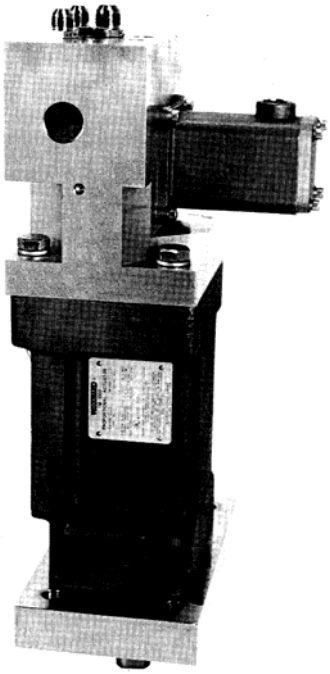
WOODWARD

Product Manual 45014
(Revision B)
Original Instructions



TM-1000LP
Linear-Proportional Actuator

Installation and Operation Manual

General Precautions

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

Practice all plant and safety instructions and precautions.

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

Revisions

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

www.woodward.com/publications

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

Proper Use

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

Translated Publications

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

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 Out-of-date translations are marked with ⚠.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

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

Contents

Illustrations and Tables

Warnings and Notices

Important Definitions

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

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

⚠WARNING

Overspeed / Overtemperature / Overpressure

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

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

⚠WARNING

Personal Protective Equipment

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

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

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

⚠WARNING

Start-up

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

⚠WARNING

Automotive Applications

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

NOTICE

Battery Charging Device

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

Electrostatic Discharge Awareness

NOTICE

Electrostatic Precautions

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

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

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

Follow these precautions when working with or near the control.

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

Chapter 1.
General Information

Description

The TM-1000LP actuator is an electro-hydraulic proportional actuator designed for use with Woodward electronic controls. The actuator may interface directly to a steam-flow control valve. The actuator has an aluminum case with through-hardened stainless-steel internal parts.

A torque-motor servo valve in the actuator is energized by the electronic control and generates a pressure differential applied to the ends of the second-stage spool valve. The spool valve regulates supply pressure that moves a double-acting servo piston and provides linear output by the actuator shaft. Internal mechanical feedback is standard. The actuator is calibrated for bias in the minimum direction in the event of a loss of input current to the torque motor.

Hydraulic fluid in the actuator is sealed from the torque motor by an o-ring between the armature and the servo-valve housing, eliminating the accumulation of magnetic contaminants. A 40 µm nominal filter fitting is provided at the hydraulic-supply port for protection in the event of an upstream filter failure.

Direction of Output

TM-1000LP actuators are available with outputs of 3/4, 5/8, 1, 1.25, 1.5, and 2 inches (19, 16, 25, 32, 38, and 51 mm) from minimum to maximum. The actuator can be designed to either retract (standard) or extend (reverse acting) toward maximum.

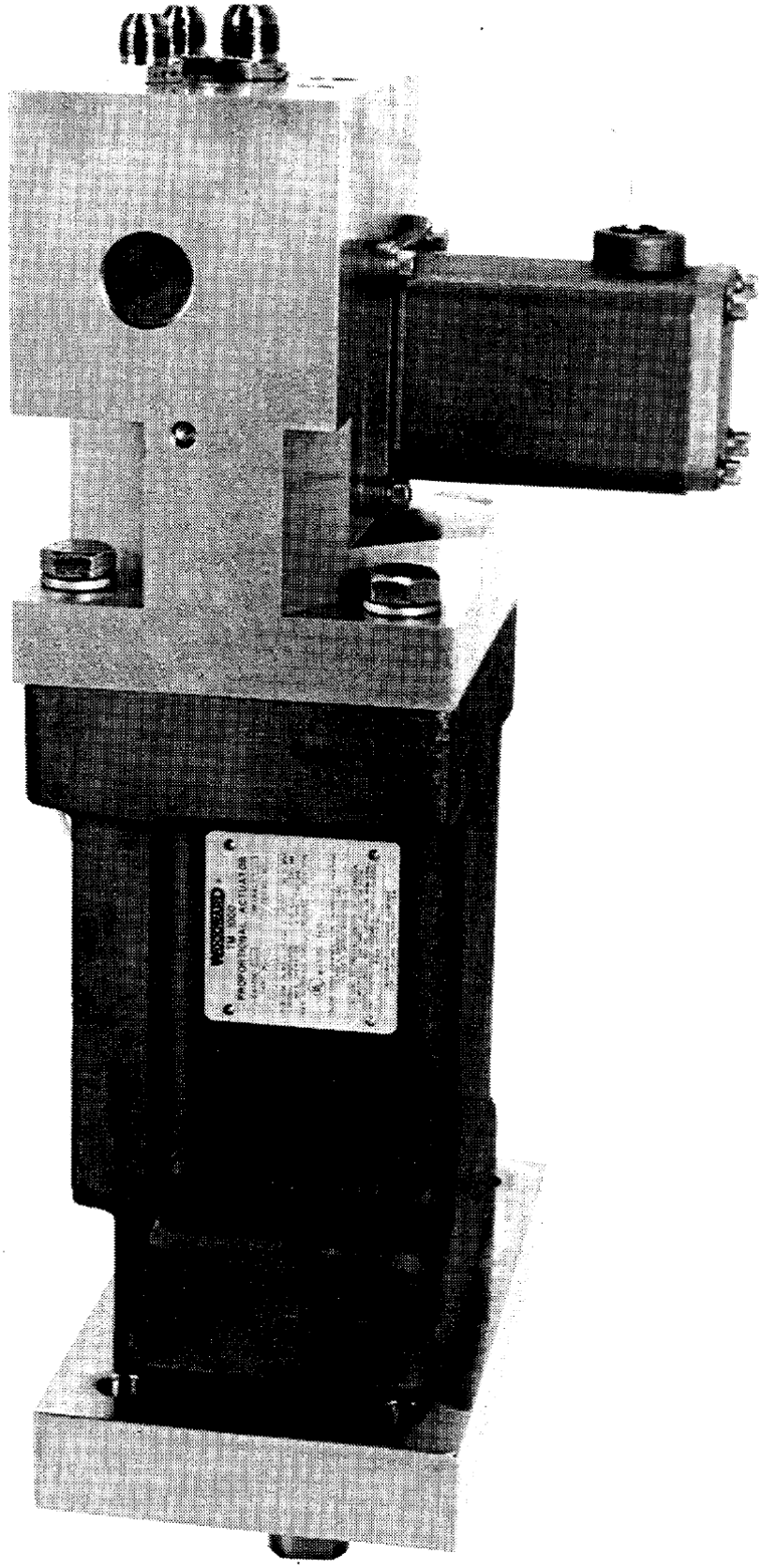


Figure 1-1. TM-1000LP Actuator

Chapter 2. Installation

Introduction

Be careful when installing the actuator. Do not damage the output shaft. Abuse of the actuator can damage seals, installation surfaces, and alter the calibration of the unit. Protect the hydraulic connections with plastic shipping caps when the actuator is not connected to the normal piping.

If the actuator has been assembled to a steam valve at the factory the only installation required will be to install the actuator-steam valve assembly as designed.

Weight

The actuator weighs about 86 pounds when sent from the factory. Installation hardware must be adequate to hold this weight and still provide stable support for the actuator. Do not lift the unit by the torque motor housing. Use a sling around the upper part of the actuator to lift with a hoist.

Receiving

The actuator is calibrated and drained of calibration fluid at the factory. It is then placed in a cardboard container filled with urethane foam for delivery to the customer. Additional cleaning or calibration is not necessary before installation or operation.

Storage

The actuator may be stored as received from the factory for a period of time before installation. If storage will exceed nine months please contact Woodward.

Installation

See Outline Drawing, Figure 2-2, for:

- Overall dimensions
- Installation hole locations
- Hydraulic fitting sizes
- Output shaft dimensions.

Proper filtration of the hydraulic fluid that is to be supplied is extremely important. A 40 µm (nominal) filter must be installed in the supply to the actuator within 1 meter of the supply port. It is necessary to keep the immediate area and equipment clean and free of dirt and contaminants while working on and connecting the hydraulic lines.

Hydraulic supply may be connected to either the Supply or the Accumulator (Acc) connection on the actuator. If an accumulator is not used this connection must be capped.

The attitude in which the actuator is installed does not affect the performance of the actuator.

Connect all hydraulic lines to the actuator. Supply pressure can be from positive displacement or centrifugal type pumps. Use a pressure switch in the supply line to be sure that correct supply pressure is established before start up and maintained thereafter.

Mineral or synthetic based oils, diesel fuels, kerosenes, gasolines, or light distillate fuels may be used for hydraulic supply. The hydraulic fluid should have a specific gravity of 0.6 to 1.0 with a recommended viscosity of 0.6 to 400 centistokes. With a supply at 750 psig (5171 kPa) the steady state flow will be about 1 US gal/min (3.8 L/min) with a maximum transient flow of 15 US gal/min (57 L/min). The hydraulic pump should be capable of supplying the maximum transient flow on a constant basis to avoid sluggish actuator response.

It is very important that the linkage between the actuator output and the fuel system be of correct relationship for proper operation. Use as much of the output travel as possible between minimum and maximum flow points.

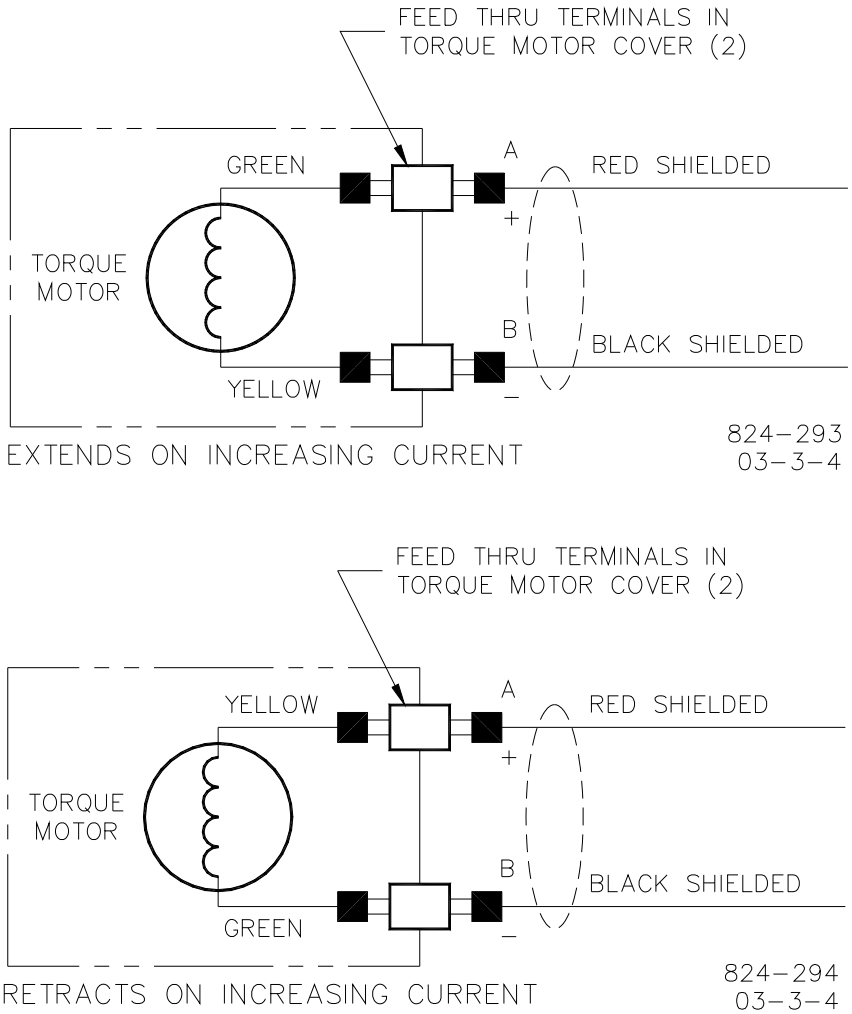


Figure 2-1. Actuator Wiring

Use the correct Woodward control manual when making all electrical connections. A twisted pair of 14 AWG (2.0 mm²) shielded wire extends from the actuator. Continue the Red lead to the positive (+) terminal on the control. Continue the Black lead to the negative (–) terminal on the control. Continue the shields to a ground on the control end, not the actuator end of the wiring.

The electrical connection instructions are provided as a help for most installations. In some cases special wiring has been ordered with the TM-1000LP. In these instances the installer will be provided with other instructions. In all cases yellow (+) and green (–) wires come out to the torque motor cover. Use the correct Woodward control manual when making all electrical connections.

The torque motor has an input current range of 20 to 200 mA. The coil resistance is 30 Ω maximum at 100 °F (38 °C). Maximum coil current is 250 mA.

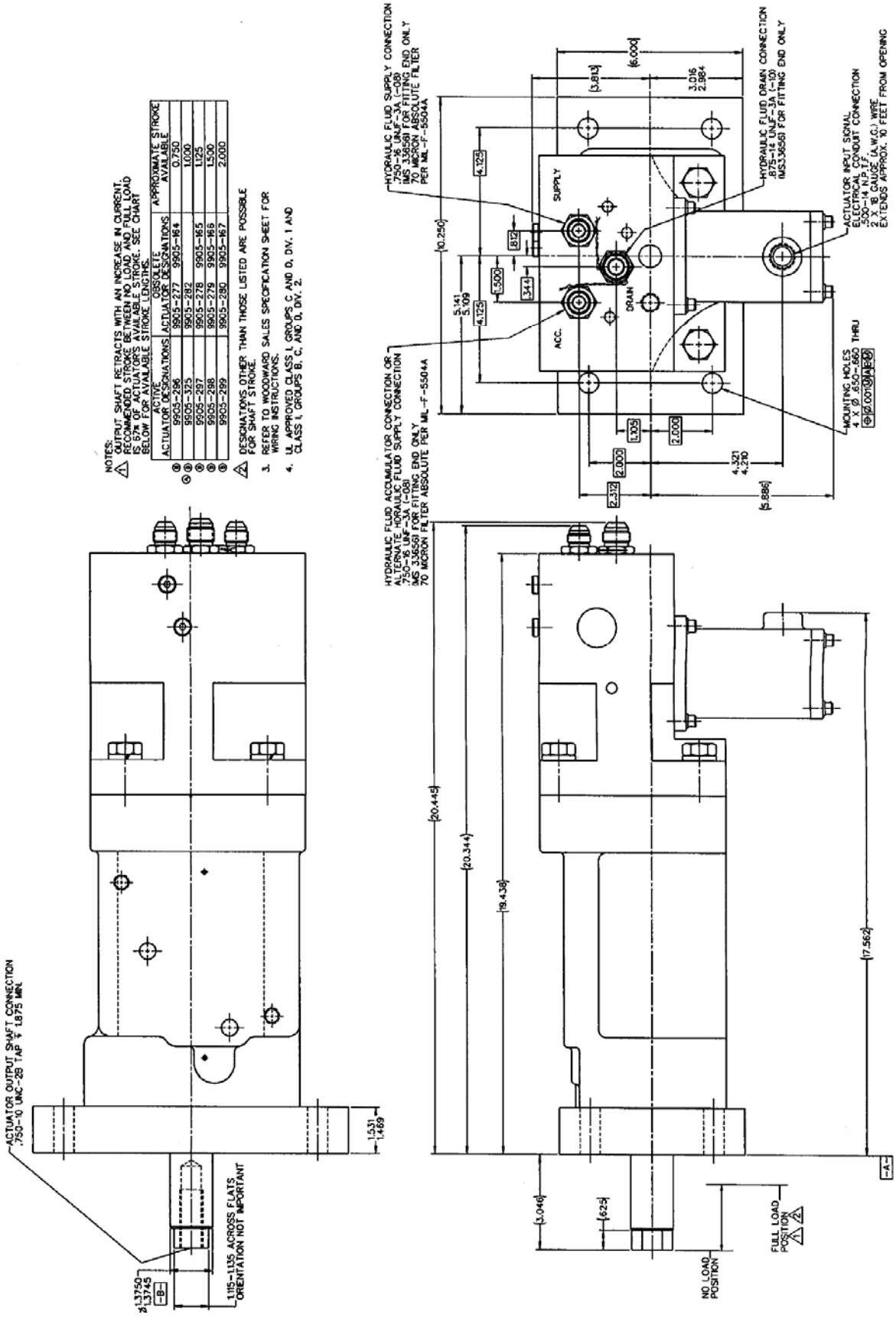


Figure 2-2. Outline Drawing of TM-1000LP Actuator

Chapter 3.
Initial Operation

Introduction

Before the initial operation of the actuator, be sure that all previous installation and hookup procedures are accomplished and all linkages (if any), electrical connections, and hydraulic fittings are secure and properly connected.

Be sure the correct hydraulic-supply pressure to the actuator is established before start up. Trapped air within the hydraulic system may cause momentary erratic behavior of the actuator at the initial operation. Use the correct Woodward manual for the Woodward electronic control to begin prime-mover operation.

⚠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.

Adjustments

Normally all operating adjustments are made to the actuator during factory calibration according to specifications provided by the customer and should not require further adjustment. Do not attempt adjustments to the actuator unless thoroughly familiar with the proper procedures.

Adjustments are available at the factory to set the level position of the output, the distance of output for a given control voltage change and total movement of the actuator output.

Chapter 4.
Principles of Operation

The actuator consists of three basic sections:

- A torque-motor servo valve
- A spring-centered, four-land spool valve
- A double-sided, equal-area servo piston with a linear output shaft

The TM-1000LP actuator has a torque-motor servo valve. The servo valve uses a double nozzle and flapper to generate a differential pressure to operate the second-stage spool valve. The torque motor receives dc signals from the electronic control and applies torque to the single-piece armature and flapper which is supported on a torsion flexure. The servo valve uses the flapper as a variable flow restrictor and throttles the flow of hydraulic fluid from a nozzle on each side of the flapper.

The two nozzles are supplied hydraulic fluid from the actuator supply pressure inlet through separate, fixed orifices. During steady state operation, the flapper is centered between the nozzles and the two pressures, Pc1 and Pc2, are equal.

When input current is increased to the torque motor coil, the limited pivotal movement of the flapper to increase (counterclockwise on the schematic) restricts hydraulic flow from the lower nozzle while flow from the upper nozzle increases. The resulting differential pressure is applied to the ends of the spool valve, raising it from its spring-centered null position.

When raised, the spool valve directs supply pressure to the bottom side of the servo piston and, at the same time, vents the top side to drain at the upper control port. The servo piston then moves up, increasing actuator output shaft position. Servo piston movement also provides position feedback to the servo-valve.

An extension of the flapper is held between the feedback spring and the level adjusting spring. Increasing servo piston movement increases the feedback spring torque load on the flapper to center it. When a force balance is obtained among the torque motor, level adjusting spring, and the feedback spring, the spool valve is centered and further servo movement is halted.

Operation of the actuator is similar in the decrease direction. Movement of the flapper restricts flow from the upper nozzle, while increasing flow from the lower nozzle. The pressure differential this time lowers the spool valve and uncovers

ports to direct supply pressure to decrease actuator output position. The centering action is provided as servo piston movement decreases compression of the lower spring, centering the flapper.

In some applications a rate-limiting restrictor is placed in the supply connection to the increase side of the second-stage pilot valve. This feature reduces actuator velocity in the increase direction only as a safety feature.

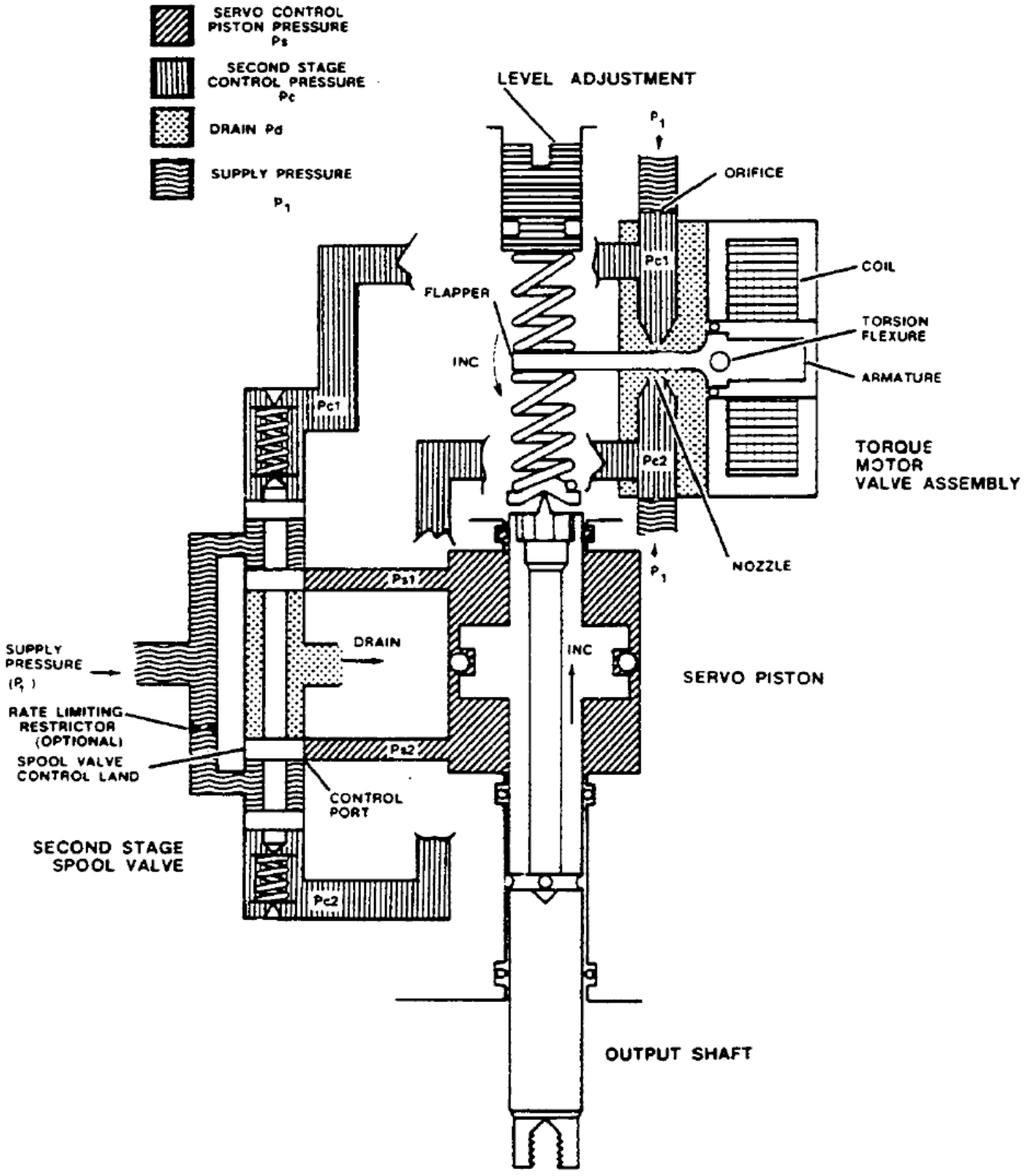


Figure 4-1. Schematic Drawing of TM-1000LP Actuator

Chapter 5. Maintenance

Introduction

This chapter provides instructions for trouble-shooting and preventive maintenance of TM-1000LP actuators.

The service life of the actuator is increased with the use of clean supply flow.

Filter Cleaning

The TM-1000LP is equipped with a 40 µm nominal/70 µm absolute filter fitting at the supply connection. See the outline drawing, Figure 2-2, for the location of the fitting. If the filter becomes clogged, as evidenced by sluggish response of the actuator, it may be removed, cleaned ultrasonically and back flushed with a light solvent. Be prepared to replace the O-ring after cleaning the filter.

NOTICE

Do not run the actuator with the inlet filter fitting or the in-line filter removed or bypassed as extensive repairs can be made necessary by only momentary exposure of the interior of the torque motor to contaminants.

Troubleshooting

Malfunctions of the governing system are usually revealed as speed variations of the prime mover, but it does not necessarily mean that such speed variations indicate governing system problems. When improper speed variations appear, inspect all components, including the turbine, for proper operation. See the correct Woodward control manual for assistance in isolating the trouble.

The following steps describe troubleshooting the actuator:

1. If, during the starting sequence, the actuator does not respond to electrical control input, check the actuator pressure supply and supply filter.

2. If the actuator does not respond to electrical input, disconnect the output linkage and attach a power supply and milliammeter. Increase current to the actuator and the output shaft should follow smoothly with increasing current. Do Not exceed 250 mA.

Disassembly of the actuator in the field is not recommended. Under unusual circumstances where field repair becomes necessary, all work and calibration should be done by personnel thoroughly trained in the proper procedures.

When requesting information or service help from Woodward, it is important to include in your communication the part number and serial number of the actuator.

Chapter 6.
Service Options

Product Service Options

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

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

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

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

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

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

www.woodward.com/directory

Woodward Factory Servicing Options

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

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

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

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

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

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

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

Returning Equipment for Repair

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

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

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

Packing a Control

Use the following materials when returning a complete control:

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

NOTICE

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

Replacement Parts

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

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

Engineering Services

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

- Technical Support
- Product Training
- Field Service

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

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

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

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

How to Contact Woodward

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

Electrical Power Systems

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

Engine Systems

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

Turbine Systems

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

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

www.woodward.com/directory

Technical Assistance

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

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

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

We appreciate your comments about the content of our publications.

Send comments to: icinfo@woodward.com

Please reference publication 45014B.

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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.

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