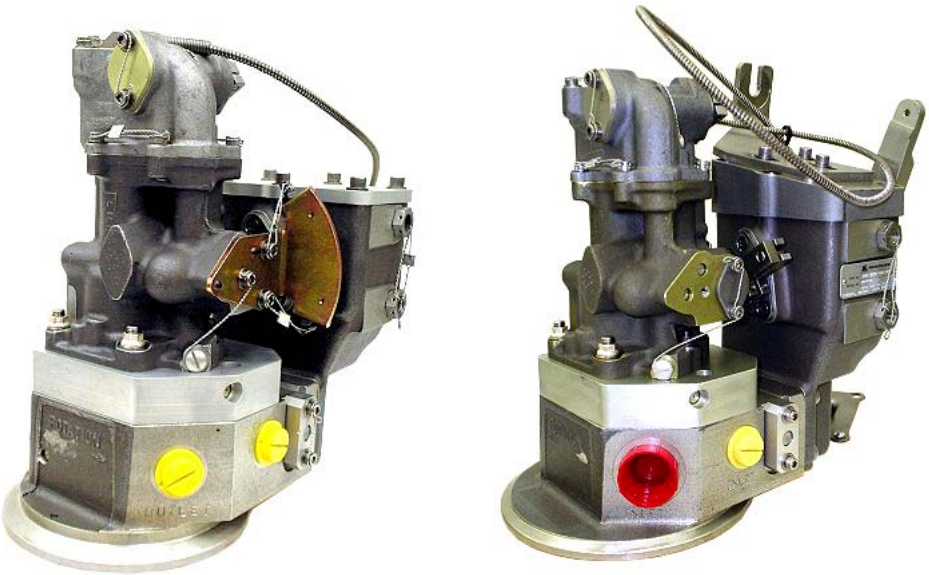
WOODWARD

Product Manual 40110
(Revision A, 5/2004)
Original Instructions



VSV Variable Stator Vane Control

9902-332, 9902-405, 9902-406

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 Out-of-date translations are marked with ⚠.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

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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.

Chapter 1.
General Information

Description

This manual describes the installation and operation for the VSV Variable Stator Vane Control, models 9902-332, 9902-405, and 9902-406. The VSV control is used on non-airborne gas turbines to position the variable stator vanes to prevent turbine compressor stall and to allow efficient operation at reduced rpm. The control consists of a pump, tachometer, temperature sensor, and servo.

The drive shaft of the VSV control is driven directly by the turbine shaft to rotate the VSV control's integral oil pump. This provides the required oil pressure and flow to operate the VSV control, and also to sense the speed of the turbine.

VSV Control Specifications

Hydraulic Fluid	US MIL-L-23699 or MIL-L-7808
Filtration	10 µm
Environmental Specifications:	
Altitude	Sea level to 2500 m (8000 ft)
Fluid Temperature	4 to 82 ° C (40 to 180 °F) normal operating range
Normal Ambient Temperature	–7 to +93 °C (20 to 200 °F) normal operating range
Extreme Ambient Temperature	–29 to +121 °C (–20 to +250 °F) (permissible for a maximum of 2% of the VSV control's total service life only)
Dry Weight	12 kg (26 lb)

	9902-332 Per GEAE Spec M50TF1994	**9902-405 Per GEAE Spec M50TF1838**
Inlet Pressure	138–586 kPa (20–85 psig)	138–690 kPa (20–100 psig)
Outlet Pressure	4654–5000 kPa (675–725 psig)	3103–3448 kPa (450–500 psig)
Drive Speed	0–5980 rpm	0–5850 rpm
Drive Rotation	clockwise	counterclockwise
Speed Sensing Range	2400–6100 rpm	2200–6000 rpm

Regulatory Compliance Specifications

European and International Compliance:
Compliance with the following European Directives does not qualify this product for application of the CE Marking:

ATEX Directive:	The VSV control is exempt from the ATEX Directive 94/9/EC as non-electrical equipment bearing no potential ignition sources in accordance with EN13463-1.
Machinery Directive:	Compliant as a component with 98/37/EC Directive of 23 July 1998 on the approximation of the laws of the Member States relating to 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.

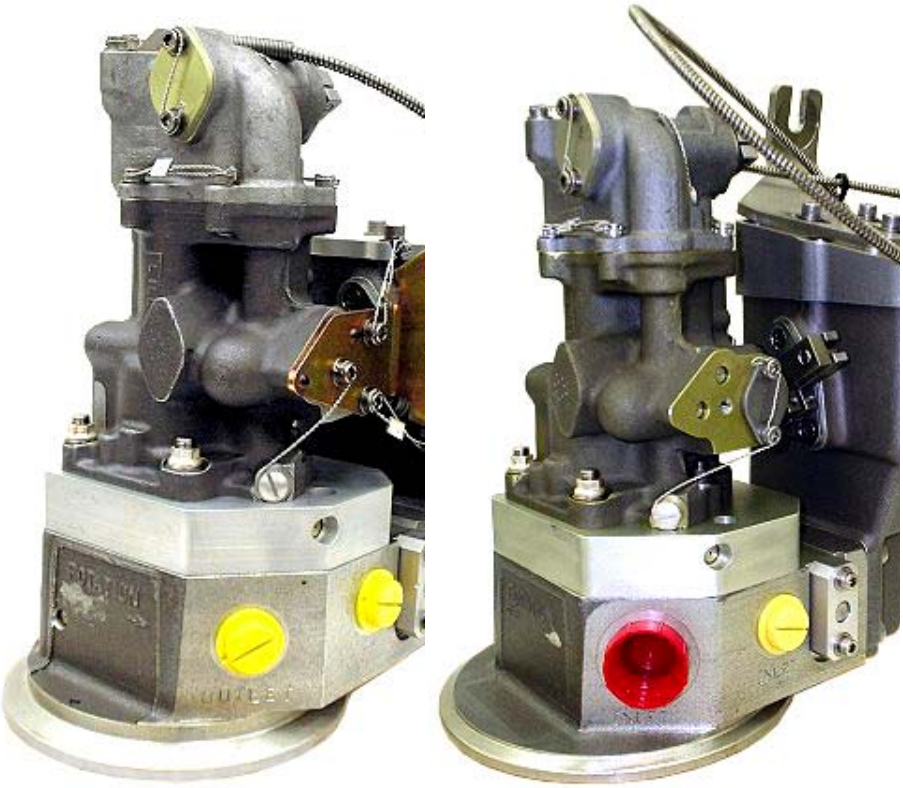


Figure 1-1. Photos of VSV Controls
(9902-332 left, 9902-405 right)

Chapter 2.
Installation, Calibration, and Maintenance

Installation

Figure 2-1 shows the overall dimensions of the VSV control, and also the connections for the hydraulic lines.

Use a lifting strap and hoist for lifting and moving the VSV control.

Be careful when installing the VSV control on the turbine. The serrated drive shaft of the tachometer pump must be correctly aligned for unencumbered rotation.

The feedback cable between the VSV control and the stator vanes must be rigged according to the engine manufacturer's specification, and aligned to eliminate sticky or binding linkage.

⚠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.**

⚠CAUTION	**Due to typical noise levels in turbine environments, hearing protection should be worn when working on or around the VSV control.**

⚠CAUTION	**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.**

NOTICE	**To prevent damage to the VSV and to maintain proper function, do not drop or set the control on the serrated drive shaft. The shaft must freely slip into the mating drive coupling of the turbine.**

NOTICE	**Do not coil the capillary tube of the CIT sensor assembly smaller than a 64 mm (2.5 inch) radius (127 mm/5 inch diameter) to avoid kinking or distortion of the tube.**

Calibration

DO NOT attempt to adjust the VSV control. The control is calibrated by Woodward to exact specifications provided by the turbine manufacturer. The control cannot be repaired or calibrated in the field.

When requesting information or service help from Woodward, include in your communication the part number and serial number of your VSV control.

Maintenance

The oil for lubrication of moving parts and for the hydraulic supply pressure is supplied from the turbine's lubricating oil tank. Follow the turbine manufacturer's requirements for scheduled oil checks and fluid replacement.

There are no other maintenance requirements for the VSV control.

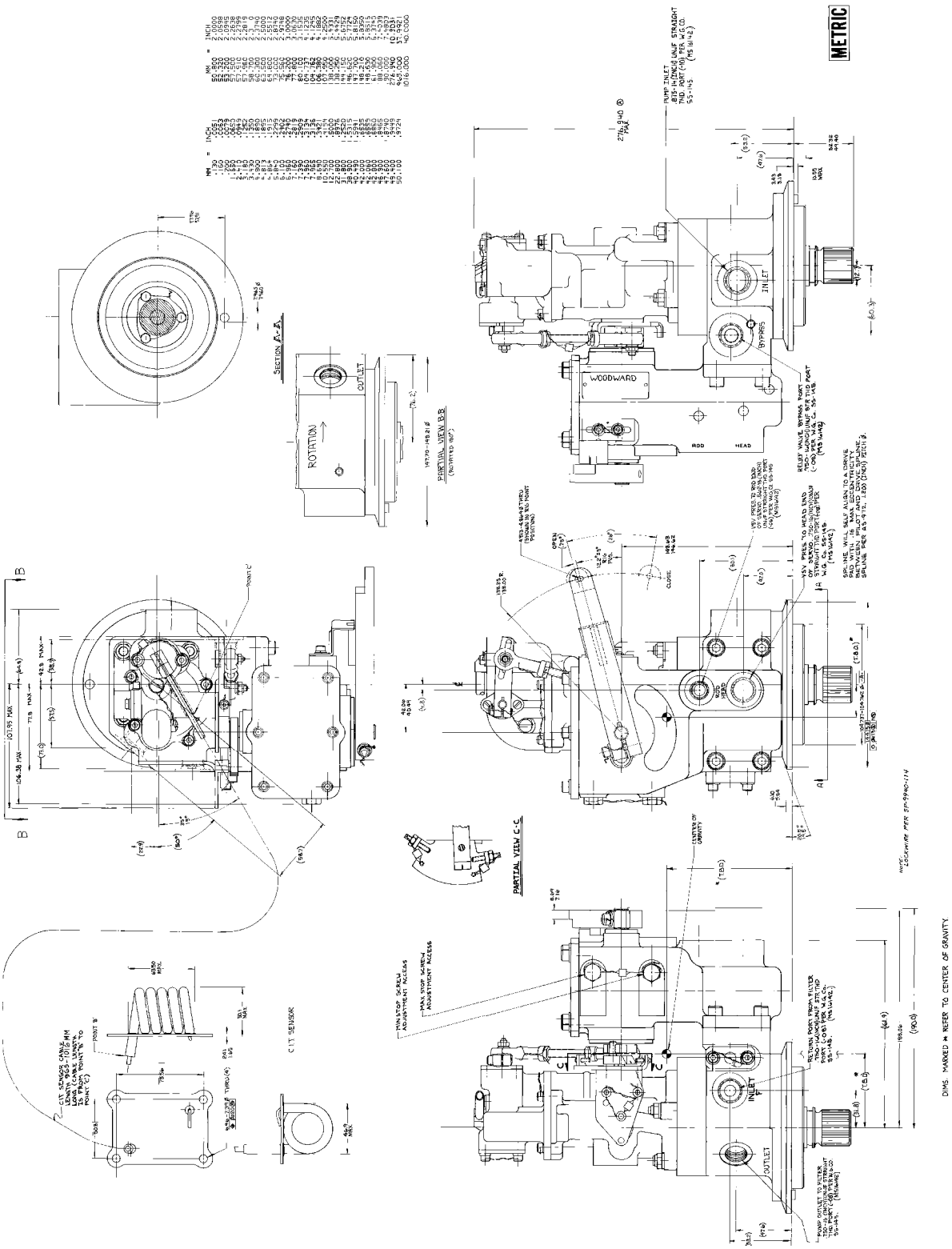


Figure 2-1a. Outline Drawing of the 9902-332 and 9902-406 VSV Control

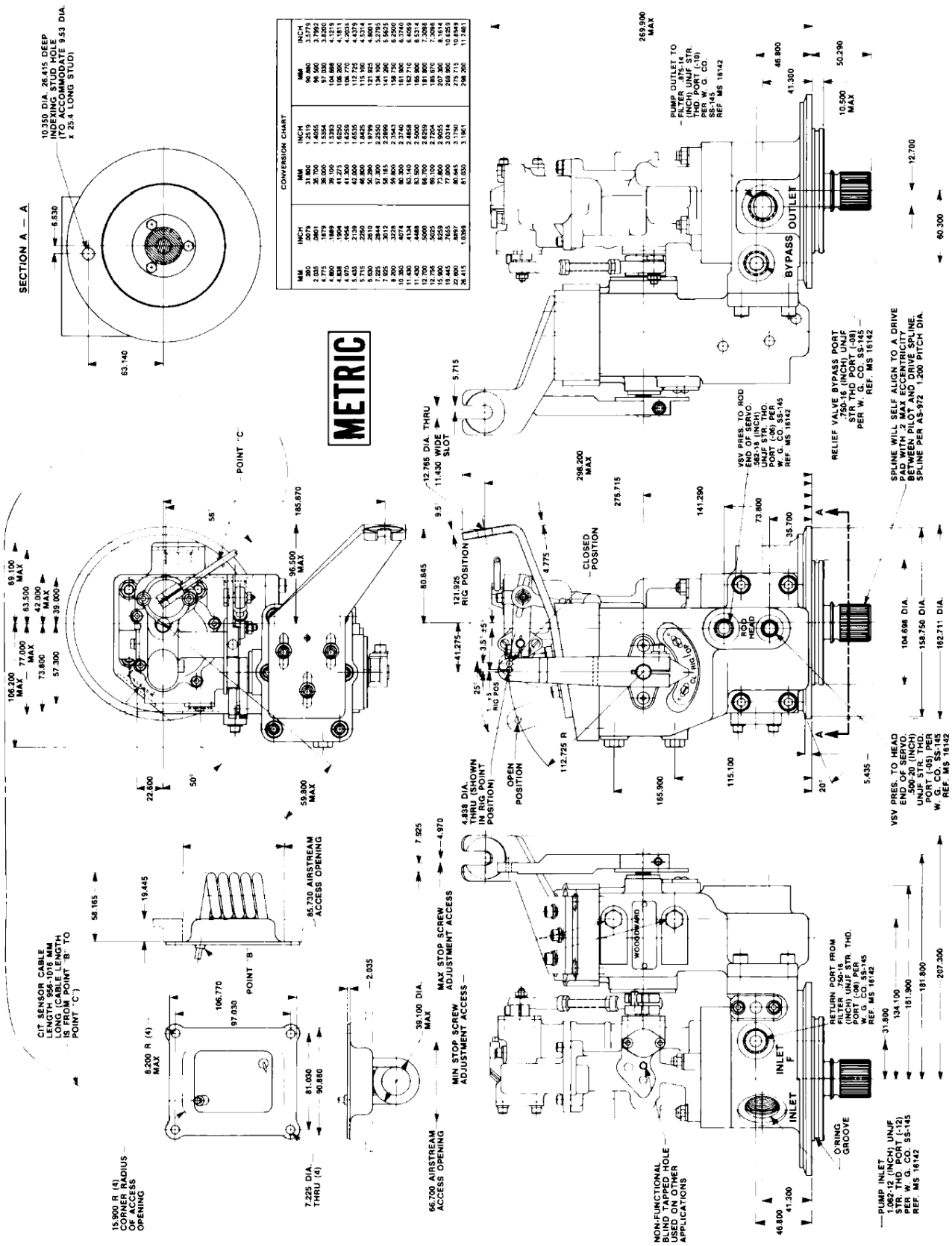


Figure 2-1b. Outline Drawing of the 9902-405 VSV Control

Chapter 3. Principles of Operation

Introduction

The VSV Variable Stator Vane Control is a device for use on non-airborne gas turbines, and senses turbine driven shaft speed and compressor inlet temperature (CIT). See Figure 3-2 for a schematic of the VSV control.

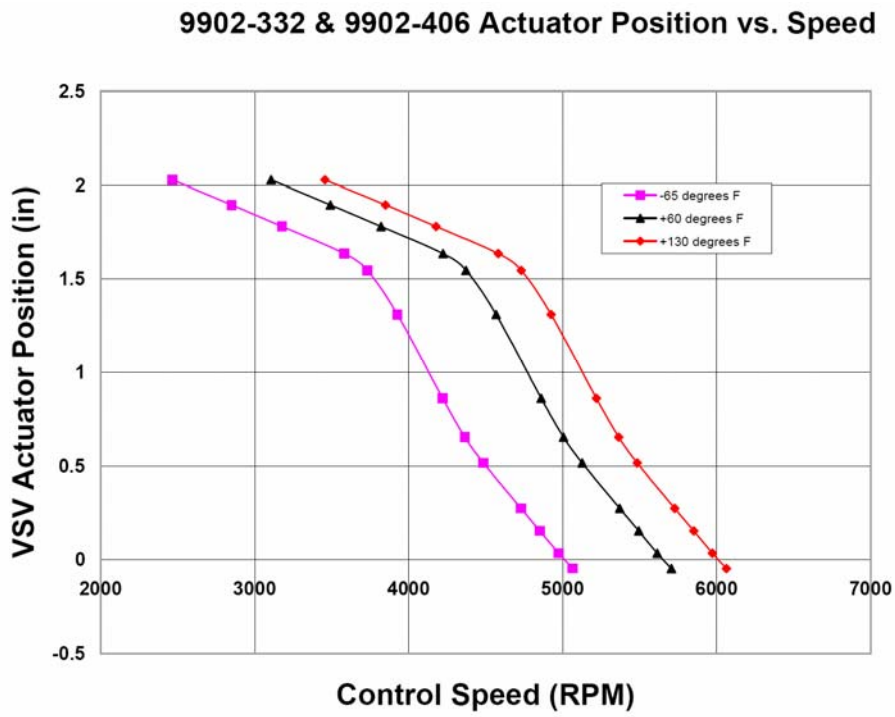
General Theory

The oil pump is rotated by the tachometer drive shaft, and supplies 24 L/min (6.4 US gal/min) of oil to a customer-supplied filter. Oil returned from the filter is regulated and supplied to the pilot valve plunger and the small servo piston. The control also supplies regulated pressure oil to operate the servo valve and actuator/fuel valve. Cooling oil, at a rate of 7.6 L/min (2 US gal/min), is bypassed through the bypass valve orifice to the supply tank. During steady state operation, the excess oil moves through the bypass valve to the tank where it is cooled before circulating through the pump again.

The tachometer drive shaft passes through the pump gear and into the ballhead, thus providing a direct drive from the turbine to the flyweights. The pilot valve plunger is attached to, and is rotated within, the pilot valve bushing by the flyweight head. Relative motion between the plunger and bushing creates a hydro-dynamic film, which reduces friction between the parts. This makes the tachometer extremely sensitive to any engine speed changes. With the turbine on-speed. the centrifugal force of the flyweights balances the opposing force of the speeder spring.

If the tachometer senses an increase in turbine shaft speed, the centrifugal force of the flyweights become greater than the opposing force of the speeder spring, and the pilot valve plunger is moved up. When the pilot valve plunger is moved above its center position, oil is vented from the large servo piston through the control port of the pilot valve bushing to the pump inlet. Pump oil pressure (Pc) on the small servo piston pushes the piston up, rotating the output shaft clockwise. As the output shaft rotates, external linkage rotates the feedback cam. The feedback cam contour is designed to compress the speeder spring through the downward movement of the floating lever. The output shaft will continue to rotate clockwise until the speeder spring force balances the flyweight force, at which time the pilot valve is on null. Therefore, the tachometer output shaft position is a function of speed and the contour of the feedback cam.

The CIT (compressor inlet temperature) sensor is installed in the turbine air inlet, to sense changes in the ambient temperature. The CIT bellows will remain stationary until there is a change in compressor inlet temperature. If there is a decrease in CIT, the bellows contracts, and the speeder spring force decreases. The pilot valve plunger moves above its centered position, and supply oil moves through the control port of the pilot valve bushing from the internal servo piston. The output shaft rotates clockwise, decreasing output shaft position. The output shaft position is a function of speed and the contour on the feedback cam, biased by compressor inlet temperature.



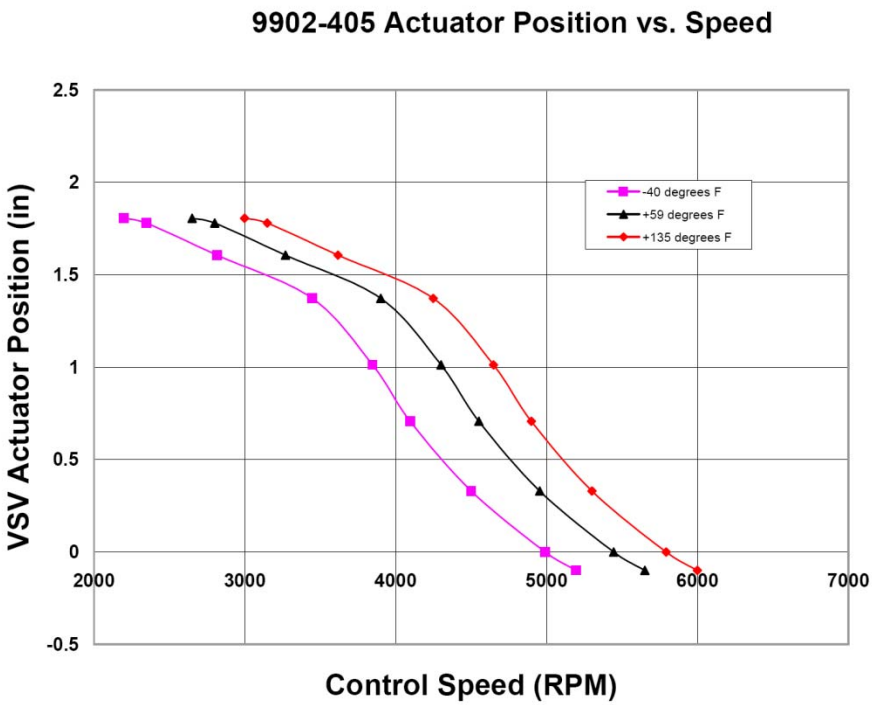


Figure 3-1. Actuator Position as a Function of Temperature and Speed

The tachometer controls the servo-valve in this manner: If the tachometer senses a decrease in turbine speed, the tachometer output shaft rotates in a counterclockwise direction. This movement, through linkage, raises the servo valve, which allows control pressure (Pc) to the rod side of the customers actuator servo, and at the same time drains control pressure from the head of the actuator servo back to the tank. The actuator servo then moves down, closing the guide vanes. The actuator servo uses a feedback cable to mechanically re-center the servo-valve in the tachometer. This provides the tachometer output with a proportional remote servo output (see Figure 3-1).

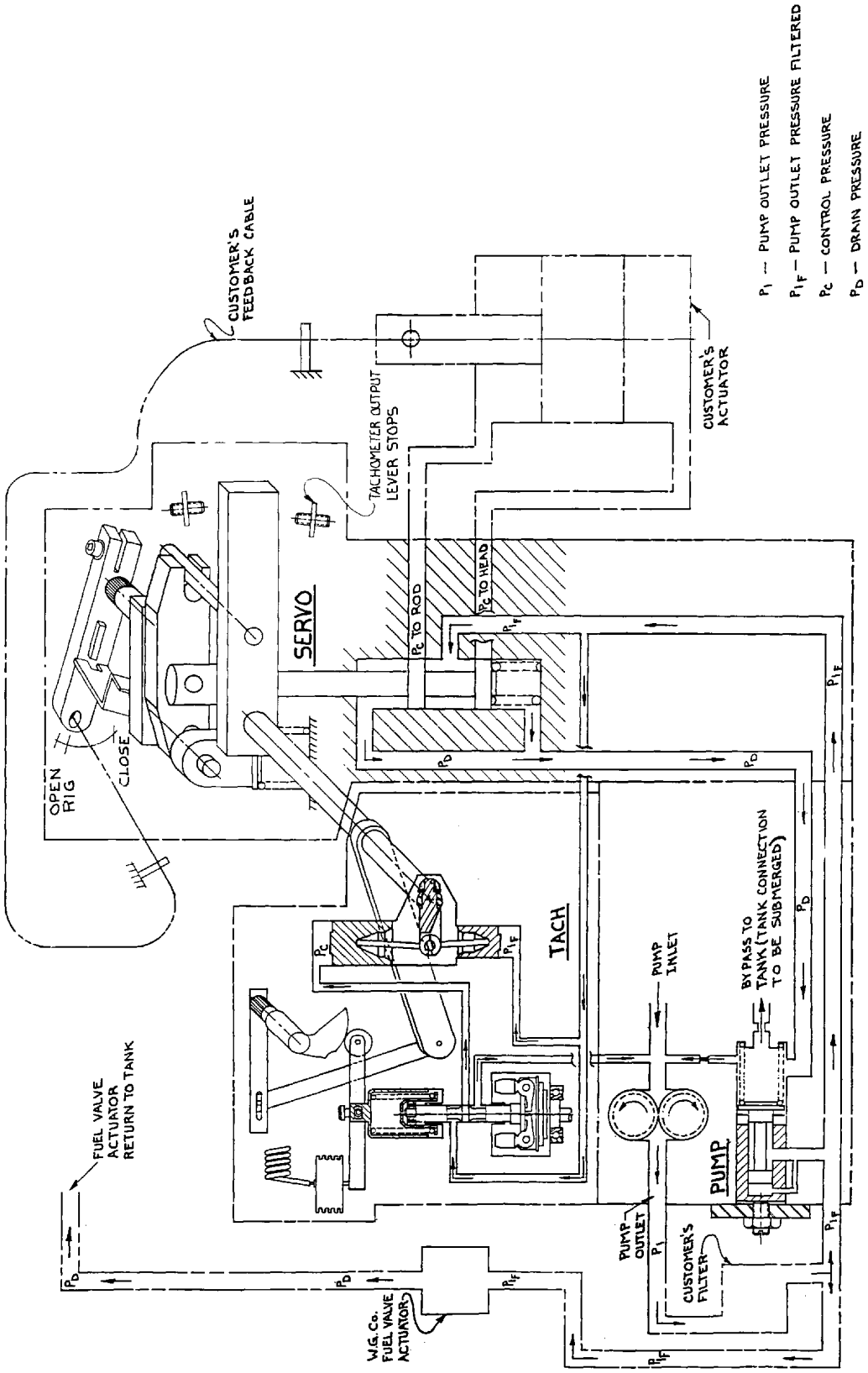


Figure 3-2a. Schematic of the 9902-332 and 9902-406 VSV Control

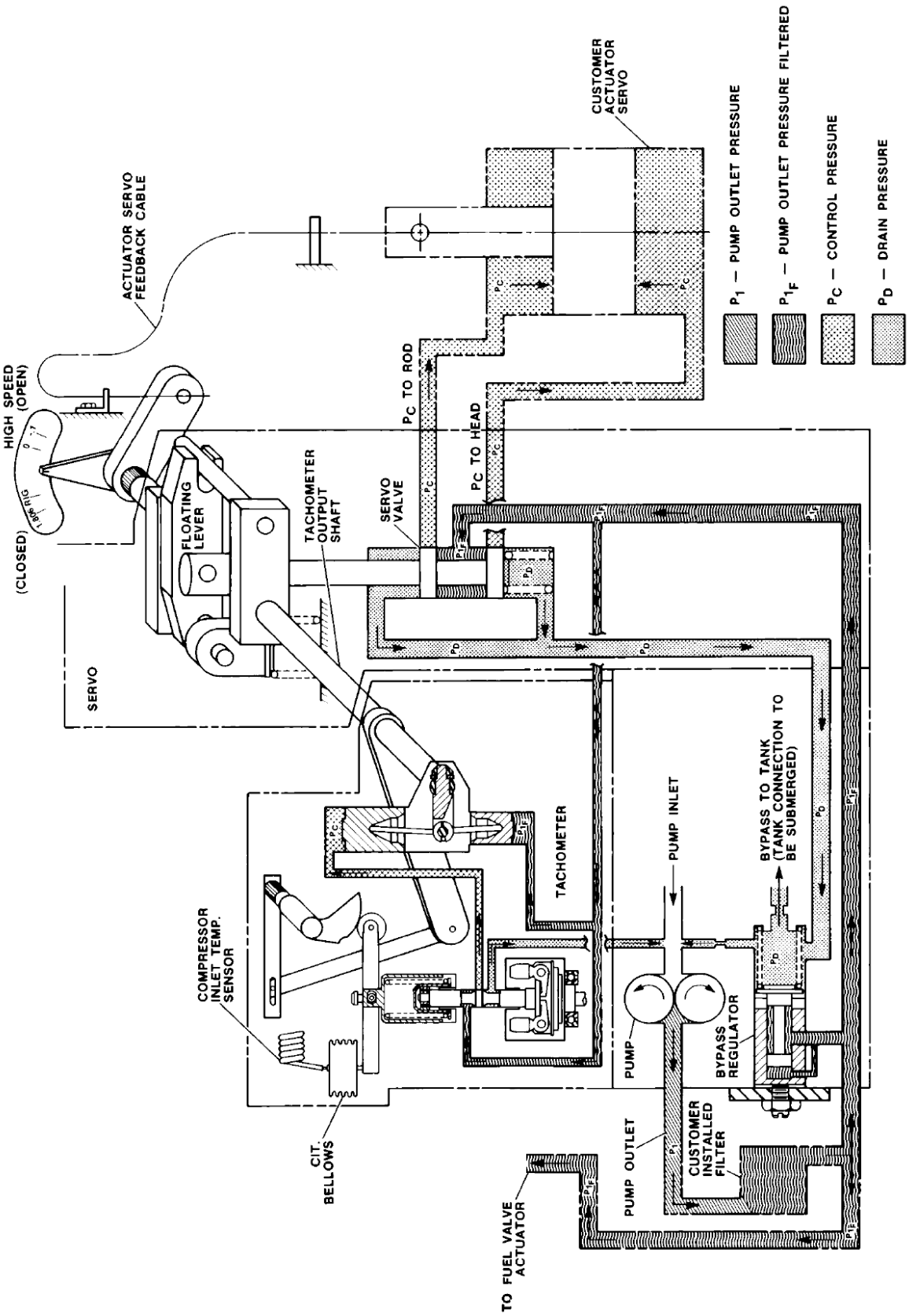


Figure 3-2b. Schematic of the 9902-405 VSV Control

Chapter 4.
Service Options

Product Service Options

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

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

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

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

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

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

www.woodward.com/directory

Woodward Factory Servicing Options

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

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

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

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

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

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

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

Returning Equipment for Repair

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

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

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

Packing a Control

Use the following materials when returning a complete control:

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

NOTICE

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

Replacement Parts

When ordering replacement parts for controls, include the following information:

- the part number(s) (XXXX-XXXX) that is on the enclosure nameplate;
- the unit serial number, which is also on the nameplate.

Engineering Services

Woodward offers various Engineering Services for our products. For these services, you can contact us by telephone, by email, or through the Woodward website.

- Technical Support
- Product Training
- Field Service

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

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

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

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

How to Contact Woodward

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

Electrical Power Systems

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

Engine Systems

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

Turbine Systems

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

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

www.woodward.com/directory

Technical Assistance

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

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

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

Control/Governor #1
Woodward Part Number & Rev. Letter _____
Control Description or Governor Type _____
Serial Number _____

Control/Governor #2
Woodward Part Number & Rev. Letter _____
Control Description or Governor Type _____
Serial Number _____

Control/Governor #3
Woodward Part Number & Rev. Letter _____
Control Description or Governor Type _____
Serial Number _____

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

Declarations

Declaration of Incorporation

Woodward Governor Company
1000 E. Drake Road
Fort Collins, Colorado 80525
United States of America

Product: Variable Stator Vane (VSV) Controls
Part Number: 9902-XXX

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 the following EU Directives as they apply to a component:

98/37/EEC (Machinery)

This product is intended to be put into service only upon incorporation into an apparatus/system that itself will meet the requirements of the above Directives and bears the CE mark.

MANUFACTURER

Signature

Douglas W. Salter
Full Name

Engineering Manager
Position

WIC, Fort Collins, CO, USA
Place

3/24/03
Date

5-09-1182 (REV. 3) 24-Feb-03 00305-04-EU-02-01

We appreciate your comments about the content of our publications.

Send comments to: icinfo@woodward.com

Please reference publication 40110A.

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Email and Website—www.woodward.com

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

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