2.3 Limitorque Actuators

The Limitorque valve actuator is an electrically driven device that is used to open or close a valve from a remote location. It can also be placed in the manual mode and operated by a handwheel by depressing a declutching lever. Figure 2-8 shows a Limitorque actuator on a typical gate valve.

Figure 2-8 Limitorque Actuator

The Limitorque SMB actuator was introduced to replace the SM and SMA actuators. The SMB actuator was first introduced in 1964 and continued to be manufactured on an assembly line basis through 1982, and can still be special ordered. Limitorque has estimated that over 80 percent of all MOV actuators in use today worldwide are Limitorque SMB actuators.

There are two major designs in the SMB line. They are the SMB-000 or SMB-00, and the SMB-0 through SMB-4. The power trains are significantly different, so they need to be addressed as separate actuators. The SMB-5 actuator is also a different design and extremely rare, and are beyond the scope of this training. The SMB line is qualified for nuclear service in accordance with the requirements of 10 DFR 50.49 for environmental qualifications, as well as being qualified electrically and seismically.

As shown in Table 2-1, the SMB series of actuators is available in a full range of torque and thrust ratings suitable for operating many different sizes of valves. The SMB-000 is the smallest version of the line and the SMB-5 is the largest. The SMB-4 and SMB-5 sizes have torque only designs without suitable thrust bearings to absorb valve thrust loads. Torque only designs carry the SMB-4T and SMB-5T designations.

SMB actuators have excellent protective features and control capabilities. Each size SMB actuator can be individually tailored ta a specific valve. The number of possible combinations of different variables is very large. The SB/SBD actuator designs are modified SMB actuators for high speed valve applications. Secondary gearboxes, called HBC actuators are available for large quarter-turn valve applications.

Table 2-1 SMB Actuators Torque and Thrust Ratings

Maximum Torque, ft-lb

Type	Size	Nuclear Rating	Commercial Rating	Maximum Thrust, lb	Max Threaded Stem Diam. in.
SMB	000	90	120	6,000	1-1/8
SMB	00	250	280	14,000	1-3/4
SMB	0	500	700	24,000	2-1/8
SMB	1	850	1,100	45,000	2-7/8
SMB	2	1,800	1,950	90,000	5-1/2
SMB	3	4,200	4,500	140,000	5
SMB	4647	7,800	8,300	250,000	5
SMB	5657	20,000	20,000	500,000	6-1/4

Limitorque SMB Theory of Operation

The actuator is expected to perform a number of simultaneous functions perfectly. The actuator should provide remote operation, safety, and manual operating capabilities.

In electrical or remote operation, the actuator must close the valve with the proper seating force, at the correct speed, shutting off power at the appropriate point without damage to the equipment. It should open the valve against the system's differential pressure and to place the valve on or near to the backseat. At the same time, it is necessary to make sure that the indication matches the valve position, and maybe to operate some permissives or interlocks.

Electrical Operation

The actuator operation is initiated by pressing an open or close push-button or use an automatic circuit to initiate motion. This signal starts the motor rotating in the correct direction, and if necessary disengages the actuator from the manual mode and places it in the electric or motor mode.

When the valve stem begins to move to reposition the valve, the indication and control circuitry reacts to the motion, going from the closed or open state to a mid-position condition.

When the valve reaches the desired open or closed position, the electric circuitry again changes to stop the motion, either by sensing valve position or by sensing the mechanical load on the actuator. The indication reacts to the change in valve position and shows the correct position of the valve.

Manual Operation

In manual, the person operating the actuator will place it in the manual mode and position the actuator to the desired position. The indication and control circuits will respond to the position change and be correct for the valve position. In addition, should someone try to electrically operate the valve, the person operating the valve in manual will not be injured by the operation of the motor. In this case, the declutch lever may be kicked up by spring action and the person operating the valve should stand clear. Table 2-2 summarizes the modes of operation of the actuator.

Limitorque motor actuators produce torque. Their operation is controlled by limit switches, torque switches, or both. Some MOVs controlled by limit switches also have a torque switch in the circuit to serve as a safety device, and some do not.

Table 2-2 SMB Actuator Modes of Operation

Modes of Operation
• Electrical operation has electrical control for actuator motion. The actuator and valve are protected by the torque switch.
• Manual operation still has the indication, but the operator controls position.
• The two modes are separated by a clutching mechanism which prevents simultaneous operation.

Limit switches are gear-driven, and their operation is based on valve stem position. Torque switches are displacement-driven, and their operation is based on compression of a torque spring as it responds to the increasing torque load experienced by the actuator.

Figure 2-9 is a simplified sketch of a Limitorque actuator geartrain. The electric motor, typically turning at about 1700 rpm in an ac-powered operator (some ac motors turn at other speeds, for example, 3400 rpm), provides input to the gearbox, where a gear reduction increases the torque and reduces the speed.

The gear reduction typically includes a set of helical gears and a worm/worm-gear set. The worm drives the worm gear, which directly drives the drive sleeve, containing the valve stem nut. The torque applied by the gearbox to the valve stem nut is the *actuator torque*, referred to frequently in this manual.

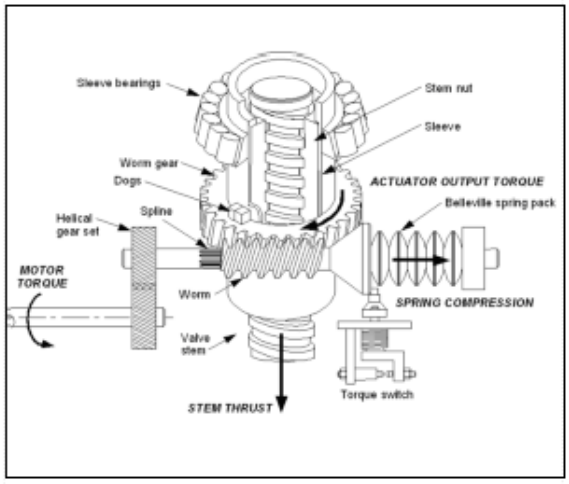

Figure 2-9 Limitorque Actuator Geartrain

For a rising-stem valve application, the stem nut turns on the threaded portion of the valve stem. Thrust bearings hold the stem nut in place, so that the rotation of the stem nut on the stem drives the stem upward or downward, opening or closing the valve.

In a typical actuator, the worm gear and drive sleeve are equipped with lugs commonly called “dogs,” such that at the beginning of the closing stroke, the worm gear makes about one-half turn on the drive sleeve before engagement the drive sleeve does not begin to turn until the worm gear dog hits the drive sleeve dog. The same thing happens at the beginning of the opening stroke: the worm gear makes about a half turn on the drive sleeve in the opening direction, the worm gear dog engages the

drive sleeve dog, and then the stem nut turns on the stem. This mechanism allows the motor to get up to speed on startup before it must operate against a load.

As the resistance to motion in the stem (the stem thrust load) increases, the stem nut and thus the drive sleeve becomes difficult to turn. This resistance to rotation at the at the drive sleeve causes the worm to move itself in relation to the worm gear and compress the torque spring.

As the stem load increases, the worm climbs the worm gear, sliding further on the splined shaft until it trips the torque switch. The tripping of the torque switch actuates a relay, which in turn shuts off power to the electric motor. Motor momentum continues to drive the worm against the torque spring after the torque switch trips, producing an increase in stem load after torque switch trip. The torque switch serves to limit the amount of torque the valve actuator can produce.

Some valves are controlled by limit switches that turn the motor off on valve position rather than on actuator torque. These valves might or might not include a torque switch that serves as a safety device to prevent structural overloads.

For example, in the event that the limit switch fails to shut off the motor in time. Whether the torque switch serves as a control device or a safety device, the setting of the torque switch is equally important. An incorrectly set torque switch can either (a) cause the motor to shut off before the valve is all the way closed, or (b) cause the motor to stall after the valve is closed, by failing to shut off power to the motor.

Usually the actuators are equipped with a torque switch bypass switch controlled by valve position. The purpose is to bypass the torque switch at the beginning of the opening stroke to allow the actuator to get the disc off the seat without a torque limit. After the valve position reaches an adjustable set point, the bypass switch is disabled, and the torque switch becomes the controlling mechanism.