Table 2.8.2.11.4.2-2 – Swing span centering latches condition coding guide

Functioned properly during the stated percentage of opening	Condition Coding
More than 90 percent	"Good"
Between 75 percent and 90 percent	"Fair"
Between 60 percent and 75 percent	"Poor"
Less than 60 percent	"Severe"

Other "poor" or "severe" condition ratings may also be present based on structural condition (see Section 3.2) or excessive deterioration of individual mechanical or electrical components as discussed elsewhere for such components. These ratings should be modified by judgment based on their anticipated impact on latch operation.

Drum girder: Drum girder structural coding should be based on the requirements of Section 3.2. Tapered roller treads should be coded based upon the requirements for rolling lift tread plates and balance wheel treads herein. Any signs of cracks, holes, vertical or horizontal motion of the drum girder relative to the rollers or support structure should be coded "severe" until an engineering study is performed to allow coding based on the engineering judgment using the result of the study.

2.8.2.11.4.3 Lift Span Components

Wire ropes and sockets: ANSI replacement standards have been developed for running and standing wire rope fittings on various types of cranes and hoists. The presence of wear and abrasion in running wire ropes and the presence of kinks, cracks in wires, and breaks in wires for running or standing wire ropes should be coded "poor" or "severe." ANSI standards AIO.4 and AIO.5 for hoists and B30.2 through B30.8 for various types of cranes, derricks, and hoists indicate that a wire rope should be replaced based upon the number of broken wires and a number of other criteria. Wire rope that is categorized by any of the following criteria is recommended therein for replacement:

- is crushed or flattened
- shows evidence of jammed, high strands or unlaying of strands or wires; bird caging; severe internal corrosion; excessive stretching; core protrusion; heat damage; torch burn; or arc strikes

- has kinks, bulges, gaps or excessive clearance between strands or wire

For movable bridges the presence of such conditions should be coded “fair,” “poor,” or “severe” based upon the number of wires affected or as presented in Table 2.8.2.11.4.3-1.

The table assumes a minimum factor of safety of 4 was used for design of standing ropes and a factor of safety of 6 for the design of running ropes.

Table 2.8.2.11.4.3-1 – Wire rope coding criteria

	Number of wires broken or damaged in two strand lays			
	In running wire ropes		In standing wire ropes	
	In entire rope	In one strand	In entire rope	In end connection
“Fair”**	2 or less	1 or less	1 or less	N/A
“Poor”**	3,4, or 5	2	2	1 or less
“Severe”*	6 or more	3 or more	3 or more	2 or more

*based on ANSI replacement specifications
**developed from ANSI replacement data

Sockets and Other Fittings: Sockets and other fittings that are severely corroded, cracked, bent, worn, or improperly applied should be coded “severe” unless an engineering study finds that they are serviceable.

2.8.2.12—Hydraulic Components

Some movable bridges’ functional systems may employ hydraulic components to create controlled appropriate motion. The purpose of this section is to discuss inspection of hydraulic components. It is intended for specially trained inspectors and maintainers. The coordination of inspection and maintenance efforts, as discussed in Section 2.8.2, is applicable to hydraulic components as well. Chapters 2.8.2.1 through 2.8.2.10 cover mechanical components and the general statements about the purposes of mechanical components therein also apply to hydraulic systems.

Leaks in high pressure hydraulic systems are potentially hazardous to personnel. Eye protection is necessary at all times when inspecting hydraulic components and it is extremely inadvisable to check for leaks with bare fingers or hands. High pressure oils are capable of causing severe injury if a leak develops. Use a tool, such as a clean paint stirrer stick or other

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See Section 2.4 for inspector qualifications. Individuals who disassemble hydraulic system components should be properly trained as hydraulic specialists. Disassembly of hydraulic components can be hazardous.

Since many types of hydraulic components are available, it is not feasible to provide specific data pertinent to disassembly and troubleshooting of specific brands. Inspectors and maintainers should obtain copies of manufacturer's data for specific components to be inspected or disassembled and review it prior to performing any inspection or maintenance work on hydraulic components.

device, to verify the location of pinhole leaks or other leaks that produce a high pressure jet of fluid.

Inspectors and maintainers should be properly trained hydraulic specialists. Manufacturer's catalogue cuts and recommended inspection and maintenance procedures for individual components should be obtained by the inspectors/maintainers.

Routine inspection should, in general, not include any disassembly of components, but should be based upon close visual inspection for leaks, operational performance testing, and verifying system pressures. In-depth inspection should include all the items done for routine inspection and also disassembly and special testing as necessary. A schematic diagram for the hydraulic system should be reviewed before attempting any disassembly for inspection purposes. Disassembly should be done during in-depth inspections or if previously noted problems indicating internal defects must be investigated. Disassembly should be done only by experienced, qualified personnel.

2.8.2.12.1 Hydraulic System Basic Principles

One of the basic theories behind hydraulic systems can be reduced to the following equation:

$$F = PA \qquad \textbf{Equation 2.8.2.12.1-1}$$

where:

F = Force, in any units (pounds, kips, or kN)
P = Pressure, in units consistent with F and A, e.g., in psi (MPa) if F = lbs. (N) and A = in^2 (mm^2)
A = Area on which the pressure acts, in units consistent with pressure, e.g., A = in^2 (mm^2) if P = psi (MPa)

This static equation indicates how mechanical advantage is gained in a hydraulic system (more area = larger force). The simplest form of a hydraulic system, a basic hydraulic jack, shown in Figure 2.8.2.12.1-1, can be used to illustrate the principle.

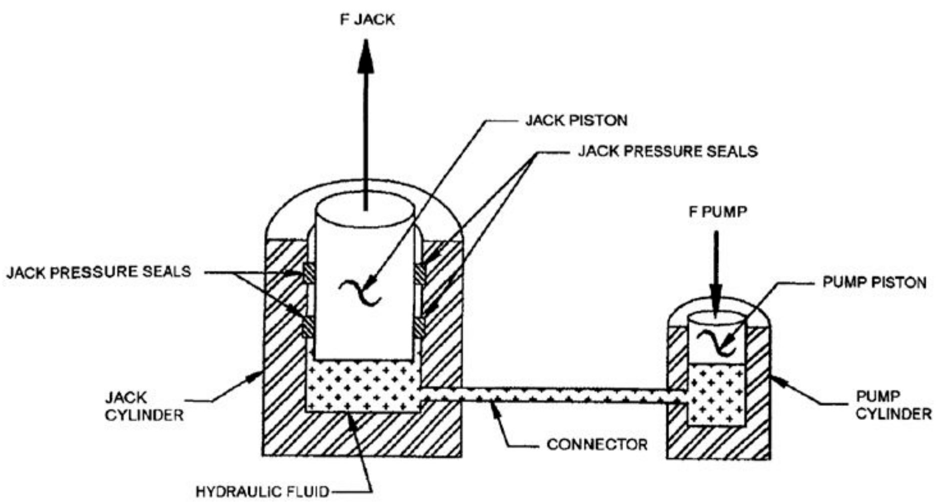

Figure 2.8.2.12.1-1 – Basic hydraulic jack, which illustrates basic hydraulic principles

By applying Equation 2.8.2.12.1-1 to Figure 2.8.2.12.1-1, assuming that the hydraulic fluid is incompressible and that the pressure in the jack and the pump cylinders is equal (i.e. no pressure loss in the hose or pipe between the cylinders) the following relationship results:

$$P_{pump} = \frac{F_{pump}}{A_{pump}} = \frac{F_{jack}}{A_{jack}} \qquad \textbf{Equation 2.8.2.12.1-2}$$

$$\text{or} \quad F_{jack} = F_{pump} \times \frac{A_{jack}}{A_{pump}}$$

Using Equation 2.8.2.12.1-2, the mechanical advantage between the force applied at the pump piston and the force developed by the jack is the ratio of the piston areas. If the area of the jack piston is ten times the area of the pump piston, then the hydraulic system mechanical advantage is ten to one. One pound (Newton) applied to the pump piston will provide ten pounds (Newtons) of force at the jack piston.

Hydraulic motors may also use torque multiplier principles as explained in Appendix A for gear systems. Hydraulic system design is a complex task that should be performed by a certified fluid power engineer. However, for the purposes of basic inspection, the above simplistic model should suffice.

2.8.2.12.2 Hydraulic Components on Movable Bridges

Hydraulic systems used on movable bridges are more complex than the above example. The large distances between the pump and the jack lead to pressure losses in the system. In addition, the speed of motion and force at the jack must be controlled. In general, fluid pressure controls force and fluid flow rate controls speed. On a hydraulic jack, speed is controlled by the person pumping the lever that applies force to the pump piston. On a movable bridge, the motion is usually controlled by valves that regulate the line pressure, direction of flow, and/or fluid velocity of hydraulic fluid from the pump to the jack, hydraulic cylinders, or other hydraulic devices that provide motion. Figures 2.8.2.12.2-1 and 2.8.2.12.2-2 illustrate a simple typical hydraulic system schematic layout and simplified piping and component layout. Additional complexity is added by the inclusion of the mechanical pumps used to pressurize the hydraulic fluid. The valves used to control flow or pressure are not usually as sensitive as a hand on a jack lever, so a means is needed to smooth out instantaneous pressure surges that can occur in an incompressible hydraulic fluid when a pump suddenly starts or stops, or a valve opens or closes quickly. This phenomenon is equivalent to a “water hammer” type pressure spike in potable water piping systems.

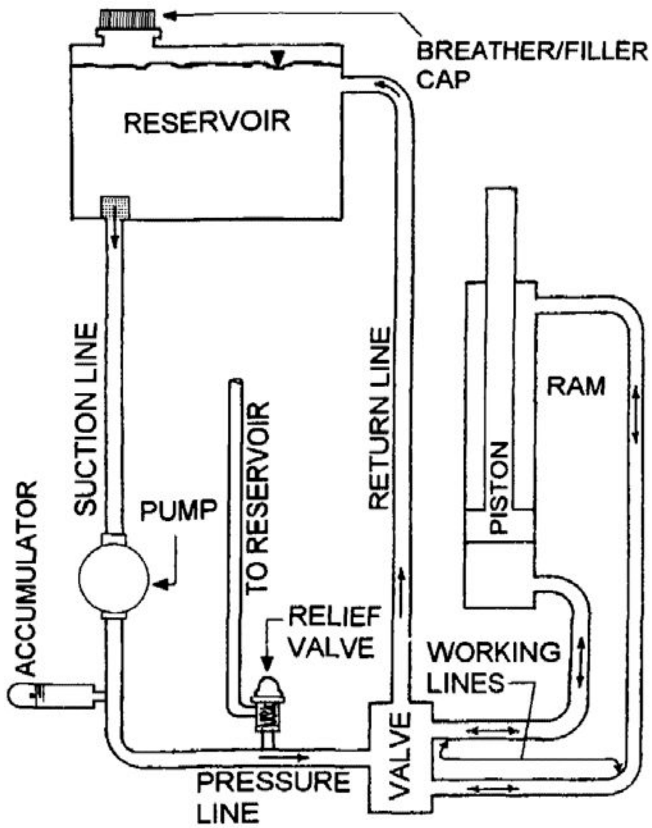

Figure 2.8.2.12.2-1 – Typical double-acting hydraulic system layout

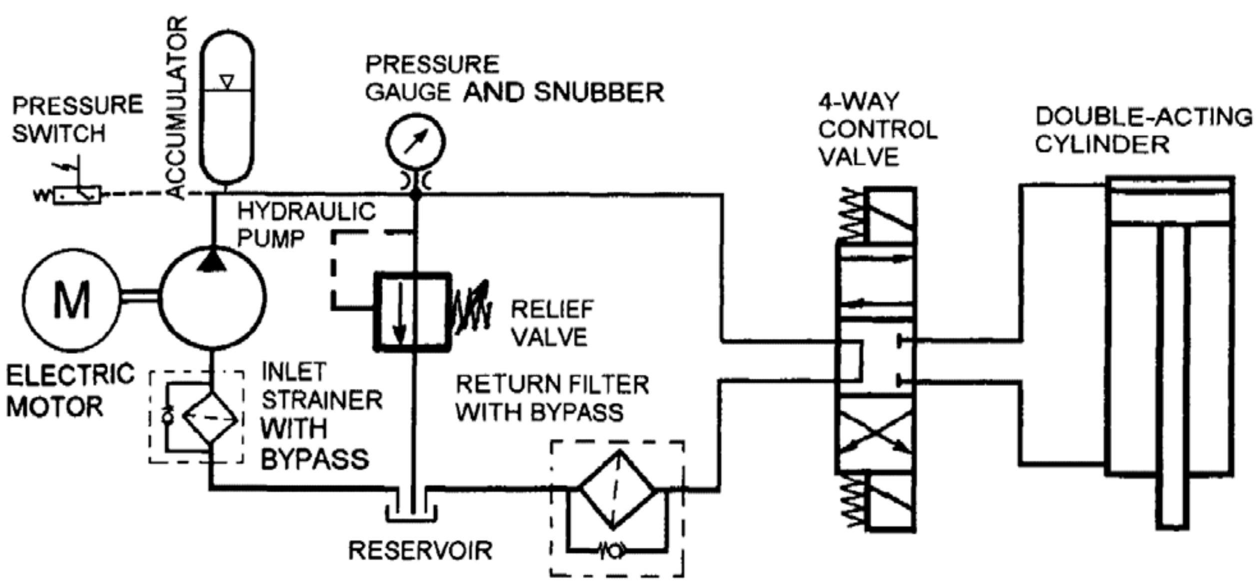

Figure 2.8.2.12.2-2 – Simplified hydraulic schematic circuit layout

2.8.2.12.3 Accumulators

An accumulator is a simple pressure tank containing a compressible inert gas or an elastomeric membrane bladder in contact with the hydraulic fluid, as seen in Figures 2.8.2.12.3-1 and 2.8.2.12.3-2.

The main reason for incorporating an accumulator in the system design is to serve as an energy storage device that reduces the power requirements and required pump size. The accumulator also serves to smooth out operating pressures so the pumps do not cycle on and off rapidly or run continuously during system operation. The fluid level rises and falls to absorb pressure spikes or “hammer” that might otherwise damage hydraulic system components.

Not all hydraulic systems utilize accumulators. A simple pressure relief valve, which allows fluid to escape to the tank, and numerous other devices can be designed to control overpressure “hammer” or other overpressure conditions.

On a movable bridge, the consequences of the failure of a hydraulic system component are typically quite severe. Petroleum products are not permitted to be discharged into navigable waterways. Hydraulic fluid leakage is therefore generally unacceptable. If existing hydraulic systems are encountered on movable bridges that do not have accumulators, and the system has a history of leaks and hydraulic line breaks, it may be appropriate to consider designing a retrofit incorporating accumulators.

Accumulators should be inspected during routine inspections for leaks and for the fluid level inside the tank. Insufficient inert gas cushion can be a major problem. Inspectors should listen to the accumulators during system operation and sound the tank with a hammer handle or mallet to determine fluid level during system operation and at rest, and mark them on the tank for future reference. Bladder type accumulators are more difficult to sound, but they are generally more reliable since the inert gas cushion cannot escape as bubbles in the fluid. One likely sign of inadequate inert gas cushion is rapid on/off cycling of the pumps. Other potential causes (e.g., a major leak, improperly set pressure switches, reduced actuator speeds) should be investigated prior to identifying the cause of rapid pump cycling as insufficient gas cushion in the accumulator.

An accumulator application has a specified gas pressure, based on the application. If pressure precharge is lower than specified due to valve leak, broken bladder, or small transfer of gas through membrane over time, then performance is affected. It is common to check and replenish precharge as necessary, similar to checking air in car tires. Inspectors need not disassemble the accumulator, but only check for gas pressure with a gauge to determine the need to replenish gas or to detect a broken bladder.

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The relationship between the fluid pressure and fluid temperature is given by the law of Gay-Lussac. The law of Gay-Lussac states that when the volume of a gas is held constant, the pressure of the gas varies directly with the absolute temperature of the gas, as graphically depicted in Figure C2.8.2.12.3-1. The law can mathematically be expressed as:

$$\frac{P}{T} = Constant$$

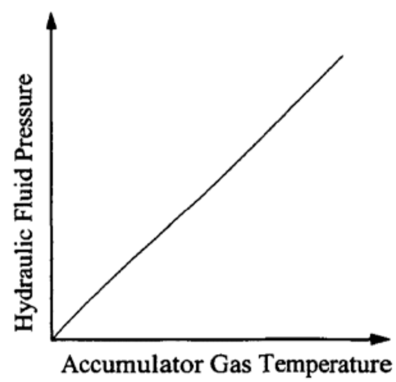

Figure C2.8.2.12.3-1 – Gay-Lussac’s Law

Since accumulators are not to be disassembled by inspectors, further discussion of the various design types not included.

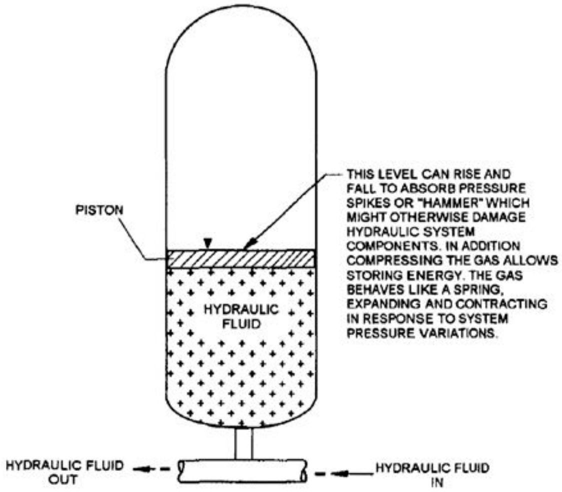

Figure 2.8.2.12.3-1 – Hydraulic piston type accumulator

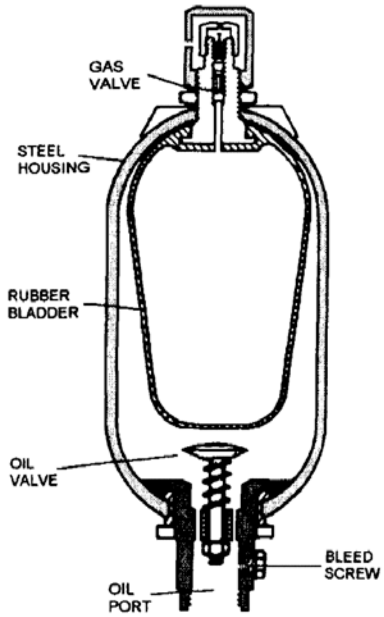

Figure 2.8.2.12.3-2 – Bladder type accumulator

2.8.2.12.4 Valves

There are three basic types of valves used in hydraulic systems:

Pressure control valves: Control pressure by opening in an overpressure condition (relief valves) or change the pressure from one part of the hydraulic system to another (pressure reducing valves). Sequence valves direct flow depending on the pressure.

Pressure control valves limit the pressure (and force) imposed on system components and hydraulic lines. Motion control or counterbalance valves provide smooth starts/stops of actuators.

Directional control valves: Control the direction in which hydraulic fluid flows through the lines. They can be one way (check valves), valves that allow flow only in one direction, or operator controllable valves that shunt fluid flow into different lines in response to control input. Operator controllable valves sometimes permit flow control as well as direction.

Flow control valves: Allow the operator to control the amount of fluid through the valve, and are used to regulate the flow rate of hydraulic fluid through the lines to control the speed of cylinder or hydraulic motor operation. One specialized type of flow control valve is an "equalizing" or "flow divider" valve that is used to confirm that two or more cylinders operate at the same speed.

Figure 2.8.2.12.4-1 shows a schematic of a basic pressure reducing valve, Figures 2.8.2.12.4-2 and 2.8.2.12.4-3 show two stage pilot operated and spool type pressure relief valves, while Figure 2.8.2.12.4-4 shows a check valve.

Directional valves on movable bridges are often remote solenoid actuated types. A four way, three position solenoid operated directional control valve is shown in Figure 2.8.2.12.4-5 and a two stage, four way, three position directional control valve is shown in Figure 2.8.2.12.4-6.

Manual ball valves are typically used as component isolators to allow disassembly for inspection, maintenance, or replacement of individual components. Modern valves often are complex electromechanical assemblies incorporating microswitches and sensors that can control system flow or system pressure.

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There are many different valve designs and functional mechanisms designed into valves available from various manufacturers. Inspectors and maintainers should obtain catalogue cuts, and inspection and maintenance data from operating or maintenance manuals or from the valve manufacturer to understand the design features and potential internal defects of individual valves. For the purposes of inspection, the questions to be answered are relatively simple:

- What is a valve supposed to do?
- Does the valve work?
- Does it leak?
- Is it likely to stop working or start leaking before the next inspection?
- Is the valve operating at the intended pressures (check pressures)?
- For pressure reducing valves, are the high and low pressures correct?

Relief valve operation should be verified during in-depth inspection.

The intended function of a pressure relief valve is of vital importance. Pumps are typically positive displacement which means that as long as the flow and load is constant, the pressure is constant. If the flow decreases or load increases, the pressure will increase to keep equilibrium. When flow stops, pressure increases rapidly and hose damage can occur. When a pump drives a cylinder, the pressure is constant as the piston extends. When the piston dead heads, the pressure rises quickly. The pressure relief valve or bypass valve redirects flow to the reservoir, thereby lowering pressure buildup.

The bypass pressure should be a specific set amount above dead head pressure and should be tested.

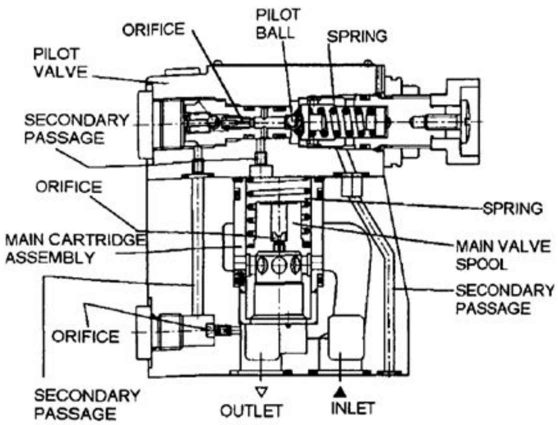

Figure 2.8.2.12.4-1 – Functional diagram of pressure reducing valve

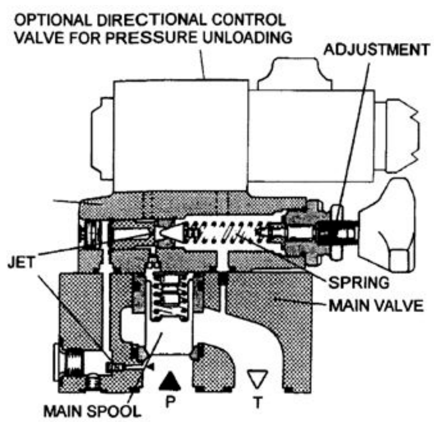

Figure 2.8.2.12.4-2 – Two stage pilot operated pressure relief valve

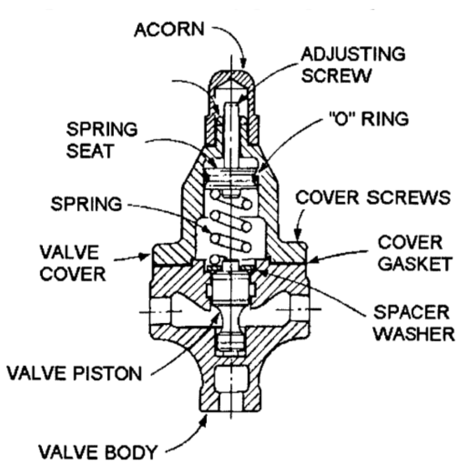

Figure 2.8.2.12.4-3 – Spool type pressure relief valve