5.0 THEORY OF MOTORIZED VALVE ACTUATOR CONTROLS

5.1 Limitorque Electrical Controls

Introduction

Limitorque actuators allow valves to be remotely operated and, by use of a motor, allow rapid valve operation that otherwise would not be feasible.

This section deals with the control circuit and operation of the actuator in the motor mode. Although there are several power sources used in actuators, this section will be directed strictly to the use of electric motors.

5.1.1 Components

In the circuit in Figure 5-1, control power is transformed off incoming motor leads. The stop switch is normally closed allowing a current flow path to exist up to the open and closed switches. The circuit as shown is deenergized with the valve in the full open position.

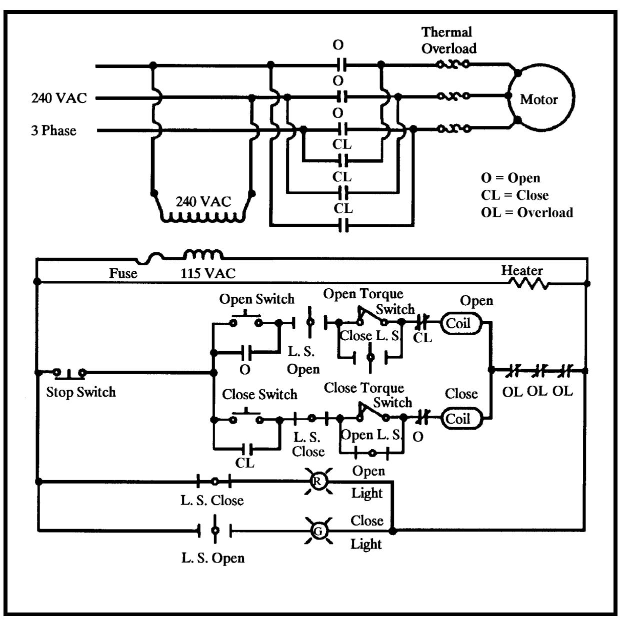


Figure 5-1 Typical Wiring Diagram

When the close direction switch (close switch) is closed, the closing coil of the Reversing Starter is energized. This will close the main line (motor leads) "CL" contacts to start the motor in the close direction, close the "CL" contact around the close switch (seal-in contact) and open the "CL" contact (electrical interlock contact) in series with the open coil. The actuator will continue to position the valve in the close direction until the torque and/or limit switch detect binding or full stem travel, the respective contact will then open deenergizing the close coil which results in the main line contacts opening, the seal-in contact opening and the electrical interlock contact shutting.

The actuator can then be operated in the open direction in the same manner as described above. In the mid-position, the actuator can be operated in either direction.

Power Supply

The function of the power supply is to supply the energy required to operate the valve to which the actuator is attached. Although there are many sources of power, the assumption is made that 240 Volt Alternating

Current (VAC), which is a typical selection, is the power source.

Motor

The function of the motor is to convert electrical power to mechanical power. Reversing any two of the three leads to the motor will result in a change in the direction of rotation. The typical motor on Limitorque actuators is limited to a 15 minute duty cycle which must be considered when performing maintenance.

Overload Heater Coils

Overload heater coils (thermal overload relays) are a form of protection in the event of excessive motor current. Care must be exercised when sizing the heaters due to their time delay.

Reversing Starter

Reversing starters have two separate functions: 1) to interchange power leads which change the direction of rotation, and 2) to provide mechanical and electrical safety interlocks that prevent the contacts for both directions being closed at the same time which would cause a direct short between phases. The operation of the reversing starter is based on using a small control current to control the larger motor current through electromagnetic switching. The coils shown in Figure 5-1 operate the main contacts of the starter when an open or close pushbutton is pushed. In addition, the seal-in contacts and contacts labeled "CL" and "O" are operated by the same coils in the reversing starter.

Control Transformer

The function of the control transformer is to reduce the control voltage to a lower and safer level. Normally, the primary windings of the transformer is connected to two phases of the motor power. The secondary windings provide the control voltage as single phase, normally 115 VAC. The primary side may have two fuses for protection, while the secondary side normally has one.

Stop Pushbutton(s)

The stop pushbutton(s) are always functional and are wired in series in the control circuit so that an operation by any one of them will open the circuit, which causes starter drop out and halts actuator operation. They are a normally closed momentary open contact which de-energizes part of the circuit when pushed. Stop pushbuttons are usually located at each of the operating stations and locally at the actuator.

Open and Close Pushbuttons

The function of the open and close pushbuttons is to initiate operation of the control circuit, which will result in energizing the actuator motor. In typical applications, there are two sets installed - one at the valve (local) and one in the control room (remote). In some systems, only one set of open and close pushbuttons is energized at a time. See REMOTE/LOCAL switch.

Seal-in Contacts (Contactor Auxiliary Contacts)

The function of seal-in contacts is to allow the person operating the actuator to release the open and close pushbuttons without having the actuator stop. This allows electric controls to stop the operation automatically at a pre-set condition without operator intervention. As an example, once energized, the actuator can be stopped by either the torque switch or limit switch depending on set-up of the valve-actuator. The seal-in contacts are labeled "O" and "CL" in Figure 10-1 and are in parallel with either the open or closed switch.

Remote/Local Switch

This is a selector switch which determines the location of control for the actuator. If the remote location is selected, the local control pushbuttons will not work.

Overload Contacts

The function of the overload contacts is to protect the circuit from an overload condition by interrupting the control circuit. The contacts are an integral part of the sensing heaters, normally 1 per phase. Great care must be exercised when working on equipment which is protected with heaters which reset automatically when they cool. Some nuclear plants do not have protective heaters and some have them only when the actuator operates in a certain direction.

Electrical Interlock Contacts

The electrical interlock contacts, (contactor auxiliary contacts), prevent both the open and close contactors from operating at the same time. If the relay is protected by mechanical means, the electrical interlocks operate as a backup. The contacts are normally CLOSED contacts that open when the associated contactor operates. The open auxiliary contact is wired into the close circuit, and the close auxiliary contact is wired into the open circuit. They are labeled "O" and "CL" in Figure 10-1 and are in series with either the open or closed coils of the reversing starter.

Lights

The lights' functions are to give approximate valve position information and as a useful tool for troubleshooting the actuator. The lights indicate the point where a particular rotor operates when activated by the limit switch, and is the same point where associated actions, if any, should be activated by contacts on the same rotor. Normal operation has the open rotor turning off the red closed light and the close rotor turning off the green open light, with both lights on between the open and closed position. The contacts are normally aligned with the motor contacts on the rotor and are 90 degrees off from the spare and torque switch bypass contacts. In actuators where the functions are divided by the use of additional rotors, (4 train limit switches) the lights may not function at the same time as the rest of the contacts. The lights may be driven by relays or actuated by external switches on the valve. There are many different control circuit arrangements.

5.1.2 Geared Limit Switches

Limit Switch

The function of the geared limit switch is to count turns of the drive sleeve (or wormshaft in SMB-0 through SMB-5 actuators) in order to keep track of valve position, to shut off power to the actuator motor at the proper stroke position, to turn indicating lights on and off at the proper positions, and provide interlocks, etc, as required. The limit switch is a relative mechanism and proper operating points must be set to match any desired valve positions.

Limit Switch Construction

Refer to Figure 5-2. The standard Limitorque limit switch is made up of four main components: the rotors, the finger base, the gear frame containing the intermittent gear set, and the drive assembly or cartridge. There may be a four-train (4 rotor) limit switch

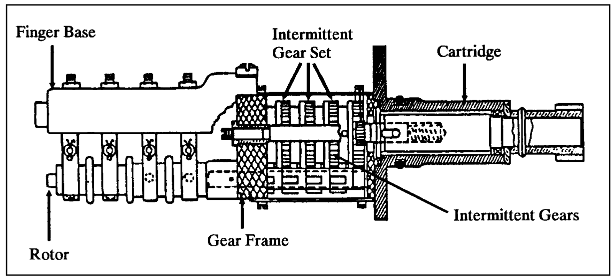


Figure 5-2 Standard Limit Switch

assembly (Refer to Figure 5-3) when the standard limit switch does not provide enough contacts, or the logic required for the control circuit.

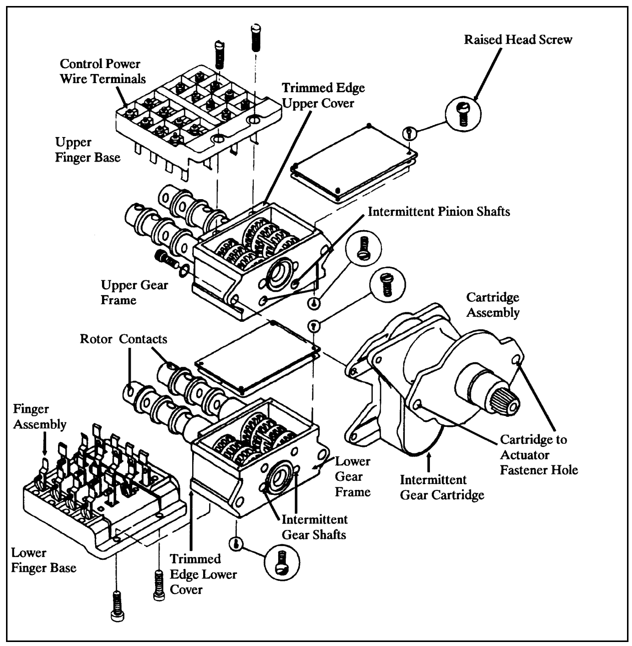


Figure 5-3 Four-Train Limit Switch

The rotors are a form of drum switch with 4 contacts each. Normally 2 make and 2 break, although Limitorque will provide other configurations. There is usually one rotor for the open position which trips at the full open position, and one rotor for the close position which trips at the full close position. The finger base is where the wiring is connected to the limit switch.

Finger bases and rotors for outside containment use are made of black or red plastic (Durez). For inside containment use, the finger bases and rotors were originally made from a white/gray plastic (Melamine), but are now made from Fibrite, a glass reinforced phenolic with a brown color. The finger base is mounted on one side of the gearcase and is equipped with spring loaded contact fingers and wire terminals.

The actual counting function of the limit switch takes place in the intermittent gear set which can be compared to the odometer of a car speedometer. Each rotor has its own intermittent gear set and can be set independently. The range of the intermittent gear set is determined by the number of counter gears in each set which can be either 3, 4, or 5, with 4 being the standard number. The intermittent gears are housed in an enclosed gearbox called the gear frame and have two covers with a gasket for sealing the grease in the box. The center of one face of the gearbox has a set rod which pushes the secondary drive pinion out of engagement with the first intermittent gear, which allows setting of the limit switch. The setrod is threaded flush or backed out of the case to perform its function and is sealed by an "O" ring.

The cartridge assembly, which drives the limit switch, is the connection between the intermittent gears and the limit switch drive gear located on either the drive sleeve or worm shaft, depending on actuator size. The cartridge has either a straight or helical drive pinion gear and a spring loaded spur gear called the secondary drive pinion which meshes with the intermittent gears.

Refer to Figure 5-4. The primary control functions on a standard four-contact rotor are the motor control, the indication, a spare contact, and if installed, the torque switch bypass (MIST). The standard four-contact rotor is arranged so that the open rotor is to the left and close to the right when looking down on the limit switch with the fingerbase up and rotors pointing toward the observer. Normal limit switch operation has the rotors positioned with the indication and motor contacts closed except at the very ends of the valve stroke where the open rotor rotates 90 degrees at the open end and the close rotor rotates 90 degrees at the closed end. The tripped rotor will immediately trip back to the in-between condition when the valve starts being driven toward the other end. There is no normal condition where both rotors are tripped at the same time, because you would not be able to drive the actuator in either direction. All contacts on a rotor rotate when the rotor trips.

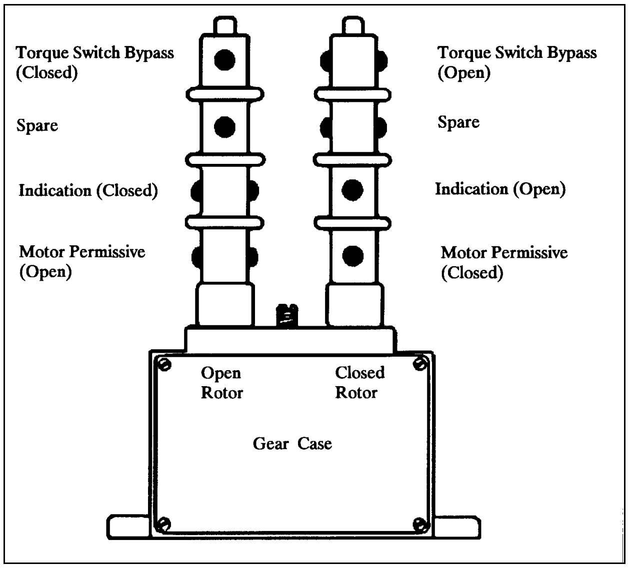


Figure 5-4 Limit Switch Control Functions

The indication contacts operate opposite from their expected manner. The indication contact on the close rotor turns off the open light when the valve is closed, and the indication contact on the open rotor turns off the close light when the valve is open. Both lights are on during in between open and closed travel.

The interlock, or spare, contact is located above the indication contact and is 90 degrees out of phase with the motor and light contact. When the motor and light contacts are CLOSED, the spare contact is OPEN.

The purpose of the torque switch bypass contact is to act as a bypass around the torque switch FOR THE OPPOSITE DIRECTION to allow for high starting torque situations. The open rotor has the close torque switch bypass contact and the close rotor has the open torque switch bypass contact. These contacts allow a valve to be opened or closed when there is a high pressure across the valve, thermal expansion of the stem, or some other requirement.

The torque switch bypass is normally set by percentage of valve stroke. For example, if the drive sleeve of a valve turns 100 turns from full open to full closed, then 10% bypass will be ten drive sleeve turns from the open or closed position. The bypass is normally percentage-based for the shut seat only, because of pressure differentials across the valve adding to the torque load for opening the valve. The problem with adding any percentage bypass when using a two train limit switch is you have to trip the associated rotor early. Example: the torque switch is bypassed for 10 percent of valve stroke when opening a valve, the close rotor has to trip at 90 percent of the closing stroke. This requires the motor contact on the close rotor to be jumpered and have the torque switch shut off the actuator, plus you get a closed light indication at 90 percent closed instead of 100 percent. For this reason, many plants have gone to 4-train limit switches where the light indication, or the bypass, is placed on a different rotor.

Limit Switch Setting

A most important point to remember in setting a limit switch is that a rotor cannot be set unless the valve is in the exact position where you want that rotor to trip. The open rotor cannot be set when the valve is closed and vice versa. Neglecting this point could result in valve or actuator damage due to mis-adjusted limit switches.

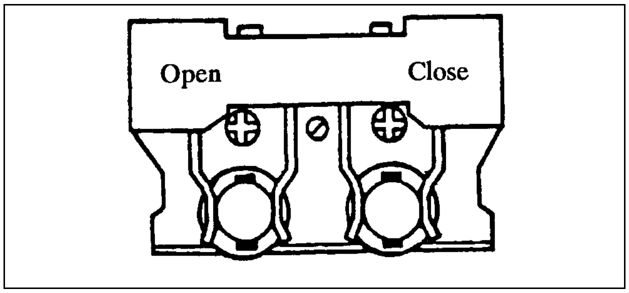


Figure 5-5 End of View Rotors

Figure 5-5 shows an end view of the rotors, which means that you are seeing the torque switch bypass contacts are visible and not the motor contacts for the rotor being set.

Figure 5-6 shows the four possible conditions of the limit switches. The first is the condition when the valve reaches the open position; the second occurs in mid-position; and the third is at the position called closed. Condition 4 should not occur.

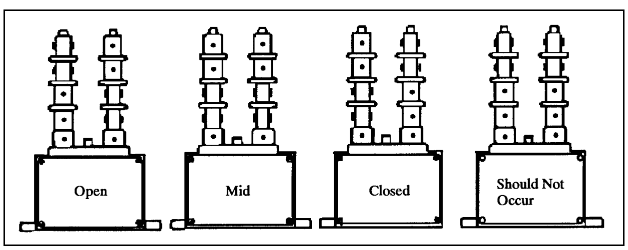


Figure 5-6 Limit Switch Conditions

5.1.2.1 Limit Switch Adjustment Procedure

1. Reposition the valve to the desired position. Note the direction of rotation of the intermittent gear shafts while the valve is being repositioned.
2. Observe the contact that you want to set as the valve reaches the position. For example, if you are setting the open rotor to turn off the motor when the valve reaches the open position, watch the open motor contact.

NOTE: If the contact is tripped before you start driving the valve, turn the set rod in to disengage the secondary drive pinion. If the rotor trips and opens the contact while driving the valve to the desired position, stop immediately and turn the set rod in.

3. Note whether the contact has tripped to shut off the motor when the valve is in its desired position. If it did so at the correct valve position, the rotor does not need to be adjusted. If it did so before the valve reached its desired position, the contact needs to be "backed up" by turning the intermittent shaft in the opposite direction you observed in step 1. If it hasn't yet tripped, the intermittent shaft needs to be rotated further in the direction it was turning. Note that there is no FIXED DIRECTION to rotate an individual intermittent shaft. If you stopped and ran the set rod in during the positioning, run the set rod out, gently turn each intermediate shaft in both directions to be sure the secondary drive pinion has meshed

with the intermediate gears, then check to be sure the rotor is tripping at the correct position. If you turned the set rod in before starting to position the valve, go to step 5.

4. Disengage the spring loaded drive pinion (secondary) from the intermittent gears using the set rod. Screw the set rod down flush with the case.
5. Turn the intermittent shaft of the rotor you are adjusting in the direction you worked out in step 3 above until the rotor rotates 90 degrees. When the limit switch is in the exact position of breaking the contacts from the direction that the intermittent shaft should be turning when that rotor turns, the limit switch is set correctly. Since contacts really break when the rotor is at the 45 degree position, that is where they should be set. If you want the contacts to perform their function when the valve is going open, then your final positioning of the rotor should be done by turning the intermittent shaft in the direction it rotates while going open until the rotor is in the desired 45 degree position.
6. Reengage the spring loaded secondary drive pinion by backing out the set rod. Don't use a lot of force on the set rod; you'll break the screw slot and have to disassemble the limit switch to repair it. All you want to do is seal the gearcase by lightly compressing the "O" ring.
7. Verify that the gears are engaged by wiggling the intermittent shaft with a screwdriver. It should be held by the secondary drive pinion and not turn. Don't do this fast, because the secondary drive pinion might ride across several teeth before engaging.
8. Verify the operation of the limit switch by manually positioning the valve a few turns and then returning it to where the limit switches were set. The switch should function at that point every time.

5.1.2.2 Limit Switch Repair

Rotor Replacement

If a rotor on the limit switch breaks, it is very easy to damage the replacement if the following steps are not followed. Refer to Figure 5-7.

1. Remove the damaged rotor from the stem spur pinion shaft. (Note the orientation of the contacts)
2. Do not attempt to force the pin through the new rotor as the rotor will most likely break at the pin hole.
3. Place the new rotor on the stem spur pinion shaft and align the hole molded in the rotor with the hole drilled in the shaft. There are generally two different holes 90 degrees apart which

allow you to align the contacts for the correct logic.

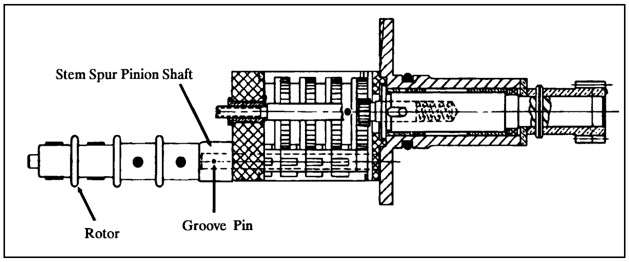


Figure 5-7 Limit Switch

4. Using a Number 40 drill (0.098") and the existing shaft hole as a guide, drill through the rotor.
5. Install the 3/32" dia. x 3/4" long groove pin through the hole.

5.1.3 Torque Switch

The torque switch used in the SMB/SB has two possible functions. The first, on torque closed valves, is to ensure that the valve has sufficient and accurate thrust on the valve stem to guarantee seating. The second, on limit controlled valve operations, is to ensure that the actuator and valve are protected from possible excessive thrust. The double-contact torque switch, with one set of contacts being for the open direction and the other being for the close direction, is normally used. Refer to Figure 5-8.

The torque switch is operated by the axial motion of the worm in both directions. The contacts on the torque switch are double break contacts and are not self-wiping, which can lead to continuity problems in some actuators because of an oil film forming on the contacts.

Torque switches are provided with limiter plates which limit settings to a safe value, and prevents overtorquing a valve in case the

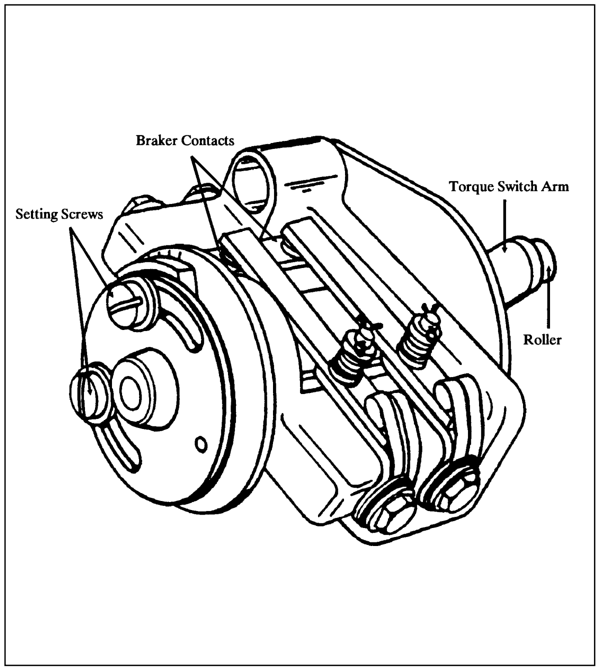


Figure 5-8 Leaf Type Torque Switch

setting screws come loose. There is no overtorque protection from incorrectly set or installed torque and limit switches.

The torque switch performs as though it senses torque, although it is simply sensing how far the worm shifts on the wormshaft, which depends on the resistance of the drive sleeve to turning. When the torque or thrust reaches a preset amount, the torque switch will open. The torque switch doesn't care how the torque and thrust forces are applied and used. If packing is too tight, if valve components are blocking the stem during the valve stroke, or if the stem threads are damaged, the torque switch will still operate at the set amount of torque.

Construction and Operation

When the worm overcomes the resistance of the spring pack Belleville springs, it moves axially, which through a linkage, rotates the shaft of the torque switch and opens a set of contacts. The direction of worm movement determines if the open or close torque switch contacts open.

The setting screws on the face of the torque switch determine the distance the worm must move against the spring pack before opening the contacts. A higher setting will cause additional travel, requiring more output torque to be developed before opening a contact.

A limiter plate designed to prevent moving the settings beyond a certain point is mounted on the torque switch. The maximum setting allowed by the limiter plate should match the value on the torque switch calibration plate. The torque switch limiter plates used on SMB and SB actuators are not adjustable and should stay with the individual actuator throughout its service life. If a new torque switch is placed in an actuator, the limiter plate should be removed from the old torque switch and placed on the new one. If the replacement torque switch is a newer style and the limiter plate will not fit, a new limiter plate should be ordered from Limitorque. On SMB-000 and 00 leaf type torque switches, the limiter plate is not exposed but is located behind the striker hub which has the switch setting numbers. On the SMB-0 and larger actuators, the limiter plate is fully exposed.

SMB-000 and 00 Leaf Type Torque Switch

The smaller size SMB actuator torque switch (Figure 5-8) is a fairly simple device, with only one set of adjustments. The motion of the worm is transferred through a lever arm with a roller on the end and causes the shaft to rotate. The striker hub is mounted on the shaft and the adjusting screws clamp a set of strikers to the striker hub. The contacts for each direction are long metal fingers that are lifted off their contact screws by the direct action of a cam. The cam has a protrusion that is pushed by the adjustable strikers after the lost motion is traveled, which will lift the long metal fingers and open the contacts. The metal fingers are held on with the same screws that hold the wire terminals, and replacing the wires or changing the torque on the mounting screws can change the operating point of the torque switch. If this is done, the balance of the torque switch should be checked.

SMB-0 and Larger Torque Switch

The motion of the worm in a SMB-0 and larger actuator is sensed through a rack and pinion arrangement, with the rack being the outside surface of the bearing cartridge and the pinion being the gear on the end of the torque switch input shaft (Figures 5-9 and 5-10). The motion of the worm is sensed through the rack and pinion gear and fed through the shaft to the actuating link which operates the dial through a set of positioning screws. The setting screws clamp pointers to the dial, and the pointers act directly on the blocks which have the contacts mounted to them.

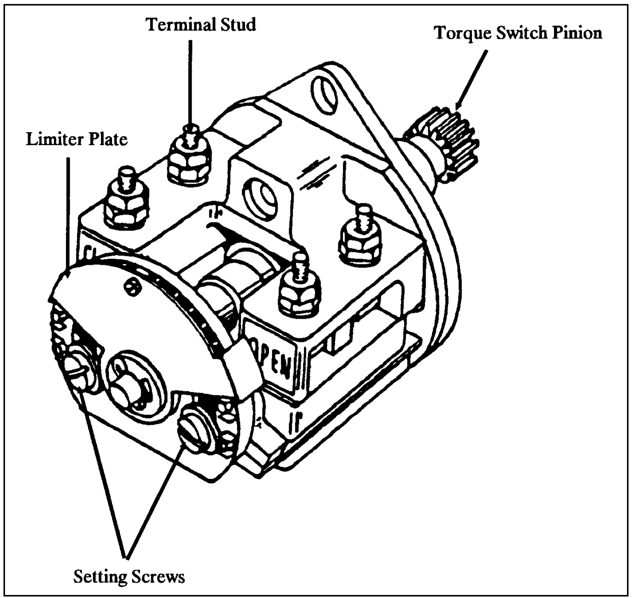


Figure 5-9 Knee Type Torque Switch (Old Style)

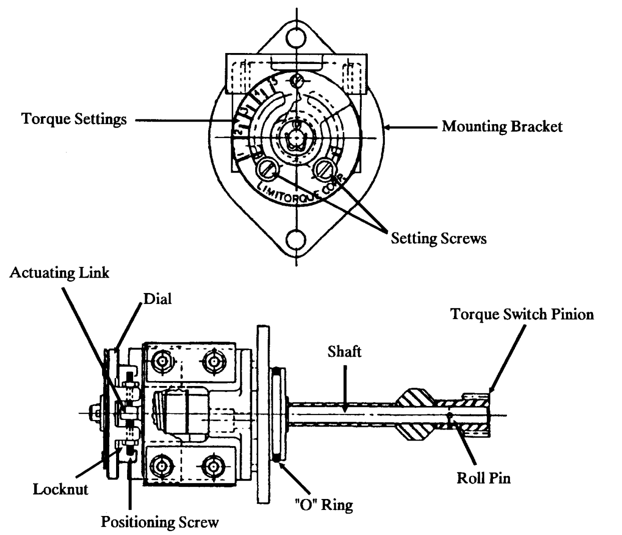


Figure 5-10 Knee Type Torque Switch (New Style)

The positioning screws are used for mechanical balance during installation and allow movement of the torque switch during installation when the pinion and bearing cartridge teeth do not line up. The same balancing screws are used to adjust for an electrical balance after installation to accommodate any Valve Diagnostic Testing Equipment such as MAC, MOVATS, VOTES, etc.

Installation

SMB-000/00

NOTE: Do not attempt to install any torque switch into an actuator that is in a torqued condition. This is to prevent and pre-compression of the Belleville spring pack which would negate the torque switch settings.

Installing the torque switch in an SMB-000 and 00 actuator is accomplished by ensuring the switch is oriented properly, inserting it in the proper hole, and ensuring that the roller fits properly in its groove on the worm.

SMB-0 and Larger

When installing a torque switch in an SMB-0 and larger actuator, preload can be built into the torque switch setting in two ways.

1. If the valve is in a torqued condition when the torque switch is installed, the worm is shifted and the rack and pinion drive will be engaged in the wrong position.
2. If the holes on the mounting bracket do not line up with the holes in the housing and the mounting bracket is rotated to make them line up, one set of torque switch contacts will require less motion than the other to open. To prevent this from occurring, both settings should be set to 1, the adjusting screws should be backed out to the shoulders before attempting installation, and the mounting holes should be lined up as close as possible. The actuating link should not come into contact with either of the shoulders during installation. The mounting screws should be tighten, and the adjusting screws should be turned until they just touch the actuating link, and locked in position. Then the torque switch should be reset to the original settings.

Setting

It is possible to adjust the leaf type torque switch on an SMB-000 and 00 actuator while the torque switch is out of the actuator if a calibration fixture is available.

The torque switch for an SMB-0 and larger cannot be adjusted if it is not installed in the actuator.

To set any of the torque switches, the two screws located on the striker hub are loosened and moved to the desired open and close setting from minimum. Adjust the torque switch to the value supplied by Engineering or to any other acceptable specification, and then tighten the screws to lock-in the setting. If the screws are left loose, the setting could drift and it will always drift toward a higher setting.

The torque switch numbers are meaningless except when used with the torque switch calibration plate, or have been checked using diagnostic equipment. Otherwise the only relationship between these numbers and the actual value of torque is that higher numbers will cause higher torque. If the spring pack is not correctly set, or the adjustment goes above the range of the torque limiting sleeve-thrust washer (X dimension) limit, the actuator and valve may go to a locked rotor condition.

Torque Switch Bypass

The use of the torque switch bypass by the limit switch is to bypass the open or close torque switch contact for a preset period. Bypassing is used to ensure that the actuator gets a valve off either the mainseat or backseat and drives it whatever distance the bypass covers. During this period of travel the only protection provided the valve and actuator is the motor protection (fuses, relays, etc.). Some nuclear plants do not have this protection for safety related valve/actuators.

Because the torque switch bypass has a major effect on the operation of the valve/actuator, it needs to be thoroughly understood. Determination of the proper bypass travel should be accomplished by a thorough engineering evaluation. In order to properly set the limit switches, it is important that the person setting the limit switches understands the action of the torque switch bypass on the setpoints of the limit switches.

The amount of bypass is normally expressed as a percentage of the valve stroke.

Switch Connection Variations

Limit-Open Connection

The function of a limit-open connection is to use the open rotor motor control contact to open and stop the motor at the end of the open valve stroke. This is the normal set-up, since few rising stem valves have backseats that will withstand torque opening, and most quarter turn valves are limit controlled in both directions. The rotor is adjusted to de-energize the circuit at the proper valve position to allow for coast and inertia (drift) before the torque switch operates. The open torque switch normally serves as a protective backup to the limit switch.

Limit-Close Connection

The function of a limit-close connection is to use the motor control contact on the close rotor to stop the motor at the end of the valve closing travel. The rotor is adjusted to de-energize the circuit at the proper valve position to allow for coast and inertia before the torque switch operates. The torque switch normally serves as a protective backup to the limit switch.

Torque-Close Connection

The function of a torque-close connection is to use the torque switch to open the circuit at the end of the close stroke instead of the motor control contact on the close rotor. This is accomplished by bypassing the close rotor motor contacts with a jumper. When this is done, the limit switch rotor turns to indicate the valve position, but the motor continues to run until the torque switch de-energizes the circuit. The need to control the torque switch bypass to a percentage of valve travel forces the use of the torque-close arrangement unless more than two rotors are available. This is the most common close connection in nuclear service.

Torque-Open Connection

The use of the torque-open arrangement to control valve position is rarely used, but is similar in concept to that of the torque-close arrangement. In this case, the motor contacts on the open rotor are jumpered and the torque switch operates to de-energize the circuit. This connection may be used on quarter turn valves which require torque opening, on some three way valves, and other special set-ups.

5.1.3.1 Testing After Maintenance

One of the most critical steps after performing maintenance is the initial operation and follow-up testing. Many newly rebuilt actuators, and/or associated valves have been damaged the first time they are run after having been repaired because of mistakes in the testing process.

An actuator should never be run until the limit switches and direction of rotation of the motor have been checked. The limit switch functions should be checked in manual by positioning the valve at the desired positions and observing that the switches operate. Something as simple as leaving the set rod screwed in at the wrong time can cause major damage, and the only way to verify this is by manually checking.

The most important operational check is the direction of rotation test. If the motor runs the actuator in the wrong direction for the full stroke, the only protection will be the motor overloads. None of the other designed-in protection will protect the actuator due to the operating protection being on the wrong side of the control circuit.

The most effective steps for testing after maintenance are:

1. Manually open the valve and verify the open limit switches.
2. Manually close the valve and check the close limit switches. Observe any binding or resistance to operation.
3. (The above two can be reversed depending on starting position.)
4. Manually mid-position the valve for the first electrical operation. If there are problems with the settings, the valve will not immediately be in a position which could cause damage.
5. Energize the actuator and verify the indication is correct for mid-position. This will indicate that the limit switches are in an expected position.
6. Prepare for the first electrical run by placing your hand physically on the STOP control, so that the actuator can be stopped immediately if a problem develops.
7. Check the direction of rotation. Press the CLOSE button and verify that the actuator rotates in the correct direction, then stop the actuator. The easiest way to verify the direction of

rotation is to compare drive sleeve rotation by motor to drive sleeve rotation in manual after checking the arrow on the handwheel for proper rotation.

8. If the direction of rotation is incorrect, stop the actuator IMMEDIATELY and reverse two of the motor leads for opposite rotation. If the actuator is allowed to run to the point where the limit or torque switch should stop the operation, the actuator will continue to run because the protective and controlling features are on the wrong side of the control circuit.
9. If the direction of rotation is correct, start the actuator in the close direction. Be ready to stop the actuator if the motor begins to sound like the load is increasing beyond an acceptable point, otherwise, let the motor run until the limit or torque switch stops the motor.
10. Verify that the shut indication is correct. If not, the limit switch is out of adjustment.
11. Verify that the valve is fully closed by placing it in manual and turning the handwheel in the close direction. If it is not, the limit or torque switch will need to be adjusted.
12. Operate the actuator in the open direction. Be ready to stop the actuator if the motor begins to sound like the load is increasing beyond an acceptable point, otherwise, let the motor run until the limit or torque switch stops the motor.
13. Verify that the open indication is correct.
14. Verify that the valve is in the correct open position by placing it in manual and checking in the open direction.
15. Operate the actuator from open to closed as necessary to verify that everything is functioning.
16. Place the actuator in manual. Note any problems in going from electric operation to manual. Operate electrically. Verify the operation of the declutch components in going from manual to electric. This will insure that the actuator is ready to be released for unrestricted use.

5.1.4 Data

Unique Features

High rated starting torque - The motor is sized so that its rated starting torque is above the required torque to operate the valve. This torque is needed for a very short time (on the order of fractions of a second to several seconds). The rated starting torque of the motor is usually between 65% and 90% of the motor stall torque. The rated starting torque can be delivered for only fractions of a minute (10 to 15 seconds is average) before the allowable temperature rise is exceeded and rotor or stator damage occurs. Since the starting torque is needed for only a small fraction of the stroke, the temperature rise of the motor is not exceeded.

Short duty-cycle - These short duty-cycle motors do not reach thermal equilibrium during operation. The duty-cycle is normally 15 minutes for three-phase AC motors and five minutes for DC motors and single phase AC motors. This duty-cycle is based on the temperature rise for a motor running at 20% of the rated starting torque. The justification for using this lower torque value to establish the duty-cycle is that the stem thrust for most of the valve stroke is approximately 20% or less of the thrust during seating for most applications. Motors are also available with a duty-cycle based on 40% of the rated starting torque.

Totally enclosed nonventilated (TENV) frame - Standard NEMA TENV motor frames are used because a ventilating fan is not effective for cooling a motor which operated for short intervals. TENV motor frames are enclosed to prevent the exchange of air between the inside and outside of the case but they are not "airtight". Most MOV's for safety-related applications inside harsh environments use T-drains to drain condensate formed by steam entering the motor, and to equalize the internal and eternal motor housing compartments (under accident conditions). The drains prevent submergence of the motor insulation which could cause winding short circuits.

Power cable sizing - Power cables for these motors should be sized to provide at least the current at rated starting torque at the motor rather than the current at running torque. This is because the limiting condition is "starting" and not "running". Some power cables are sized based on the locked-rotor current since the locked-rotor current is a conservative estimate of the current at starting.

Limited duty-cycle, high starting torque motors are used instead of continuous-duty motors for MOV service. This is primarily to limit the size and inertia of the motor. The equivalent continuous-duty motor would require a larger frame and have a higher inertia.

AC Motors

Most AC motors in nuclear power plant MOV applications are three-phase 220/440, 230/460, or 240/480 VAC squirrel cage induction motors with factory lubricated sealed ball bearings. The motors are dual voltage (Limitorque usually sets the voltage at the factory). Either nominal voltage is available, depending on how the leads are connected (e.g., a 240/480 VAC motor can be configured as either a 240 VAC motor or as a 480 VAC motor). The use of single-phase AC motors in nuclear power plant MOV applications is rare.

Motor insulation is currently available in the following classes:

Class B – This insulation is rated for 125°C (insulation hot spot) and is used in mild environments and nonsafety-related applications. (Note: This insulation was previously available for safety-related applications.)

Class RH – This insulation is rated for 175°C (insulation hot spot) and is used in harsh environments and is safety-related applications.

Class LR – This insulation is rated for 250°C (insulation hot spot) and is used in MOV's which might have to operated in unusually high temperature environments (e.g., in the vicinity of potential high energy line breaks).

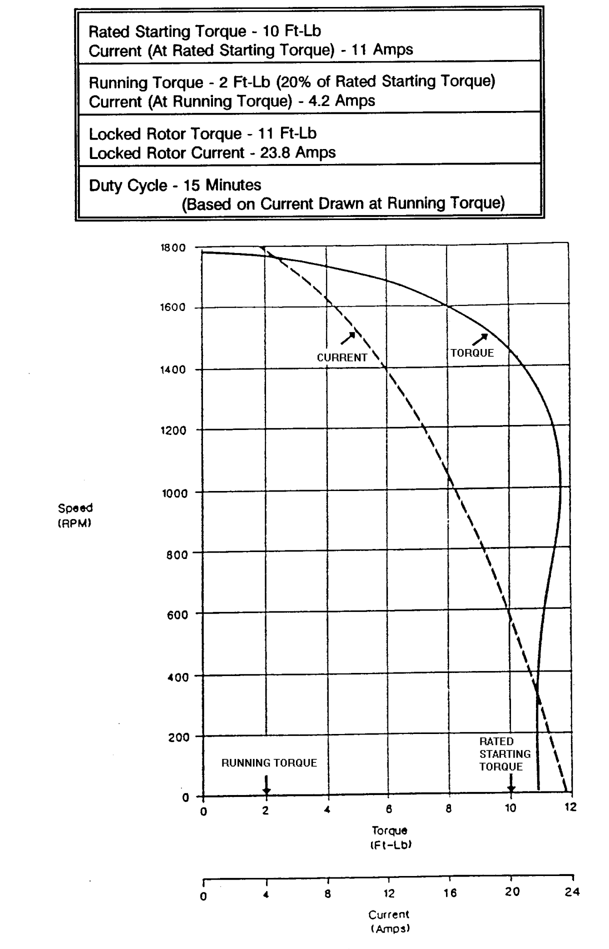
The motors are available in three speeds: 900 RPM (8 poles), 1800 rpm (4 poles), and 3600 rpm (2 poles). The squirrel cage winding is normally made of cast aluminum alloy but may be of cast magnesium alloy. In general, frame sizes 48 to 56 have aluminum alloy rotors, frame sizes 180 and greater have magnesium alloy rotors.

Performance characteristics (speed versus torque and current are presented in Figure 5-11 for a typical 1800 rpm, 60 Hz, three-phase, 230 VAC motor.

(NOTE: Motor performance curves for 230/460 and 240/480 VAC motors are typically given for 230 VAC only. The parameters are adjusted by the user for other voltages.) The major points are:

- The rated starting torque (10 ft-lb) is 90% of the locked-rotor torque (11 ft-lb); however, the current at rated starting torque is only 11 amps, compared with the locked-rotor current of 23.8 amps.
- At the running torque of 2 ft-lb (20% of the rated starting torque), the speed is about 1760 rpm and the current is 4.2 amps. The duty cycle of 15 minutes is based on the current drawn at running torque.
- The motor speed changes very little with variations in motor torque near synchronous speed. For example, for the torque range of 0 ft-lb to 4 ft-lb, the speed only changes from 1785 rpm to 1740 rpm.
- The nominal speed published by Limitorque (for selection purposes) for this motor is 1700 rpm. Based on the data presented above, this is a conservative (low) value; i.e., the motor actually runs faster than 1700 rpm. the motor actually operated at 1700 rpm, it would draw excessive current; therefore, the nominal speed published by Limitorque should be used only to estimate the valve stroke time.

Usually a match between the MOV motor capability and the strength of the valve



Speed vs. Torque and Current for Typical 1800 RPM, 60 HZ, 3-Phase, 230 VAC Motor

Figure 5-11 Typical AC Motor Performance Curve

and operator components can be obtained when the available voltage is maintained between + 10% and -10% of the motor design voltage. This variation is within the design margin of the operator; however, specification of a reduced voltage for a safety-related valves (for example, 70% of rated voltage) can result in a valve and operator that cannot withstand a motor stall at nominal voltage. To operate at reduced voltage, the motor is sized so that the required starting torque is achieved at the minimum voltage. The MOV is normally operated at full voltage. For an AC motor, the torque is proportional to the square of the voltage. Thus, at 100% voltage, an AC motor can produce about twice the 70% voltage torque. In this case, the large difference between the minimum and maximum thrust capabilities of the operator (due to the large range in voltage) requires the survivable thrust to be much greater than the required stem thrust.

DC Motors

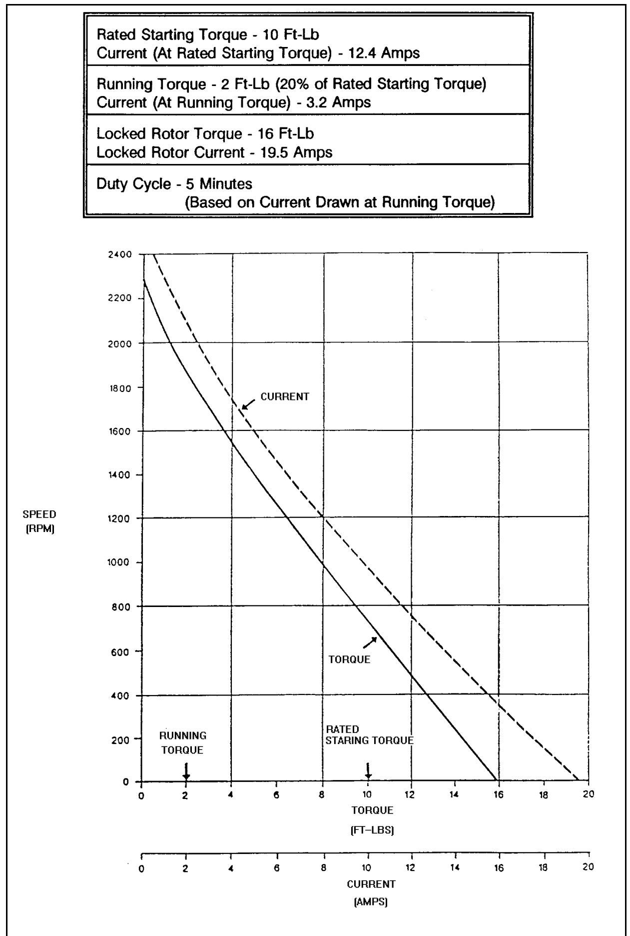
Applications for DC motors include redundant MOV's for vital services to critical equipment and safety-related MOV's that operate after a loss of both off-site and on-site AC power or to meet a unique electrical train power separation requirement. However, DC motors are not as well suited as AC motors for MOV applications. DC motors are more expensive, have larger frame sizes for equivalent torque ratings, have poor speed regulation, and have a shorter duty-cycle and so are specified only for special applications.

The DC motors are 125/250V, 1900 rpm, compound-wound motors. A compound-wound motor is a compromise between a shunt-wound motor, which has good speed regulation, and a series-wound motor, which has a higher starting torque but poor speed control. If the load on a series-wound motor is reduced, the speed can increase to several times the rated speed.

Performance characteristics (speed versus torque and current) are presented in Figure 5-12 for a typical 1900 rpm, 250V DC, compound-wound motor. As with the AC motor described above, the rated torque is 10 ft-lb and the running torque is 2 ft-lb (20% of the rated torque). The major differences are as follows:

- The rated starting torque (10 ft-lb) is 63% of the locked-rotor torque (16 ft-lb). This margin is larger than in an AC motor.
- The speed regulation of the DC motor is not as good. The speed drops from 2300 rpm to 1550 rpm when the motor torque goes from 0 ft-lb to 4 ft-lb.

The effect of reduced voltage on a DC motor is not as significant as on an AC motor. The change in starting torque varies proportionally with change in available voltage. For example, an increase in available voltage from 70% to 100% only increases the motor torque 43% for a DC motor (compared to a 100% increase in motor torque for an AC motor.



Speed vs. Torque and Current for Typical 250 VDC Compound-Wound Motor

Figure 5-12 Typical DC Motor Performance Curve