WOODWARD

UG-25+ Governor (P3 version)

Installation and Operation Manual

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

⚠️ **Revisions**	**This publication may have been revised or updated since this copy was produced. To verify that you have the latest revision, check manual *26311* , *Revision Status & Distribution Restrictions of Woodward Technical Publications*, on the *publications page* of the Woodward website:** **www.woodward.com/publications** **The latest version of most publications is available on the *publications page*. If your publication is not there, please contact your customer service representative to get the latest copy.**

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

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 Out-of-date translations are marked with ⚠.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

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

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Important Definitions

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

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

⚠ **WARNING** Overspeed / Overtemperature / Overpressure	The engine, turbine, or other type of prime mover should be equipped with an overspeed shutdown device to protect against runaway or damage to the prime mover with possible personal injury, loss of life, or property damage. The overspeed shutdown device must be totally independent of the prime mover control system. An overtemperature or overpressure shutdown device may also be needed for safety, as appropriate.
⚠ **WARNING** Personal Protective Equipment	The products described in this publication may present risks that could lead to personal injury, loss of life, or property damage. Always wear the appropriate personal protective equipment (PPE) for the job at hand. Equipment that should be considered includes but is not limited to: • Eye Protection • Hearing Protection • Hard Hat • Gloves • Safety Boots • Respirator Always read the proper Material Safety Data Sheet (MSDS) for any working fluid(s) and comply with recommended safety equipment.
⚠ **WARNING** Start-up	Be prepared to make an emergency shutdown when starting the engine, turbine, or other type of prime mover, to protect against runaway or overspeed with possible personal injury, loss of life, or property damage.
⚠ **WARNING** Automotive Applications	On- and off-highway Mobile Applications: Unless Woodward's control functions as the supervisory control, customer should install a system totally independent of the prime mover control system that monitors for supervisory control of engine (and takes appropriate action if supervisory control is lost) to protect against loss of engine control with possible personal injury, loss of life, or property damage.

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

Electrostatic Discharge Awareness

NOTICE **Electrostatic Precautions**	Electronic controls contain static-sensitive parts. Observe the following precautions to prevent damage to these parts: • Discharge body static before handling the control (with power to the control turned off, contact a grounded surface and maintain contact while handling the control). • Avoid all plastic, vinyl, and Styrofoam (except antistatic versions) around printed circuit boards. • Do not touch the components or conductors on a printed circuit board with your hands or with conductive devices. To prevent damage to electronic components caused by improper handling, read and observe the precautions in Woodward manual *82715, Guide for Handling and Protection of Electronic Controls, Printed Circuit Boards, and Modules.*

Follow these precautions when working with or near the control.

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

Regulatory Compliance

European Compliance for CE Marking:
These listings are limited only to those units bearing the CE Marking.

EMC Directive:	Declared to 2004/108/EC COUNCIL DIRECTIVE of 15 Dec 2004 on the approximation of the laws of the Member States relating to electromagnetic compatibility and all applicable amendments.

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

Machinery Directive:	Compliant as partly completed machinery with Directive 2006/42/EC of the European Parliament and the Council of 17 May 2006 on machinery.
Pressure Equipment Directive:	Compliant as "SEP" per Article 3.3 to Pressure Equipment Directive 97/23/EC of 29 May 1997 on the approximation of the laws of the Member States concerning pressure equipment.

Marine Compliance:
Type Approval with the following Marine Classification Societies:

ABS:	2007 Steel Vessel Rules 1-1-4/7.7.4-9-7/13.1
BV:	BV Rules for the Classification of Steel Ships
CCS:	Part 3, Chapter 9; Part 7, Chapter 2 of CCS "Rules for Classification of Sea-going Steel Ships" (2009) and its 2010/2011 Amendments
DNV:	Det Norske Veritas Rules for Classification of Ships, High Speed & Light Craft and Det Norske Veritas Offshore Standards
G. Lloyd's:	Guidelines for the Performance of Type Approvals VJ 7 2 Edition 2003
KR:	Pt. 6 Ch. 2 Art. 301 of the Rules for Classification, Steel Ships
LRS:	For use in environmental categories ENV1, ENV2, ENV3, and ENV4 as defined in LR Test Specification No.1: 2002
NKK:	Chapter 1, Part 7 of Guidance for the approval and type approval of materials and equipment for marine use and relevant Society's Rules

Special Conditions for Safe Use:
Field wiring must be suitable for at least 55 °C.

Compliance with the Machinery Directive 2006/42/EC noise measurement and mitigation requirements is the responsibility of the manufacturer of the machinery into which this product is incorporated.

Chapter 1.
General Information

How to Use This Manual

The following summarizes how to install a UG-25+ governor into a new or existing system:
- Unpack and inspect the hardware.
- Mount and wire the hardware following the procedures and recommendations in Chapters 2–3.
- Configure application-specific settings (Chapter 6).
- Speed control tuning information is found in Chapter 7.
- Specifications and Troubleshooting information are provided in the Appendixes.

General Description

The Woodward UG-25+ governor is a microprocessor controlled mechanical hydraulic governor for controlling diesel, gas, or dual fuel engines, or steam turbines. The UG-25+ governor includes enhanced control capabilities, such as start fuel and boost limiting schemes. The additional transient fuel limiting (jump-rate) improves the engine load acceptance and reduces transient emissions significantly.

The UG-25+ governor provides a fast-acting and high-work-output governor, without the need for any auxiliary devices such as a start booster.

The UG-25+ governor offers speed control with software-selectable speed setpoints, dynamics, fuel limiting, and start behavior.

Front panel and external speed settings make synchronization easy for generator applications. A 4–20 mA speed setting is available for variable speed applications or for remote synchronization or remote setting of speed/load.

Adjustable droop permits load division and balancing among paralleled prime movers. Droop can be set with a knob on the front panel between 0–10%. The load limiter knob allows you to limit the governor output stroke manually.

The UG-25+ governor uses an internal, self-contained oil system operating at 1034 kPa (150 psi) internal pressure with an internal oil pump driven from the governor's drive shaft. Oil pressure is maintained by a relief valve system with a drain to an internal oil sump.

The UG-25+ governor combines all the advantages of a traditional mechanical governor with the state-of-the-art control algorithms for optimal engine operation.

Controller Features

The governor features include:
- State-of-the-art speed sensing and control algorithms
- Built-in user interface which provides speed raise/lower and local shutdown functions
- Speed Control with Droop and Dynamics features
- Configurable speed settings and adjustment rates
- Multiple Fuel Limiting algorithms, such as jump-rate, boost pressure, and start fuel limiting
- Temperature monitoring
- Run / Stop
- Status discrete output
- Speed setpoint adjustments using a 4–20 mA analog input or raise/lower discrete inputs or front panel raise/lower commands
- Front panel Droop, Stability, and Load Limit adjustments are also available
- Comprehensive diagnostics for easy troubleshooting

Inputs / Outputs

The following optional inputs and outputs are available, only input power is required.
- Input Power (single or dual)
- Run/Stop discrete input
- Unit Healthy Status discrete output
- Speed Setpoint Raise discrete input
- Speed Setpoint Lower discrete input
- Analog Speed Setpoint 4–20 mA input
- Analog Speed Setpoint Enable discrete input
- Boost Pressure 4–20 mA input
- Boost Pressure Input Enable discrete input

Available Terminal Shafts and Drive Shafts

The following output terminal shafts and drive shafts are available:

Standard—
    0.625–36 serrated terminal shaft
    0.625–36 serrated drive shaft
    0.625 keyed drive shaft with 0.625-18 thread

Available (for special applications at additional cost)—
    0.562 / 0.625 D-shaped terminal shaft
    Extended 0.625 keyed drive shaft

UG Governor Similarities

The base is designed to fit any drive designed for a UG governor. The terminal shaft location relative to the mounting base is similar to a UG governor.

Hydraulic Pump

The UG-25$^+$ governor is equipped with a Gerotor fixed displacement pump (3161 governor type) with a relief valve. The pump/relief valve uses oil from its self-contained sump to provide 1035 kPa (150 psi) internal operating pressure.

Two displacements are offered to cover the speed range up to 1700 grpm. The large displacement pump (0.875 inch/22.22 mm thick) is intended to be used with governor drive speeds from 350 to 1200 rpm. Running the large displacement pump continuously above 1200 grpm could result in excessive oil temperatures. The small displacement pump (0.625 inch/15.88 mm thick) is designed to be used with governor drive speeds between 500 and 1700 rpm maximum continuous operation. The description of governors (naming in the extended description) refers to the thickness (equals flow) of the pump segment in inches.

The direction of rotation is selected by pump housing alignment. Once this selection is made, the pump operates in one direction only. The drive uses a maximum of 335 W (0.45 hp).

References

The following publications provide additional information about installation, operation, and storage of Woodward products. All are available on the Woodward website (**www.woodward.com**).

Publication
25071	Oils for Hydraulic Controls
25075	Commercial Preservation Packaging for Storage of Mechanical-Hydraulic Controls
50516	Governor Linkage for Butterfly Control Valve
03339	UG-25$^+$ Governor Product Specification
36684	Booster Servomotor

Contact your nearest Woodward Distributor or Authorized Independent Service Facility about repairs.

Serviceability

The UG-25$^+$ governor has no field-replaceable parts.

Recommended service interval is 20 000 hours of normal operation. Units may need to be re-manufactured/overhauled before that time if there is oil leakage, parts become loose, or if the unit experiences severe operating conditions of heat or vibration.

⚠ **WARNING** | **The UG-25$^+$ governor is not equipped with an overspeed trip function. 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.

Figure 1-1a. UG-25+ Governor Outline Drawing (31 lb-ft version shown)

(.907)

.510
.490

R.192
.162

.416
.396

.625-36 SERRATION PER
WOODWARD SS-154

25 LB-FT
(SCALE 0.750)
BOTH SIDES

(1.170)

.510
.490

R.1975
.1775

.510
.490

.750-48 SERRATION PER
WOODWARD SS-154

31 LB-FT
(SCALE .750)
BOTH SIDES

△2
DETAIL A

OIL LEVEL GAUGE
RIGHT SIDE SHOWN
(OPTION)

5.750 MAX
[146.05]

3.040 MAX
[77.22]

OIL SIGHT GLASS LOCATION
NOT USED, PLUG
RIGHT SIDE

TERMINAL SHAFT
POSITION INDICATOR
RIGHT SIDE

15.191 MAX
[385.85]

(14.389)
[365.48]

(11.811)
[299.99]

(8.935)
[226.95]

WARNING

CASE DRAIN, OIL TO BOOSTER INLET
.438-20 UNJF (INCH) STRAIGHT THREAD
PORT PER WOODWARD SS-145
(MS 16142 EXCEPT MODIFIED MINOR
DIAMETER TO ACCEPT "J" THREADS)

(.250)
[6.35]

(.750)
[19.05]

(1.937)
[49.2]

(3.875)
[98.43]

-B-

.302 -.322
[7.68 -8.17]

(1.606)
[40.8]

OIL FROM BOOSTER OUTLET #1, PUMP
PRESSURE TEST POINT
.438-20 UNJF (INCH) STRAIGHT THREAD
PORT PER WOODWARD SS-145
(MS 16142 EXCEPT MODIFIED MINOR
DIAMETER TO ACCEPT "J" THREADS)

2.135 MAX
[54.229]

Ø 3.246 -3.248
[82.45 -82.49]
-C-

SEE FIGURE 1-2

NOTES:

△1 2/3 STROKE RECOMMENDED FOR NO LOAD TO FULL LOAD, SEE MANUAL.

△2 TERMINAL SHAFT VARIATIONS.

TERMINAL SHAFT CONFIGURATION TABLE	
OUTPUT RATING	DIM. 'A'
25 LB-FT	3.972-4.222 [100.88-107.22]
31 LB-FT	4.235-4.485 [107.57-113.91]

265-049B
(9999-1401sh1)
2012-1-11

Figure 1-1b. UG-25$^+$ Governor Outline Drawing (31 lb-ft version shown)

DRIVE SHAFT O.D. = .6240-.6245
[15.85-15.86]
WITH .188 [4.78] SQUARE KEY
(1.062 [26.97] LONG)

-B-
BOTTOM OF PUMP BASE

1.983-2.083
[50.37-52.90]

3.973-4.153
[100.91-105.47]

(0.699)
[17.75]

(1.250)
[31.75]

AFTER DRIVE GEAR INSTALLATION,
TORQUE TO 34-41 Nm (25-30 LB-FT)

BOTTOM OF PUMP BASE
-B-

2.309-2.489
[58.65-63.22]

(0.668)
[16.97]

.625-36 SERRATION PER
WOODWARD 3-09-0278 OR 3-09-0298

263-076C
(9999-3115sh2)
2012-1-12
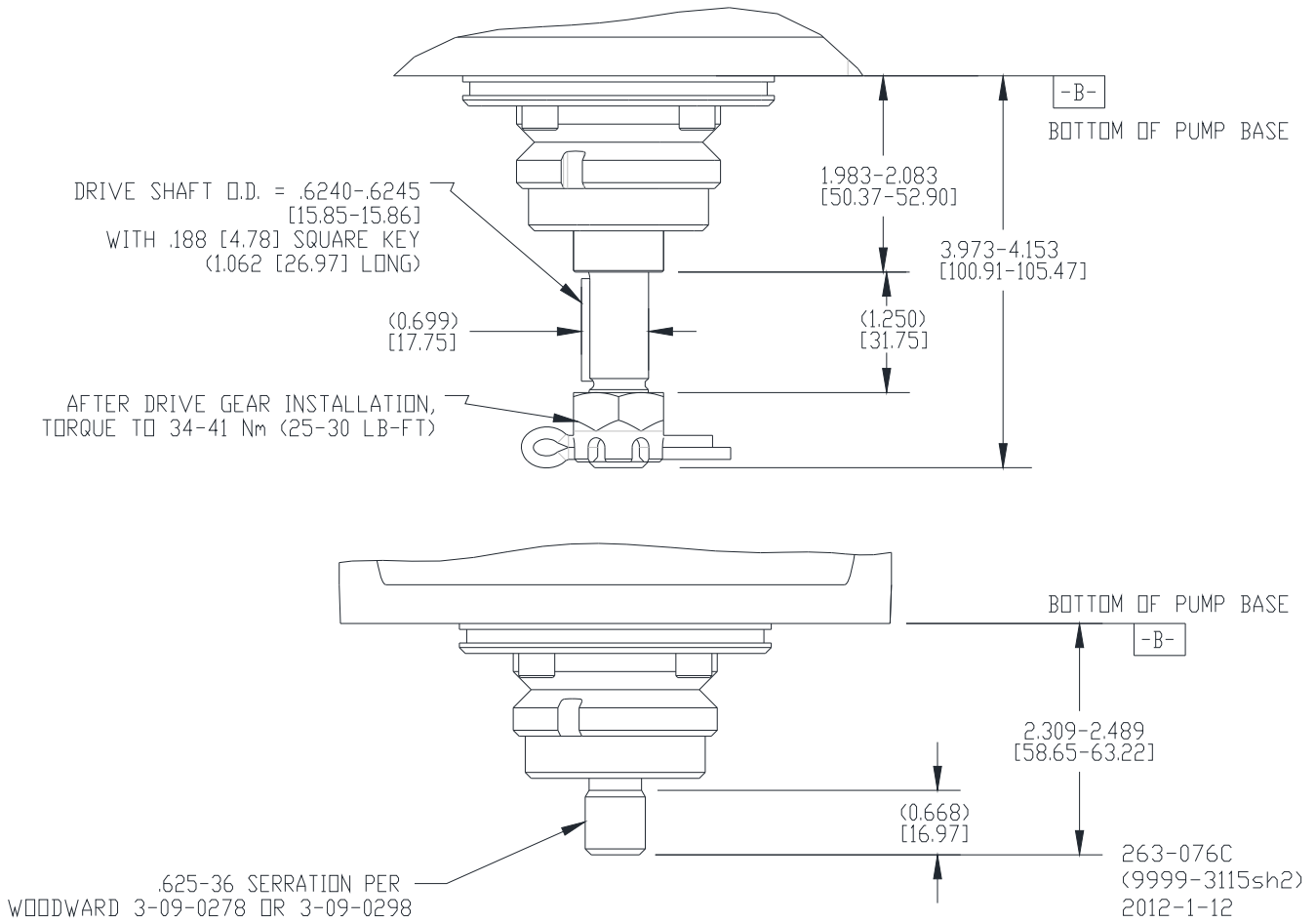
Figure 1-2. UG-25+ Governor Drive Shaft Configurations

Chapter 2.
Mechanical Installation

Introduction

This chapter describes receiving, storage, and installation requirements for the UG-25$^+$ governor.

⚠ WARNING	Due to typical noise levels in turbine or engine environments, hearing protection should be worn when working on or around the UG-25$^+$ governor.

⚠ WARNING	The surface of this product can become hot enough or cold enough to be a hazard. Use protective gear for product handling in these circumstances. Temperature ratings are included in the specification section of this manual.

⚠ WARNING	Use of an independent device for positive shutdown, such as a fuel shut-off valve, is highly recommended. Failure to comply with this recommendation can cause personal injury and/or property damage.

⚠ WARNING	Use of an external spring to return to minimum fuel is highly recommended. Failure to comply with this recommendation can cause personal injury and/or property damage.

⚠ WARNING	Use of a predicted minimum fuel shutdown procedure is highly recommended. Failure to comply with this recommendation can cause personal injury and/or property damage.

NOTICE	Use care while handling and installing the UG-25$^+$governor. Be particularly careful to avoid striking the drive shaft, terminal shaft, or the electrical connector. Abuse can damage seals, internal parts, and factory adjustments. Do not set the governor on its drive shaft.

⚠ WARNING	External fire protection is not provided in the scope of this product. It is the responsibility of the user to satisfy any applicable requirements for their system.

Initial Operation

⚠ WARNING	Before initial operation of the engine equipped with a UG-25$^+$governor, read all of Chapters 2 and 3, Installation Procedures and Electrical Installation. Make sure that all installation steps have been correctly accomplished and all linkages are secured and properly attached. Carefully review the direction of rotation for the actuator oil pump. Configure the software settings following the instructions in Chapter 6.

Follow this procedure when putting a new or repaired UG into service.

1. Check that the actuator is full of the proper type and grade of clean oil.

2. Properly adjust the linkage.

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

3. Select a low speed setting to give low engine 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.**

4. Follow the engine manufacturer's instructions, and start the engine.

5. Adjust the selected speed setting to bring the engine to rated speed.

6. Obtain system stability as outlined in Chapter 7 (Speed PID Tuning). (If less than the recommended actuator output stroke is used, it may cause for less than optimum engine stability or response.)

All operating adjustments of the UG-25⁺ governor are made during factory calibration. Additional adjustment should not be needed.

Unpacking

Be careful when unpacking the unit. Check the unit for signs of damage, such as bent or dented panels, scratches, and loose or broken parts. Notify the shipper and Woodward if damage is found.

Receiving

After factory testing and calibration, the UG-25⁺ governor 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 governor is clean, multi-viscosity engine oil, which will not contaminate the oil selected to operate the governor.

Fill the governor with 2.1 liters (2.2 quarts) of oil selected to match the expected operating conditions. (If the governor is a direct replacement for a UG 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 governor. Do not allow dirt or contamination to enter the governor while filling with operating oil. Do not use oil drained from the UG governor.
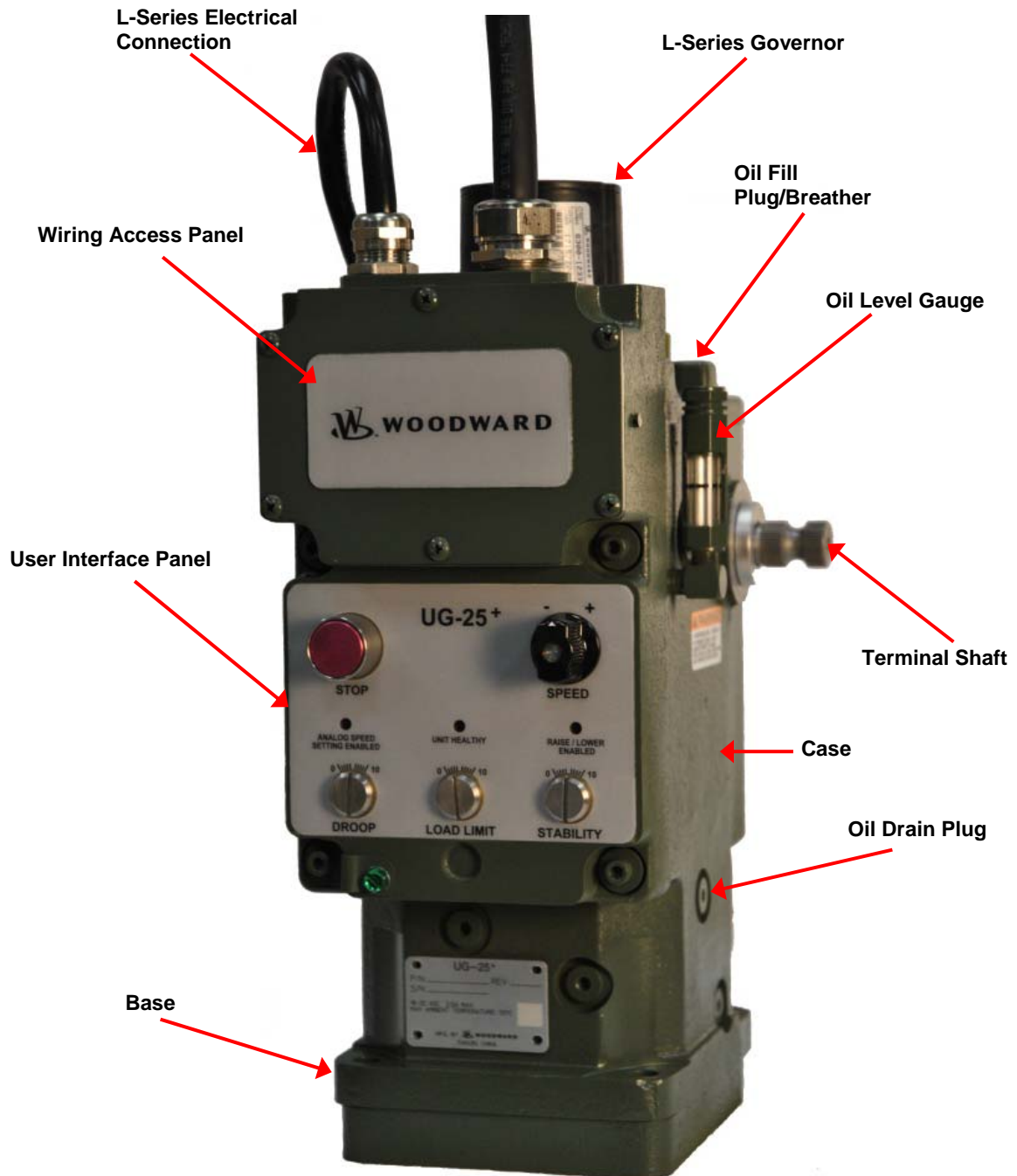
Figure 2-1. UG-25⁺ Governor Overview

Storage

The UG-25⁺ governor 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 governor is installed on the engine for storage, fill the governor with oil and follow preservation packaging instructions in Woodward manual 25075, *Commercial Preservation Packaging for Storage of Mechanical-Hydraulic Controls*.

Drive Shaft Rotation

The governor drive-shaft rotation is one direction only. Rotation, as viewed from the top of the governor, must be the same as that of the engine drive when looking down on the mounting pad.

If the governor oil pump is rotated in the wrong direction, oil pressure will not be generated in the governor.

NOTICE	Be sure engine mounting-pad drive and governor-drive rotation are the same. Incorrect drive rotation will cause the governor to become inoperative, and may cause governor damage.

THIS FIGURE SHOWS COUNTERCLOCKWISE
ROTATION WHEN VIEWED FROM TOP OF ACTUATOR.

ALIGN THE ROTATION ARROW
WITH NOTCH IN BASE.

PUMP
HOUSING
SCREWS

820-552A
09-7-6
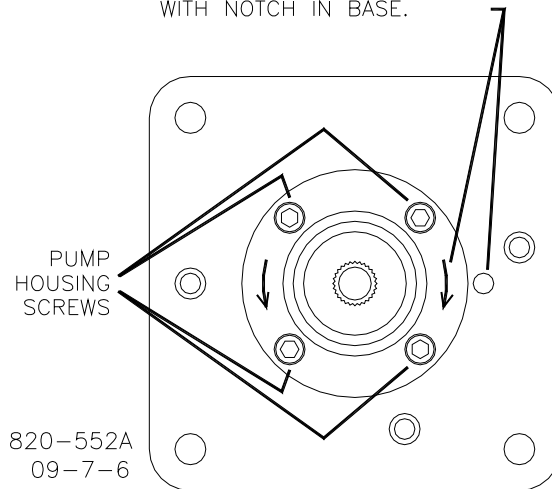
Use the following procedure to change the direction of rotation:
1. Remove the four pump-housing screws located on the bottom of the UG-25^{+} governor.
2. Index the pump plate 180 degrees to align the arrow corresponding to the direction of rotation selected with the reference notch in the base.
3. Replace the four screws, and torque the screws to 10.2 N·m (90 lb-in).
4. Make sure that the governor drive shaft rotates freely.

Mounting Location

Locate the UG-25^{+} governor a distance from sources of extreme radiant heat, such as exhaust manifolds, turbochargers, or live steam lines. The ambient operating temperature range of the control is 0 to 55 °C (32 to +131 °F) [maximum allowable governor case temperature is 100 °C (212 °F max)]. In spark-ignited applications, make sure the UG-25^{+} governor is located away from the ignition coil, and that harness wires are not routed next to the spark plug wires.

As shown in the specifications, the UG-25^{+} governor has been designed for and verified to a given accelerated life vibration test level at the mounting surface of the governor. The user should be aware that in any application, bracket design could significantly change the vibration levels at the module. Therefore, every effort should be made to make the bracket as stiff as possible so that engine vibrations are not amplified, creating an even more severe environment at the module.

Attitude

The UG-25⁺ governor can be installed in a vertical or near vertical position without affecting its calibration. Do not install more than 45 degrees from vertical. See the outline drawing for installation instructions and dimensions.

Mounting Dimension

When using the O-ring to seal between the governor and governor mounting pad on the engine, the mounting hole should have dimensions of 82.7–83.2 mm (3.255–3.275 inches) in order to provide the correct amount of squeeze on the o-ring. The mounting hole must be concentric with the drive in order to avoid side-loading the governor drive shaft. (This O-ring part number 1355-308 can be ordered separately from Woodward.)

Lifting Method

When mounting the UG-25⁺ on the engine, a lifting sling can be used as shown in the photo below.

NOTICE	**This lifting method should be used only for normal installation of the UG-25⁺. Do NOT use this method for removing the UG-25⁺ if the governor may be stuck in/on the engine drive. This could result in serious damage to the UG-25⁺.**

Drive Connection

Make sure the governor drive shaft turns freely before installing the governor. The drive gear or coupling must slip freely into the governor drive of the engine. Torque the nut that secures the drive gear to 34–41 N·m (25–30 lb-ft) maximum.

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 governor-drive seizure.

Mount the governor squarely on the mounting pad. Torque the mounting bolts evenly. There can be no movement or rocking of the governor on the engine-mounting pad.

Control Linkage

The terminal shaft rotates 42 degrees. Use 2/3 of the total rotation 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 governor position (see Figure 2-2).

Figure 2-2. Terminal Shaft Travel

Many control problems are related to the linkage between the governor and the engine. Use only high-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 engine-caused vibration. The linkage must be as light as possible and still maintain the attributes of stiffness. Linkage which is too heavy can damage the governor as well as make it difficult to achieve steady control.

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 governor moves the linkage rapidly.

Use a linear linkage for most diesel applications. Most gas-fueled engines will require a non-linear linkage. See Figures 2-3 and 2-4 for information on the arrangements of linear and nonlinear connections. Linear linkage moves the fuel setting shaft in direct proportion to the movement of the governor output.
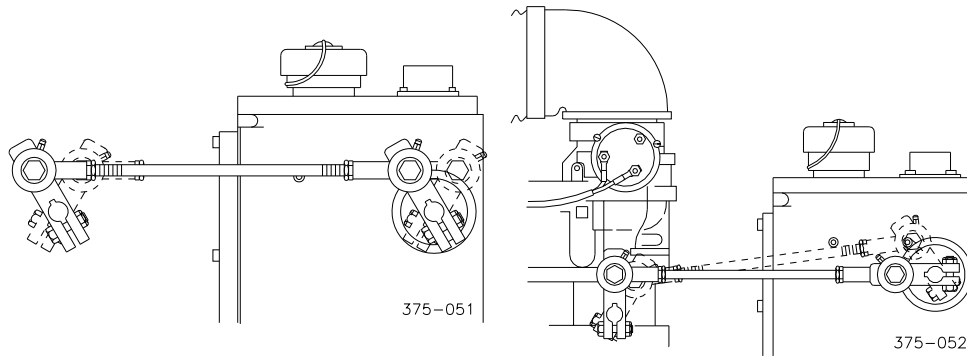
Figure 2-3. Linear Linkage   Figure 2-4. Non-linear Linkage

A non-linear fuel arrangement lets the governor move the fuel setting more at maximum settings than it does at minimum settings. Woodward application note 50516, *Governor Linkage for Butterfly Throttle Valves*, provides more information about non-linear linkage.

Design the linkage so the power output of the engine is proportional to the position of the governor output shaft.

Follow the engine manufacturer's instructions on linkage selection, installation, and adjustment. In almost all cases, the linkage designed for a UG-8 governor will work with the UG-25+ governor, with the exception that the standard terminal shaft size is 0.625-36 serrated versus the UG-8 standard size of 0.50-36 serrated. In the case of a direct exchange, make sure that the linkage is in good condition and the installation of the lever on the governor is in the same position as it was on the old governor.

Oil Supply

See Woodward manual 25071, *Oils for Hydraulic Controls*, for more details on oil supply.

Use the information given in Figures 2-5 and 2-6 as a guide in the selection of a suitable oil. Oil grade selection is based on the operating temperature range of the governor. Also use this information to aid in recognizing and correcting common problems associated with oil used in the governor. Many operation and maintenance problems associated with UG-25+ governors are directly related to the selection and condition of the oil in the governor. Use care in the selection and make sure that the oil in the governor is not contaminated.
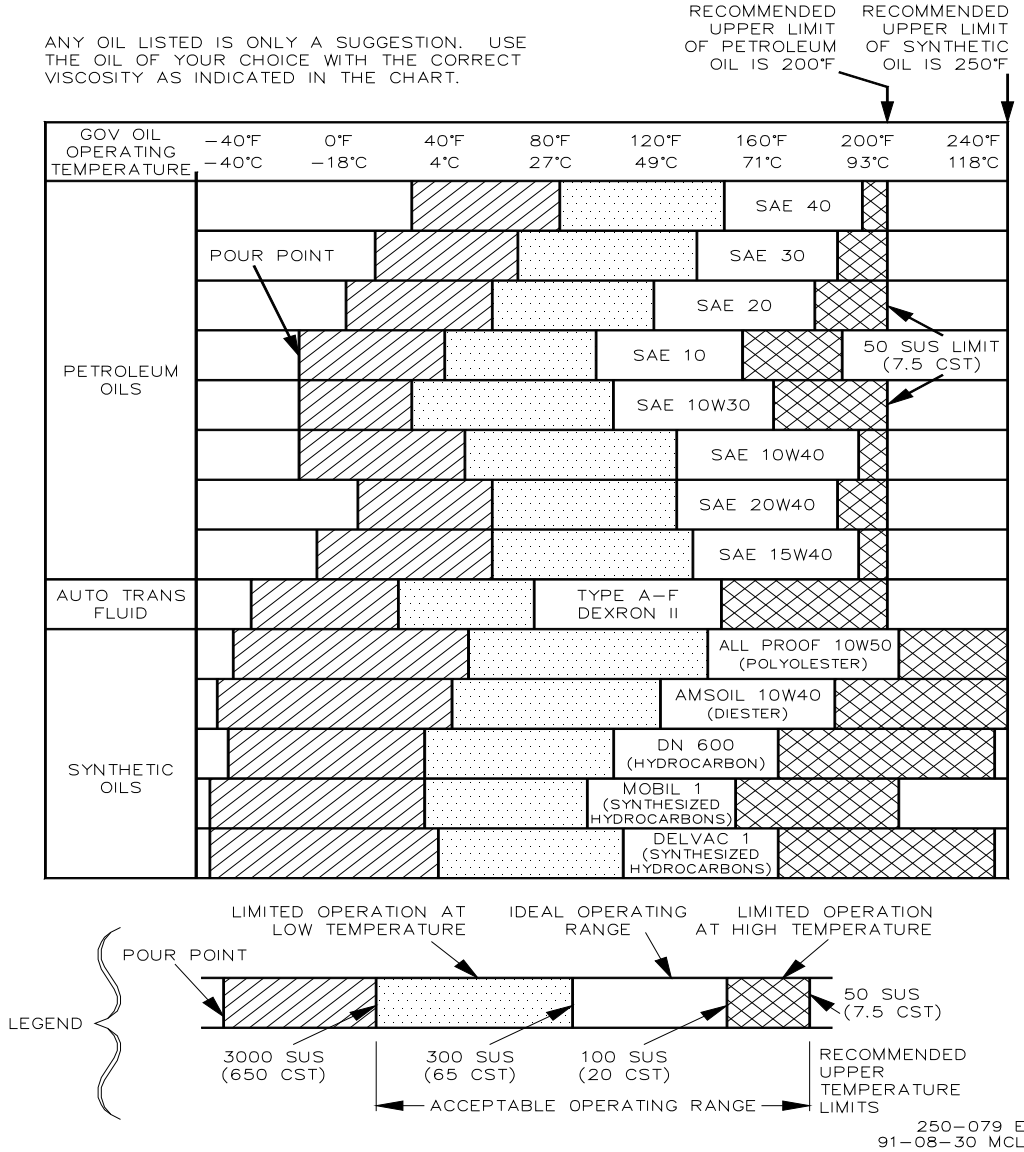
Figure 2-5. Oil Chart

The oil in the UG-25+ governor 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 UG-25+ governor is designed to give stable operation with most oils, if the fluid viscosity at the operating temperature is within a 50 to 3000 SUS (Saybolt Universal Seconds) range (see Figure 2-6). Poor governor response or instability is an indication that the oil is too thick or too thin.

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

Governor 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 governor with about 2.1 liters (2.2 quarts) of oil, to a level visible in the oil sight glass. After the engine is started and the governor is at operating temperature, add oil if necessary. Oil must be visible in the glass under all operating conditions.

Excessive component wear or seizure in the governor indicates the possibility of:

1. Insufficient lubrication caused by:
• an oil that flows slowly when it is cold, especially during start-up;
• no oil in the governor.

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

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

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

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

Oil Maintenance

Replace the governor 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 governor 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 governor 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 governor 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 governor and improve governor operation. Properly selected oil should permit annual oil changes, but more frequent changes are recommended. Too long an interval between oil changes can result in sticking of components and plugged oil passages.

Heat Exchanger

A heat exchanger for the UG-25+ governor is not available from Woodward.

Recommended Service Intervals

Change the oil and flush the governor twice a year if possible.

To change oil, remove the drain plug and drain out the old oil. Flush the governor by filling it with fuel oil, and with the prime mover running at low speed, cycle the governor by increasing the Stability knob setting on the user interface until the governor hunts. Let the governor hunt for a minute or two, then stop the engine and drain the governor. Flush the governor once again. Refill the governor with oil (see Chapter 2, Oil Supply).

Restart the engine and reset the Stability knob.

Woodward recommends the UG-25+ governor be overhauled after 20 000 hours of operation to inspect for wear and to replace seals, bearings, etc.

Chapter 3.
Electrical Installation

Introduction

This chapter provides instructions for making the proper electrical connections to the UG-25$^+$ governor. Detailed wiring diagrams and recommended wiring practices are given to make the electrical installation as straightforward as possible. There are several functional wiring options for UG-25$^+$ governor, and these are outlined in this chapter. The only input that is absolutely required is a power connection; all others are optional features. All wiring and accessories (connectors, pins, plugs, etc) are provided by the customer, but are shown in this chapter for ease of assembly.

The UG-25$^+$ governor has an operating voltage range of 18 to 32 Vdc. It is reverse input polarity protected, and consumes approximately 27 W maximum power at a peak current of 1.5 A (18 V) at 25 °C. Maximum power at the UG-25$^+$ governor is only realized if an internal fault occurs. Nominal operating current will be less than 500 mA at 24 V nominal.

The control system should be protected with a 6 A fuse in the voltage supply lines. The application should be configured to apply power to the UG-25$^+$ governor when the engine is first cranked, or slightly before.

Unit Grounding

The governor housing must be electrically bonded to earth ground through the mechanical mounting interface in order to ensure proper EMC and Safety compliance. Do this using a 1" wide braided grounding strap with as short a length as possible. The ground strap can be tied to the ground post on the front of the governor, directly below the user interface panel.

Tie Ground Strap Here

> **NOTICE**
>
> Do not connect any cable grounds to "instrument ground", "control ground", or any non-earth ground system. Make all required electrical connections based on the wiring diagrams (Figures 3-2 and 3-3).

Shielded Wiring

The use of cable with individually shielded-twisted pairs is required where indicated by the control-wiring diagram (Figure 3-2). Cable shields must be terminated as indicated in the control-wiring diagram using the installation notes described below. DO NOT attempt to directly ground the shield at both ends or an undesired ground loop condition may occur. It is best to terminate the shield at the UG-25+ governor, leaving the other end of the shield unterminated or electrically floating.

Installation Notes

- Wires exposed beyond the shield should be as short as possible, not exceeding 50 mm (2 inches).
- The shield termination wire (or drain wire) should be kept as short as possible, not exceeding 50 mm (2 inches), and where possible the diameter should be maximized.
- Installations with severe electromagnetic interference (EMI) may require additional shielding precautions. Contact Woodward for more information.

Failure to provide shielding can produce abnormal conditions which are difficult to diagnose. Proper shielding at the time of installation is required to assure satisfactory operation of the product.

⚠ WARNING	**External independent safety devices are always recommended by Woodward. Fuse the Power Input +(Terminal 19) with a 6 A fuse. Fuse Boost Pressure Sensor Power Output+ (Terminal 5) with a 500 mA fuse. See Figure 3-2.**

⚠ WARNING	**This UG-25+ governor does NOT provide for power-loss annunciation. Woodward recommends that the device that is powered by this UG-25+ governor have an independent power-loss annunciation.**

Electrical Connections

Prior to installation, refer to the wiring diagrams and the representative I/O interfaces schematic in this chapter. Also, review the hardware I/O specifications in Appendix B.

Use 1.3 mm² (16 AWG) stranded copper wire with insulation that meets temperature requirements in the harness design. A wiring harness stress relief within 400 mm (16") of the UG-25+ governor is recommended.

Contain the harness with wire loom or sheath to make it into a single bundle or a cable with an overall jacket containing the signal wires. Use grommets when passing the harness through metal panels.

Recommended Signal Wire Specifications

1.3 mm² (16 AWG), Minimum Insulation O.D. 1.96 mm (0.077"), –65 to +200 °C, 1000 Vrms, 19/29 Stranded Conductor, Teflon Insulation (TFE).

All field communications and commands enter the UG-25+ governor through a threaded port in the top of the UG-25+ governor User Interface panel assembly. These signal wires should be contained in a cable with an overall jacket or bundled together with an overall sheath. To maintain the IP-56 ingress protection rating, the field cable must be installed through a cable gland nut, which is threaded into the cable entry port in the top of the User Interface panel. Several suggested gland nut sizes are listed in table below, depending on the overall diameter of the field cabling used in the installation.

Remove the wiring access cover plate located on the front of the User Interface panel by removing the six M4 x 0.7, 10 mm long locking screws (Woodward part number 1031-1806) to access all customer field connection terminal blocks. Securely replace the wiring cover plate after completing the wiring connections to ensure the integrity of electromagnetic noise interference capabilities of the UG-25+ governor.

⚠WARNING   **The UG-25+ governor will not meet ingress protection requirements unless the cover is in place. See Figure 3-1 for warning label found on the inside of the cover.**

```
INFORMATION FOR REFERENCE ONLY  TERMINAL# --SIGNAL NAME
REFER TO INSTALLATION MANUAL B26579    1 -- ANALOG GND
PRIOR TO WIRING, TESTING, OR           2 -- AUX PWR OUT GND
INSTALLING FERRULES ON WIRES.          3 -- ANALOG GND
                                       4 -- CHASSIS GND
HI-POT JUMPER MUST BE REMOVED BEFORE   5 -- AUX PWR OUT+
HI-POT TESTING IS PERFORMED.           6 -- SPEED RAISE
HI-POT JUMPER MUST BE INSTALLED PRIOR  7 -- SHUTDOWN
TO GOVERNOR OPERATION.                 8 -- SPEED SET ENABLE
                                       9 -- SPEED SET-
ACCESS PANEL FASTENERS: 1031-1806     10 -- SPEED SET+
   (SIZE: M4 X 0.7 X 10MM LONG)       11 -- STATUS OUT
                                      12 -- SHIELD
        TERMINAL #'S                  13 -- BOOST 4-20 mA +
                                      14 -- BOOST 4-20 mA -
  UP       16      8                  15 -- SPEED LOWER
           15      7                  16 -- BOOST SET ENABLE
   22      14      6                  17 -- HI-POT
   21      13      5                  18 -- HI-POT
   20      12      4                  19 -- PWR INPUT+
   19      11      3                  20 -- PWR INPUT RET
   18      10      2                  21 -- PWR INPUT RET
   17       9      1                  22 -- PWR INPUT +

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Figure 3-1. Access Cover Instruction Label

Slide the cable gland over the end of the cable with the cable gland threads toward the cable end. Select the appropriate cable gland from the chart below, depending upon the cable size.

Woodward Part Number	Heyco Part Number	Cable Diameter in mm	Mounting Hole Size
1325-4007	4572	9.5 - 12.5	0.750-14 (3/4" NPT)
1325-4008	4573	12.5 - 16	0.750-14 (3/4" NPT)
1325-4009	4574	16 - 20.5	0.750-14 (3/4" NPT)

Remove approximately 100 mm (4 inches) of the overall cable jacket to provide a sufficient service loop inside the User Interface panel to land the individual signal wires on the proper internal terminal.

Strip approximately 10 mm (0.4 inch) of insulation from each individual signal wire and crimp on a wire ferrule, Woodward part number 1606-667 (Phoenix part number 3200043) for 16 AWG wire, to the end of each signal wire. Use the proper crimp tool, "CRIMPFOX 6H" Woodward part number 8996-2197 (Phoenix part number 12 12 046) to crimp the ferrules onto the signal wires with a hexagonal crimp. The wire should extend to the end of the ferrule, but not beyond it. If the wire extends beyond the end of the ferrule, cut the excess wire off with wire cutters. The ferrule assures the signal wire does not slip out of the terminal block in high vibration environments. Tinning (soldering) the ends is not an acceptable option since the spring terminals will not grip the wires as well.

Remove the threaded plug from the customer wiring port located on the top of the User Interface panel. Insert the ferrules and wires through the threaded port far enough to hook up the wiring. Use the small terminal release tool (Woodward part number ST-15011, WAGO part number 236-332), located inside the wiring cavity of the UG-25⁺ governor, to assist in the insertion of the ferrule on the end of each signal wire into its associated terminal location. The terminal release tool is the best way to release the spring-loaded connection clamp located in the wiring terminal block, but a thin, flat-bladed screw driver can also be used if the terminal release tool is not available.

To provide better access to the terminal blocks, install wires going into Terminals 8 through 1 first, followed by the wires going into Terminals 16 through 9 next, and then wires going to Terminals 22 through 17 next.

After installing the wires, apply thread sealant (Woodward part number 2001-4002, Loctite 572 or equivalent) to the NPT threads and screw into the customer wiring port in the top of the UG-25⁺ governor User Interface panel assembly. Make sure that the cable's overall jacket extends slightly past the cable gland so that the rubber seal completely and tightly grips the cable jacket.

Tighten the NPT thread to 10 N·m (88 lb-in).

Then tighten the cable gland top dome nut securely against the rubber gland as shown below.

Correct Installation   Incorrect Installation
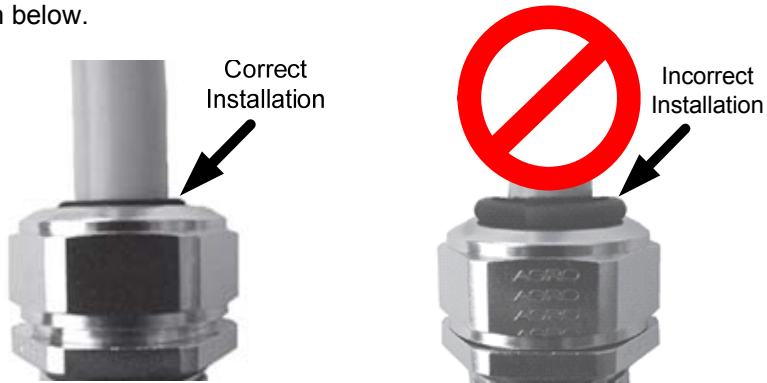
Do not over-tighten the top dome nut. Over-tightening the top dome nut causes the rubber gland to "bulge" out the top of the dome nut, as shown below, and compromises the IP-56 ingress protection seal.

Replace the wiring access cover plate and the six M4 screws holding it to the User Interface panel. Torque all six screws to 3.4 ±0.2 N·m (30 ±2 lb-in).

When routing cables, allow a sufficient service loop when routing the cable around corners. Two customer cable clamp mounting holes are located on the top, front corners of the User Interface panel and accept M5 x 0.8, 10 mm long screws, Woodward part number 1029-972.

Figure 3-2. UG-25+ Governor Application Wiring
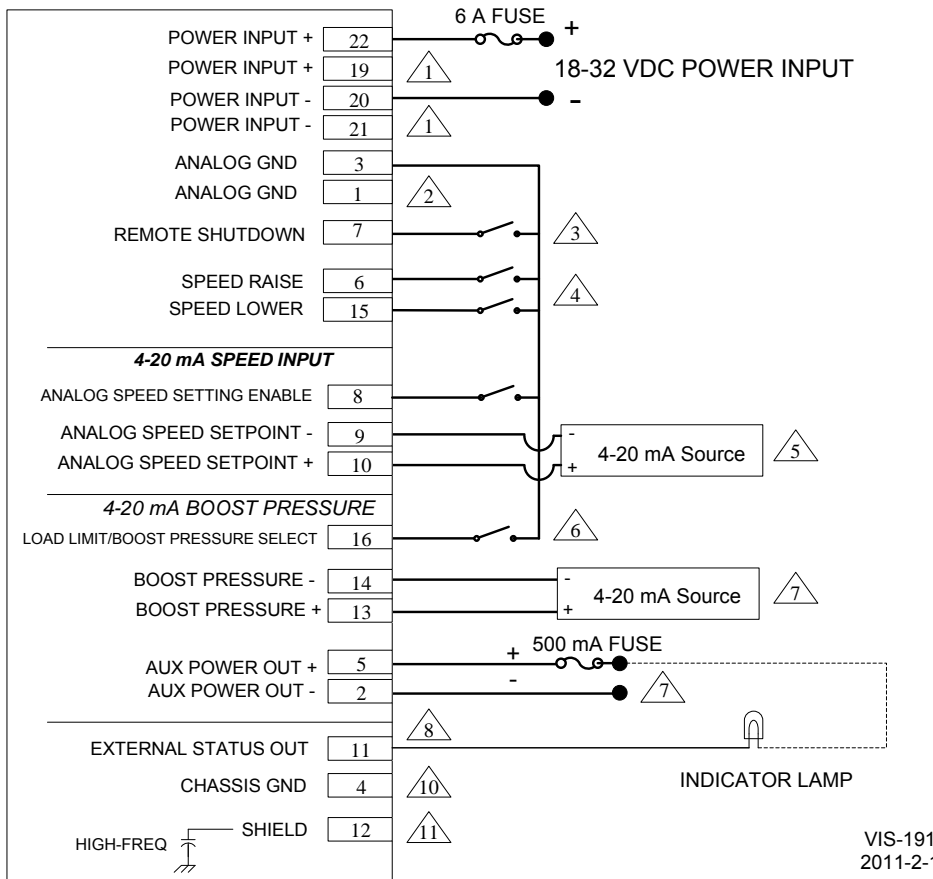
WHEN USING REDUNDANT POWER, CONNECT TO TERMINALS 19 AND 21 IN THE SAME MANNER AS TERMINALS 22 AND 20 (USING A 6 A STANDARD FUSE). OTHERWISE LEAVE THESE TERMINALS UNTERMINATED.

A REDUNDANT ANALOG GROUND IS PROVIDED.

WHEN USING REMOTE SHUTDOWN, CONNECT AS SHOWN: OPEN TO RUN, CLOSE TO STOP (MOMENTARY CLOSED).

WHEN USING SPEED RAISE/LOWER, CONNECT AS SHOWN.

WHEN USING 4-20 mA SPEED INPUT. TERMINAL 8 MUST BE CONNECTED TO ANALOG GND.

WHEN USING 4-20 mA BOOST PRESSURE, TERMINAL 16 MUST BE CONNECTED TO ANALOG GND. IF PIN 16 IS LEFT FLOATING THEN LOAD LIMIT IS SELECTED.

A CONDITIONED 24V POWER SOURCE IS PROVIDED FOR POWERING EXTERNAL DEVICES (eg. BOOST PRESSURE SENSOR) AND THE STATUS OUTPUT. A FUSE SHOULD BE USED AS SHOWN.

THIS IS AN OPTIONAL HOOKUP. THIS PROVIDES FOR A REMOTE "UNIT HEALTHY" STATUS. IF AN EXTERNAL INDICATOR LAMP IS DESIRED, WIRE AS SHOWN.

CHASSIS GROUND IS PROVIDED, IF NEEDED.

SHIELDING IS NOT REQUIRED FOR EMC COMPLIANCE, HOWEVER A SHIELD TERMINATION POINT IS PROVIDED IN THE EVENT SHIELDING IS DESIRED BY THE CUSTOMER.
NOTE: THE SHIELD TERMINATION POINT CONSISTS OF A HIGH-FREQUENCY CAPACITOR WHICH ALLOWS THE CUSTOMER TO 'HARD GROUND' THE SHIELD ON THE OPPOSITE END OF THEIR CABLE, IF DESIRED.

GENERAL NOTE: FLOATING INPUTS ON TERMINALS 6, 7, 8, 15, AND 16 IS ACCEPTABLE BECAUSE THEY ARE INTERNALLY PULLED-UP TO +7 VDC. EXTERNAL PULL-UPS ARE *NOT* REQUIRED *NOR* RECOMMENDED.

Figure 3-2. UG-25+ Governor Application Wiring

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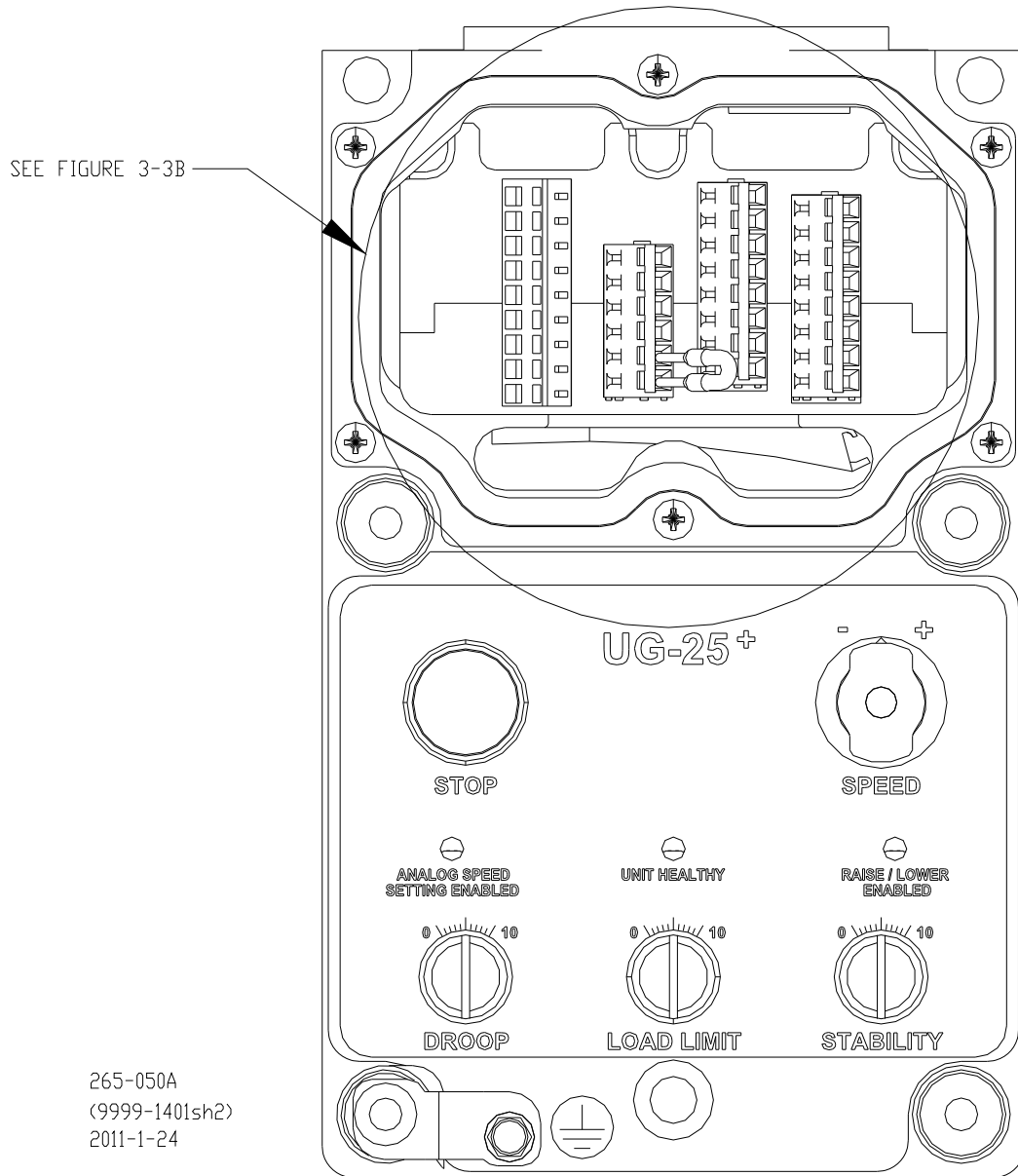
Figure 3-3a. Connector Wiring

NOTICE	Do not connect any cable grounds to "instrument ground", "control ground", or any non-earth ground system. Make all required electrical connections based on the wiring diagrams (Figures 3-2 and 3-3).

NOTICE	The Hi-Pot jumper must be installed for normal operation, and must be removed only during a Hi-Pot test.
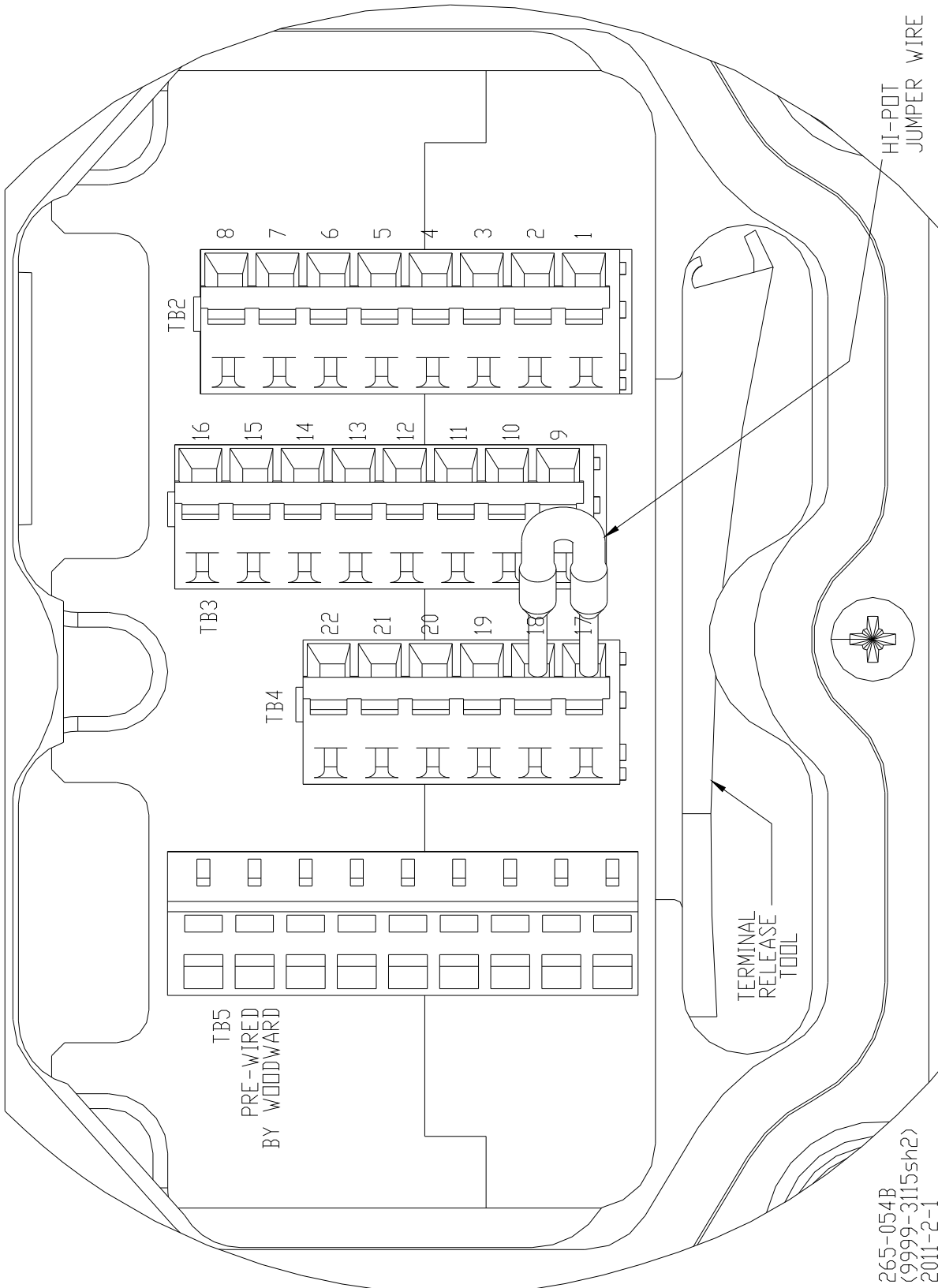
Figure 3-3b. Connector Wiring

CUSTOMER INTERFACE CONNECTIONS

USER PANEL

SIGNAL NAME	TERMINAL #	PCB REFERENCE DESIGNATOR	UG25+ (P3) WIRING FOR GOVERNOR SIGNAL FUNCTION
ANALOG GND	1	TB2-1	SIGNAL GROUND
AUX PWR OUT GND	2	TB2-2	OPTIONAL: AUX POWER OUT GND; RETURN FOR SUPPLY POWER FOR EXTERNAL BOOST PRESSURE SENSOR AND STATUS OUT-- OUTPUT ONLY
ANALOG GND	3	TB2-3	SIGNAL GROUND
CHASSIS GND	4	TB2-4	CHASSIS GROUND
AUX PWR OUT +	5	TB2-5	OPTIONAL: AUX POWER OUT +; SUPPLY POWER + FOR EXTERNAL BOOST PRESSURE SENSOR AND STATUS OUT -- OUTPUT ONLY
SPEED RAISE	6	TB2-6	CONNECT TO GROUND TO INCREASE GOVERNOR SPEED
SHUTDOWN	7	TB2-7	RUN/STOP INPUT -- FLOAT FOR RUN, TIE TO GROUND FOR 'STOP'
SPEED SET ENABLE	8	TB2-8	CONNECT TO GROUND TO USE THE 4-20 mA ANALOG SPEED SETPOINT
SPEED SET -	9	TB3-1	4-20 mA SPEED SETPOINT SIGNAL - (GROUND TERMINAL #8 TO ENABLE)
SPEED SET +	10	TB3-2	4-20 mA SPEED SETPOINT SIGNAL + (GROUND TERMINAL #8 TO ENABLE)
STATUS OUT	11	TB3-3	OPTIONAL: PROVIDES A REMOTE 'UNIT HEALTHY' STATUS
SHIELD	12	TB3-4	USE FOR TERMINATION WHEN THERE IS A SHIELDED CABLE
BOOST 4-20 mA +	13	TB3-5	4-20 mA BOOST COMMAND SIGNAL + (GROUND TERMINAL #16 TO ENABLE)
BOOST 4-20 mA -	14	TB3-6	4-20 mA BOOST COMMAND SIGNAL - (GROUND TERMINAL #16 TO ENABLE)
SPEED LOWER	15	TB3-7	CONNECT TO GROUND TO DECREASE GOVERNOR SPEED
BOOST SET ENABLE	16	TB3-8	CONNECT TO GROUND TO USE THE 4-20 mA BOOST COMMAND SIGNAL
HI-POT	17	TB4-1	HI-POT (JUMPER FROM TERMINAL #17 TO TERMINAL #18 ALREADY INSTALLED, REMOVE FOR HI-POT TEST -- SEE MANUAL)
HI-POT	18	TB4-2	HI-POT (JUMPER FROM TERMINAL #17 TO TERMINAL #18 ALREADY INSTALLED, REMOVE FOR HI-POT TEST -- SEE MANUAL)
PWR INPUT +	19	TB4-3	POWER INPUT +
PWR INPUT RET	20	TB4-4	POWER INPUT RETURN, USE WITH REDUNDANT POWER, OTHERWISE LEAVE PIN FLOATING
PWR INPUT RET	21	TB4-5	POWER INPUT RETURN
PWR INPUT +	22	TB4-6	POWER INPUT +, USE WITH REDUNDANT POWER, OTHERWISE LEAVE PIN FLOATING

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Figure 3-3c. Connector Wiring

Customer I/O Terminal Position Assignment

Terminal Position	Description	Comment	Type
1 (TB2-1)	Analog Ground	Circuit Ground for the following functions: Remote Run/Stop, Remote Speed Raise, Remote Speed Lower , Analog Speed Setting Enabled, Load Limit/Boost Pressure Select. *Do not connect Analog Ground to Input Power (–)*	N/A
2 (TB2-2)	Boost Pressure Sensor Power Out – (Return for 18-32 Vdc supply input)	Return for Supply Power for External Boost Pressure sensor. *Do not connect Analog Ground to this terminal.*	Output
3 (TB2-3)	Analog Ground	Circuit Ground for following functions: Remote Shutdown, Remote Speed Raise, Remote Speed Lower, Analog Speed Setting Enabled, Load Limit/Boost Pressure Select. *Do not connect Analog Ground to Input Power (–)*	N/A
4 (TB2-4)	Chassis Ground	This terminal connects to Chassis ground through the circuit board, and then to the UG-25$^+$ governor metal housing.	N/A
5 (TB2-5)	Boost Pressure Sensor Power Out + (Supply Power, 18-32 Vdc, 1.5 A max.)	Supply Power for External Boost Pressure sensor. This is an *output* only! Do not connect external power to this power output. This output voltage follows the Power Input(+) minus a protection diode drop.	Output
6 (TB2-6)	Remote Speed Raise	Connecting this terminal to Analog Ground, 1, *increases* the UG-25$^+$ governor speed. This terminal is internally pulled-up to 7 Vdc.	Input
7 (TB2-7)	Remote Shutdown	Connecting this terminal to Analog Ground, 1, turns OFF (stops) the UG-25$^+$ governor. This terminal is internally pulled-up to 7 Vdc.	Input
8 (TB2-8)	Analog Speed Setting Enabled	This terminal *must* be connected to Analog Ground in order to use the 4–20 mA Analog Speed Setpoint. This terminal is internally pulled-up to 7 Vdc.	Input

Terminal Position	Description	Comment	Type
9 (TB3-1)	Analog Spd Setpoint –	This is the negative input of 4–20 mA circuitry. Pin 8 *must* be connected to Analog Ground to use this function.	Input
10 (TB3-2)	Analog Spd Setpoint +	This is the positive input of 4–20 mA circuitry. Pin 8 *must* be connected to Analog Ground to use this function.	Input
11 (TB3-3)	External Status Output	This provides for a remote "Unit Healthy" status. See UG-25+ Governor Application Wiring Figure 3-2.	Output, open drain, low-side switch.
12 (TB3-4)	Shield	This terminal is a conditioned shield tie point. (capacitively coupled to Chassis Ground)	N/A
13 (TB3-5)	Boost Pressure Input +	This is the positive input of the 4–20 mA circuitry. Pin 16 *must* be connected to Analog Ground to use this function.	Input
14 (TB3-6)	Boost Pressure Input –	This is the negative input of the 4–20 mA circuitry. Pin 16 *must* be connected to Analog Ground to use this function.	Input
15 (TB3-7)	Remote Speed Lower	Connecting this terminal to Analog Ground *decreases* the UG-25+ governor speed. This terminal is internally pulled-up to 7 Vdc.	Input
16 (TB3-8)	Load Limit/Boost Pressure Select	When Terminal 16 floats, Load Limit is selected. When Terminal 16 is connected to Analog Ground, Boost Pressure is selected. This terminal is internally pulled-up to 7 Vdc.	Input
17 (TB4-1)	Hi-Pot Test Jumper		Input
18 (TB4-2)	Hi-Pot Test Jumper		Input
19 (TB4-3)	Power Input +	Supply Power (18-32 Vdc, 1.5 A max.)	Input
20 (TB4-4)	Power Input –	Return for 18-32 Vdc Supply Input.	Input
21 (TB4-5)	Power Input –	Return for 18-32 Vdc Supply Input.	Input
22 (TB4-6)	Power Input +	Supply Power (18-32 Vdc, 1.5 A max.)	Input

Detailed Description of UG-25⁺ Governor Electrical I/O
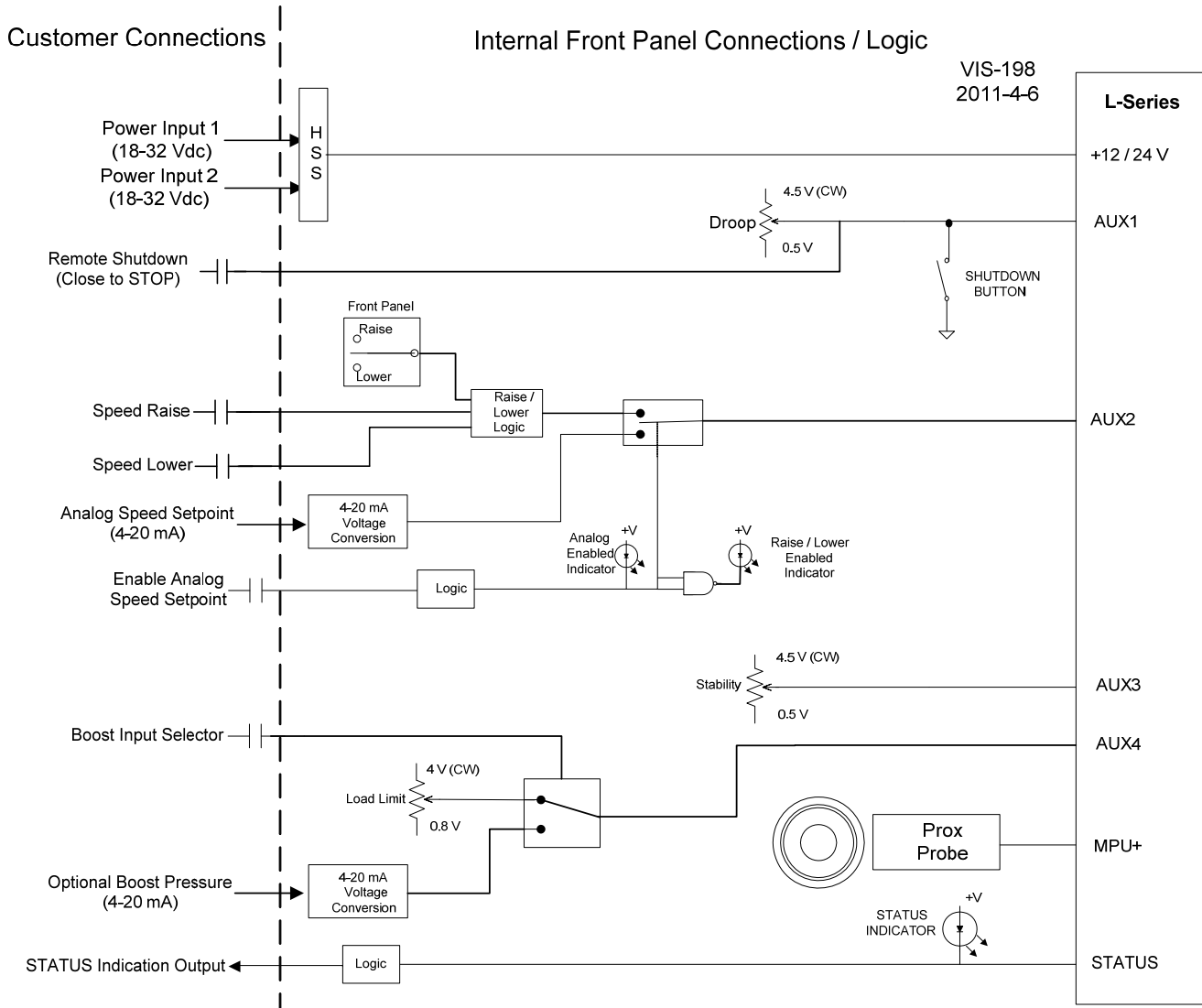
Figure 3-4. Internal Block Diagram

Power Supply Input 1 (18–32 V at Terminal 19, Power Input – at Terminal 21)
Power Supply Input 2 (18–32 V at Terminal 22, Power Input – at Terminal 20)

The UG-25⁺ governor will handle a voltage range of 18 to 32 Vdc, with an absolute maximum of 60 V.

The power supply terminals are reverse polarity protected, and in the case that a reverse polarity condition exists, the UG-25⁺ governor will not power-up and the output will remain at 0 Vdc.

Woodward recommends using a 6 A fuse on the power supply line feeding Terminals 19 and 22 of the UG-25⁺ governor.

⚠ WARNING   The input power must be fused. Failure to fuse the UG-25⁺ governor could, under exceptional circumstances, lead to personal injury, damage to the control valve, and/or explosion.

NOTICE   If circuit ground and chassis ground are shorted together at the UG-25⁺ governor, there is an increased risk of EMI susceptibility.
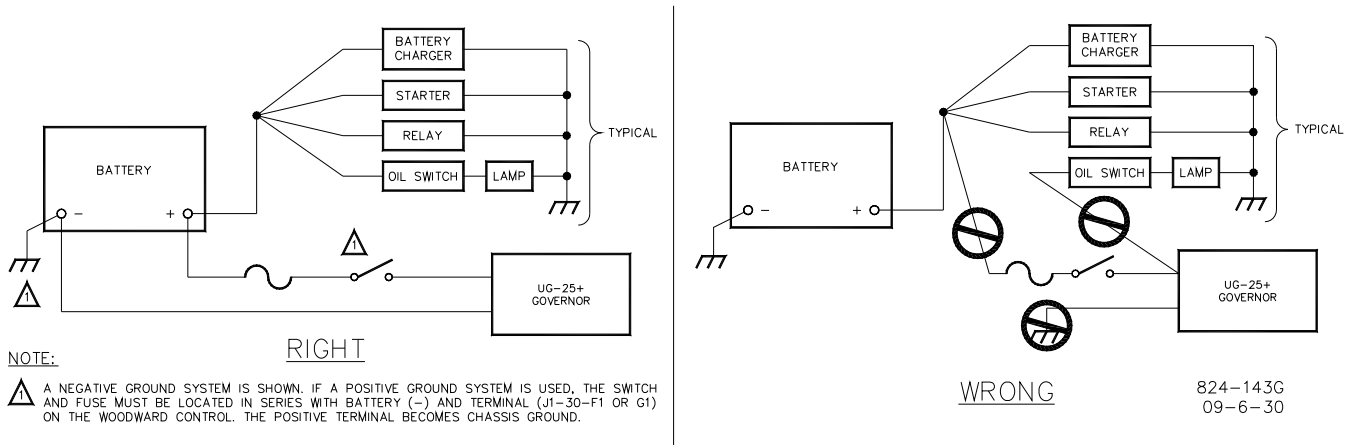
Figure 3-5. Correct and Incorrect Wiring to Power Supply

Woodward recommends using a standard 6 A fuse on the 18–32 Vdc input as show in Figure 3-2. *Do NOT use a slow-blow-type fuse in this application.*

Relay Driver Output (Status/Unit Healthy)
A discrete output is provided to serve as a status indicator, mimicking the front panel Unit Healthy LED. This switchable discrete output is a closure to ground capable of sinking 500 mA maximum with an output voltage rise of less than 1.5 V, and it is available to power external relays for devices such as alarms or fuel shutoff solenoids. The circuit is protected internally against over-current and inductive spikes, so external clamping is not necessary.
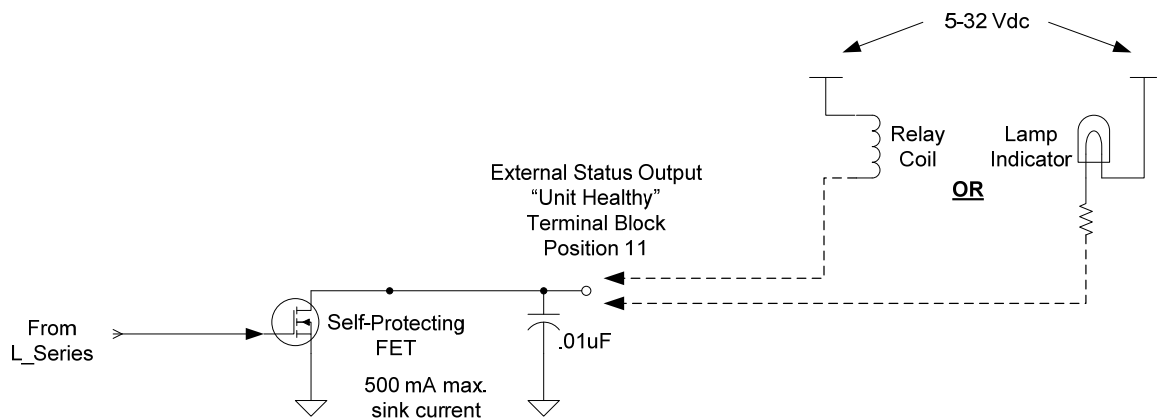
Figure 3-6. Relay Driver Output

Analog Speed Setpoint
This input accepts a 4–20 mA current input that is proportional to a desired speed setpoint. In order to use this input, the external Analog Speed Setpoint Enable signal must be connected to Analog Ground.

> **IMPORTANT**
> **The user must provide an external means to clamp the speed bias input at 3 mA and 21 mA. An analog speed-bias input below 3 mA or above 21 mA is out of the normal 4 to 20 mA input range and may cause the analog speed bias function to become disabled even though the Analog indication LED remains on.**

Analog Speed Setpoint Enable
The Analog Speed Setting Enable allows for remote speed settings. This input is enabled when the input is pulled to ground (0 Vdc). When this signal is not grounded, it can remain floating (no connection).

Boost Fuel Limit Input
This input accepts a 4–20 mA current input that is proportional to a desired boost signal. In order to use this input, the external Load Limit/Boost Pressure Select signal must be connected to Analog Ground.

Boost Input Selector
This external customer input allows the user to select either Load Limit or Boost Pressure. If the input floats and is not connected to analog ground, then Load Limit is selected. If the input is connected to Analog Ground, then Boost Pressure is selected.

Speed Raise/Lower command
The UG-25⁺ governor has both local and remote speed raise/lower capability. The local raise/lower is handled by using a magnetic proximity switch on the PCB that is actuated by a spring-loaded knob, mounted to the panel assembly. The knob can be set to either "+" or "–", but not both simultaneously.
- The remote raise/lower adjustments are made by connecting their respective connector pins to analog ground.
- There is hardware arbitration that must take place for this scheme to work.
The rules are as follows:
1) The local raise and lower adjustments have priority over the remote raise and lower adjustments.
2) If remote raise and local lower are activated simultaneously, the control will default to "lower".
3) If remote raise and remote lower are activated simultaneously, the control will default to "lower".

Stop command
The shutdown feature of the UG-25⁺ governor interface panel allows the user to force the governor to min fuel by either pushing the big red button on the UG-25⁺ governor front panel, or by connecting Terminal 7 to analog ground (momentary closed) (in situations where the shutdown signal is to come from a control room).

> **NOTICE**
> **To avoid EMI interference between the wire bundle and the interface panel, route the wires out of the connectors away from the panel controls. Do not allow the interface wiring to drape in front of the panel controls.**

> **NOTICE**
> **MAGNETIC FIELDS—During installation, avoid placing the interface panel in close proximity with any source of strong magnetic field (permanent magnet motor, magnetized tools, etc.). Strong magnetic fields can inject error into the adjustments available on the front of the interface panel.**

High Potential Testing

Occasionally, marine certification requires that a high potential (HI-POT) test of the engine or prime mover be performed after the UG-25+ governor is installed. The
UG-25+ governor is designed to accommodate this testing. Before performing any HI-POT testing, remove the small HI-POT jumper, Woodward part number 2008-1443, located between Terminals 17 and 18, which are found under the wiring access cover plate on the front of the User Interface panel.

The HI-POT test voltage is +755 Vdc. Repeat the test with the polarity reversed at –755 Vdc.

Apply the HI-POT voltage between all customer input and output terminals (located under the wiring access cover plate on the front of the User Interface panel) connected together and chassis ground (located on the front of the UG-25+ governor), except that Terminal 4 (chassis ground) and Terminal 12 (shield) must remain un-connected and not electrically tied to the other terminals during this test. The HI-POT test voltage ramp-up time is 5 seconds, and dwell is 60 seconds, or as specified by the certification authority.

Use the ground terminal located on the outside of the User Interface panel as the chassis ground tie point for the HI-POT test. Using Terminal 4 as the chassis ground tie point during the test does not properly check the internal chassis to circuit board connection.

NOTICE	Do not perform "AC" Hi-Pot testing on this assembly.

Securely replace the jumper between Terminals 17 and 18 after completing the HI-POT test to ensure that the electrical power surge protection on the electrical circuit board is maintained during normal operation.

NOTICE	Install the jumper between Terminals 17 and 18 for normal operation. The UG-25+ governor may be damaged by power surges if this jumper is not properly installed.

Insulation Resistance Testing

Occasionally, marine certification requires that an insulation resistance test of the engine or prime mover be performed after the UG-25+ governor is installed. The UG-25+ governor is designed to accommodate this testing. Before performing any insulation resistance testing, remove the small HI-POT jumper, Woodward part number 2008-1443, located between Terminals 17 and 18, which is found under the wiring access cover plate on the front of the User Interface panel.

Connect the plus (+) probe of a multi-meter to each terminal block location in turn and the minus (–) probe to chassis ground.

NOTICE	Do not use test equipment that is powered from a power source that exceeds 64 Vdc to perform the insulation resistance testing. It may damage the governor electronics.

The resistance measured between each terminal block location (Terminals 1 through 3, 5 through 11, 13 through 16, and 19 through 22) and chassis ground must be greater than 830 kΩ.

Use the ground terminal located on the outside of the User Interface panel as the chassis ground tie point for the insulation resistance test. Using Terminal 4 as the chassis ground tie point during the test does not properly check the internal chassis to circuit board connection.

Securely replace the jumper between Terminals 17 and 18 after completing the insulation resistance test to ensure that the electrical power surge protection on the electrical circuit board is maintained during normal operation.

NOTICE	Install the jumper between Terminals 17 and 18 for normal operation. The UG-25⁺ governor may be damaged by power surges if this jumper is not properly installed.

Chapter 4.
Description of Operation

General

The UG-25$^+$ governor is a digital speed control with integral speed and position feedback. The governor output shaft provides a maximum rotation is 42 degrees for controlling diesel, gas, or dual fuel engines, or steam turbines. The speed setpoint can be adjusted with a 4–20 mA analog input or with raise/lower discrete inputs.

The UG-25$^+$ governor front panel provides a convenient operating interface for the user. These functions and adjustments include:

STOP—Pushing this red button forces the governor to immediately go to the minimum fuel position. The shutdown/stop condition remains active until speed drops to zero.

SPEED—Selecting the (+) and (–) direction causes the speed setting to be raised or lowered. The speed setting will move toward the speed setting's upper or lower limit at the raise and lower speed setting rates for as long as the spring-loaded, return-to-center, selector switch is manually held in the (+) or (–) direction. Releasing this switch causes the speed setpoint to remain at that setting. Speed adjustment commands from this front panel switch have priority over external raise and lower commands. When raise and lower commands come from the front panel, remote raise and lower commands are ignored. This switch and external raise and lower commands are not active and will not change the speed setpoint when the external Analog (4 to 20 mA) speed setting signal is enabled.

ANALOG SPEED SETTING ENABLED LED—This LED illuminates when the external Analog (4 to 20 mA) speed setting signal is enabled. The speed setpoint can be moved with the external Analog (4 to 20 mA) speed setting signal between Min Speed Limit (4 mA) and Max Speed Limit (20 mA). The manual front panel SPEED switch and the external raise and lower contact inputs are not active when this LED is on.

UNIT HEALTHY LED—This LED illuminates when there is electrical power supplied to the UG-25$^+$ governor and the L-Series electronic governor internal to the UG-25$^+$ governor is working properly. This LED goes off if supply power is removed or there is a fault in the L-Series electronics. See the "Shutdown Faults and Stop Details" section later in this chapter.

RAISE / LOWER ENABLED LED—This LED illuminates when either the manual front panel SPEED switch or the external raise and lower contact inputs are available to change the speed setpoint. This LED goes off if the external Analog (4 to 20 mA) speed setting signal is enabled.

DROOP Adjustment—This adjustment allows the amount of output position droop (as a function of terminal shaft position) to be set between zero and to about ten percent (assuming 30 degrees of terminal shaft travel). Setting the adjustment fully CCW (counterclockwise) sets zero droop into the governor for isochronous operation.

LOAD LIMIT Adjustment—This adjustment limits the rotational travel of the output terminal shaft, which in turn, limits the fuel going to the engine and, therefore, the amount of load the engine can carry. The position limit setting is linear from 0% at full CCW to 100% at full CW. The use of the LOAD LIMIT adjustment must be configured when the governor is configured and the external Boost Input Selector discrete input must be open (disabled).

STABILITY Adjustment—This adjustment allows quick access to the governor's dynamic performance adjustments: P (proportional) and I (Integral) gain terms. The adjustment ranges from 0.5 (fully CCW) and 2.0 (fully CW) times the nominal gain settings. A multiplication factor of one is applied to the gain settings when the adjustment is set to mid position (12 o'clock).

See Figure 4-1 the location of these adjustments and indicators.

Figure 4-1. UG-25⁺ Governor Front Panel Overview

Control adjustments are made from a PC using the UG-25⁺ governor Service Tool. The Service Tool is a Windows-based software tool used to configure, monitor, adjust, and troubleshoot a UG-25⁺ governor. It runs on a personal computer and communicates with the UG-25⁺ governor through an RS-232 serial connection. The UG-25⁺ governor Service Tool includes optional password protection to provide security against tampering.

The internal speed sensor input contains a filter that minimizes the effects of firing torsionals that occur normally in reciprocating engines. This filter ensures the governor will not react to speed sensor input changes produced by firing torsionals. This provides exceptionally smooth steady-state speed control and allows matching the control dynamics solely to the engine rather than detuning dynamics to compensate for firing torsional frequencies.

The control has a switching power supply with excellent spike, ripple, and EMI (electromagnetic interference) rejection. Discrete inputs are capable of rejecting EMI and variable resistance in switch or relay contacts. Analog inputs are differential type with extra filtering for common-mode noise rejection.

The control provides one discrete output, which provides a Unit Healthy indication.

⚠ **WARNING**	The UG-25+ governor should not be used as the primary means of shutting down the engine.

Principal of Operation

The UG-25+ governor consists of the following 3 main components:

- **L-Series Governor**
  Controls prime mover speed/load with proportional rotary output by using speed reference/customer inputs.
- **Hydraulic Amplifier**
  Amplifies work output of L-Series governor.
- **User Interface**
  Provides local control of droop, load/fuel limiting, stability and shutdown functions. Also provides electrical connector for power and customer inputs.

The hydraulic amplifier operation is depicted in Figure 4-2, which illustrates the working relationship of the various parts. The main elements of the hydraulic amplifier are listed below:

Oil Pump
Gerotor pump configuration. Pump is driven by the governor drive-shaft to provide oil pressure for the governor. The pump is fed oil from the self-contained sump.

Relief Valve
Set to maintain internal operating pressure at 1034 kPa (150 psi).

Rotary to Linear Conversion Mechanism
This mechanism converts rotary to linear motion to operate the pilot valve. It also provides enough linear motion to convert 50 degrees of L-Series travel to 42 degrees of terminal shaft rotation when coupled to the rest of the linkage in the hydraulic amplifier.

Return Spring
Used to provide shutdown to minimum fuel position upon loss of function of the L-Series.

Pilot Valve Plunger
The 3-way pilot valve directs flow to the control side of the differential area power piston or to governor drain.
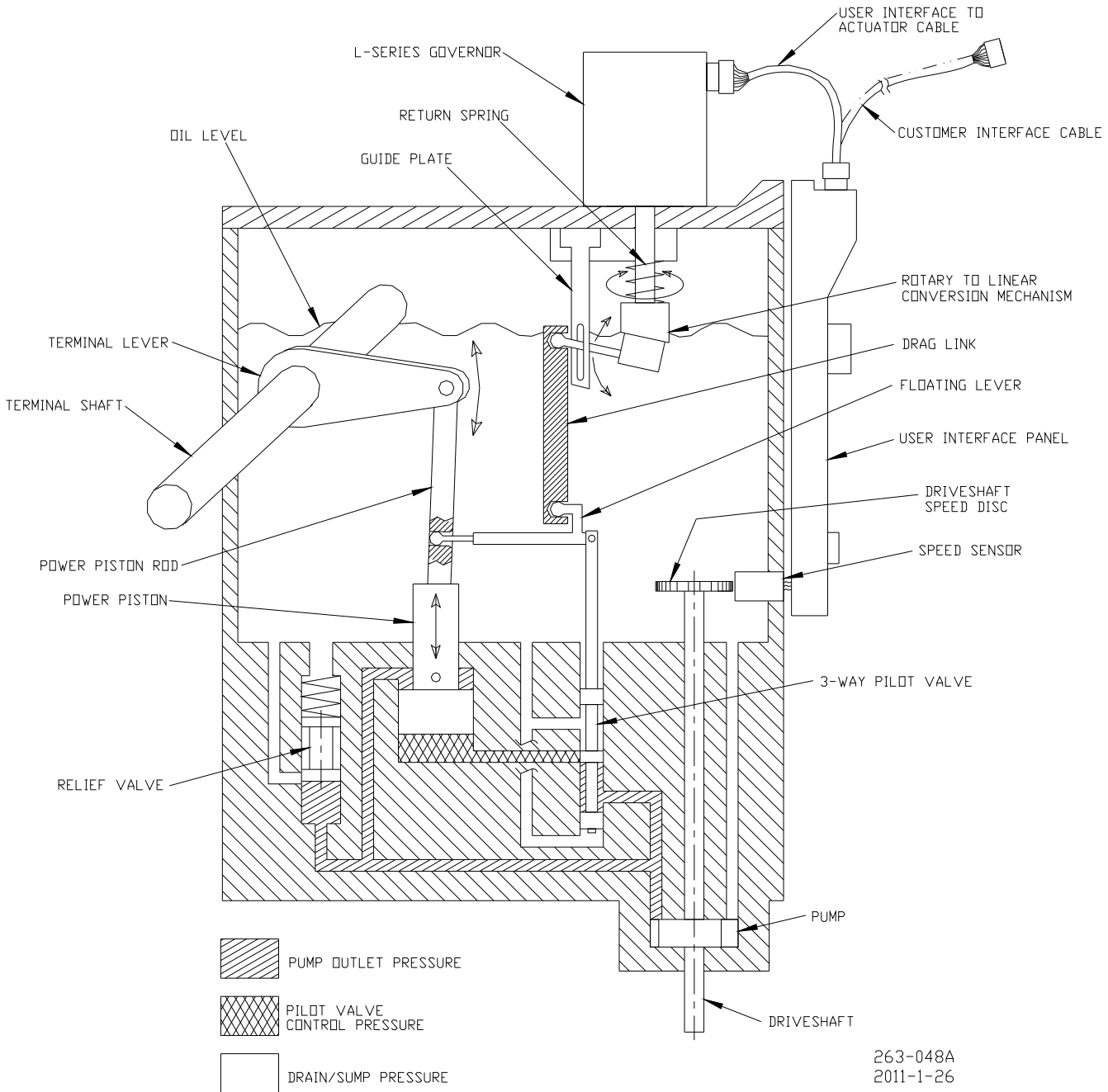
Figure 4-2. Governor Functional Overview

Power Piston, Terminal Lever, and Terminal Shaft
The terminal lever converts the linear motion of the differential-type servo piston to rotary motion of the terminal shaft, which in turn moves the fuel linkage. The terminal-shaft position is fed back to the torque-motor beam to provide the proportional control.

Speed Sensing Disk and Speed Sensor
Drive-shaft-driven 20-tooth gear with proximity probe speed sensor used to provide a speed signal to the L-Series governor.

Increase in Load or Speed Setting

An increase in load, or speed setting, causes the L-Series governor output shaft to rotate CCW when viewed from the top on the UG-25+ governor. This, in turn, causes the pilot valve to lift allowing control pressure to act on the underside of the power piston. This pressure underneath the power piston opposes the pump outlet pressure acting on the topside and causes the piston to rise, since the piston bottom has twice the area of the topside.

As the power piston rises, the power piston rod moves with it and rotates the terminal shaft, converting the output motion back to rotary. One end of the floating lever is directly connected to the power piston rod and this end rises correspondingly.

When the desired terminal shaft position is reached due to the correct speed or load setting being achieved, the floating lever provides a mechanical feedback/restoring signal between the power piston rod and the pilot valve. During this condition, the pilot valve will be a its "null" position. Therefore, the L-Series governor and the hydraulic amplifier are proportional devices with their positions a direct function of the load or speed setting.

Decrease in Load or Speed Setting

A decrease in load, or speed setting, causes the L-Series governor output shaft to rotate CW. This, in turn, causes the pilot valve to lower allowing the control pressure acting on the underside of the power piston to flow to drain. The pump outlet pressure acting on the topside of the power piston will cause the piston to lower.

As the power piston lowers, the power piston rod moves with it and rotates the terminal shaft towards the minimum fuel direction. The floating lever then lowers its end coupled to the power piston rod and provides its position feedback/restoring feedback to the power piston and pilot valve.

Loss of Control Voltage

Upon loss of control voltage, the governor terminal shaft goes to minimum fuel, thus offering a safety feature. With loss of control voltage, the L-Series governor loses torque and the force of the loading or return spring causes the center adjustment to lower. The pilot valve follows, keeping the control port uncovered. Trapped oil escapes to drain, and the servo power piston moves down until it reaches minimum fuel position.

Speed Governor Features Description

The user must set up the speed input, speed setpoint/rates, start settings and fuel limit. The user can set multiple dynamics as necessary for stable operation. The user can choose all or none of the security functions depending on the application.

The governor features include:
- Speed Control with Droop and Dynamics features
- Fuel/Load Limiter (both startup and run time)
- Jump & Rate Limiter
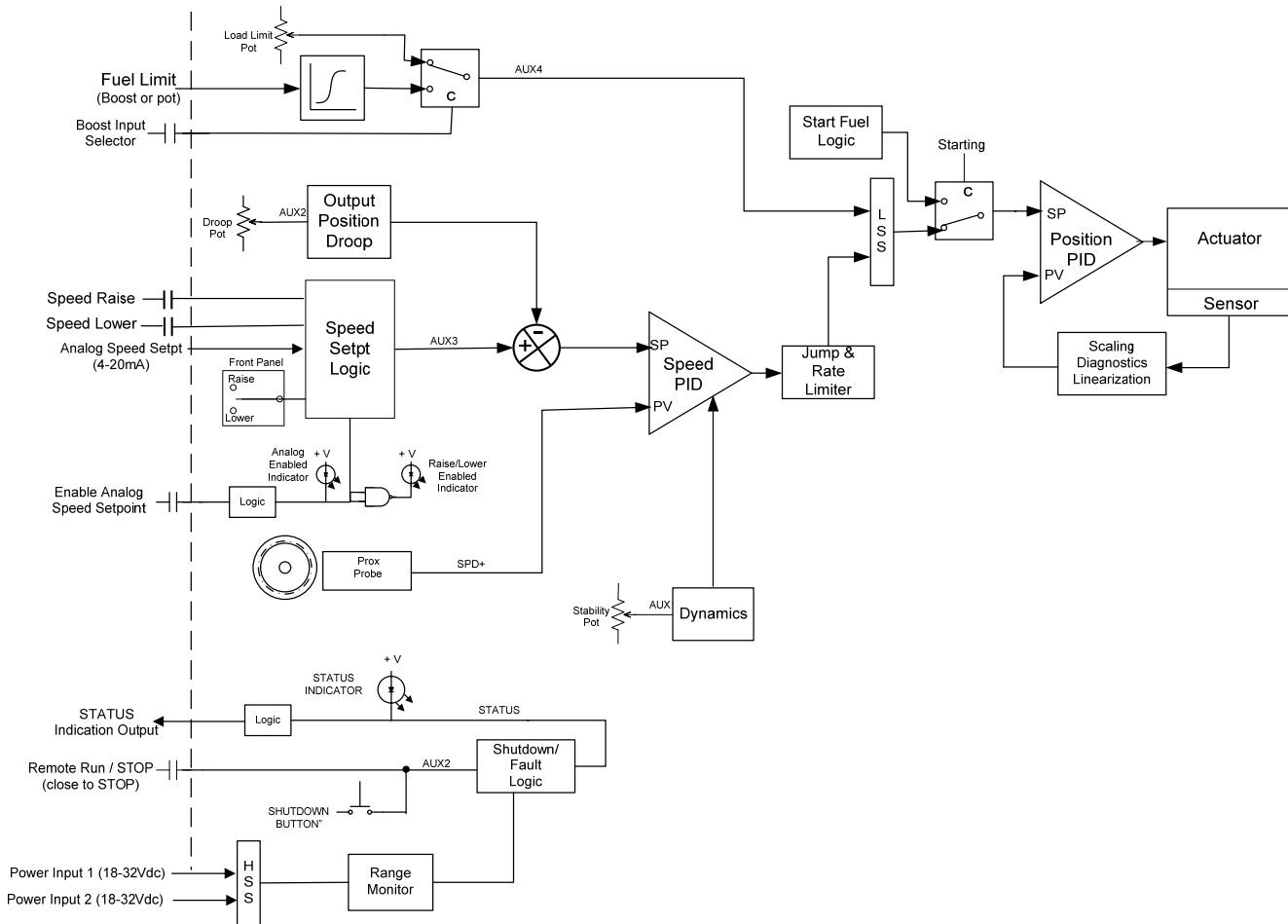- Temperature monitoring
- Run / Stop
- Status discrete output

Figure 4-3. Governor Functional Overview

Starting the Engine

The following describes a typical engine starting sequence. The Run/Stop input must be open to permit a start.

When the starter is engaged and speed increases above the Start Speed 1 Threshold, the UG-25$^+$ governor will position the governor output shaft to the Start Fuel position. If two Start Fuel positions are used, the UG-25$^+$ governor will position the governor output shaft to the Start Fuel 2 position setting when the permissive is met. Depending on the configuration, this is either when the speed increases above the Start Speed 2 Threshold or after the delay time expires. Once the engine speed is above the Run Speed Threshold, the output will switch from start fuel demand to the fuel demand from the speed controller PID. At this point, the UG-25$^+$ governor is in speed control and will control the engine to the speed setpoint. The PID output tracks the start fuel values, during a start, providing a bumpless transfer to speed control. Once in speed control, the speed setpoint increases to the configured start target speed setting - min speed or rated speed.

If a shutdown fault is detected, the control will drive the output to the minimum position.

Speed Control Functions

The speed controller consists of a speed input, speed setting logic, speed biasing logic, and speed dynamics options.

Speed Input

Internally, the UG-25$^+$ governor houses a proximity probe mounted next to a 20-tooth gear, which provides a speed signal to the control. Digital speed detection with firing torsional filtering is used for detecting engine speed. This digital detection method senses speed very quickly for rapid response to speed changes. The input frequency is converted to engine speed based on the number of gear teeth, gear ratio, number of cylinders, and engine stroke settings configured.

Speed Setting Options

The speed control's setpoint is adjustable with raise or lower commands through the user interface on the UG-25$^+$ governor front panel or from remote contact inputs. In addition, a 4–20 mA analog input provides for remote speed setpoint control.

The speed setpoint can be in Analog or raise/lower mode. The front panel LEDs will display the active speed setpoint mode (Analog or raise/lower). When in the Analog mode, the setpoint signal comes from the UG-25$^+$ governor analog speed setpoint input (derived externally by a customer supplied device). When in the raise/lower mode, the setpoint is adjusted using raise and lower commands available both on the front panel and through customer inputs.

Analog Speed Setpoint—The Analog Speed Setpoint input directly sets the internal speed setpoint. The maximum rate at which the analog input signal can change the speed setpoint is programmable and provides separate increase and decrease rate limits. The analog setpoint is enabled with the Enable Analog Speed Setpoint discrete input. The analog setpoint scaling is based on the Min Speed Limit and Max Speed Limit settings, a 4 mA input corresponds to Min and a 20 mA input corresponds to Max.

Analog Speed Setting mode is active only when the Analog Enable input is closed and the analog input signal is above 2.5 mA. All Setpoint Raise/Lower commands are ignored when the Analog Speed Setting mode is active.

The user must provide an external means to clamp the analog speed setpoint input between 3 and 21 mA. An analog speed setpoint command input below 3 mA or above 21 mA is out of the normal 4 to 20 mA input range and may cause the analog speed setpoint command function to become disabled even though the Analog indication LED remains on.

When the Analog Speed Setpoint mode is disabled, by loss of input signal or opening the Analog Enable input, the speed control's setpoint is held at the last setting and remains there until adjusted using the Raise or Lower commands.

Lower—The Lower Speed discrete input and front panel Lower command act directly on the internal speed setpoint and will progressively decrease the speed setpoint down to a programmable lower limit at the programmed lower rate for as long as the input is selected (closed). When this input is not selected (opened), the speed reference will remain fixed at the last setting.

Raise—The Raise Speed discrete input and front panel Raise command act directly upon the internal speed setpoint and will progressively increase the speed reference up to a programmable upper limit at the programmed raise rate for as long as the input is selected (closed). When this input is not selected (opened), the speed reference will remain at the last setting.

Front panel commands have priority over external commands – when Raise or Lower is selected locally, the remote raise/lower commands are ignored. In the event of a simultaneous external Raise and Lower command, the Lower has priority over a Raise command.

⚠️ **WARNING** | **It is recommended that the actual engine speed be used to externally verify that the speed command matches the command signal sent. Failure to comply with this recommendation can result in undetected system faults.**

Speed Setting Functions

The control provides run speed, min speed, max speed, and rated speed setpoints with a lower and raise limit, plus raise and lower ramps and a starting ramp. All ramp rate settings are in rpm/sec and all speed setpoint changes are ramped for smooth setpoint transition. For emergency standby applications, a very high ramp rate effectively cancels the ramp function to provide rapid starting. Starting ramp determines how fast speed is increased from run to the start target speed (Min or Rated). Raise and lower rates determine how fast speed is increased or decreased by the raise and lower command inputs. A maximum adjustment rate limit is provided for the remote speed setpoint input. See Figure 4-4 for relative speed values. For additional details on these settings refer to the Overview tab and Setpoint tab configuration settings in Chapter 6.

The Run Speed setting must be above cranking speed, but below the speed attained at ignition speed by the start fuel limit setting. The speed control activates at Run speed by grabbing the current operating speed as the initial speed setpoint then ramping the setpoint up to the start target speed setting at the start target speed rate.
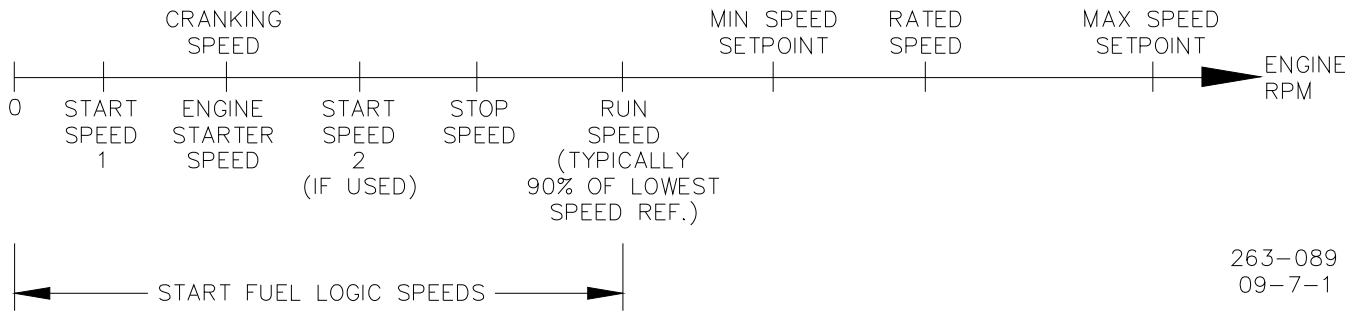

```
      CRANKING                                    MIN SPEED     RATED         MAX SPEED
       SPEED                                      SETPOINT      SPEED         SETPOINT
                                                                                           ENGINE
 |    |      |        |       |        |              |           |               |    ▶   RPM
 0  START  ENGINE   START   STOP      RUN
    SPEED  STARTER  SPEED   SPEED    SPEED
     1     SPEED      2             (TYPICALLY
                   (IF USED)       90% OF LOWEST
                                    SPEED REF.)
                                                                                    263-089
 |                                        |                                         09-7-1
  ◀────────── START FUEL LOGIC SPEEDS ──────▶
```

Figure 4-4. UG-25+ Governor Relative Speed Values

If the target speed is Rated and a raise or lower command is selected during the ramp to target (Rated), the speed setpoint will halt and follow the raise/lower commands. If the halt is issued prior to reaching the Min Setpoint Limit, then the setpoint will continue up until Min prior to stopping.

Droop
This feature allows for a change in speed setpoint with a change in load. This feature is primarily used when the generator is connected to a utility bus or paralleled with another gen-set on an isolated bus. In this situation, the utility will determine the frequency of the generator and the speed of the engine. Should the governor speed reference be less than the utility frequency, power in the utility bus will flow to the generator and motor the unit. If the governor speed is even fractionally higher than the frequency of the utility, the governor will go to full load in an attempt to increase the bus speed. Since the definition of a utility is a frequency that is too strong to influence, the engine will remain at full fuel.

Droop is one method of creating stability in a governor. Droop is also used to divide and balance load between units driving the same shaft or paralleled in the electrical system. Droop is the decrease in speed that occurs when the governor output shaft moves from the minimum to the maximum fuel position in response to a load increase, expressed as a percentage of rated speed.

Too little droop can cause instability in the form of hunting, surging, or difficulty in response to a load change. Too much droop can result in slow governor response in picking up or dropping off a load.

Reducing droop to zero allows the unit to change load without changing speed (isochronous operation). Normally, set zero droop on units running alone. On interconnected units, set the least amount of droop possible to provide satisfactory load division. For ac generating units tied in with other units, set droop sufficiently high to prevent interchange of load between units. If one unit in the system has enough capacity, set its governor on zero droop (isochronous operation), and it will regulate the frequency of the prime mover system. If its capacity is not exceeded, this unit will handle all load changes.

Marks on the droop adjustment scale on the front panel are reference numbers only and do not represent actual droop percentages. The governor droop percentage set by the droop pot is scaled 0 to 18% of the full 42 degrees of output shaft travel, but since the typical application uses 30 degrees travel, the pot roughly corresponds to 10% at full CW position. Shaft positions must be entered for no-load and full load to correlate the speed setting to load. Configuration settings are available on the Setpoint tab for the nominal droop percentage, no load, and full load positions.

The desired engine speed reduces with the following formula:

$$\frac{\text{Rated speed setpoint * droop percentage * (actual position – no load governor position)}}{\text{(full load governor position – no load governor position)}}$$
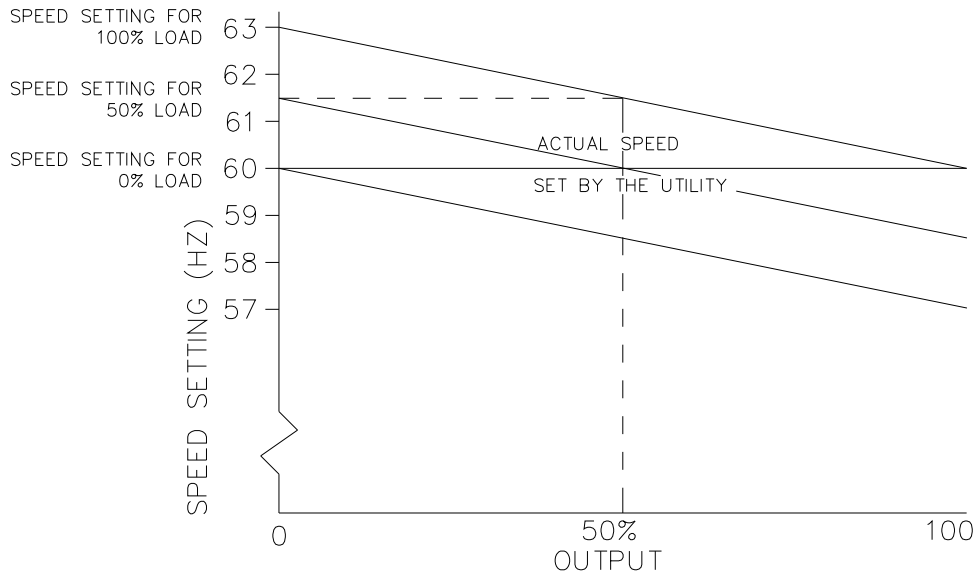
Figure 4-5. 5% Droop Example

Speed Control Dynamics

The control algorithms used in the UG-25⁺ governor are designed specifically for reciprocating engine applications. The UG-25⁺ governor offers either a single set of dynamics or a position-based curve. In addition, cold start dynamics and dual gain settings can be configured for use in more demanding applications. These options are described below. A front-panel Stability potentiometer is provided to allow quick access to dynamic performance adjustments. Refer to the Dynamics tab in Chapter 6 for configuration details. Information on tuning of the speed control dynamics is provided in Chapter 7.

Cold Start Gain
In demanding gen-set applications that require ISO 8528-5, Class G3 performance but are also intolerant of cold start instability, the UG-25⁺ governor offers a cold start gain function that sets the gain of the controller to a lower-than-normal value until a programmable speed threshold is exceeded (see Start Gain and Start Gain Speed Threshold settings in Chapter 6). This gives an engine time to warm up slightly before switching to a normal gain value.

Single Gain
If configured for Single Gain, once the Start Gain Speed Threshold is exceeded, the proportional gain remains constant as entered and does not vary with engine speed or load. These are simplest dynamics and suit most constant speed applications. A single gain setting is typically used on engines that operate continuously at rated speed or on variable speed engines that tend to be stable at all speeds with constant dynamic settings.

Position Curve

A Position Curve varies the proportional gain value with fuel demand (governor position). Fuel demand is roughly proportional to load but not necessarily in a linear manner. A 5-breakpoint gain curve is provided to map gain versus fuel demand. Gain is applied linearly between breakpoints. This gain curve is particularly useful for non-linear fuel systems (e.g., intake butterfly valves).

Integral and Derivative

The integral gain varies with engine speed. Idle Integral applies when running at the initial Run Speed. Rated Integral applies when operating at rated speed or higher. The gain varies linearly at intermediate speeds. For all dynamic configurations, the Derivative setting is constant and does not vary with either engine speed or load.

Stability Pot

The front panel stability pot provides a quick adjustment on the speed controller P (proportional) and I (integral) gain terms. This pot output, with a range of 0.5 to 2 X, is multiplied with the nominal gain settings to adjust the resultant performance. When the pot is at mid position, the multiplier is '1.0' and gains are at their nominal configured settings. At full clockwise position, P and I-term gains at multiplied by '2' providing increased response and at full counter-clockwise position the multiplier is at 0.5. The stability pot input and resultant gains can be monitored from the Overview tab on the Service Tool (see Chapters 5 and 7).

Dual Gain Settings

Gain Window and Gain Ratio settings further modify the applied gain. These Dual Gain Dynamic settings can improve both steady state and transient load performance by automatically switching between two gain settings. A low gain setting is applied during steady-state operation. A high gain setting is applied during load transients. Dual Gain Dynamics are available for all gain configurations.

During steady-state loaded operation, the control uses the primary gain setting (rated gain, idle /rated gain, etc.). In this region, gain is set to prevent the control from responding to minor speed fluctuations inherent with reciprocating engines. This essentially eliminates harmful jiggle of the governor output and the fuel system linkage during steady-state loaded operation.

During load transients, should the speed error exceed the adjustable Gain Window width, the primary gain setting is multiplied by the gain ratio setting to temporarily increase the applied gain. This higher gain produces a faster fuel response to quickly restore engine speed to the speed setting. Speed error is the difference between actual engine speed and the engine speed setting. The primary gain setting is restored once the control senses a return to steady-state operation (see Figure 4-6). Setting the gain ratio to 1 disables the function.
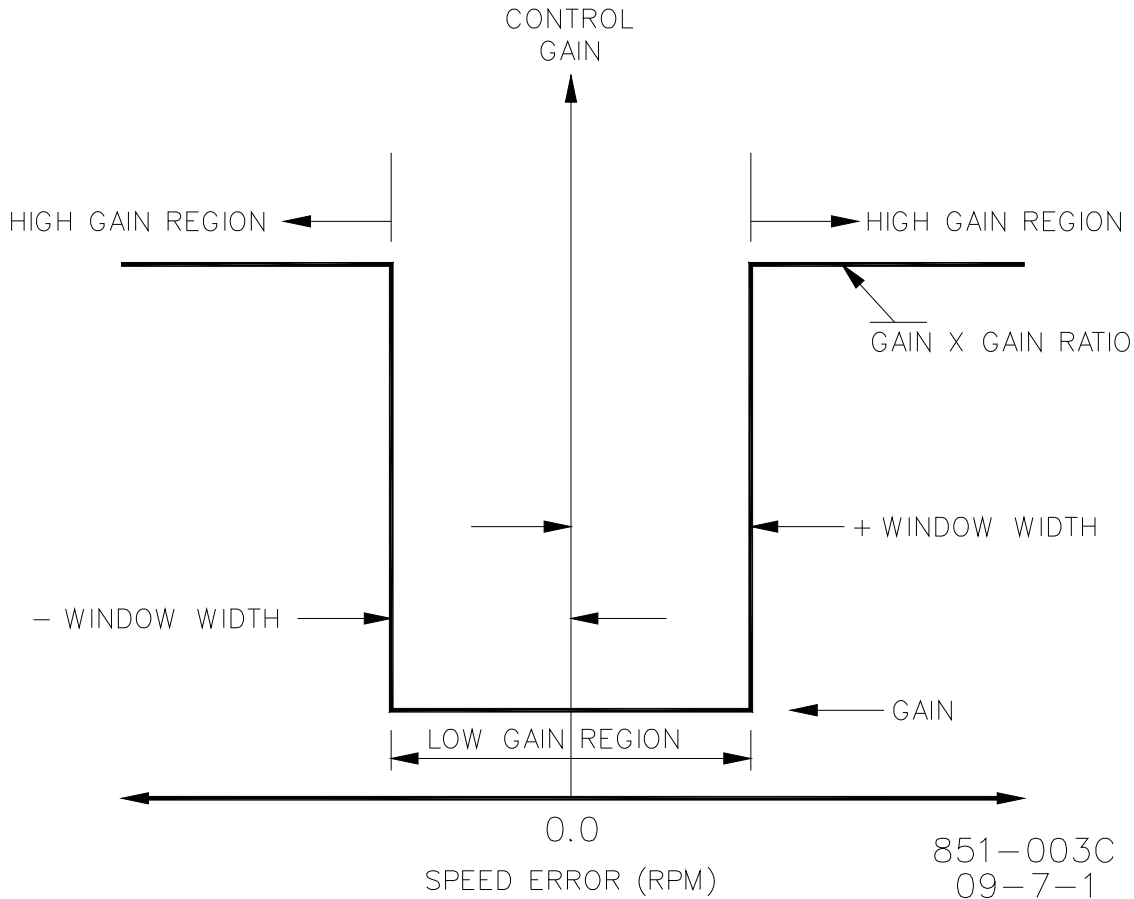
Figure 4-6. Dual Gain Settings

Fuel Limiting

Two modes of fuel limiting are provided, one during startup (start fuel) and one during normal operation (run time).

Start Fuel Limit Function

The Start Fuel Limit (SFL) is an adjustable limiter on the fuel demand that prevents over fueling during engine starting. Two configurable start fuel limiters are available:
• Single Start Fuel Limit
• Dual Start Fuel Limit
• Dual Limit with Time Delay

The simple Start Fuel Limit is suitable for most applications. With this configuration, the fuel demand immediately switches to the adjustable SFL1 Limit setting when the engine is cranking at the adjustable Start1 Speed setting. The SFL1 Limit is removed once the engine accelerates to the Run Speed. At the Run Speed the fuel is controlled by the speed control setpoint and ramping functions. The Run Speed setting must be set below the speed reached with the SFL1 Limit setting. See Figure 4-7.

The Dual Start Fuel Limit is appropriate for engines that need a rather high fuel setting to start the engine, but a much lower setting immediately thereafter to minimize speed overshoot, black smoke or to prevent an overspeed shutdown. The start sequence will work the same as with only one start fuel setting, but once engine speed is above the Start2 Speed setting, the fuel demand starts ramping to the SFL2 limit at the configured actuator ramp rate.
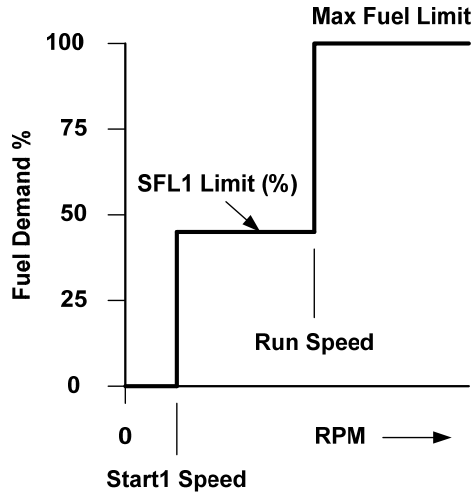
Figure 4-7. Single Start Fuel Limit

A Dual Limit with Time Delay start fuel limit option is available. Using this option, if the start 2 speed threshold is not exceeded, the fuel demand starts to ramp to the start fuel 2 (SFL2) limit after the configured time delay expires.

If the ramp rate is set to its maximum value, the change to the second start fuel is nearly instantaneous. This will essentially eliminate the ramp feature. Start2 Speed must be set higher than the Start1 Speed setting. The SFL2 Limit can be set lower or higher than the SFL1 Limit setting. Otherwise, function is the same as the Start Fuel Limit described above. See Figure 4-8.

Figure 4-8. Dual Start Fuel Limiters

Run Time Fuel Limiting

During normal operation, the fuel limit can be set by the front panel load limit pot as a function of the operating speed or through an external analog setting. The appropriate hardware jumper (see Boost Input Selector discrete input in Chapter 3) AND software configuration selection must be set for the desired input. An absolute Maximum Fuel Limit is also available. Refer to Fuel Limiting tab in Chapter 6 for configuration details.
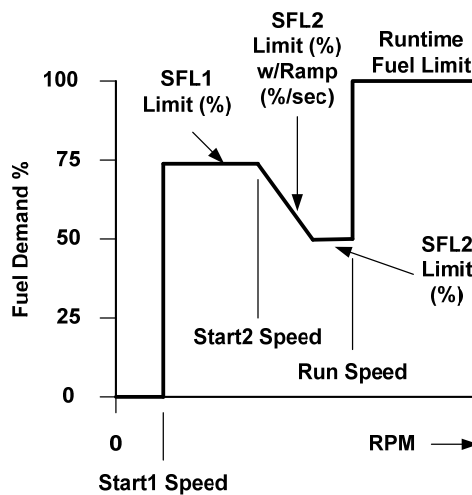
Maximum Fuel Limit

The Maximum Fuel Limit software setting places a fixed absolute maximum limit on the fuel demand (governor position), independent of the front panel fuel limit pot or analog input. It is generally adjusted to prevent engine overloading at rated speed or to merely limit fuel delivery to the engine for other situations (e.g., to prevent detonation). Configuring the Max Fuel Limit setting to 100% disables the function.

Boost (Analog Input) Fuel Limit Function

The Boost fuel limit is a software adjustable five-breakpoint curve based on an external transmitter analog input signal. Manifold Air pressure (MAP) is typically used for the external fuel limiter signal. The purpose of the manifold air pressure fuel limiter is to prevent over fueling during loading to significantly reduce black smoke in diesel engine exhaust and unburned hydrocarbons in spark gas engine exhaust. A fuel demand (governor position) limit is set for each specific air manifold pressure breakpoint.

The limiting value is linear between breakpoints as shown in Figure 4-9. The engineering units for each breakpoint are in percent and user set input units. The limiter must be carefully set since excessive fuel limiting can degrade the loading response. On occasion, exhaust temperature or other engine parameters are used for the external fuel limiting function. The external fuel limiter is disabled whenever the input signal is failed. The external fuel limiter is not active below the run speed setting.

To select this input, the Boost Analog Input must be configured and the Boost Input Selector discrete input must be closed.
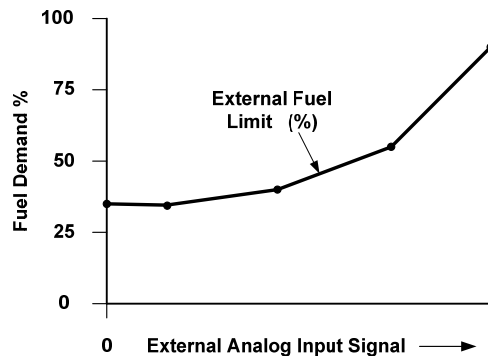

Figure 4-9. Boost (External) Fuel Limit Curve

Fuel Limit Pot
The front panel fuel limit pot is a run time fuel limit that is set based on the position of the potentiometer. The position limit settings for this function is linear from 0%, pot full counter-clockwise, to 100% with the pot fully clockwise.

To select this input, the Front Panel Pot must be configured and the Boost Input Selector discrete input must be open.

Speed-based Fuel Limit Function
The Speed-based fuel limit is a software-adjustable, five-breakpoint curve with the input as actual engine speed and the output as the fuel limit in percentage of full 42 degrees of travel. The limiting value is linearly interpolated between breakpoints. To use this limiter function, the speed-based curve must be configured, and the Boost Input Selector discrete input must be open.

Jump and Rate Limiter

A jump and rate limiter is available to limit the governor output position command in the fuel increasing direction. This function provides a limit on instantaneous increases (Max Jump Up) and a limit on the rate of increasing shaft position output (Max Up Rate). Settings of 100% and 200%/sec for Max Jump Up and Max Up Rate, will disable this function. The jump rate limiter is not active below the run speed setting. Refer to Fuel Limiting tab in Chapter 6 for configuration details.
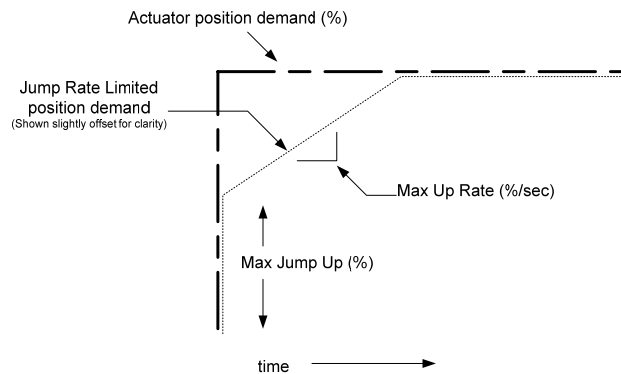
Figure 4-10. Jump Rate Limiter

Discrete Output – Unit Healthy Indication

A discrete output is provided to mimic the front panel 'Unit Healthy' LED. When OFF, indicates a shutdown condition in the unit. The Service Tool can be used to display all faults, current and historical (logged).

Run / Stop (Shutdown) Functionality

The UG-25⁺ governor can be shut down from the front panel or through the external Shutdown discrete input (Open to Run, Close to Stop). When a 'stop' is commanded, the output shaft position will be commanded to minimum (0%).

Temperature Sensing

The UG-25⁺ governor has an on-board temperature sensor to monitor board temperatures and protect the unit from over-temperature. This temperature is monitored and a fault is annunciated if the setpoint is exceeded.

Current Limiting based on Temperature

The controller provides governor current limiting based on the electronics temperature. Dependent on board and governor thermal models, the software reduces current as necessary to avoid conditions that would damage the device due to extreme temperatures.

Current limiting based on temperature begins when the combined current and temperature environment causes board temperatures greater than 117 °C. The limit curve is a linear derate from full current at 117 °C down to zero current at 125 °C. At 125 °C, an OverTemp fault is annunciated. Depending on the current (governor torque) and ambient operating temperatures, the unit may never reach a reduced level.

Control Modes

The Service Tool displays the state of the UG-25⁺ governor, the present mode of the unit. Options include:

- Stopping
- Engine Stopped
- Power-down
- Start Fuel 1
- Start Fuel 2
- Ramping
- Running Rated

Stopping
The stopping state indicates the control has a shutdown fault and is driving the output shaft position to the closed position. Once speed has reached zero rpm, the control transfers to the stopped state.

Engine Stopped
In this state the engine is stopped and the control is ready to begin the startup cycle if there are no shutdown's active. After the Stopped State Delay, the holding current is applied to the governor to limit the current draw and prevent battery drain.

Power down
In this state the governor position controller is turned off and the holding current is applied to the governor to limit the current. This state is only used if the engine is stopped and the run enable discrete input is not active.

Start Fuel 1
The Start Fuel 1 state is selected if the engine speed is higher then the Start Speed 1 threshold. In this state the governor position is set to the Start Fuel 1 value.

Start Fuel 2
The Start Fuel 2 state is selected if the engine speed is higher then the Start Speed 2 threshold. In this state the governor position is set to the Start Fuel 2 value. This state is only used if two start fuels are selected.

Ramping
The ramping state is used to ramp from one setpoint to another setpoint.

Running Rated
Indicates the unit is running at the rated speed setpoint or the changed rated setpoint if raise, lower, or analog control is used.

Fault Detection and Annunciation

The UG-25⁺ governor provides complete shutdown fault monitoring. A detected shutdown condition forces the governor to a go to the min fuel (0%) position. When the shutdown condition no longer exists, the UG-25⁺ governor is returned to a non-shutdown state. Faults are globally set as non-latching. When the condition no longer exists, the fault is automatically cleared without any reset.

Current (Active) Faults and Logged Faults

Faults are separated into two categories: Logged Faults and Current (Active) Faults. All faults are logged. Status of both current and logged faults is provided on the Service Tool. A Current Fault indicates a fault that is presently active/detected and causes the Unit Healthy LED to turn off. A Logged Fault is a fault that occurred since the last time the fault log was cleared. All logged faults are latched and written to the EEPROM. They must be cleared through the Service Tool. Each possible fault is described below.

Shutdown Faults and Stop Details

Shutdown - Voltage Sense Fail
Indicates an out-of-range signal on the input power. Could indicate input power out of range or a fault in the supply voltage sense circuitry.

This shutdown causes the Unit Healthy LED to turn off and the External Status output (Terminal 11) to open-circuit, turning off any External Status device that is connected.

Failure levels: >33 V and <6.25 V
Persistence: 650 ms

Shutdown - Temp Sense Fail
Indicates a failure of the internal on-board Temperature Sensor.

This shutdown causes the Unit Healthy LED to turn off and the External Status output (Terminal 11) to open-circuit, turning off any External Status device that is connected.

Failure levels: >150 °C and <–45 °C
Persistence: 650 ms
Hysteresis: 5 °C (<145 °C or >–40 °C to clear)

Shutdown - OverTemp
If the on-board temperature sensor reads above 125 °C, this error will be set. The Current Limiting based on temperature will effectively make the output "limp" by reducing the drive current to zero (see Current Limiting Based on Temperature section for details).

This shutdown causes the Unit Healthy LED to turn off and the External Status output (Terminal 11) to open-circuit, turning off any External Status device that is connected.

Failure levels: >125 °C
Persistence: 650 ms
Hysteresis: 5 °C (<120 °C to clear)

Stop - Zero Speed Detected
Loss of speed input signal.

Dedicated shutdown. The control must return to a safe condition, determined as the power-down or stopped state, prior to resuming operation.

Failure levels: < (Start Speed / 2)
Persistence: 13.0 ms

Stop - Stop Input Command
The Stop discrete input is opened or STOP is selected from the front-panel user interface. This is a hard-coded shutdown. This shutdown remains active until the speed has dropped to zero.

Persistence: 650 ms

Shutdown - EEPROM Fail (internal fault)
EEPROM Fail indicates failure or corruption of the internal non-volatile memory. This is a hard-coded internal shutdown. If detected, the control output will go limp. A power cycle is required to clear this fault.

This shutdown causes the Unit Healthy LED to turn off and the External Status output (Terminal 11) to open-circuit, turning off any External Status device that is connected.

Shutdown - Position Sense Fail (internal fault)
This indicates a failure of the internal Position Sensor. This is a hard-coded internal shutdown. If detected, the control output will drive to the Fail Direction using current control. This fault latches and requires a reset or power cycle to clear.

This shutdown causes the Unit Healthy LED to turn off and the External Status output (Terminal 11) to open-circuit, turning off any External Status device that is connected.

Failure levels: >4.75 V and < 0.25 V
Persistence: 650 ms

Chapter 5.
Service Tool

Introduction

This chapter covers the process of installing and servicing the control via the UG-25⁺ governor Service Tool. It is assumed that the control has already been installed on the engine.

IMPORTANT	**Many applications are delivered pre-configured, calibrated, and tuned. These units do not require the use of the Service Tool.**

Description

The Service Tool software is used to configure, tune, and troubleshoot the UG-25⁺ governor. This chapter describes installation and use of the Service Tool. It identifies the parameters available that can be viewed. It also provides detailed information on configuring and setting up the UG-25⁺ governor to the customer-specific field application.

The Service Tool software resides on a PC (personal computer) and communicates to the UG-25⁺ governor through terminal block TB5 Terminals 4 and 6. An external RS-232 transceiver is necessary to make communications possible with the Woodward UG-25⁺ governor service tool. A connectivity kit can be purchased from Woodward to accomplish this (Woodward part number 8923-1061).
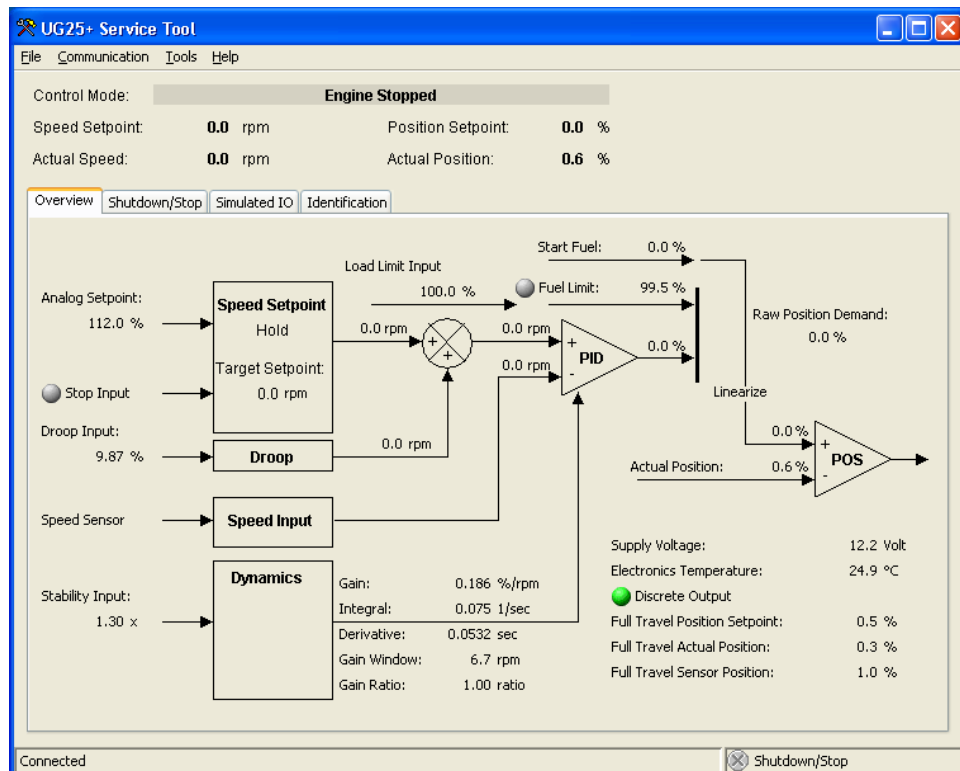
Figure 5-1. Example Service Tool Screen

The following hardware is required to work with the UG-25⁺ governor:
- PC-compatible laptop or desktop computer* with at least one available serial communications port, and Windows 95/98/00/NT/Me/XP as the operating system.
- Programming/datalink harness as shown in Figure 5-2.

In addition to the hardware, the following are the distributions of tool software needed to communicate with the control:
- Woodward part number 9927-1366, UG-25⁺ governor Service Tool

NOTICE	**There is a potential for serial port damage when communicating with the UG-25⁺ governor. This is caused by a difference in ac voltage between neutral and earth ground. If the PC RS-232 port ground is referenced to ac neutral, and the UG-25⁺ governor is referenced to battery ground (ac earth ground), a large amount of current can be experienced. To avoid this situation, we strongly recommend placing an isolation transformer between the ac outlet and the PC or using a battery-powered PC such as a laptop.**

Figure 5-2a. Programming Harness Connection
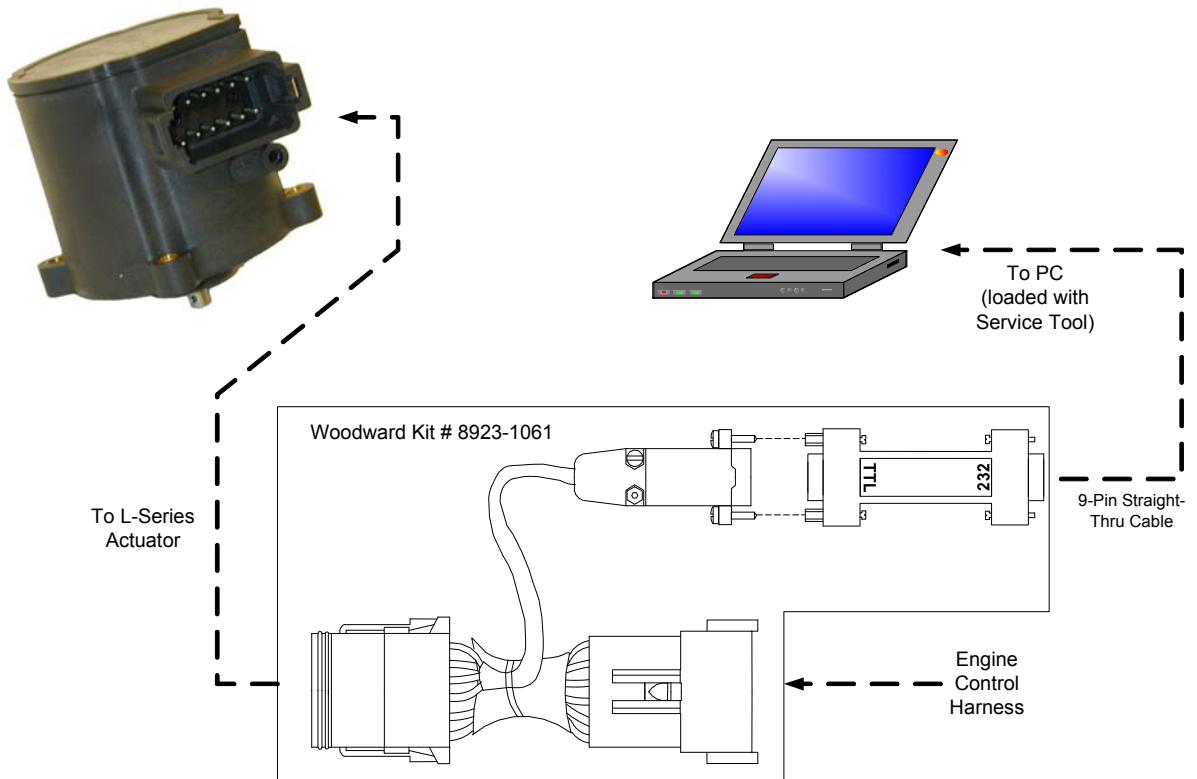
Pinouts Viewed Looking into Control Connector and Computer Connector

Figure 5-2b. Typical Programming Datalink Harness Wiring

Getting Started

Harness Connection

The programming harness is required to communicate with the Service Tool. To install the harness, remove the connector from the L-Series and insert the harness between this connector and the L-Series (see Figure 5-2a).

IMPORTANT	**Connecting the programming harness causes some hardware inputs to cease operating. These include the following commands:** • **front panel stability** • **front panel load limit** • **external boost pressure (4–20 mA)** **Although these hardware inputs are not available when the programming harness is connected, these input commands can be simulated in software using the simulated I/O screen.**
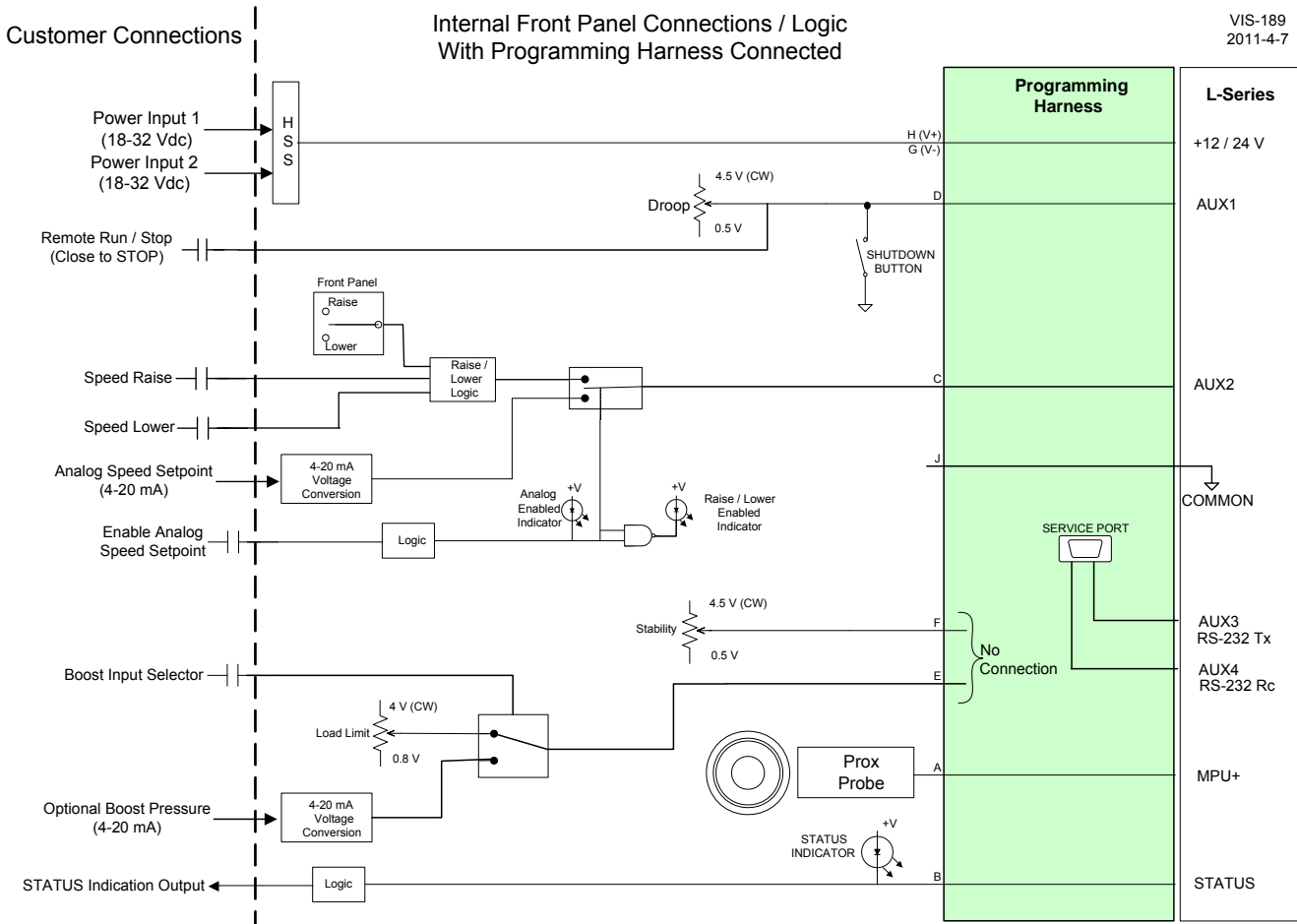
Figure 5-2c. Internal Block Diagram with Programming Harness Connected

Software Installation Procedure

The Service Tool software (entitled UG-25+ governor Service Tool) can be downloaded and installed from the Woodward internet site (**www.woodward.com**).

What to do next
After the software is installed, connect a serial communications cable between the RS-232 connections on the UG-25+ governor and an unused serial port on your computer. Run the Service Tool program and select the appropriate comm port. Once connected to the control, the status bar will display 'connected' and the Service Tool screen will populate with monitor parameters.

⚠ WARNING	An unsafe condition could occur with improper use of these software tools. Only trained personnel should have access to these tools.

Service Tool Help

More help on using Service Tool is available and included with the installation of the Service Tool product. Service Tool Help can be accessed from the Service Tool 'Contents' drop-down window selection under the Help menu located on the Main Window (see Figure 5-1).

Software Version Identification

The Service Tool software version can found by selecting 'About' under the Help menu. The software version is identified as the 'Software Part Number' on the Service Tool screen. The Service Tool and Control must be connected to view this information. Refer to this version information in any correspondence with Woodward.

Service Tool Security

Various levels of security are available to protect application settings. One password is available that provides the ability to inhibit tampering of control settings. The individual protection settings include a general password protection on configuration reading (from the control), configuration loading (to the control), and speed PID tuning.

Monitoring the Governor

The Service Tool has 4 different tab sheets (seen in Figure 5-1) to monitor governor parameters while the engine or steam turbine is running or shut down. The tab sheet screens include:
- Overview (see Figure 5-3)
- Shutdown/Stop (see Figure 5-4)
- Simulated I/O (see Figure 5-5)
- Identification (see Figure 5-6)

Each screen will display the UG-25+ governor control mode, actual speed, speed setpoint, position setpoint, and actual position values.

Control Mode
Displays the state of the UG-25+ governor, the present mode of the unit. Options include:
- Power-down
- Engine Stopped
- Stopping
- Start Fuel 1
- Start Fuel 2
- Ramping
- Running Rated

Speed Setpoint
Displayed value of the speed setpoint (after droop is subtracted) - in engine rpm.

Actual Speed
Displayed value of the actual speed – in engine rpm.
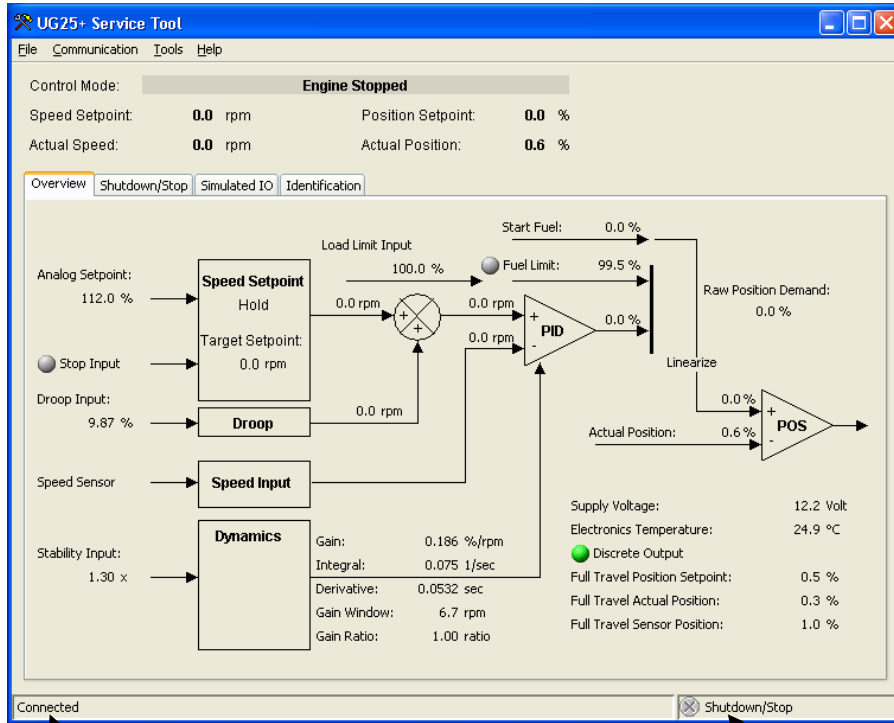
Figure 5-3. Service Tool – Overview Tab

Communication status   **Shutdown/Stop status**

Position Setpoint
Displayed value of the position demand—in percent of full travel (42 degrees).

Actual Position
Displayed value of the actual position—in percent of full travel (42 degrees).

Status Bar Indications
At the bottom of the Service Tool window is a status bar. The status bar has two sections. The bottom left section displays the communication status and bottom right section displays the shutdown status.

Communication Status
This section of the status bar shows the status of communication between the service tool and the device. For more information, see Establishing Communication.
- **Connected**—The Service Tool is connected to and communicating with the driver.
- **Not Connected**—The Service Tool is not connected to the driver.
- **Connecting**—The Service Tool is attempting to connect to the driver. This message is displayed when Connect is selected from the Communications menu or when attempting to re-establish communication to the driver. If the connection is lost it will continuously attempt to re-connect.

Shutdown/Stop Status
One or more faults on the Shutdowns/Stop screen is active.

Overview Parameters Screen
To monitor the overview parameters, go to the Overview page on the main
window. This screen dynamically populates based on the unit's
configuration. If a function is not programmed, then it will not appear.

Supply Voltage
Displayed value of the input power, in volts, as read by the processor.

Electronics Temperature
Displayed value of the electronics temperature sensor, in degrees Celsius,
as read by the processor. The temperature sensor is physically located
between the electronics module and the LAT motor.

Discrete Output
On/Off status of the discrete output command. The indicator is illuminated
when the channel is commanded to ON and grayed-out when the command
signal is OFF.

Full Travel Position Setpoint
Indication of the position setpoint in terms of total overall unit travel. Useful if a
less than full-travel user-calibrated range is used.

Full Travel Actual Position
Indication of the actual position in terms of total overall unit travel. Useful if a less
than full-travel user-calibrated range is used.

Full Travel Sensor Position
Indication of the position in terms of total overall unit travel before linearization.
This value will match the internal Travel Position Sensor (TPS) output.

The actual real-time values of the various parameters are shown on the
functional block diagram. When the engine or turbine is shut down, some of
these parameters are zero.

Shutdown and Stop Indications

The Shutdown / Stop screen displays the status of both active and logged fault
conditions. The logged indications provide a history of events even after the unit
has been powered down and power is reapplied again.

  Indicates a logged shutdown condition.
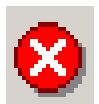
  Indicates an active shutdown condition.

An active fault is one that is currently active or latched in the control. The
latching/non-latching faults configuration setting factors into this indication. If the
fault is latching, then an active fault could either be one that is still present or one
that occurred but has not been reset. Latched faults can be cleared by cycling
power on the UG-25$^+$ governor or by selecting the 'Reset Shutdowns' button on
the Shutdown/Stop screen.

A logged fault is one that occurred but is no longer currently active or latched in
the control. Logged faults are permanently cleared by selecting the 'Reset
Logged Shutdowns' button on of the Shutdown/Stop screen.

Shutdown/Stop Screen

To monitor the shutdown conditions, go to the Shutdown/Stop pages (Figure 5-4) on the main window. The values displayed on the Shutdowns screen dynamically change with the fault configuration. Refer to Chapter 4 for a complete listing and details of all the faults.

A reset command is available on this screen to clear any current faults, if they are latched on. If a fault condition occurred but is no longer present, it will remain as a logged fault until cleared. The 'Reset Logged Shutdowns' command will clear all logged faults.
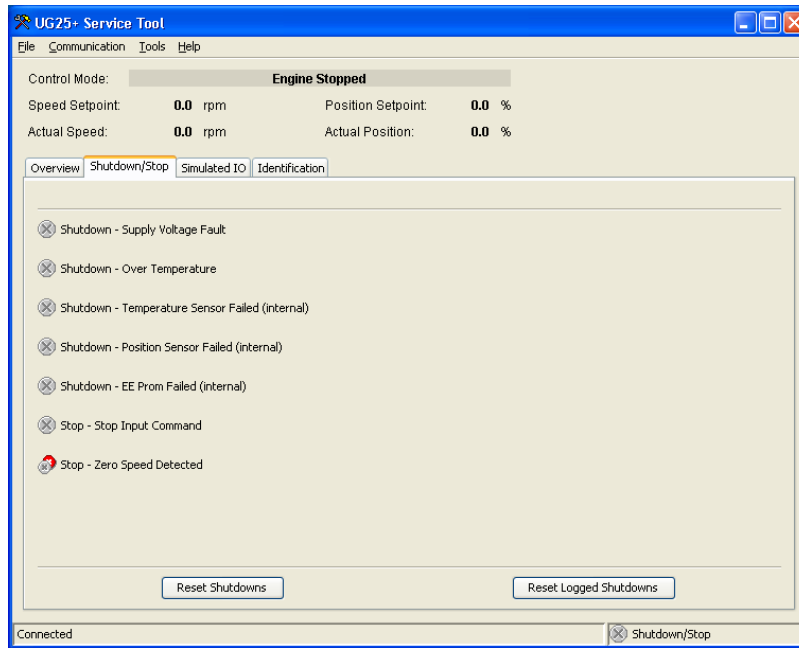
Figure 5-4. Service Tool – Shutdown/Stop Tab

Simulated I/O Screen

While communicating to the service tool, Stability and Load Limit inputs (Aux 3 and Aux 4) are not functional since these input pins are used for both Input and for serial communications. The Simulated I/O screen (Figure 5-5) is provided to facilitate operational testing while connected to the Service Tool.
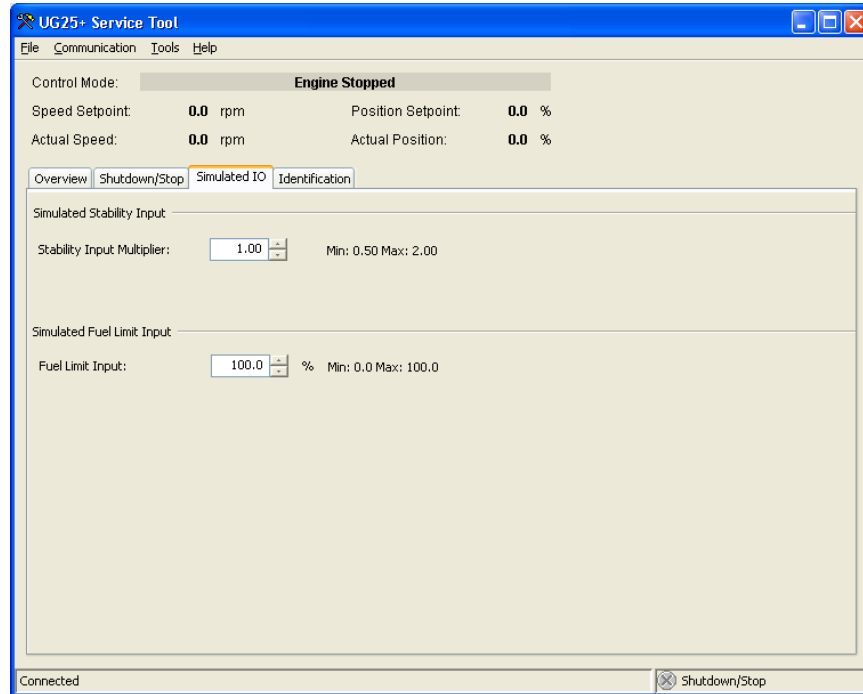
Figure 5-5. Service Tool – Simulated I/O Tab

Identification Screen

To monitor the UG-25⁺ governor product identification, go to the Identification page on the main window. Information displayed includes the part number of the embedded UG-25⁺ governor software and the serial number of the unit.

Figure 5-6. Service Tool – Identification Tab

Chapter 6.
Configuration

Overview

The UG-25+ governor is configured using the Service Tool, refer to Chapter 5 for Service Tool installation and connection instructions.

The UG-25+ governor can be configured either on-line or off-line. On-line configuration can only be performed when the Service Tool is connected to and communicating with the UG-25+ governor. Off-line configuration can be done at any time, however, settings will not take effect until they are loaded into the governor.

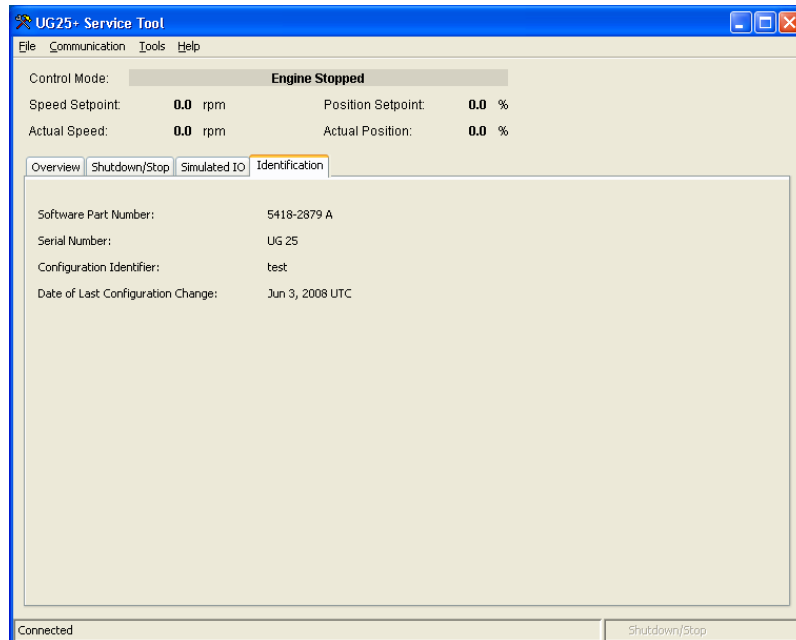| **IMPORTANT**	Many applications are delivered pre-configured, calibrated, and tuned. These units do not require the use of the Service Tool. Configuration reading and loading can be individually password protected for security purposes. If security is applied, these features will not be accessible without the password.

If using dynamics curves or fuel limiting curves, control power must be cycled after loading a new configuration before the new settings will take effect.

⚠WARNING	An unsafe condition could occur with improper use of these software tools. Only trained personnel should have access to these tools.

The current UG-25+ governor configuration settings can be viewed at any time when connected to the control by opening the Configuration Editor (File/Open Control Configuration), assuming password protection is not active. See Figure 6-1.

Configuring the Unit—On-Line

Unit configuration is summarized as follows:
1. Connect to the UG-25+ governor using the Programming Harness (see Chapter 5 for details).
2. Open the Configuration Editor Dialog by selecting 'File/Open Control Configuration'.
3. Edit the configuration settings.
4. Optionally, save the configuration to a file on your PC. Saving the configuration prior to loading it will provide an identifier in the control. Only the first 8 characters are saved in the control, so it is best to ensure these identify the application.
5. Load the configuration to the UG-25+ governor by selecting "Load Configuration File to Control".

IMPORTANT	As changes are made to Configuration parameters, they are not used by the driver until a 'load' command is issued. Selecting the 'Cancel' button closes the Configuration Editor and does not make any changes to the driver.

Configuring the Unit—Off-Line

Unit configuration is summarized as follows:
1. Open the Configuration Editor Dialog using the File/New or File/Open options.
2. Edit the configuration settings.
3. Save the configuration to a file. At a later date simply open the configuration and load it into the control. Only the first 8 characters are saved in the control, so it is best to ensure these identify the application.
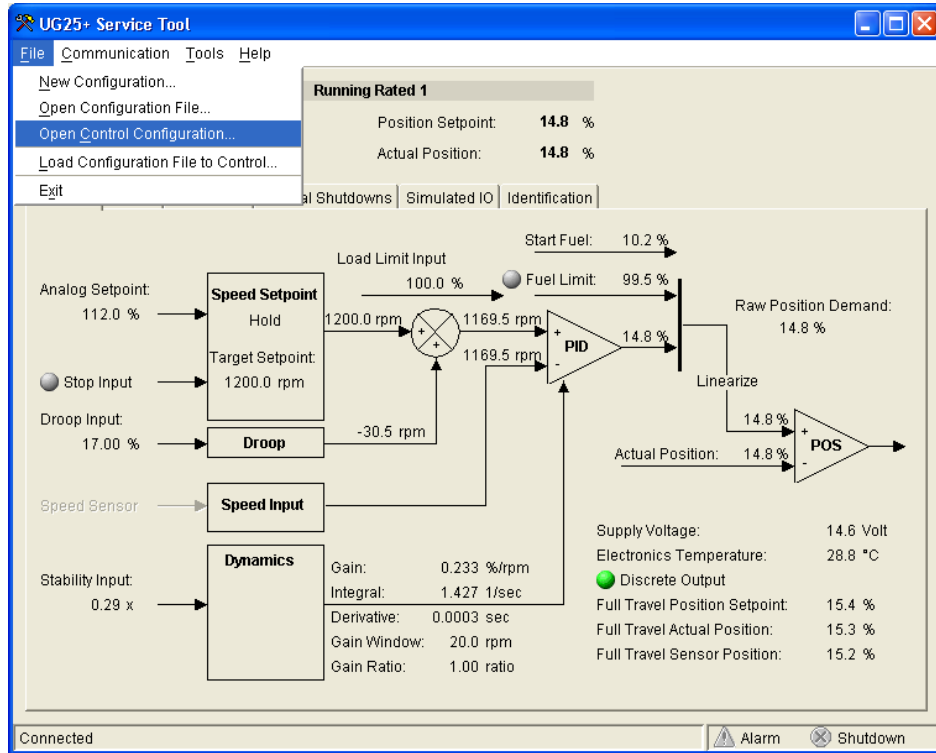
Figure 6-1. Configuration Selection Options

Application File Data

The OEM or customer can save configuration file specific data with the service tool by selecting Properties under the File menu pull down. This is a text field and can be used to store data such as:
- Customer
- Engine Type
- Application Type
- Notes
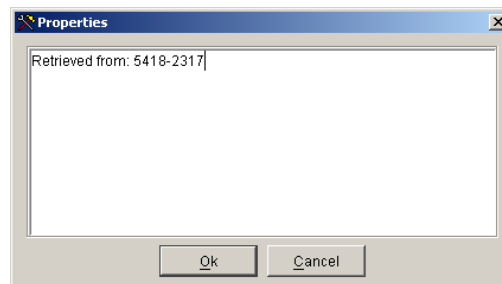
Configuration Parameters

There are 5 different screens that display/set the configuration settings in the UG-25+ governor: Overview, Setpoint, Fuel Limiting, Dynamics, and Security.

Overview Tab

The overview tab provides speed sensing and position controller configuration settings.
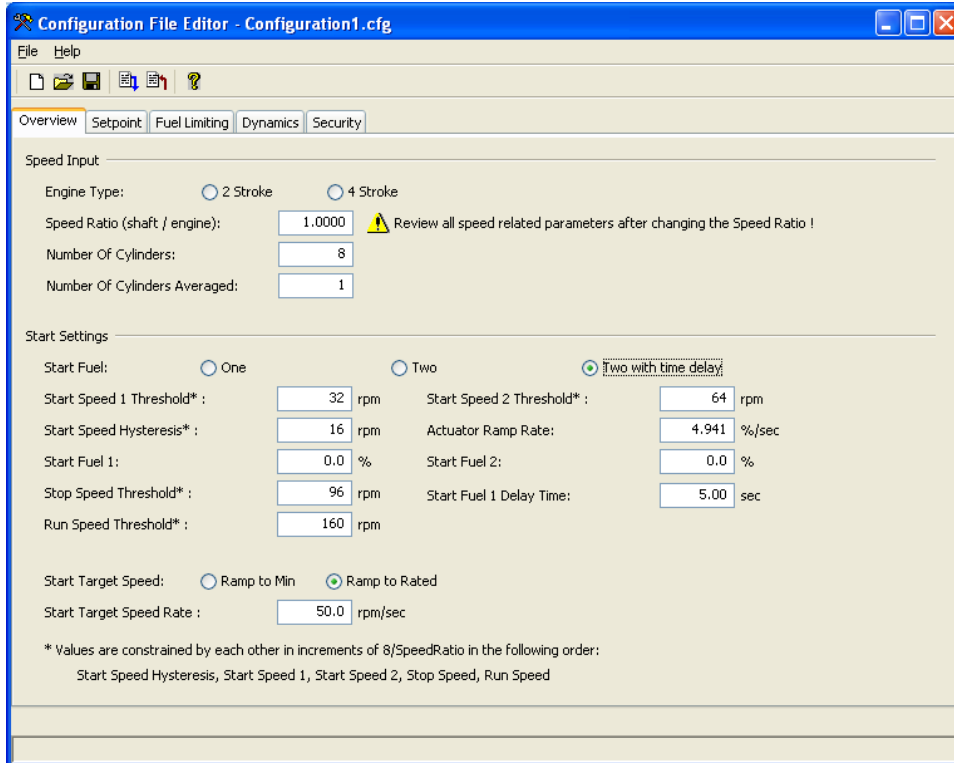
Figure 6-2. Configuration Editor – OVERVIEW TAB

Speed Input Configuration Settings

Engine Type
Set to either 2-stroke or 4-stroke.

Speed Ratio (shaft to engine speed)
Set the governor drive ratio between UG-25+ governor shaft speed (governor speed) and actual engine speed. This parameter sets the relationship between the speed of the governor (UG-25+ governor shaft speed) and actual engine speed (governor speed/engine speed). All speed values shown on the software service tool are engine speed values. When set to '1', all speed settings will be displayed in terms of governor shaft speed. Allowed values: 0.0625 – 50.

Number of Cylinders
Sets the number of cylinders.
Allowed values: 1 – 20.

IMPORTANT | **Allowed adjustment ranges are displayed in the lower left corner of the window when an adjustable parameter is selected.**

Number of Cylinders Averaged
Sets the number of cylinders to be averaged by the speed sensing algorithm. This setting is used as a filter to minimize the effects of firing torsionals that occur normally in reciprocating engines. A lower value gives less filtering, producing higher steady-state speed variation but allowing a higher speed control gain setting for better transient response. A higher value produces less steady-state speed variation with correspondingly slower transient response. If unsure, set this to either '1' or half the 'Number of Cylinders' for a 4-stroke. On a 2-stroke engine, '1' or 'Number of Cylinders' are good choices.

For uneven firing patterns, 'Number of Cylinders Averaged' should be selected to eliminate repeating torsionals. If cylinder firings are paired, 'Number of Cylinders Averaged' should also be paired (2, 4, 6, …). If unsure, set to 'Number of Cylinders'.

Allowed values: 1 to 'Number of Cylinders'.

IMPORTANT	Steam Turbine applications settings should be 2-stroke, 1:1.0 Speed Ratio, 1 cylinder, and 1 cylinder averaged. For these applications all configured and displayed speed values will be in terms of governor (shaft) speed, not engine speed.

The UG-25$^+$ governor speed settings must follow the following general order.
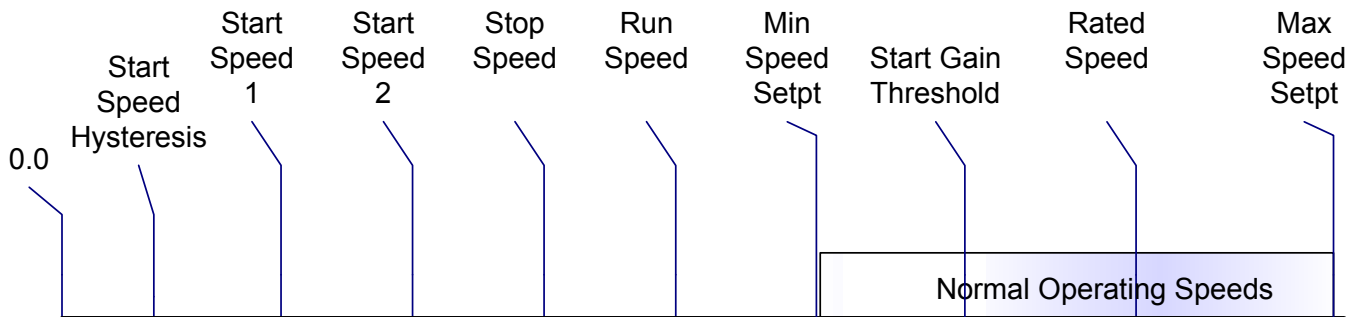
Starting the Engine

The engine starting sequence will look like this, if no errors are detected:

While stopped, make sure the Run/Stop input is in the RUN position. Start (crank) the engine. When the engine speed increases above the Start Speed 1 Threshold, the governor will go to the Start Fuel 1 position demand. If two start fuel positions are used, as the engine speed increases above the Start Speed 2 Threshold, the governor will go to the Start Fuel 2 position demand. At this point the governor is still running open loop, the speed control PID is not controlling the governor position. Once the engine speed is above the run speed threshold, the governor will bumplessly switch from start fuel demand to the fuel demand from the speed PID. At this point the unit is in speed control, and the UG-25$^+$ governor will control the engine as determined by the speed setpoint. The speed setpoint will ramp up to the configured control speed, rated or minimum speed setpoint. From this point the speed setpoint can be adjusted as needed using either raise/lower commands or the analog speed setpoint.

If an error is detected, the control will go to the stopping state. Once the engine speed decreases to zero rpm, the unit will be in the stopped state.

> **⚠ WARNING**
>
> **The UG-25$^+$ governor is not equipped with an overspeed trip function. 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.**

Engine Start Settings

> **IMPORTANT**
>
> **All speed settings are in terms of engine speed and all position settings are in terms of percentage of full (42 degrees) shaft rotation. Speed values and adjustment increments are listed in terms of governor shaft speed with a Speed Ratio of 1.0, and will vary with the Speed Ratio setting.**

Start Fuel Selection
Set to either one start fuel setting or 2 start fuel settings with a ramp between the settings. A single start fuel is suitable for most applications. With this configuration, the fuel demand immediately switches to the Start Fuel 1 setting when the engine speed has exceeded the Start1 Speed setting.

Dual start fuel configuration is appropriate for engines that need a rather high fuel setting to start the engine, but a much lower setting immediately thereafter to minimize speed overshoot, minimize black smoke, or to prevent an overspeed shutdown.

Start Speed 1 Threshold
Start Speed 1 Threshold is set below the starter speed. Once this threshold is exceeded, the control determines a start is in progress and opens the governor to the start fuel setting. At this point the governor state changes from 'Stopped' to 'Start Fuel 1'. Typical value is 64 rpm (engine) to detect engine cranking. Allowed values: between 0 and 'Stop Speed Threshold' but must be less than 'Start Speed 2 Threshold' (if used). Adjustment Increment: 8 rpm (governor shaft).

Start Speed Hysteresis
Hysteresis is provided for the start speed threshold to ensure that a normal amount of variance in engine speed while in the Start Fuel State does not cause the control to enter the Stopping state. After the control has reached the Start Fuel state, it will go to the Stopping state if engine speed drops below the (Start Speed 1 Threshold – Start Speed Hysteresis) value.
Allowed values: 50% of 'Start Speed 1 Threshold' to 'Start Speed 1 Threshold'.
Adjustment Increment: 8 rpm (governor shaft).

Start Fuel 1
Specifies the maximum permitted shaft position when the governor state is 'Start Fuel 1'. Typical value is the same as the full load governor position.
Allowed values: 0 – 100 % of full 42 degree shaft rotation.

Start Speed 2 Threshold
Specifies the speed at which the Governor State changes from 'Start1' to 'Start2.' Typical value is 50% of the lowest speed reference. Only displayed if two start fuel limits are configured.
Allowed values: Must be between 'Start Speed 1 Threshold' and the 'Stop Speed Threshold'. Adjustment Increment: 8 rpm (governor shaft).

Start Fuel 2
Specifies the maximum permitted shaft position when the governor state is 'Start Fuel 2'. Only displayed if two start fuel limits are configured.
Allowed values: 0 – 100 % of full 42 degree shaft rotation.

Actuator Ramp Rate
Specifies the rate, in governor output shaft position %/second, the control will move the governor position from the Start Fuel 1 to the Start Fuel 2 position. If the ramp rate is set to its maximum value, the change to the second start fuel setting is nearly instantaneous, essentially eliminating the ramp feature. Only displayed if two start fuel limits are configured.
Allowed values: 0.235 – 200 %/second

Stop Speed Threshold
Specifies the speed at which the Governor State changes from 'Stopping' to 'Stopped'. If the engine is stopped by a shutdown, the control will go to the Stopping state and the engine must stop before proceeding to any other state. If the engine is stopped by the Run Enable input, the control will again go to the Stopping state. In this case, however, if engine speed is still above the Stop Speed Threshold, making the Run Enable switch active again will allow the control to go directly back to the running state. Below the Stop Speed Threshold, the control will not allow a coast-down restart of the engine.
Allowed values: Must be greater the 'Start Speed Threshold' and less than 'Run Speed Threshold'. Adjustment Increment: 8 rpm (governor shaft).

Run Speed Threshold
Specifies the speed at which the Governor State changes from 'Start Fuel' to 'running.' Typical value is 90% of the lowest speed reference. If the engine speed is above the Run Speed Threshold, the control will switch to one of the running states and start using the speed control to drive the governor position demand up to the configured Start Target Speed setpoint.
Allowed values: Must be greater than 'Stop Speed Threshold' and less than 'Min Speed Setpoint'. Adjustment Increment: 8 rpm (governor shaft).

Start Target Speed Selection
Sets the desired speed setpoint at the conclusion of the start sequence. The 2 options are either Rated Speed or Min Speed Setpoint – both of these are set on the Setpoint tab.

Start Target Speed Rate
Specifies the ramping rate for the speed setpoint from Run Speed up to the specified Start Target Speed setpoint. Allowed values: 0.2 – 500 rpm/second (governor shaft).

Start Fuel 1 Delay Time
Sets the time delay at the start fuel 1 limit prior to ramping to the start fuel 2 limit. Only displayed if start fuel is configured as 'Two with time delay'. Allowed values: 0.1 – 429 seconds.

Setpoint Tab

The Setpoint tab provides the speed setpoint configuration settings.
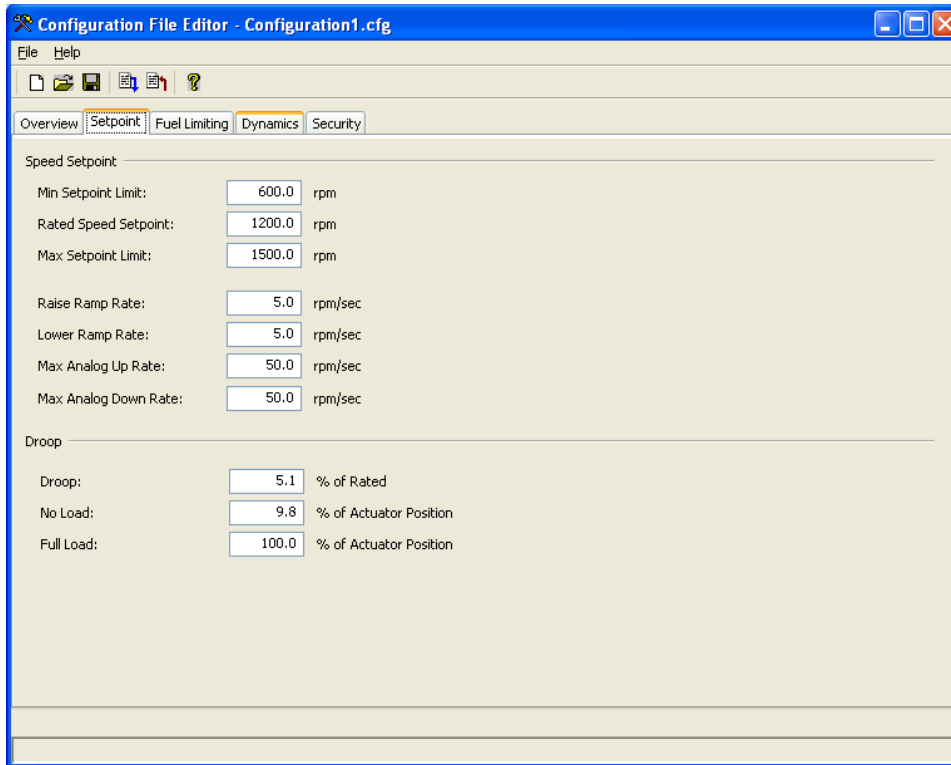
Figure 6-3. Configuration Editor—SETPOINT TAB

Min Setpoint Limit
Specifies the lowest desired speed setpoint possible that can be adjusted with the Raise/Lower Adjust or Analog functions. Allowed values: From 'Run Speed' to the 'Rated Speed Setpoint'.

Rated Speed Setpoint
Sets the Rated Speed Setpoint. Allowed values: From the 'Min Setpoint Limit' up to the 'Max Setpoint Limit'.

Max Setpoint Limit
Specifies the highest desired speed setpoint possible that can be adjusted with the Raise/Lower Adjust or Analog functions. Allowed values: From the 'Rated Speed Setpoint' up to 4080 rpm, but must be less than the factory set/installed pump speed limitation. Existing pump speed limits are 1700 and 1200 rpm (governor shaft), but are subject to change.

Raise Ramp Rate
Specifies the ramping rate for the speed setpoint Raise function. Allowed values: 0.2 – 500 rpm/second (governor shaft).

Lower Ramp Rate
Specifies the ramping rate for the speed setpoint Lower function. Allowed values: 0.2 – 500 rpm/second (governor shaft).

Max Analog Up Rate
Specifies the maximum rate allowed for the speed setpoint Analog adjust
function in the increase direction. Allowed values: 0.2 – 500 rpm/second
(governor shaft).

Max Analog Down Rate
Specifies the maximum rate allowed for the speed setpoint Analog adjust
function in the decrease direction. Allowed values: 0.2 – 500 rpm/second
(governor shaft).

IMPORTANT	**It is recommended the Max Analog Rate settings be set to values that will prevent overshoot and possible overspeed on enabling of the Remote Input.**

Droop
Specifies the nominal droop as a percentage of the Rated Speed Setpoint value.
Allowed values: 0 – 100 % of Rated.

No Load
Sets the no load shaft position for the droop function. Below this shaft position
the droop is zero. Allowed values: 0 – 100 %.

Full Load
Sets the full load shaft position for the droop function. Allowed values: "No Load'
setting to 100%.

⚠WARNING	**The UG-25^{+} governor is not equipped with an overspeed trip function. 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.

Fuel Limiting Tab

The fuel limiting tab provides run time and boost fuel limiting configuration settings.

Fuel Limiting Settings

Maximum Fuel Limit
Sets the maximum permitted shaft position. Allowed values: 0 – 100 % of full 42
degree shaft rotation.

Fuel Limit Input Selection
Selects between the Boost Input Curve (analog input) vs front panel Load Limit
potentiometer. This selection must be done in conjunction with the wiring option
to properly select the desired input (see Load Limit/Boost Pressure Select
discrete input in the wiring section).
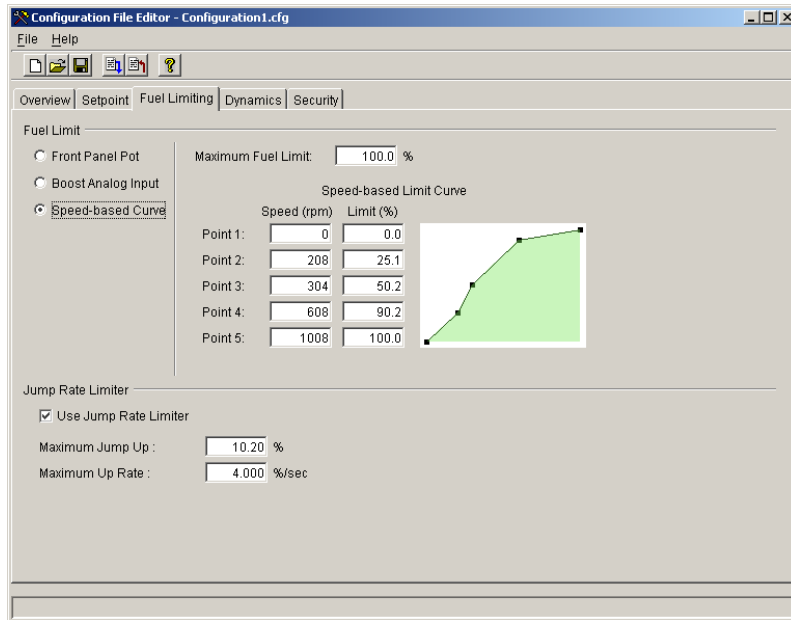
Figure 6-4. Configuration Editor– Fuel Limiting Tab

Boost Fuel Limiting Curve Settings
These settings are only displayed when the Fuel Limit Input selection is set to 'Boost Analog Input'.

Boost (%)
Fuel limit curve inputs. Allowed values: 0 –100 % of full analog input range (4 mA is 0% and 20 mA is 100%). Each point [5] must be larger than the previous and less than the next value, in increments of 1.2%.

Limit (%)
Fuel Limit curve outputs. Sets the maximum governor positions [5] based on the boost analog input. Allowed values: 0 – 100 % of full 42 degree shaft rotation.

Speed-based Curve Settings

These settings are displayed when the Fuel Limit selection is set to 'Speed-based Curve'.

Speed (rpm)
Fuel Limit curve input breakpoints, in rpm. Allowed values: 0–4080 rpm. Each point [5] must be larger than the previous value and less than the next value, in increments of 16 rpm (governor shaft).

Limit (%)
Fuel Limit curve outputs, in percentage. Sets the maximum governor positions [5] based on engine speed. Allowed values: 0–100% of full 42 degree shaft rotation.

Jump Rate Limiter Settings

The Jump Rate Limiter can be used limit the increasing fuel position output to prevent excessive emissions.

Use Jump Rate Limiter
Enables or disables the jump rate limiter function. If used, "jump up" and "up rate" limit are available.

Max Jump Up
Specifies the ramping rate for the speed setpoint Raise function. These settings are only displayed when the 'Use Jump Rate Limiter' option is selected. Allowed values: 0 – 100 % of full 42 degree shaft rotation.

Max Up Rate
Specifies the max governor output rate in the increasing direction. ramping rate for the speed setpoint Lower function. These settings are only displayed when the 'Use Jump Rate Limiter' option is selected. Allowed values: 0.235 – 200 %/second.

Dynamics Tab

The Dynamics tab provides speed controller dynamics settings. The dynamic settings can also be adjusted from the Edit Speed Dynamics screen during run-time.

See Chapter 7 (Speed PID Tuning) for a description of the terms used in the Dynamics tab.
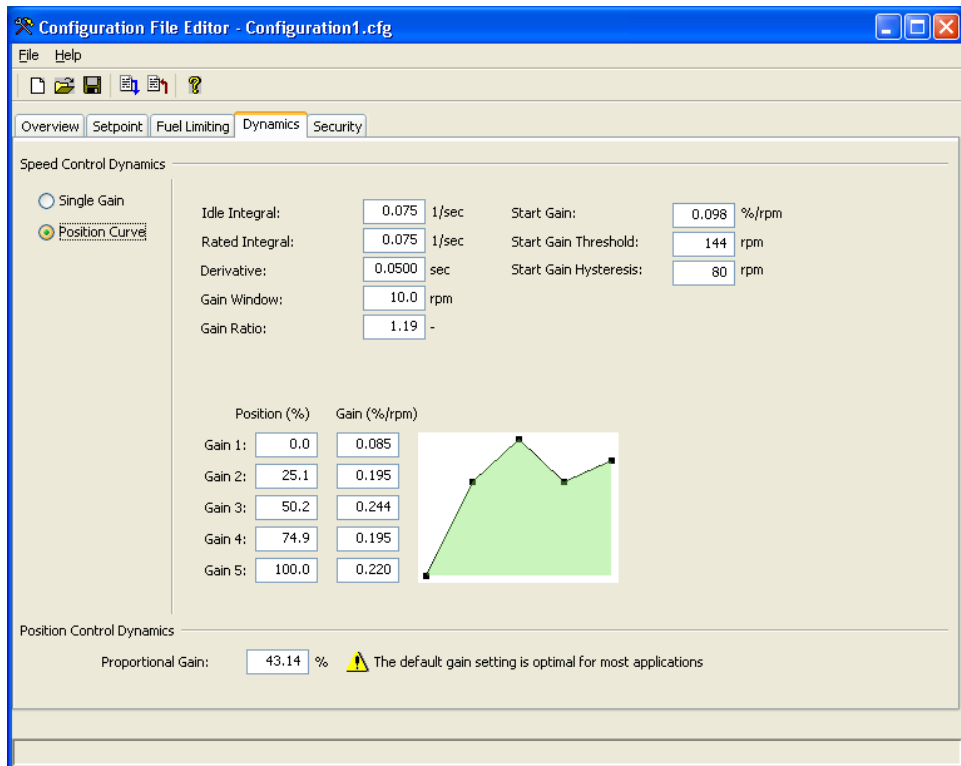
Figure 6-5. Configuration Editor–Dynamics Tab

Speed Controller Dynamics Settings

Single Gain or Position Curve—selects the type of P-gain term used in the PID.

Single Gain is a single speed gain term which remains constant and does not vary with engine speed or load. These are simple dynamics that suit most constant speed applications. Rated dynamics are typically used on engines that operate continuously at rated speed or on variable speed engines that tend to be stable at all speeds with constant dynamic settings.

Position Curve adjusts the gain term based on governor output shaft position using a 5-pt curve. Fuel demand is roughly proportional to load but not necessarily in a linear manner. A 5-breakpoint gain curve is provided to map gain versus fuel demand. Gain is applied linearly between breakpoints. A common gain setting is also provided to shift all gain curve gains higher or lower. This gain curve is particularly useful for non-linear fuel systems (for example, intake butterfly valves).

Start Gain
Sets the gain to be used during a start. Typically this is set to a lower than normal gain value. The Start Gain Threshold and Hysteresis are used to select the Start Gain. Allowed values: 0 – 3.114 %/rpm.

Start Delay
Sets the number of seconds the Start Gain is used during a start. To disable the Start Gain, set the Timer to zero. Allowed values: 0 – 300 seconds.

Start Gain Threshold
Sets the speed threshold for the Start Gain, which is the speed controller gain used during a start. The Start Gain is active until the Start Gain Threshold is exceeded at which point it will use the configured gain (Rated or Rated Curve) based on the Single Gain or Position Curve selection. The Start Gain is re-activated if the speed drops below the Start Gain Threshold minus the Start Gain Hysteresis. Allowed values: 'Run Speed Threshold' (Overview tab) to 'Min Setpoint Limit' (Setpoint tab). Adjustment Increment: 8 rpm (governor shaft).

Start Gain Hysteresis
Sets the amount of hysteresis, in rpm below the Speed Threshold, before re-activating the Start Gain. Below this speed setting (Threshold – Hysteresis), the Start Gain is active. Allowed values: 0 to 'Start Gain Threshold'. Adjustment Increment: 8 rpm (governor shaft).

Idle Integral
Speed control nominal PID integral term at Idle (run speed threshold), in repeats per second. The integral gain value is interpolated between Idle and Rated based on the speed setpoint. In addition, the value is manipulated by the front panel Stability pot, and will be equal to the nominal setting when the pot is in mid position. The actual 'used integral gain' can be viewed on the Overview tab of the Service Tool. Allowed values: 0 – 19.15 repeats/second.

Rated Integral
Speed control PID integral term at or above the configured Rated speed setpoint, in repeats per second. The actual 'used gain' is manipulated by the front panel Stability pot, and will be equal to the nominal setting when the pot is in mid position. Allowed values: 0 – 19.15 repeats/second.

Derivative
Speed control PID derivative term in seconds. Allowed values: 0 – 0.1036 seconds.

Gain Window
Speed control PID gain window, in rpm. When the speed error is greater than the window, the proportional Gain is multiplied by the Gain Ratio. Allowed values: 0 – 255 rpm.

Gain Ratio
Speed control PID gain ratio. When the speed error is greater than the window, the proportional Gain is multiplied by the Gain Ratio. Allowed values: 1 – 15.

Proportional Gain
Speed control nominal PID proportional gain term. This setting is only displayed when 'Rated' dynamics mode is selected. The actual 'used gain' is manipulated by the front panel Stability pot, and will be equal to the nominal setting when the pot is in mid position. Allowed values: 0 – 3.114 %/rpm.

Position (%)
Position breakpoints for the gain curve. These settings are only displayed when 'Rated Curve' is selected. Allowed values: Each point [5] must be larger than the previous and less than the next value, in increments of 0.4%.

Gain (%/rpm)
Sets the nominal PID proportional gain value [5] based on the position. These settings are only displayed when 'Rated Curve' is selected. The actual 'used gain' is manipulated by the front panel Stability pot, and will be equal to the nominal setting when the pot is in mid position. Allowed values: 0 – 3.114 %/rpm.

Position Controller Dynamics – Proportional Gain (%)
Sets the Position Controller PID proportional gain value. Note that the default gain setting is optimal for must applications. Increased gain corresponds to increased PID output (higher proportional = faster response). This setting is not affected by the front panel Stability pot. Allowed values: 25.88 – 60 %.

Security Tab

The security tab provides the security configuration settings. To use any security, the Read Configuration security must be configured for use. Once selected, the Security Password must be set (Figure 6-7). One common password is used for all security selections (password is case-sensitive). The password entry is prompted (Figure 6-8) whenever a secured function is selected by the user.
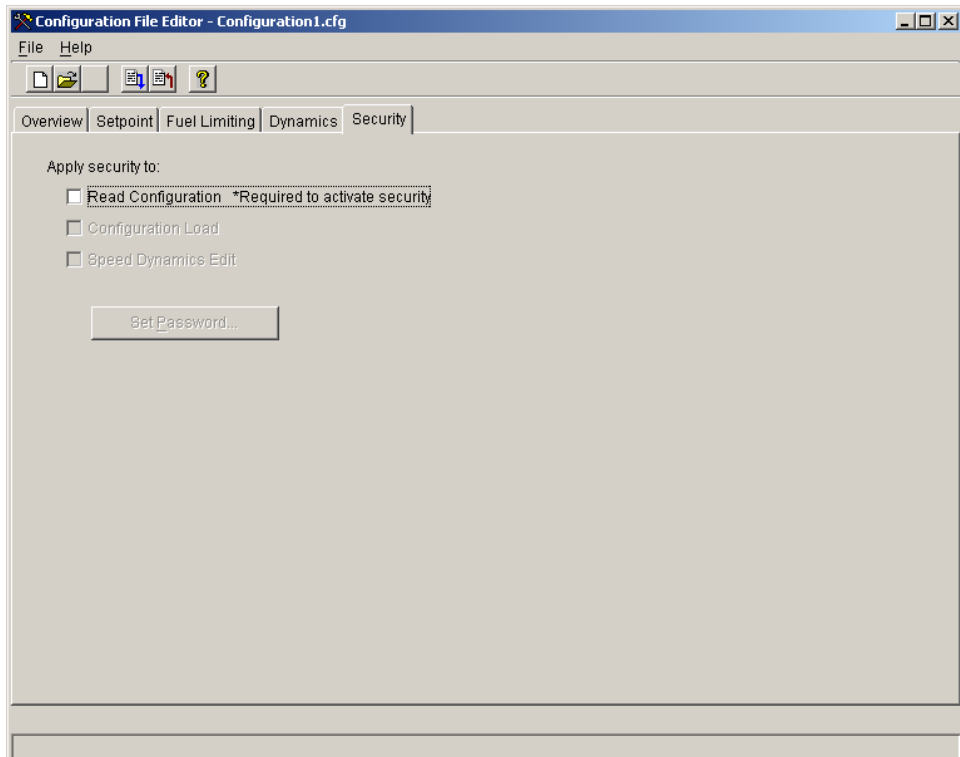
Figure 6-6. Configuration Editor– Security Tab

Security Configurations

All checked features will have the security password enforced prior to allowing the function. Unchecked features will not be prompted with a password.

Read Configuration
When checked, requires a password before the configuration can be read from the UG-25⁺ governor (protects Open From Control execution).

Configuration Load
When checked, requires a password before a configuration can be loaded into the UG-25⁺ governor (protects Load to Control execution).

Speed Dynamics Edit
When checked, requires a password before allowing tuning to the speed PID (protects Edit Speed Dynamics screen).
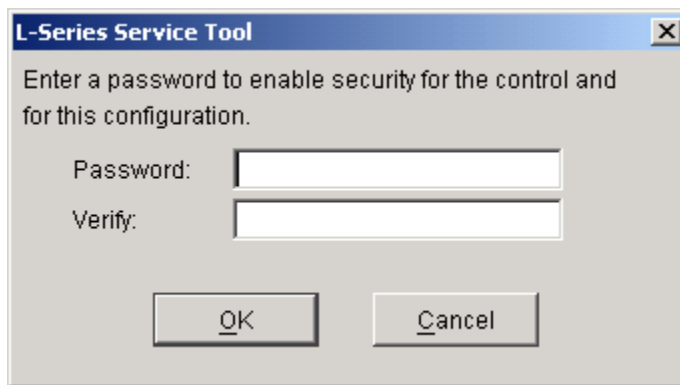
Figure 6-7. Security tab Set Password Pop-up
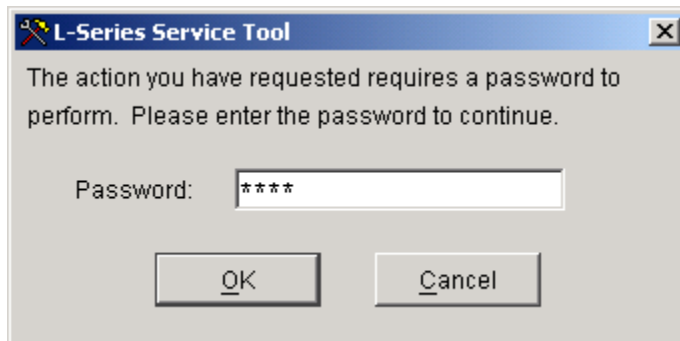
Figure 6-8. Password Entry Prompt

Loading the Configuration (Save)

Select the File/'Load to Control' option from the menu or Blue Arrow icon on the Configuration Editor to load the changes into the control. The UG-25$^+$ governor speed must be zero prior to allowing a 'Load' command. This feature can be optionally password protected.
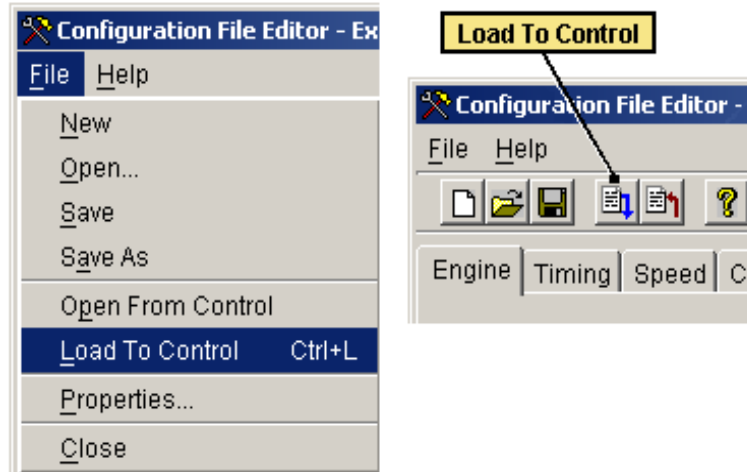
Load Configuration File to Control
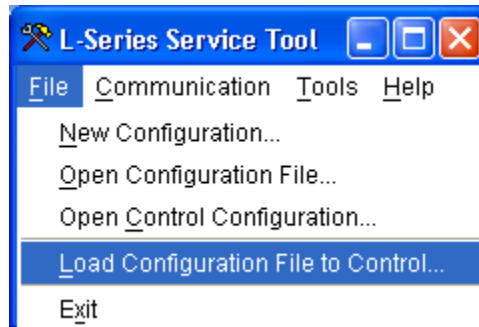
Figure 6-9. Direct Load of Configuration File

The 'Load Configuration File to Control' option under the Run screen File menu allows loading a configuration file to a control without opening it. Thus, a password protected configuration file can be downloaded without entering the password while preserving the configuration's security.

If you are downloading a configuration to a control that already contains a configuration with password protection enabled for configuration loads, you will need to use that password.

Configuration Checks

Whenever a configuration is saved or loaded to the control, some basic checks are performed. This check cannot determine if the values are realistic, but it makes sure that values are loaded into the required parameters. If an error is found, the Service Tool will not allow the load or save function to be performed until the error is corrected.

1. **Speed range exceeds governor limits (Max Setpoint Limit setting)**. The setting for Max Setpoint Limit (on the Setpoint tab) must be less than the Max Pump Speed Limit or this Configuration Error message is displayed. Since the Pump Size is based on the installed UG-25⁺ governor pump size, this check is only done when a Load to Control is selected.
2. **Run Speed > Min Speed Setpt**. The setting for Run Speed Threshold (Overview tab) must be less than the Min Setpoint Limit (Setpoint tab) or this configuration error message is displayed.
3. **Speed sensing/filtering limits exceeded**. Try reducing the Number of Cylinders Averaged . This error message is displayed when the settings exceed control limits. The limit is determined by Service Tool calculations and based on the speed input settings of stroke, gear ratio, number of cylinders and number of cylinders averaged.
4. **Start Gain Threshold exceeds Rated Speed Setpt**. The setting for the Start Gain Threshold (Dynamics tab) must be less than the Rated Speed Setpoint (Setpoint tab) or this configuration error message is displayed.

Chapter 7.
Speed PID Tuning

Introduction

The UG-25⁺ governor is configured using the Service Tool, refer to Chapter 5 for Service Tool installation and connection instructions. This chapter covers the process of tuning and servicing the control via the UG-25⁺ governor Service Tool. It is assumed that the control has already been installed on the engine.

An application requires the following setup steps. In many applications these steps have already been performed by the OEM.

Configure the UG-25⁺ governor (configuration is covered in Chapter 6).
Tune the Speed controller loop PID for each application.

In addition, jump and rate limit settings and the position controller proportional gain term can be adjusted to meet application requirements.

IMPORTANT	**Setup and tuning features can be individually password protected for security purposes. If security is applied, these features will not be accessible without the password.**

IMPORTANT	**Many applications are delivered pre-configured, calibrated, and tuned. For most applications, the default gains do not need to be changed.**

⚠WARNING	**An unsafe condition could occur with improper use of these software tools. Only trained personnel should have access to these tools.**

NOTICE	**When the Service Tool programming harness is connected, the speed setpoint (raise/lower/analog) and load limit functions are no longer available. However, simulation of these functions is provided in the Service Tool software.**

The Service Tool can be used to tune the Speed PID or to just trend/monitor the speed PID output. The Speed PID Dynamics screen (Figure 7-1a & b) is opened by selecting 'Edit Speed Dynamics' under the 'Tools' menu (Figure 5-1).

Pressing the Properties button pops open the Properties Window. From this window the user can adjust the trending window properties including the speed range, update rate and display range.
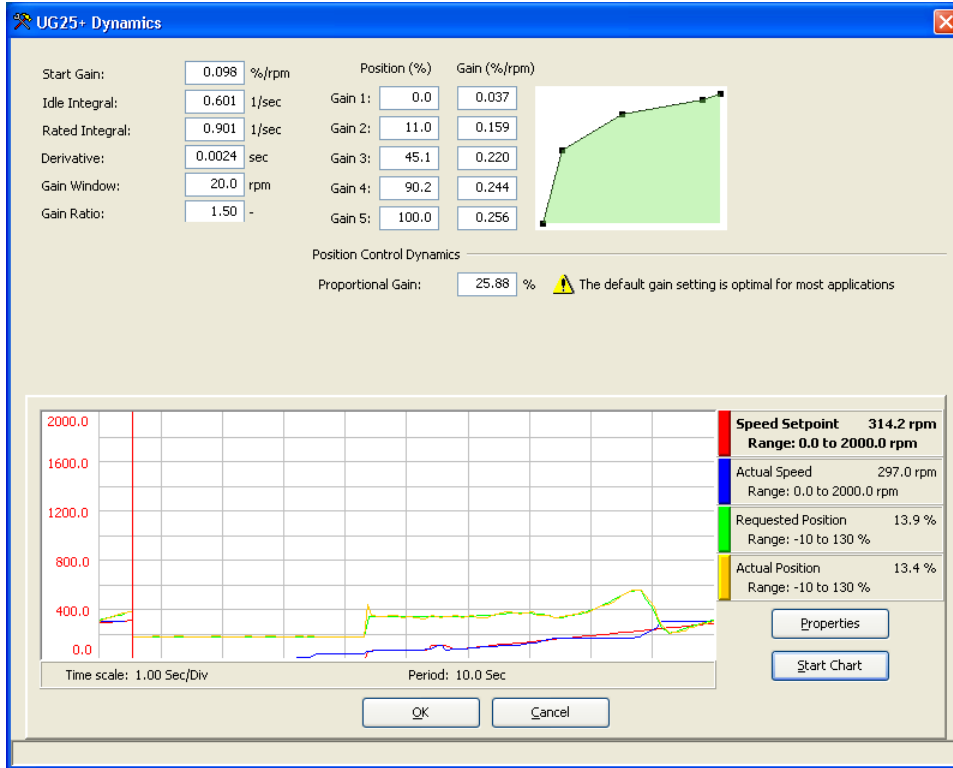
Figure 7-1a. Service Tool – Speed Dynamics Position Curve
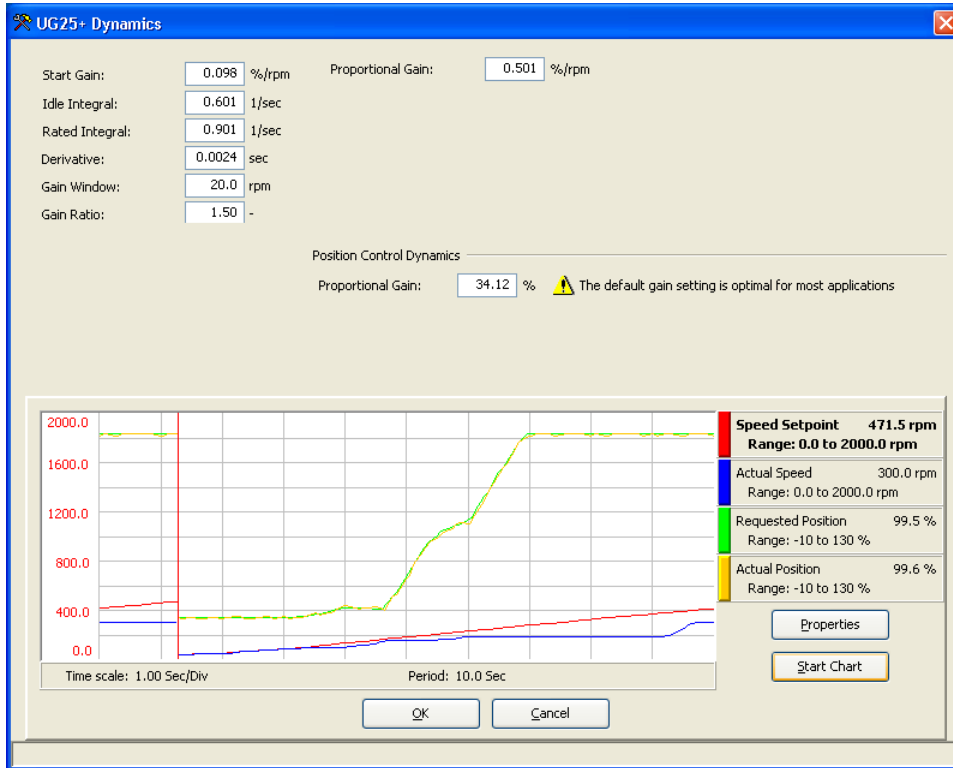
Figure 7-1b. Service Tool – Speed Dynamics Single Gain

IMPORTANT   **If the dynamics curve inputs (position values) are changed, the values are not applied until the OK button is selected.**

Adjusting Trend Settings

Pressing the Properties button pops open the Properties Window (Figure 7-2). From this window the user can adjust the trending window properties including the update rate and display range.
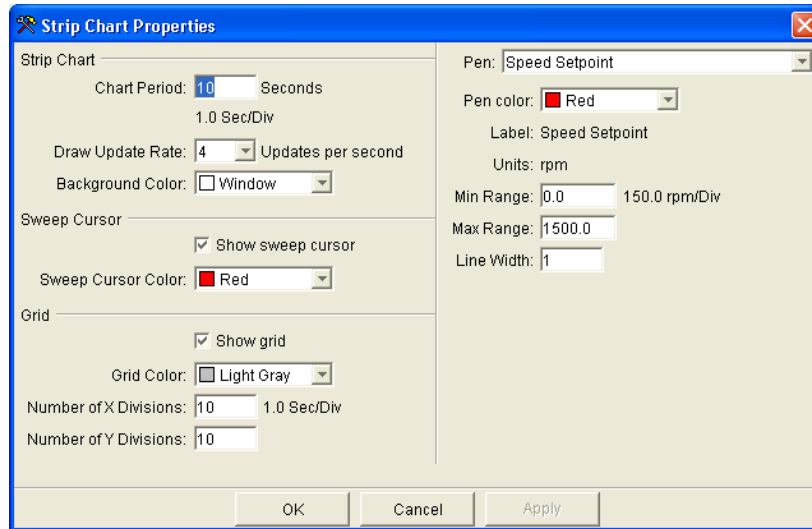
Figure 7-2. Service Tool – PID Tuning Properties Window

Each trend line, called pens, can be individually modified from the Properties window. To change the properties of a trend, select the pen from the drop-down window. The color, range, and line width of each pen can be modified.

Speed PID Dynamic Settings

The Speed loop utilizes a PID controller. The response of this control loop can be adjusted for optimum response, however it is important to understand what a PID controller is and the effect each controller adjustment has on the controller response. Proportional gain (P), integral gain (I), and derivative (D) are the adjustable and interacting parameters used to match the response of the control loop with the response of the system.

Proportional Control

Proportional response is directly proportional to a process change.
Analogy: Setting the throttle on an automobile to keep constant speed on a straight and level road.
Proportional control (using the same analogy) results in a certain speed as long as the automobile is not subjected to any load change such as a hill. If a throttle is set to any particular setting, the speed of the automobile will remain constant as long as the automobile remains on a straight and level road. If the automobile goes up a hill, it will slow down. Of course, going down a hill the automobile would gain speed.

Integral Control

Integral compensates for process and setpoint load changes.
Analogy: An automobile's cruise control maintains the automobile's constant speed regardless of hills.
Integral, sometimes called reset, provides additional action to the original proportional response as long as the process variable remains away from the setpoint. Integral is a function of the magnitude and duration of the deviation. In this analogy the reset response would keep the automobile's speed constant regardless of the terrain.

Derivative

Derivative provides a temporary over-correction to compensate for long transfer lags and reduce stabilization time on process upsets (momentary disturbances).
Analogy: Accelerating an automobile into the high speed lane with merging traffic.
Derivative, sometimes called "preact" or "rate", is very difficult to draw an accurate analogy to, because the action takes place only when the process changes and is directly related to the speed at which the process changes. Merging into high speed traffic on a highway from an "on" ramp is no easy task and requires accelerated correction (temporary overcorrection) in both increasing and decreasing directions. The application of brakes to fall behind the automobile in the first continuous lane or passing gear to get ahead of the automobile in the first continuous lane is derivative action.

Proportional Response

The amount of controller change is directly related to the process change and the Proportional gain setting on the controller; Controller output change is Proportional to the process change. If there is no process change, there is no change in output from the controller (or valve change) regardless of the deviation. This results in an undesired offset between the original desired Setpoint and the resulting drop in the Control Point.

Figure 7-3 shows the effect of Proportional gain settings on control. Starting at the top of the graph a load change is introduced. With a small Proportional gain (meaning a large process change is required to produce full valve travel), stability is good but offset is very high. With a moderate gain setting (higher number setting) stability is still good - offset is still fairly high. With a high setting, offset is considerably smaller but the stability is poor. The 0.25 ratio effects a minimum area whereby the offset is reduced to a minimum while stability is in a decaying manner at 0.25% ratio. The decay ratio used (0.25%) means that if the second cycle is 1/4 of the first cycle, then each succeeding cycle will be 1/4 of the preceding cycle until the cycle is not visible.

Since Proportional gain is adjusted to produce (only) the proper stability of a process, do not continue increasing its effect to correct offset conditions. The amount of stability and offset is directly related to the setting of the Proportional setting. Stability is of course also affected by the stability of the process. In essence, the amount of output from the controller due to the Proportional setting is from the error. If there is no error, then there is no Proportional effect.

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830-360
92-08-03 DAR
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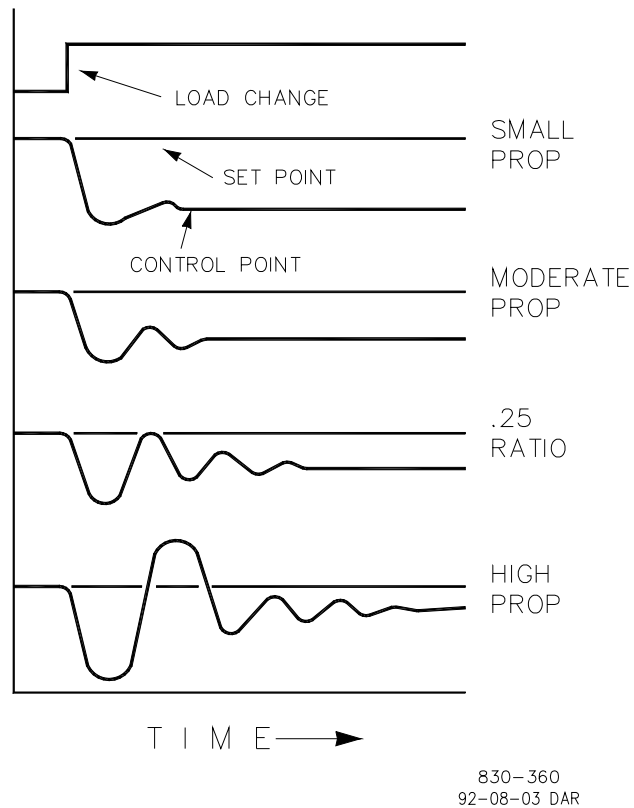
Figure 7-3. Proportional Gain Setting Effects

Integral Response

In the UG-25⁺governor, integral gain is in units of repeats per second (or Reset Rate). Therefore, a high amount of Integral gain (high number) would result in a large amount of Reset action. Conversely, a low Integral gain (low number) would result in a slower reset action.

Integral response is provided to eliminate the offset that resulted from straight Proportional control. Figure 7-4 shows how the controller action is Proportional to the measurement change, but this results in offset. The Integral (or Reset) action is a function of both time and magnitude of the deviation. As long as an offset condition (due to load changes) exists, Integral action is taking place.

The amount of Integral action is a function of four things:
1.   The magnitude of the deviation.
2.   The duration of the deviation.
3.   The Proportional gain setting.
4.   The Integral setting.
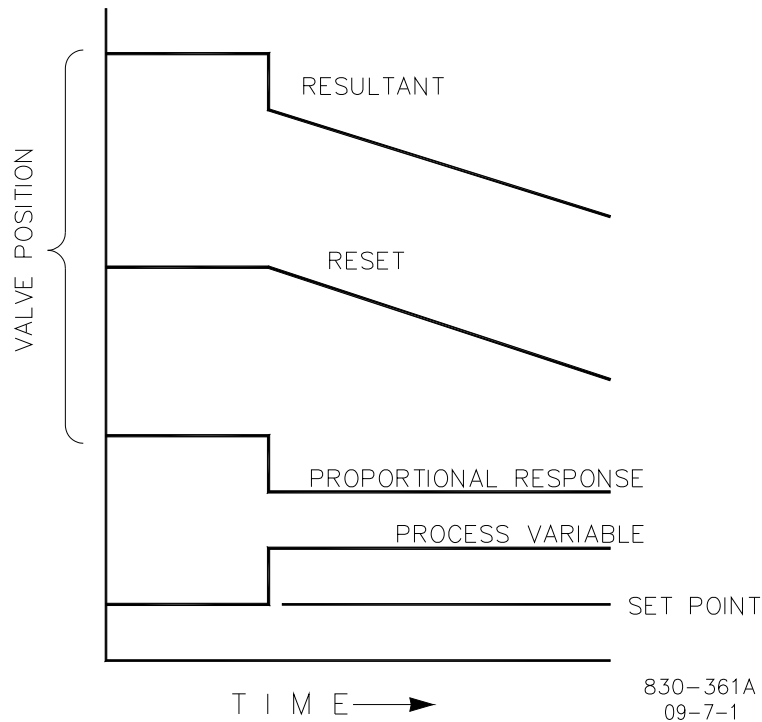
Figure 7-4. Open Loop Proportional and Integral Response

In this Open Loop figure (Figure 7-4), the Integral response is shown increasing due to the offset condition existing between the process variable (like speed) and the setpoint. The resultant action is the top curve showing the step Proportional response that ends as soon as the measurement stops changing. Then the Integral (or reset) action is added to the Proportional action in an amount equal to the Integral of the deviation. In other words, Reset action continues (in either or both directions) as long as there is a difference (deviation) between the setpoint and the process measurement. In this case, the deviation will never be eliminated (or even reduced) because the system is in Open Loop.

Figure 7-5 shows the closed loop effects of integral action. The bottom curve displays the load change. The next curve up shows the setpoint and the measured process variable. With the load change, the process variable (like speed) droops or deviates from the setpoint. The next highest curve is the Proportional action and follows the measured variable proportionately. The Integral curve adds to the Proportional curve resulting in a different output position, thereby returning the process to the Setpoint.

In Closed Loop, however (as opposed to Open Loop), as the measurement decays toward the Setpoint the Proportional action is taking place Proportionally to the measurement change, and the Integral action is decaying proportionately to the magnitude and duration of the deviation until the measurement reaches the setpoint at which time the Integral action is zero.
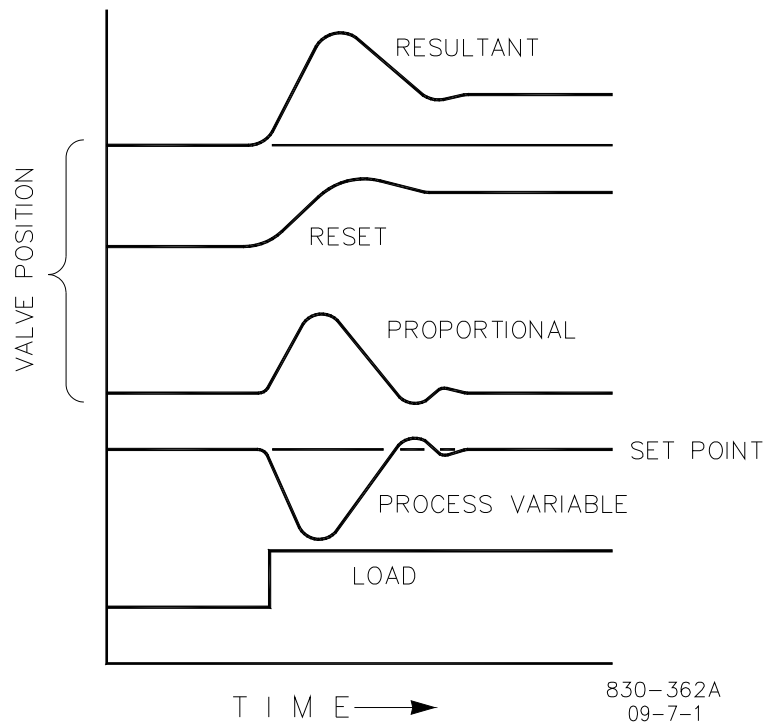
Figure 7-5. Closed Loop Proportional and Integral Response

Figure 7-6 shows the effect of fast or slow Integral action. For a given load change an offset results with Proportional response only. Since recovery time (for a given load change) is important, the Integral setting should remove the offset in a minimum time without adding additional cycling. Ideally, the process should not continue to cycle after the setpoint has been reached as in the second curve from the bottom.
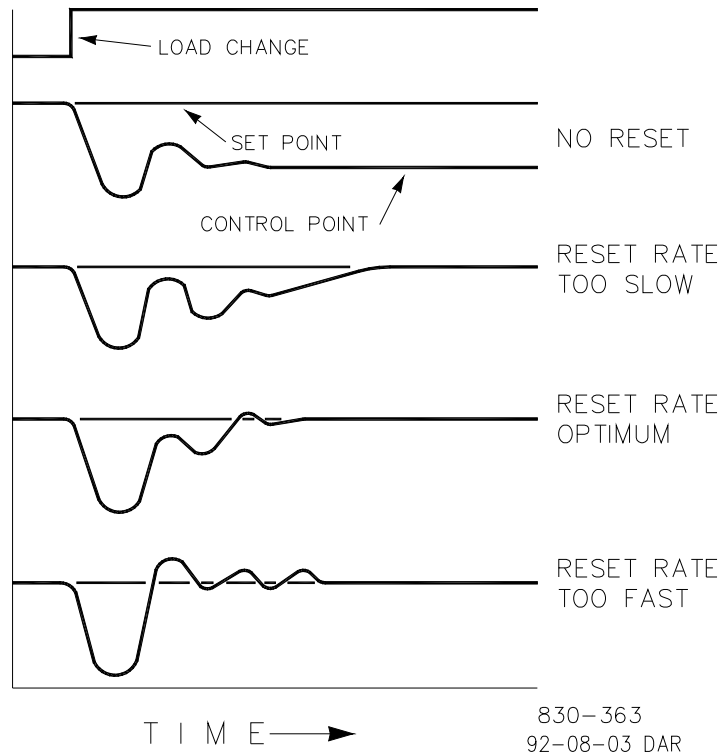
Figure 7-6. Integral Gain (Reset) Setting Responses

Derivative Response

In a process control loop the Derivative action is directly related to how fast the process changes (rate of change). If the process change is slow then the Derivative action is proportional to that rate of change. Derivative acts by advancing the Proportional action. Derivative acts at the start of the process change, when the process changes its rate and when the process stops its change.

Derivative action takes place at only three times:
1. When the process starts to change.
2. When the rate of change takes place in the process.
3. When the process stops changing.

The net result of Derivative action is to oppose any process change and combined with Proportional action to reduce stabilization time in returning the process to the setpoint after an upset. Derivative will not remove offset.

Figure 7-7 shows how Derivative acts to oppose a change in process in either direction. The dashed line shows the Derivative action going through zero to oppose the process deviation traveling toward zero. Notice offset still exists between the desired setpoint and the drooped control point that resulted from the load change. The top curve is the resultant controller output, Proportional plus Derivative. If an upset (momentary) had occurred rather than a load change, there would be no offset.
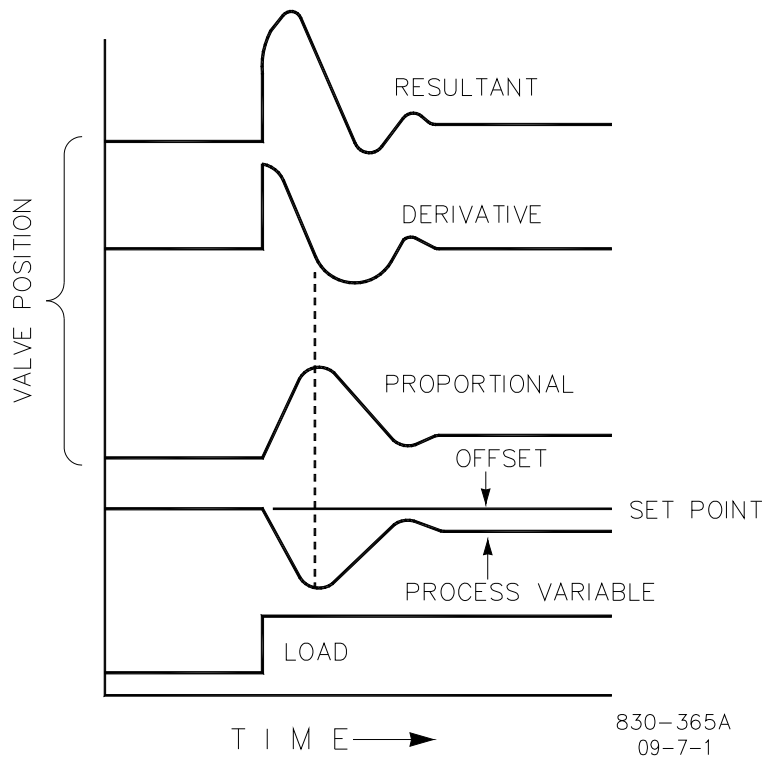
Figure 7-7. Closed Loop Proportional and Derivative Action

Figure 7-8 shows the effect of different Derivative settings. The curves are relative since it depends on what type of control is desired in order to properly adjust Derivative time. In all the above curves, the offset still exists since offset can only be eliminated by the addition of Integral (or Reset).
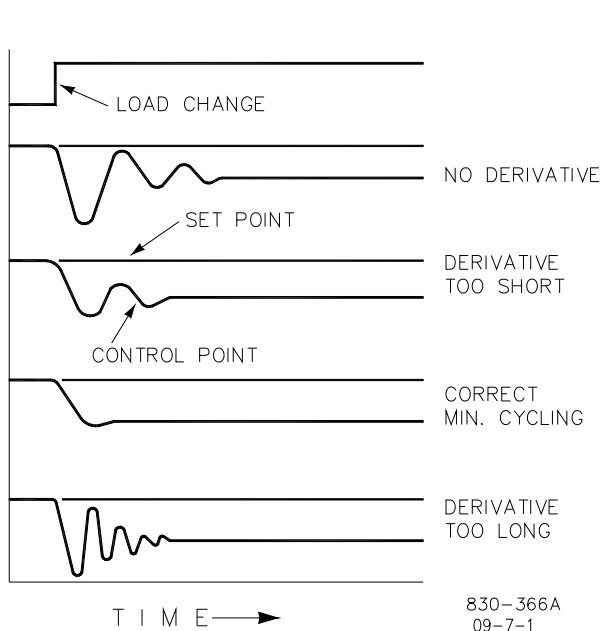
Figure 7-8. Derivative Setting Effects
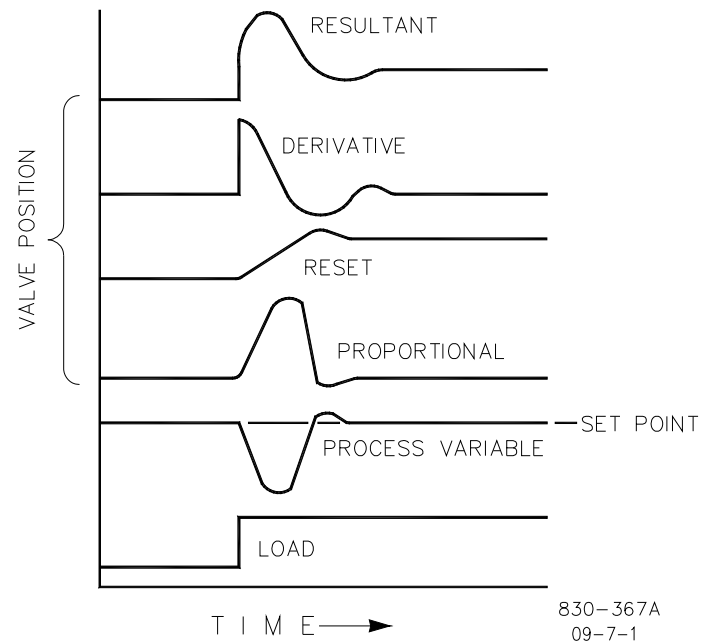
Figure 7-9. Closed Loop Proportional, Integral and Derivative Action

Figure 7-9 shows the relationship of output position to the interaction of the PID modes of control whenever a load change takes place in closed loop. As the process variable drops due to the load change, the proportional action moves the control valve proportionately to the measurement (process variable) change. The integral gain/reset adds to the proportional action as a result of the magnitude and time (duration) of the deviation. And the derivative temporarily over-corrects based on the speed at which the measurement moves in any direction. The resultant curve (at the top) shows a similar over-correction (in this case), but in addition the valve will stay at the new position required to keep the measurement at the setpoint.

Derivative provides a temporary over-correction to compensate for long transfer lags and reduce stabilization time on process upsets (momentary disturbances).

Another possible use of the derivative adjustment is to reconfigure the controller from a PID to a PI controller. This is done by adjusting the derivative term to zero.

General Field Tuning Guidelines

Best results are obtained when the adjustment (tuning) is done systematically. Prior training and experience in controller tuning are desirable for effective application of this procedure. The settings made for one operating set of conditions may result in excessive cycling or highly damped response at some other operating condition. The tuning procedure should be applied under the most difficult operating conditions to assure conservative settings over the normal operating range. The UG-25$^+$ governor can be configured for a 5-point position curve, providing greater flexibility in dynamics settings over this range.

It is good practice to keep the average of the setpoint changes near the normal setpoint of the process to avoid excessive departure from normal operating level. After each setpoint change, allow sufficient time to observe the effect of the last adjustment. It is wise to wait until approximately 90% of the change has been completed.

Another item to keep in mind is that the stability and load limit functions are physically disconnected when the service tool harness is installed (see Chapter 5, Service Tool Harness Connection). The ability to replicate (simulate) these inputs is provided on the Simulated IO tab (Figure 7-10).

To provide the same dynamic/performance settings, the gain value of the front panel stability pot must be replicated/simulated in software. This can be done either by moving the stability pot back to mid (multiplier of '1') or by setting the service tool multiplier to match the pot value. Note that the stability pot provides a multiplier on the gain (P) and integral (I) settings. When the pot is at mid-position, the multiplier is '1' and the gains will be at their nominal configured values (see Dynamics in Chapter 6). The multiplier is '0.5' when the pot is fully CCW and '2.0' in the full CW position.
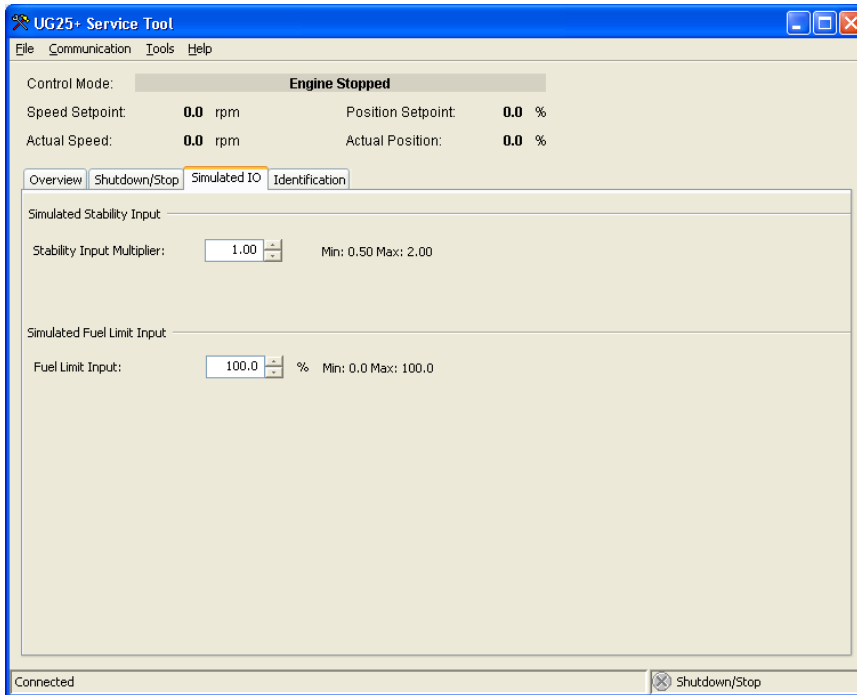
Figure 7-10. Simulated IO Tab

If System is Unstable
If the system is unstable, make sure the speed PID dynamics is the cause. This can be checked by reducing the load limiter until it has control of the governor output. If the governor is causing the oscillation, time the oscillation cycle time. A rule-of-thumb is, if the system's oscillation cycle time is less than 1 second reduce the Proportional gain term. A rule-of-thumb is, if the system's oscillation cycle time is greater the 1 second reduce the Integral gain term (proportional gain may need to be increased also).

On an initial startup with the UG-25+ governor, all PID dynamic gain terms will require adjustment to match the PID response to that of the control loop.

The proportional gain setting of the position controller is also available for adjustment on the dynamics tuning window. Reducing this gain will lower the overall control bandwidth. Lowering this gain term in some systems can reduce the nervousness of the output shaft. The nominal gains settings are optimal for most applications but if the speed controller dynamic adjustments do not achieve the desired results, modifying this setting may help.

Chapter 8.
Troubleshooting

Introduction

This chapter presents several broad categories of application failures typically experienced in the field, possible causes, and some tests used to verify the causes. The exact failure experienced in the field is the product of the mechanical/electrical failure combined with the configuration file resident in the control. Ideally, the troubleshooting chart contains information about mechanical, electrical, engine, and load failures in addition to the possible governor failures.

The troubleshooting scenarios listed below assume that the user has a digital multimeter for testing voltages and checking continuity, and assume that the application has been engineered and tested thoroughly.

There are four parts to the troubleshooting section:
- General Troubleshooting
- Engine/Generator Troubleshooting
- Troubleshooting Shutdown Diagnostic Flags
- Input/Output (I/O)Troubleshooting

⚠ **WARNING**	The actions described in this troubleshooting section are not always appropriate in every situation. Always make sure that any action taken will not result in loss of equipment, personal injury, or loss of life.

⚠ **WARNING**	The UG-25⁺ governor is not equipped with an overspeed trip function. 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**	The UG-25⁺ governor is used on prime movers that typically have a high noise level. Always use appropriate hearing protection while working around the UG-25⁺governor.

General System Troubleshooting Guide

The following is a general troubleshooting guide for areas to check which may present potential difficulties. Make these checks before contacting Woodward for technical assistance.

- Valves
- Is the wiring correct?
- Is the shaft direction correct?
- Is the direction of the stroke correct?
- Is the direction of the failsafe shutdown correct?
- Does the output shaft move through its proper stroke smoothly?
- Does the output travel its full stroke?
- Can mid-stroke be obtained and held?
- Does the output fully seat (close)?
- Does the output fully open?

Oil

Keep the governor oil level to the mark on the oil sight glass with the unit operating. Dirty oil causes governor problems. Use clean, new, or filtered oil. Oil containers used must be perfectly clean. Oil contaminated with water breaks down rapidly, causing foaming, and corrodes internal governor parts.

Preliminary Inspection

Governor problems are usually revealed in speed variations of the prime mover, but it does not necessarily follow that such variations are caused by the governor. When improper speed variations appear, the following procedure should be performed:

1. Check the load to be sure the speed changes are not the result of load changes beyond the capacity of the prime mover.

2. Check engine operation to be sure all cylinders are firing properly and that the fuel injectors are in good operating condition and properly calibrated.

3. Check the linkage between the governor and fuel racks or valve. There must be no binding or lost motion.

4. Check that the oil is clean and oil level is correct at operating temperature. The source of most problems in any hydraulic governor stems from dirty oil. Grit and other impurities can be introduced into the governor with the oil, or form when the oil begins to break down (oxidize) or becomes sludgy.

    The internal moving parts are continually lubricated by the oil within the unit. Valves, pistons, and plungers will stick and even "freeze" in their bores, due to grit and impurities in the oil.

    If this is the case, erratic operation and poor response can be corrected (if wear is not excessive) by flushing the unit with fuel oil or kerosene.

    The use of commercial solvents is not recommended as they may damage seals or gaskets.

Change the oil and flush the governor twice a year if possible.

To change oil, remove the drain plug and drain out the old oil. Flush the governor by filling it with fuel oil, and with the prime mover running at low speed, cycle the governor by increasing the Stability knob setting on the user interface until the governor hunts. Let the governor hunt for a minute or two, then stop the engine and drain the governor. Flush the governor once again. Refill the governor with oil (see Chapter 2, Oil Supply).

Restart the engine and reset the Stability knob.

5. Check that the drive to the governor is correctly aligned and free of roughness, side loading, and excessive backlash.

Engine/Generator Troubleshooting

Problem	Possible Cause	Suggested Test/Correction
Engine hunts or surges	The problem may be originating in the governor or prime mover.	Block the throttle, fuel racks, or steam valve in the direction of increase fuel. (Never block the governor output shaft in the direction that would prevent a complete shutdown.) The same blocking action can be performed by using the load limit knob on the governor panel. **⚠ WARNING** **The UG-25⁺ governor is not equipped with an overspeed trip function. 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.** If hunting and/or surging continues while the governor output shaft is blocked, the problem is in the prime mover. If, after removing the block, hunting and/or surging starts again, the problem can be in the governor or in the prime mover. Go through the dynamics adjustment procedure for the governor (see Chapter 7). If the problem is still there, replace the governor with a replacement governor. Go through the dynamics adjustment procedure for the replacement governor. If the hunting and/or surging continues, the problem is in the prime mover.
	Controller gain adjustments incorrect.	Adjust the gain settings using the Service Tool (see Chapter 7).
	Oil varnish, which causes sticking of parts.	Add oil to the mark on oil sight glass. If oil level decreases and no external oil leaks can be seen on the governor, check the drive shaft for oil leak. If foaming continues, drain oil and refill using a non-detergent type oil. See Woodward manual 25071, Oils for Hydraulic Controls.

Problem	Possible Cause	Suggested Test/Correction
Engine hunts or surges (continued)	Dirty oil (sludge) in governor.	Drain oil, clean governor, and refill.
	Lost motion in engine linkage or fuel pumps.	Repair linkage and/or pumps.
	Binding in engine-to-governor linkage or fuel pumps.	Repair and realign linkage and/or pumps.
	Governor output shaft travel too short to provide full fuel.	Adjust travel until proper travel is obtained.
	Low oil pressure.	Return governor for repair.
	Fuel linkage incorrectly set. This might occur if the governor has been changed or removed and replaced. Relationship of governor travel to power output of engine should be linear.	Rework or reset the linkage from governor to unit to obtain the linear relationship.
	Faulty linkage.	Linkage should be free of binding and lost motion throughout service life of unit. Check yield links, shutdown arrangements, etc, to be sure that prime mover power changes for very small increments of governor output shaft travel. Stability and good steady-state performance will suffer unless this condition is met.
	Incorrect non-linear relationship between governor travel and power output of the prime mover. Engine may hunt with light loads and be stable with a heavy load.	Adjust linkage from governor to gas valve to obtain linear relationship between governor travel and engine output. See Figures 2-3 and 2-4. Also, see application note 50516.
	Gas or steam pressure too high.	Adjust gas or steam pressure.
	Engine misfiring (bad fuel injector or low pilot fuel on dual fuel engine).	Check pyrometer readings of each cylinder and make necessary repairs or adjustments.
	Governor dynamics/stability issue.	See Engine Unstable section below.
	Governor worn.	Return governor for repair.
Jiggle at governor output shaft	Rough engine drive or governor drive.	Inspect drive mechanism. a. Check alignment of gears. b. Inspect for rough gear teeth, eccentric gears, or excessive backlash in gear train. c. Check gear keys and nuts or set screws holding drive gears to shafts. d. Check for bent drive shaft. e. Check serrated or spline coupling for wear and alignment. f. Tighten chain between crankshaft and camshaft (if used). g. Check engine vibration damper (if used).
	Governor is not aligned properly.	Loosen governor mounting screws and move the governor slightly on its mounting pad to align the drive shaft with its coupling.
	Governor dynamics/stability issue.	See Engine Unstable section below.
Engine does not start	Stuck throttle/frozen shaft	Move throttle by hand. Assess smoothness, friction, and return spring force.
	Power not applied to control	Test for +18 to 32 Vdc between input power pin and ground pin.
	No configuration or incorrect configuration in controller.	Using Service Tool, read configuration from controller and evaluate parameters for correction.
	Fault detected in controller.	Using Service Tool, read faults from controller. Verify/correct any shutdown conditions (see fault troubleshooting below).

Problem	Possible Cause	Suggested Test/Correction
The governor is not opening the fuel control valve during engine cranking.	The control has detected a shutdown situation and has not been reset.	Reset the control by cycling power to the control or hitting reset on the Service Tool, (see fault troubleshooting below). Verify Remote Stop input is open.
	There is no power supplied to the control.	Check fuse, wiring, and battery voltage.
	The control does not read any speed. Speed sensor defect or wiring defect.	Read speed on the Service Tool to verify the governor detected speed. If incorrect, check speed input configuration settings.
	The control reads an actual engine speed below the start speed threshold.	Start speed is set too high. Lower start speed threshold.
	The Start Fuel 1 and or 2 setup is incorrectly set to zero position or set to a value too low.	Set up the Start Fuel to the correct value for this engine.
	Load limit pot not working.	Attempt to start with the Service Tool / harness connected, this bypasses the Load Limit pot.

Check voltage at L-Series pin 6 and verify voltage changes with pot position. |
| | Load limit analog input fault. | Verify that boost input selector wire is connected to ground.

Check voltage at L-Series pin 6 and verify voltage changes with analog input.

Verify Load Limit configuration settings. |
The engine will not go to rated speed.	The Control is not configured for Ramp To Rated operation.	Configure the Control for Ramp To Rated (operation if that is the correct operation mode.
	Droop pot not working.	Check voltage at L-Series pin 10 and verify voltage changes with pot position.
	Wiring fault in analog speed setpoint.	Verify analog speed setting input is selected and wired correctly.
The engine will not raise the speed setpoint.	Analog setpoint mode is active.	Check Raise/Lower Enabled LED on Front Panel. Raise and lower commands are not functional when Analog mode is active.
	The Raise input wiring is defective.	See Service Tool overview screen for input open/closed status.

Check wiring. |
| The engine will not lower the speed setpoint. | Analog setpoint mode is active. | Check Raise/Lower Enabled LED on Front Panel. Raise and lower commands are not functional when Analog mode is active. |
| | The Lower input wiring is defective. | See Service Tool overview screen for input open/closed status.

Check wiring. |

Problem	Possible Cause	Suggested Test/Correction
Engine unstable	Improperly tuned dynamics.	Using Service Tool, tune the speed dynamics. Turn the front panel Stability pot in the CCW direction to reduce the gains.
	If analog mode is active, device sending analog command is sending oscillating signal.	Measure input signals.
	Stability pot fault.	Check voltage at L-Series pin 8 and verify voltage changes with pot position.
	If analog mode is active, device sending analog command is sending oscillating signal.	Measure input signal. Verify signal using Service Tool.
Poor frequency control	Improperly tuned dynamics.	Using Service Tool, tune the dynamics. Turn the front panel Stability pot in the CW direction to increase the gains.
	Output speed not at setpoint.	Verify that linkage is free. Verify that load limit is not active.
Unable to develop full power	Non-indexed linkage slipped on shaft.	Manually verify full travel of throttle plate.
	Fault detected in controller.	Using Service Tool, view status of fault codes. Take appropriate action for active faults.
Unit Healthy LED is off	No power.	Verify supply voltage.
	Controller fault.	Using Service Tool, verify detected faults.
	Overtemperature or internal temperature sensor failure.	Using Service Tool, verify internal temperature. Verify faults.
Discrete output not working	Wiring fault.	Check the wiring leading to Terminal 11 for open connections or misconnections. Verify that Terminal 11 is not connected directly to input power or ground.
	Internal governor fault.	Verify Unit Healthy Status LED functionality. Both Discrete out and LED are driven from the same controller terminal and should activate together (L-Series Terminal B on TB5-2). Verify on/off command signal to discrete out using Service Tool (overview tab).
Service Tool not communicating–'Not Connected' status indicated	Wiring fault.	Check programming harness and serial cable for loose or mis-connected connections. Check fuse, wiring, and battery voltage.
	The Service tool is disconnected.	Verify harness setup and connections (see Chapter 4). Check that Service Tool is running.
	The wrong communication port has been selected.	Verify the port setting is correct. Connect the service tool by using the connect menu.
Service Tool not communicating–'Error message displayed on PC when trying to connect	Old version of Service Tool or file corruption or bad install.	Re-install Service Tool, get the latest version from the Woodward web site (**www.woodward.com**).

Problem	Possible Cause	Suggested Test/Correction
Service Tool will not accept password	Caps Lock is on.	Password is case sensitive, make sure you enter the password correctly using upper and lower case. If password is lost contact the OEM for retrieval.

Troubleshooting Shutdown Faults

Error Flag	Description	Possible Source	Possible Action
Stop- Zero Speed Detected	Indicates speed sensor input pulses have not been detected.	Engine stopped. Damaged, loss of speed probe or wiring. Damaged or loss connector. Speed input incorrectly configured.	Verify engine was stopped by some external source or command. Fix wiring. Return to replace connector or speed probe. Check speed input and speed ratio configuration settings using the service tool.
Stop - Stop Input Command	A shutdown (stop) command is issued.	Stop command is still active. Defective Front Panel interface or stuck Stop button. Speed did not go to zero.	Verify Stop input status using Service Tool. Check wiring for bad or loss connection. Check Stop button. Check wiring for bad or loss connection. A Stop command is latched-in until speed reaches zero.
Internal Shutdown	All internal shutdowns will set this flag.	The Control is defective.	Return unit for repair.
Shutdown - Temperature Sensor Failed	This error is set if the temperature inside the control is higher or lower than allowed by the specifications.	Control has been placed in an environment that is too hot or too cold. The internal temperature sensor is defective. This can be determined by checking the temperature of the unit and comparing this to the service tool value of the electronics temperature.	Lower temperature by adding cooling, heat shielding, moving the unit, etc. Increase temperature, if low, by adding heat. Verify Control detected temperature reading using Service Tool. Return unit for repair.
Shutdown – Over Temperature	High internal temperature.	Detection of high temperature.	Check ambient temperature around control. Verify Control detected temperature reading using Service Tool. If the temperatures seem normal, could indicate a problem with the internal temperature sensor.

Error Flag	Description	Possible Source	Possible Action
Shutdown - Voltage Sense Failure	The power supply voltage is higher than the diagnostic limits. The Power supply voltage is lower than the diagnostic limits.	Bad or damaged battery. Defective battery charging system. Incorrect setting of power supply voltage level. Power supply wiring to long or to thin. Control will flag low voltage during higher power uses.	Replace battery. Fix battery charging system. Set correct voltage levels on power supply. Make sure wiring is of the correct thickness and length according to manual.
Shutdown - Position Sensor Failure (internal fault)	If the internal position sensor is outside the diagnostic limits.	Internal failure of position sensor.	Cycle power on the unit. Return unit for repair.
Shutdown - EEPROM Failure (internal fault)	The software can't write to the EEPROM. The software can't read from the EEPROM.	The control is experiencing problems with internal EEPROM.	Cycle power on the unit. Return unit for repair.

Electrical Troubleshooting Guide

Speed Input
If the speed input is not functioning properly, verify the following:
- Check the values seen by the UG-25+ governor using the Service Tool and verify that is matches the input signal.
- Check the wiring. Look for loose connections and disconnected / misconnected cables/connections.
- Check the software configuration to ensure that the input is configured properly as the demand source.
- Measure the input voltage and frequency (internal 20 tooth gear is driven off governor shaft). Terminal Block TB5-11 (+) to Terminal Block TB5-3 (–).

Analog Input
(Faulty Speed Setting or Faulty Stability Input or Faulty Fuel Limit Input)
If an Analog Input is not functioning properly, verify the following:
- Measure the input. Refer to Analog Input in Specifications section for input impedances.
- Check the values seen by the UG-25+ governor using the Service Tool and verify that it matches the input signal. Note that when using the Service Tool, the Load Limit and Speed Setpoint inputs are disconnected and thus the values displayed are actually set using the simulated I/O.
- Verify that there are no or minimal ac components to the Analog Input signal. AC components can be caused by improper shielding.
- Check the wiring. If the inputs are reading 0 or the engineering units that correspond to 0 V, look for loose connections and disconnected / misconnected cables/connections.

Discrete Input
If a discrete input is not functioning properly, verify the following:
- Measure the input voltage on the terminal block. Refer to Discrete Input in Specifications section for expected ON/OFF voltage levels.
- Check the status of the input from the Overview screen of the Service Tool.
- Check the wiring, looking for loose connections or misconnected cables.
- Verify the input is properly configured.

Shutdown Conditions

If the UG-25$^+$ governor has any shutdown conditions, refer to Chapter 4 for fault details. The Service Tool must be used to determine the cause of any shutdown condition. Refer to the Troubleshooting of Shutdown Faults earlier in this chapter.

Discrete Output

If the discrete output is not functioning properly, verify the following:

- Measure the output voltage on the terminal block. It should be in the range of 10–28 Vdc when the output is off/false. The voltage will be in this range only if all shutdowns are false. This can be verified through the Service Tool.
- Check the wiring, looking for loose connections or disconnected / misconnected cables.

Service Tool

If the service tool is not functioning properly, review the installation information in Chapter 4. Verify the following:

- Check the wiring, looking for loose connections or disconnected / misconnected cables (Programming harness or equivalent must be used).
- Check that Service Tool is running. Verify the Port setting is correct.
- Follow on-screen error messages. Re-install software as needed. The latest version of software is available for download from the Woodward web site (**www.woodward.com**).

Chapter 9.
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.

Appendix A.
Acronyms / Abbreviations

CCW	counterclockwise
CW	clockwise
CMRR	common-mode rejection ratio
CRC	cyclic redundancy count
EMC	electro-magnetic compatibility
I/O	inputs/outputs
L-Series	Woodward electronic engine governor that contains both a rotary governor and a controller circuit board
O.D.	outside diameter
OEM	original equipment manufacturer
PID	proportional/integral/derivative
ppm	parts per million
TPS	travel position sensor
UG-25⁺	Universal Governor 25+

Appendix B.
UG-25⁺ Governor Specifications

Governor

Power Supply	18 to 32 Vdc, dual inputs at 2.5 A max. each
Power Consumption	Reverse polarity protection, 32 W max
Torque/Work Output (minimum)	45.4 N·m (33.5 lb-ft) torque; 32.9 J (24.3 ft-lb) of work over 42 degrees (standard version, which has a 0.625 inch diameter terminal shaft)
	55.5 N·m (40.9 lb-ft) torque; 40.2 J (29.6 ft-lb) of work over 42 degrees (increased output version, which has a 0.75 inch diameter terminal shaft)
Continuous Speed	500 rpm to 1700 rpm (governor shaft speed) max (small pump); 350 rpm to 1200 rpm (governor shaft speed) max (large pump)
Hysteresis	1.0 % or less (measured over full terminal shaft travel)
Temperature Drift	1.0 % of full terminal shaft travel between 27 °C and 77 °C (80 °F and 170 °F)
Linearity	2.5 % or less (measured over full terminal shaft travel)
Ramp-up Rate	configurable from 0.2 to 200 rpm/s (governor shaft)
Steady State Speed Band	±0.25% of rated speed (under normal operating conditions)
Weight	28 kg (62 lb), dry weight

Governor Drive / Hydraulic System

Input Shaft Options	0.625 keyed drive shaft with 0.625-18 threads or 0.625-36 serrated (standard version); 0.750-36 serrated (increased output version)
Output	42.2 ± 0.6 degrees rotary
Terminal Shaft Options	0.625-36 serration
Drive Power Requirement	335 W (0.45 hp) max.
Internal Hydraulic Pressure	1034 kPa (150 psi)
Oil	Self-contained sump (2.2 qt/2.1 L capacity). See Woodward Manual 25071, Oils for Hydraulic Controls, for oil recommendations.
Drive Rotation	Pump can be configured to operate in CW or CCW direction

Environment

Ambient Operating Temperature	0 to +55 °C (32 to +131 °F)
Governor Case Temperature	100 °C (212 °F) maximum
Storage Temperature	–40 to +85 °C (–40 to +185 °F), limited by electronics
EMC	EN61000-6-4, 2007: EMC Part 6-4: Generic Standards - Emissions for Industrial Environments
	EN61000-6-2, 2005: EMC Part 6-2: Generic Standards - Immunity for Industrial Environments
Humidity	US MIL-STD 810E, Method 507.3, Procedure III
Shock	MS1-40G 11 ms sawtooth

Vibration Validation   Power Spectral Density (PSD) must not exceed the level or frequency as shown in the curve while the governor is running on a loaded engine, as measured at governor base.

UG25+ Maximum Allowed Application Vibration PSD vs. Frequency
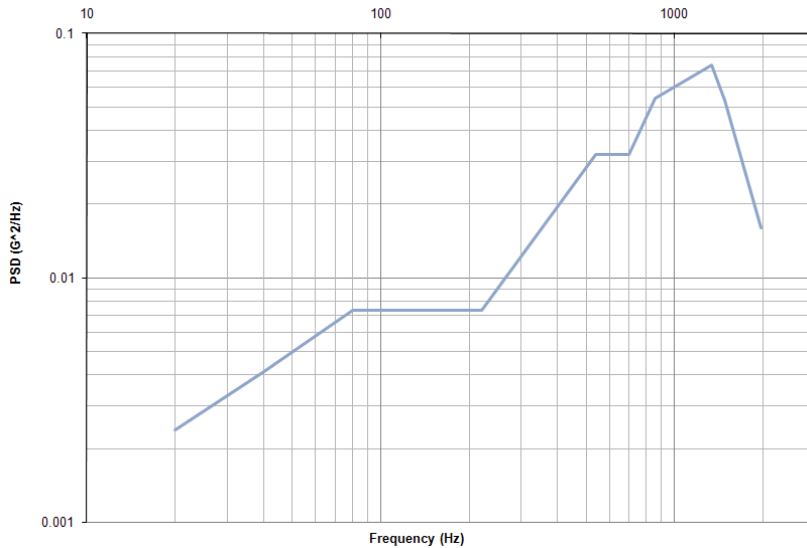
Frequency (Hz)	Allowed PSD Level (G²/Hz)
20	0.00240
40	0.00414
80	0.00736
220	0.00736
540	0.03197
700	0.03197
860	0.05453
1340	0.07452
1480	0.05339
1960	0.01595

Thermal Shock   SAE J1455, Paragraph 4.1.3.2
Ingress Protection   IP45 for Entire Unit, IP56 for User Interface per EN60529 and only if proper cable glands are used as described in this manual.

Functions

Function Options   Start Fuel Limiter; Adjustable Max Fuel Stop; Jump and Rate Limiter; Position-based Gain curve; Manifold Air Pressure Biased Fuel Limiter, Analog set-point rate limit; separate Raise and Lower Rates; Start Gain

Programming Port   Programmable with Windows GUI (Graphical User Interface) software (9927-1366) and harness

I/O   4–20 mA analog speed setting; Analog Speed Set-point selector
Raise, Lower, and Stop discrete inputs
Analog Speed Set Enable discrete input
4–20 mA boost fuel limiter input; Boost Input selector
Unit Healthy discrete out

Front Panel Functions   Raise and Lower speed set-point commands
Stop command; Droop adjustment; Stability adjustment, Fuel-Limit adjustment

Front Panel Indications   Unit Healthy status indication, Speed Set-point mode indications (Raise/Lower or Analog)

I/O Specifications

Power Input (1 and 2)

Parameter	Value
Range	18–32 Vdc
Power Consumption	Nominal consumption is less than 500 mA. If internal failures occur, the device can draw 32 W maximum. (18 V @ 1.8 A)
Protection	Reverse-polarity protected
Isolation	None

Status (Unit Health) Output

Parameter	Value
Output Type	Low-side output driver
Max Contact Voltage (Open)	32 V
Max Current	0.5 A
Max Contact Voltage at 0.5 A (Closed)	1.5 V
Max Delay Time for Opening Contact	6.5 ms
Default at Power Up	On (conducting), if there are no faults
During Error Condition	Off
Driving Inductive Loads	Yes, internally protected low-side switch
Protection	Utilizes circuitry that will open the contact when output contacts are short-circuited. Self-resetting when fault is removed

Boost Input

Parameter	Value
Input Type	4–20 mA
Input Scaling	4 mA is minimum boost signal 20 mA is maximum boost signal
Max Input (Full Scale)	0 mA to 25 mA
Input type	Differential
3 db Circuit Bandwidth	30 Hz
Input Impedance	200 Ω
Anti-Aliasing Filter	1 anti-aliasing pole at 0.47 ms (338 Hz)
Resolution	10 bits
Accuracy	±0.8% of full scale at 25 °C
Drift	80 ppm/°C
I/O Latency	6.5 ms
CMRR	60 dB
Common-Mode Range	45 Vdc

Boost Input Selector

Parameter	Value
Input Type	Active-Low, discrete input
Activation	Pull this input to UG-25⁺ governor analog ground to allow for 4–20 mA boost signal to be used.
If unused	Floating allowed and recommended (internally pulled-up to 7 V)
Isolation	None

Analog Speed Setpoint

Parameter	Value
Input Type	4–20 mA
Input Scaling	4 mA is minimum speed setpoint 20 mA is maximum speed setpoint
Max Input (Full Scale)	0 mA to 25 mA
Input type	Differential
3 db Circuit Bandwidth	30 Hz
Input Impedance	200 Ω
Anti-Aliasing Filter	1 anti-aliasing pole at 0.47 ms (338 Hz)
Resolution	10 bits
Accuracy	±0.8% of full scale at 25 °C
Drift	80 ppm/°C
I/O Latency	6.5 ms
CMRR	60 dB
Common-Mode Range	45 Vdc
Fault Detection	< 2.5 mA, analog mode is disabled, raise/lower mode is enabled and last speed setpoint is held

Analog Speed Setpoint Enable

| Parameter	Value
Input Type	Active-Low, discrete input
Activation	Pull this input to UG-25^{+} governor analog ground to allow for 4–20 mA remote speed signal to be used.
If unused	Floating allowed and recommended (internally pulled-up to 7 V)
Isolation	None

Remote Run/Stop Input

Parameter	Value
Input Type	Active-Low, discrete input
Activation	Pull this input to UG-25^{+} governor analog ground to shut down the governor.
If unused	Floating allowed and recommended (internally pulled-up to 7 V)
Isolation	None

Remote Speed Raise/Lower Discrete Inputs

Parameter	Value
Input Type	Active-Low, discrete input
Activation	Pull these inputs to UG-25^{+} governor analog ground (individually) to remotely apply speed raise or speed lower commands.
If unused	Floating allowed and recommended (internally pulled-up to 7 V)
Isolation	None

UG-25⁺ Governor Transfer Function
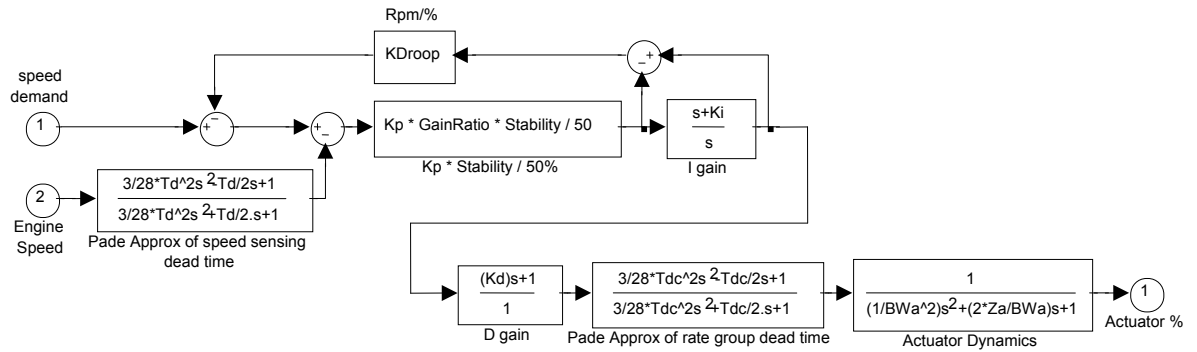
Td = Speed Sensor delay. Depends on Speed Sensor settings and speed.
   Td = 15 / rpm * Nstroke * CylindersAveraged/CylinderCount

Nstroke = 2 or 4 (2 stroke or 4 stroke)

CylindersAveraged = 1 to CylinderCount (speed input setting)

CylinderCount = total number of cylinders (speed input setting)

KDroop = Droop [% speed droop/100% load] * Rated Speed [rpm]/100%

Kp = Proportional Gain [%/rpm]

GainRatio = 1 within the GainWindow, as set in speed loop setup outside the GainWindow

Stability = Proportional Gain modifier. 50% = Gain of 1.

Ki = Integral Gain [repeats/sec]

Kd = Derivative Gain [sec]

Tdc = calc time delays, including 1.5 multiplier = 0.011 [sec]

BWa = actuator Bandwidth Depends on position loop gain.
   @ P=44, BWa=30. @ P=36, BWa=25. @ P=26, BWa=15

Za = actuator damping ratio. Depends on position loop gain.
   @P=44, Za=0.8 @ P=36, Za=0.7 @ P=26, Za=0.7

Pade = a type of approximation for a time delay (dead time); exp(–Td·s)

Revision History

Changes in Revision D—
- Clarified O-ring source (page 11)
- Explained lifting method for governor installation (page 11)

Changes in Revision C—
- Updated Regulatory Compliance information
- Added fire protection warning (page 7)
- Removed Hazardous Location & UL information (pages 15/17/18/23/86)
- Added Declarations

Changes in Revision B—
- Figure 1-1—Updated call-outs
- Figure 1-2—Updated dimension lines

Changes in Revision A—
- p.33—changed button name from SHUTDOWN to STOP
- Updated Figures 5-5 & 7-1a/b
- Updated description at end of Chapter 7, including new Figure 7-10

Declarations

<div style="border:1px solid">

DECLARATION OF CONFORMITY

</div>

Manufacturer's Name: WOODWARD, INC.

Manufacturer's Address: Building A, Ditiantai Industrial Park, Huaihedao, Beichen High-Tech Industrial Park, Tianjin, China
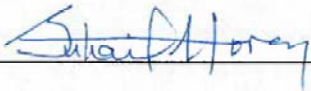
Model Name(s)/Number(s):   UG25+ Governor/UG25+ Actuator/UG25+

Conformance to Directive(s):   2004/108/EC COUNCIL DIRECTIVE of 15 December 2004 on the approximation of the laws of the Member States relating to electromagnetic compatibility and all applicable amendments.

Applicable Standards: EN61000-6-4, 2007: EMC Part 6-4: Generic Standards - Emissions for Industrial Environments
EN61000-6-2, 2005: EMC Part 6-2: Generic Standards - Immunity for Industrial Environments

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

MANUFACTURER

Suhail Horan
_____
Signature

Suhail Horan
_____
Full Name

Quality Manager
_____
Position

Fort Collins, CO, USA
_____
Place

24-May-2012
_____
Date

5-09-1183 Rev 10, 15-Jul-05   00332-04-EU-02-01

+---

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

+---

Manufacturer's Name: WOODWARD, INC

Manufacturer's Address: Building A ,Ditiantai Industrial Park, Huaihedao, Beichen High-Tech Industrial Park, Tianjin, China

Model Names: UG25+ Governor/UG25+ Actuator/UG25+

This product complies, where applicable, with the following Essential Requirements of Annex I: 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7

The relevant technical documentation is compiled in accordance with part B of Annex VII. Woodward shall transmit relevant information if required by a reasoned request by the national authorities. The method of transmittal shall be agreed upon by the applicable parties.

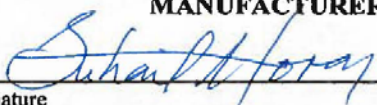The person authorized to compile the technical documentation:

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

This product must not be put into service until the final machinery into which it is to be incorporated has been declared in conformity with the provisions of this Directive, where appropriate.

The undersigned hereby declares, on behalf of Woodward Governor Company of Loveland and Fort Collins, Colorado that the above referenced product is in conformity with Directive 2006/42/EC as partly completed machinery:

MANUFACTURER

(signature)

Signature

Suhail Horan

Full Name

Quality Manager

Position

Fort Collins, CO, USA

Place

24-May-2012

Date

UG-25⁺ Governor Configuration Summary

APPLICATION _____

ACTUATOR SERIAL NUMBER _____
For details on individual settings refer to Chapter 6.

Properties _____

Speed Input

Engine Type (stroke)	2 ____ 4-Stroke ____
Speed Ratio (engine to shaft)	= _____
Number of Cylinders	= _____
Number of Cylinders Averaged	= _____

Start Settings

Start Fuel	One ____ Two ____
	Two w/delay ____
Start 1 Speed Threshold	= _____
Start Speed Hysteresis	= _____
Start Fuel 1	= _____
Stop Speed Threshold	= _____
Run Speed Threshold	= _____
Start 2 Speed Threshold	= _____
Actuator Ramp Rate	= _____
Start Fuel 2	= _____
Start Fuel 1 Time Delay	= _____
Start Target Speed	Min ____ Rated ____
Start Target Rate	= _____

Speed Setpoint

Min Setpoint Limit	= _____
Rated Speed Setpoint	= _____
Max Setpoint Limit	= _____
Raise Ramp Rate	= _____
Lower Ramp Rate	= _____
Max Analog Up Rate	= _____
Max Analog Down Rate	= _____

Droop

Droop (% of Rated)	= _____
No Load (% of position)	= _____
Full Load (% of position)	= _____

Fuel Limit

Mode	Pot ____ Analog ____ Speed ____
Maximum Fuel Limit	= _____
Input % (pt 1)	= _____
Input % (pt 2)	= _____
Input % (pt 3)	= _____
Input % (pt 4)	= _____
Input % (pt 5)	= _____
Limit % (pt 1)	= _____
Limit % (pt 2)	= _____
Limit % (pt 3)	= _____
Limit % (pt 4)	= _____
Limit % (pt 5)	= _____

Jump Rate Limiter

Use Jump Rate Limiter?	Yes ____ No ____
Maximum Jump Up %	= _____
Maximum Up Rate %/sec	= _____

Dynamics

Mode	Single ____ Curve ____
Start Gain (%/rpm)	= _____
Start Gain Spd Threshold (rpm)	= _____
Start Gain Spd Hysteresis (rpm)	= _____
Idle Integral Gain (1/sec)	= _____
Rated Integral Gain (1/sec)	= _____
Derivative Gain (sec)	= _____
Gain Window (rpm)	= _____
Gain Ratio	= _____
Proportional Gain (%/rpm)	= _____
Position % (pt 1)	= _____
Position % (pt 2)	= _____
Position % (pt 3)	= _____
Position % (pt 4)	= _____
Position % (pt 5)	= _____
Gain %/rpm (pt 1)	= _____
Gain %/rpm (pt 2)	= _____
Gain %/rpm (pt 3)	= _____
Gain %/rpm (pt 4)	= _____
Gain %/rpm (pt 5)	= _____

Security

Read Configuration security?	Yes ____ No ____
Configuration Load security?	Yes ____ No ____
Speed Dynamics Edit security?	Yes ____ No ____
Password	= _____

We appreciate your comments about the content of our publications.

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

Please reference publication **26579D**.

B26579:D

WOODWARD