETUP mode. To place the controller in the SETUP mode, switch S1 on the PCB attached to the back of the user interface panel must be placed in the CONFIG position. See Fig C- 1 on page 87 for the location and positions of switch S1.

The green “POWER” LED on the user interface panel will flash while the controller is in the SETUP Mode.

WARNING

Switching S1 from the RUN position to the CONFIG position will freeze the position of the fuel valve. Therefore, the fuel valve should be taken out of service before S1 is placed in the CONFIG position.

Upon entering the SETUP mode, the user will be at the top of the SETUP menu sequence shown in Fig 21. Each box in the figure corresponds to an LCD display in the SETUP menu.

The eight MAIN menu modes are located along the left side of Fig 21. Each of these MAIN modes are discussed in subsequent sections.

Note

The controller firmware version (such as 4.00e) is shown on each MAIN menu LCD display.

Pressing ESC(APE) at any point in the SETUP menu returns the user to the top of the MAIN menu sequence.

Any changes to displayed values that have not been saved with the SEL(ECT) key will be ignored.

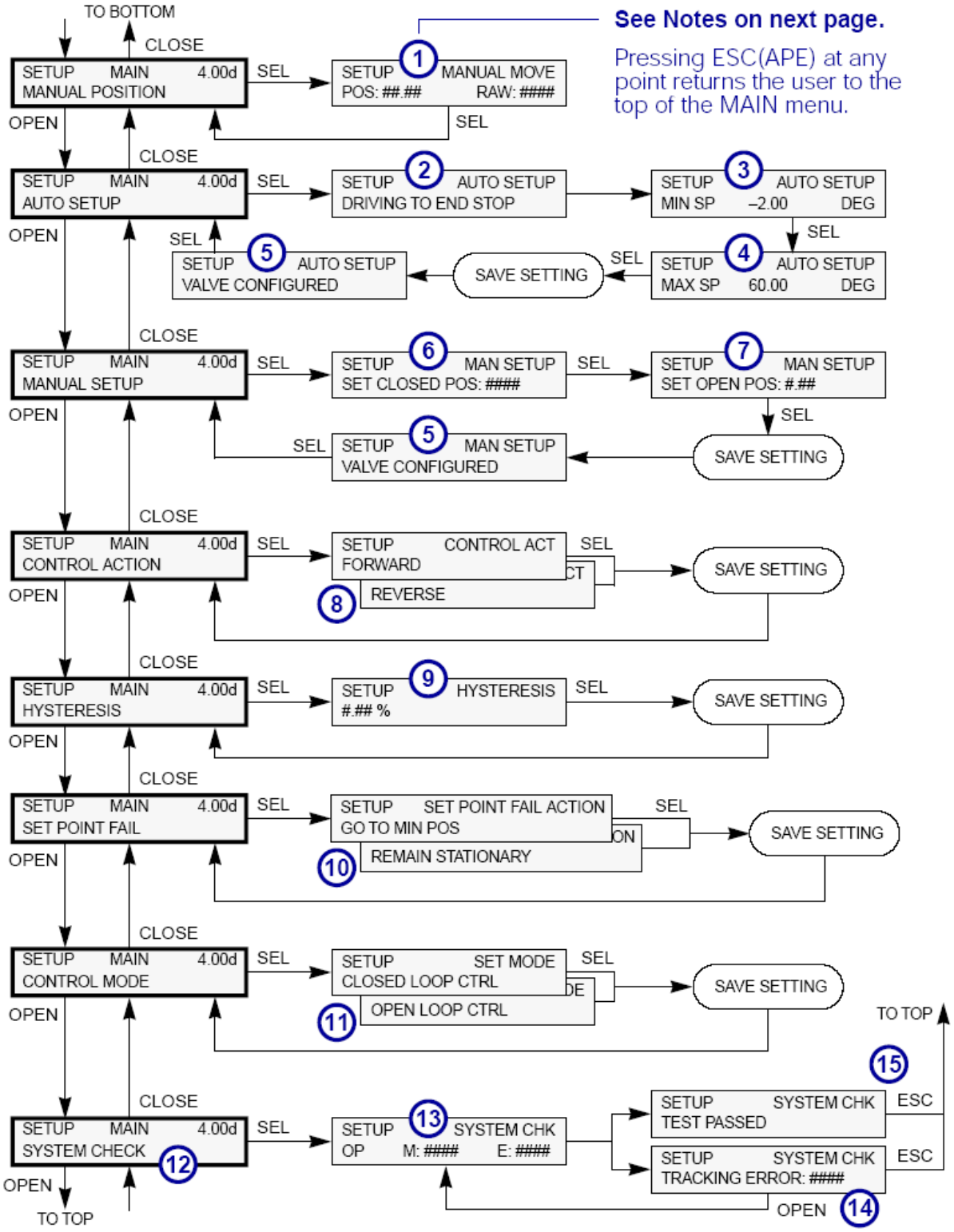


Fig 21 Controller Setup Menu and Sequence (Firmware Version 4.00)

Figure 4-11 Notes:

1 Use OPEN and CLOSE to raise and lower the valve position.

2 At this point, the actuator will be driving towards the "fully closed" point until it reaches the end stop.

3 Position the valve slightly off the end stop by **setting the MIN SP to -1.00°** using OPEN and CLOSE. Use a calibrated current source to input the "fully closed" set point signal (normally 4 mA) before pressing SEL(ECT).

4 Use OPEN and CLOSE to set the desired maximum SP. Use a calibrated current source to input the "fully open" set point signal (normally 20 mA) before pressing SEL(ECT).

5 This screen confirms that the actuator is configured.

6 Position the valve (using OPEN and CLOSE) and input the "fully closed" set point signal (normally 4 mA) before pressing SEL(ECT).

7 Position the valve (using OPEN and CLOSE) and input the "fully open" set point signal (normally 20 mA) before pressing SEL(ECT).

8 Use OPEN or CLOSE to toggle between the FORWARD and REVERSE options.

9 Use OPEN and CLOSE to adjust the hysteresis setting. This is adjustable in the range 0.05 to 9% in 0.05% steps.

10 Use OPEN or CLOSE to toggle between the GO TO MIN POS and REMAIN STATIONARY options.

11 Use OPEN or CLOSE to toggle between the CLOSED LOOP CTRL and OPEN LOOP CTRL options.

12 Do not select SYSTEM CHECK if fuel is supplied to the valve.

13 An encoder test in progress can be aborted by pressing ESC(APE).

14 If an error is detected during the encoder test, a TRACKING ERROR message will be displayed along with the number of counts in error. The test may be restarted from this point by pressing OPEN. This ensures that the full span of the encoder can be tested. Pressing ESC(APE) will stop the test.

15 At the conclusion of a test, press ESC(APE) to return to the top of the SETUP menu.

5.7.1 Manual Position

The MANUAL POSITION function is used to manually move the actuator and fuel valve to any desired position.

From the MAIN menu, use OPEN or CLOSE to select MANUAL POSITION (see Fig 21 on page 54).

Press SEL(ECT) to initiate the MANUAL POSITION sequence and go to the MANUAL MOVE display. The OPEN and CLOSE buttons will raise and lower the

actuator and fuel valve position as shown by the angular position (POS: ##.##, degrees) and encoder absolute position count (RAW: #####, 0 to 4095) readouts. Motor speed will increase after a button has been held down for two seconds.

In this mode, the angular position (POS: ##.##) is valid only if the fuel valve has been properly configured. The encoder absolute position count (RAW: #####) is independent of calibration.

No restriction is placed on actuator and valve movement. The actuator may be driven into the end stops.

Pressing SEL(ECT) will exit this mode and return the user to the MANUAL POSITION mode of the MAIN menu.

5.7.2 Auto Setup

The AUTO SETUP sequence calibrates the actuator for the open and closed set points and control inputs.

From the main menu, use OPEN or CLOSE to select AUTO SETUP (see Fig 21 on page 54).

Press SEL(ECT) to initiate the AUTO SETUP sequence. The message "DRIVING TO END STOP" will be displayed while the actuator moves to the fully closed end stop. This end stop is set at the factory to be -2° past the minimum flow point.

Min SP (Fully Closed Position)

When the end stop is reached, "MIN SP -2.00 DEG" will be displayed. Use OPEN and CLOSE to set the SP to -1.00°. The current set point position is displayed in degrees. A negative value indicates a position at less than minimum flow. The fully closed signal should then be applied (minimum 4 mA).

Press SEL(ECT) to go to the MAX SP display.

Max SP (Fully Open Position)

Note that the fuel valve will not move from the fully closed point during this sequence.

The display will read "MAX SP 60.00 DEG," which corresponds to the current fully open point. Set the desired maximum set point using OPEN and CLOSE to raise and lower the displayed value. The fully open set point signal should now be applied (maximum 20 mA).

Press SEL(ECT) to enter the desired fully closed and open set points into memory.

Note

A "CONFIGURATION ERROR" message will be displayed if the input signal is not changed between the minimum and maximum set points (that is, if 4 mA is input for both the fully closed and fully open positions).

The message "VALVE CONFIGURED" will be displayed indicating the successful completion of this sequence.

Pressing SEL(ECT) will exit this mode and return the user to the AUTO SETUP mode of the MAIN menu.

5.7.3 Manual Setup

The MANUAL SETUP sequence also calibrates the actuator with open and closed set points and control inputs. This procedure is slightly longer than the AUTO SETUP procedure and provides for calibration of the closed position at the fuel valve flow crack point.

From the MAIN menu, use OPEN or CLOSE to select MANUAL SETUP (see Fig 21 on page 54).

Press SEL(ECT) to initiate the MANUAL SETUP sequence.

Set Closed Position (Fully Closed Position)

The message "SET CLOSED POS: #####" will be displayed. The encoder absolute position count is available in this mode. Use OPEN and CLOSE to raise and lower the actuator to the desired fully closed position. The fully closed set point signal should then be applied (minimum 4 mA).

Press SEL(ECT) to go to the SET OPEN POS display.

Set Open Position (Fully Open Position)

The message "SET OPEN POS: #.## degrees" will be displayed. Use OPEN and CLOSE to raise and lower the actuator to the desired fully open position (normally 60.0°). The fully open set point signal should then be applied (maximum 20 mA).

Press SEL(ECT) to enter the desired fully closed and open set points into memory.

The message "VALVE CONFIGURED" will be displayed indicating the successful completion of this sequence. Pressing SEL(ECT) will exit this mode and return the user to the MANUAL SETUP mode of the MAIN menu.

5.7.4 Control Action

The CONTROL ACTION sequence configures the actuator for forward or reverse control action.

From the MAIN menu, use OPEN or CLOSE to select CONTROL ACTION (see Fig 21 on page 54).

Press SEL(ECT) to initiate the CONTROL ACTION sequence. The "CONTROL ACT" display will show the current mode of operation, either "FORWARD" or "REVERSE." Use OPEN or CLOSE to toggle between the FORWARD and REVERSE options.

Note

Normally, a FORWARD action provides for the safest operation of the actuator because a lost demand signal tends to close the fuel valve (see Set Point Fail on page 60).

Pressing SEL(ECT) saves the chosen option into memory and returns the user to the CONTROL ACTION mode of the MAIN menu.

5.7.5 Hysteresis

The HYSTERESIS sequence programs the controller with a hysteresis value.

From the MAIN menu, use OPEN or CLOSE to select HYSTERESIS (see Fig 21 on page 54).

Press SEL(ECT) to initiate the HYSTERESIS sequence. The "HYSTERESIS" display will show the current hysteresis value, in percent. Use OPEN and CLOSE to raise or lower the displayed value in 0.05% increments in the range 0.05% to 9.00%. Holding down a button for two seconds will cause the displayed value to change more rapidly.

Note

Normally, a hysteresis value less than 0.2% is desirable.

Pressing SEL(ECT) saves the desired value into memory and returns the user to the HYSTERESIS mode of the MAIN menu.

5.7.6 Set Point Fail

The SET POINT FAIL sequence programs the actuator with the desired action in the event of a set point signal failure, defined as a set point signal outside (above or below) the configured maximum and minimum values.

From the main menu, use OPEN or CLOSE to select SET POINT FAIL (see Fig 21 on page 54).

Press SEL(ECT) to initiate the SET POINT FAIL sequence. The "SET POINT FAIL ACTION" display will show the option currently selected within the controller:

- GO TO MIN POS: Move fuel valve to the fully closed position, or
- REMAIN STATIONARY: maintain current position.

Use OPEN or CLOSE to toggle to the desired option.

Pressing SEL(ECT) saves the chosen option to memory and returns the user to the SET POINT FAIL mode of the MAIN menu.

WARNING

Always test the failure action of the fuel valve after setup is complete.

5.7.7 Control Mode

The CONTROL MODE sequence configures the actuator for open loop or closed-loop valve position control (firmware version 3.00f and subsequent only).

Note

During normal RUN Mode operation the controller should be placed in the closed-loop control mode, which uses the encoder feedback value to position the fuel valve.

The open-loop control mode should be used only in the SETUP Mode. During open-loop operation, the LCD display shows OPEN LOOP. The response time during open-loop control is derated to one second (for 100% stroke). The 4-20 mA position output value is set +1% greater than the input 4-20 mA position set point to provide a way of detecting that the open-loop control mode is active when reviewing recordings of signals.

CAUTION

Calibration of the system should not be attempted when OPEN LOOP CONTROL has been selected.

From the MAIN menu, use OPEN or CLOSE to select CONTROL MODE (see Fig 21 on page 54).

Press SEL(ECT) to initiate the CONTROL MODE function. The “SET MODE” display will show the current mode of operation, either “CLOSED LOOP CTRL” or “OPEN LOOP CONTROL.”

Note

Upon power-up of the controller, the CONTROL MODE will be set to CLOSED LOOP CONTROL by default.

Use OPEN or CLOSE to toggle between the CLOSED LOOP CTRL and OPEN LOOP CONTROL options.

Pressing SEL(ECT) saves the chosen option into memory and returns the user to the CONTROL MODE mode of the MAIN menu.

During normal closed-loop control, the motor and fuel valve will freeze in position if the encoder signal is lost or disconnected. To switch from normal closed-loop control to emergency open-loop control, the user must switch to the SETUP Mode by placing switch S1 in the CONFIG position (see Fig C- 1 on page 87). The user can then select open-loop control from the Control Mode sequence as described above. Exiting the SETUP Mode by returning switch S1 to the RUN position will enable open-loop operation. This provides a way to control the fuel valve if the encoder signal is lost.

Any loss of step count during open-loop operation will result in a bump when returning to closed-loop control. Over time, open-loop operation may result in a loss of reference to the mechanical end stops. Thus, the speed control output may lose correspondence with the actual valve position, and the speed

controller output clamps may prevent the fuel valve from moving to the desired position.

5.7.8 System Check

The SYSTEM CHECK sequence is used to check the linearity of the encoder (firmware version 3.00f and subsequent only).

WARNING

Do not select a SYSTEM CHECK if fuel gas is supplied to the fuel valve.

From the MAIN menu, use OPEN or CLOSE to select MANUAL SETUP (see Fig 21 on page 54).

Press SEL(ECT) to initiate the SYSTEM CHECK sequence. The check sequence will first drive the fuel valve to the bottom end stop, then begin slowly opening the valve in steps. A successful test will slowly open the valve in steps through 60° of rotation (1667 motor steps) to fully open, and then reverse direction and slowly step the valve back down 60° to fully closed.

During the check, the LCD displays:

OP(en) or CL(ose)

M(otor): # of steps

E(ncoder): counts

Every motor step should result in a small increment in the encoder absolute count.

If the count increase is too large (greater than eight counts), the motor is stopped and a TRACKING E(RROR): message is displayed along with the number of counts in error (greater than eight). The red error LED on the user interface panel will also flash. The test may be restarted from this point by pressing OPEN. This ensures that the full span of the encoder can be tested. Pressing ESC(APE) will stop the test.

Upon completion of the test (fuel valve fully closed), a TEST PASSED message will be displayed. Pressing ESC(APE) will exit this mode and return the user to the MANUAL SETUP mode of the MAIN menu.

5.8 RUN Mode

The Rotary Fuel Valve is operated with the controller in the RUN mode. Switch 1 (S1) on the PCB should be placed in the RUN position. Refer to Fig C- 1 on page 87 for the switch location and setting.

A functional control diagram for the fuel valve closed-loop control system is given in Fig 22.

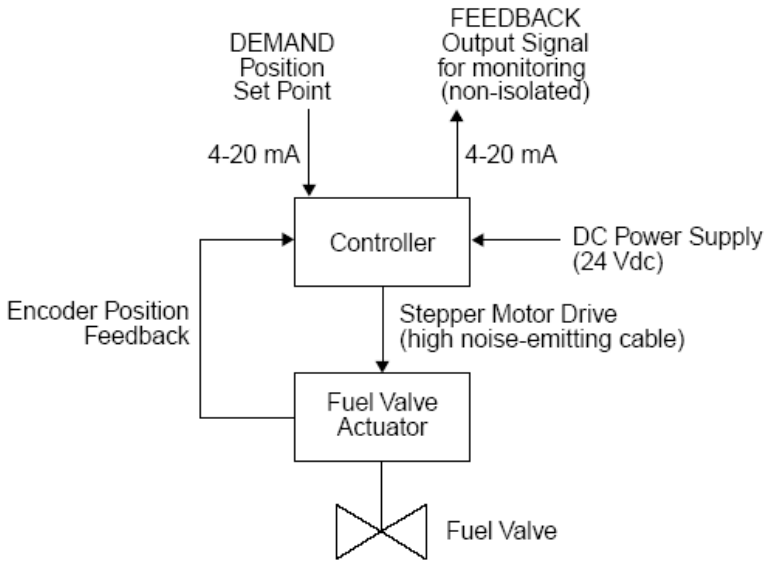


Fig 22 Functional Control Diagram for Fuel Valve System

During normal closed-loop operation, the controller will attempt to reduce any error between the demand position set point and the current fuel valve position (when the error is greater than the hysteresis value). The top line of the LCD display on the User Interface Panel (see page 46) will show the current mode of operation (RUN) and any errors. If there are no errors, the display will read "RUN NORMAL." The bottom line of the LCD will display the demand set point and the current valve position in terms of percent open. Zero percent corresponds to the fully closed point configured by the user.

The green "POWER" LED on the user interface panel will be ON continuously while the controller is in the RUN Mode.

In response to a measured error, the controller generates a velocity profile, which consists of an acceleration region, a constant velocity region, and a deceleration region. The velocity profile is calculated to optimize movement of the fuel valve to the desired position. If the set point changes before the movement is complete, a new velocity profile is calculated. The set point is sampled and the velocity profile calculated every 5 ms.

5.8.1 Tracking Error

The tracking error function within the fuel valve controller will stop the stepper motor when a difference between the intended and actual valve positions is detected (firmware version 3.00f and subsequent only). This function is intended to prevent mechanical damage to the actuator gears, in the unlikely event that the actuator or cartridge is jammed.

When the difference between the demand position set point and the actual valve position exceeds 5% for 5 seconds, the stepper motor is halted and fuel valve positioning is stopped. A "TRACKING E(RROR)" message will be displayed, and the red "ERROR" LED will be ON continuously. This will trip the

SYSTEM ERROR alarm relay (see Controller Status Relays on page 63), which will initiate the proper application-specific control action within the fuel control system.

The tracking error function will automatically clear the LCD display, reset the SYSTEM ERROR alarm relay, and resume fuel valve positioning control when the difference between the valve position set point and the actual valve position drops back below 5%.

Since this feature requires that a system be properly calibrated, it prevents windup of an uncalibrated system against an end stop upon power-up.

5.8.2 DC Power Failure

The actuator will hold its current position when 24 V dc power is removed for any reason. This will trip the SYSTEM ERROR alarm relay (see Controller Status Relays on page 63), which will initiate the proper application-specific control action within the fuel control system.

The gas forces on the flow elements are less than the detent torque of the unpowered stepper motor.

5.8.3 Set Point Failure

The limits of motion of the fuel valve, set during configuration, are stored in multiple, error-checked locations in the non-volatile memory of the controller. In response to a set point signal outside of the configured range, the controller will respond as configured (see Set Point Fail on page 58).

The presence of a set point error is indicated by a flashing red LED and an LCD message indicating the nature of the error. The displayed message will be either “SP HIGH” for a high set point value, or “SP LOW” for a low set point value. It will also trip the SYSTEM ERROR alarm relay (see Controller Status Relays on page 63), which will initiate the proper application-specific control action within the fuel control system.

After the detection of an out-of-range high or low set point failure, valve position control will be suspended until the set point is validated and back within the configured range for one second. When these conditions are satisfied, the SYSTEM ERROR alarm relay will be reset, and normal functioning will resume.

5.8.4 Fuel Valve Error

The fuel valve position limits are stored in the same manner as the maximum and minimum set points. If the controller detects that the valve position has moved outside the configured range, it will hold the current valve position, illuminate the red LED continuously, and display a “VALVE ERROR” message on the LCD. It will also trip the SYSTEM ERROR alarm relay (see Controller Status Relays on page 63), which will initiate the proper application-specific control action within the fuel control system.

5.8.5 Encoder Error

If the controller detects an encoder serial communications loss or error, it will trip the SYSTEM ERROR alarm relay, hold the current valve position, illuminate the red LED continuously, and display a “ENCODER ER” message on the LCD.

When an encoder failure is detected, the controller will pulse the 4- 20 mA feedback signal at +/-1.0% at the rate of 0.25 Hz. This signal pattern will be displayed by the Trender PC program, thus providing another diagnostic tool for identifying an encoder failure.

In the event of an encoder failure, switching to emergency open loop control in the SETUP Mode can provide a way to control the fuel valve (see Control Mode on page 59).

If the encoder position signal is restored and valid for one second, the SYSTEM ERROR alarm relay will be reset, and normal functioning will resume.

5.8.6 Data Error

If an unrecoverable data (EEPROM) corruption occurs, the red LED will illuminate continuously and a “DATA ERROR” message will be displayed on the LCD. It will also trip the SYSTEM FAULT alarm relay (see Controller Status Relays on page 63), which will initiate the proper application-specific control action within the fuel control system.

The valve configuration must be re-entered by entering the SETUP Mode (see page 52).

The configuration data is stored in multiple, individually checked blocks. If any one block becomes corrupted, the data will be copied from an uncorrupted block. This data recovery process takes place without indication to the user.

5.8.7 Controller Status Relays

The controller includes two error output relays which are energized (contacts closed) when the controller is in a healthy state. These two relays (K1 and K2) are Aromat DK-1a series with form 1a contacts rated at 10 A @ 30 V dc. The relays are socketed to allow replacement in the event they fail.

The ‘SYSTEM ERROR’ relay contacts will open if there is a DC power failure, encoder failure, valve position failure, set point failure, or tracking error.

The ‘SYSTEM FAULT’ relay contacts will open if there is a DC power failure, a processor crash, or other complete system failure. The ‘SYSTEM ERROR’ relay will also de-energize under these conditions.

SYSTEM ERRORS are generally considered to be recoverable, while SYSTEM FAULTS are considered non recoverable. Since the error outputs are non latching, the relays will return to the healthy state when the error is cleared.

5.9 Elevated Fuel Temperature

As given in Table A- 1 on page 75, the maximum operating environment temperature for the fuel valve and actuator is 158°F (70°C).

However, the fuel gas flowing through the valve may be allowed to reach a maximum temperature of 149° C (300° F), as long as the actuator environmental limit of 70° C (158° F) is maintained. Active cooling or ventilation of the actuator may be required to maintain this temperature limit under such conditions.

WARNING

For applications in which the temperature of the fuel gas approaches the allowable maximum of 149° C (300° F), the operating temperature of the actuator must be maintained at or below its temperature limit of 70° C (158° F), using active cooling or ventilation techniques if necessary.

5.10 Fuel Valve Torque

The torque required to turn the fuel valve may increase over time as contaminants build-up within the valve. When the valve torque reaches a level of 27 Nm (20 lbf ft), the valve cartridge must be cleaned to reduce the torque requirement.

WARNING

The fuel valve torque must not be allowed to exceed 27 Nm (20 lbf ft) to prevent the valve from stalling.

The fuel valve torque should be measured at the actuator coupling using a torque wrench.

WARNING

The fuel valve must be removed from service and power to the valve must be off when the valve actuation torque is checked.

If the measured fuel valve torque is 27 Nm (20 lbf ft) or greater, the valve must be cleaned to reduce the torque requirement to below 27 Nm (20 lbf ft).

The fuel valve should first be cleaned with diesel oil, as outlined in the following procedure. If this does not reduce the valve torque to below 27 Nm (20 lbf ft), the valve cartridge should be removed and cleaned.

1 Remove power to the actuator and controller.

2 Verify that the gas fuel supply to the fuel valve is not under pressure.

3 Remove the actuator cover and disconnect the field wiring (tag each wire with its connector pin-out information to aid in later reconnection of the field wiring).

4 Remove the wiring conduits from the actuator.

5 Disconnect the vent line from the fuel valve body.

6 Remove the valve from its installed position in the gas fuel line.

7 Block the exit flange and gravity fill the fuel valve completely with diesel fuel/oil.

8 Mechanically rotate the valve back and forth as necessary to free-up the valve.

9 Allow the fuel valve to soak with the diesel oil for 4 hours.

10 Remove the diesel oil from the valve.

11 Check the valve torque. If the torque is not below 20 Nm (15 lbf ft), the valve cartridge should be removed and cleaned (continue to the next step). If the valve torque has been reduced to below 20 Nm (15 lbf ft), the valve can be placed back in service (skip to Step 24).

12 Mark reference points on the yoke, cap, and fuel valve body for later reassembly and alignment.

13 Remove the bottom set screws and lock screws from the coupling (coupling shown in Fig 23).

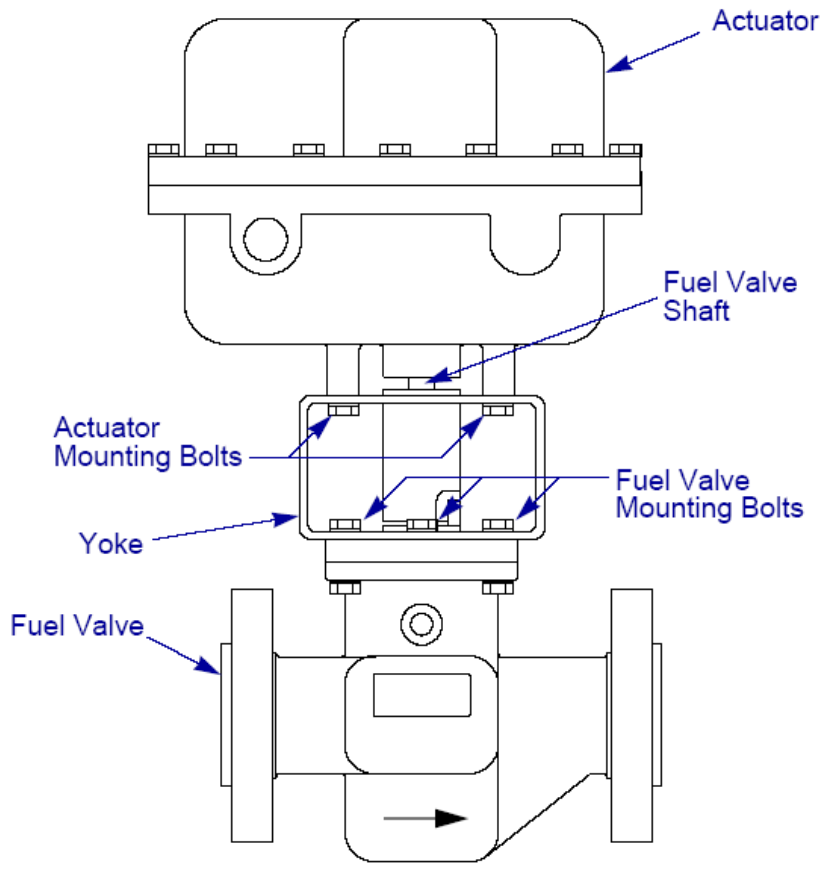


Fig 23 Fuel Valve and Actuator Assembly (2-inch Fuel Valve Shown)

14 Remove the bolts between the yoke and fuel valve body (see Fig 23), then separate the actuator from the valve.

15 Remove the valve body top cover (see Fig 24 on page 66) and pull out the cartridge using the AMOT removal tool (AMOT part number 20498), or two large wrenches between the two rotor shaft nuts.

16 Dismantle the cartridge assembly.

17 Clean the rotor with Scotchbrite or steel wool to remove all evidence of deposits.

18 Inspect the surface of the DU bearing for evidence of scoring, significant wear (subsurface bronze particles exposed on much of the surface), or other damage. DO NOT CLEAN THE DU BEARING.

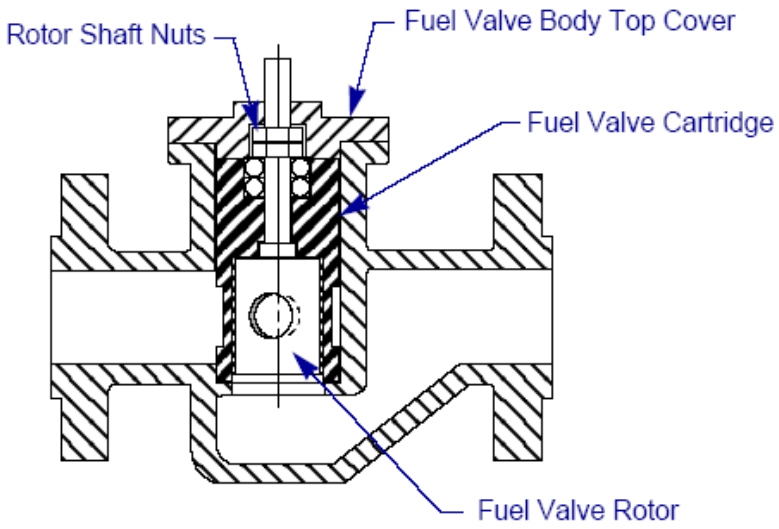


Fig 24 Cut-Away View of Fuel Valve and Cartridge (2-inch Valve Shown)

19 Inspect the inside bore of the rotor for erosion (see Fig 25). Any erosion that has reduced the wall thickness of the rotor by more than 50% is considered significant, and a replacement valve cartridge should be installed.

20 Replace all cartridge seals, O-rings, and bearings if necessary.

21 Reassemble the valve cartridge and install it back into the valve body.

22 Check that the valve torque has decreased to below 20 Nm (15 ft lbs).

23 Reassemble the fuel valve and actuator in reverse order of the disassembly procedures.

CAUTION

Care must be taken to properly align the actuator with the fuel valve shaft upon reassembly. See Actuator Mounting Alignment on page 30.

24 Install the fuel valve assembly back into the gas fuel line using new flange pipe gaskets.

25 Reconnect the vent line to the fuel valve body.

26 Reconnect the wiring conduits to the actuator and reconnect the field wiring to the actuator using the tag information recorded in Step 3.

27 Replace the actuator cover, being careful to assure the proper position and integrity of the O-ring seal to assure a gastight fit of the cover.

28 Restore the gas fuel supply pressure to the valve.

29 Perform a leak check at the vent line and at the rotor shaft-to-gear location to verify the seals are bubble-tight. Repeat any additional leak checks under full gas supply pressure that may be necessary to meet local codes.

30 Check that the calibration of the fuel valve has not changed.

31 Return the fuel valve to service.

5.11 Fuel Valve Wear

In applications where the quality of the fuel gas is poor, and the fuel gas has not been processed to remove any particles, sand, debris, and liquids from the fuel supply, the valve cartridge may develop significant wear. In such applications, the valve cartridge assembly should be considered a Parts Class 1 spare (see Appendix F).

The following procedure should be used to remove and inspect the valve cartridge for wear. If necessary, the valve cartridge should be replaced.

WARNING

The fuel valve must be removed from service and power to the valve must be off when the valve is checked for wear.

1 Remove the fuel valve from service and remove power to the actuator and controller.

2 Verify that the gas fuel supply to the fuel valve is not under pressure.

3 Remove the actuator cover and disconnect the field wiring (tag each wire with its connector pin-out information to aid in later reconnection of the field wiring).

4 Remove the wiring conduits from the actuator.

5 Disconnect the vent line from the fuel valve body.

6 Remove the valve from its installed position in the gas fuel line.

7 Mark reference points on the yoke, cap, and fuel valve body for later reassembly and alignment.

8 Remove the bottom set screws and lock screws from the coupling (see Fig 23 on page 65).

9 Remove the bolts between the yoke and fuel valve body (see Fig 23), then separate the actuator from the valve.

10 Remove the valve body top cover (see Fig 24 on page 66) and pull out the cartridge using the AMOT removal tool (AMOT part number 20498), or two large wrenches between the two rotor shaft nuts.

11 Dismantle the cartridge assembly.

12 Clean the rotor with Scotchbrite or steel wool to remove all evidence of deposits.

13 Inspect the surface of the DU bearing for evidence of scoring, significant wear (subsurface bronze particles exposed on much of the surface), or other damage. DO NOT CLEAN THE DU BEARING.

14 Inspect the inside bore of the rotor for erosion (see Fig 25 on page 69). Any erosion that has reduced the wall thickness of the rotor by more than 50% is considered significant, and a replacement valve cartridge should be installed.

15 Replace all cartridge seals, o-rings, and bearings if necessary.

16 Reassemble the valve cartridge and install it back into the valve body.

17 Reassemble the fuel valve and actuator in reverse order of the disassembly procedures.

CAUTION

Care must be taken to properly align the actuator with the fuel valve shaft upon reassembly. See Actuator Mounting Alignment on page 30.

18 Install the valve assembly back into the gas fuel line using new flange pipe gaskets.

19 Reconnect the vent line to the fuel valve body.

20 Reconnect the wiring conduits to the actuator and reconnect the field wiring to the actuator using the tag information recorded in Step 3.

21 Replace the actuator cover, being careful to assure the roper position and integrity of the O-ring seal to assure a gastight fit of the cover.

22 Restore the gas fuel supply pressure to the valve.

23 Perform a leak check at the vent line and at rotor shaft-to-gear location to verify the seals are bubble-tight. Repeat any additional leak checks under full gas supply pressure that may be necessary to meet local codes.

24 Check that the calibration of the fuel valve has not changed.

25 Return the fuel valve to service.

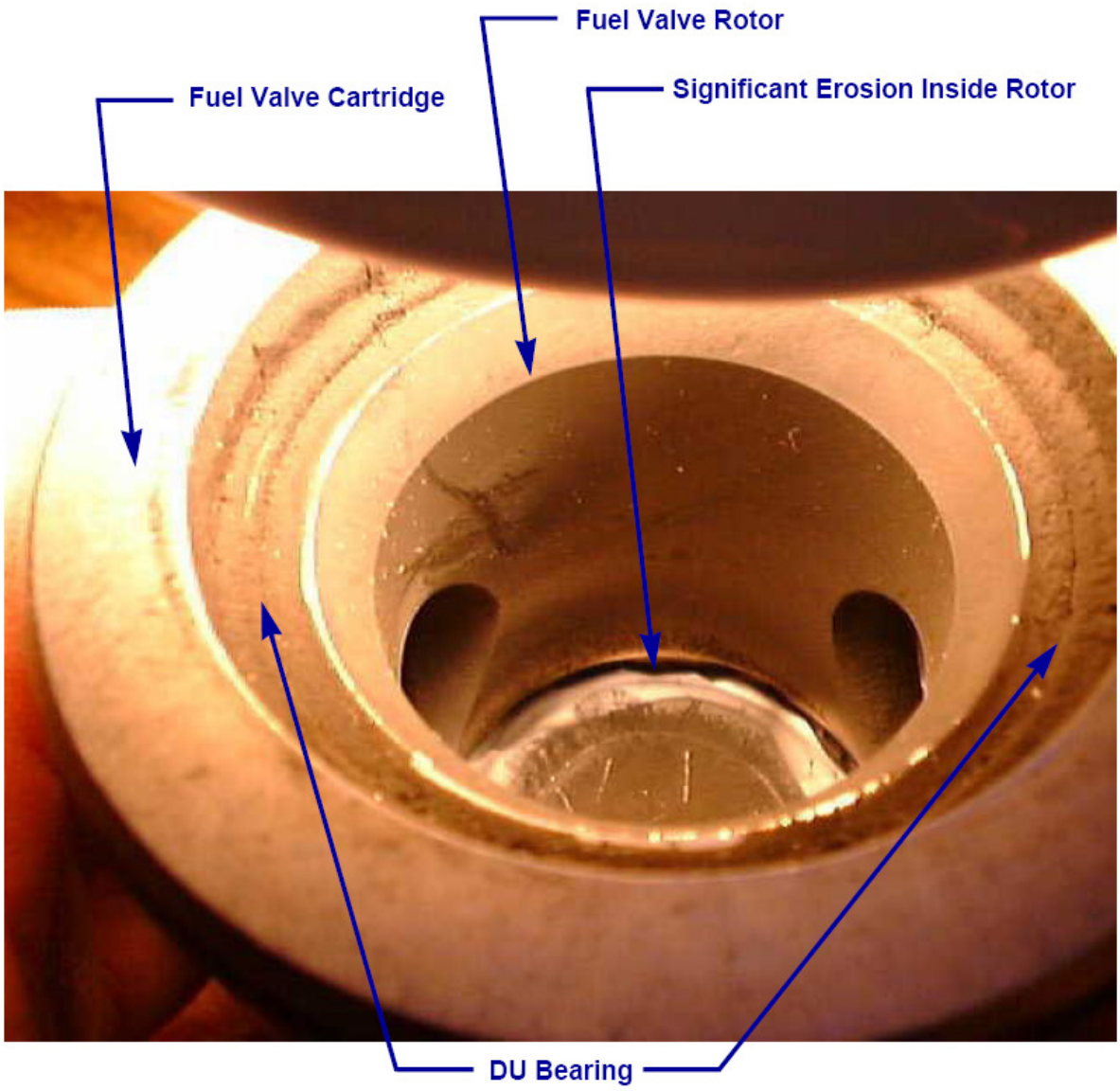


Fig 25 Example of Erosion on Inside of Rotor

5.12 Encoder Replacement

The optical encoder located within the actuator housing (see Fig 26) can be replaced in the event of an encoder failure. This section outlines the general procedures for replacing the encoder.

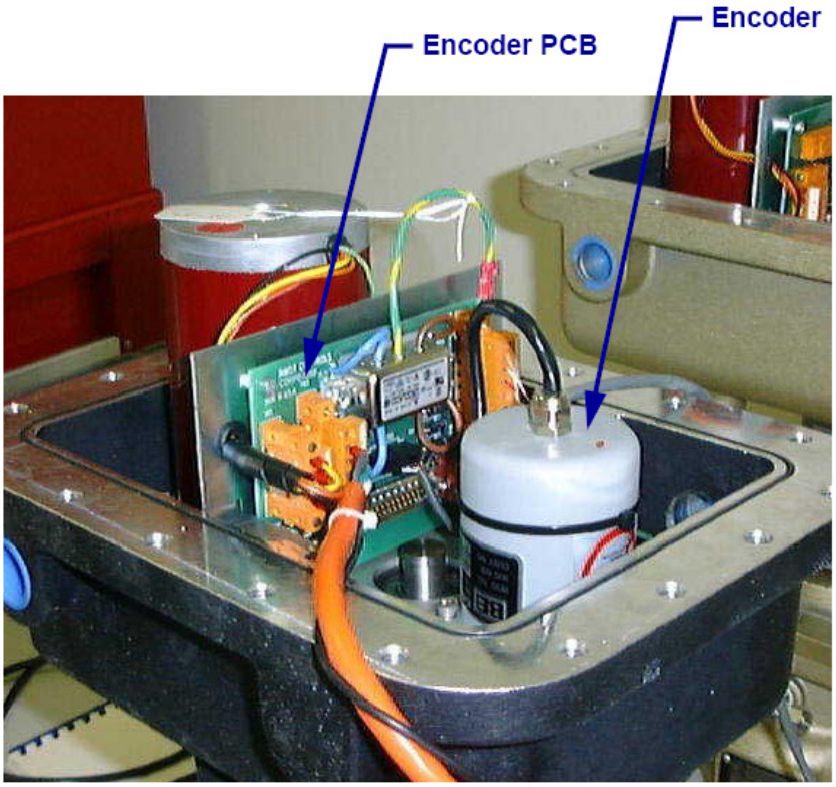


Fig 26 Location of Encoder within Actuator (Actuator Cover Removed)

5.12.1 Verification of Encoder Failure

Prior to replacement of the encoder, the following checks should be performed to verify that the encoder is actually failed:

- Check all fuses (see page 37), particularly the 600 mA fuse (F3) on the PSU/Interconnect PCB assembly (see Fig C- 4 on page 90), which is the fuse for power to the encoder.
- Check all cabling connections at the valve and controller.
- Check the 12Vdc encoder power at the valve. The encoder requires 5Vdc to operate correctly.
- Perform a system check (see page 60) to test the operation of the encoder. (This check is available only on controllers with firmware version 3.00f or later.)

If the fuses, connections, and power supply are good, and any encoder or tracking alarms are present, it may be necessary to replace the encoder.

5.12.2 Replacement Encoder

Encoders used in fuel valves with design level G or higher (see Product Identification on page 21) are of a different design than those used in previous fuel valve design levels (F or lower).

A "new" encoder can be retrofitted into older design levels of the fuel valve. However, this also requires the installation of a new encoder PCB into the actuator. (The new PCB can be used with either an old or new encoder.)

Therefore, when replacing an old encoder (fuel valve design level F or lower) with a new encoder, an updated encoder PCB (66280X) must also be installed.

Appendix F on page 107 provides information on spares, including the new encoder part number.

5.12.3 Encoder Replacement Procedures

The general procedures for replacing the encoder within the fuel valve actuator are given below. Contact AMOT if you have any questions or problems related to the replacement of the encoder.

CAUTION

This procedure should be performed only by an experienced instrument technician.

Replacing the encoder without adequate static discharge precautions could result in damage to the unit. Always wear a wrist strap connected to any unpainted metal portion of the actuator.

1 If the controller is positioning the valve correctly, carefully note the exact position of the valve with the command signal at 4mA before powering-down the valve actuator (see Fuel Valve Position Indicator on page 43). If the controller is not positioning the valve correctly, skip this step.

2 The turbine must be shut down and the fuel valve actuator powered down before the encoder is replaced.

WARNING

While removing and replacing the actuator cover, ensure that all explosion-proof certification requirements are met.

3 Remove the actuator cover and locate the encoder, as shown in Fig 26 on page 70.

4 Carefully remove the four encoder mounting screws at the base of the encoder (see Fig 27 on page 72). These screws may be locked in place with a bonding agent and difficult to remove.

5 Disconnect the encoder cable from the encoder and the encoder PCB.

6 Rotate the encoder case to loosen the assembly and remove the encoder from the actuator. Note the how the gear at the bottom of the encoder meshes with the quadrant gear on the valve shaft.

7 Carefully position the replacement encoder into the actuator, paying special attention to the meshing of the encoder and quadrant gears. Slight wiggling of the encoder may help in getting the gears to mesh properly.

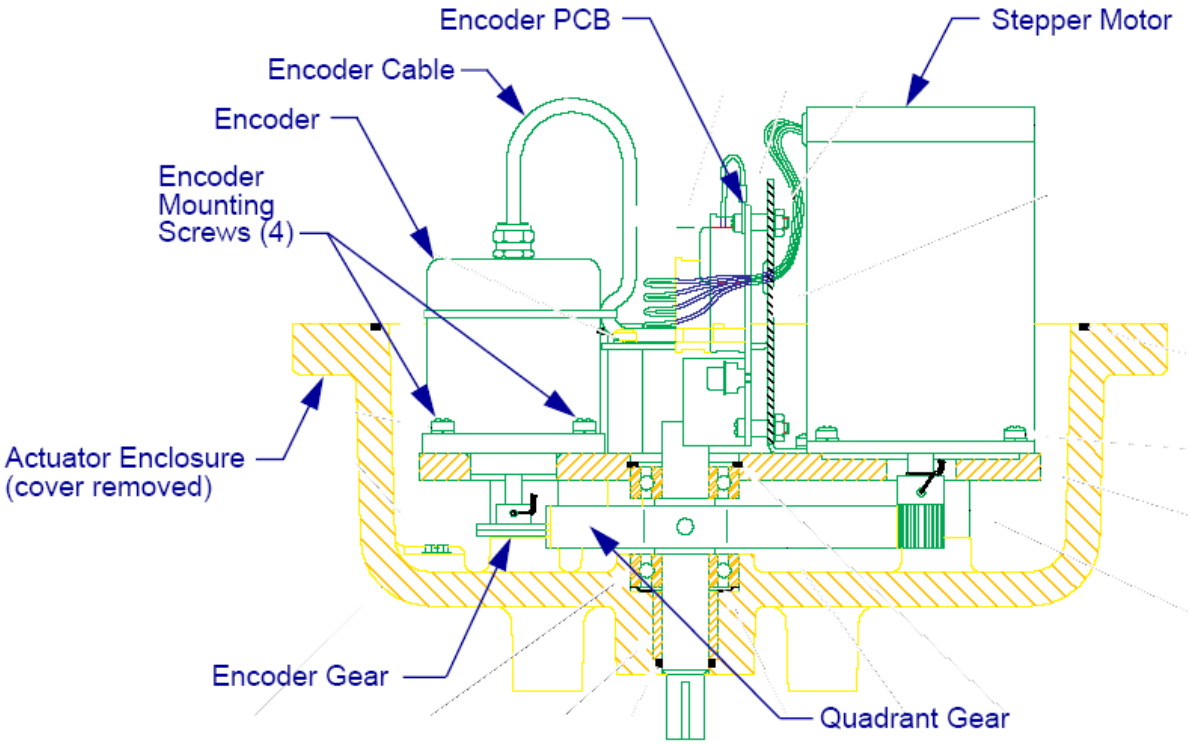


Fig 27 Encoder Removal

8 With the gears meshed, press the encoder into its seated position.

CAUTION

Coat the threads of the encoder mounting screws with a breakable bonding agent.

9 Install and tighten the four encoder mounting screws.

10 If applicable (see Replacement Encoder on page 71), replace the encoder PCB with the updated version (66280X).

11 Reconnect the new encoder cable between the encoder and PCB.

12 Replace the actuator cover.

CAUTION

Be careful to assure the proper position and integrity of the O-ring seal to assure a gas-tight fit of the cover.

13 The fuel valve actuator must be recalibrated and tested for proper operation before the fuel valve can be placed back into service. The Auto Setup procedure on page 56 is used to calibrate the actuator for the open

and closed set points. If applicable, the 4mA calibration set point should be set to correspond to the valve position recorded in Step 1.

Note

The absolute encoder position values are fixed with respect to the fuel valve trim position, and are independent of the set point calibration. The only time that the absolute encoder values change with respect to the flow crack point is if the encoder is removed from the actuator.

All zero-position information is lost, and the recalibration procedure is required, when the encoder is replaced.

14 Perform the System Check on page 60 to test the operation of the encoder and ensure that there are no current alarms. (This check is available only on controllers with firmware version 3.00f or later.)

The fuel valve can be put back into service following successful completion of the actuator recalibration and system check procedures.

Appendix A

Specifications and Approvals

This appendix lists the specifications and third-party approvals for the Rotary Fuel Valve system.

Specifications

Application: Direct Control of Natural Gas Turbine Fuel

- Fuel Valve Model No.: 4280
- Actuator Controller Model No.: 8412 (See Product Identification on page 21.)

Table A- 1 Actuator Specifications

No.	Type	Specification
1.0	**Environmental – Fuel Valve and Actuator**	
1.1	Operating temperature limits	-20 to 70° C (-4 to 158° F)
1.2	Storage temperature	-40 to +100° C (-40 to +212° F)
1.3	Actuator enclosure	Designed for Class 1, Div. 1, Group C and D; weather sealed; NEMA Type 4 / indoor and outdoor
1.4	Vibration tolerance IEC654-3, level 6	5g (10–62 Hz) 7g (63–3000 Hz)
1.5	Maximum hydrogen sulphide (H_2S) in fuel gas for carbon steel valves. (SS valves available for higher H_2S concentrations)	100 ppm
1.6	Humidity	<90% non condensing
2.0	**Actuator, Mechanical**	
2.1	Drive type	Stepper motor
2.2	Internal position measurement	Digital encoder
2.3	Fuel Valve shaft torque	50 Nm (37 lb-ft) (momentary)
2.4	Operating range	60 degrees rotation
2.5	Speed (open to close)	250 ms
2.6	Speed adjustment	Fixed
2.7	Fuel Valve seat protection	Adjustable mechanical stops at ends of travel
2.8	Motor-to-shaft drive mechanism	Precision gears (spur)
2.9	Conduit entry	Two, each 3/4 in NPT
2.10	Overall dimensions	See dimensional drawings (Appendix B)

No.	Type	Specification
2.11	Motor enclosure material/seal	Aluminium/O-ring gasketed
2.12	Exterior finish	Anodize
2.13	Mounting of actuator	On valve on standoffs; air gap above valve
2.14	Motor/valve shaft coupling type	Anti backlash helical
3.0	**Actuator, Electrical**	
3.1	Loss of set point signal	Go to 4 mA / Hold last position (configurable by user)
3.2	Action on loss of power or loss of feedback signal	Maintain current position
3.3	Field wiring terminal type	Weidmuller 2-part screw fastening type
3.4	Wiring size range	10-18 AWG (see Section 4)
3.5	Motor protection	Software
4.0	**Actuator Performance**	
4.1	Positioning repeatability	+/- 0.054%
4.2	Stepper motor error	0.066 degrees
4.3	Number of motor steps	1667 (in 60 degrees)
4.4	Fuel Valve to motor ratio (valve°:stepper motor°)	60°:600°
4.5	Fuel Valve to encoder ratio (valve°:encoder°)	60°:240°
4.6	Maximum drive speed	100% travel in 250 ms (both directions)
4.7	Temperature coefficient	N/A (absolute encoder)
4.8	Measurement error	N/A (absolute encoder)
4.9	Hysteresis	+/- 0.05%
4.10	Gear ratio, stepper motor:valve	10:1
5.0	**Controller**	
5.1	Line voltage	24 V dc (18-32 V dc)
5.2	Reserved	
5.3	Electronic platform	Digital
5.4	Power requirements	Fused; 8 amps (125 VA maximum)
5.5	4-20 mA set point input impedance	250 Ohms
5.6	Enclosure/material	NEMA 4/IP65 steel enclosure; indoor use only
5.7	Operating temp. limits	0 to 50° C (32 to 122° F)

No.	Type	Specification
5.8	Storage temperature	-20 to 70° C (-4 to 158° F)
5.9	Vibration tolerance IEC654-3	0.5 g, 10 Hz to 3 kHz
5.10	Cable(s), interconnect	see Cabling Requirements in Section 4
5.11	Position transmitter signal	4-20 mA dc; non isolated, fused
5.12	Position feedback signal update time (serial)	Less than 5 msec
5.13	4 mA point adjust	100% of full scale
5.14	20 mA point adjust	100% of full scale
5.15	Adjustable hysteresis	0.05% to 9.00% in 0.05% increments
5.16	Reverse acting	User selectable
5.17	Auto/manual control	Not switchable by operator (SETUP Mode only)
6.0	**Operator Interface**	
6.1	Setup	Push buttons/LCD display
6.2	Control indication	LCD text + LED
6.3	Fuel Valve position indication	Mechanical pointer on coupling and 4 digit BCD on LCD display
7.0	**Fuel Valve, Mechanical**	
7.1	Fuel Valve type	Rotary, balanced
7.2	Shutoff class	ANSI Class I (not tight)
7.3	Shutoff leakage	0.5% typical
7.4	Fuel Valve body configuration	Straight through
7.5	Controlled media	Natural gas
7.6	Fuel Valve Flow Coefficient (Cv)	Trim set options: 12, 25, 30, 60, 90
7.7	Supply/Discharge working pressure	Up to 69 bar (1000 psi)
7.8	User connections	ANSI Class 600 RF flange
7.9	Body material	Carbon steel / Stainless steel
7.10	Cartridge material	Stainless steel/alloy (no sour gas)
7.11	Rotor material	Stainless steel/alloy (no sour gas)
7.12	Stem material	Stainless steel/alloy (no sour gas)
7.13	Inlet port material	Stainless steel/alloy (no sour gas)
7.14	Value proof pressure rating (individually tested)	100 bar (1450 psi)
7.15	Stem packing	PTFE; double seal and vent
7.16	Packing adjustment	None
7.17	Seals, other	Viton

No.	Type	Specification
7.18	Exterior finish	Epoxy powder coating (fuel valve and yoke) (previously cadmium plate)
8.0	**Weights**	
8.1	Actuator controller	10 kg (22 lb)
8.2	Actuator	18 kg (40 lb)
8.3	Fuel Valve/Actuator	2-inch: 50 kg (110 lb) 3-inch: 109 kg (240 lb)

Third-Party Approvals

The 8412I Rotary Fuel Valve Controller has CSA general certification per CSA certificate number 2544940.

The 4280 Rotary Fuel Valve Actuator has CSA hazardous area certification per CSA certificate number 1737044:

- Class I, Division 1, Group C and D

Appendix B

Installation Dimensions

This appendix provides installation dimensions drawings for the valve controller and each fuel valve size.

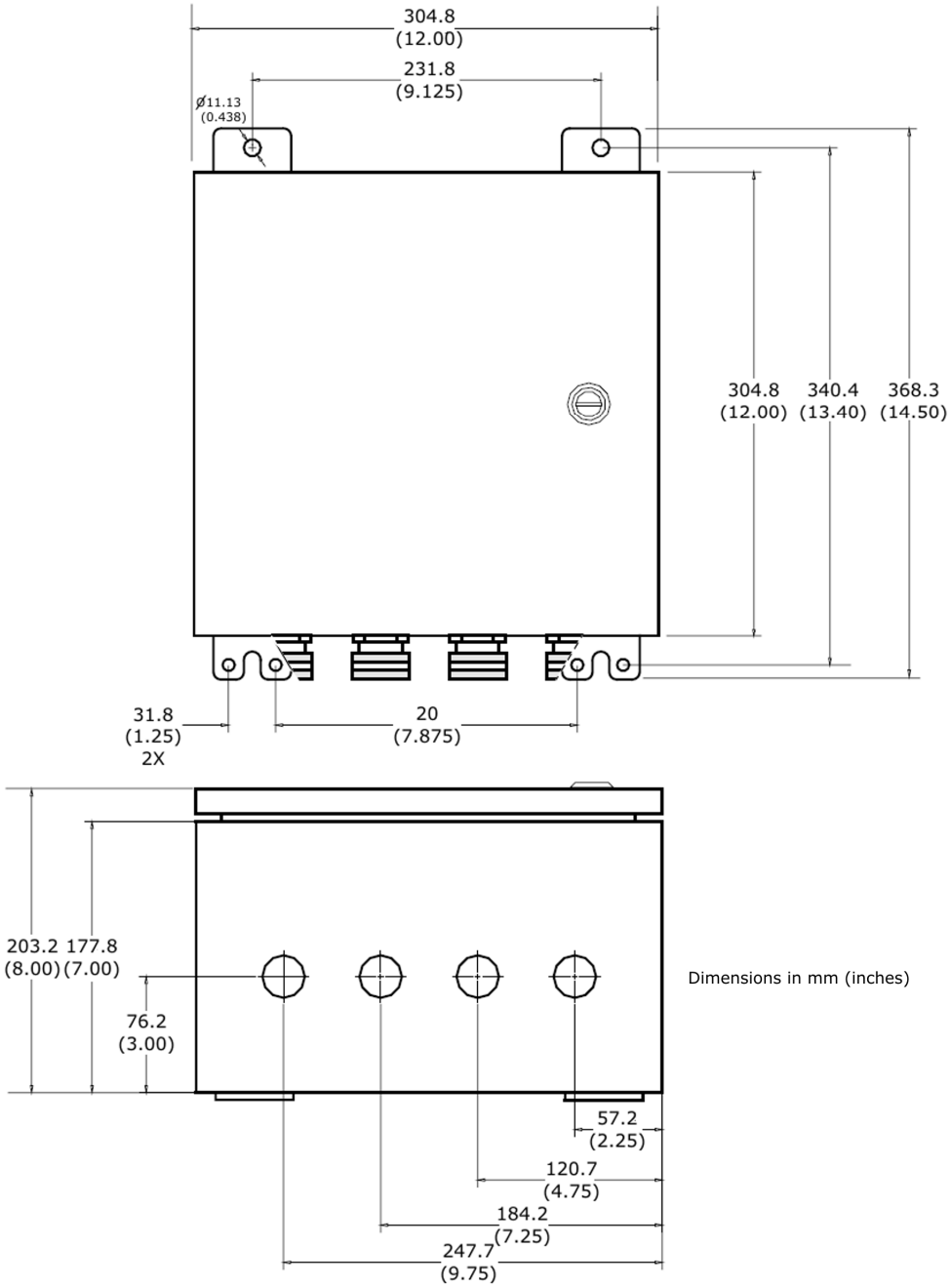


Fig B- 1 Installation Dimensions – Controller Enclosure (8412 Rev. I)

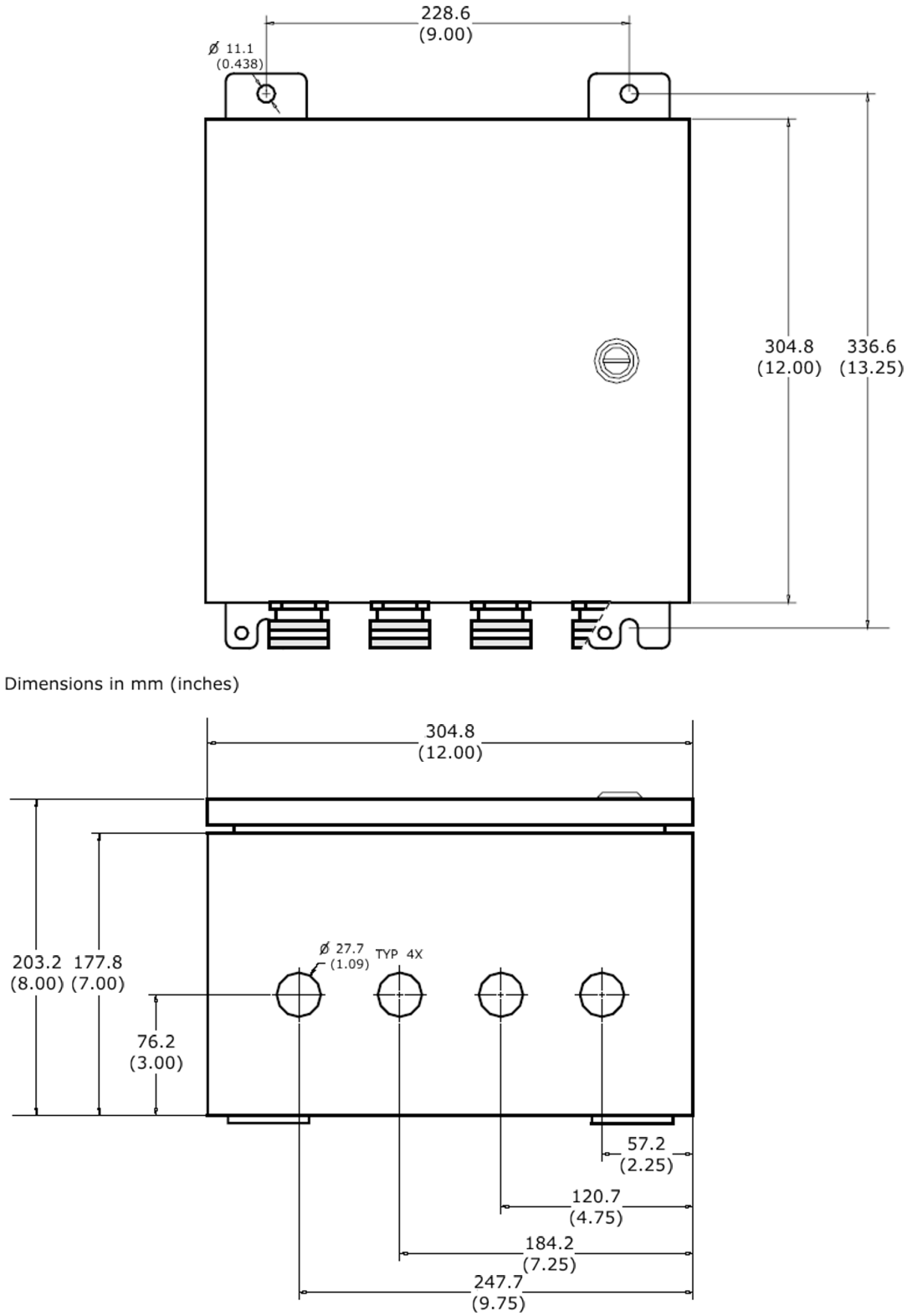


Fig B- 2 Installation Dimensions – Controller Enclosure (8412 Rev. H)

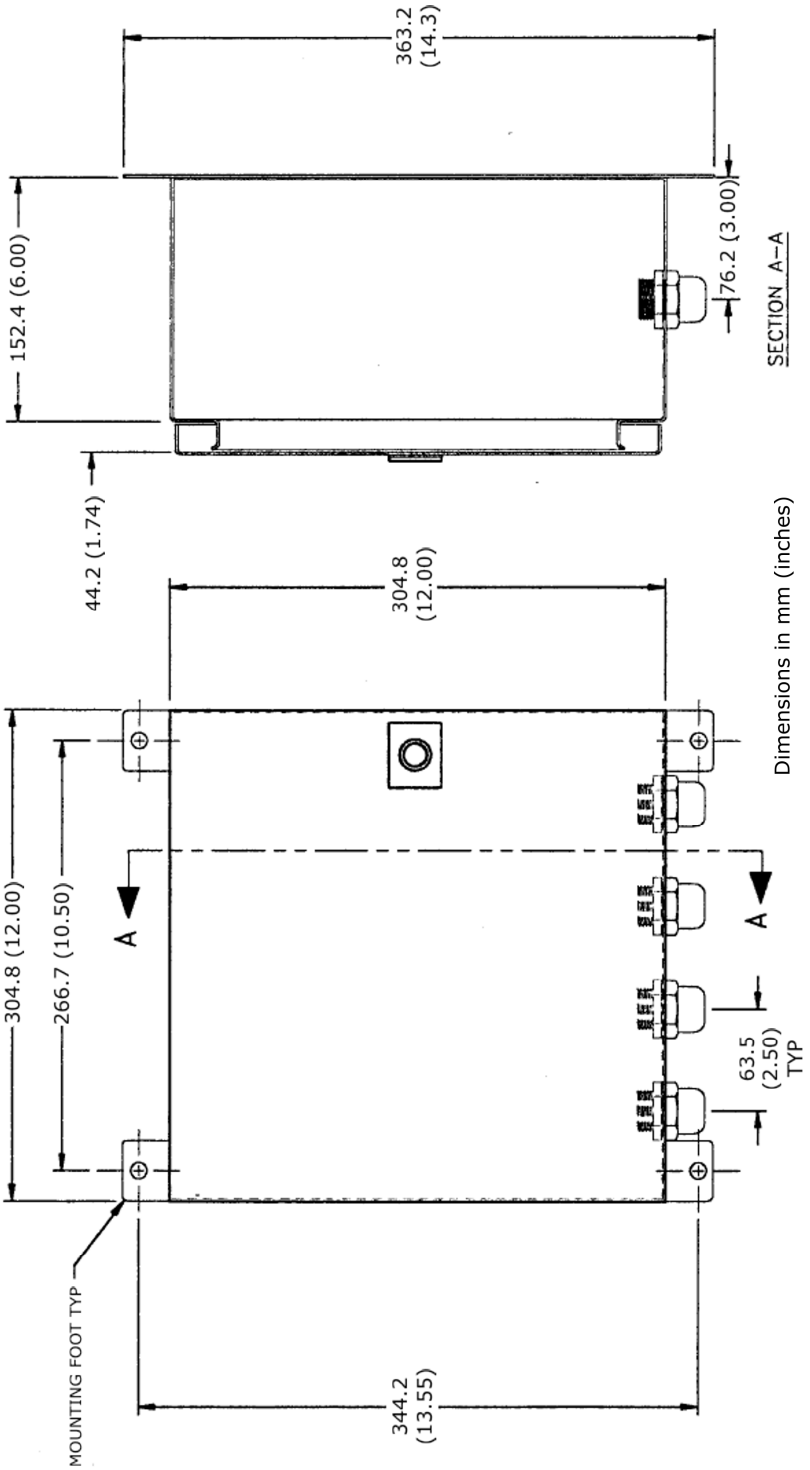


Figure B-3 Installation Dimensions – Controller Enclosure (8412 Rev. G and Previous)

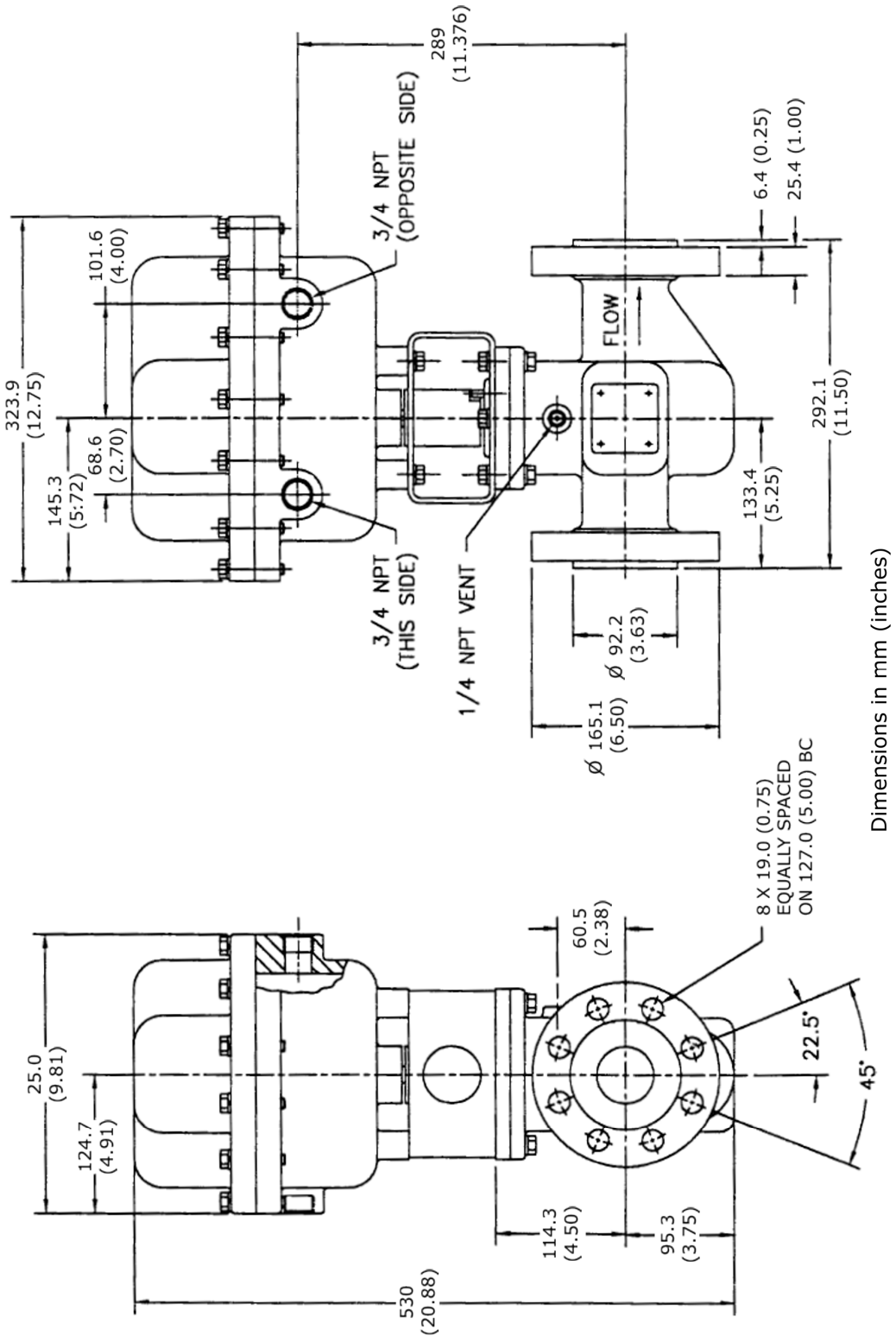


Figure B-4 Installation Dimensions – 2 in Rotary Fuel Valve/Actuator

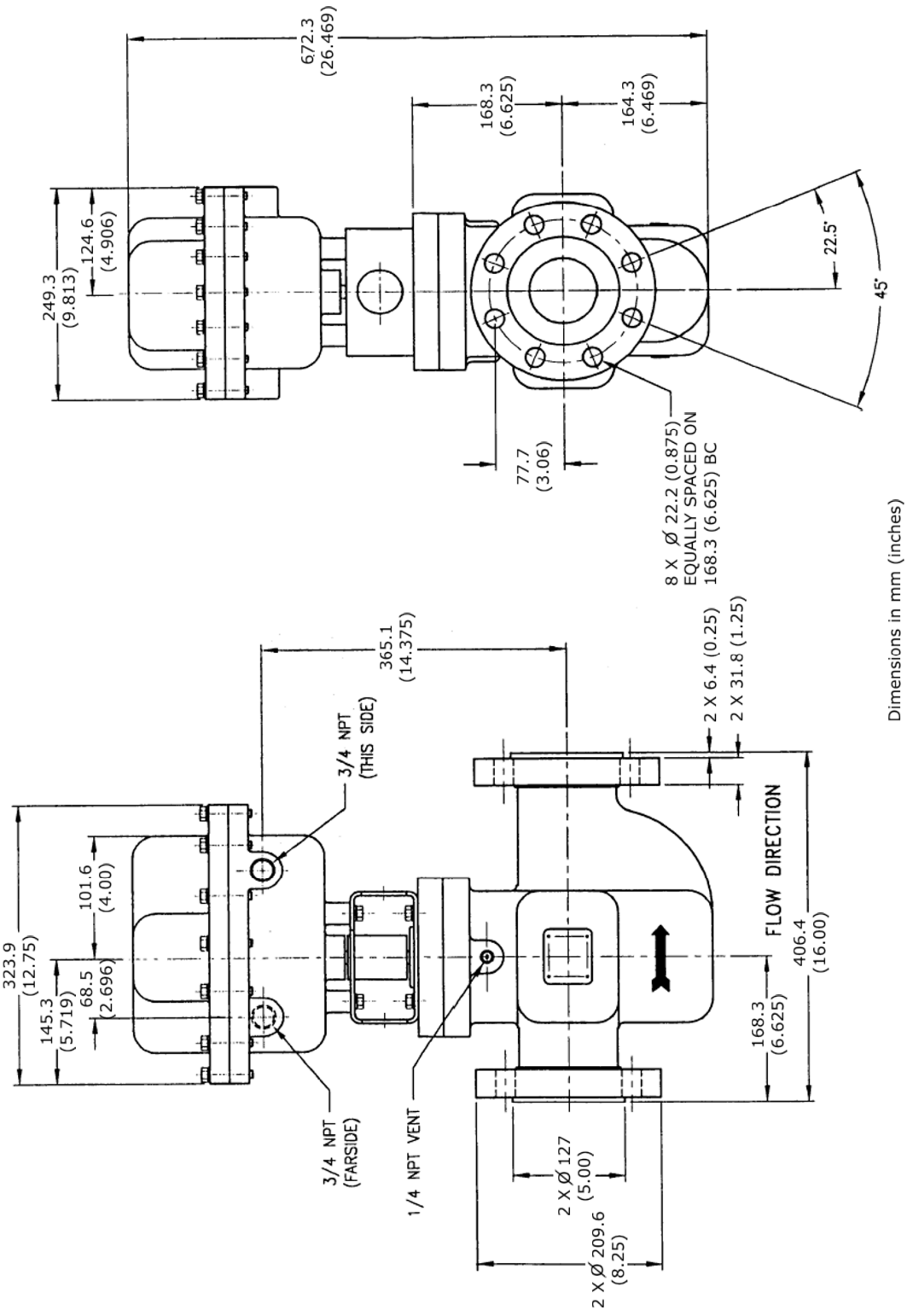
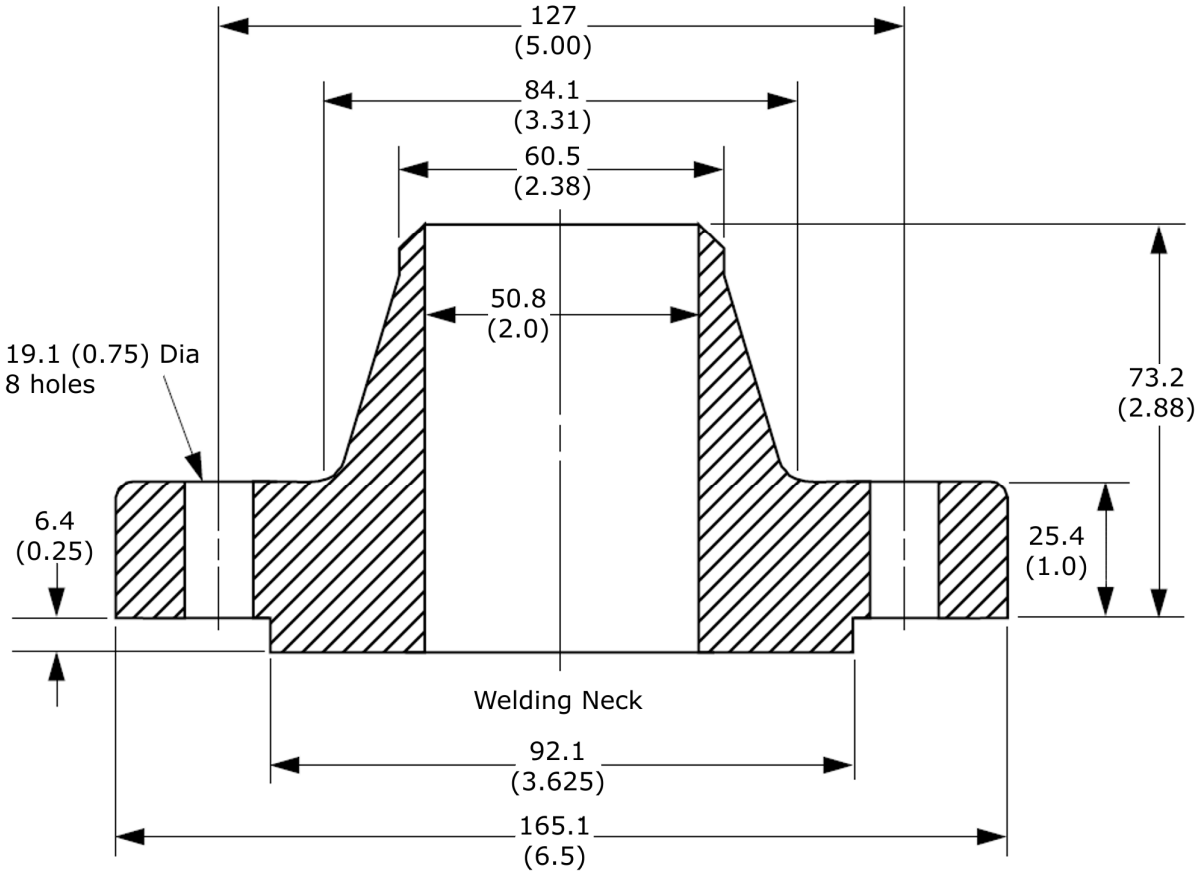
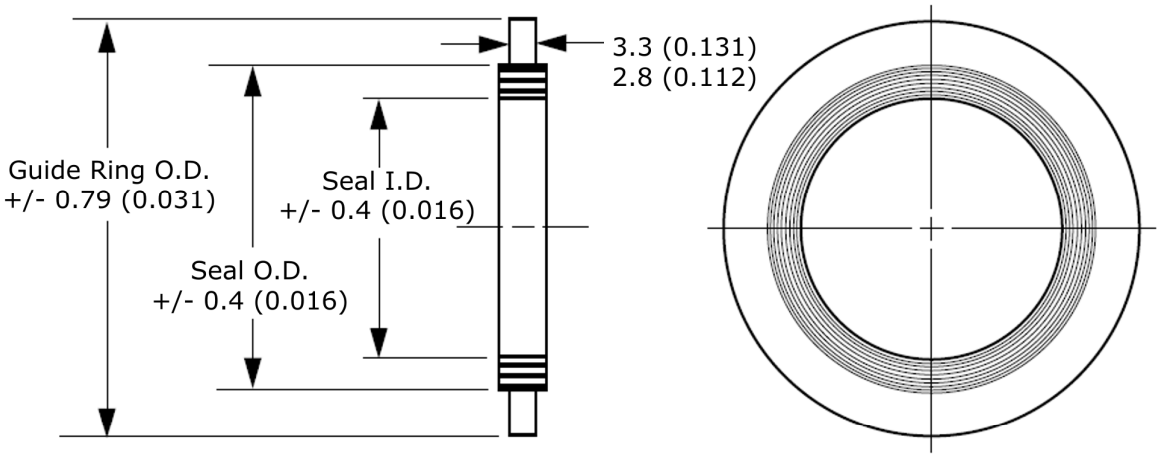


Figure B-5 Installation Dimensions – 3 in Rotary Fuel Valve/Actuator



- Dimensions in mm (inches)
- Not drawn to scale

Figure B-6 Dimensions – Class 600 Weld Neck Flange for 2 in Fuel Valve



- Dimensions in mm (inches)
- Not drawn to scale
- Material: #304 SS windings with Grafoil filler

Nominal Pipe Size	Guide Ring O.D. mm (inches)	Seal O.D. mm (inches)	Seal I.D. mm (inches)	AMOT Part No.
2 in	111.1 (4.375)	85.7 (3.375)	69.8 (2.750)	11604L200
3 in	149.2 (5.875)	120.6 (4.750)	101.6 (4.000)	11604L300

Figure B-7 Dimensions – ANSI Class 600 API 601 (Std) Spiral Wound Gasket

Appendix C

Wiring and Electronic Detail

This appendix provides wiring and PCB diagrams for the Rotary Fuel Valve system.

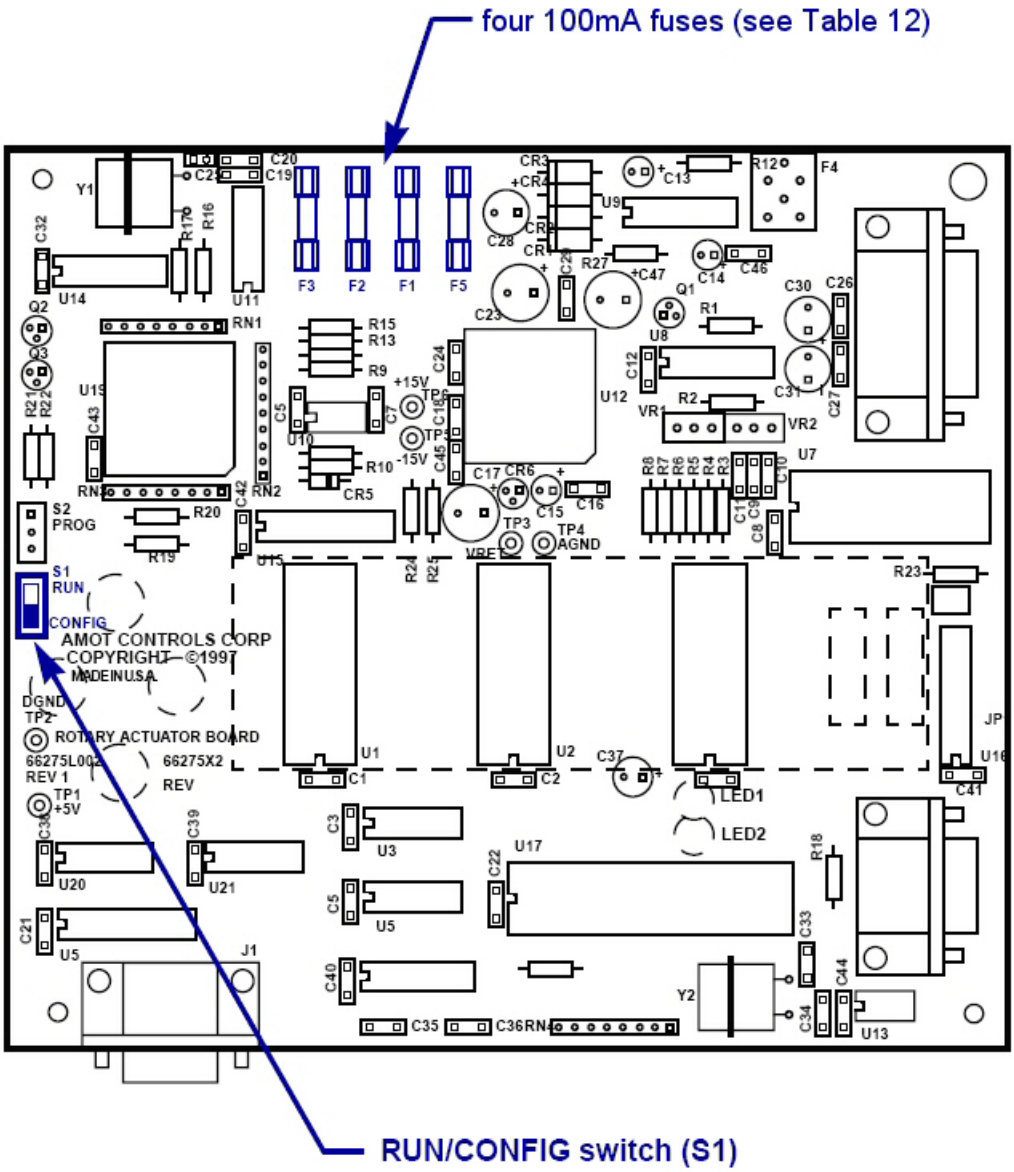


Fig C- 1 Rotary Actuator PCB Assy 66275X (Attached to Back of User IF Panel)

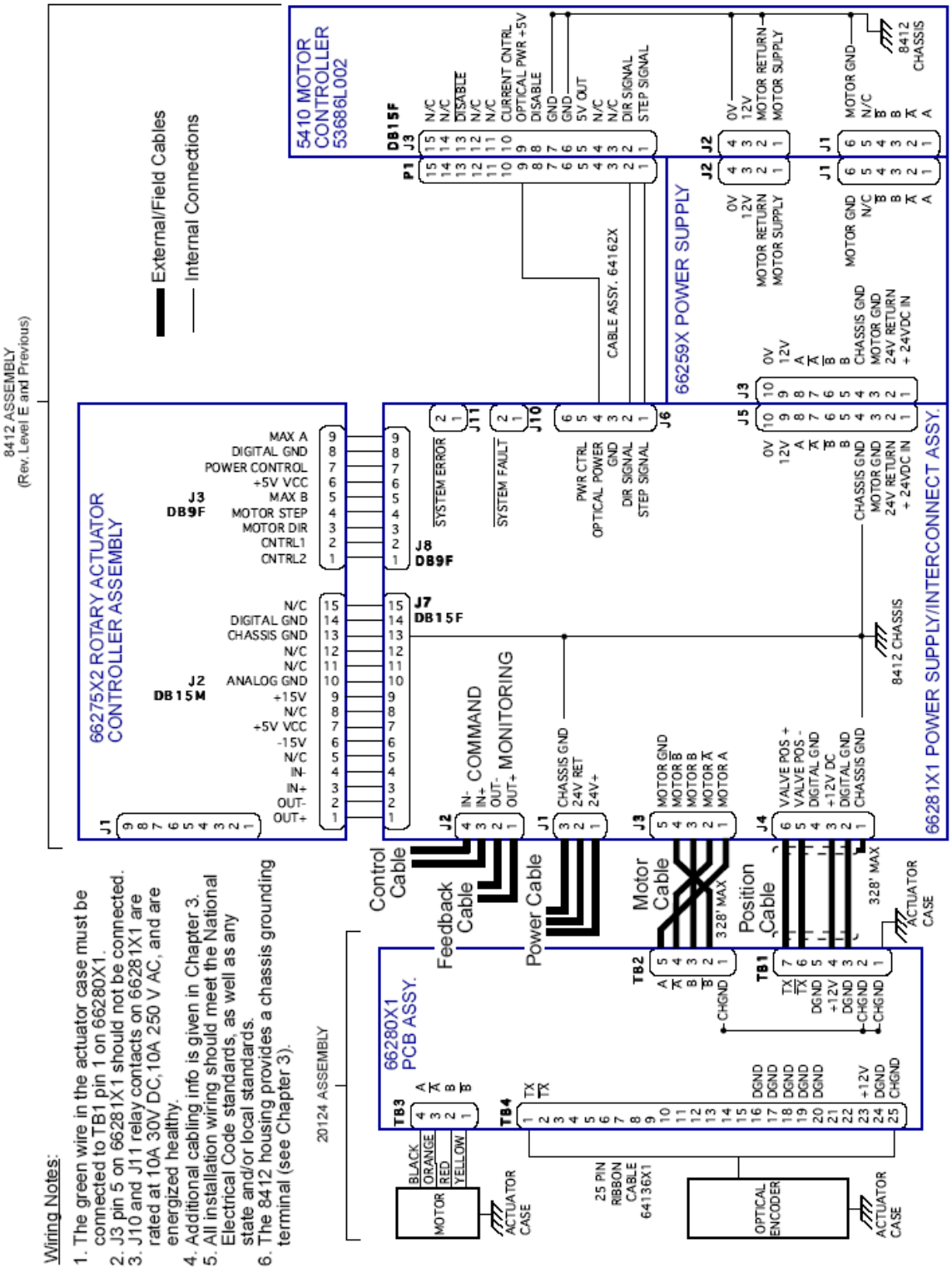


Fig C- 2 Wiring Details – Controller 8412E and Previous

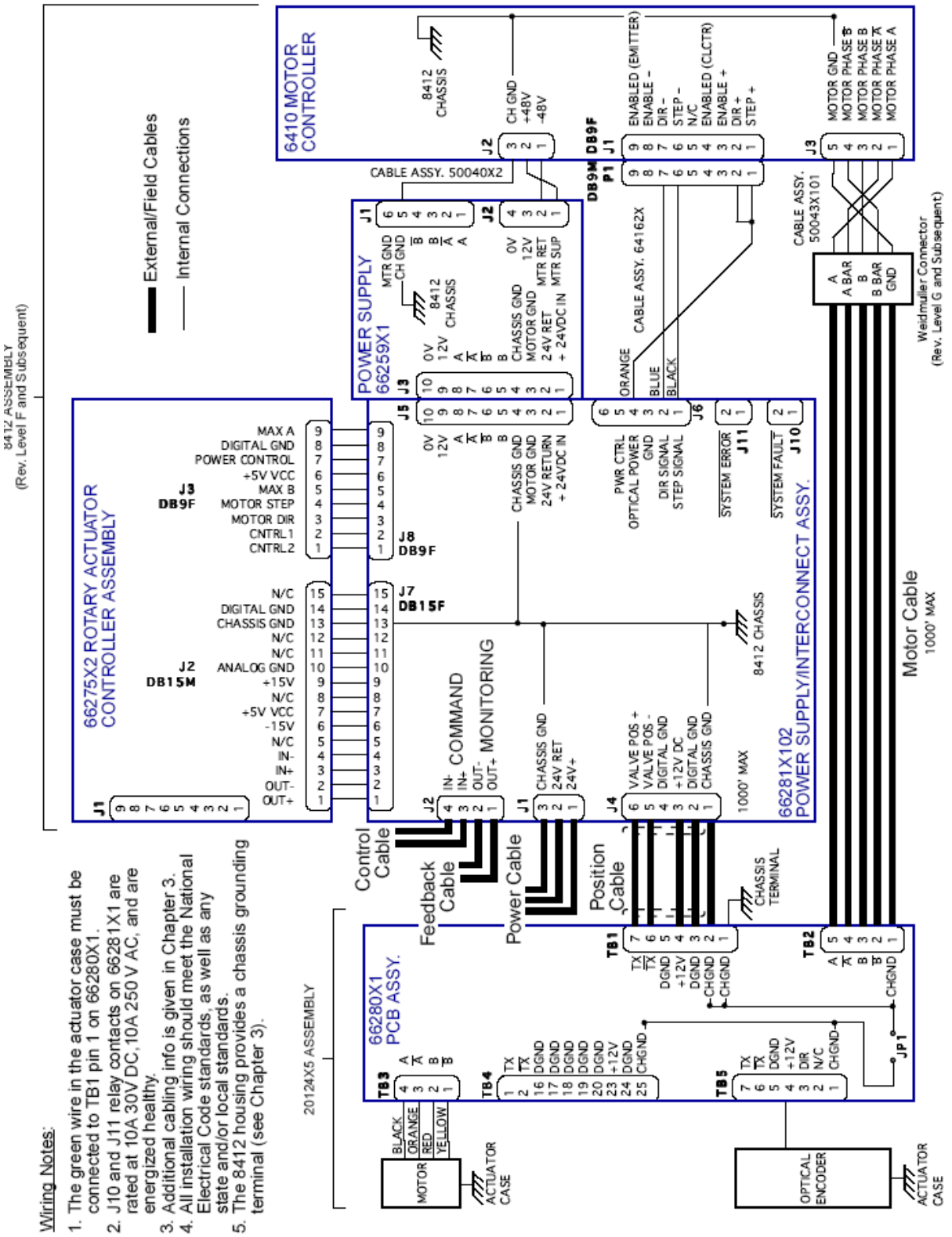


Fig C- 3 Wiring Details – Controller 8412F and Subsequent

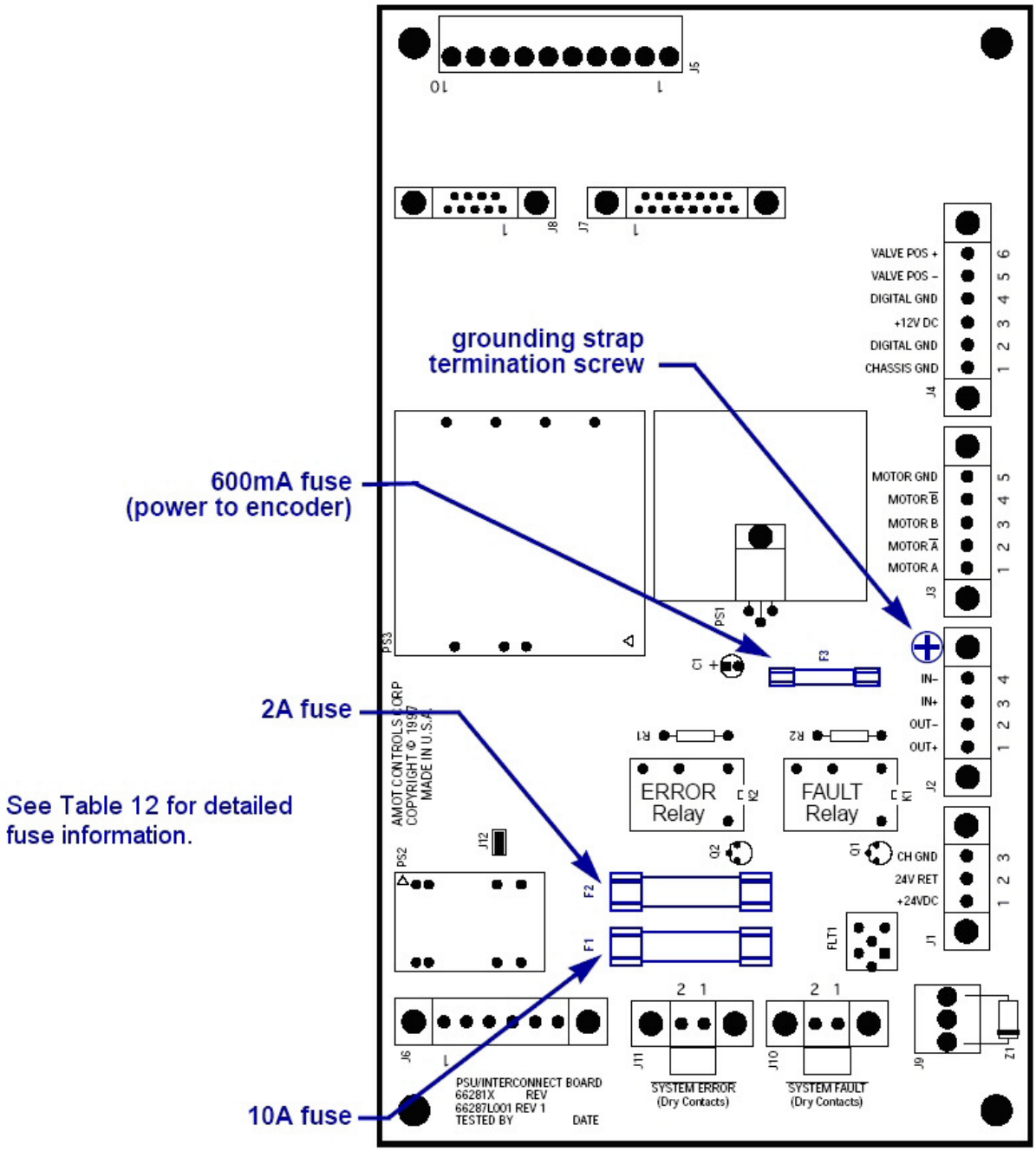


Fig C- 4 PSU/Interconnect PCB Assembly (66281X)

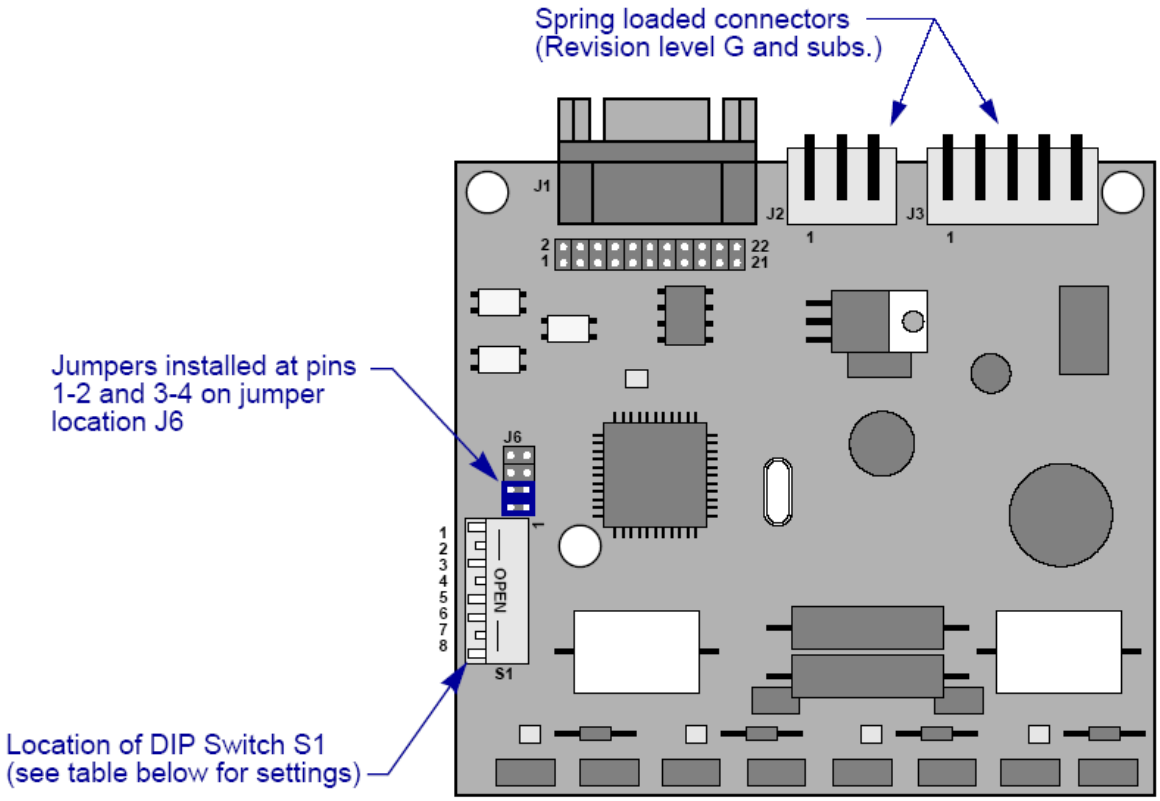


Fig C- 5 6410 Stepper Motor Drive PCB Assy (Controller 8412F & Subsequent)

Controllers of revision level F and subsequent use the 6410 stepper motor drive PCB shown above. The eight positions on DIP switch S1 shown in must be set as shown in the following table:

DIP Switch Position	Setting
1	down/closed
2	up/open
3	down/closed
4	up/open
5	down/closed
6	down/closed
7	up/open
8	down/closed

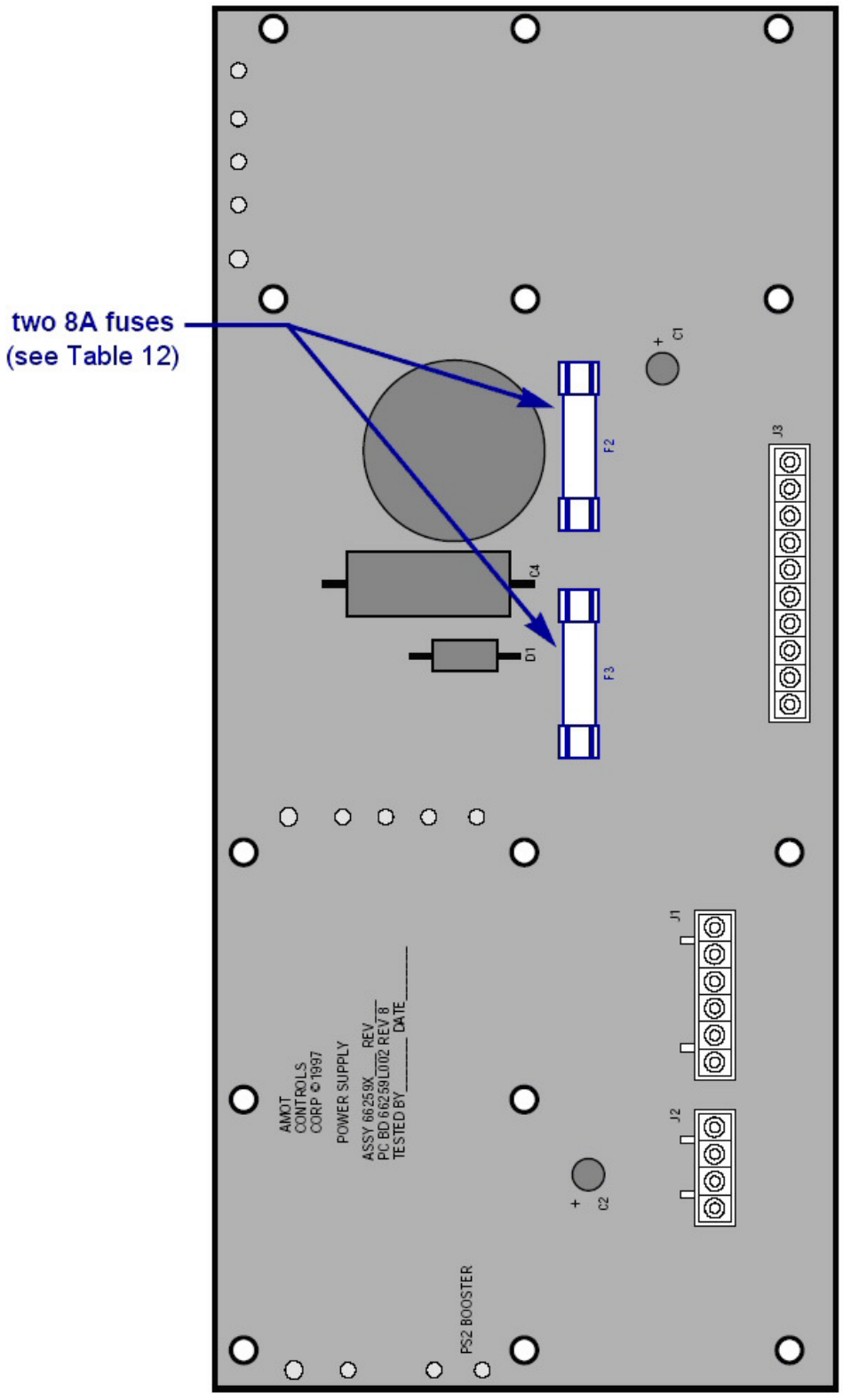


Fig C- 6 Power Supply PCB Assembly (66259X)

Appendix D

Component Identification

This appendix provides component identification drawings for the valve actuator and each fuel valve size.

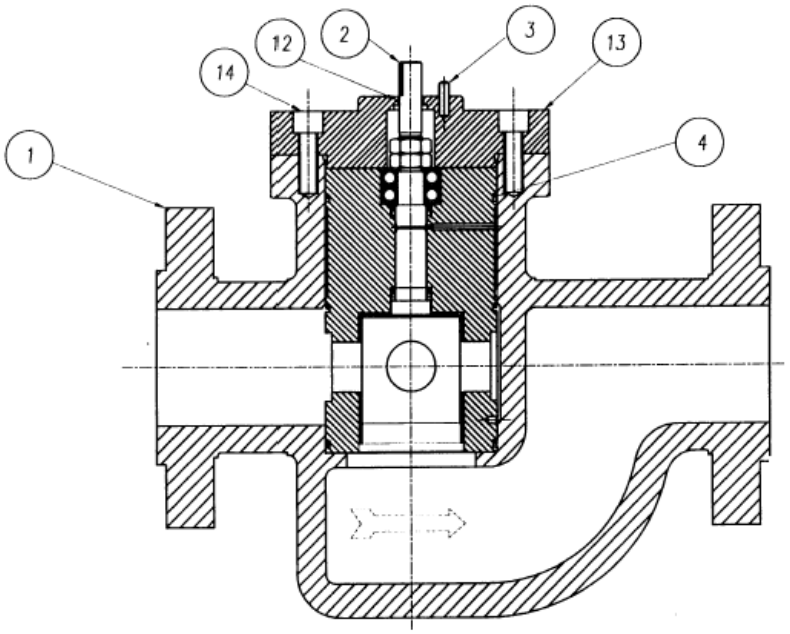


Fig D- 1 Component ID – 3 in Fuel Valve Subassembly

Table D- 1 Component ID – 3 in Fuel Valve Subassembly

Ref	Qty	Description
1	1	Body, 3 in
2	1	Cartridge Assembly
3	1	Dowel Pin
4	4	O-Ring – Viton
12	1	O-Ring – Viton
13	1	Cover
14	8	Cap screw
16	2	Position Scale (not shown)
17	1	Test Certificate (not shown)
18	1	Test Certificate (not shown)

Table D- 2 Flow Coefficient (Cv) Codes – 3 in Fuel Valve

Code	Cv	Material
D	60 Cv	Steel
P	60 Cv	Stainless Steel
E	90 Cv	Steel
R	90 Cv	Stainless Steel

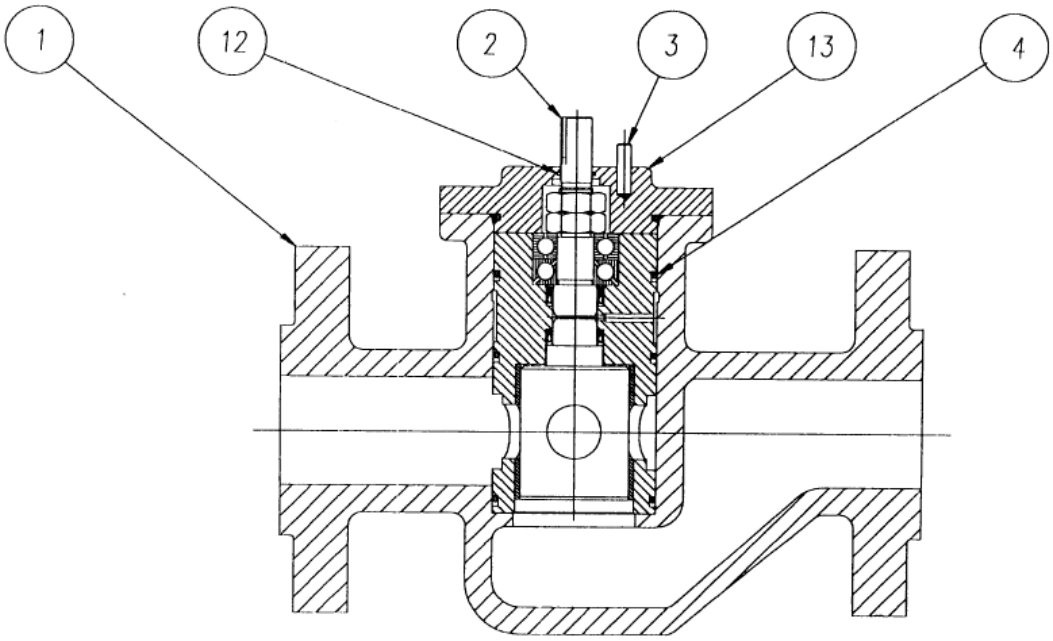


Fig D- 2 Component ID – 2 in Fuel Valve Subassembly

Table D- 3 Component ID – 2 in Fuel Valve Subassembly

Ref	Qty	Description
1	1	Body, 2 in
2	1	Rotor
3	1	Dowel Pin
4	4	O-ring – Viton
12	1	O-ring
13	1	Cover

Table D- 4 Flow Coefficient (Cv) Codes – 2 in Fuel Valve

Code	Cv	Material
A	12 Cv	Steel
L	12 Cv	Stainless Steel
B	25 Cv	Steel
M	25 Cv	Stainless Steel
C	30 Cv	Steel
N	30 Cv	Stainless Steel

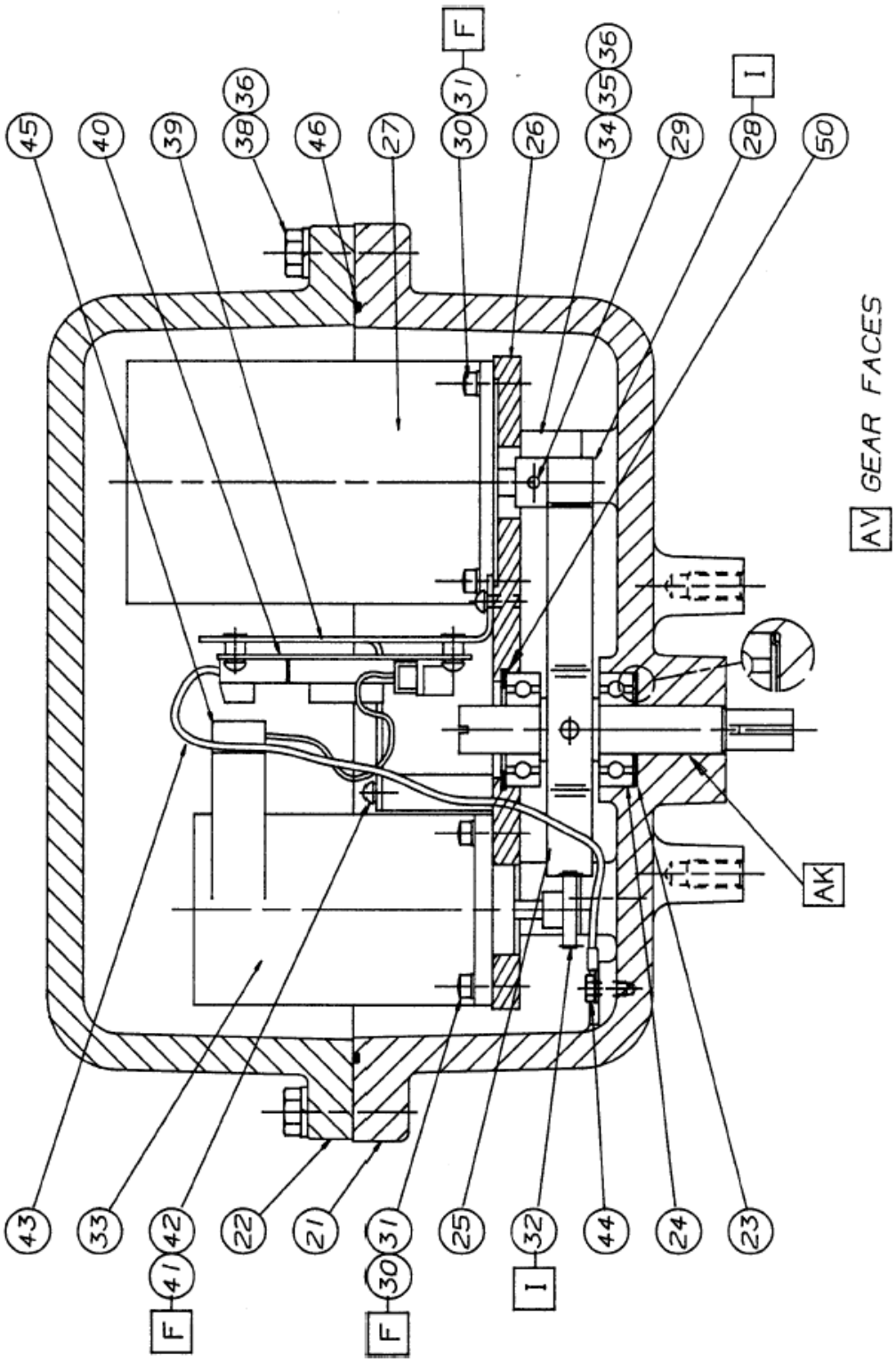


Fig D- 3 Component ID – Rotary Actuator (4280F and Previous)

See Table D- 5 on page 97 for descriptions.

Table D- 5 Component ID – Rotary Actuator (4280F and Previous)

Ref	Qty	Description
21	1	Enclosure
22	1	Cover
23	1	Finger washer
24	2	Radial bearing
25	1	Drive gear
26	1	Mounting plate
27	1	Stepper Motor (replace with 11578X101)
28	1	Pinion gear (included in 11578X101 for replacement)
29	1	Spiral pin
30	8	Screw
31	8	Lock washer
32	1	Gear, anti backlash
33	1	Optical encoder
34	4	Mounting post
35	4	Cap screw
36	10	Lock washer
37	2	Stop
38	6	Cap screw
39	1	Bracket
40	1	Terminal PCB
41	6	Screw
42	6	Lock washer
43	1	Ground (earth) wire
44	1	Ground (earth) screw
45	1	Cable assembly
46	1	O-ring
47	1	Nameplate/wiring details
48	1	Tag (serial/sub assy. no.)
49	2	Drive screw
50	1	Retaining ring

(Table refers to Fig D- 3 on page 96.)

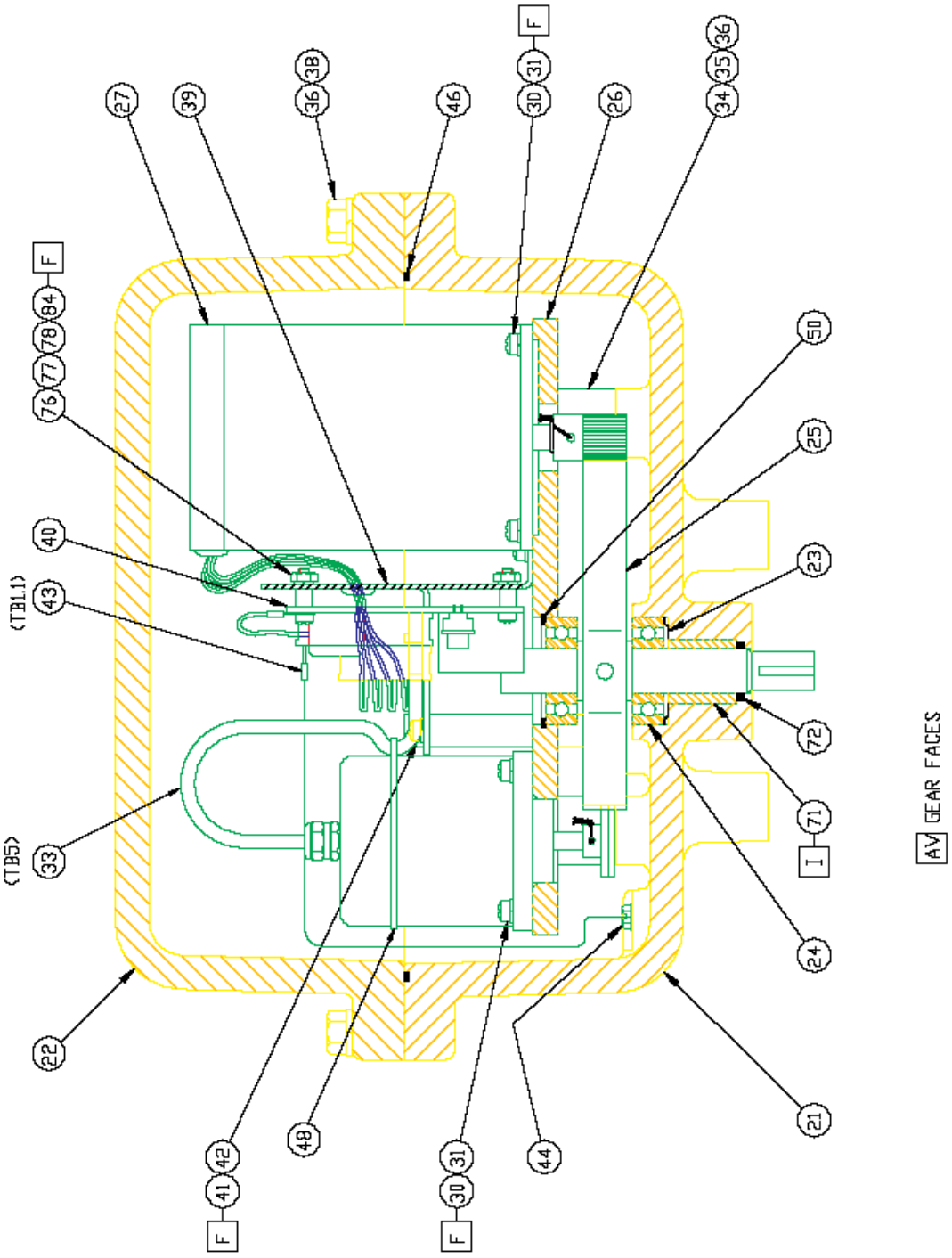


Fig D- 4 Component ID – Rotary Actuator (4280G and Subsequent)

See Table D- 6 on page 99 for descriptions.

Table D- 6 Component ID – Rotary Actuator (4280G and Subsequent)

Ref	Qty	Description
21	1	Enclosure
22	1	Cover
23	1	Finger washer
24	2	Radial bearing
25	1	Drive gear
26	1	Mounting plate
27	1	Stepper Motor (replace with 11578X101)
30	8	Screw
31	8	Lock washer
33	1	Optical encoder
34	4	Mounting post
35	4	Cap screw
36	10	Lock washer
37	2	Stop, full open (Not Shown)
38	6	Cap screw
39	1	Bracket
40	1	Actuator case Assembly
41	6	Screw
42	6	Lock washer
43	1	Ground (earth) wire
44	1	Ground (earth) screw
45	1	Cable assembly
46	1	O-ring
47	1	Nameplate/wiring details (not shown)
48	1	Cable tie
49	2	Drive screw (not shown)
50	1	Retaining ring
71	1	Bushing
72	1	O-ring (Viton)
76	4	Screw
77	4	Lock washer
78	4	Nut
79	1	Spiral Cut Tubing (Not Shown)
80	1	Grommet (Not Shown)
81	1	CSA Nameplate (Not Shown)
82	1	Stop (Shutoff) (Not Shown)

Ref	Qty	Description
84	4	Spacer
85	1	Encoder Data Tag (Not Shown)

(Table refers to Fig D- 4 on page 98.)

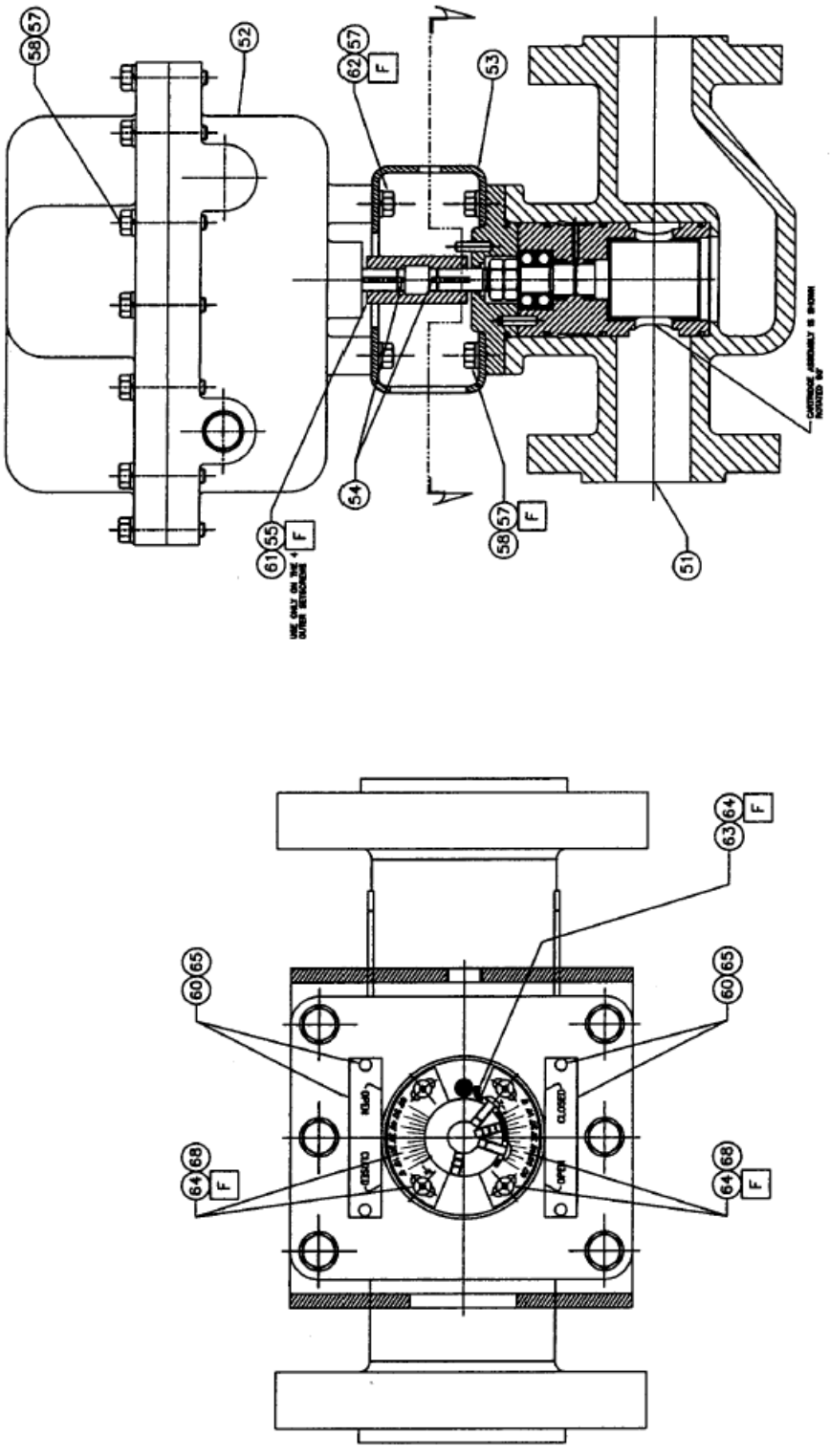


Fig D- 5 Component ID – Actuator/Fuel Valve Assembly, 4280G and Subs.

See Table D- 7 on page 102 for descriptions.

Table D- 7 Component ID – Actuator/ Fuel Valve Assembly (4280G and Subs.)

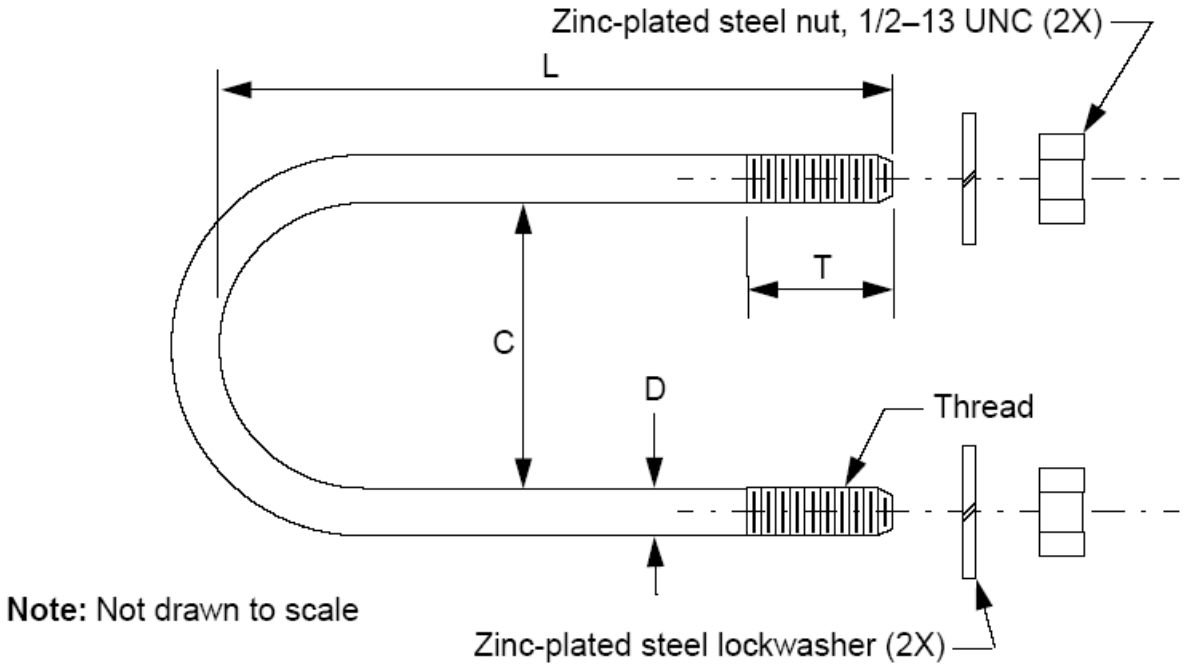
Ref	Description
51	Rotary Fuel Valve – 12, 25, 30, 60, or 90 Cv
52	Rotary Actuator
53	Yoke
54	Key
55	Rigid Coupling
56	Cap screw
57	Lock washer
58	Cap screw
60	Drive screw (Not Shown)
61	Set Screw (Not Shown)
62	Cap screw
63	Indicator and Stop Bracket
64	#8–32 UNC Button Head Screws
65	Position Scale
68	Scale Plate

(Table refers to Fig D- 5 on page 101.)

Appendix E

Mounting Details

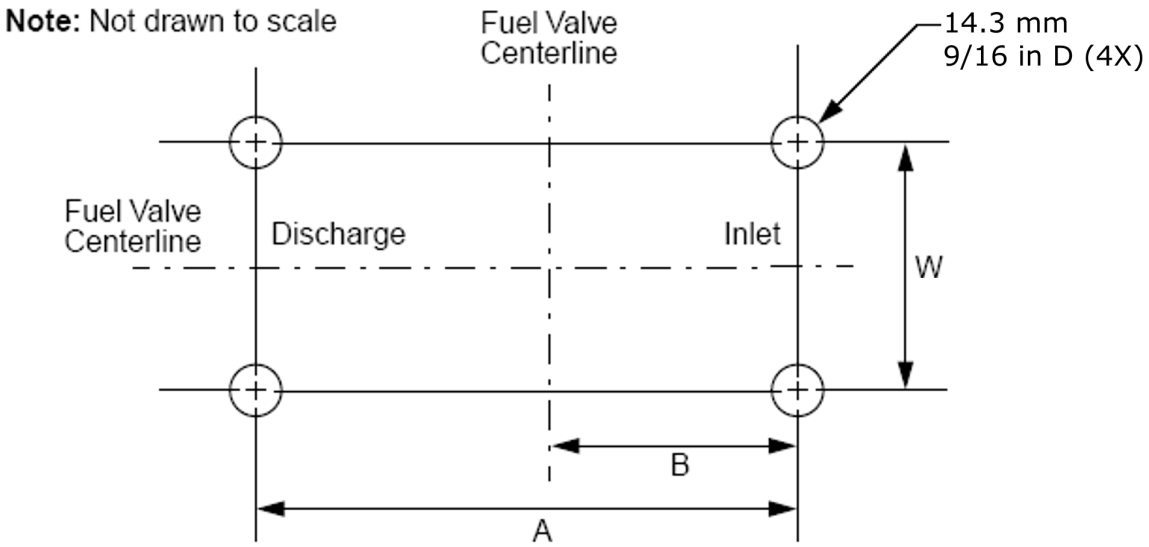
This appendix provides mounting details for each fuel valve size.



Note: Not drawn to scale

Fuel Valve Size	C mm (in)	D mm (in)	L mm (in)	T mm (in)	Thread	Material	Finish
2 in	79.4 ± 3.2 (3.125 ± 0.125)	12 (0.5)	178 (7.0)	38 (1.5)	½ - 13 UNC	Steel	Zinc Plate
3 in	13.0 ± 3.2 (5.125 ± 0.125)	12 (0.5)	254 (10.0)	38 (1.5)	½ - 13 UNC	Steel	Zinc Plate

Fig E- 1 1 1/2 in U-bolts for Mounting 2 in and 3 in Fuel Valves, Model 4280



Fuel Valve Size	A mm (in)	B mm (in)	W mm (in)
2 in	152.4 (6.0)	69.9 (2.75)	92.0 (3.625)
3 in	177.8 (7.0)	88.9 (3.5)	142.9 (5.625)

Fig E- 2 Hole Patterns for Mounting 2 in and 3 in Fuel Valves with 1/2 in U-bolts

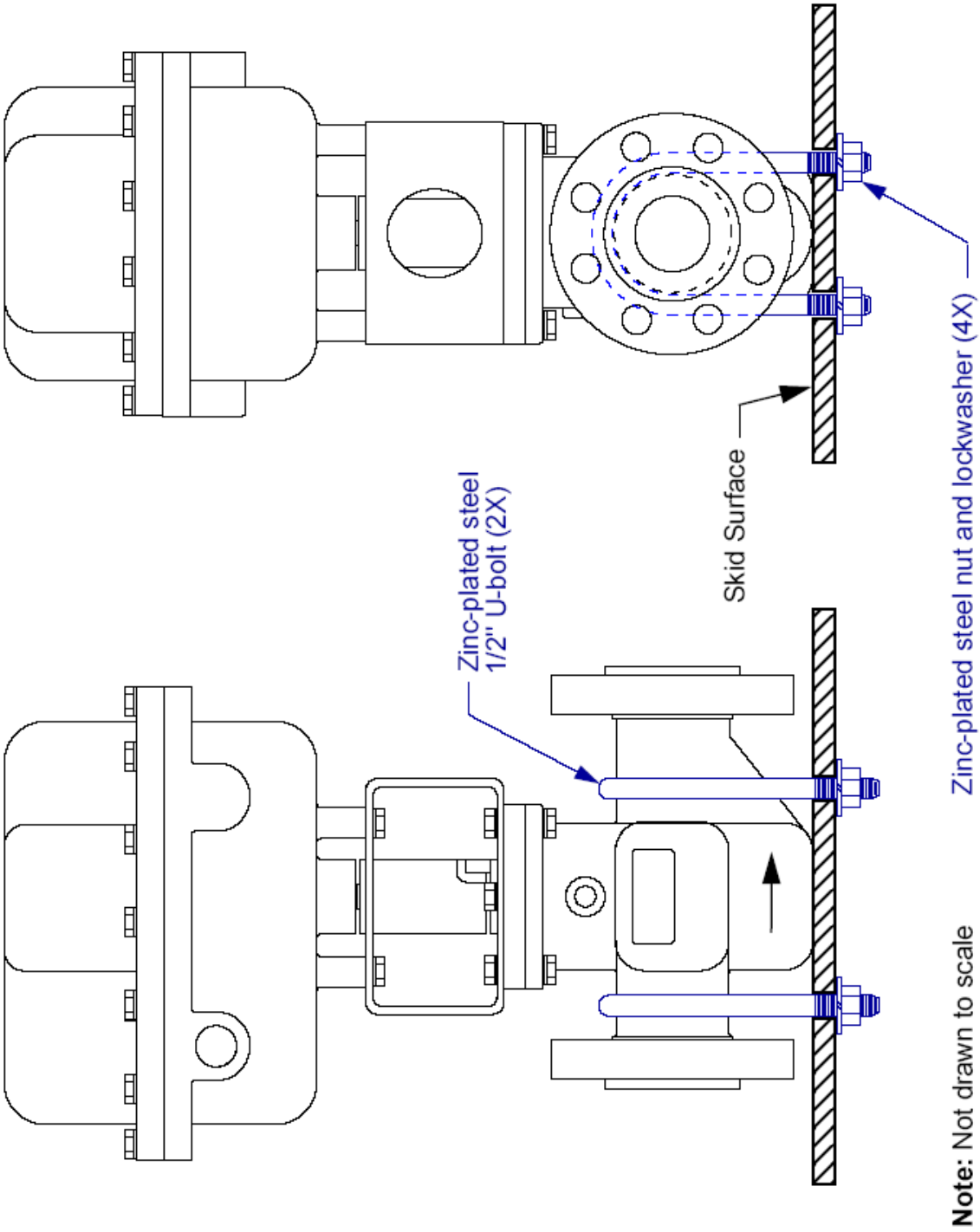


Fig E- 3 Mounting Details for 2 in and 3 in Fuel Valves (2 in Shown)

Appendix F

Spares

This appendix provides spares information and recommendations for the Rotary Fuel Valve system.

The MTBF for the Rotary Fuel Valve and Controller are given in Table F- 1.

Table F- 1 MTBF for Rotary Fuel Valve System

Product	MTBF
Model 4280 Rotary Actuated Fuel Valve	2 years
Model 8412 Controller	10 years

The subassembly components and parts which comprise the Rotary Fuel Valve and Controller are classified based on their probability of failure:

- Parts Class 1
  Failure probable within two years of continuous service. One set of spare parts should be carried per unit.
- Parts Class 2
  Failure probable within five years of continuous service. One set of spare parts should be carried at each installation location.
- Parts Class 3
  Failure not expected within the lifetime of the part. However, considering criticality and severity of down time or remoteness of installation, one set of spare parts should be considered at a central repair parts storage location.

The following tables list the spare subassembly parts available for the Rotary Fuel Valve, Actuator, and Controller, and recommend a spares strategy (Parts Class) for each.

Table F- 2 Rotary Fuel Valve Parts

AMOT Part Number	Description	Parts Class
10032X212-RTF	Cartridge (12 Cv) (complete)	1 or 2 **
10032X225-RTF	Cartridge (25 Cv) (complete)	1 or 2 **
10032X230-RTF	Cartridge (30 Cv) (complete)	1 or 2 **
10032X260-RTF	Cartridge (60 Cv) (complete)	1 or 2 **
10032X290-RTF	Cartridge (90 Cv) (complete)	1 or 2 **

** dependent on service condition (see notes below)

Note

The rotor cartridge assembly is continuously exposed to fuel gas. AMOT strongly recommends the installation of fuel flow filters to remove any particles greater than 10 microns from the fuel gas.

It is also critical that liquid condensates be removed from the fuel gas. Significant cooling which occurs as the gas expands through the valve can result in the formation of solid hydrates and ice particles, which will rapidly erode the cartridge.

The valve cartridge assembly should be considered a Parts Class 1 spare in applications where fuel gas preparation is difficult, and any particles, sand, debris, and liquids have not been removed from the fuel supply.

The valve cartridge assembly can be considered a Parts Class 2 spare in applications where preparation of the fuel gas has removed any particles, sand, debris, and liquids from the fuel supply.

Table F- 3 4280 Actuator Parts

Part Number	Description	Parts Class
	Complete 4280 Fuel Valve	
11578X101	Stepper Motor/Pinion Assembly	1
20116	Drive Gear	1
10073X101	Optical Encoder/Gear Assembly	3
11561L100	Anti-Backlash Gear	
66280X2	Actuator Case PCB Assembly	

Table F- 4 8412 Controller Parts

Part Number	Description	Parts Class
	Complete 8412 Electronic Controls	
66281X102 (Rev G, H & I) 66281X101 (Rev A to F)	Power Supply PCB	2
66275X2	LCD Display PCB (Swing-out panel)	2
48955X (Rev E & F) 53709L001 (Rev G, H & I)	Stepper Motor Driver	1
10435X	Fuse and Connector Kit (see Table 4)	1

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