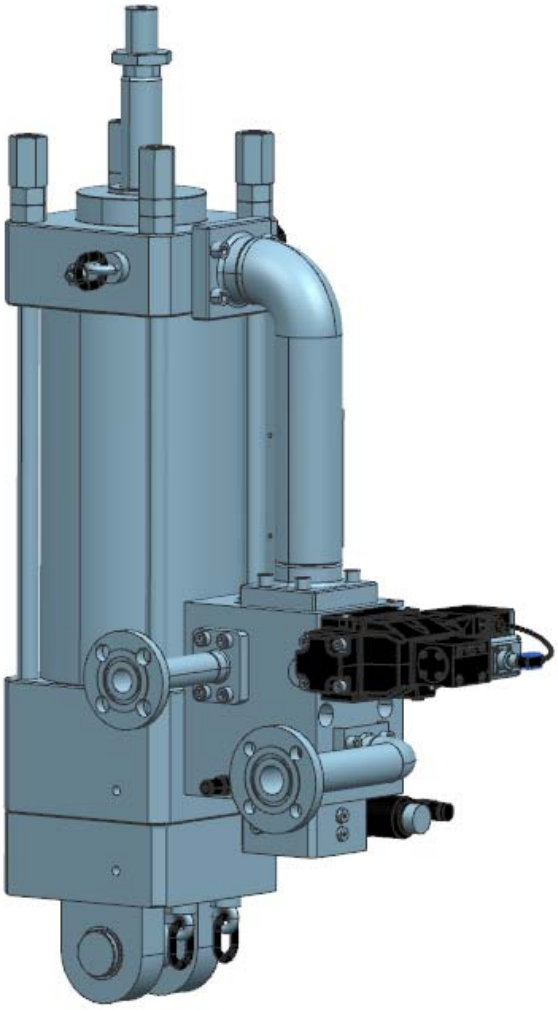
OPERATION AND MAINTENANCE MANUAL

HYDRAULIC STEAM TURBINE ACTUATOR



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Cross-reference

Please refer document **# MMI/ENGP/1008/ONM** for Operation and Maintenance manual on electronic control system and related material.

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WARNING

The Moog Hydraulic Servo Actuator involves the interface of electronics, hydraulics, mechanics and computer technology. This manual outlines the procedures required for system installation, operation, and scheduled maintenance.

Included with the Moog actuator is an Operation & Maintenance Manual, which includes an installation drawing. This drawing contains important information necessary for actuator installation. To avoid damage to facility and actuator, do not attempt installation or operation without this drawing. If the installation drawing was not received with the actuator, contact Moog to obtain a copy this drawing.

It is the responsibility of the end-user of the Moog actuator to ensure that under no circumstances, shall the forces placed upon the Moog actuator exceed the specifications given in the installation drawing.

Under no circumstances should an operator attempt to operate the actuator without training and full understanding of system operation. Should there be any questions regarding the information presented herein personnel should contact Moog for clarification.

General Safety Precautions

The Hydraulic Servo Actuator is potentially hazardous.

This Steam turbine system involves inherent hazards from high forces, rapid motions and stored energy. You must be aware of all moving and operating components that are potentially hazardous, particularly the actuator in a servo hydraulic system.

Whenever you consider that safety is compromised, press the Emergency Stop button to stop the test and isolate the system from hydraulic or electrical power.

Carefully read all relevant manuals and observe all Warnings and Cautions. The term Warning is used where a hazard may lead to injury or death. The term Caution is used where a hazard may lead to damage to equipment or to loss of data.

Ensure that the operation set-up and the actual function you will be using on materials, assemblies or structures constitute no hazard to yourself or others. Make full use of all mechanical and electronic limits features. These are supplied to enable you to prevent movement of the actuator piston or the moving crosshead beyond desired regions of operation. Limits provide protection for your machine and reduce potential hazard.

The following pages detail various general warnings that you must heed at all times while using the equipment. You will find more specific Warnings and Cautions in the text whenever a potential hazard exists.

Your best safety precautions are to obtain training in the operation of equipment that you are using and to read your Operating Instructions and Reference Manual(s) to gain a thorough understanding of that equipment.

General Warnings

Set the appropriate limits before performing loop tuning or running waveforms or tests.

Limits are included within your system to provide a safe way of limiting actuator movement. Failure to set these limits appropriately could result in injury to personnel or damage to equipment.

Actuators may move beyond their nominal stroke under some operating conditions.

Due to the inherent design of servo-hydraulic actuators, sudden movement beyond the nominal stoke of the actuator may be possible, should the closed-loop control become unstable. This may be due to inappropriate gain settings or other changes to the control loop.

Disconnect the electrical power supply before removing the covers to electrical equipment.

Disconnect equipment from the electrical power supply before removing any electrical safety covers or replacing fuses. Do not reconnect the power source while the covers are removed. Refit covers as soon as possible.

Disconnect power supplies before removing the covers to rotating machinery.

Disconnect equipment from all power supplies before removing any cover which gives access to rotating machinery. Do not reconnect any power supply while the covers are removed unless you are specifically instructed to do so in the manual. If the equipment needs to be operated to perform maintenance tasks with the covers removed, ensure that all loose clothing, long hair, etc. is tied back. Refit covers as soon as possible.

Shut down the hydraulic power supply and discharge hydraulic pressure before disconnection of any hydraulic fluid coupling.

Do not disconnect any hydraulic coupling without first shutting down the hydraulic power supply and discharging stored pressure to zero. Tie down or otherwise secure all pressurized hoses to prevent movement during system operation and to prevent the hose from whipping about in the event of a rupture.

Shut off the supply of compressed gas and discharge residual gas pressure before you disconnect any compressed gas coupling.

Do not release gas connections without first disconnecting the gas supply and discharging any residual pressure to zero.

Protect electrical cables from damage and inadvertent disconnection.

The loss of controlling and feedback signals that can result from a disconnected or damaged cable causes an open loop condition that may drive the actuator rapidly to its extremes of motion. Protect all electrical cables, particularly transducer cables, from damage. Never route cables across the floor without protection, nor suspend cables overhead under excessive strain. Use padding to avoid chafing where cables are routed around corners or through wall openings.

Take care when installing or removing a specimen, assembly or structure.

Installation or removal of a specimen, assembly or structure involves working inside the hazard area of the motion envelope of the system. Ensure that all actuator movements necessary for installation or removal are slow and, where possible, at a low force setting.

SECTION 1: INTRODUCTION

1.1 PURPOSE

The purpose of this manual is to provide detailed installation and commissioning procedures for the Moog Hydraulic Servo Actuator. Procedures in this manual are outlined to a level approved by the manufacturer, Moog. If information beyond the scope of this manual is required please contact MOOG.

In order to alert the installer and/or operator to potential hazards and highlight helpful procedures, the following conventions will be used.

WARNING

The symbol on the above and the word “WARNING” are used to call attention to safety instructions concerning a potential hazard for people. Failure to comply with these safety instructions can result in serious damage to health and can even prove fatal in extreme cases.

CAUTION

The symbol on the above and the word “CAUTION” are used to call attention to instructions concerning potential damage to the equipment or to the system as a whole.

NOTE

Notes contain useful information for the operator when starting up and operating the equipment or system.

1.2 EXPLODED VIEW

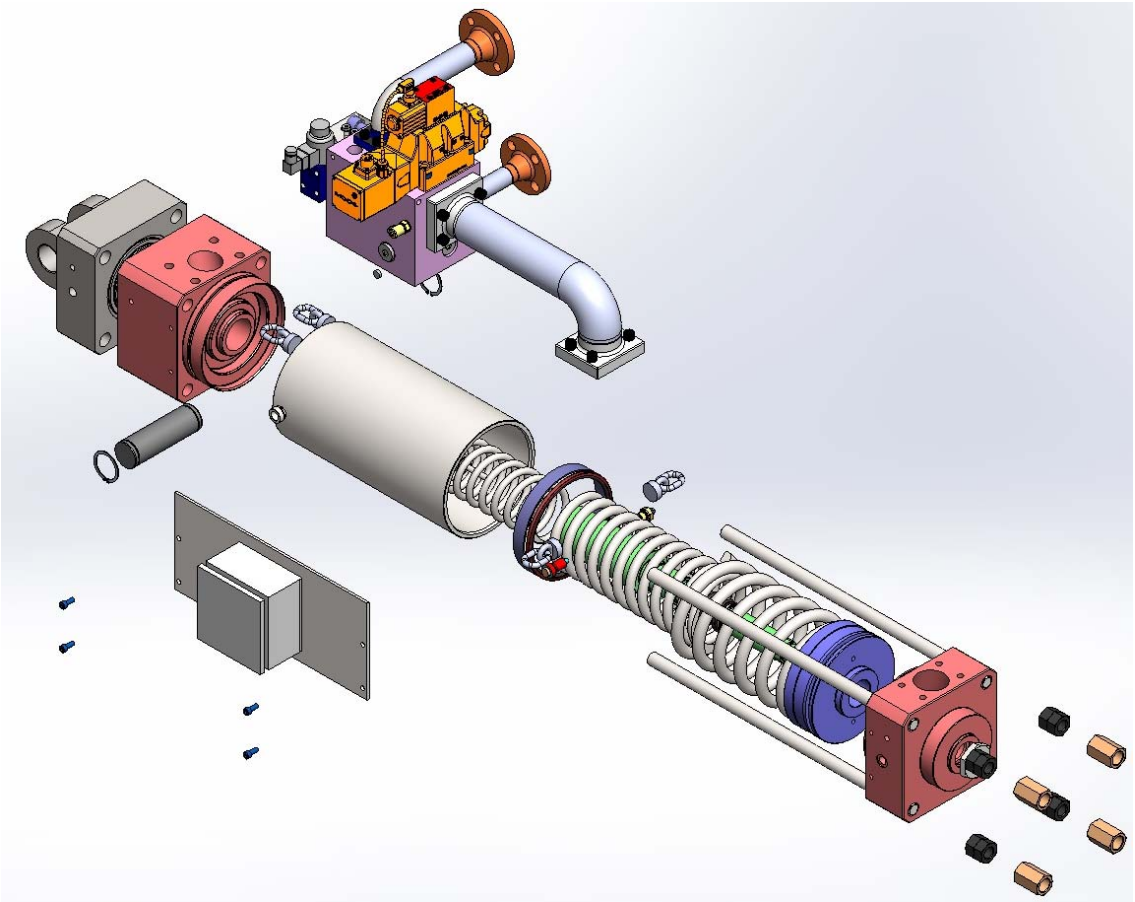


Figure 1 : Exploded view of actuator

1.3 GENERAL FEATURES

Type	Single ended actuator with spring to extend the actuator.	
Seal ratings	10 million fully reversible cycles.	
Ends	Rear End - Fork Clevis mounting and threaded rod to connect to mechanical lever of steam valve.	
Piston rods	High tensile material to ensure long term durability.	
End Cushions	Hydraulic adjustable cushion of 15mm on rod side is provided to prevent impact during emergency forward condition.	

SECTION 2: ACTUATOR FUNCTIONAL OVERVIEW

1 ACTUATOR OVERVIEW

The Actuator consists of a hydraulically powered piston which can extend and retract. A Proportional valve controls the actuator precisely and works together with a mechanical position control, which gives a command feedback, and controls piston position at all times.

Specially designed for Steam Turbine applications, the hydraulic actuator is characterized by low friction, long life, and no external leakage. It includes such features as cushioning at the end of the stroke, direct Proportional valve mounting and a displacement transducer.

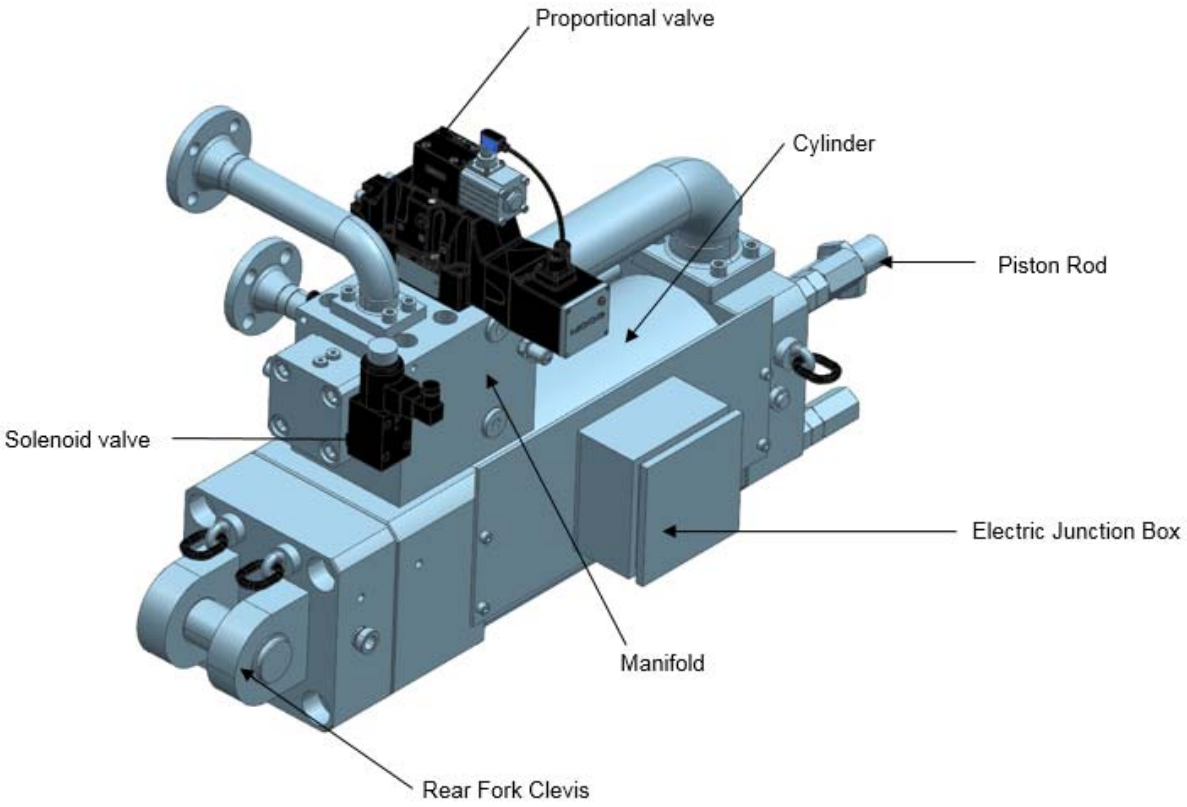


Figure 2 : Hydraulic Actuator

The main components that make up the polymer bearing hydraulic test actuator are as follows:

- **Cylinder:** The actuator cylinder body is the main structural element, and is made from high strength steel.
- **Manifold:** A manifold is used to mount the hydraulic components, including the Proportional valve. This manifold includes pressure and return ports for convenient hose attachment.
- **Cushion:** A cushion is at end of travel in forward direction. This cushion provides a reduction in velocity as the actuator approaches the end of travel at a high rate of speed. The cushion is designed to provide true active adjustable cushioning.
- **Piston Rod:** The piston rod is high strength steel and has an advanced coating which provides high surface to aid in extending seal life.

  Refer to the installation drawing provided with the Moog Hydraulic Actuator for specific installation information.

2.2 D682 SERIES PROPORTIONAL VALVE

The D682 Series Proportional Flow Control Valves are throttle valves for 2-, 3-, 4- and 5-way applications. They are suitable for electrohydraulic position, velocity, pressure and force control systems, including those with high dynamic response requirements.

The position control loop for the main stage spool, position transducer and pilot valve is closed by the integrated electronics.
An electric command signal (flow rate set point) is applied to the integrated position controller which drives the current in the pilot valve coil.
The position transducer (LVDT) which is excited via an oscillator, measures the position of the main spool (actual value, position voltage). This signal is then demodulated and fed back to the controller where it is compared with the command signal.
The controller drives the pilot valve until the error between command signal and feedback signal is zero.
Thus, the position of the main spool is proportional to the electric command signal.

Figure 3 : D682 Proportional valve

OPERATIONAL FEATURES OF THE DIRECT DRIVE PILOT VALVE

- A direct drive pilot valve requires no pilot leakage flow.
- This results in considerable energy savings, especially for systems with multiple valves.
- The dynamics of the direct drive valve is nearly independent of the operating pressure.
- Reliable operation. The excellent pressure gain of the pilot valve with spool / bushing, provides high spool driving forces to the long stroke main spool. This ensures enhanced main spool position control even with high flow forces and contaminated fluids.
- Excellent dynamics based on a high natural frequency allows high main spool position loop gain, resulting in extremely good static and dynamic response of the main valve.

DESCRIPTION OF THE DIRECT DRIVE PILOT VALVE

The D633 Series pilot valve consists of a permanent magnet linear force motor, a drive rod connecting motor armature and the spool guided in a bushing. The linear force motor contains a coil, permanent magnets, pole pieces, an armature and a centering spring arrangement.
The 4-way spool controls fluid flow from the pressure port to one of the load ports, and also from the other load port to return. Deflection of the centering spring due to spool displacement, provides a return force for the armature.
An electric current applied to the coil of the linear force motor produces an electromagnetic flux depending on the current polarity. This electromagnetic flux is superimposed on the permanent magnetic flux in the air gaps between armature and pole pieces. This results in a polarity dependent displacement of the armature against the centering spring force

OPERATIONAL FEATURES OF THE COMPLETE VALVE

- Valve body for high rated flow, optional with external pilot supply using X and Y ports.
- Failsafe versions available with defined safe spool position.
- The D680 series proportional control valves are of two-stage design.
- By combining a fast first stage, suitable main spool drive area and integrated electronics, an optimum proportional valve is offered.

Please go through the catalogue of D682 series Proportional valve catalogue provided along with this Manual for further details on this product.

2.3 ACTUATOR MANIFOLD

The D682 series Proportional valve is mounted on a manifold which mounts directly on the actuator. The manifold is designed such that not much external piping is required on the actuator. The manifold has connections for pressure and return on same sides of the manifold for ease of connection. The manifold houses all the required valves for functional output. Minimess points are provided for measuring pressure at all critical ports.

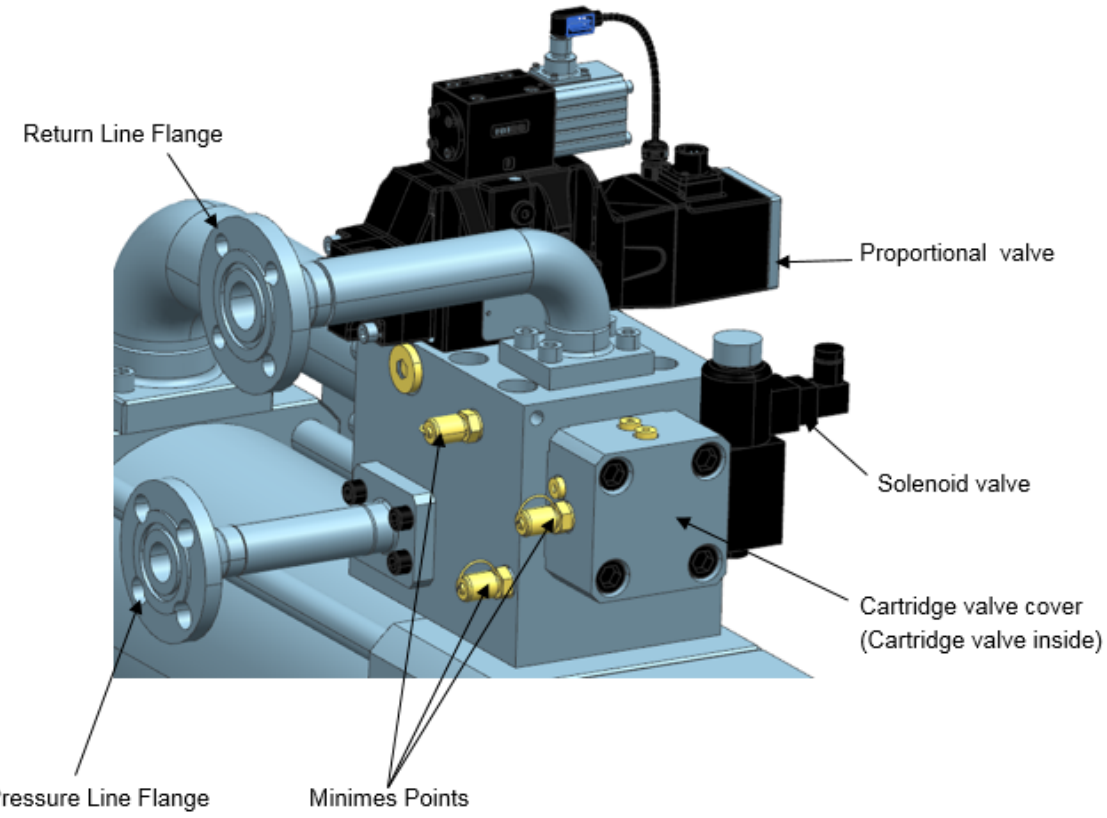


Figure 4 : Manifold Assembly

2.4 ACTUATOR SPECIFICATIONS

Description	Specified Value
Hydraulic Actuator	Actuator is spring loaded, hence is always in fully extended condition in Fail safe
Actuator Bore	Ø 200 mm
Actuator Rod	Ø 45 mm
Stroke	110+5mm (Including 15 mm for cushioning)
Mounting Style	Rear Fork Clevis Mounting
Cushioning	Front end variable cushioning
Position monitoring	Contact less displacement transducer
Working Pressure	25 Bar
Test Pressure	40 Bar
Emergency closing time	< 400 mSec
Max Force generated	50.5 kN in pulling
Minimum spring force (zero stroke)	7700N
Maximum spring force (zero stroke)	21000N
Solenoid Voltage	24 VDC
Temperature range	-20°C to +80°C ambient -20°C to +70°C fluid
Fluid	Mineral oil based Hydraulic fluid
Fluid cleanliness	ISO 4406 < 17/14/11 (NAS 5)
Pressure line connection	1" NB schedule 80 class 150
Tank line connection	1-1/4" NB schedule 80 class 150

SECTION 3: ACTUATOR THEORY AND OPERATION

3.1 INSTALLATION PREPARATION

- Clear the area surrounding the installation site.
- Flush the hydraulic supply lines of foreign material by interconnecting the pressure and return lines around the Hydraulic Actuator assembly. The actuators are clean as shipped from Moog. Flushing blocks may be used if desired.
- Circulate hydraulic fluid through the system at full pump flow.
- Replace the system filter elements when indicated by their contamination alarms.
- Flush the system until the cleanliness level required (documented in maintenance section) is achieved.
- Connect hydraulic supply pressure to P and return to R on the actuator manifold.
- Connect the instrument signal cables per the electrical schematic.

3.2 GENERAL DESCRIPTION AND OPERATION

The cylinder is designed as per customer specifications for steam control application. The Proportional valve mounted on the cylinder manifold assembly is used to control the cylinder stroke with the feedback received from Temposonic assembly which is fitted on piston rod. Special cartridge constructed valve and cover IS designed to cater the emergency condition during operation.

- The normal operation is through Proportional valve activation.
- Mounting Style of Cylinder is Vertical on Rear Fork Clevis.
- The cylinder is compact in design and easy for Maintenance.

3.3 POSITION TRANSDUCER (TEMPOSONIC) ASSEMBLY

Temposonic assembly consists of displacement transducer, Floating Magnet which is assembled on the Temposonic Rod by using a spacer. The function of Temposonic transducer is to sense the position of the cylinder with the help of Floating Magnet with respect to the total stroke and gives the feedback. The required position is achieved by the servo Valve. Temposonic Transducer is protected by the Temposonic Guard

3.4 CYLINDER CONTROL MANIFOLD BLOCK ASSEMBLY

The cylinder control manifold block assembly consist of Solenoid operated direction control Valve, Proportional Valve & Cartridge Valve Assembly.
The function of this assembly is to control the oil flow in the cylinder to achieve the required stroke with the help of Proportional Valve. The solenoid valve is used to control the Cartridge Valve assembly.
Cartridge valve assembly controls the Cartridge block and cover assembly. The solenoid valve is de-energized only during emergency conditions.
[Fig reference available in section 2.3: Actuator manifold]

3.5 SEALING ELEMENTS

The sealing elements consist of following sealing and guiding elements: Glydring, Step Seal, Wiper, and Slydring & O-Rings.

3.5.1 GLYDRING

The Function of Glydring is to provide a leak free sealing between the bore end and rod end. Glydring is preferred due to following reasons

- No stick-slip effect when starting for smooth operation of the cylinder.
- Minimum static and dynamic friction coefficient for a minimum energy loss and operating temperature.
- High wear resistance ensures long service life.
- No adhesive effect to the mating surface during long period of inactivity or storage.
- Suitable for most hydraulic fluids in relation with most modern hardware materials and surface finish
- Suitable for new environmentally safe hydraulic fluids

3.5.2 STEPSEAL

Rod seals must exhibit no dynamic leakage to the atmosphere side under all operating conditions and must be statically completely leak tight when the machine is at a standstill. This is achieved due to the hydrodynamic properties of the seal. The specially formed seal edge with a steep contact pressure gradient on the high pressure side and a shallow contact pressure gradient on the low pressure side ensures that the fluid film adhering to the piston rod is returned to the high pressure chamber on the return stroke of the rod. This prevents the micro-fluid layer, carried out of the high pressure chamber when the piston rod is extended, causing leaks.

Step seal is preferred due to following reasons:

- High static and dynamic sealing effect.
- Low friction, high efficiency.
- Stick-slip-free starting, no sticking.
- High abrasion resistance, high operational reliability.
- Wide range of application temperatures and high resistance to chemicals.
- Simple installation without seal edge deformation.

3.5.3 WIPER

Wiper is installed in hydraulic cylinders to wipe any dirt, foreign particles, chips, moisture, etc. from the piston rods as they are retracted into the system, thus preventing contamination of the hydraulic medium which would otherwise damage wear rings, seals and other components.

Wiper is preferred due to following reasons:

- Low friction.
- Good scraping effect both inwards and outwards.
- Simple, small installation groove.
- Compact design.

3.5.4 SLYDRING

The function of Slydring is to guide the piston head of hydraulic cylinder and to absorb the transverse Forces developed due to axial load. Slydrings avoid metallic contact between the sliding parts of the cylinder, e.g. piston rod and Seal retainer, Piston Head and Cylinder.

Slydring is preferred due to following reasons:

- High load bearing capacity.
- Eliminates local stress concentrations.
- Wear-resistant, long service lives.
- Favorable friction behavior.
- Damping of mechanical vibrations.
- Good wiping effect, embedding of foreign particles possible.
- Protection of the seal against “dieseling”.
- Eliminates hydrodynamic pressure problems in the guide system.
- Simple closed groove, easy installation.

3.5.5 O-RINGS

O’Rings are installed in Hydraulic cylinder and are used as sealing elements or as energizing elements. They are mainly used as static seal for Flanges, Valves, and manifold block sealing.

3.6 OPERATING PRINCIPLE

There are two situations in the operating condition of hydraulic actuator.

- Normal working mode
- Emergency mode

3.6.1 NORMAL WORKING MODE

MOOG control card (P-I Card) receives the input command from Woodward Governer (4-20mA) and control card accordingly gives command to drive the Proportional Valve D682-4241 mounted on actuator. Based on the valve opening and the inlet flow & pressure, the piston starts moving.

The position transducer inside the actuator gives a feedback to the PI Card. Based on this feedback PI Card controls the opening / closing of the servo valve to achieve the required position of the actuator piston (i.e. steam control actuator).

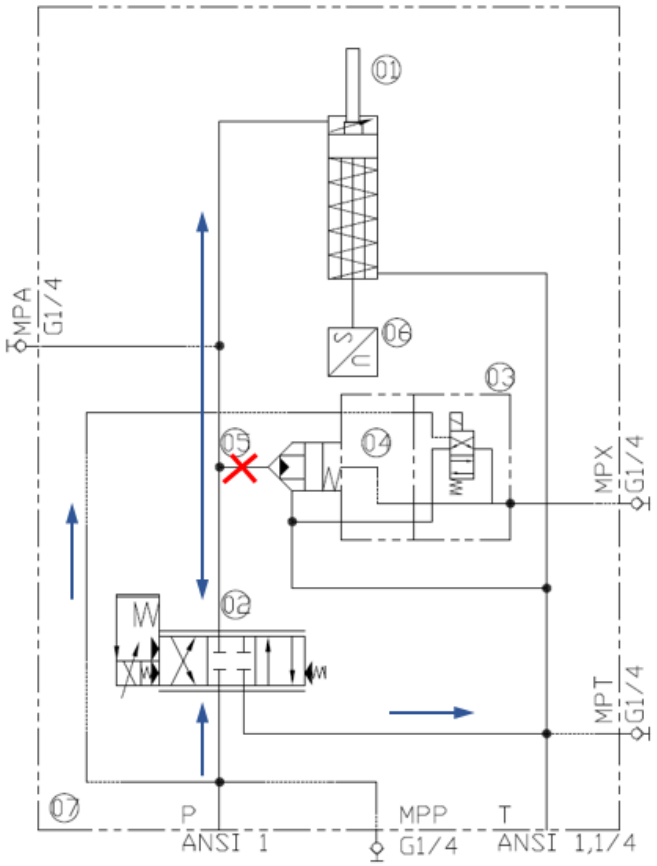


Figure 5 : Principle of Normal Working

In hydraulic terms oil supply from Pump is connected to 'P' port on actuator which is an input flow to the Proportional valve. The Proportional valve opening or closing is controlled by PI card.

- Solenoid valve (03) is always in ON condition
- Pilot line taken from main pressure line closes the cartridge valve (05) when solenoid valve is in ON condition.
- P->A & B->T can be achieved by giving 12->20 mA command to Proportional valve
- P->B & A->T can be achieved by giving 12->4 mA command to servo valve
- Normal working mode is basically "Position closed-loop"
- Depending on the demand from governor, Proportional valve will get relative command signal to keep the actuator at desired position.
- When actuator needs to retract (open steam valve), 12->20 mA command should go to Proportional valve. Proportional valve position will be P->A & B->T. Pressurized oil will go to actuator's annulus area and retract it.
- When actuator needs to forward (close steam valve), 12->4 mA command should go to Proportional valve. Proportional valve position will be P->B & A->T. Spring inside actuator will push piston forward and oil will be drained from A->T.

3.6.2 EMERGENCY MODE

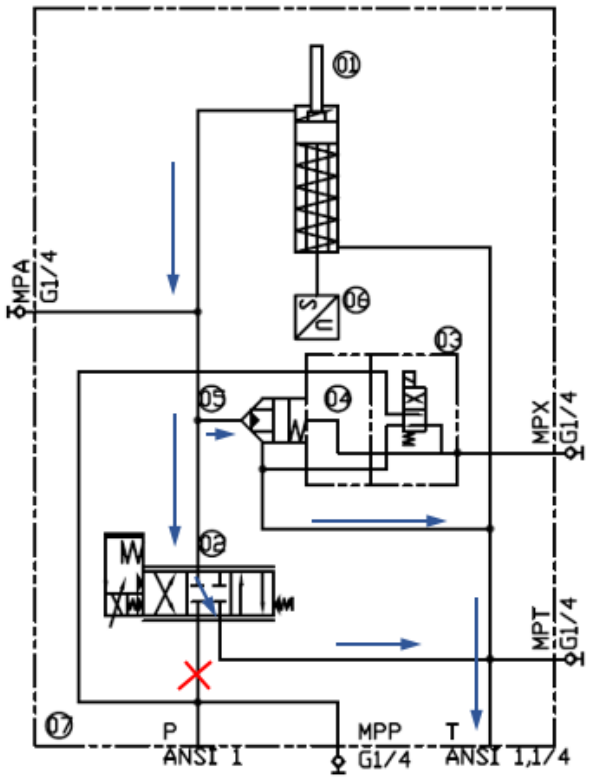


Figure 6 : Principle of Emergency mode

- Solenoid valve (03) is switched OFF
- This opens the cartridge valve (05)
- Proportional valve goes to fail-safe position which is A->T.
- Spring inside the actuator pushes piston to fully forward condition, draining the oil majorly through cartridge valve & partially through Proportional valve and hence closes the steam control valve.
-

3.7 INSTALLATION DRAWING

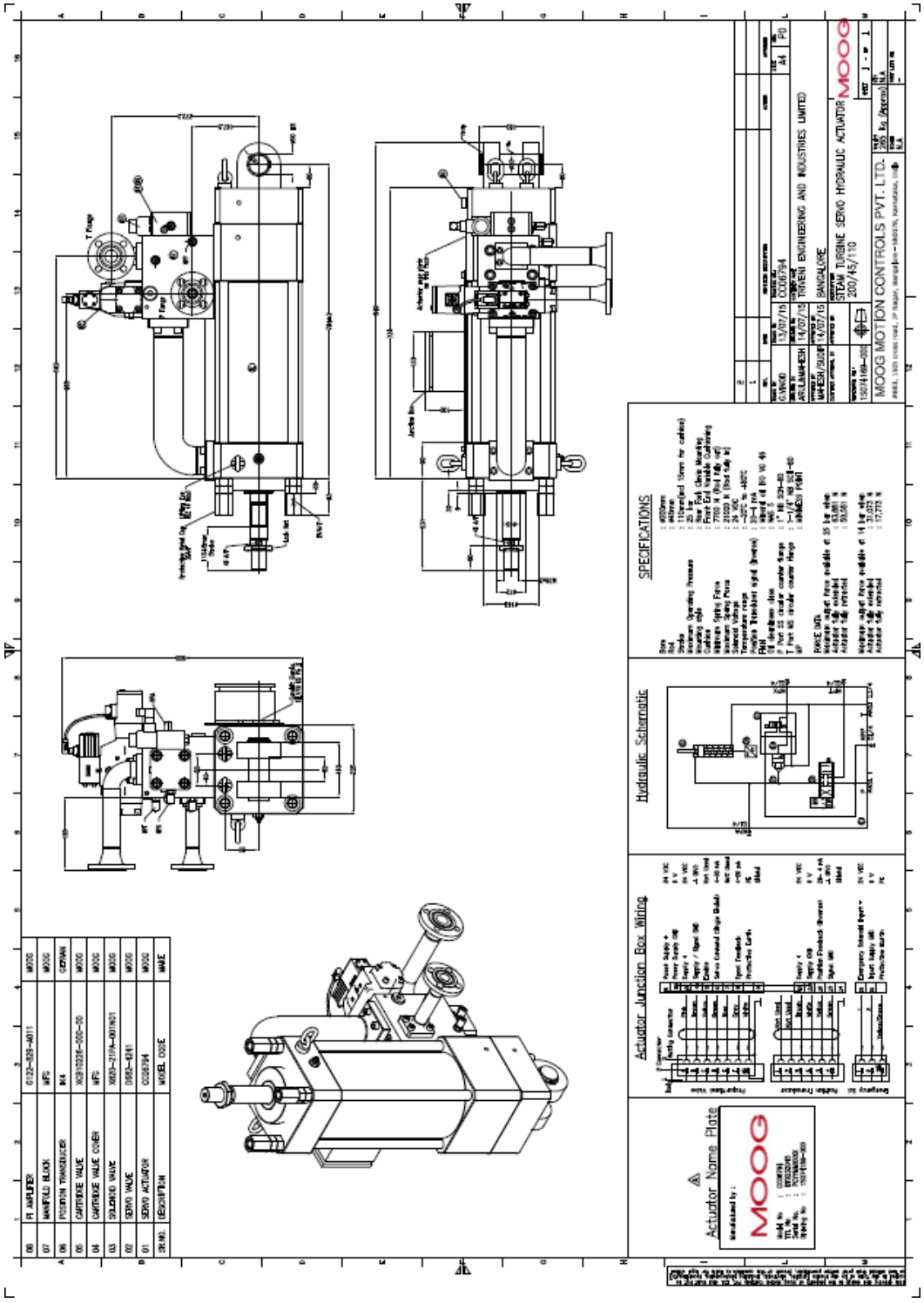


Figure 7 : Actuator Installation Drawing

Note: Please refer the installation drawing attached separately at the end of this O & M.

SECTION 4: HYDRAULIC PRESSURE & TEMPERATURE SET POINTS

The Hydraulic Actuator operates at the following pressures:

- Max Operating Pressure...……. 25 bar
- Max Return Pressure……..1.5 bar

The Hydraulic Control System should have the following pressure set points:

Name	Value	Unit
Fatal High Pressure Limit (Controller Set point)	30	Bar
Fatal Low Pressure Limit (Controller Set point)	20	Bar
System Nominal Pressure (Ref)	25	Bar

Table 1 : Hydraulic Pressure Set Points

The Hydraulic Control System should have the following temperature set points:

Name	Value	Unit
Fatal High Temp System Shutdown	65	º C
Warning High Temperature Limit	60	º C
Fatal Low Temperature Limit	10	º C
Warning Low Temperature Limit	15	º C

Table 2 : Hydraulic Temperature Set Points

SECTION 5: ACTUATOR MAINTENANCE

5.1 GENERAL MAINTENANCE GUIDELINES

Perform regular maintenance on the actuator for the following reasons:

- Safety of personnel
- Longest possible time to prepare for component failure due to wear
- Cost Savings

5.1.1 QUALIFIED PERSONNEL

Maintenance and repair of the actuator is only to be carried out by qualified technical personnel.

Technical personnel must have sufficient knowledge and training regarding safety precautions and operation of the equipment.

5.1.2 PRECAUTIONS

Before starting any repair or Maintenance verify the following:

- Safety conditions fulfilled?
- Power turned off to the system?
- Pressure has been discharged from the accumulators?

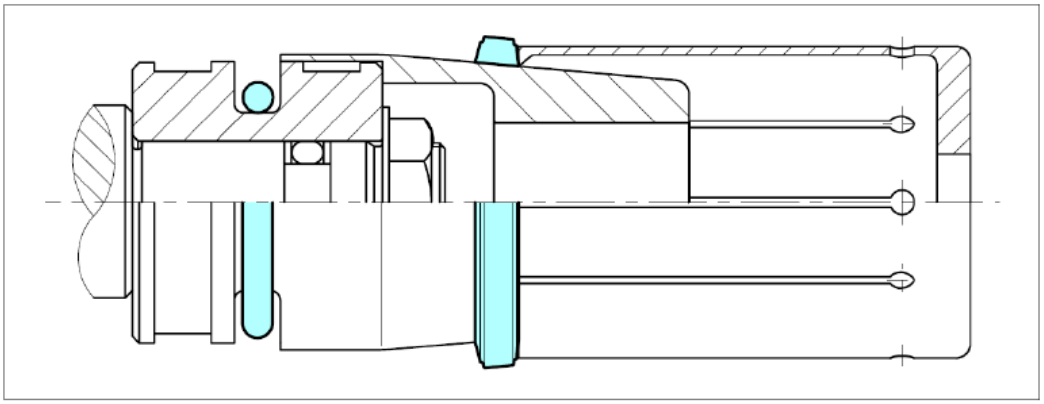
Only original Moog spare parts may be used in the Moog Hydraulic Actuator. If non-authorized parts are used, Moog will not accept liability for possible consequential damages.

5.2 INSTALLATION OF SEALS

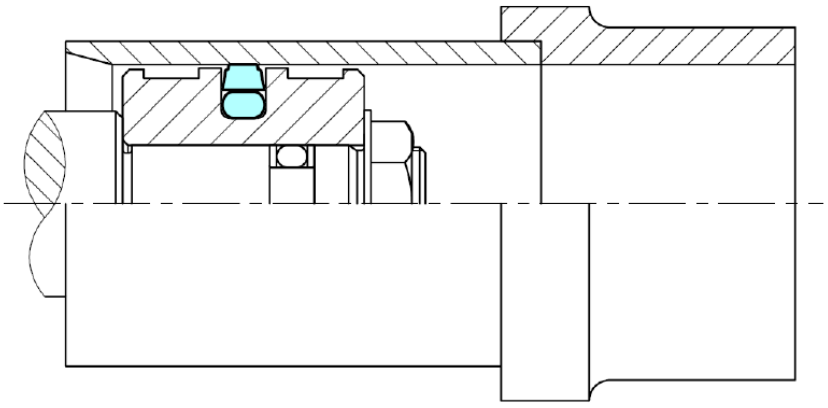
Seals are the most important elements responsible for performance and leak free holding of the cylinder. Direction of installation of some of the seals is critical from functioning point of view. One should refer to the cylinder cross-section drawing before installation. The seals catalogue give details of installation, precautions and loading tools required. Improper installation of seals may damage the seals and/or cylinder parts while installation.

5.2.1 PISTON SEALS

The loading mandrels are used to load seals on piston head. The O-Ring is first loaded in the piston groove. The outer ring is harder and not elastic enough to stretch easily on the groove. The outer ring can be stretched and mounted over the groove or can be installed using the loading mandrel. In both the cases the outer dimensions of the seal change and increase beyond the nominal bore size. The outer ring needs to be resized after installing. The resizing is done either using the sizing tool or the cylinder body itself as shown in figure 8



Expanding the Turcon® or Zurcon® sealing element using an expanding sleeve over the installation sleeve



Sizing the sealing element with sizing sleeve

Figure 8 : Installation of seals

The following points should be observed before installation of the seals:

- Ensure the cylinder tube has a lead in chamfer.
- Remove residues such as chips, dirt and other foreign particles and carefully clean all parts.
- The seals can be installed more easily if they are greased or oiled. Attention must be paid to the compatibility of the seal materials with these lubricants. Use only grease without solid additives (e.g. molybdenum disulphide or zinc sulphide).
- Use no sharp-edged installation tools.

5.2.2 ROD SEALS

Place the O-Ring into the groove. Compress the outer seals into a kidney shape. The seal must have no sharp bends as shown in figure 9. Place the seal ring in compressed form into the groove and push against the O-Ring in the direction of the arrow. After placing into the groove, form the seal into a ring again in the groove by hand as shown in figure 10. Finally size the seal ring using a mandrel which should have a chamfer of 10° to 15° over a length of approx. 30mm. It should be made up of polymer material (e.g. polyamide) with good sliding characteristics and high surface quality in order to avoid damage to the seals. The Piston rod itself can be used for calibration.

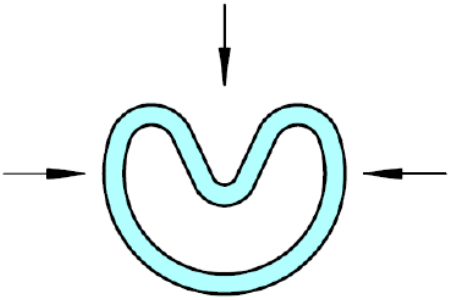


Figure 9 : Kidney-shaped deformation of the seal ring

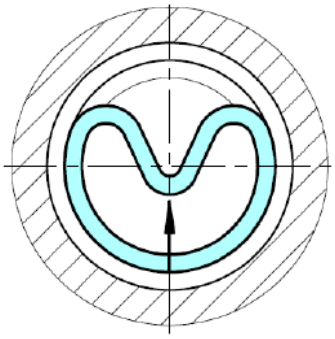


Figure 10 : Inserting the seal ring into the closed groove

The seals can be installed more easily if the rod is greased or oiled. Attention must be paid to the compatibility of the seal material with these lubricants. Use only grease without solid additives.

5.3 STEPWISE PROCEDURE OF ACTUATOR ASSEMBLY

- Place the Rear End Fork clevis on two flat surface blocks and above that Rear flange with the tube with proper lubrication as shown in figure 11.

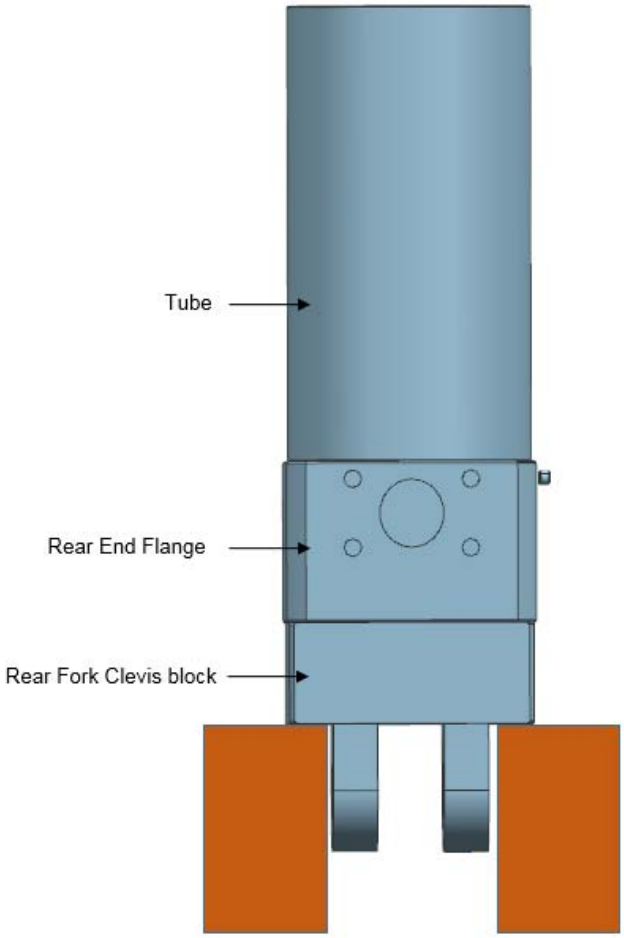


Figure 11 : Assembly Step-1

- After proper alignment of Rear fork clevis block, Rear flange and Tube, insert the Tie rods into the Rear fork Clevis block so that there is sufficient engagement in the Rear fork clevis block.

- The Rear flange has been given with the locating grooves for springs. So insert these springs one by one taking into care that these springs are properly located in those grooves as shown in figure 12 without damaging the internal diameter of the Tube.

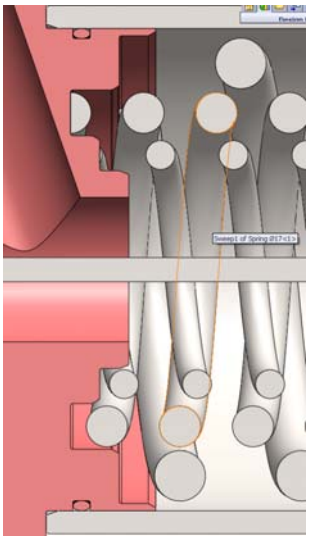


Figure 12 : Springs in actuator

- After placing the springs, insert the Piston Rod assembled with Head and the place the front flange such that it has been properly aligned. Make sure that there will be threading of the tie rod available to tighten it as shown in figure 13.

Figure 13 : Assembly Step 4

- The tightening of Nuts should be done diagonally so that there should not be any misalignment. Also keeping into the mind that while tightening there should be enough engagement at the Rear fork clevis block and when completely tightened the Tie rod is fully engaged with the Rear Fork Clevis block and also the Hex nut and Lock Nut as shown in figure 14

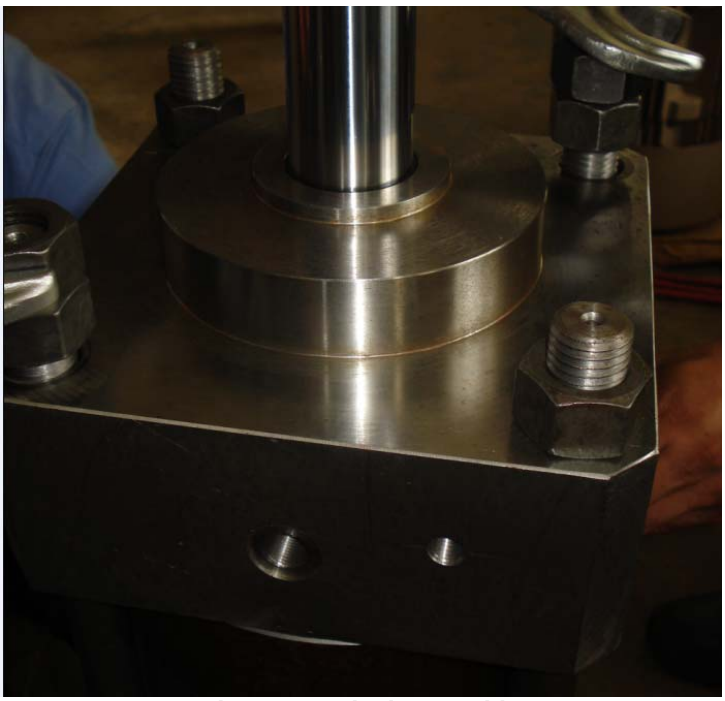


Figure 14 : Final Assembly

- Once the actuator is fully assembly with proper torque as suggested, mount other valves and components as shown in the installation drawing.

5.4 RECOMMENDED PREVENTATIVE MAINTENANCE GUIDELINES

It is recommended that a visual inspection of the Hydraulic Actuator takes place at regular intervals. If anything out of the ordinary is observed, contact a qualified maintenance technician immediately.

Daily

Wires & Cables	Visually inspect all wire and cable assemblies to verify they are routed in such a fashion that they will not be pinched or damaged as the actuator goes through its motion.
Wires & Cables	Visually inspect all wire and cable assemblies to verify they are secure and held in place (no loose or hanging wires).
Hydraulic Hoses	Visually inspect all hoses to verify they are routed in such a fashion that they will not be pinched or damaged as the actuator goes through its motion. Also inspect all hoses for damaged covers, fittings and leaks. Inspect and replace according to hose manufacturers recommendations.

Monthly

General	Perform the daily inspections shown above. Clean the exposed cylinder parts with lint free cloth.
Swivel Assembly	It is recommended that the torque on the joint assembly mounting bolts is checked at least monthly as the bolts could loosen during operation.
Mounting bolts	Paint marking fasteners is a convenient way to monitor rotation, but it may not show a loss of fastener clamp load. Check torque values as shown in this manual and on the Actuator Installation drawing.

6 Months

General	Perform the daily and monthly inspections shown above.
Hydraulic Fittings	It is recommended that the hydraulic fitting torque is checked at least twice a year as the fittings could loosen during operation.
SAE Hydraulic Flanges	It is recommended that the bolt torque on the SAE hydraulic flanges are checked at least twice a year as they could loosen during operation.

Yearly	
General	Perform the Daily, Monthly and Bi-annual inspections shown above
Oil	Obtain a sample of the oil used in the HPU, and have the state of the hydraulic oil tested at a hydraulic oil supplier. The oil should be checked for contamination level, contamination type, and water content.

5 Years	
General	Perform the inspections shown above
Hoses	It is recommended that all hoses be replaced at this time.
Seals	Replace complete seal sets – depending upon usage

5.5 CONTAMINATION CONTROL

5.5.1 SOURCES OF CONTAMINATION

There are four primary sources where solid contamination can enter a hydraulic fluid.

They are:

- **New oil**
  Even using fluids from reputable suppliers, sampling has shown that new oil needs to filtered before being used in a hydraulic system to maximize component life. A portable oil filter cart fitted with a 3 Micron filter is recommended when filling the oil reservoir of a hydraulic system. By doing this the contamination is removed from the new oil before the contamination enters and damages the components in the hydraulic system.

- **Contamination due to the assembly or repair process**
  New equipment always contains a certain amount of built-in contamination. Even with careful system assembly, and new component flushing, the amount of contamination is reduced, but is never completely eliminated. During the assembly process Moog carefully cleans each component before assembly to minimize the amount of contamination. Moog flushes the hydraulic actuator before initial startup with motion.

- **Contamination from the outside environment**

  Contamination from the environment can be ingress into the hydraulic system. The key is to limit the access environmental contamination has to enter the hydraulic system. There are four major ways dirt can enter a system:

  - Reservoir vent ports (Where air breathers are installed)
  - Power unit or system access plates
  - Components left open during maintenance
  - Cylinder seals

  All possible care should be taken to ensure that open ports are kept covered or plugged and component disassembly and rework is done in an area that is protected from excessive airborne dirt and contamination. An air breather with a filter is recommended. A Desiccant air breather which also prevents water ingression is preferred. Lint free rags should be used for component clean-up.

- **Internally-generated contamination from worn components**

  Contamination is generated by the system itself during normal operation. In a properly filtered system running on clean fluid, few particles are generated. Components, such as pumps create a small amount of particles during normal operation due to the interaction of internal moving parts relative to each other.

5.5.2 ISO CLEANLINESS RECOMMENDATION

The best way to minimize internal contamination generation within a hydraulic system and maximize the longevity of the hydraulic components is to start with a clean (fully flushed) system and maintain the system fluid to the recommended ISO cleanliness levels. The Proportional valves are the most sensitive components in the hydraulic system to contamination due to the tight tolerances needed for high performance. For the hydraulic test actuator, Moog recommends the following ISO cleanliness levels:

- For Normal Life: ISO 4406 < 18 / 15 / 12
- For Extended Life: ISO 4406 < 17 / 14 / 11

The chart below explains the ISO code.

NAS 1638	4	5	6	7	8	9	10	11
ISO 4406-1999	15/13/10	16/14/11	17/15/12	18/16/13	19/17/14	20/18/15	21/19/16	22/20/17

ISO 4406

First number: particles grather than 4µm
Second number: particles grather than 6µm
Third number: particles grather than 14µm

ISO/Range Code	Min. particles /mL	Max particles /mL
1	0	0.02
2	0.02	0.04
3	0.04	0.08
4	0.08	0.15
5	0.15	0.3
6	0.3	0.6
7	0.6	1.3
8	1.3	2.5
9	2.5	5
10	5	10
11	10	20
12	20	40
13	40	80
14	80	160
15	160	320
16	320	640
17	640	1,300
18	1,300	2,500
19	2,500	5,000
20	5,000	10,000
21	10,000	20,000
22	20,000	40,000
23	40,000	80,000
24	80,000	160,000
25	160,000	320,000
26	320,000	640,000
27	640,000	1,300,000
28	1,300,000	2,500,000
29	2,500,000	5,000,000
30	5,000,000	10,000,000

Figure 15 : ISO Cleanliness Code

5.6 CALIBRATION REFERENCE

Actuator stroke calibration in PI Amplifier:

Please note that for 4mA Governor Command = cylinder is extended and for 20mA Governor Command = cylinder is retracted.

Attention!

The PI Servo amplifier is pre calibrated with full stroke of the actuator i.e. 115mm. If you want to restrict the actuator stroke to say for example 100mm then only we have to follow the below procedure.

1. Disconnect the Governor command from P-I Amplifier Pin 7.
2. Disconnect the Servo command from P-I Amplifier Pin 31 (Proportional Valve Pin D)
3. Do not disturb the other connections.
4. Connect a digital multi-meter (DMM), on DC Volts, between the front panel feedback amp and ground test points.
5. Connect the current source or Governor command (isolator output) (4-20mA) to the Proportional Valve Pin D directly. (Make sure that current source / Governor command (isolator output) GND and Proportional valve GND are same.)
6. Apply 4mA command (i.e., 0%) from the Governor, the actuator will extend.
7. Adjust the feedback Zero trim pot until the digital multi-meter (DMM) reads 0.00V.
8. Then provide a spacer / metal block for required stroke of the actuator say for example 100mm.
9. Now, Apply 20mA command from the current source or Governor command (i.e., 100%). The actuator will retract until the spacer / metal block provided.
10. Adjust the feedback Gain trim pot until the digital multi-meter (DMM) reads -10.00V.
11. Repeat Step 6, check the feedback test point is still 0.00V. Trim if necessary and check the 0.00V setting again.
12. Repeat Step 9, check the feedback test point is still -10.00V. Trim if necessary and check the -10.00V setting again.
13. Finally connect the Governor command to P-I Amplifier Pin 7 and Proportional command to P-I Amplifier Pin 31 (Proportional Valve Pin D).

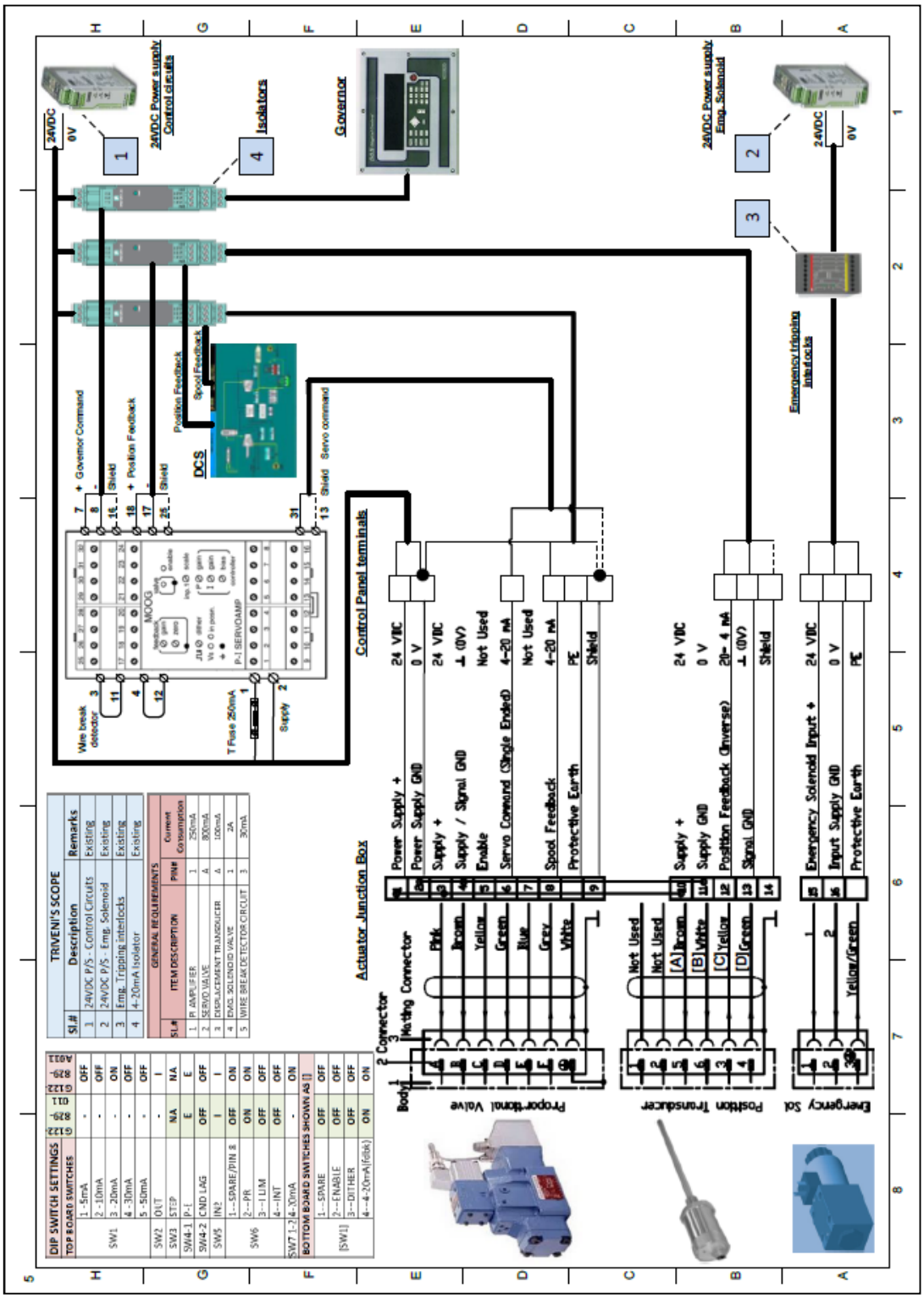


Figure 16: Wiring diagram

5.7 RECOMMENDED SPARES

Sl.No	Description	Moog Part No.	Qty
1	Proportional Valve	D682-4241	1No.
2	Emergency Solenoid Valve	X820-21PA -001N01	1No.
3	Cartridge Valve	XCB10226-000-00	1No.
4	PI Amplifier	G122-829-A011	1No.
5	Actuator Seal Kit	CC01741	1set
6	Position Transducer	CC01742	1No.
7	Cable assembly with connector for Position transducer	CC01743	1set
8	Cable assembly with connector for Emergency Solenoid valve	CC01744	1set
9	Cable assembly with connector for Proportional valve	CC01745	1set
10	Flushing plate - NG 16 with seals & mounting screws	CC01746	1set
11	Minimess Hose 1mtr length with Pr. Gauge 4"dial, 0-40bar glycerin filled	CC01747	1set

Table 3 : Recommended Spares

5.8 TIGHTENING TORQUE

The following tightening torques and assembly preloads apply to the screws with metric thread specified below:

- Allen screws in accordance with DIN 912
- Hexagon head bolts in accordance with DIN 931
  - Property class 10.9 according to DIN ISO 898 μ=0,1
  - Head contact surface and thread lubricated with MoS2
  -

THREAD	PRELAOD	MAX TIGHTENING TORQUE	Used
M5	9.7 kN	7 Nm	Solenoid Valve - Cartridge Valve cover Position sensor cover- Plate
M 6	14.3 kN	12.5 Nm	Proportional valve - Manifold
M 8	26 kN	30 Nm	Junction box - Junction box mounting plate End caps - Junction box
M 10	42 kN	60 Nm	Pressure line flange - Manifold Return line flange - Manifold Proportional valve - Manifold
M 12	61 kN	104 Nm	Connecting flange - Front End cap Lifting eye - Front End cap Connecting flange - Manifold
M 24	260 kN	850 Nm	Tie Rods Nuts- End cap
M 36	600 kN	3000 Nm	Piston rod lock nut

Table 4 : Tightening Torques

SECTION 6: ACTUATOR TROUBLE SHOOTING

Problem : 1. No response from the Actuator

Possible Causes	Remedies
Control oil pressure is low	Check the inlet pressure (25kg/cm2)
No Power supply for PI Amplifier / Proportional valve / Position sensor / Emergency Solenoid valve	Check the input power supply (24VDC)
No signals to PI Amplifier / Proportional valve / Position sensor	Check all signals are arriving at actuator Junction Box
Loss of command signal / Cable damages / Puncture in cables	Check the cable conditions by continuity / insulation test
Corrosion in mating connectors	Clean / replace the mating connectors
PI Amplifier - failure of cable break detector circuit due to current >30mA	Check the wiring and then replace PI Amplifier
Proportional valve - failure of valve internal electronics due to wrong wiring / improper earthing & shielding / welding when the valve is ON	Check the wiring / remove the connector while welding. Replace proportional valve if malfunctioning.
Proportional valve - No movement of pilot / main spool due to contamination	Identify the source of contamination and flush the circuit and then replace Proportional valve
Position sensor - failure of internal electronics due to wrong wiring / improper earthing & shielding / welding when the valve is ON / high temperature	Check the wiring / remove the connector while welding / provide additional heat insulator and then replace position sensor
Emergency Solenoid valve - No spool movement due to contamination	Identify the source of contamination and flush the circuit and then replace Solenoid valve

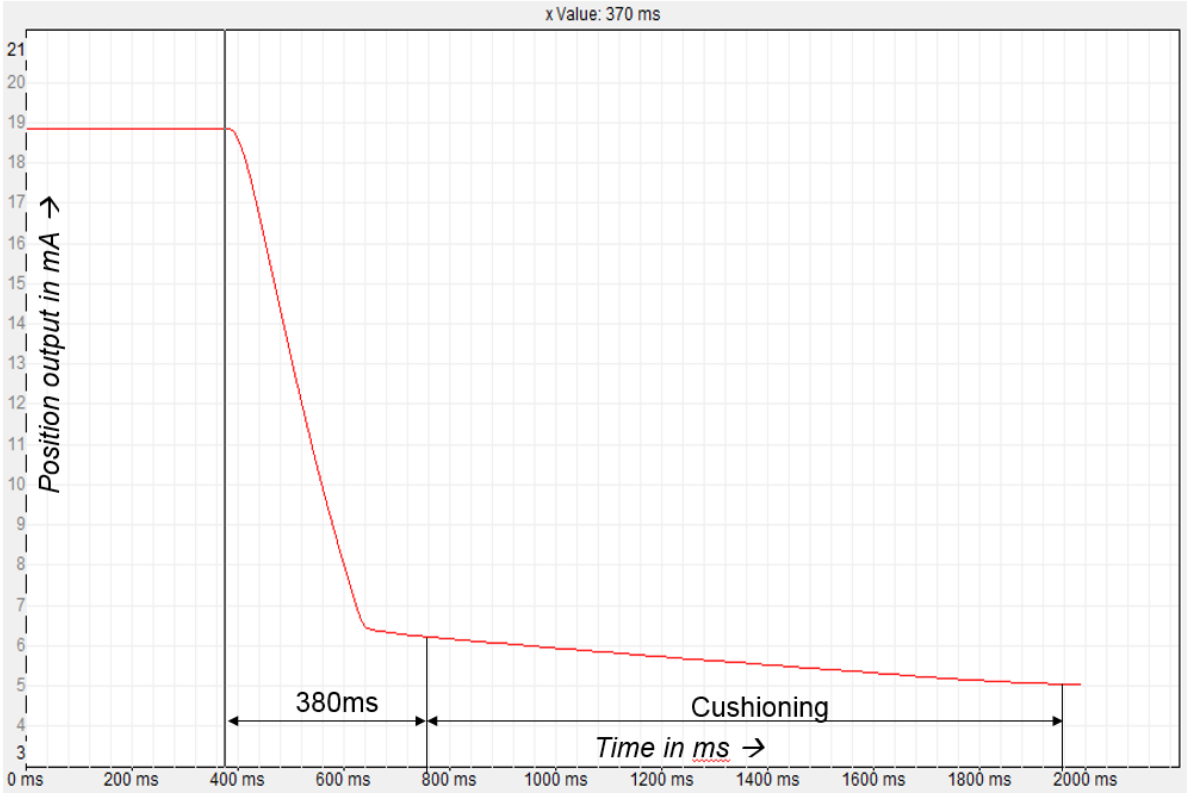
Problem : 2. During load throw off condition, the actuator returns slowly

Possible Causes	Remedy
Governor command is given slowly	Make the Governor command faster

Problem : 3. External Leakages from actuator

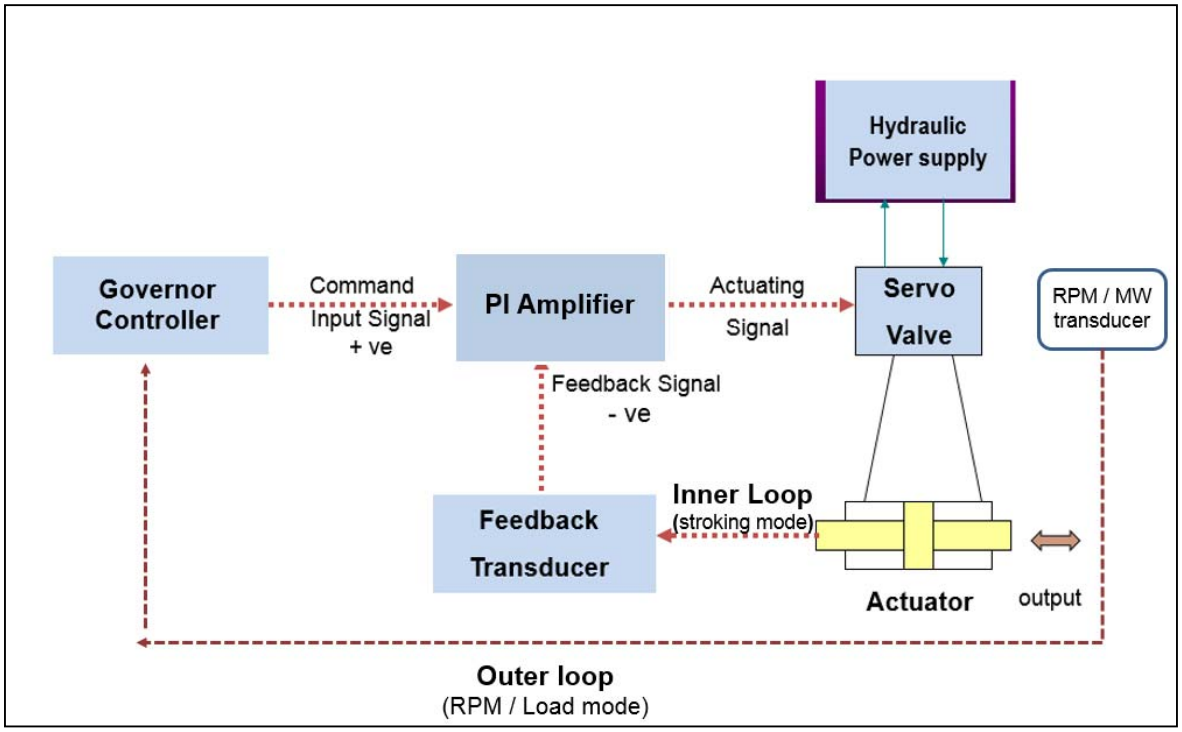
Possible Causes	Remedies
Rod seal worn out	Replace the seals. Keep the surroundings free from dust / metal particles. Check for misalignment.
Loose parts	Tighten parts with appropriate torque
Piston rod damages	Check rod for dent marks or scratches that could cause seal damage or allow oil leakage. Replace damaged rod.

Emergency Response Curve



Problem : 4. Actuator is hunting / inlet pressure is fluctuating /pipeline is vibrating / RPM is overshooting / MW is overshooting

Possible Causes	Remedies
P Gain in PI Amplifier is set more	Set appropriate P gain in PI amplifier (Normally it is3.5full turns).
Governor PID gain / Dither / other controller parameter value for Speed / Load control mode is set more / less.	Set appropriate Governor PID gain / Dither / other controller parameter values / Also in AVR (Automatic Voltage Regulator).
Loose Connections	Check is there any loose connections in PI card wiring or in actuator Junction box.
RPM / MW transducer wire loose connections / Mounting is loosened / Faulty sensor	Check the connectors and terminals for proper tightness / Check the sensors for proper functioning.
Oil contamination	Identify the source of contamination and flush the circuit.
Inlet pressure fluctuations	Check for accumulator pre-charge pressure / Check for pump relief valve pressure setting / Check for Pump discharge.



Problem : 5. The control oil inlet pressure drops when governor command is given

Possible Causes	Remedy
Malfunctioning of Emergency solenoid / Cartridge valve	Replace the Emergency solenoid / Cartridge valve or spring, seals

Problem : 6. Abnormal Noise from the actuator

Possible Causes	Remedy
Aeration or cavitation	Bleed the air by stroking the actuator several times / Check the pump shaft bearing / Oil level

Problem : 7. TG is tripping due to malfunctioning of actuator

Possible Causes	Remedies
Proportional valve - No moment of pilot / main spool due to contamination	Identify the source of contamination and flush the circuit and then replace Proportional valve
Position sensor - failure of internal electronics due to wrong wiring / improper earthing & shielding / welding when the valve is ON / high temperature	Check the wiring / remove the connector while welding / provide additional heat insulator and then replace position sensor
Field wires - Cable damages / Puncture in cables	Check the cable conditions by continuity / insulation test
Power supply	Provide dedicated power supply for control circuit and field I/Os.
High Temperature	Provide additional heat insulator / heat enclosure with cooling circuit

Problem : 8. Wire break detection not working

Possible Causes	Remedy
PI Amplifier - failure of cable break detector circuit due to wrong wiring (current >30mA)	Check the wiring and then replace PI Amplifier

Problem : 9. System operates Erratically

Possible Causes	Remedies
Air in system	Examine suction side of the pump
Spool sticking or binding.	Check for dirt or gummy deposits. If contaminated, try to find the source of contamination.
Dirt in Emergency Solenoid Valve	Clean the valve or replace.
Restriction in pressure line filter	Replace filter element.

Problem : 10. Spool is moving in one direction only

Possible Causes	Remedy
Proportional valve - partial blockage of valve due to contamination	Identify the source of contamination and flush the circuit and then replace Proportional valve

Problem : 11. No change in Proportional Valve Spool Feedback

Possible Causes	Remedies
Control oil pressure is low	Check the inlet pressure (25kg/cm2)
No command signals to Proportional valve	Check the signal is arriving at actuator valve connector
Loss of command signal / Cable damages / Puncture in cables	Check the cable conditions by continuity / insulation test
Corrosion in mating connectors	Clean the mating connectors
Proportional valve - failure of valve internal electronics due to wrong wiring / improper earthings & shielding / welding when the valve is ON	Check the wiring / remove the connector while welding and then replace Proportional valve
Proportional valve - No movement of pilot / main spool due to contamination	Identify the source of contamination and flush the circuit and then replace Proportional valve

Problem : 12. Proportional Valve sticks or works Hard

Possible Causes	Remedy
Mounting bolts too tight	Don't apply excessive torque. M 10 x 60 - 54 Nm (4Nos.) M 6 x 55 - 11 Nm (2Nos.)

Problem : 13. Feedback Keeps changing or unstable or not within limits

Possible Causes	Remedies
Wrong wiring / improper earthings & shielding	Check the wiring as per the circuit diagram
Proportional valve / Position sensor internal electronics failure	Correct the wiring / Replace the proportional valve / position sensor

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