WOODWARD

**Product Manual 40159**
**(Revision E)**
**Original Instructions**

# EM-35 Electric Powered Actuator and 1907 Large Liquid Fuel Valve

## Installation and Operation Manual

**General Precautions**

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

**Practice all plant and safety instructions and precautions.**

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

**Revisions**

**This publication may have been revised or updated since this copy was produced. To verify that you have the latest revision, check manual *26311* , *Revision Status & Distribution Restrictions of Woodward Technical Publications*, on the *publications page* of the Woodward website:**

**www.woodward.com/publications**

**The latest version of most publications is available on the *publications page*. If your publication is not there, please contact your customer service representative to get the latest copy.**

**Proper Use**

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

**Translated Publications**

**If the cover of this publication states "Translation of the Original Instructions" please note:**

**The original source of this publication may have been updated since this translation was made. Be sure to check manual *26311* , *Revision Status & Distribution Restrictions of Woodward Technical Publications*, to verify whether this translation is up to date. Out-of-date translations are marked with ⚠. Always compare with the original for technical specifications and for proper and safe installation and operation procedures.**

**Revisions—Changes in this publication since the last revision are indicated by a black line alongside the text.**

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# Warnings and Notices

## Important Definitions

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

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

**⚠WARNING**

**Overspeed / Overtemperature / Overpressure**

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

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

**⚠WARNING**

**Personal Protective Equipment**

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

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

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

**⚠WARNING**

**Start-up**

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

**⚠WARNING**

**Automotive Applications**

**On- and off-highway Mobile Applications: Unless Woodward's control functions as the supervisory control, customer should install a system totally independent of the prime mover control system that monitors for supervisory control of engine (and takes appropriate action if supervisory control is lost) to protect against loss of engine control with possible personal injury, loss of life, or property damage.**

**NOTICE**

**Battery Charging Device**

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

# Electrostatic Discharge Awareness

**NOTICE**

**Electrostatic Precautions**

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

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

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

Follow these precautions when working with or near the control.

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

# Regulatory Compliance

Check actuator and resolver certification labels for appropriate hazardous locations ratings.

The actuator and resolvers are suitable for use in Class I, Division 1, Groups C and D, and Class I, Division 2, Groups B, C, and D, hazardous locations.

Wiring must be in accordance with the proper Division wiring methods and in accordance with the authority having jurisdiction.

**⚠WARNING**

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

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

**⚠AVERTISSEMENT**

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

**La substitution de composants peut rendre ce matériel inacceptable pour les emplacements de Classe I, Division 2.**

# Chapter 1. Description

## Introduction

The EM-35 electric actuator is used to drive a 1907 large liquid valve, closed loop to position demand. Position feedback is provided by a resolver connected to the valve metering sleeve. Closed loop position control is accomplished through an EM-35 motor driver. Having the feedback on the valve allows the motor assembly to be repaired or changed in the field without the loss of valve calibration.

## Liquid Fuel Valve

The liquid fuel valve is a device for metering fuel to the gas turbine. A differential pressure regulator incorporated in the fuel valve maintains a constant pressure drop across the metering port so the fuel flow at a given position of the fuel valve will be unaffected by discharge pressure or inlet flow variations. The fuel valve is available in various flow ranges for different applications. The exact range of each valve is selected to meet the requirements of the installation. The port in the metering valve sleeve is capable of metering fuel from 68 to 11 340 kg/h (150 to 25 000 lb/h).

### Fuel Type

The valve is compatible with most types of diesels, kerosenes, gasolines, heavy and light distillates including naphtha, gas turbine fuels and fuel oils, and other liquid fuels such as biodiesel that are compatible with fluorocarbon (FKM) type elastomers and conform to international standards for utility, marine, and aviation gas turbine service. Ultra low sulfur diesels are also acceptable with proper lubricity additives. Other fuels such as ethanol or methanol may be acceptable with internal seal compound substitutions. Contact Woodward for these and other special fuel applications.

### Fuel Viscosity

Fuel viscosity must be between 0.5 and 12.0 centistokes.

### Fuel Cleanliness

Liquid fuel must be filtered to limit particulate size to 20 µm or smaller. Water content must be limited to 0.1% by volume. Solids, sediment, and particulates must be limited to 1.0 mg per liter of fuel.

## EM-35 Actuator

The EM-35 actuator is an all electric actuator designed for use in industrial gas turbine control applications. It is designed for use with Woodward EM-35 analog and digital motor drivers. The motor is a brushless dc motor with a motor clutch and gearhead assembly. The motor uses Samarium Cobalt permanent magnets bonded and sleeved to the rotor element. All stator windings are completely sealed. Rotor position sensing is performed through the use of a brushless field director and motor velocity feedback is performed by means of a brushless tachometer.

The motor assembly is housed in a cast aluminum explosion-proof housing. A thermal potting compound is used to transfer waste heat generated by the motor to the cast, explosion-proof housing and out to the ambient environment. Wiring to the motor is accomplished through two 0.5 inch (~13 mm) NPT conduit connections into a wiring compartment integral to the housing. One conduit is for the motor power wires, the other is for the motor sense wires.

## Resolver

Position feedback is accomplished using a highly accurate brushless resolver. The resolver is directly coupled to the valve metering shaft through use of a stainless steel bellows and is housed in an explosion proof enclosure. The resolver receives its excitation from the EM-35 driver. The EM driver uses a resolver to digital converter to determine valve position using the output voltages from the resolver's two secondary windings. Resolver accuracy is ±0.05x. Wiring to the resolver is accomplished through two 0.75 inch (~19 mm) NPT conduit connections.

# Chapter 2.
# Installation

## Unpacking

Be careful when unpacking the EM-35 driver and EM actuator/1907 large liquid valve. Check the devices for signs of damage such as bent or dented case and loose or broken parts. If damage is found, notify the shipper immediately. The devices may be stored in their original shipping containers until they are ready for installation. Protect the devices from weather and from extreme humidity or temperature fluctuations during storage.

## Power Requirements

The EM-35 actuator receives all of its power from the EM-35 driver. The operating range of the actuator is 18–32 Vdc. The maximum steady state driver input current is 4.5 A continuous with peaks of 25 A for 50 ms.

**⚠WARNING**

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

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

## EM Actuator/1907 Large Liquid Valve Installation

Use care while handling and installing the valve/actuator. Abuse can damage seals, installation surfaces, and factory adjustments. Fuel connections must be protected by plastic shipping caps or covers whenever the valve/actuator is not connected to the normal service connections.

See Figure 2-5 for:
- Overall dimensions
- Installation hole locations
- Adjustment locations
- Electrical connections

Installation attitude does not affect actuator or fuel valve performance. Make sure that adequate room is allowed for required wiring and that the wiring and valve/actuator are accessible for service.

The overboard drains on the 1907 large liquid fuel valve (see Figure 2-5) must be plumbed to an area outside the turbine enclosure. These drains vent the cavity between the inner and outer seals on the valve metering sleeve shaft.

# Electrical Connections

## Shielded Wiring

1. All shielded cable must be twisted conductor pairs with either a foil or a braided shield.
2. All signal lines should be shielded to prevent picking up stray signals from adjacent equipment.
3. Connect the shields as shown in the Plant Wiring Diagram (Figures 2-2, 2-3, and 2-4). Wire exposed beyond the shield must not exceed 50 mm (2 in.). The other end of the shield must be left open and insulated from any other conductor.
4. Do not run shielded signal wires with other wires carrying large currents.
5. See manual 50532, *EMI Control in Electronic Governing Systems*, for more information.

Installations with severe electromagnetic interference (EMI) may require shielded cable run in conduit, double shielded wire, or other precautions. Contact Woodward for more information.

## Control Wiring

Figure 2-2 is the control wiring diagram for the EM-35 analog driver, EM-35 actuator/1907 large liquid valve. Figures 2-3 and 2-4 are the control wiring diagrams for the EM-35 digital driver, EM-35 actuator/1907 large liquid valve when conduit is used for all wire runs. If conduit is not used with the EM-35 digital driver, the eight single wires from the driver to the FTM must use 2–4 conductor, shielded wires to prevent EMI interference. If conduit is not used with either driver, all of the shields (except for the motor wire shield) from these wires must be connected to the ground studs or ground screws in the bottom of the driver chassis.

1. Power wiring between the motor and the driver should be three-conductor 5 mm² (10 AWG) shielded wire to prevent EMI emissions. The shields must be terminated to the ground screw in the motor wiring cavity and the driver terminal block. The wiring must not exceed 30 m (100 ft) maximum length, to minimize voltage drop. Any extra motor wire in the installation should be cut off and discarded, not coiled.

**IMPORTANT** **Coiled wire will cause an inductance which could be greater than that of the motor.**

2. The wiring between the EM-35 driver and the feedback resolver must be limited to 30 m (100 ft) and must be low capacitance (46 pF/m; 14 pF/ft) cable. For the analog driver, if the resolver cable is less than 6 m (20 ft), standard shielded cable may be used, but it should not exceed 164 pF/m (50 pF/ft). For the digital driver, communication wire from the FTM to the driver must also use low capacitance wire and must not exceed 300 m (1000 ft). Contact Woodward Governor Company for available sources of low capacitance wire.
3. The metering valve is not shipped with any field wiring attached (such as pigtails) but rather is provided with internal terminal blocks for field wiring. These terminal blocks are located under the explosion proof covers on the actuator and resolver housings.
4. The actuator housing has two 0.5 inch NPT taps (~13 mm) and the resolver housing has two 0.75 NPT taps (~19 mm).

5. For the actuator, the power wires should go through the NPT tap in front of the three-pole Phoenix screw-type terminal block. The sense wires need to be run separately and should go through the NPT tap in front of the 10-pole WAGO terminal block.

The terminal blocks provided for the motor sense wires and the resolver are WAGO 264 series. These terminal blocks are top-load terminal blocks and are actuated by inserting a DIN 5264 screwdriver into the opening behind the wire slot. Once the cage clamp has been opened, the wire can be inserted and the screwdriver removed (see the illustration and instructions below).

1. Insert the screwdriver into the operating slot up to the stop.
2. The screwdriver blade holds the clamping spring open automatically so that the conductor can be introduced into the clamping unit.
3. Withdraw the screwdriver. The conductor is automatically clamped.

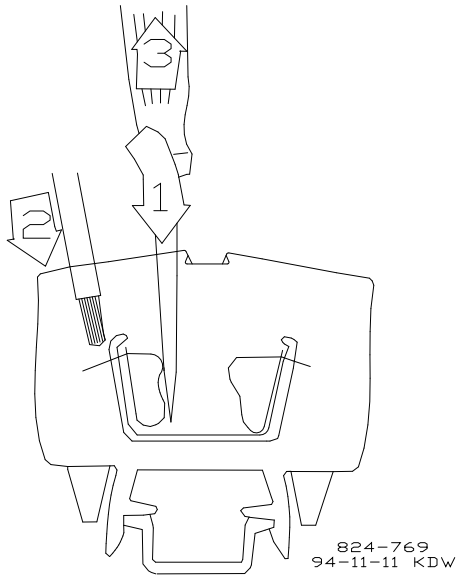
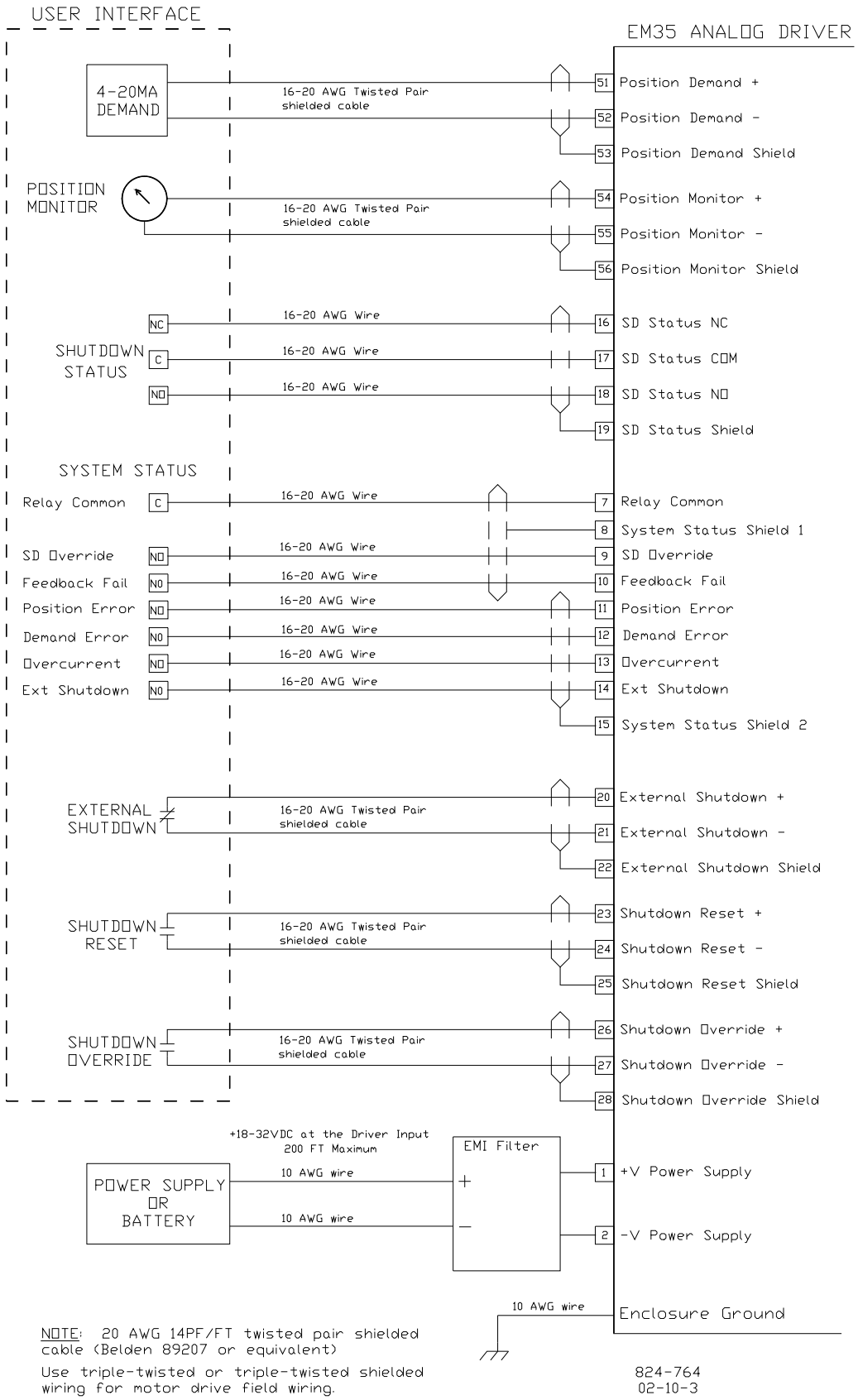



Figure 2-1. WAGO 264 Series Terminal Block


USER INTERFACE
EM35 ANALOG DRIVER
4-20MA DEMAND
16-20 AWG Twisted Pair shielded cable
51 Position Demand +
52 Position Demand -
53 Position Demand Shield
POSITION MONITOR
16-20 AWG Twisted Pair shielded cable
54 Position Monitor +
55 Position Monitor -
56 Position Monitor Shield
SHUTDOWN STATUS
NC
C
NO
16-20 AWG Wire
16 SD Status NC
17 SD Status COM
18 SD Status NO
19 SD Status Shield
SYSTEM STATUS
Relay Common
SD Override
Feedback Fail
Position Error
Demand Error
Overcurrent
Ext Shutdown
16-20 AWG Wire
7 Relay Common
8 System Status Shield 1
9 SD Override
10 Feedback Fail
11 Position Error
12 Demand Error
13 Overcurrent
14 Ext Shutdown
15 System Status Shield 2
EXTERNAL SHUTDOWN
16-20 AWG Twisted Pair shielded cable
20 External Shutdown +
21 External Shutdown -
22 External Shutdown Shield
SHUTDOWN RESET
16-20 AWG Twisted Pair shielded cable
23 Shutdown Reset +
24 Shutdown Reset -
25 Shutdown Reset Shield
SHUTDOWN OVERRIDE
16-20 AWG Twisted Pair shielded cable
26 Shutdown Override +
27 Shutdown Override -
28 Shutdown Override Shield
+18-32VDC at the Driver Input 200 FT Maximum
EMI Filter
POWER SUPPLY OR BATTERY
10 AWG wire
10 AWG wire
1 +V Power Supply
2 -V Power Supply
10 AWG wire
Enclosure Ground
NOTE: 20 AWG 14PF/FT twisted pair shielded cable (Belden 89207 or equivalent)
Use triple-twisted or triple-twisted shielded wiring for motor drive field wiring.
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02-10-3

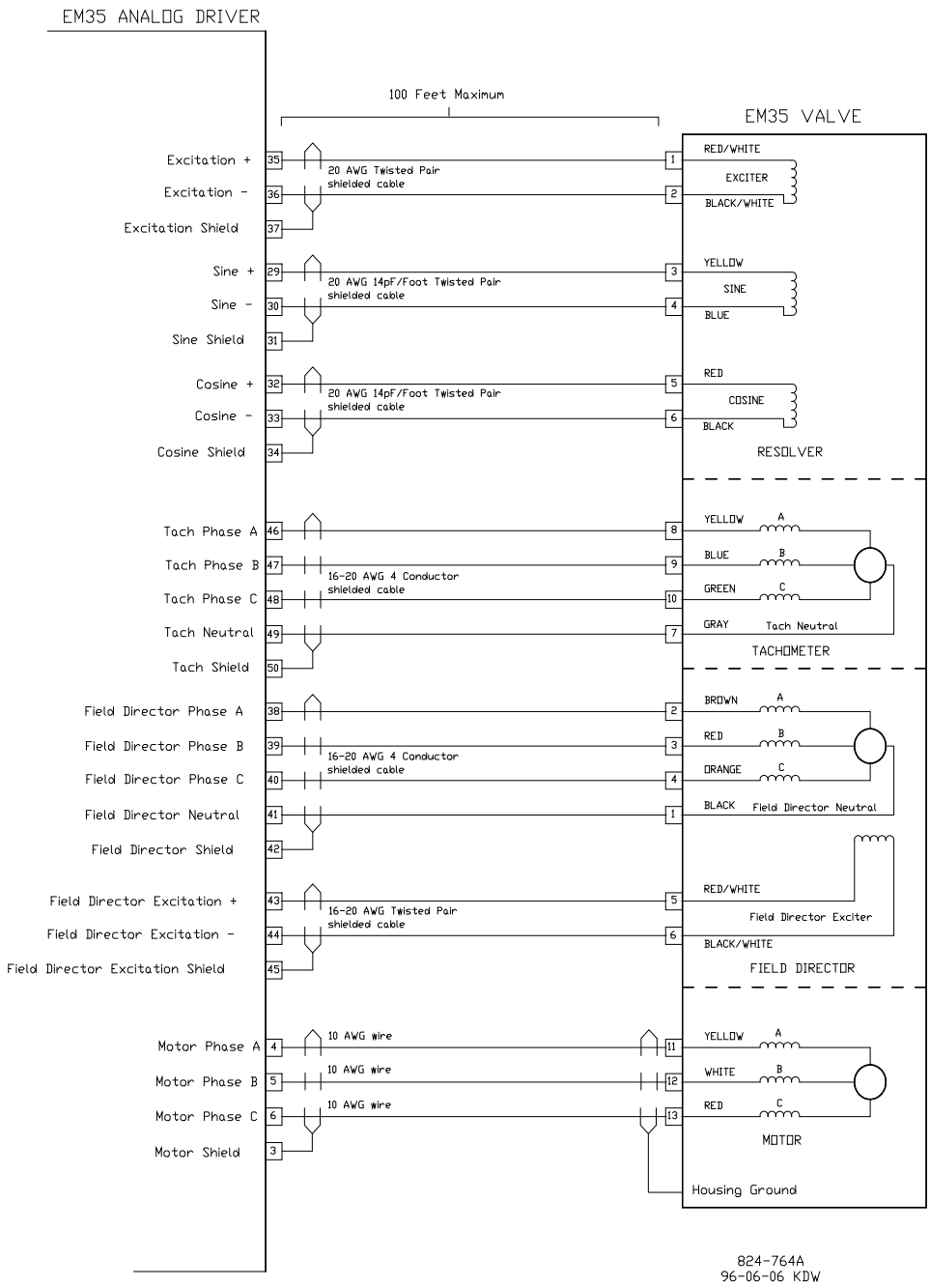
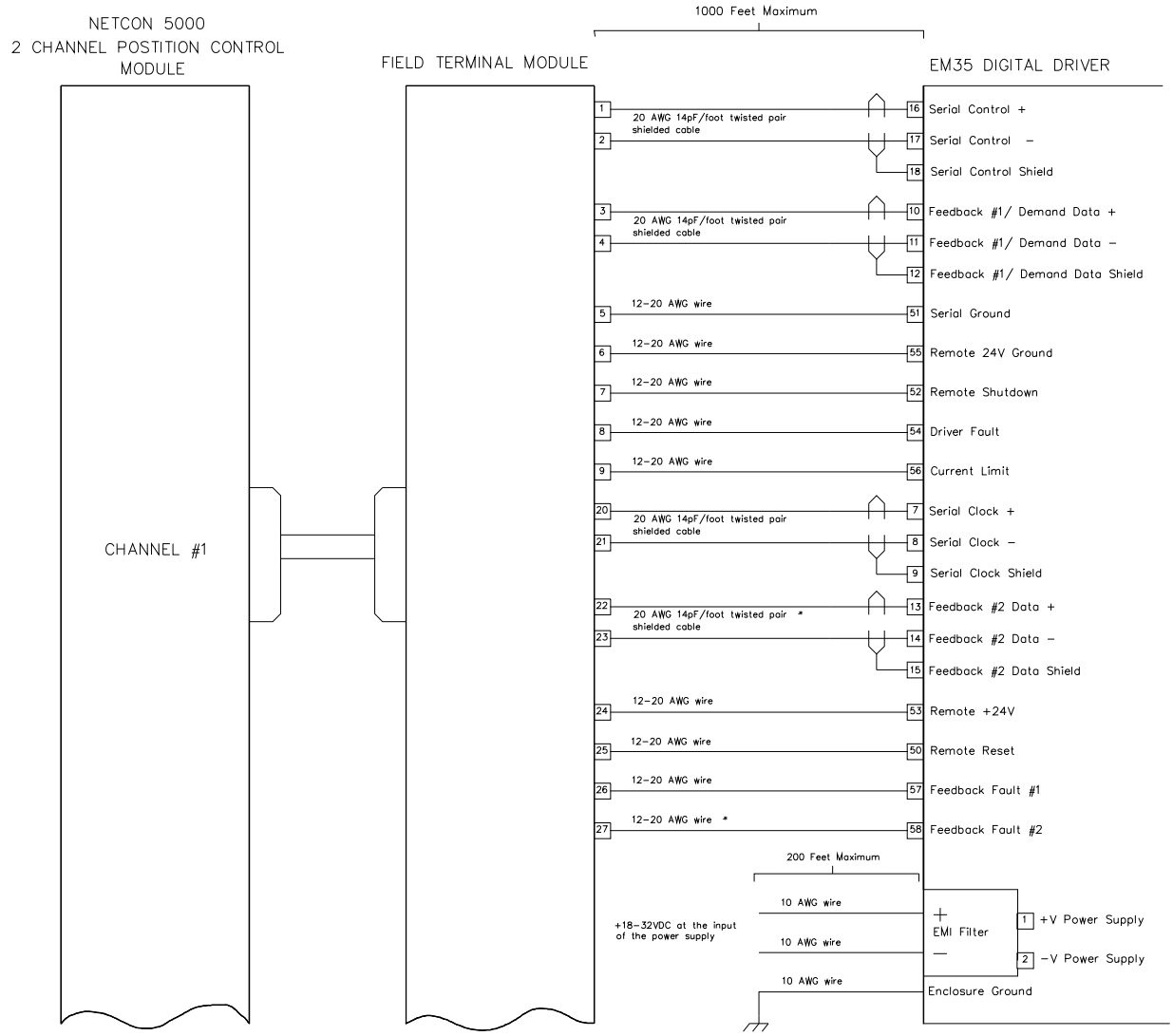



Figure 2-2. Control Wiring Diagram (Analog)




20 AWG 14pF/foot twisted pair shilded cable: Belden Part Number: 89207 or equivalent
Use triple–twisted or triple–twisted shielded wiring for motor drive field wiring.

* NOT NEEDED FOR SINGLE FEEDBACK

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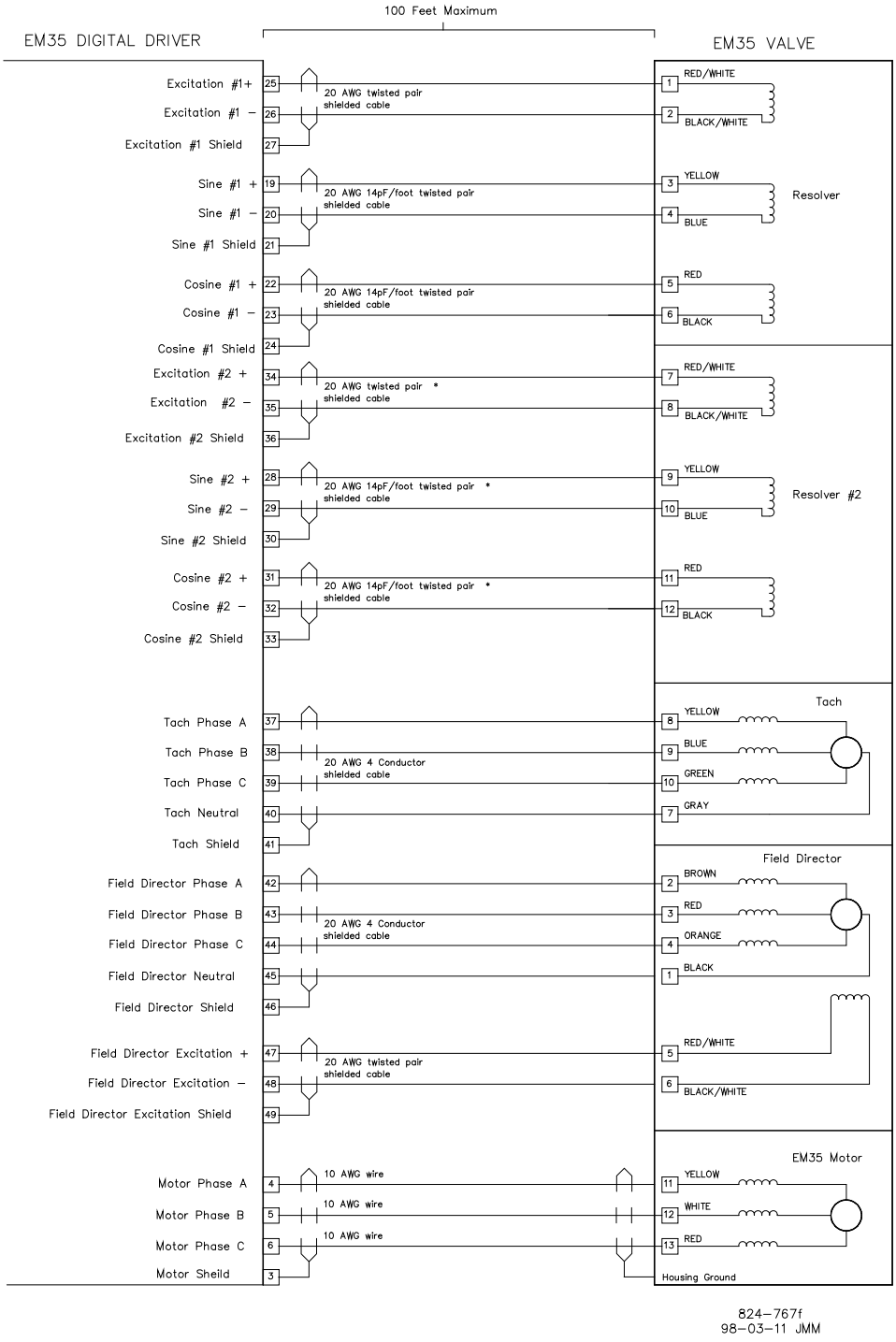
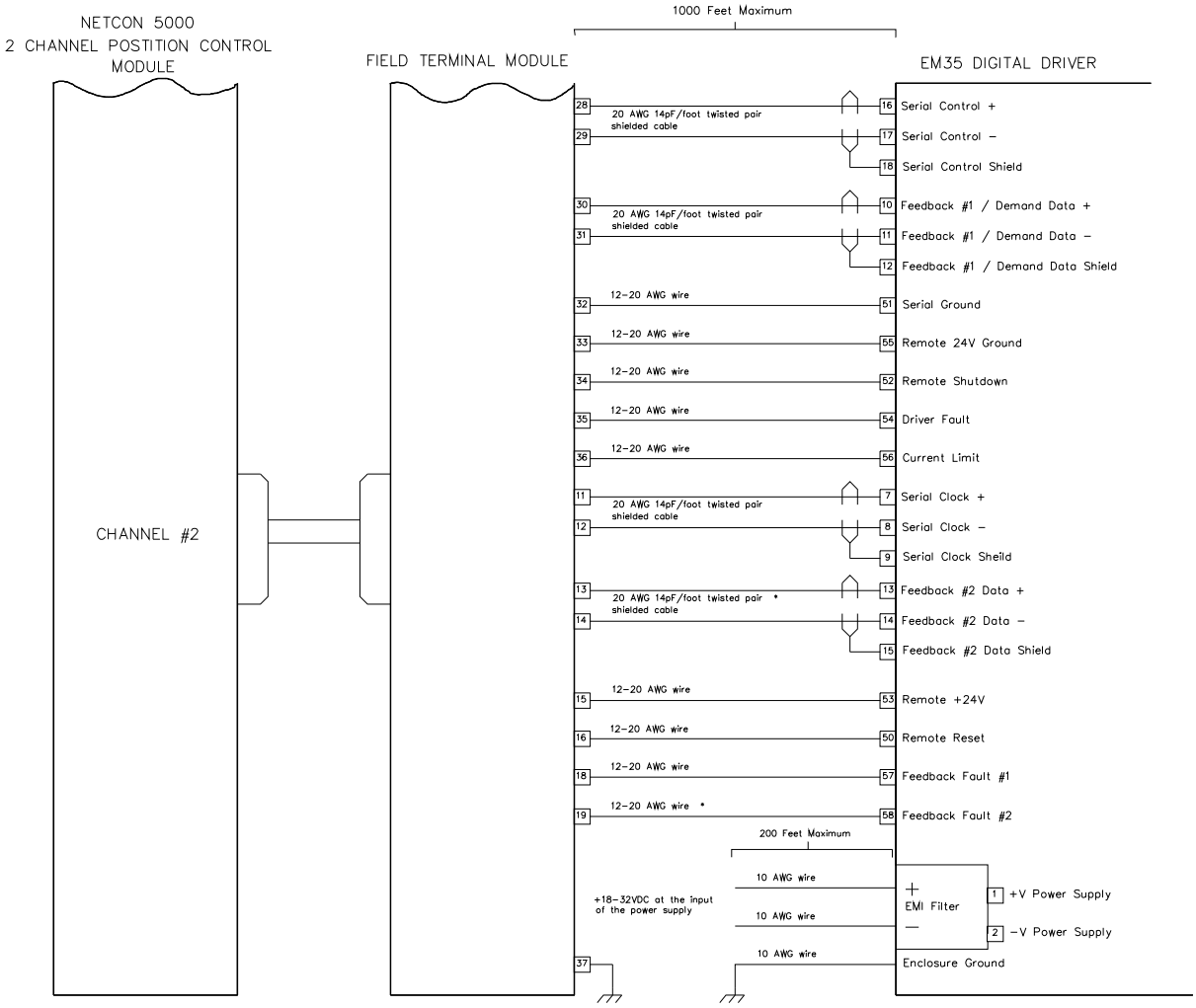



Figure 2-3. Control Wiring Diagram (Digital Channel 1)




20 AWG 14pF/foot twisted pair shilded cable: Belden Part Number: 89207 or equivalent
Use triple-twisted or triple-twisted shielded wiring for motor drive field wiring.

* NOT NEEDED FOR SINGLE FEEDBACK

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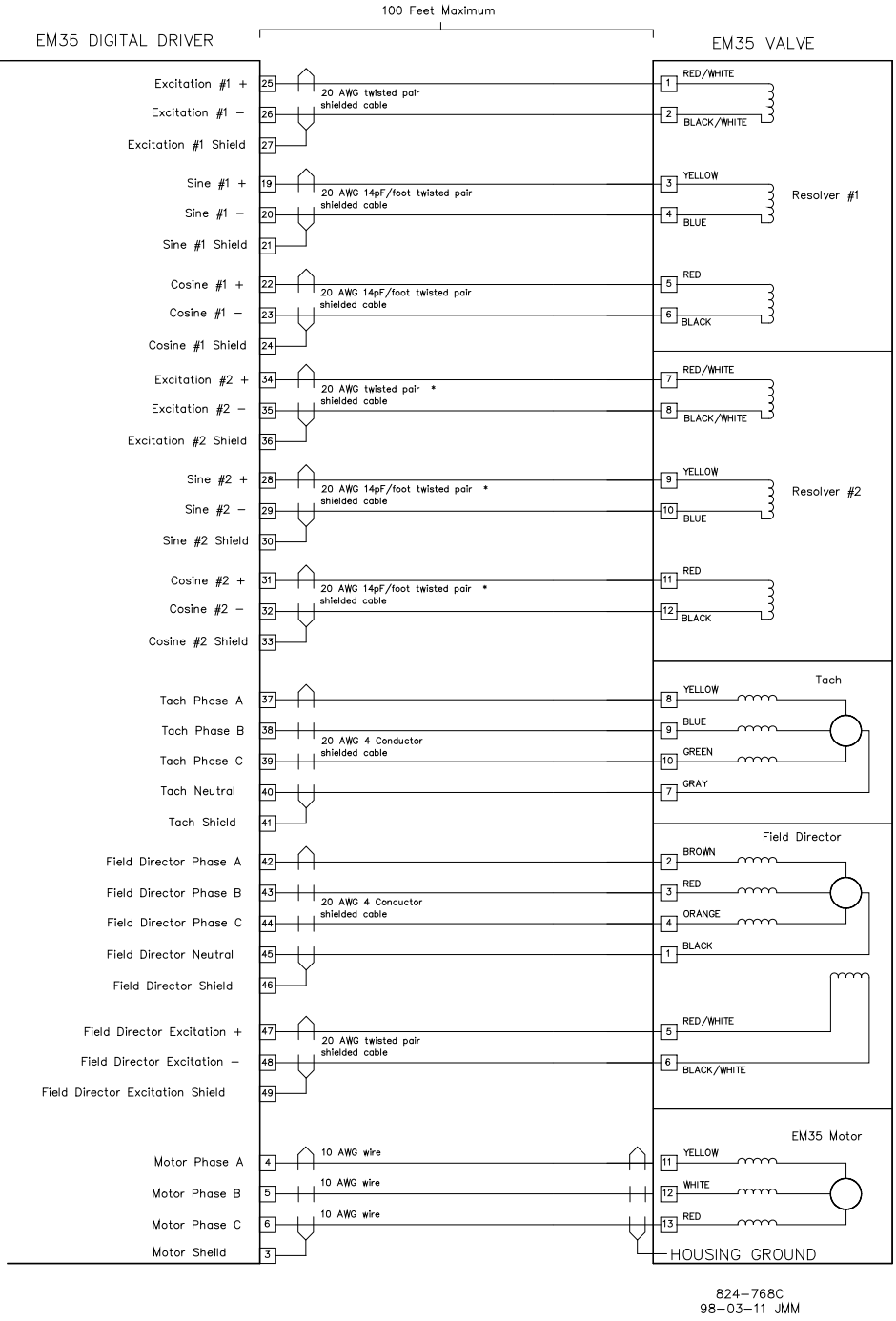


Figure 2-4. Control Wiring Diagram (Digital Channel 2)

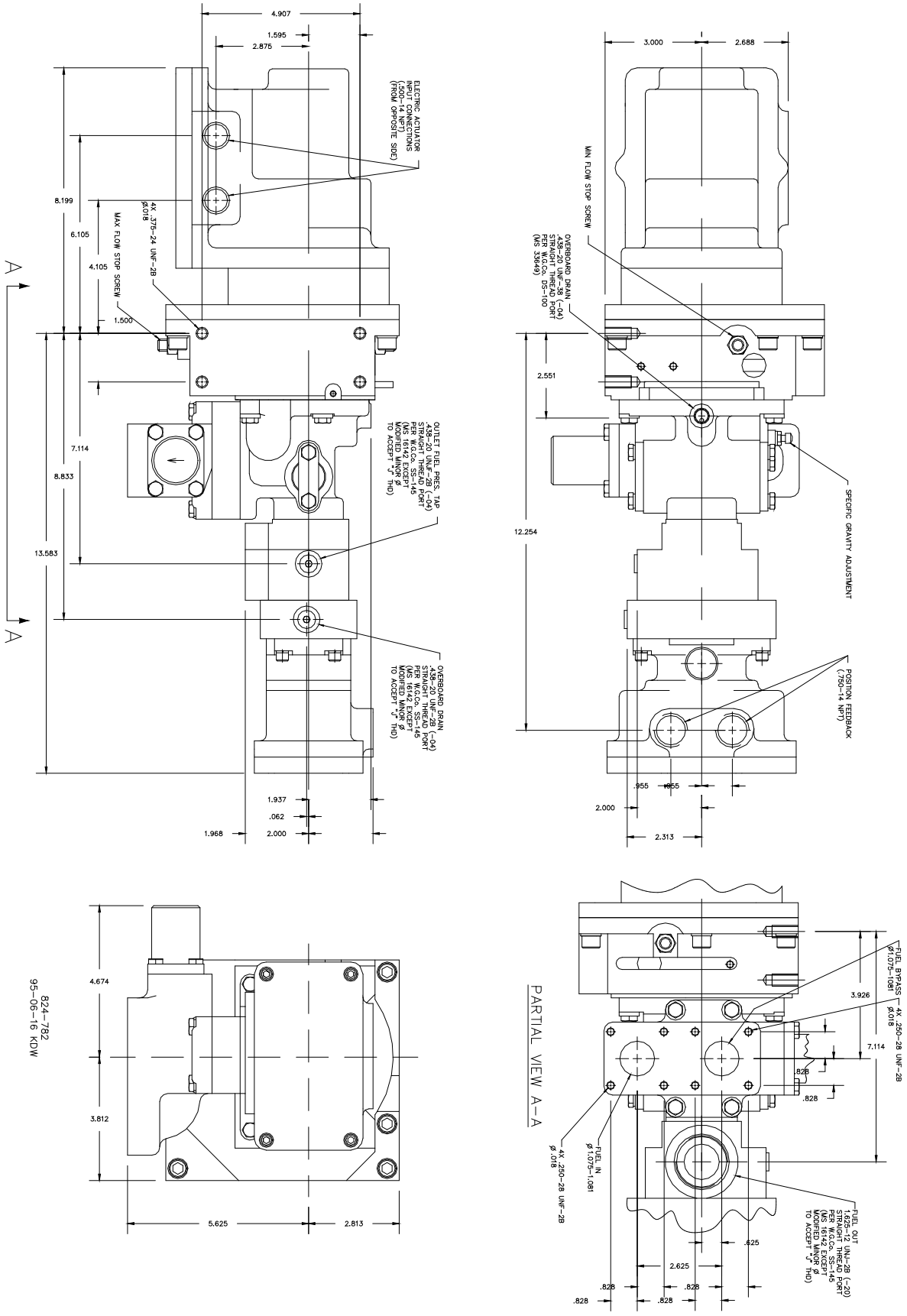


Figure 2-5. EM-35 Actuator/1907 Large Liquid Fuel Valve Outline Drawing

# Chapter 3.
# Description of Operation

## EM-35 Actuator

The EM-35 electric actuator is comprised of a brushless dc motor, a clutch assembly, a gearhead assembly, and an explosion-proof housing. The brushless dc motor uses samarium cobalt permanent magnets bonded and sleeved to the rotor. The high-speed motor output shaft is clutched before the gearbox assembly. This clutch prevents damage to the motor shaft and gearbox should an external force suddenly stop the rotation of the gearbox output shaft. The output shaft of the geartrain is supported by two roller bearings. The clutch slips at 1.5 times the maximum output force of the motor/gearbox assembly. The motor gearbox is a planetary gearbox and is used to reduce the output speed and increase the output torque.

A field director is attached to the back end of the motor rotor shaft. The field director is a brushless, three-phase, position sensor used to control the commutation of the motor. A field director is used rather than the conventional Hall effect sensor due to the high ambient temperatures possible at the valve location.

The control signals for the motor come from an external motor driver. The motor driver handles motor commutation as well as closed loop position control. The position feedback comes from a precision resolver directly coupled to the valve metering sleeve. This arrangement prevents any errors in sensing the desired valve position through linkages and geartrains and results in precise position control. Having the feedback on the valve also allows for the motor to be repaired or replaced in the field without any loss of calibration.

The entire motor assembly is installed in a cast explosion-proof housing. The motor is heat sunk to this external housing to allow heat generated by the motor to be effectively transferred to the ambient environment.

## 1907 Large Liquid Fuel Valve

The liquid fuel valve meters fuel as a function of the angular position of its ported metering sleeve. The metering sleeve is positioned by the EM-35 Actuator. See Figure 3-1 for a schematic diagram of the liquid fuel valve.

The liquid fuel valve maintains a constant pressure drop across the fuel metering ports in the metering sleeve. The fuel flow through the metering ports is proportional to the area of the port opening, without regard to changes in metered fuel discharge pressure. Fuel flow through the metering port is described by the equation:

$$W_f = K_1 a(\Delta P)^{1/2}$$

**where:**
$K_1$ = a constant dependent upon fuel and port characteristics
**a** = area of port opening
**ΔP** = pressure drop across fuel valve ($P_1 – P_2$)

With ΔP held constant, accurate fuel metering is accomplished by controlling the metering port opening.

Under operating conditions, fuel at inlet pressure ($P_1$), flows to the metering sleeve, one side of a bellows, to the bypass valve, and to an orifice. Metered fuel at pressure ($P_2$) is directed to the turbine and the opposite side of the bellows.

The bellows takes a position at which the sum of the force from pressure P1 and the force of spring $S_1$ acting on one side of the bellows is equal to the sum of the forces from pressure $P_2$ and the force of spring $S_2$ acting on the opposite side. When the balance of forces has been established, the difference between the spring forces ($S_2$–$S_1$) is equal to the difference between the pressures ($P_1$–$P_2$). By varying the force of spring $S_1$, ΔP can be adjusted to suit the requirements of a particular application.

The position of the bellows determines the position of the bleed valve check-ball, which then regulates the rate of fuel flow through the orifice. The pressure $P_r$ varies with the rate of fuel flow through the bleed valve; high flows result in relatively lower pressures and low flows result in relatively higher pressures. Pressure $P_r$ plus the force of spring $S_3$ close the bypass valve piston. These are opposed by pressure $P_1$, which opens the bypass valve piston. The bypass valve piston then takes a position at which pressure $P_1$ is equal to the sum of pressure $P_r$ and the force of spring $S_3$. By varying the amount of fuel bypassed, pressure $P_1$ is maintained at a constant differential above pressure $P_2$, regardless of variations in pressure $P_2$ or flow.

Opening the metering port to increase fuel flow to the turbine results in an increase in pressure $P_2$. This unbalances the forces across the bellows, increases the force on spring $S_1$ and allows the bleed valve check ball to partially close, reducing the rate of fuel flow through the bleed valve. With reduced bleed flow, pressure $P_r$ increases and results in an unbalance of the forces across the bypass valve piston. The piston moves to decrease the bypass flow and direct a greater amount of fuel to the metering port. With more fuel being directed to the metering port, pressure $P_1$ increases until the balance of forces across the bypass valve piston and the bellows is established and further movement of the piston or bellows is stopped.

Closing the metering port to decrease fuel flow to the turbine results in a decrease in pressure $P_2$. The resulting unbalance of forces across the bellows forces the check ball further off its seat and increases the rate of flow through the orifice. With the resulting decrease in pressure $P_r$, the unbalance in forces across the bypass valve piston causes the piston to move further open and bypass a greater amount of fuel with less fuel directed to the metering port. Pressure $P_1$ then decreases until the balance of forces across the piston and bellows is established and further movement of the piston and bellows is stopped.

The purpose of the orifice in the relief valve in Figure 3-1 is to eliminate bypass valve damping when a sudden increase in bypass flow is needed. The damping is needed for ΔP stability in normal operation, and when change in inlet or metered outlet flows are relatively small. Damping is provided by a restriction between the bleed valve and the bypass valve piston. When large decreases in metered outlet or inlet flow occur rapidly, it is essential that the bypass valve open immediately to prevent a transient rise in valve inlet pressure. This transient rise would raise the pressure differential above the rating of the ΔP sensing bellows. The damping restriction is provided by the orifice in the relief valve plunger. If the pressure drop across this restriction exceeds 345 kPa (50 psi) when the bypass valve is moving in the open direction, the relief valve opens to bypass flow around the damping restrictor. This allows the bypass valve to open rapidly.

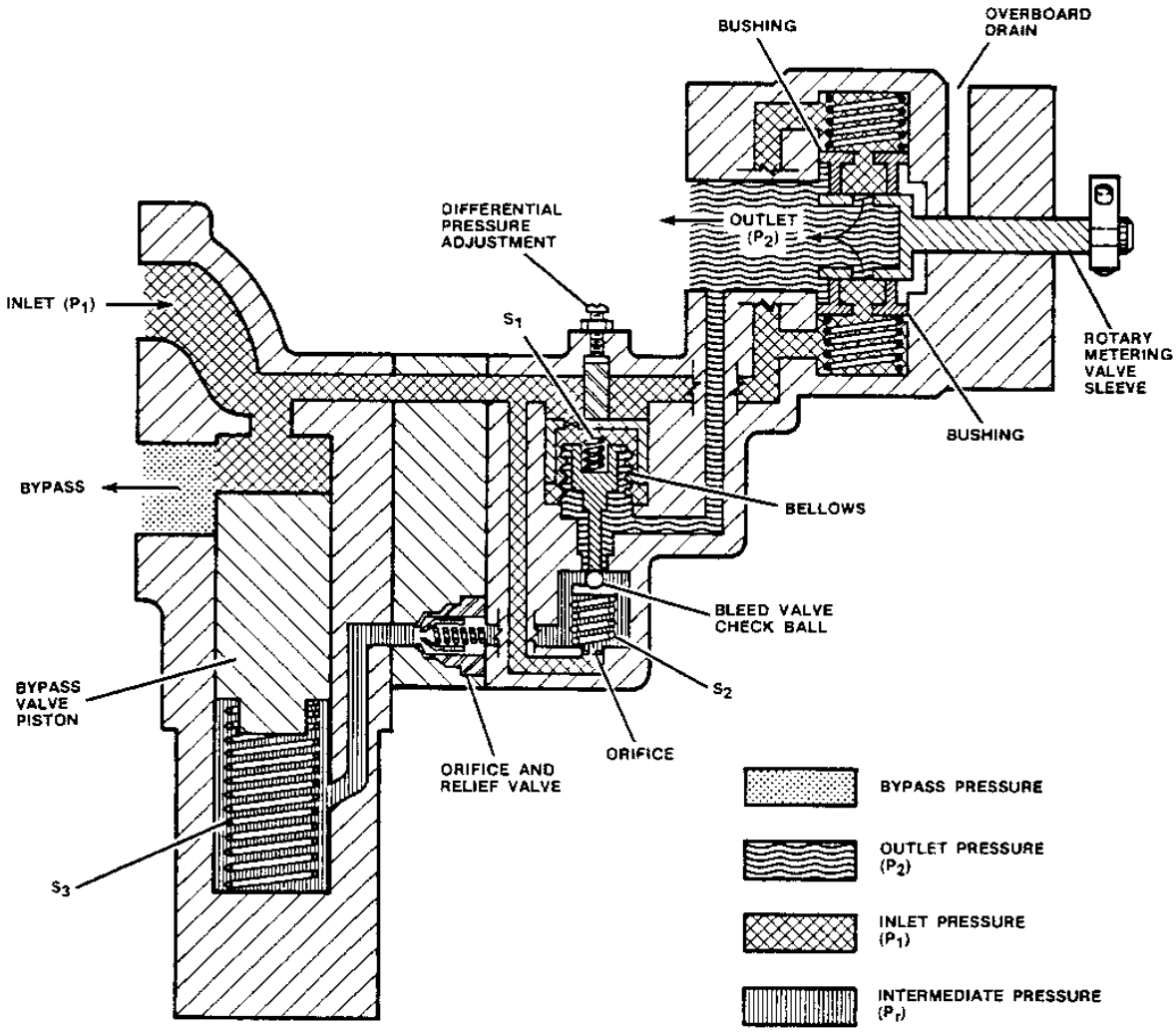


Figure 3-1. Schematic Flow Diagram of Liquid Fuel Valve With Orifice and Relief Valve

The 1907 large liquid valve is a pressure compensated flow control valve that is intended for use on positive displacement fuel forwarding systems only. The optional bypass dump port allows the 1907 valve to be used with both two-way and three-way engine fuel shut-off valves (SOV). If the 1907 fuel valve is used with a two-way SOV, when the SOV is closed the positive displacement fuel pump could be "dead headed". This could damage the fuel pump, piping, the 1907 fuel valve.

A typical fuel system that uses a three-way SOV is shown in Figure 3-2. In this system when the SOV is actuated to the shut-down position, all of the fuel is bypassed through the SOV back to the tank or to back to the fuel pump.

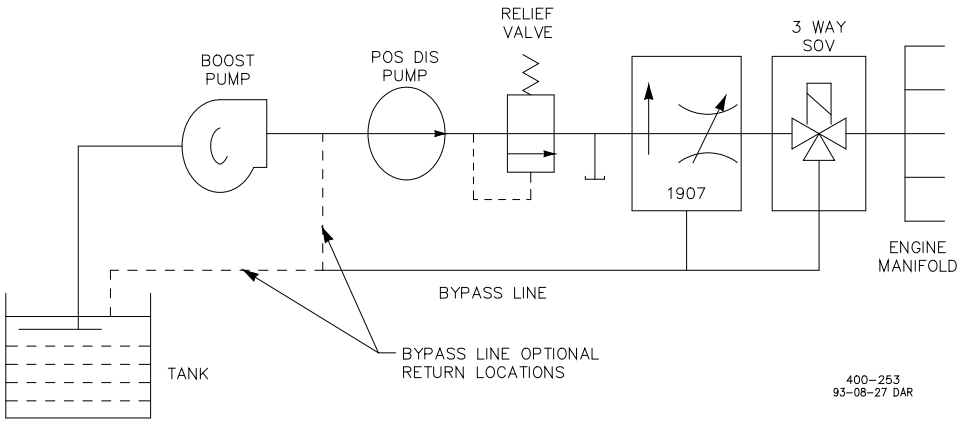


Figure 3-2. Three-way SOV Fuel System Schematic

Figure 3-3 shows a system that uses a two-way engine fuel SOV. In this system, a normally open SOV is interlocked with a normally closed valve mounted on the optional bypass dump port on the 1907 large liquid valve. When the SOV is closed, the bypass dump valve is opened. The control pressure under the bypass piston is vented back to the tank and the bypass piston moves to its full bypass position. Thus, the bypass dump in combination with a two-way SOV mimics the function of a three-way SOV.

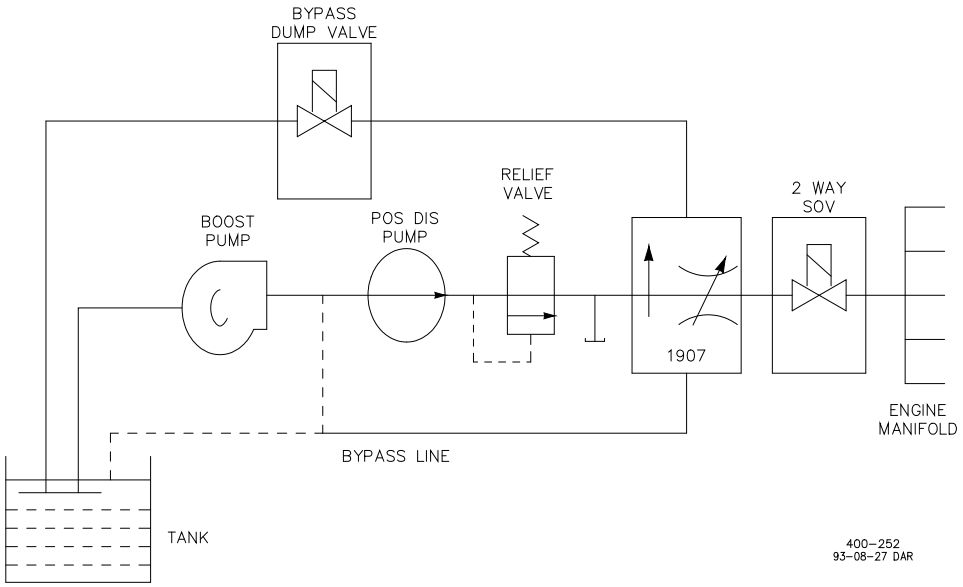


Figure 3-3. Two-way SOV with Bypass Dump Fuel Schematic

It is important that the valve used to vent the control pressure under the bypass piston be large enough to handle all of the flow with a minimum pressure drop. Residual pressure under the bypass piston will raise the system pressure during a shut-down. See Figure 3-4 to determine the amount of flow the bypass dump valve must pass for a given valve inlet pressure. The valve used for the bypass dump must also be situated a closely as possible to the 1907 valve and no air must get into the line between the bypass dump valve and the 1907 bypass dump port. This assures that the valve bypass will be active and in control as quickly as possible after the bypass dump valve closes.

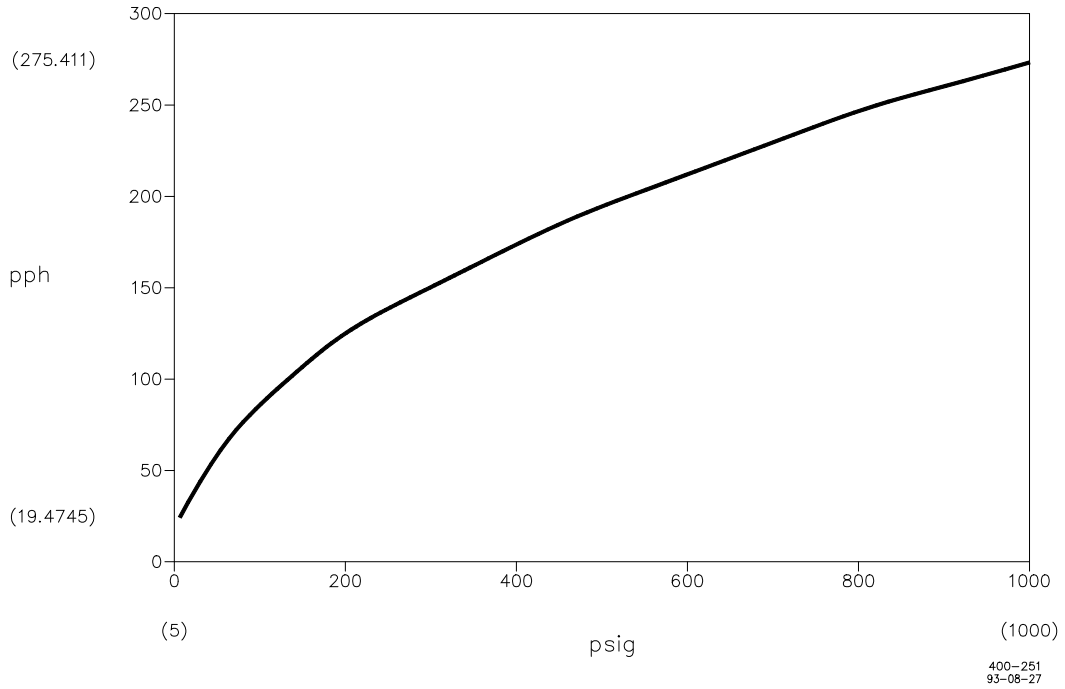


Figure 3-4. Bypass Dump Flow as a Function of Valve Inlet Pressure

# Chapter 4.
# Actuator/Valve Calibration

## EM-35 Actuator/1907 Large Liquid Valve with Analog Driver

The mechanical stops on the valve are to limit valve travel and prevent damage to the valve by driving it beyond its normal range. Minimum and maximum flow calibration is achieved using the resolver feedback. In order to make drivers interchangeable, a simple driver adjustment is needed during field installation. No field rigging is required.

With 4 mA applied to the driver input, the offset pot needs to be adjusted for the resolver feedback voltage that corresponds to minimum flow. With 20 mA applied to the driver input, the gain pot is adjusted for the resolver feedback voltage that corresponds to maximum flow. These voltages are determined for each valve during flow testing at the factory and are recorded on the valve test specification procedure (TSP) document that includes the valve serial number and part number. A copy of the TSP is shipped with each EM-35 actuator/1907 large liquid valve assembly.

See the EM-35 analog driver manual (40152) for details on test point and potentiometer locations.

## EM-35 Actuator/1907 Large Liquid Valve with Digital Driver

EM-35 actuator/large liquid valve used with the digital driver are typically for use in applications that require extremely high accuracy, like dry low emissions (DLE) control. For that reason, all calibration of the actuator/valve assembly is performed at the factory.

The mechanical stops on the valve are to limit valve travel and prevent damage to the valve by driving it beyond its normal range. Flow calibration is achieved using the digital resolver feedback and a valve characterization table. The flow vs. angle data is determined for each valve during the flow testing and is recorded on a floppy disk.

A personal computer is needed to download the table to the NetCon® SIO module. No field rigging is required to calibrate the valve. There is a warning tag on the valve and a warning message on the operator panel that the table identification (serial number and date code) must match the valve identification.

**⚠WARNING**

**Significant turbine damage, high emissions levels, release of high temperature gas, fire, damage to nearby equipment, injury to personnel, or death may result from incorrect fuel valve calibration. To correctly operate the fuel metering valve(s), the NetCon controller must be programmed with the correct valve characterization curve for the specific valve being used. Woodward provides the programming information to the valve purchaser in the form of a data file specifically identified by the valve serial number and date. The supplier of the application program must incorporate the valve characterization data file into the application program by following the procedure described in this manual. Failure to follow the procedure herein, or any non-Woodward alteration (including attempt to repair), or damage to the valve, may result in a change of characteristics leading to the same potential hazards.**

**⚠WARNING**

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

Following is the procedure for downloading the correct valve characterization information to the NetCon control.

***IMPORTANT***

**This procedure is intended for use by qualified engineering personnel only. Familiarity with the use of Woodward GAP™ programming is required.**

1. Obtain the serial number and calibration date of the fuel metering valve that is being used on the system. These are located on the nameplate and date sticker on the valve assembly.

2. Obtain the valve characterization data file for the valve in number one above from Woodward. The valve characterization file name and the valve serial number must match. The date on the valve and the date on the data file must match. If either of these items do not match, DO NOT continue with this procedure. Contact Woodward.

3. Rename this file to FMV.VLV and place this file in the same directory as the <application filename>.CDR file, and recode the program using the Woodward GAP coder.

4. Install this application in the NetCon controller CPU and enter the service mode. Go to the prompt "FMV S/N Verification". Follow the steps under this category to verify that the valve serial number and the valve data file match. Operator confirmation of this match will be a permissive to run the engine.

# Chapter 5. Inspections/Troubleshooting

## General

Woodward recommends a yearly visual inspection of the bypass housing and bypass sleeve in the area where cavitation is expected due to high differential fuel pressure. Cavitation will be more pronounced on valves that are operated in high pressure applications or are in continuous service. Remove the customer fuel piping from the ”Bypass” flange on the valve and visually inspect the bypass sleeve and internal surfaces of the bypass housing for cavitation and erosion wear. If significant wear is observed, replacement parts can be procured from Woodward.

Faults in the governing system are usually revealed as speed variations of the prime mover, but it does not necessarily follow that such speed variations indicate governing system faults. Therefore, when improper speed variations appear, check all components including the prime mover for proper operation.

Problems with the EM-35/valve assembly will usually show up as faults in the valve driver. The type of fault is indicated by LEDs on the driver circuit board. See the appropriate driver manual (manual number 40152 for the analog version or manual number 40161 for the digital version) for detailed information on fault annunciation.

## Field Repairs

Since the calibration is between the valve and the resolver, it is possible to replace the actuator in the field without the loss of calibration. Failures of the resolver will most likely result in the unit having to be recalibrated at the factory. Consult a qualified Woodward service facility for more information.

# Chapter 6.
# Service Options

## Product Service Options

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

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

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

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

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

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

**www.woodward.com/directory**

## Woodward Factory Servicing Options

The following factory options for servicing Woodward products are available through your local Full-Service Distributor or the OEM or Packager of the equipment system, based on the standard Woodward Product and Service Warranty (5-01-1205) that is in effect at the time the product is originally shipped from Woodward or a service is performed:

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

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

This option allows you to call your Full-Service Distributor in the event of an unexpected outage, or in advance of a scheduled outage, to request a replacement control unit. If the unit is available at the time of the call, it can usually be shipped out within 24 hours. You replace your field control unit with the like-new replacement and return the field unit to the Full-Service Distributor.

Charges for the Replacement/Exchange service are based on a flat rate plus shipping expenses. You are invoiced the flat rate replacement/exchange charge plus a core charge at the time the replacement unit is shipped. If the core (field unit) is returned within 60 days, a credit for the core charge will be issued.

**Flat Rate Repair:** Flat Rate Repair is available for the majority of standard products in the field. This program offers you repair service for your products with the advantage of knowing in advance what the cost will be. All repair work carries the standard Woodward service warranty (Woodward Product and Service Warranty 5-01-1205) on replaced parts and labor.

**Flat Rate Remanufacture:** Flat Rate Remanufacture is very similar to the Flat Rate Repair option with the exception that the unit will be returned to you in “like-new” condition and carry with it the full standard Woodward product warranty (Woodward Product and Service Warranty 5-01-1205). This option is applicable to mechanical products only.

## Returning Equipment for Repair

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

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

- return authorization number;
- name and location where the control is installed;
- name and phone number of contact person;
- complete Woodward part number(s) and serial number(s);
- description of the problem;
- instructions describing the desired type of repair.

### Packing a Control

Use the following materials when returning a complete control:
- protective caps on any connectors;
- antistatic protective bags on all electronic modules;
- packing materials that will not damage the surface of the unit;
- at least 100 mm (4 inches) of tightly packed, industry-approved packing material;
- a packing carton with double walls;
- a strong tape around the outside of the carton for increased strength.

**NOTICE**

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

## Replacement Parts

When ordering replacement parts for controls, include the following information:
- the part number(s) (XXXX-XXXX) that is on the enclosure nameplate;
- the unit serial number, which is also on the nameplate.

## Engineering Services

Woodward offers various Engineering Services for our products. For these services, you can contact us by telephone, by email, or through the Woodward website.
- Technical Support
- Product Training
- Field Service

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

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

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

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

# How to Contact Woodward

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

### Electrical Power Systems

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

### Engine Systems

| Facility | Phone Number |
|---|---|
| Brazil | +55 (19) 3708 4800 |
| China | +86 (512) 6762 6727 |
| Germany | +49 (711) 78954-510 |
| India | +91 (129) 4097100 |
| Japan | +81 (43) 213-2191 |
| Korea | +82 (51) 636-7080 |
| The Netherlands | +31 (23) 5661111 |
| United States | +1 (970) 482-5811 |

### Turbine Systems

| Facility | Phone Number |
|---|---|
| Brazil | +55 (19) 3708 4800 |
| China | +86 (512) 6762 6727 |
| India | +91 (129) 4097100 |
| Japan | +81 (43) 213-2191 |
| Korea | +82 (51) 636-7080 |
| The Netherlands | +31 (23) 5661111 |
| Poland | +48 12 295 13 00 |
| United States | +1 (970) 482-5811 |

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

**www.woodward.com/directory**

# Technical Assistance

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

| | |
|---|---|
| Your Name | |
| Site Location | |
| Phone Number | |
| Fax Number | |
| Engine/Turbine Model Number | |
| Manufacturer | |
| Number of Cylinders (if applicable) | |
| Type of Fuel (gas, gaseous, steam, etc) | |
| Rating | |
| Application | |
| **Control/Governor #1** | |
| Woodward Part Number & Rev. Letter | |
| Control Description or Governor Type | |
| Serial Number | |
| **Control/Governor #2** | |
| Woodward Part Number & Rev. Letter | |
| Control Description or Governor Type | |
| Serial Number | |
| **Control/Governor #3** | |
| Woodward Part Number & Rev. Letter | |
| Control Description or Governor Type | |
| Serial Number | |

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

# EM-35/1907 Control Specifications

**Description**
The EM-35 electric actuator was designed to position Woodward gas and liquid valves equipped with resolver feedback. The actuator requires a final driver for driving the motor and for closed loop control.

The EM-35 actuator uses a brushless dc motor with a 108:1 reducing planetary gearhead. The motor is designed with samarium cobalt permanent magnets bonded to the rotor element, and all stator windings are completely sealed. Rotor position sensing is performed by the field director unit integral with the motor. This inductive device requires excitation and demodulation within the electronic motor controller.

**Mechanical**

| | |
|---|---|
| Output Shaft Rotation | 60° (rotation limited by valve stops) |
| Actuator/Valve Coupling | cam follower |
| Torque Constant | 1.8 N·m/A (16 lb-in/A) |
| Continuous Output Torque | ±25 N·m (±220 lb-in) maximum |
| Peak Output Torque | ±45 N·m (±400 lb-in) minimum |
| Clutch Breakaway Torque | ±68 N·m (±600 lb-in) |
| Valve Liquid Connection | MS 33786-20 ports |
| Liquid Fuel Flow | 68 to 11 340 kg/h (150 to 25 000 lb/h) |

**Electrical**

| | |
|---|---|
| Power input | 28 Vdc nominal, 18–32 Vdc operating<br>4.5 A continuous<br>25 A peak for 50 ms |

**Performance**

| | |
|---|---|
| Slew time (50×) | 150 ms open, 80 ms close at 28 V (100 ms close for 137:1 gear ratio) where slew time = valve travel ÷ maximum slew rate |
| Bandwidth | >4.5 Hz |
| Position accuracy | ±0.50° using analog driver<br>±0.10° using digital driver |

**Environmental**

| | |
|---|---|
| Temperature | |
| Valve: | –18 to +121 °C (0 to +250 °F) |
| Actuator and Resolver: | –40 to +149 °C (–40 to +300 °F) |

**Hazardous Area Certification**

| | |
|---|---|
| Class Protection | Class I, Division 1, Groups C and D<br>Class I, Division 2, Groups B, C, and D |

**We appreciate your comments about the content of our publications.**

**Send comments to: icinfo@woodward.com**

**Please reference publication 40159E.**

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

2013/1/Colorado