WOODWARD

Installation and Operation Manual

PGPL Actuator/Driver

Manual 37519 (Revision G)

IMPORTANT

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

DEFINITIONS

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

WARNING

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

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

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

This publication may have been revised or updated since this copy was produced. To verify that you have the latest revision, be sure to check the Woodward website:

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

NOTICE

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

NOTICE

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

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

Contents

Illustrations and Tables

Chapter 1.
General Information

Introduction

This manual describes the installation and operation of the PGPL Actuator/Driver.

Regulatory Compliance

1. The PGPL actuator and driver are suitable for use in Class I, Division 2, Groups A, B, C, and D, or non-hazardous locations only per UL certification. [Actuators with the magnetic pickup option are not UL/cUL listed.]

2. Wiring for the PGPL actuator and driver must be in accordance with Class I, Division 2 wiring methods and in accordance with the authority having jurisdiction.

3. Connect the ground terminal to earth ground.

4. Wiring must be suitable for at least 90 °C.

⚠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 applications.

⚠AVERTISSEMENT

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

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

Description

The PGPL Actuator/Driver is an electrohydraulic actuator with a proportional driver interface which can be used with electronic controls providing a 0 to 200 mA position signal. The actuator is designed for use with Woodward 2301A series, 700-series, Peak® 150, and 505 controls.

The driver converts a given electrical signal into a mA output to the actuator which drives the output shaft position through the action of a torque motor and follower-type pilot valve. A contactless sensor located on the power cylinder provides the position feedback necessary for loop closure. Power cylinders with 16, 23, 39, and 79 J (12, 17, 29, and 58 ft-lb) outputs are available with linear output (see manual 36692, PG Power Cylinder Assemblies), and 16, 23, 39, and 79 N·m (12, 17, 29, and 58 lb-ft) rotating output.

The PGPL Actuator/Driver is used on gas engines or steam turbines to replace PG–PL, PGD, and PGL governors, providing the advantages of electronic control with the convenience of the existing PG-type drive and linkage.

PG Governor Similarities

The PGPL Actuator/Driver uses the standard PG, UG, UG-90, and ALCO governor bases and all drive shaft options (see manual 36693, *PG Base Assemblies*). The output shaft or rod end and rack position indicators are the same parts used in the PG governor and in the same relative position. The existing booster, remote heat exchanger, and remote servo options can be used.

The actuator may be equipped with a special 50-tooth gear and magnetic pickup, using the governor drive to sense prime mover speed. This permits an added convenience when converting from a PG hydraulic-mechanical governor to an electronic control system.

⚠WARNING

To prevent possible serious injury or loss of life, or damage to the prime mover, do NOT use the MPU as part of any overspeed shutdown system.

IMPORTANT

The actuator MPU will sense the speed of the governor drive, which is not necessarily the same rpm as the prime mover. The frequency sensed by the MPU must match the frequency range of the electronic control.

Hydraulic Pump

The PGPL Actuator is equipped with a PG spur gear pump in high speed and low speed versions. The pump uses oil from the self-contained PGPL Actuator/Driver sump to provide 896 kPa (130 psi) internal operating pressure (1655 kPa/240 psi in the 58 ft-lb model).

The drive uses a maximum of 375 W (0.5 hp). In some cases the actuator may require an oil cooler to operate at the high end of the drive speed range. Contact your Woodward representative for help on determining if an oil cooler is needed.

The actuator uses a PG spur gear pump. The pump is 20.62 mm (0.812 inch) thick for application speeds below 1000 rpm, and 14.27 mm (0.562 inch) thick for application speeds above 1000 rpm. The relief valve is set at 896 kPa (130 psi) standard (1655 kPa/240 psi in the 58 ft-lb model).

Drive speeds from 200 to 1000 rpm are available with check valves for either clockwise or counterclockwise rotation. Speeds up to 1500 rpm maximum are available with plugs for single direction only.

Actuator Response

The PGPL Actuator/Driver output is directly proportional to a 0 to 200 mA signal from an electronic control system.

This manual provides outline drawings to show the most common actuator configurations (refer to manual 36693 for other PG base assemblies). The outline drawings include information on electrical wiring, installation dimensions, drive requirements, oil requirements, and output shaft dimensions. The drawings are provided for reference only. Do not use the drawings for construction.

Driver

The driver requires 18–32 Vdc supply voltage and a 0–200 mA input from the governor control. The driver sends excitation voltage to the position sensor and receives feedback voltage. It sends a 0–200 mA output to the actuator torque motor. The driver has a built-in 210 mA current limit to prevent damage to the torque motor. The driver also provides a 4–20 mA position output signal that is suitable for driving a valve position indicator.

References

The following publications provide additional information about installation, operation, and storage of Woodward products.

Pub. Number	**Title**
25071	*Oils for Hydraulic Controls*
25075	*Commercial Preservation Packaging for Storage of Mechanical-Hydraulic Controls*
50516	*Governor Linkage for Butterfly Throttle Valves*
36641	*Governor Oil Heat Exchanger, Remote and Integral Types*
36692	*PG Power Cylinder Assemblies*
36693	*PG Base Assemblies*
37520	*PGPL Actuator/Driver Product Specification*
50532	*EMI Control for Electronic Governing Systems*

This manual does not attempt to provide information about the electronic control which determines the position of the PGPL Actuator/Driver output. This information must be obtained from the appropriate manual for the electronic control.

Chapter 2. Installation

Introduction

This chapter describes receiving, storage, and installation requirements for the PGPL Actuator/Driver.

Use care while handling and installing the PGPL Actuator/Driver. Be particularly careful to avoid striking the drive shaft, terminal shaft, or the electrical connectors. Abuse can damage seals, internal parts, and factory adjustments. Do not set the actuator on its drive shaft.

Receiving

After factory testing and calibration, the PGPL Actuator is drained of oil. This leaves a light film of oil on internal parts to prevent rust. External parts are painted or coated with a spray lubricant/rust inhibitor.

No internal cleaning or flushing is necessary before installation and operation. The little oil left in the actuator is clean, multiviscosity engine oil which will not contaminate the oil selected to operate the actuator.

Fill the actuator with oil selected to match the expected operating conditions. (If the actuator is a direct replacement for a PG governor, you may use the same grade and weight of oil that was being used in the governor.) Use only new, clean oil in the actuator. Do not allow dirt or contamination to enter the actuator while filling with operating oil. Do not use oil drained from the PG governor. Refer to “Oil Supply” later in this chapter, and to manual 25071, *Oils for Hydraulic Controls*, for more information.

Storage

The PGPL Actuator/Driver may be stored for short periods of time (less than a year) as received from the factory. For long-term storage (more than a year), storage in an environment with large temperature changes, humid or corrosive atmosphere, etc., or if the actuator is installed on the prime mover for storage, fill the actuator with oil and follow preservation packaging instructions in Woodward Manual 25075, *Commercial Preservation Packaging for Storage of Mechanical-Hydraulic Controls*.

Attitude

The PGPL Actuator should be installed in a vertical or near vertical position. See the outline drawing for installation instructions and dimensions.

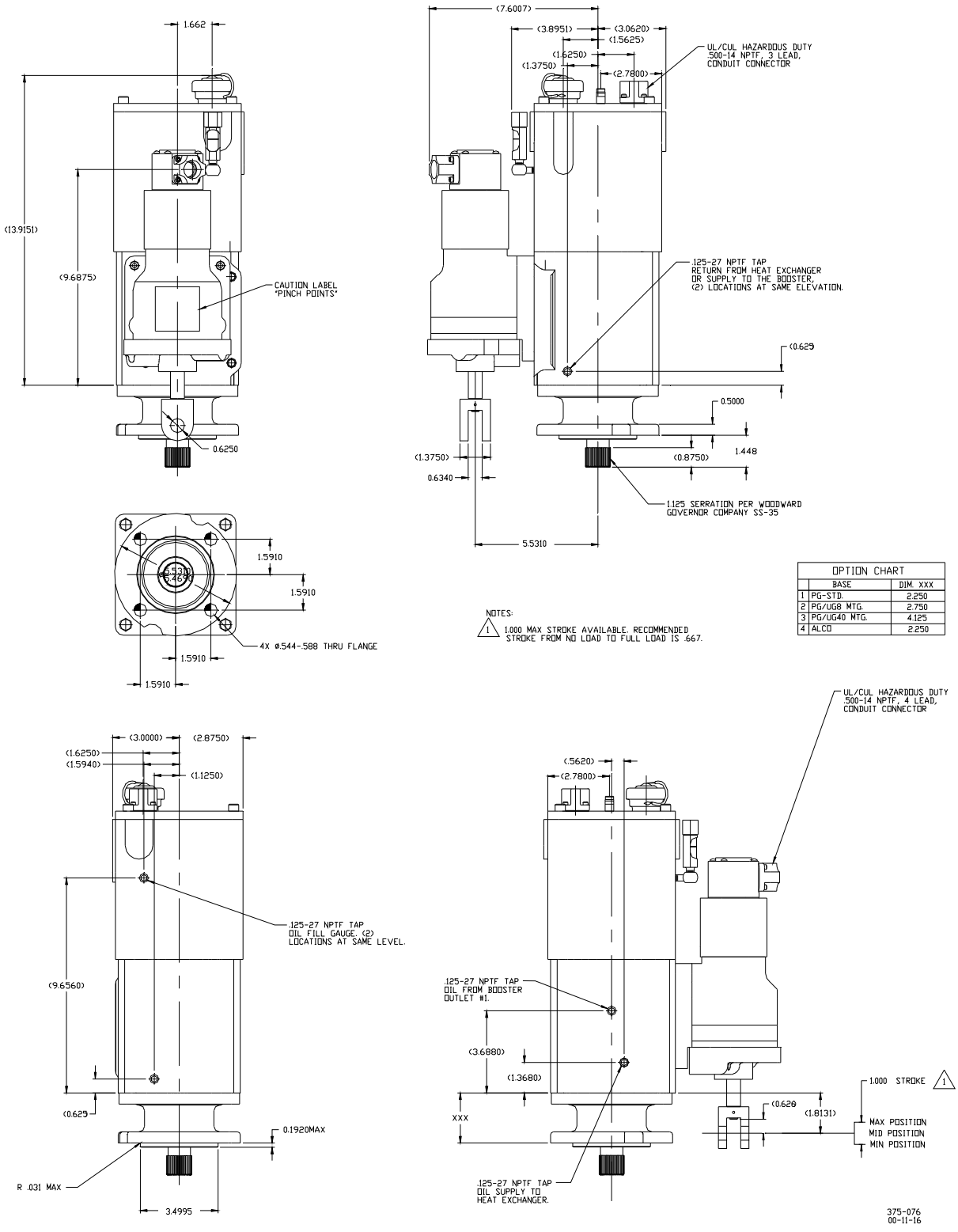


Figure 2-1. Outline Drawing of PGPL Actuator (29/58 ft-lb; pull to increase)

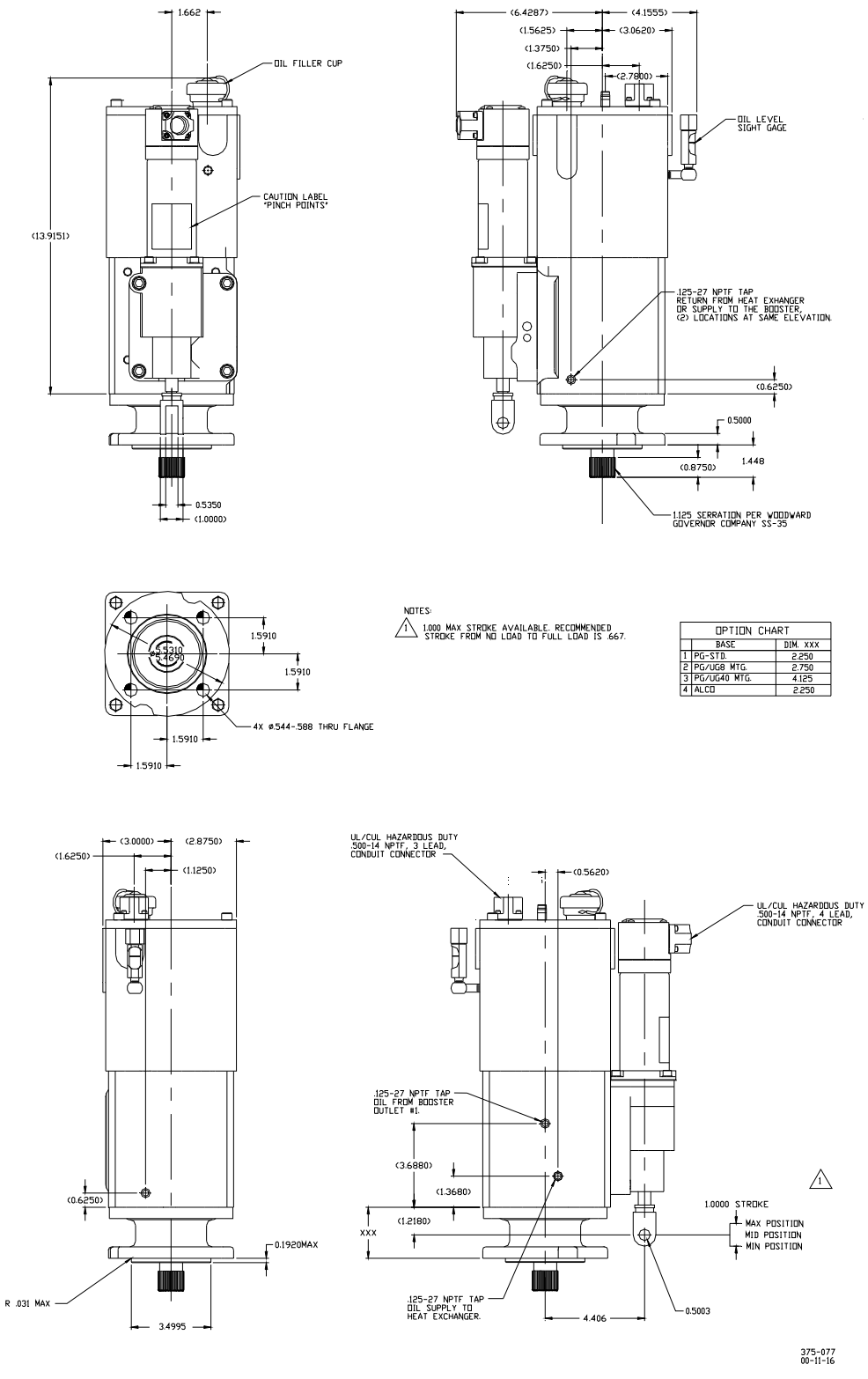
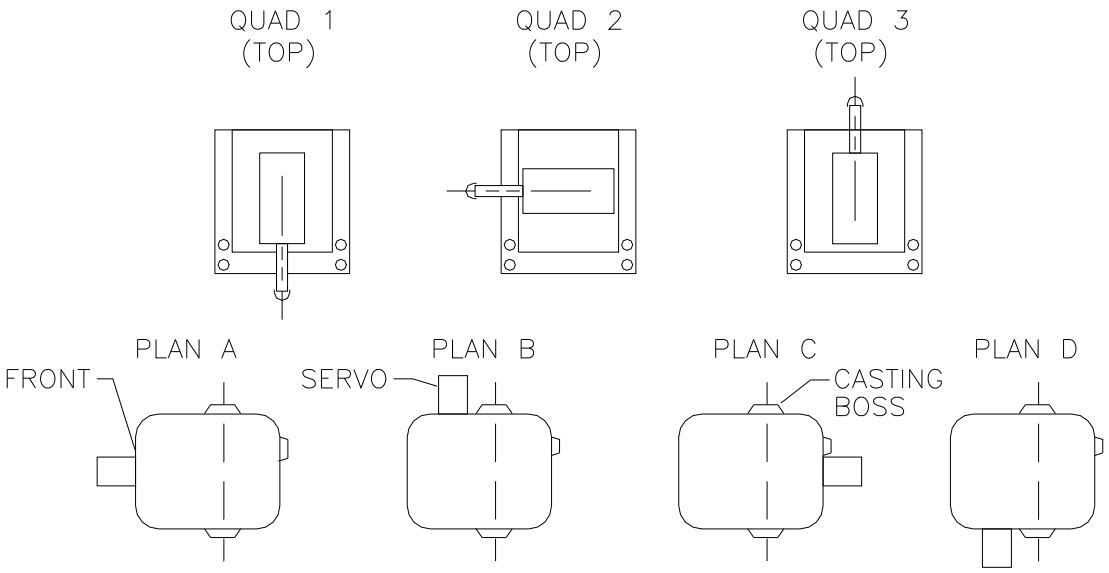


Figure 2-2. Outline Drawing of PGPL Actuator (12 ft-lb; spring return)



PLAN	OIL GAUGE		MAGNETIC PICKUP		12 FT-LB LINEAR SERVO			
	R.H.	L.H.	R.H.	L.H.	QUAD 1	QUAD 2	QUAD 3	
A	X	X	X	X	X	X	X	
B	X	NOTE#1		NOTE#2		X		
C	X	X	X	X	X	X	X	
D	NOTE#3	X	NOTE#4			X		

NOTE#1: L.H. OIL GAUGE CAN BE USED WITH A QUAD 2 SERVO.

NOTE#2: L.H. MAGNETIC PICKUP CAN BE USED WITH A QUAD 2 SERVO.

NOTE#3: R.H. OIL GAUGE CAN BE USED WITH A QUAD 2 SERVO.

NOTE#4: R.H. MAGNETIC PICKUP CAN BE USED WITH A QUAD 2 SERVO.

PLAN	29/58 FT-LB LINEAR SERVO				12/29/58 FT-LB ROTARY SERVO		
	QUAD 1	QUAD 2	QUAD 3		QUAD 1		
A	X	X	X		X		
B	X	X			X		
C	X	X	X		X		
D	X	X			X		

NOTE:
To help identify a replacement product, please identify the existing WGC P/N and revision letter. The above is a sample of some available configurations.

Please contact your local WGC Rep for more information.

375-091
98-03-03 skw

Figure 2-3. PGPL Actuator Options

Drive Connection

Make sure the actuator drive shaft turns freely before installing the actuator. The drive gear or coupling must slip freely into the governor drive of the prime mover. Do not apply external force. The drive must be free of binding, side load, or excess end-play. Improper alignment or fit between the parts can result in excessive wear or actuator-drive seizure.

Mount the actuator squarely on the mounting pad. Torque the mounting bolts evenly. There can be no movement or rocking of the actuator on the prime mover mounting pad.

Control Linkage

The terminal shaft provides the following outputs: linear version—25.4 mm (1 inch) linear; rotary version—30° rotary. Refer to manual 36692, *PG Power Cylinder Assemblies*, for servo options.

Use 2/3 of the total travel between no load and full load. The additional "overtravel" should be split and used at both ends to provide maximum fuel when required and to assure shutdown at minimum-fuel actuator position (see Figure 2-5).

⚠WARNING

To prevent possible serious injury or loss of life, or damage to the prime mover, be sure to allow sufficient overtravel at each end of the terminal shaft, so the actuator can shut down the prime mover, and also give maximum fuel when required. Misadjusted linkage could prevent the actuator from shutting down the prime mover.

Many control problems are related to linkage between the actuator and the prime mover. Use only first-quality rod ends for the linkage, rod ends that will last under the nearly constant motion associated with precise speed control. The linkage must be stiff, not subject to vibration from the prime mover. The linkage must be as light as possible and still maintain the attributes of stiffness. Linkage which is too heavy can damage the actuator as well as make it difficult to achieve steady control.

All dynamic adjustments are made in the electronic control. The actuator has a plug in place of the PG needle valve, and turning it will have no effect.

Installed linkages must operate smoothly, be free of binding, and free of lost motion due to worn parts. If there is a collapsible member in the linkage, be sure it does not yield each time the actuator moves the linkage rapidly.

Design the linkage so the power output of the prime mover is proportional to the position of the actuator output shaft.

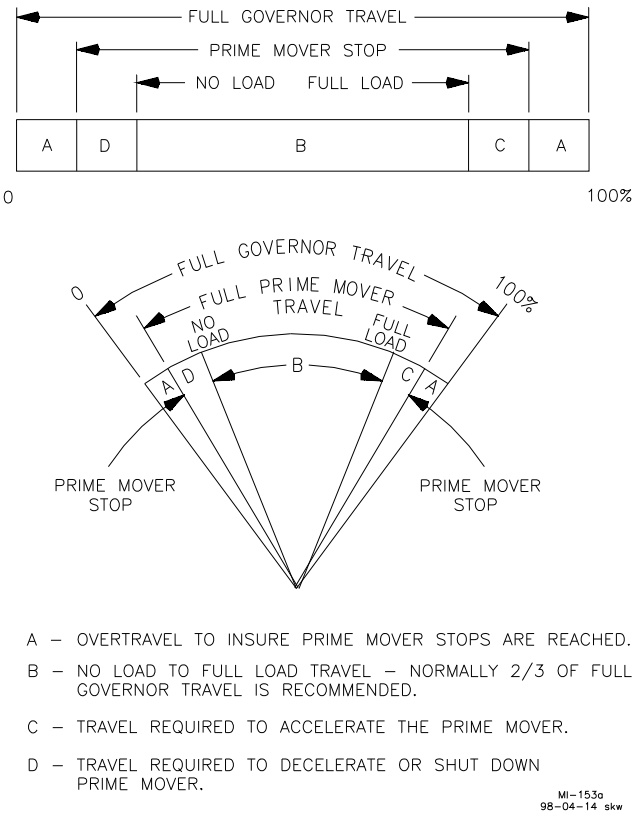


Figure 2-4. Terminal Shaft Travel

Follow the prime mover manufacturer's instructions on linkage selection, installation, and adjustment. In almost all cases, the linkage designed for a PG governor will work with the PGPL Actuator/Driver. In the case of a direct exchange, make sure that the linkage is in good condition and the installation of the lever on the actuator is in the same position as it was on the governor.

⚠WARNING

The engine manufacturer normally designs the linkage arrangement, which varies with every installation. To prevent possible injury while the PGPL Actuator is moving the linkage through its normal operating range, make sure you provide adequate guarding around the linkage.

Oil Supply

Use the information given in Figures 2-6 and 2-7 as a guide in the selection of a suitable oil (also refer to manual 25071, *Oils for Hydraulic Controls*). Oil grade selection is based on the operating temperature range of the actuator. Also use this information to aid in recognizing and correcting common problems associated with oil used in the actuator. Many operation and maintenance problems associated with PGPL Actuators are directly related to the selection and condition of the oil in the actuator. Use care in the selection and make sure that the oil in the actuator is not contaminated.

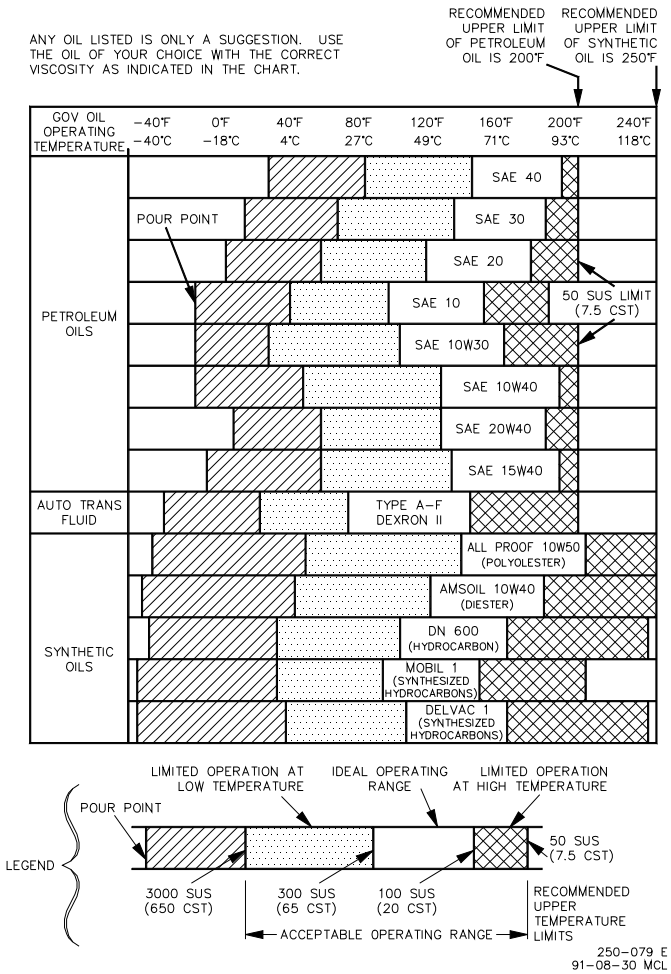


Figure 2-5. Oil Chart

VISCOSITY COMPARISONS				
CENTISTOKES (CST, CS, OR CTS)	SAYBOLT UNIVERSAL SECONDS (SUS) NOMINAL AT 100 DEGREES F	SAE MOTOR (APPROXIMATE)	SAE GEAR (APPROXIMATE)	ISO
15	80	5W		15
22	106	5W		22
32	151	10W	75	32
46	214	10	75	46
68	310	20	80	68
100	463	30	80	100
150	696	40	85	150
220	1020	50	90	220
320	1483	60	115	320
460	2133	70	140	460

250−087
97−11−04 skw

Figure 2-6. Viscosity Comparisons

The oil in the PGPL Actuator is both a lubricating and hydraulic oil. It must have a viscosity index that allows it to perform over the operating temperature range and it must have the proper blending of additives that cause it to remain stable and predictable over this range.

The PGPL Actuator is designed to give stable operation with most oils, if the fluid viscosity at the operating temperature is within a 100 to 300 SUS (Saybolt Universal Seconds) range (see Figure 2-7). Poor actuator response or instability is an indication that the oil is too thick or too thin.

Actuator oil must be compatible with seal material, that is, nitrile, polyacrylic, and fluorocarbon. Many automotive and gas engine oils, industrial lubricating oils, and other oils of mineral or synthetic origin meet these requirements.

Fill the actuator with oil to the mark on the oil sight glass. After the prime mover is started and the actuator is at operating temperature, add oil if necessary. Oil must be visible in the glass under all operating conditions.

IMPORTANT

On 16 J/12 ft-lb linear or rotary actuator only: After filling the actuator with oil, vent the air from the return spring guard by removing the 1/16 pipe plug on the feedback housing just below the conduit connections. When oil starts to run out of the tapped hole, replace the pipe plug.

Excessive component wear or seizure in the actuator indicates the possibility of:
Insufficient lubrication caused by:
- an oil that flows slowly when it is cold, especially during start-up;
- no oil in the actuator.

Contaminated oil caused by:
- dirty oil containers;
- an actuator exposed to heating and cooling cycles, which created condensation of water in the oil.

Oil not suitable for the operating conditions caused by:
- changes in ambient temperature;
- an improper oil level which creates foamy, aerated oil.

⚠WARNING

To prevent possible serious injury or loss of life, or damage to the prime mover, resulting from prime mover overspeed or runaway, be sure to use only oil that falls within the 50 to 3000 SUS range. Using oils outside this range could cause the actuator to be unable to prevent a runaway prime mover.

Operating an actuator continuously beyond the high limit temperature of the oil will result in oil oxidation. This is identified by varnish or sludge deposits on the actuator parts. To reduce oil oxidation, lower the actuator operating temperature with a heat exchanger or other means, or change to an oil more oxidation-resistant at the operating temperature.

Oil Maintenance

Replace the actuator oil if it is contaminated, and change it if it is suspected of contributing to instability. Drain the oil while it is still hot. Flush the actuator with a clean solvent having some lubricating quality (fuel oil or kerosene) before refilling with new oil. If drain time is insufficient for the solvent to completely drain or evaporate, flush the actuator with the same oil it is being refilled with to avoid dilution and possible contamination of the new oil.

Oil that has been carefully selected to match the operating conditions and is compatible with actuator components should give long service between oil changes. Check oil conditions regularly and change oil if any deterioration or contamination is suspected.

Regularly scheduled oil changes will extend the life of the actuator and improve actuator operation. Properly selected oil should permit annual oil changes, but more frequent changes are recommended.

Electrical Connection

⚠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 applications.

⚠AVERTISSEMENT

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

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

The electrical connectors on the PGPL Actuator are 0.500–14 NPTF conduit with 1.2 m (4 ft) of lead wire to both the actuator torque motor and position sensor. These wires must be terminated inside a junction box external to the actuator.

Input and output wiring must be in accordance with Class I, Division 2 wiring methods and in accordance with the authority having jurisdiction.

Wiring must be suitable for at least 90 °C.

Wiring Instructions

External wiring connections and shielding requirements for a typical control installation are shown in the plant wiring diagram (Figures 2-8 and 2-9). These wiring connections and shielding requirements are explained in the balance of this chapter.

Electromagnetic interference (EMI) is the undesirable interaction of electronic circuits with each other and sometimes with themselves. Woodward has established procedures to prevent most EMI which will affect prime mover control circuits. Following these procedures is a slight extra expense in planning and installing electronic governing system, but is inexpensive insurance over the life of the plant. Follow all of the shielding instructions to assure maximum efficiency and dependability of the electronic governing system.

Application Note 50532, *EMI Control for Electronic Governing Systems*, has additional information on EMI causes and prevention.

See Figure 2-10 to see how to connect wiring from the battery to the control. Maximum wire lengths are:

	1.5 mm² (16 AWG) wire	2 mm² (14 AWG) wire
battery to driver	457 m (1500 ft)	610 m (2000 ft)
driver to actuator	457 m (1500 ft)	610 m (2000 ft)

IMPORTANT **For supply connections, use wire rated for at least 90 °C.**

Shielded Wiring

All shielded cable must be twisted conductor pairs. Do not tin (put solder on) braided shield. All signal lines should be shielded to prevent picking up stray signals from adjacent equipment. Connect the shields to the control case as show in Figure 2-8. Wire exposed beyond the shield should be as short as possible, not exceeding 150 mm (6 inches). The other end of the shields must be left open and insulated from any other conductor. Do not run shielded signal wires with high voltage or high current wires.

Driver Mounting

Install the driver box in a location with space for wiring access. Do not expose the driver to sources of radiant heat. Do NOT install the driver box directly on the prime mover. Choose a protected location so the control will not be damaged when moving the prime mover or when nearby equipment is moving. Mount the driver close enough to the actuator and battery to meet the wire-length requirements (listed above).

No special ventilation is required, except that the driver must be open to normal air movement to dissipate the small amount of heat it generates.

Ideally, the driver should be mounted flush to the metal side of a control cabinet, protected from the weather and high humidity. The location should provide protection from high-voltage or high-current devices, or devices which produce electromagnetic interference. Once the wiring is complete, ready access to the driver will not be required for normal prime mover operation.

DO NOT install the driver box directly on the prime mover.

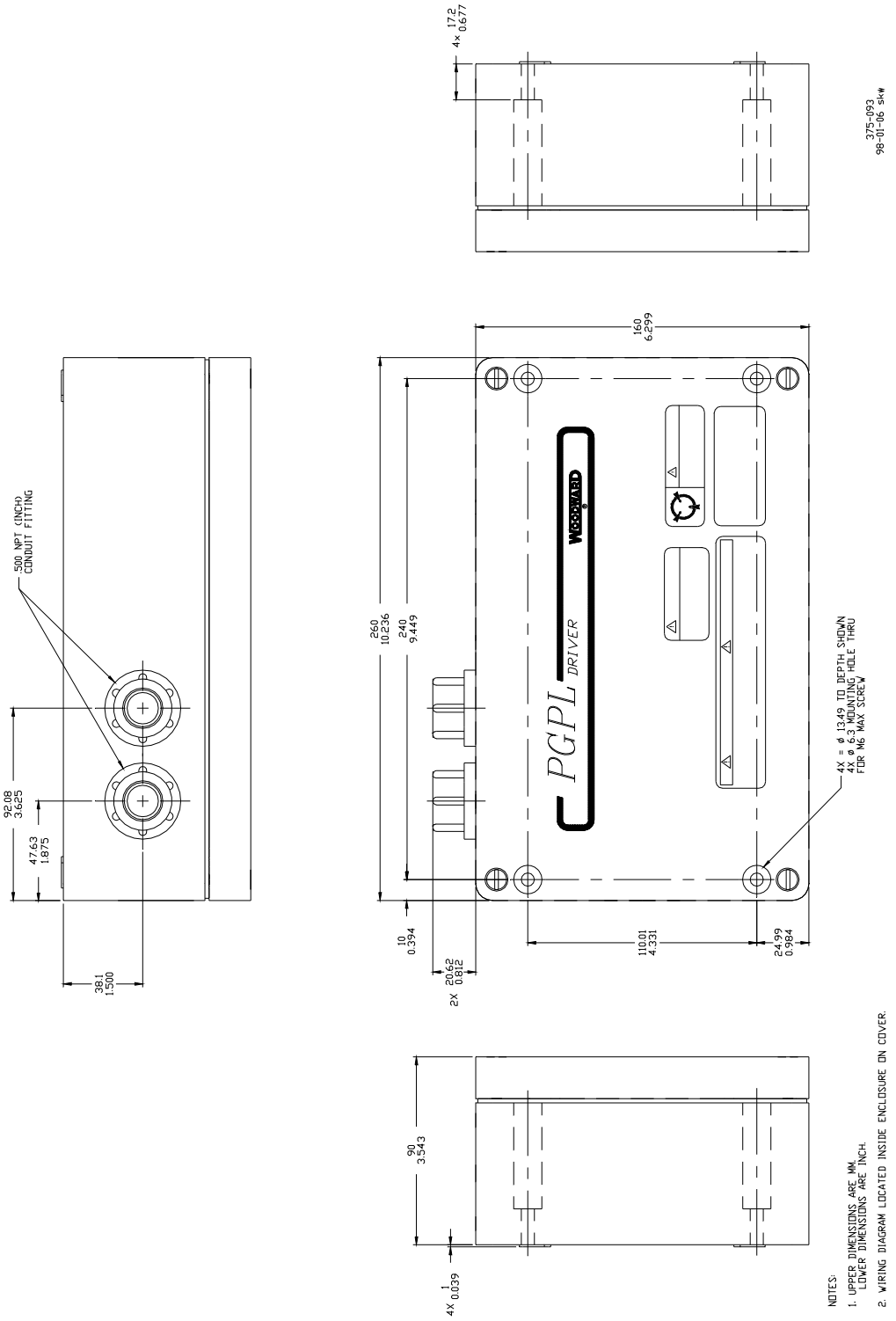


Figure 2-7. PGPL Driver Outline Drawing

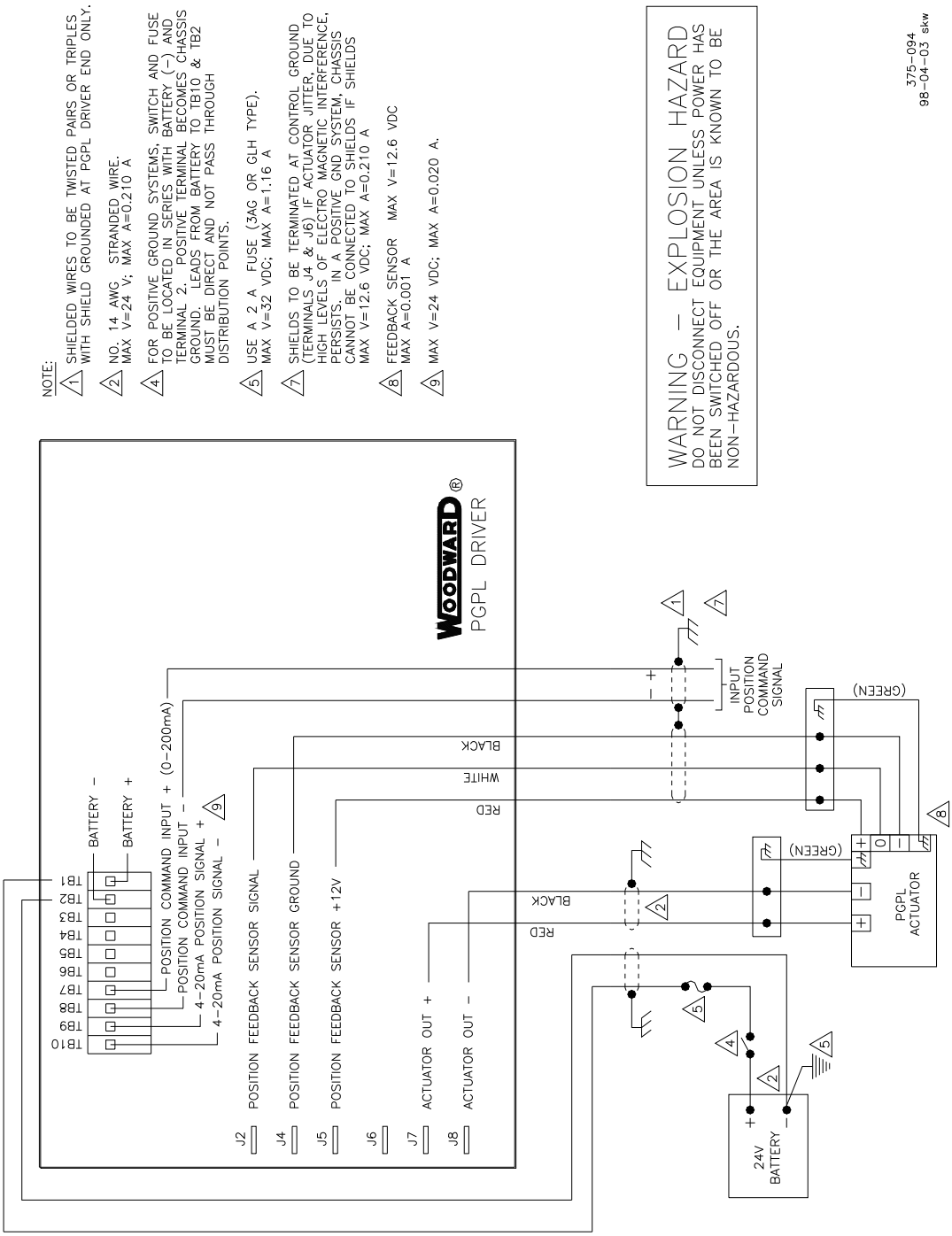


Figure 2-8. PGPL Driver Outline and Plant Wiring

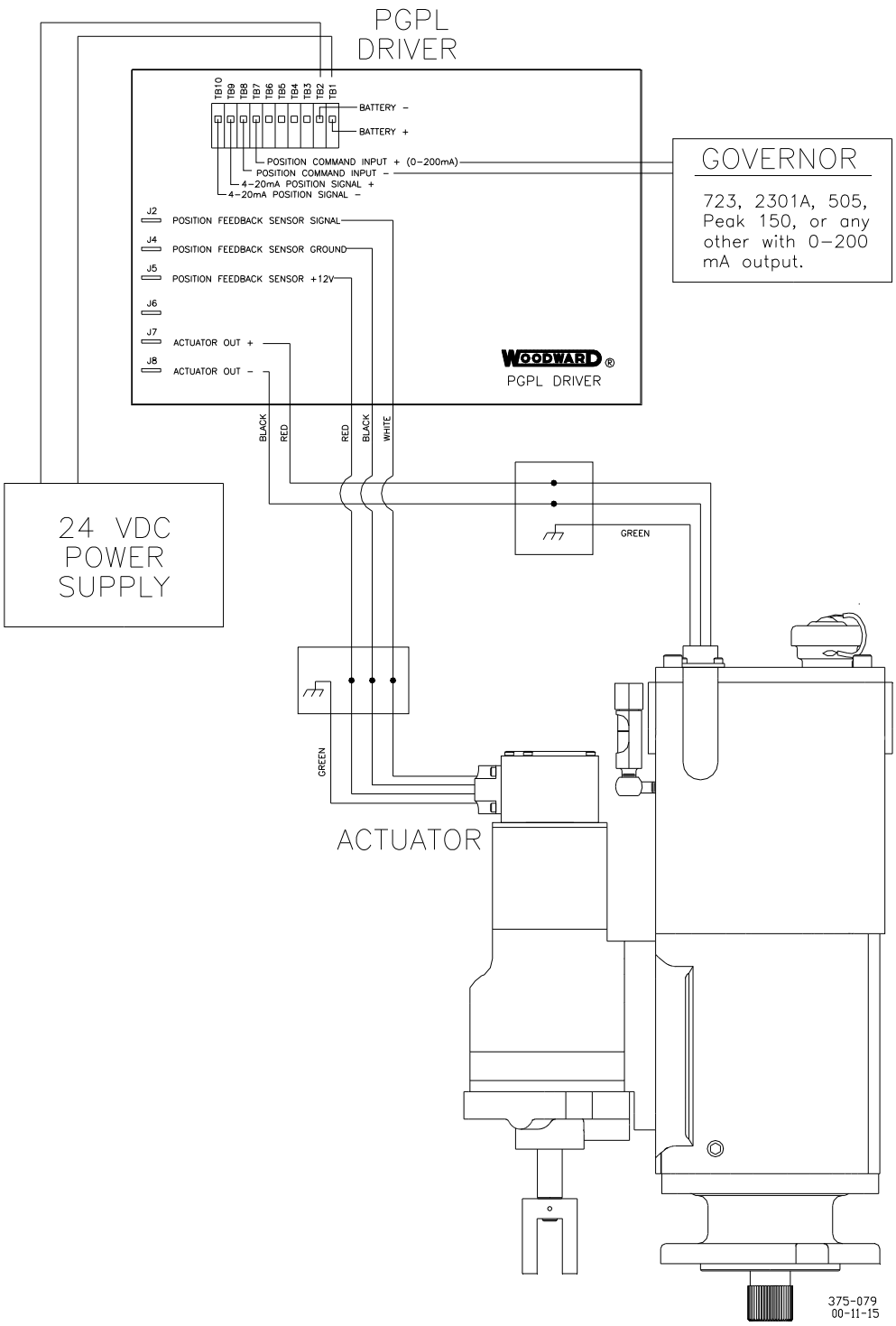


Figure 2-9. System Wiring Overview

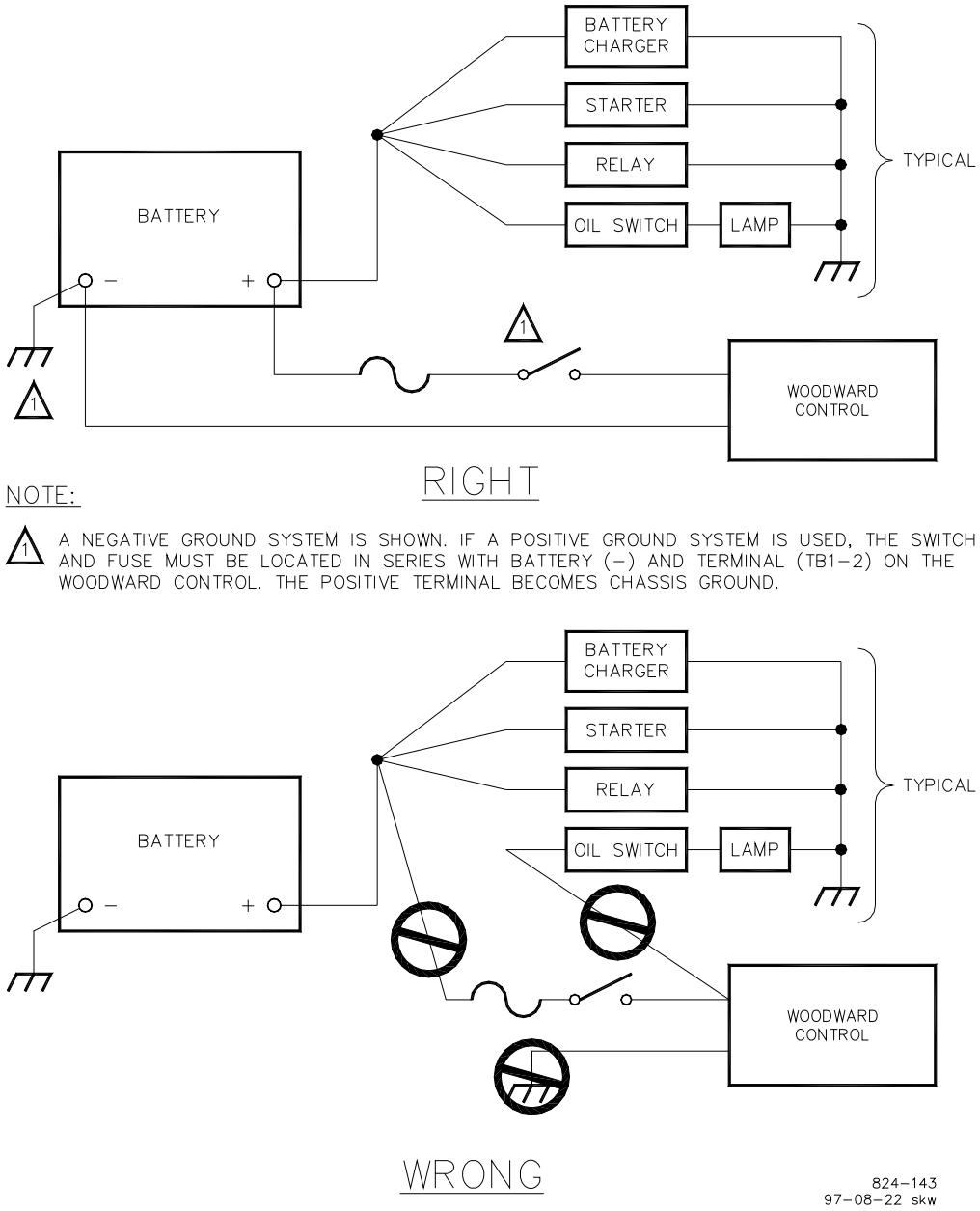


Figure 2-10. Wiring Direct from Battery to Control

Chapter 3.
Actuator Operation

Introduction

This chapter provides initial operation instructions for the PGPL Actuator/Driver.

Initial Operation

Before initial operation of the prime mover equipped with a PGPL Actuator/ Driver, read all of Chapter 2, Installation Procedures. Make sure that all installation steps have been correctly accomplished and all linkages are secured and properly attached.

Follow this procedure when putting a new or repaired PGPL Actuator/Driver into service.

Check that the actuator is full of the proper type and grade of clean oil. Verify that there are no external leaks.

⚠WARNING

To prevent possible serious injury or loss of life, or damage to the prime mover, be sure to allow sufficient overtravel at each end of the terminal shaft, so the actuator can shut down the prime mover, and also give maximum fuel when required. Misadjusted linkage could prevent the actuator from shutting down the prime mover.

Select a LOW SPEED setting on the Woodward electronic control to give low prime mover speed at initial start up.

⚠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.

Follow the manufacturer's instructions, and start the prime mover.

Adjust the selected speed setting on the Woodward electronic control as necessary to bring the prime mover to rated speed.

Obtain system stability as outlined in the electronic control instruction manual. (If less than the recommended actuator output stroke is used, it may cause less than optimum prime mover stability or response.)

All operating adjustments of the PGPL Actuator/Driver are made during factory calibration. Additional adjustment should not be needed.

Chapter 4.
Principles of Operation

Introduction

This section describes the operation of the PGPL Actuator/Driver (see Figure 4-1).

Connecting oil passages between components are simplified for ease in visualizing the system.

The PGPL Actuator contains its own sump.

The PGPL Actuator/Driver consists of the following basic components:

Oil Pump
PG spur gear pump in low and high speed versions.

Relief Valve/Accumulator
Set to maintain internal operating pressure at 896 kPa/130 psi in the 12, 17, and 29 ft-lb models (1655 kPa/240 psi in the 58 ft-lb model).

Oil Filter
Filters oil to the pilot valve to prevent contamination of the orifice and nozzle. Control oil flows through the filter, providing a filter-cleaning function.

Torque Motor, Torque Motor Beam, Level Spring, and Loading Spring
Used to establish a mechanical position of the pilot valve flapper in response to the dc current being sent to the actuator from the driver.

Pilot Valve Plunger
A follower-type valve, which duplicates the movement of the torque-motor beam, but at a much higher force level, controls flow of oil to and from the servo. The pressure regulator is used to minimize calibration shifts due to speed-induced pump pressure changes.

Power Cylinder
The power piston moves the actuator linear or rotary output shaft as directed by the pilot valve. A contactless position sensor on the power cylinder feeds the piston position back to the driver through a signal-conditioning circuit board to match the output of the position sensor to the driver.

Driver
The driver provides an interface between the governor control and actuator to provide an actuator output position proportional to input current.

Increase in Load or Speed Setting

An increase in load, or speed setting, causes an increase in control current from the electronic control to the driver. This, in turn, causes an increase in control current to the torque motor and an increase in the torque-motor force, tending to lower the centering adjustment end of the torque motor beam. The flow of oil through the nozzle is decreased, which increases pressure on the top side of the differential power land. Pressure above the differential power land then moves the pilot-valve plunger down, or allows the plunger to follow the torque-motor beam as if they were one piece. Pressure oil is now directed to the underside of the power piston, causing it to move upward, which moves the output shaft in the increase-fuel direction.

The upward movement of the power piston rotates the position sensor, decreasing the feedback voltage, which reduces the control current to the torque motor, causing the torque-motor beam to move away from the nozzle. As flow through the nozzle is less restricted, pressure decreases on the top side of the differential power land to start moving the pilot-valve plunger up. The terminal shaft and pilot-valve plunger movement continues until the decrease in feedback voltage equals the control voltage being sent to the driver by the governor, returning the torque motor current to a null value. When the pilot-valve control land is centered, all movement stops at the new position required to run the prime mover at the increased load or speed setting.

Decrease in Load or Speed Setting

A decrease in load, or speed setting, causes a decrease in control current from the electronic control to the driver. This, in turn, causes a decrease in control current to the torque motor and a decrease in the torque-motor force, tending to raise the centering adjustment end of the torque motor beam. The pilot valve follows the beam and uncovers the control port. Oil trapped under the power piston escapes to drain, causing the power piston to move downward and the output shaft to move in the decrease-fuel direction.

The downward movement of the power piston rotates the position sensor, increasing the feedback voltage, which increases the control current to the torque motor. The terminal shaft rotates until the increase in feedback voltage equals the control voltage being sent to the driver by the governor, returning the torque motor current to a null value. This stops the power piston and the actuator shaft in the new position needed to run the prime mover at the decreased load or speed setting.

Loss of Control Voltage

Upon loss of control voltage to the governor or feedback sensor, the actuator output goes to minimum fuel, thus offering a safety feature.

With loss of control voltage, there is no current sent to the driver or torque motor and no magnetic force generated. The torque motor and attached beam and the force of the bias and loading spring causes the center adjustment to raise. The pilot valve follows, keeping the control port uncovered. Trapped oil escapes to drain, and the power piston moves down until it reaches minimum fuel position.

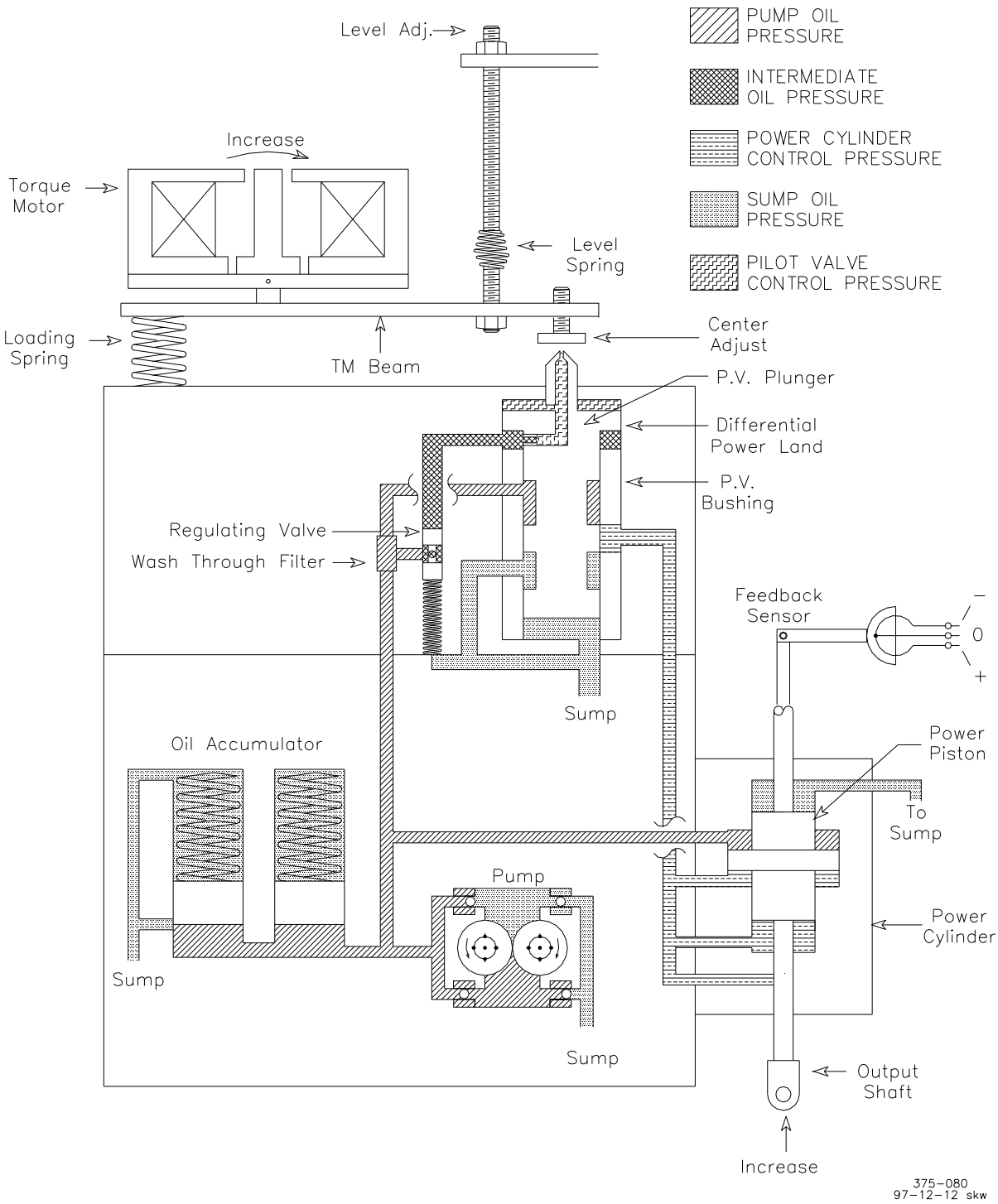


Figure 4-1. PGPL Actuator Schematic

Chapter 5. Troubleshooting

Introduction

This chapter gives instructions for checking the operation of the PGPL Actuator/ Driver.

Poor governing may be due to faulty actuator performance, or it may be due to the actuator attempting to correct for faulty operation of the prime mover or the equipment driven. When improper operation is evident, check all components, adjustment settings, and the prime mover for proper operation.

Actuator troubles also can be related to control-signal problems. Refer to the applicable Woodward manual for troubleshooting the Woodward electronic control used with the PGPL Actuator/Driver.

Use the troubleshooting table in this chapter to isolate and remedy suspected faults in the governed system.

Terms used in the chart are defined as follows:

HUNT
A rhythmic variation of speed which can originate in the actuator or in the prime mover. A hunt usually has a frequency of less than 50 cycles per minute.

SURGE
A sudden variation of speed occurring at periodic intervals which also can originate in the actuator or in the prime mover.

JIGGLE
A high frequency movement of the actuator terminal shaft and fuel linkage. Do not confuse this with normal controlling action of the actuator. A jiggle has a frequency of more than 50 cycles per minute.

⚠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.

Troubleshooting

The actuator and electronic control cannot control prime mover speed during this test procedure. If the prime mover is to be used to provide pump rotation of the actuator, other means must be provided to control prime mover speed. Other means to provide the needed rotation (a test stand) should be used if possible.

⚠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 applications.

⚠AVERTISSEMENT

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

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

1. Shut down the prime mover.
2. Disconnect the actuator from the electronic control. Disconnect the linkage from the actuator to the prime mover.
3. Verify that there is a 23 to 26 Ω resistance at 20 °C (68 °F) across the torque motor.

4. Remove the PGPL Actuator from the prime mover and set it on the test stand.
5. Make sure that the actuator is full of oil (see "Oil Supply" in Chapter 2).
6. Rotate the drive shaft in the proper direction at about 700 rpm.
7. Disconnect wires from TB7 and TB8 on the driver. Measure the resistance across TB7 and TB8. It should read 38 ± 2 Ω.
8. Connect the circuit in Figure 5-1 to the actuator (also see plant wiring, Figure 2-5).
9. Verify that the voltage from the power supply to the driver is 18–32 Vdc [from driver terminal TB1(+) to TB2(–)]. Also verify that the position feedback voltage from driver terminal J5(+) to J4(–) is 12 Vdc.
10. WITH DRIVER IN CIRCUIT, the actuator output should reach minimum position at 10 ±5 mA, and maximum position at 175 ±10 mA.
11. Verify that the position sensor signal voltage from terminal J2(+) to J4(–) varies from 3.58 Vdc at maximum fuel to 4.43 Vdc at minimum fuel as the actuator is stroked.
12. With the actuator controlling at approximately mid position, measure the voltage across J7(+) and J8(–). This voltage should read 2.6 ± 0.4 Vdc.
13. WITHOUT DRIVER IN CIRCUIT, the actuator should integrate from minimum to maximum at approximately 100 ±5 mA.
14. The movement of the terminal shaft from minimum to maximum should be linear, and the actuator should return to the same location at the same current setting when changed from the increase or decrease position.
15. Rotate the potentiometer and watch the output as it moves through the range of travel.
16. If the terminal shaft does not move, or if the actuator movement is erratic, or the actuator is not in calibration, return the unit to the factory for repair.
17. Verify the proper current output from the electronic control. Refer to the applicable Woodward manual for troubleshooting the electronic control used with the PGPL Actuator/Driver.

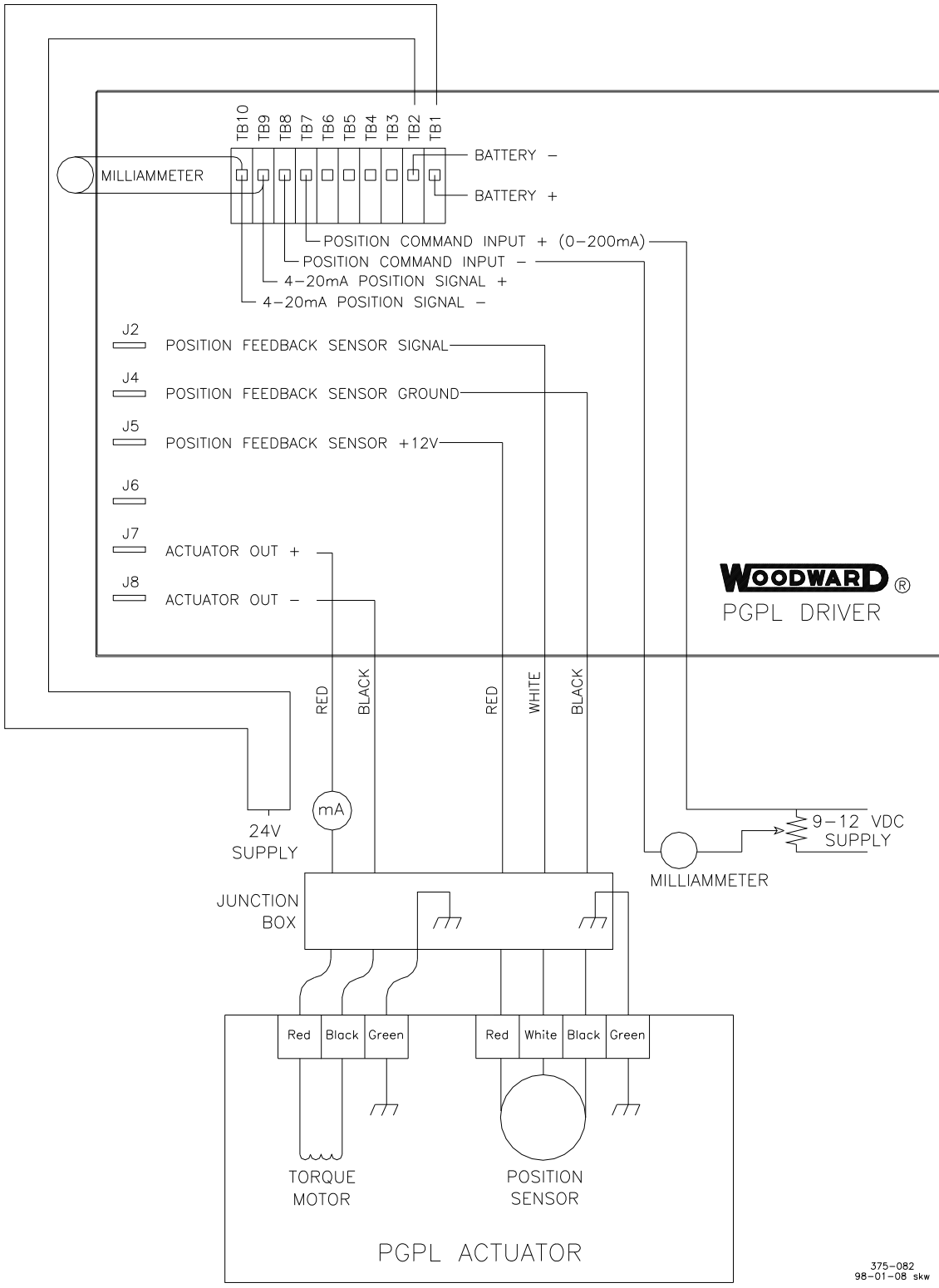


Figure 5-1. Test Wiring Schematic

Troubleshooting Table

Symptom	Cause	Correction
Failure to open racks. Failure to start.	Actuator is not receiving an electrical signal.	Verify there is power from the battery to the control. Make sure the electronic control is sending a signal.
	No oil pressure generated by the actuator oil pump.	Oil pump is rotated in the wrong direction. No oil in actuator.
	Actuator leads shorted or open.	See wiring diagram in Chapter 2.
	Linkage is binding.	Check and repair linkage.
Fuel racks do not open quickly.	Cranking speed too low.	Pump rotation must be adequate to provide internal pressure required to move rack or fuel valve. Use booster servo if necessary.
	Oil viscosity too low.	Use higher viscosity oil.
	Yield link too weak.	Install heavier springs.
	Actuator pump worn.	Return actuator to a repair facility.
	Linkage is binding.	Check and repair linkage.
Actuator leaks.	Actuator worn or gaskets failed.	Return actuator to a repair facility.
	Oil reservoir over-filled.	Reduce oil to correct level.
Excessive heat buildup.	Drive speed too fast for the ambient temperatures.	Investigate way to lower ambient temperature or attach an oil cooler to the actuator.
	Improper oil (viscosity, contaminated).	Replace with proper oil.
Instability. Prime mover hunts or surges.	Linkage between actuator and prime mover.	Repair or reset linkage as required. Check strength of yield springs in linkage. Check for binding in linkage or in fuel racks or valves. Linkage must be nearly linear in respect to power output of prime mover. Correct linkage for recommended actuator output between minimum and maximum fuel.
	Engine misfiring.	Check pyrometer readings of each cylinder and make necessary repairs to injectors, valves, pilot fuels, or other engine problems.
	Dirty or foaming oil.	Oil should be changed. Check that the oil used is properly matched to the operating conditions.
	Electronic speed control out of adjustment.	Make sure electronic control is properly adjusted.
Does not maintain rated speed.	Improper linkage arrangement. Actuator stops before achieving full fuel.	Rework or reset the linkage.
	Speed changes may be the result of load changes beyond the capacity of the prime mover.	Reduce load on the prime mover.
	Low steam pressure; low gas pressure.	Check prime mover pressure; increase pressure.
Drive shaft seizure.	Misalignment, binding, or excessive backlash of the actuator-driving gears.	Correct alignment, binding, or backlash.
	Improper lubrication of actuator. Actuator is too hot.	Check oil level and oil condition in actuator. Consider an oil cooler. Consider changing grade or weight of oil used in the actuator.
	Incorrect drive rotation.	Replace actuator, and verify direction of rotation is correct.

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.

A current list of Woodward Business Partners is available at **www.woodward.com/support**.

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 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 and reference **www.woodward.com/support**, and then ***Customer Support***.

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
Australia	+61 (2) 9758 2322
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany:	
Kempen	+49 (0) 21 52 14 51
Stuttgart	+49 (711) 78954-0
India	+91 (129) 4097100
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
Poland	+48 12 618 92 00
United States	+1 (970) 482-5811

Engine Systems

Facility	Phone Number
Australia	+61 (2) 9758 2322
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany:	
Stuttgart	+49 (711) 78954-0
India	+91 (129) 4097100
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
The Netherlands	+31 (23) 5661111
United States	+1 (970) 482-5811

Turbine Systems

Facility	Phone Number
Australia	+61 (2) 9758 2322
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
United States	+1 (970) 482-5811

You can also contact the Woodward Customer Service Department or consult our worldwide directory on Woodward's website (**www.woodward.com/support**) for the name of your nearest Woodward distributor or service facility.

For the most current product support and contact information, please refer to the latest version of publication **51337** at **www.woodward.com/publications**.

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:

General

Your Name _____
Site Location _____
Phone Number _____
Fax Number _____

Prime Mover Information

Engine/Turbine Model Number _____
Manufacturer _____
Number of Cylinders (if applicable) _____
Type of Fuel (gas, gaseous, steam, etc) _____
Rating _____
Application _____

Control/Governor Information

Please list all Woodward governors, actuators, and electronic controls in your system:

Woodward Part Number and Revision Letter _____
Control Description or Governor Type _____
Serial Number _____

Woodward Part Number and Revision Letter _____
Control Description or Governor Type _____
Serial Number _____

Woodward Part Number and Revision 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.

PGPL Actuator/Driver Specifications

Hysteresis	Within 3% of maximum stroke when measured over full stroke Within 0.5% of maximum stroke when measured over 4% of full travel at 0.1 Hz
Temperature Drift	Nominally ±4% of full stroke at 38 °C (100 °F)
Linearity	Within 2.5% of full stroke

Dynamic Performance

Frequency Response (phase shift 45 degree lag)

	39 J/29 ft-lb	23 J/17 ft-lb	16 J/12 ft-lb
±1% actuator travel	2.5 Hz	3.3 Hz	4.0 Hz
±5% actuator travel	2.7 Hz	4.0 Hz	4.6Hz
10 to 90% slew rate	670 ms	420 ms	330 ms
90 to 10% slew rate	630 ms	430 ms	330 ms

with 896 kPa/130 psi, 0.812 inch pump, 400 rpm, and with 125 SUS viscosity oil at 66 °C/150 °F

Output

The actuator can be fitted with different servo options. Contact Woodward for a full list. Some common options are:

- 16 J (12 ft-lb) spring return pull to increase fuel. 25 mm (1 inch) linear stroke.
  Max work over full stroke:
  17.6 J (13.0 ft-lb) in decrease direction
  23.6 J (17.4 ft-lb) in increase direction
- 23 J (17 ft-lb) differential pull or push to increase fuel. 25 to 51 mm (1 to 2 inch) linear stroke.
  Max work over 25 mm (1 in) stroke:
  14.5 J (10.7 ft-lb) in both directions
- 39 and 79 J (29 and 58 ft-lb) differential pull to increase fuel. 25 mm (1 inch) linear stroke.
  Max work over full stroke:
  47 or 73 J (35 or 54 ft-lb) depending on pump pressure
- 39 and 79 N·m (29 and 58 lb-ft) rotary output; 30° output shaft stroke with 1.00-48 serration standard.
  Max work over full stroke:
  47 N·m (35 lb-ft) depending on pump pressure
  16 N·m (12 lb-ft) is .750 to 48

The linear output servos can be mounted with the output shaft in various quadrants, and can be remotely mounted.

Usable stroke and work is 2/3 of the maximum values.

Actuator Construction

Base, column, and power block are cast iron. Feedback housing is aluminum. Internal parts are case-hardened steel.

Pump	PG spur gear. Drive speeds below 1000 rpm = 20.62 m (0.812 inch) thick. Speeds above 1000 rpm = 14.27 m (0.562 inch) thick. Relief valve set at 896 kPa (130 psi) standard [1655 kPa (240 psi) is also available].
Drive/Base	1.125-48 serration. 0.625-36 serration, or keyed drive shafts. PG round, UG8, UG8-90 degree, or Alco base available.
Weight	40 kg (89 lbs) dry weight [UG-90 degree base, 39 J servo]
Vibration Resistance:	
Actuator	Vibration tested to WGC RV2 test procedure with an overall 7.648 GRMS (in the axis parallel to the drive shaft, 7 G maximum).
Driver	Vibration tested to WGC RV5 test procedure with an overall 1.04 GRMS.

Drive/Hydraulic Specifications

Drive Speed and Rotation	Drive speeds from 200 to 1000 rpm available with check valves for either clockwise or counterclockwise rotation. Speeds up to 1500 rpm maximum available with plugs for single direction only. Oil cooler may be required.
Drive Power Requirement	Drive will use 375 W (0.5 hp) typical maximum.
Hydraulic Supply	Self contained sump, 2.5 liter (2.6 quart) capacity. See Woodward manual 25071, Oils for Hydraulic Controls, for specific recommendations. In most cases, the same type and weight of oils used in the engine can be used in the governor.
Operating Temperature:	
Actuator	–29 to +104 °C (–20 to +220 °F), within the limits of the oil being used in the governor
Driver	–40 to +70 °C (–40 to +158 °F)

Electrical Specifications

Electrical Connector	0.500–14 NPTF conduit with 1.2 m (48 inch) lead wire. One on cover for torque motor and one on servo for feedback to the driver.
Coil Resistance	23–26 Ω at 20 °C

Optional Features

Heat Exchanger	A heat exchanger helps maintain governor temperature below 93 °C (200 °F). Governor temperature depends on ambient temperature, governor drive speed, operating internal pressure, etc. Remote heat exchangers are available upon request.
Booster Servomotor	A booster servomotor, mounted externally, uses start air to supply immediate oil pressure to the governor as an aid for quick starts.
MPU	Actuator can be fitted with one or two MPUs (magnetic pickups). NOTE that the MPU option is NOT UL approved.

Driver Enclosure

Cast aluminum box, NOT intended for engine mounting.

Power Required	18–32 Vdc
Input to Driver	Will accept inputs (0–200 mA) from Woodward controls such as standard 2301A, 701, 505, Peak 150, etc. 3.6–4.4 Vdc from position sensor on actuator.
Output from Driver to Actuator	0–200 mAdc to the torque motor coil. 12 Vdc excitation to the position sensor.
Position Sensor	Contactless Hall Effect sensor
Calibration	The PGPL Driver/Actuator is fully calibrated when shipped.
Position Output	4–20 mA position output proportional to actuator position.
Wire Lengths:	
1.5 mm² (16 AWG) wire—	
Battery to driver	457 m (1500 ft)
Driver to actuator	457 m (1500 ft)
2.5 mm² (14 AWG) wire—	
Battery to driver	610 m (2000 ft)
Driver to actuator	610 m (2000 ft)

Regulatory Compliance

European Compliance: Compliance with the following European directive does not qualify this product for application of the CE Marking.

Machinery Directive:	Compliance as a component with 98/37/EC COUNCIL DIRECTIVE of 23 July 1998 on the approximation of the laws of the Member States relating to machinery.

North American Compliance

UL:	UL Listed for Class I, Division 2, Groups A, B, C, & D, T3 for use in United States and Canada. E49265 (actuator) E175243 (driver)

We appreciate your comments about the content of our publications.

Send comments to: icinfo@woodward.com

Please reference publication 37519G.

B37519:G

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Email and Website—www.woodward.com

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

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

2009/9/Fort Collins