WOODWARD

Product Manual 36646
(Revision NEW)
Original Instructions

PG Torque Limiter
Auxiliary Compatible

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 Out-of-date translations are marked with ⚠.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.

Contents

Illustrations and Tables

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.

Chapter 1.
General Information

Introduction

The Woodward Auxiliary Compatible PGA Governor with Torque Limiter is pressure compensated with pneumatic, lever, and manual speed setting and fuel limiting on a schedule determined by the combination of engine speed and fuel setting.

Torque Limitation

The governor will limit torque in the governed engine on a preset schedule. This limitation of torque is scheduled according to the actual speed of the controlled engine in relationship to load. Torque Limiting is provided to prevent engine overloading, to reduce smoke, improve fuel economy and prevent cavitation in a driven pump or from a propeller.

Droop

The governor includes provisions for droop speed setting (decreasing speed setting with increasing load) and will run when connected with other engines. The amount of droop is adjustable but should not need adjustment during operation.

Speed Setting Features

Speed of the governor is determined by any of three speed-setting devices:

Pneumatic speed setting is the normal method used to set the speed of the governor. This system accepts a 10 to 80 psi (69 to 552 kPa) air signal and sets the speed of the engine proportionately: 10 psi (69 kPa) will provide a low speed and 60 psi (414 kPa) will provide the high speed. Pneumatic speed setting permits the setting of two or more governors with a single air signal.

Lever speed setting is provided from the front of the governor permitting the substitution of a cable should the control air pressure be lost. The lever setting will override the pneumatic setting.

A **Speed Setting Knob** is available for the operation of the governor. The knob speed setting is advanced by manually turning the knob clockwise. The knob should normally be set as far counterclockwise as possible.

IMPORTANT

The speed-setting knob provides a minimum speed setting. If the knob speed setting is changed it will change the reference point of both the pneumatic and lever speed setting.

Vibration Resistance

The PGA-TL governor has been designed to be resistant to damage from vibration associated with modern engines. Weight and mass of parts has been held to a minimum while wear and durability has been increased, partially through drip or pressure lubrication of critical parts.

Rotation

Check valves in the governor power case permit the governor drive to rotate either clockwise or counterclockwise. Reversible drive allows a reversing engine to be controlled with equal accuracy. (The torque limiter includes a single schedule of limitations and will function at the same points, regardless of engine rotation.)

Accessories

The Auxiliary Compatible Torque Limiter may be equipped with the Manifold Pressure Fuel Limiter, Lube Oil Shutdown Alarm, and other accessories often used with a PGA governing system. Rotary and linear PGA power cylinders, from 12 to 500 ft-lb (16 to 678 J) output, and most other PGA options, may be included with the torque limiter.

Indicators

A microswitch provides limit Identification. Two identical microswitches can be mounted directly to the spring guard to provide indication of fuel position.

Shutdown Solenoid

The PGA-TL may be equipped with a shutdown solenoid. The shutdown feature will cause the governor to go to minimum fuel immediately. The engine may then be restarted with an undisturbed speed setting.

References

Manual 36652, *PG Automatic Safety Shutdowns and Alarms*
Manual 25071, *Oils for Hydraulic Controls*
Manual 25075, *Commercial Preservation Packaging for Storage of Mechanical-Hydraulic Controls*

Chapter 2. Installation

Receiving

A new or rebuilt PGA-TL will arrive bolted to a wooden skid in a cardboard box. The governor has been thoroughly tested and calibrated at the factory and no adjustments should be necessary. It has been drained of oil and a film of oil remains which will protect the governor from rust for the period of time of shipping and storage before prompt installation. If longer storage is planned, the governor should be filled with oil and anti-rust precautions taken in the column and cover areas. For additional information see Woodward Manual 25075, *Commercial Preservation Packaging for Storage of Mechanical-Hydraulic Controls*.

Mounting

For installation dimensions, see the outline drawing (Figure 2-1). The governor must fit evenly on the mounting pad. Use a thin gasket between the mounting pad and the base of the governor, if desired. Take care that the mounting surface and the base are smooth before installation. The use of fluid-gasket materials or cements is not recommended. The gasket, if used, provides some thermal isolation for the governor and accommodates possible imperfections in the installation surfaces. It is not used to prevent the movement of oil. The four mounting bolts must be evenly torqued and there must be no movement or rocking of the actuator on its installation surface.

The drive shaft must fit into the drive coupling with a free slip fit. Do not apply external force. Be sure the drive does not bind or have too much side load or end play.

Control Linkage

The linkage design for each PGA-TL governor must be set by the manufacturer or builder who sets the limiting schedules included in the torque-limiter section of the governor. These schedules are all based on the assumption that the linkage is exactly linear (governor terminal shaft movement is proportional to changes in the power output of the engine).

Do not change the proportions and dimensions of the original linkage arrangements or the torque limiting features will be compromised.

The linkage must be free of binding, without backlash. If there is a collapsible member in the linkage, it must not yield when the actuator moves the linkage rapidly. The linkage may be spring loaded to remove looseness, but be sure the spring load is toward minimum fuel.

Most linkage is designed to use 2/3 of the total travel between no load and full load with the additional “overtravel” split and used at both ends to provide overfuel for transients and to assure shutdown at minimum fuel position. However, the torque limiting feature is individually tailored to meet specific engine or load conditions and this may determine that the linkage will not follow the “normal” condition. Linkage must follow the manufacturer’s or designer’s specifications it the torque limiter is to function correctly.

Filling the Governor

The PGA-TL governor will require about 1.5 quarts (1.4 L) of oil if it is totally empty. (200/300 and 500 ft-lb governors require about 6 quarts/5.7 L.) Fill with the selected weight and grade of oil to the proper level on the oil sight gauge. Do not overfill as this will cause the oil to aerate and the governor to lack stability.

The governor must run for several minutes after filling before all air is exhausted from the system. After the governor has been run for several minutes check the oil level to make sure it remains in the sight gauge. (Most governors will require additional oil.) Add oil as necessary. Check the oil level again when the governor is at operating temperature.

Selecting the Proper Oil

In general the oil used in the engine will be satisfactory for use in the governor.

Proper oil selection is necessary to realize best governor performance and maximum service life. The oil should have a minimum tendency to foam or retain air, form sludge, or deposit varnish. It should protect governor parts from corrosion and not be detrimental to oil seals or paint. Refer to Woodward manual 25071 for more information on selection of oils for use in hydraulic governors.

The oil selected should have a high-viscosity index, within the range of 100 to 300 SUS at normal operating temperatures. Only oils of the grade specified for a particular temperature range should be used (see Figure 2-1).

Many oil problems are caused by the use of the wrong oil for the temperatures being experienced within the governor. Careful selection of the oil is extremely important.

NOTICE

Oil contamination is the major cause of actuator troubles. Use only new oil or filtered oil. Containers used for filling the actuator must be clean and should be rinsed with a light grade of the same oil before using.

Speed Setting Devices

Normal speed-setting control of the PGA-TL governor is through the pneumatic control. The speed setting is proportional to an air signal. The speed-setting mechanism is a bellows type, permitting load division of paralleled units as well as a definite, accurate relationship between speed and speed signal.

The PGA-TL governor also offers lever-speed setting, allowing cable control of the speed setting should control air not be available. The lever speed setting will override the pneumatic speed setting.

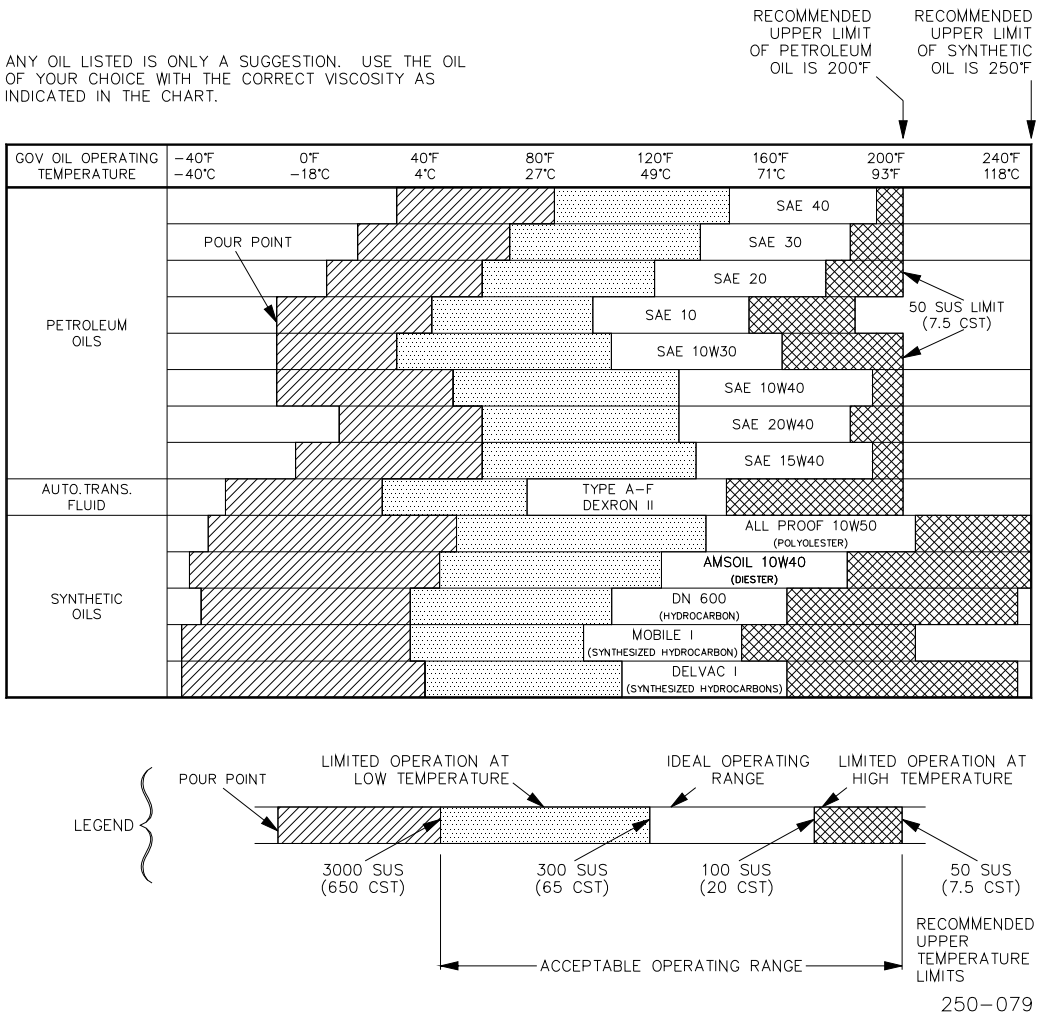

Figure 2-1. Oil Viscosity Chart

A speed-setting knob, which will firmly set the speed of the governor should both the lever- and pneumatic-speed-setting devices fail, is located on the front panel of the governor. The knob allows speed setting at the governor rather than from the remote locations used for the pneumatic- and lever-control systems.

IMPORTANT

Always turn the speed-setting knob to the counterclockwise stop when not in use. If the knob is left with any speed set this will be added to the speed setting of the pneumatic system.

Droop

The PGA-TL governor is normally set with about 5 percent droop. Droop allows the governed engine to assume a share of load with a parallel engine and adds stability to governors which are operating alone. PGA-TL droop is adjustable. (See Principles of Operation.)

In most cases droop is selected by the engine manufacturer and should not be changed. When droop is included in the governor the engine will operate at a slower speed at full load than it does at no load. (An engine set to operate at 1000 rpm at no load will be governed at 950 rpm at full load.)

Needle Valve

The PGA-TL governor is equipped with a needle valve which must be adjusted for the type of oil being used, the engine being controlled, and the normal heat at which the governor operates.

To Initially Adjust the Needle Valve:
With the engine running at idle, open the needle valve three turns to cause the engine to hunt. The droop in the governor may prevent hunting, even with the needle valve open several turns. If necessary manually disturb the output shaft to induce hunting. If the governor still does not hunt you should disturb the governor several times to assure that all of the trapped air in the governor is expel led.

IMPORTANT

It may be impossible to cause the governor to hunt as described above. In this case, set the needle valve at 2 turns open. Be prepared to reduce this setting if instability is discovered at full load. Do not fully close the needle valve.

When all of the air is expelled, close the needle valve gradually until hunting is just eliminated. Keep the needle valve open as far as possible to prevent sluggishness in governor response. The needle valve setting varies from 1/8 to 2 turns open. Never close it tight, the governor cannot operated satisfactorily when this condition exists.

Check governor stability by manually disturbing the governor speed setting. The compensation adjustment is satisfactory when the governor returns to speed with only a slight overshoot or undershoot. Once the needle-valve adjustment is correct it is not necessary to change the setting. except for large, permanent changes in temperature or other changes which affect governor oil viscosity.

⚠WARNING

Do not back out the needle valve too far. Beyond six full turns there is danger that the needle valve will be disengaged from the threads and 100 psi (690 kPa) oil will be expelled from the running governor.

Prior to Operation of the Engine

After any installation of a new or repaired governor make a final check of the following items before leaving the job:

1. Inspect the four bolts which fasten the governor to the pad. They must be evenly torqued, and the governor must not rock or move.

2. Inspect the linkage attachment between the governor and the engine. It must not come free during operation and it must not bind. The torque limit feature is proportional to the position of the linkage. The linkage must be in compliance with that specified by the engine manufacturer or the system designer.

3. Check the speed-setting attachments to be sure they are secure and dependable. Be sure the manual speed-setting knob is at the maximum counterclockwise setting.

4. Affirm that the overspeed protection is in place and is operative. Check the operation of the overspeed-protection device, if possible.

5. Be sure the oil level is correct and the oil is in good condition. Do not leave the governor with oil that indicates it has air in it or is otherwise in less that perfect condition.

⚠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.

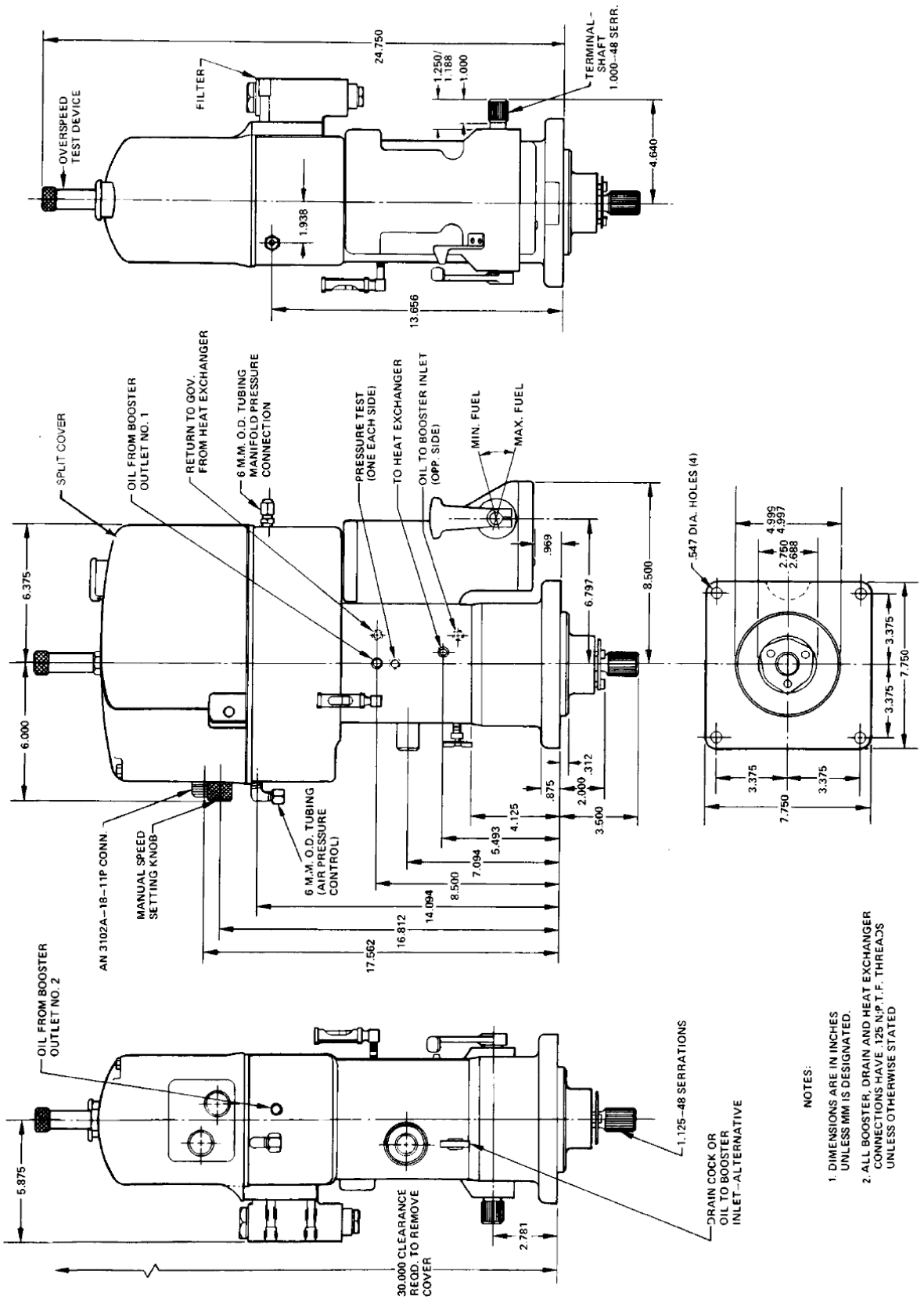

Figure 2-2. PGA-TL Governor Outline Drawing
(Do not use for construction.)

Chapter 3. Adjustments

Introduction

These adjustments may be made on the engine for optimum performance or after repairs. Always note the starting point before making any adjustment.

Normally, the only requirements for putting a new or overhauled governor into service are filling the governor with oil and adjusting the compensation needle valve to obtain maximum stability. All other operating adjustments are made during factory testing according to the engine manufacturer's specifications and should not require further adjustment. Do not attempt internal adjustment of the governor unless thoroughly familiar with the proper procedures.

Compensation Needle Valve

The compensation needle valve is an adjustable part of the compensation system. Its setting, which directly affects governor stability, depends upon the individual characteristics of the engine and of the oil used in the governor.

See Figure 2-2 for location of the needle valve.

To Adjust the Needle Valve:

1. With the engine operating at IDLE, open the needle valve several turns to cause the engine to hunt. In some cases opening of the needle valve may not cause the engine to hunt but manually disturbing the governor speed setting or the output-shaft position will induce the governor to move through its full output stroke. If the governor has just been filled with oil allow several minutes of hunting to remove trapped air in the hydraulic circuits. If it was necessary to force the governor to move through its output stroke this should be done several times to be sure the hydraulic circuits are clear of air.

2. Close the needle valve gradually until hunting is just eliminated. Keep the needle valve open as far as possible to prevent sluggishness in governor response. Needle valve settings will vary from 1/8 to 2 turns open. Never close the valve tight. The governor cannot operate satisfactorily with this condition. In the case of governors which will not hunt as described above set the needle valve 2 turns open and be prepared to close the needle valve should instability be observed when load is applied.

3. Check governor stability by manually disturbing the speed setting. The compensation adjustment is satisfactory when the governor returns to speed with only a slight overshoot or undershoot. Ideally, the response to a load change (speed change) should include an over-response followed by a lesser deviation from set speed in the opposite direction before the exact fuel setting is found. If the needle valve is open too far it may cause numerous deviations before the new fuel setting is found. If the needle valve is closed too far it may provide the new fuel setting with almost no deviations from set speed, but it may take too long to reach the new fuel setting, causing an unacceptable lag in response to load change.

IMPORTANT

If the engine does not return to stable condition after a disturbance and the needle valve is almost closed, it may be necessary to change the scale of the buffer springs. This solution to control problems should be used only after all other possibilities have been exhausted.

Speed Setting Adjustments

Pneumatic

The pneumatic speed-setting mechanism is a direct type which increases the governor speed setting as the control air-pressure signal increases. The speed settings are set at the factory and must not be changed, except by a qualified repairman with adequate test stand facilities. All speed settings are interrelated between the manual, pneumatic, and torque limiting features of the governor.

Details on position of the governor output shaft in relation to control air pressure should be provided by the engine manufacturer or the system designer. Woodward will provide details for a particular governor on request. Be sure to include the governor number and the serial number with the request for setup information.

IMPORTANT

When attempting to set up the speed setting range on a PGA-TL governor make sure that the limiter is not keeping the governor from reaching the needed high speed. Limiting scales are such that it should be possible to reach the high recommended speed without interference from the limiter.

Cable Speed Setting

The minimum and maximum stops on the lever speed setting may be changed, should it be necessary. The lower screw should provide a minimum low-specified-speed setting. To check the location remove all control air pressure from the governor. The upper screw should provide a maximum-speed location. Again, before making any adjustment be sure the limiter is not keeping the governor from reaching the needed high speed.

The lever speed setting minimum-speed location must be lower than the 10 psi (69 kPa) position under pneumatic control, or it will provide the minimum-speed stop for the governor at all times. The maximum-speed setting will not effect pneumatic control, but should be set low enough to prevent overspeed should the lever speed-setting mechanism be used. The lever speed-setting mechanism will only set speeds in excess of the pneumatic control.

Speed Setting Knob

Speeds set by the speed-setting knob will be added to those called for by the pneumatic control. The speed-setting knob must be set at the maximum counterclockwise position anytime pneumatic control is being used. In the absence of a pneumatic signal the speed-setting knob may be used to set the governor speed. The cable-speed-setting (lever) device will provide speed control from the speed set by the knob to the maximum speed setting of the cable device.

NOTICE

Do not attempt to adjust the pneumatic or knob speed setting devices as they are related to the torque-limiting speed settings. These adjustments should only be attempted by qualified repair persons with repair or test stand facilities.

Shutdown Solenoid

Normal shut down of the engine is accomplished by energizing the shutdown solenoid. When energized the solenoid bleeds oil pressure from the speed-setting servo, lowering the speed setting below that of the minimum knob-speed setting, and causing the servo to move the output to a shutdown position.

WARNING

Do not use the solenoid shutdown for a safety device. All safety shutdown devices must be totally independent of the governor to provide protection against governor failure.

To Adjust the Shutdown Solenoid

IMPORTANT

This adjustment has been made when the governor was calibrated and should not be necessary under normal operating conditions.

Remove the locknut and the plunger stop plug, then energize the solenoid. Turn the adjusting screw down (clockwise) until oil starts to seep from the slot in the shutdown-valve body. Turn the adjusting screw down 1.250 turns farther. De-energize the solenoid and insert the plunger stop plug. Screw the plug down until it touches the solenoid plunger. Back off the plunger stop plug 2 turns, and lock it in place with the lock nut.

Torque Limit Adjustments

Feedback Adjustment
The feedback adjustment changes the relationship between speed and the position of the speed cam. This adjustment should only be changed when the governor is on a test stand. If the adjustment is moved it can be difficult to bring the limiting feature back into specifications. The correct Feedback adjustment will cause the speed cam to rise 0.00175 of an inch for every rpm increase in speed. The accuracy of this setting in five digits is necessary to maintain the correct slope.

Fuel Cam
The fuel cam is held on its shaft with two screws. The slope of the cam can be changed by loosening the upper screw and pivoting the cam on the lower screw. This adjustment should only be changed on a test stand. If the adjustment is moved it can be difficult to bring the limiting feature back into specifications. The slope of the fuel cam is such that the cam follower should move half of the distance that the fuel cam moves up or down. (If the fuel cam moves 0.250 inch [6.35 mm], the cam follower pin should move 0.125 inch [3.18 mm].)

Limit Level
This screw sets the limiting scale at the correct engine rpm. Moving this screw out a number of turns will completely disable the limiter allowing unlimited operation of the engine under governor control.

Speed Level
The adjustment of the screw on top of the speeder spring on the auxiliary ballhead determines the speed range of the limiting scale. The screw is adjusted to provide the limiting scale in the proper speed range.

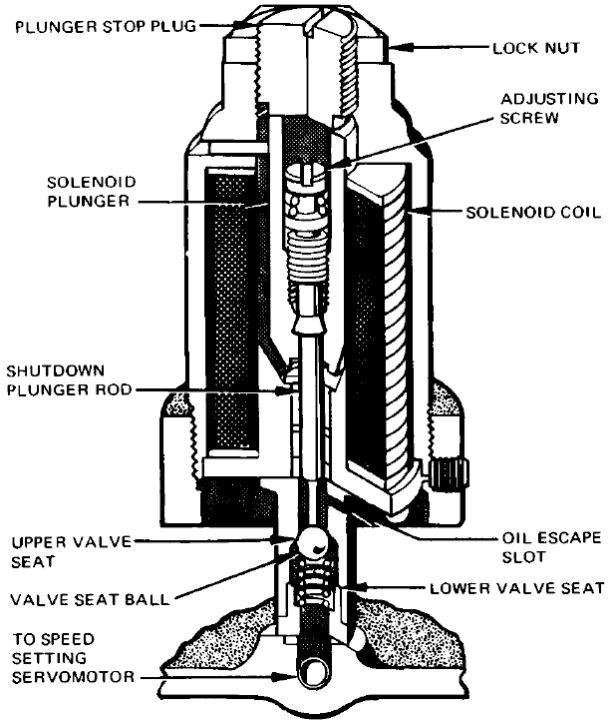

Figure 3-1. Shutdown Solenoid

Min Speed Cam Stops
This stop limits speed cam travel. Setting is determined by the manufacturer's specifications.

Shutdown Nuts
The shutdown nuts are adjusted so the lift lever will just touch when the lever is parallel to the column.

Limit Indication Switch
This optional switch should just activate (close the circuit) when the lift lever raises the shutdown rod to limit fuel, The switch is adjusted by moving it on the slotted mounting bracket.

Max Fuel Position Switch
This optional microswitch is mounted on the spring guard and should close the circuit when the power cylinder is at the maximum-fuel position. The switch is adjusted by turning the collapsible actuating screw.

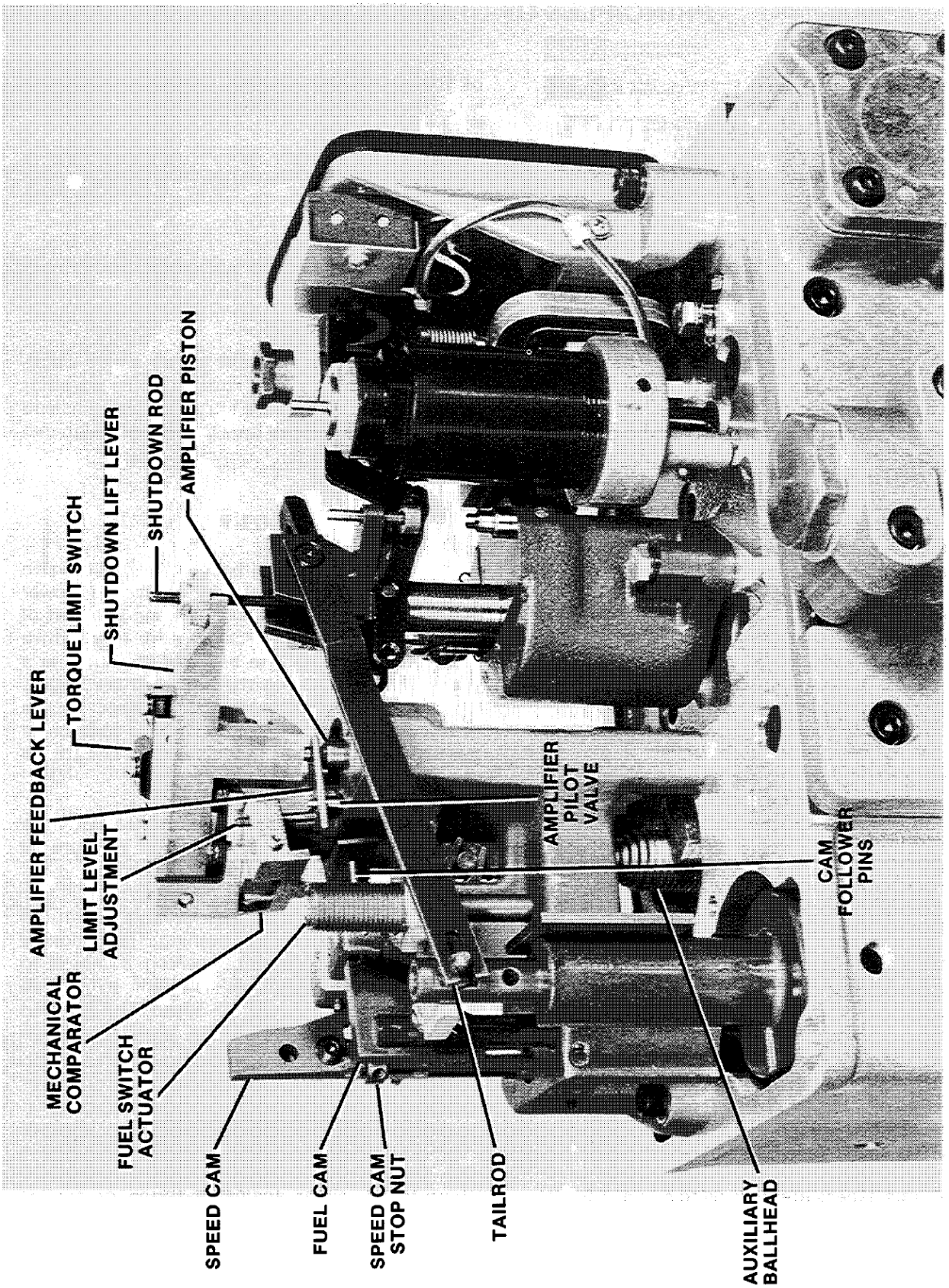

Figure 3-2. Torque Limiter Adjustments

Chapter 4.
Principles of Operation

Introduction

Governor response to either speed change or load change is almost instantaneous within the limitations imposed by the torque-limiting feature and by the capacity of the engine to respond to fuel setting changes.

Since load change is always seen as a speed change of the engine, there is no difference in governor response between a governor-speed change and an engine-load change. The terms “load change” and “speed change” are used interchangeably in the following description of how the governor operates.

Two Functions

For purposes of description the PGA-TL governor consists of the basic governor portion and the speed-setting portion.

The basic governor can be divided into three sections: the hydraulic-pressure section; the speed-sensing section, and the power-servo section. The speed-setting portion of the governor divides into the speed-setting section, the fuel-limiting section, and the droop section.

All of the sections operate dependently within the governor and are separated in this discussion only for the convenience of description.

Basic Governor

In the hydraulic-pressure section the governor drive shaft passes through the governor base and engages the oil-pump drive gear. The rotating bushing and ballhead come through the top of the power case and engage the oil-pump drive gear.

The pump supplies pressure oil for operation of the entire governor. The pressure oil from the two-gear pump is directed through check valves to two accumulator pistons. The pistons are pushed up against springs until they uncover a bypass valve which returns excess pressure oil to sump. The oil in the accumulator cylinders provides a reservoir of 100 psi (690 kPa) oil available to operate the governor servo and the speed-setting devices.

The PGA-TL 58 uses 200 psi (1379 kPa) pressure for the power cylinder. A pressure reducing valve provides 100 psi (690 kPa) oil pressure to the control portions of this governor.

PGA-TL 200/300 and 500 governors use different accumulators and servos but the theory of operation is the same as for the smaller governors.

A check valve arrangement allows either clockwise or counterclockwise rotation of the governor drive. Some governors are fitted with plugs instead of check valves and can only rotate in a designated direction.

Ballhead and Pilot Valve

The main speed-sensing ballhead and pilot valve control the flow of pressure oil to the power cylinder. The drive gear of the pump is a part of the rotating bushing which, in turn, is the drive link to the ballhead. The ballhead is rotated at a speed proportionate to the speed of the engine and the ballarms (flyweights) attached to the ballhead are tipped according to the balance of the force of the speeder spring and the centrifugal force created by the engine speed.

The toes of the ballarms position the pilot-valve plunger, which regulates the flow of pressure oil to and from the power cylinder in the servo.

The pilot-valve plunger does not rotate with the ballhead and the pilot-valve bushing. The stationary plunger and the rotating bushing combine to provide a reduced-friction condition to provide more exact control of engine speed. The ballhead also rotates the speed-setting bushing and the torque-limiting ballhead.

Governor Servo

The governor servo is positioned by governor pressure oil, either against a spring or against governor pressure oil. When the 100 psi (690 kPa) pressure oil is directed through the pilot valve to the bottom of the piston, the piston raises. When oil below the piston is held motionless by the pilot valve, the piston remains stable. When the pilot valve vents control oil from the bottom of the piston the return force causes the piston to move down, the control oil flows to sump, and the rod end moves toward reduced fuel.

Power Cylinders

12 Foot-Pound

All power cylinder assemblies operate under the same basic principle, with a reciprocating (push-pull) motion. Power cylinder assemblies with a rotary terminal shaft are available as an alternate, depending upon the installation requirements. In the arrangement shown in Figure 4-2, the oil needed to move the power piston in the increase-fuel direction is obtained when the governor pilot-valve plunger is lowered below its centered or balanced position. The open port admits pressure oil to the buffer piston area, moving the buffer piston, transferring an equal volume of oil to the power cylinder, and forcing the power piston to move in the direction to increase fuel to the prime mover.

To move the power piston in the decrease-fuel direction, the governor pilot-valve plunger is raised above its centered position. The trapped oil in the power cylinder is released to the sump and the power spring forces the power piston in the decrease-fuel direction.

Rotary output governors work in the same manner as linear output, with the servo motion mechanically converted to a rotary output.

PGA-TL 200, 300, and 500 ft-lb governors amplify the output from the servo with an additional servo.

29 Foot-Pound (Rotary Output)

With rotary output power cylinders the linear motion is converted to a rotary motion. This power servo (Figure 5-3) pulls to increase fuel to the prime mover. The oil needed to move the power piston is obtained when the governor pilot-valve plunger is lowered below its centered or balanced position. The open port admits pressure oil to the buffer piston area, moving the buffer piston, transferring an equal volume of oil to the power cylinder and forcing the power piston to move in the direction to increase fuel to the prime mover.

To move the power piston in the decrease-fuel direction, the pilot-valve plunger is raised above its centered position. When the trapped oil below the power piston is released to the sump, the pump pressure above the piston forces the piston in the decrease direction

Compensation System

Governor control of the engine would be erratic if compensation were not present to prevent large overshoots and undershoots during load or speed changes. The compensation system provides temporary speed-setting changes within the governor while the engine moves to a new load or speed position. The compensation system must be adjusted to match the time lag between a change in fuel-rack position at the engine and the engine reaching the new speed or power setting caused by the change in fuel supply.

The compensation system is needed to match the extremely quick reaction of the governor to the slower reaction level of the engine. The compensation system does not slow the rate of movement of the governor output shaft, but rather limits this movement to the location needed for the completion of a specific load or speed change.

The flow of pressure oil to, or from, the power piston activates the compensation system in the PGA-TL governor. As the oil in the control circuit flows, it moves the compensation piston from its normal centered position, to a position off center. The position provides a spring-loaded pressure differential within the control circuit. The pressure differential is sensed by the compensation land of the pilot valve, causing the pilot valve to be influenced by a pressure urging it toward the null position.

The compensation pressure is always in the direction opposing the load or speed change, temporarily balancing out some of the speed change being ordered by the flyweights.

The pressure differential in the control circuit is allowed to dissipate at a controlled rate through the needle valve. If the needle valve is correctly set, the pressure differential will be equalized at the same moment that the engine is settled at the new speed or load position.

Compensation Cutoff

With a large decrease in speed setting, or large load decrease, the power piston moves to the “no fuel” position and blocks the compensation oil passage between the power cylinder and needle valve to prevent normal equalization of the compensation pressures. This holds the buffer piston off center and increases the level of the pressure transmitted to the upper side of the plunger compensation land. The increased pressure differential, added to the scale of the speeder spring, temporarily increases the governor speed setting. The governor begins corrective action as soon as engine speed drops below the temporary speed setting and starts the power piston upward to restore the fuel supply in sufficient time to prevent a large underspeed transient.

This action is called “compensation cutoff.” When the upward movement of the power piston again uncovers the compensation oil passage, normal compensating action is resumed and engine speed is stabilized at the actual speed setting of the governor.

IMPORTANT

Due to the location of the compensation cutoff port in the power cylinder wall, the governor-fuel rack linkage must be adjusted so the power piston “gap” does not exceed 0.032 inch (0.81 mm) at idle-speed, no-load, or less than 4 degrees from minimum fuel.

Speed-Setting Changes and Controls

Governor speed reference is determined by the compression of the speeder spring which rides on the toes of the flyweights. Greater compression of the spring will increase the governor control speed. Lessening the compression of the speeder spring will reduce the governor control speed.

Pneumatic Control

Speed reference in the PGA-TL is normally set by a change in the pneumatic signal to the governor. The pneumatic control will cause the governor to go from low speed to high speed as the pneumatic signal varies from minimum to maximum. (Note that all control features respond to a desired change in engine speed. Changes in load, which are referenced by the governor as changes in engine speed, are automatically corrected within the governor.)

A change in the pneumatic signal strength causes a change in the length of the bellows which move the link and the attached speed setting plunger. This plunger, located in a rotating, speed-setting bushing, directs oil to or from the speed-setting servo, which, in turn, changes the compression of the speeder spring. The link is balanced between the bellows pressure pushing it down toward increase fuel and the restoring spring which attempts to move it and the attached plunger toward minimum fuel.

A loss of air pressure causes the governor to go toward minimum fuel to an idle speed. The idle speed is set by the low-speed adjusting screw located on the link hitting a stop pin in the restoring lever. This speed-setting location is the lowest that can be achieved by any of the three methods of changing the speed setting.

The absolute maximum-speed-setting position for the pneumatic control is controlled by the maximum-speed limiting valve located in the top of the speed-setting servo. As the servo piston moves down to increase the speed setting of the speeder spring, it also lowers the limiting-valve adjustment screw attached to the piston rod. When this screw dislodges the ball in the limiting valve it releases oil from on top of the speed-setting piston to sump in exact proportion to the oil being directed to the speed-setting servo from the speed-setting valve.

Speed Setting Lever

A speed-setting lever provides remote speed setting for the PGA-TL governor should the pneumatic speed-setting signal be interrupted or lost. The lever is attached, through a spring connection, to the link. It can provide a minimum-speed stop which is faster (more rpm) than the pneumatic-speed stop, should the limit screws located on the front of the governor be incorrectly set. The maximum stop on the front of the governor will not effect the other speed-setting devices, but can limit the lever speed setting to a speed which is lower than that set by the limiting-valve adjustment on the speed-setting servo. The maximum setting will not provide a speed setting in excess of that of the limiting valve.

Manual Speed Setting Knob

The manual speed-setting knob permits adjustment of the governor speed setting at the governor by turning the knob clockwise. The knob setting will override either the pneumatic- or the lever-speed setting in the maximum-fuel direction. The knob will not override the maximum-speed limiting valve. Any of the three speed-setting mechanisms will provide the minimum setting with the highest speed setting of the three controlling the governor speed. The knob setting will provide a minimum reading which will be added to the pneumatic setting if the knob is not at its minimum location (fully counterclockwise).

When the knob is turned, it raises or lowers the pivot bracket located on the speed-setting assembly, raising or lowering the restoring lever and the attached “C” link. The “C” link then repositions the speed-setting plunger with governor oil pressure moving the speed-setting piston and changing the tension of the speeder spring. The piston also moves one end of the restoring lever, causing the speed-setting plunger to be re-centered and to stop the movement of the speed-setting cylinder.

The pivot bracket location on the speed-setting assembly is adjustable, but should never need to be moved. The adjustment is set by the manufacturer to match the governor to the specified pneumatic speed-setting range.

Shutdown Rod

A rod is attached directly to the top of the speed setting pilot-valve plunger. The rod extends through the speeder spring and through the power-piston rod inside the speed-setting piston. The rod then extends above the speed-setting servo. This rod allows for the mechanical drain of pressure oil from the governor servo anytime the rod is lifted. The governor shutdown solenoid drains oil from the speed-setting servo to the extent the speed-setting piston rod lifts the shutdown rod, shutting down the engine. The rod is also used to prevent increased fuel setting when it is held by the torque-limit linkage.

Droop

The PGA-TL is provided with the standard PGA droop which is adjustable from isochronous (no droop) to 10 percent droop. When droop is set in the governor it provides a constant rpm drop proportional to the fuel position. The use of droop allows the engine to work in tandem with another engine without trading loads and becoming unstable.

The droop mechanism consists of a fulcrum block attached to the upper end of the speed-setting piston rod, a lever and fulcrum pin assembly connected between the fulcrum block and the power-piston tailrod, an adjustable cam attached to the fulcrum pin, and a moveable plunger housed within the speed-setting piston rod. The movement of the power piston, transmitted through the lever assembly, causes a rotational movement of the cam which contacts the top of the plunger. This, in turn, causes an upward or downward movement of the plunger which rests on top of the speeder spring.

The position of the cam lobe with respect to the centerline of the fulcrum pin determines the proportion of lever movement transmitted to the plunger. When the centerline is common to both pin and cam lobe, no movement is transmitted to the plunger. With this setting the governor maintains the set speed regardless of load (isochronous operation). If the lobe of the cam is positioned at increasing distances from the centerline of the fulcrum pin, an increasing proportion of lever movement is transmitted to the plunger (droop operation). The cam must never be positioned on the opposite side of the fulcrum pin centerline (toward the pneumatic receiver) as negative droop (speed increases with movement of the power piston in the increase direction) occurs and results in unstable operation.

Torque Limit

Torque limiting (see Figure 4-2, Torque Limiting Schematic) is a function of engine speed and fuel position in comparison to a predetermined schedule provided by the slope on the speed cam.

An auxiliary ballhead provides the speed reference used in the torque limit schedule. The auxiliary ballhead’s pilot valve controls the flow of pressure oil that positions the cam. Feedback from the speed-servo piston to the auxiliary ballhead allows a constant position of the speed cam at any given speed. The feedback lever has slots at both ends. The slots linearize the input/output relationship of the lever throughout the operating range because the effective lever lengths change the same amounts as the lever swings through an arc.

The fuel position reference is provided by a fuel cam which presents a constant 2:1 slope in proportion to the servo position. The relative slopes of the fuel cam and the speed cam are opposite.

Followers on the two cams position the comparator lever. A rocker on the comparator lever averages the two cam positions and transmits the result through the amplifier-feedback lever to a pilot valve. Oil from the pilot valve positions the amplifier piston which positions the other end of the amplifier feedback lever and the lift lever. The lift lever can cause limitation of additional fuel by lifting the shutdown rod as necessary to maintain the fuel limiting schedule.

Up to 20 pounds of force (89 N) may be required to lift the shutdown rod during limiting operations. Using a hydraulic amplifier to transmit the limiter position to the shutdown rod allows the use of vibration resistant parts throughout the torque limiting areas.

Fuel limiting is available only between the positive high- and low-limit stops on the speed cam. These stops allow start-up (minimum stop) and maximum fuel beyond the fuel limit schedule.

Schematic 4-2 shows that the torque limiting speed cam takes a position in direct proportion to the speed read by the auxiliary ballhead. The limiting function of this position, after comparison with the position of the tailrod and the fuel cam, is determined by the slopes incorporated in the speed cam by the engine manufacturer. The fuel cam slope is used in the calculations to design the speed cam. Since the comparator assembly provides an average of the two positions, the speed cam provides an exact fuel position for any specific governor speed.

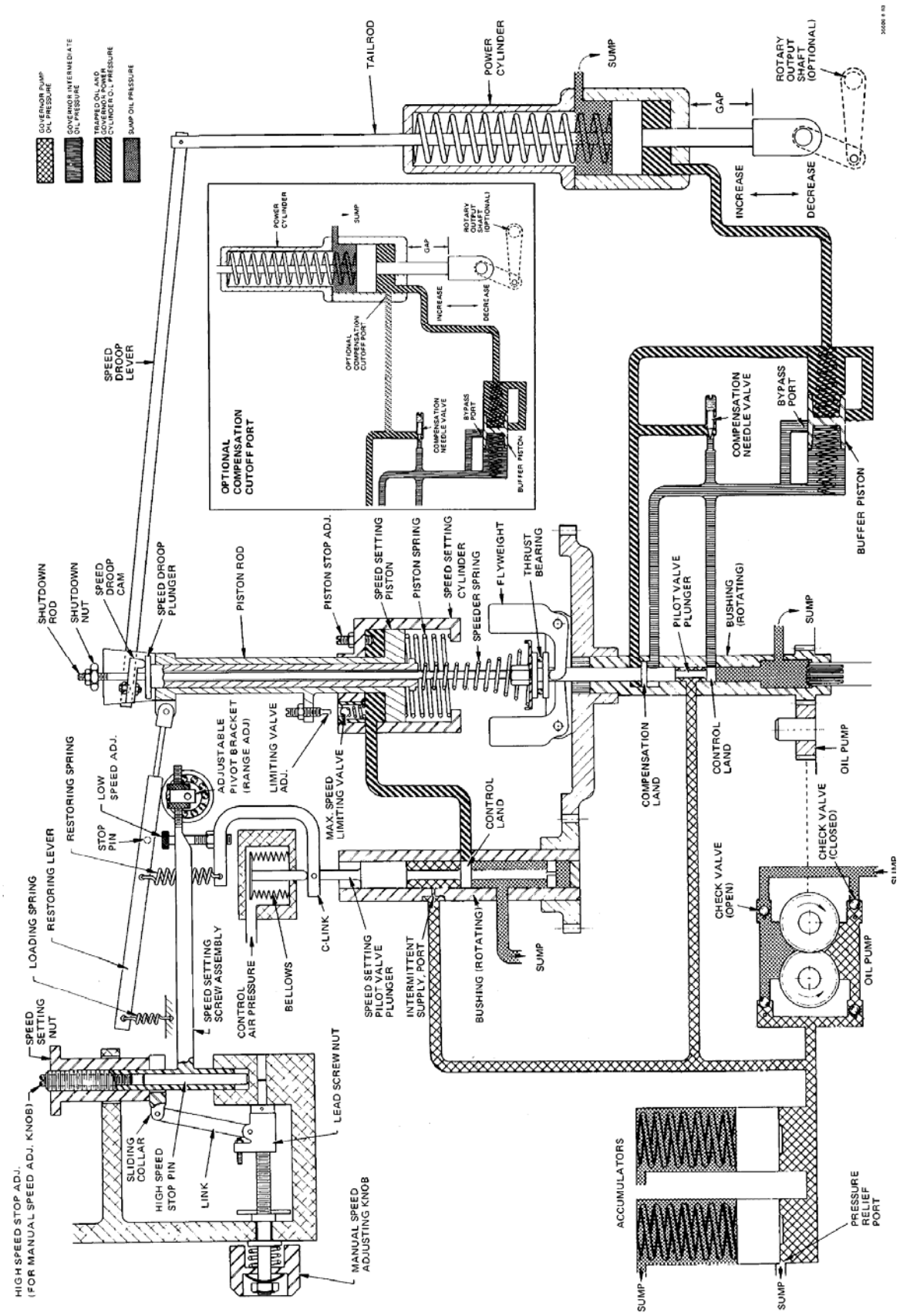

Figure 4-1. Schematic Diagram of PGA Governor

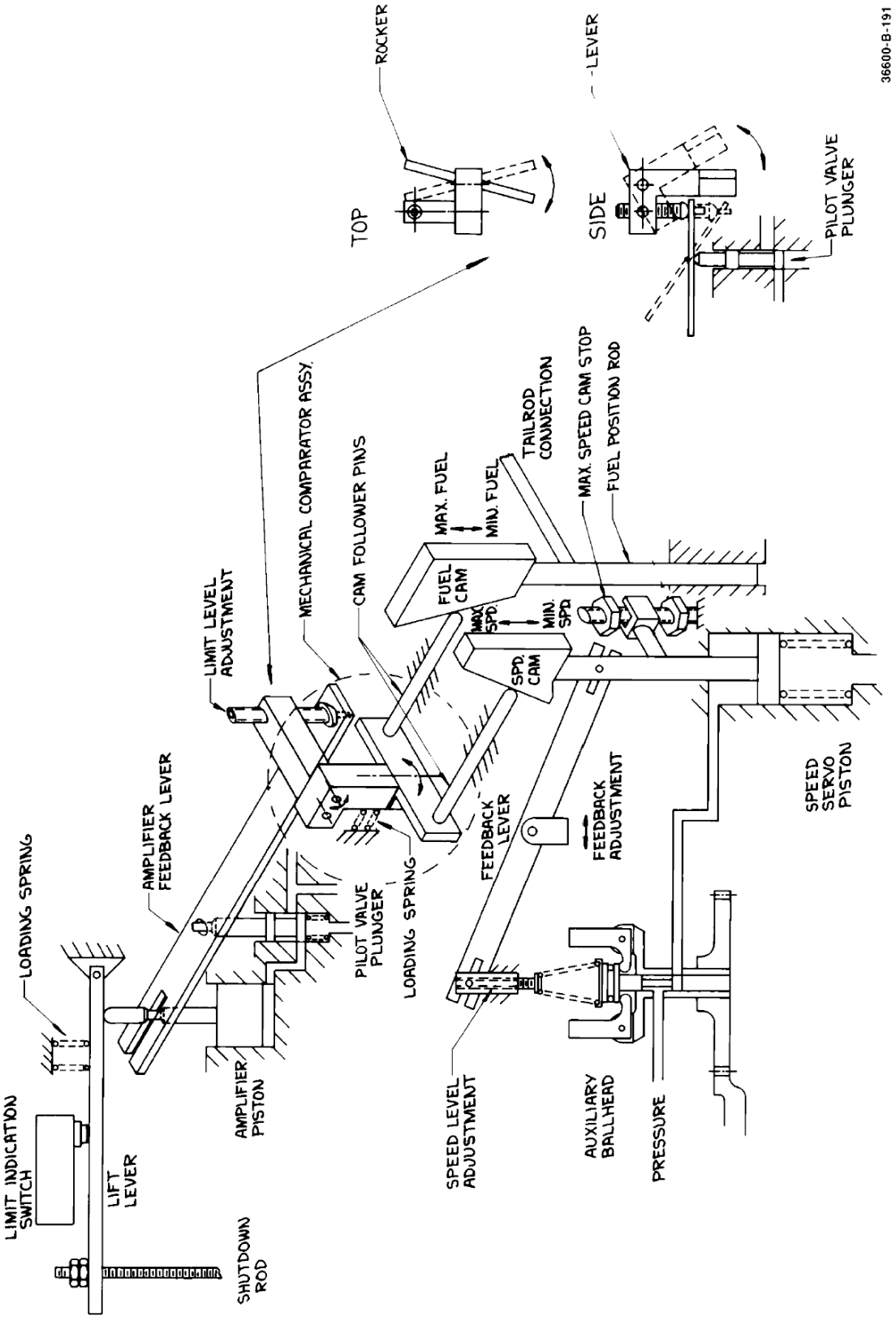

Figure 4-2. Schematic of Torque Limit Operation

Chapter 5.
Product Support and Service Options

Product Support Options

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

1. Consult the troubleshooting guide in the manual.
2. Contact the **OE Manufacturer or Packager** of your system.
3. Contact the **Woodward Business Partner** serving your area.
4. Contact Woodward technical assistance via email (**EngineHelpDesk@Woodward.com**) with detailed information on the product, application, and symptoms. Your email will be forwarded to an appropriate expert on the product and application to respond by telephone or return email.
5. If the issue cannot be resolved, you can select a further course of action to pursue based on the available services listed in this chapter.

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

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

- A **Full-Service Distributor** has the primary responsibility for sales, service, system integration solutions, technical desk support, and aftermarket marketing of standard Woodward products within a specific geographic area and market segment.
- An **Authorized Independent Service Facility (AISF)** provides authorized service that includes repairs, repair parts, and warranty service on Woodward's behalf. Service (not new unit sales) is an AISF's primary mission.
- A **Recognized 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 current list of Woodward Business Partners is available at **www.woodward.com/directory**.

Product Service Options

Depending on the type of product, the following options for servicing Woodward products may be available through your local Full-Service Distributor or the OEM or Packager of the equipment system.

- 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 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.

Flat Rate Repair: Flat Rate Repair is available for many of the standard mechanical products and some of the electronic 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.

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. 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's Full-Service Distributors offer various Engineering Services for our products. For these services, you can contact the Distributor by telephone or by email.

- 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.

Product Training is available as standard classes at many Distributor locations. Customized classes are also available, which can be tailored to your needs and held at one of our Distributor 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 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 one of the Full-Service Distributors listed at **www.woodward.com/directory**.

Contacting Woodward's Support Organization

For the name of your nearest Woodward Full-Service Distributor or service facility, please consult our worldwide directory published at **www.woodward.com/directory**.

You can also contact the Woodward Customer Service Department at one of the following Woodward facilities to obtain the address and phone number of the nearest facility at which you can obtain information and service.

Products Used In Electrical Power Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany:	
Kempen	+49 (0) 21 52 14 51
Stuttgart	+49 (711) 78954-510
India	+91 (129) 4097100
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
Poland	+48 12 295 13 00
United States	+1 (970) 482-5811

Products Used In Engine Systems

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

Products Used In Industrial Turbomachinery 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

For the most current product support and contact information, please visit our website directory at **www.woodward.com/directory**.

Technical Assistance

If you need to contact technical assistance, you will need to provide the following information. Please write it down here before contacting the Engine OEM, the Packager, a Woodward Business Partner, or the Woodward factory:

General

Your Name _____

Site Location _____

Phone Number _____

Fax Number

Prime Mover Information

Manufacturer _____

Engine Model Number _____

Number of Cylinders _____

Type of Fuel (gas, gaseous, diesel, dual-fuel, etc.) _____

Power Output Rating _____

Application (power generation, marine, etc.)

Control/Governor Information

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

Symptoms

Description _____

_____

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

We appreciate your comments about the content of our publications.

Send comments to: icinfo@woodward.com

Please reference publication 36646.

PO Box 1519, Fort Collins CO 80522-1519, USA
1000 East Drake Road, Fort Collins CO 80525, USA
Phone +1 (970) 482-5811 • Fax +1 (970) 498-3058

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.

2012/11/Colorado