Fail-Safe Hoist Features

These Seatrax hoists are individual **hydraulic motor** driven units, which consist of the following major components:

- High speed, fixed displacement, low torque **hydraulic motor** either of the gear, vane, or axial piston type, depending on crane and hoist models.
- **Fail-safe** spring-applied, pressure-released **dynamic brake valve** direct connected to the inlet port of each **hydraulic motor**.
- **Gear reduction** connecting the **hydraulic motor** to the **drum shaft**.
- One-piece, solid **drum shaft** supported on both ends by **anti-friction bearings**, which drives the **hoist drum** through a hardened **spline connection**.
- **Fail-safe** spring-applied, pressure-released **static parking brake** acts directly on the **hoist drum**.

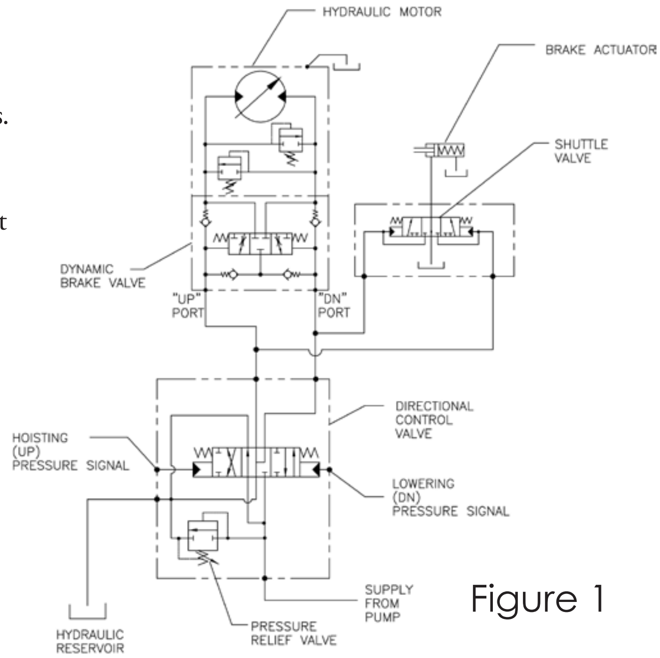

Figure 1

Seatrax cranes use **open loop** hydraulic systems. The hoist portion of this **hydraulic system** schematic is demonstrated in **Figure 1.** The system consists of the following major components:

- **Fixed or variable displacement pumps**. Individual **pumps** are provided for each of the three primary crane motions of **hoist**, **luff** and **slew**. These **pumps** take oil directly from the **hydraulic reservoir** after passing through **inlet strainers** and then discharge to the **pressure relief valves**.
- **Pressure relief valves** are fitted in each circuit between the pumps and the **directional control valves**. These valves bypass the **pump** flow to the **hydraulic reservoir** whenever the preset pressure is exceeded.
- Four-way, three-position, spring-centered, spool-type **directional control valves** control each primary motion. These valves select either **up** or **down** depending on control input. Lack of control input causes the springs to automatically center the valve to the **neutral** or **stopped** position, which makes these **directional control valves fail-safe**. These valves come equipped with **motor spools**, which connect both up and down hoist lines to each other and to the **hydraulic reservoir** whenever the spool is in the **neutral** position.
- A **return line filter** is fitted between the discharge port of the **slew directional control valve** and the **oil cooler**. The discharge ports of both **hoist directional control valves** directly connect to the **hydraulic reservoir**.

- An **oil cooler** is fitted between the **return line filter** and the **hydraulic reservoir**.

On Seatrax hoists, the **dynamic brake valve** accomplishes dynamic braking duties. This two-way, two-position, normally closed, spring offset, throttling spool valve directly bolts to the **up port** of the **hydraulic motor** and consists of the following major components:

- **Free flow check valve**
- **Throttling spool**
- **Return spring**
- **Pilot orifice**
- **Spring cavity vent**

This **dynamic brake valve** functions as follows:

- When the **directional control valve** spool moves into the **up** or hoist position, fluid flows from the **directional control valve** through the **check valve** section and rotates the **hydraulic motor** in the **up** or hoisting direction. The **check valve** allows the fluid to bypass the **throttling spool**, and the system behaves as if the **dynamic brake valve** is not present.

- When the **directional control valve** spool returns to the **neutral** or **stopped** position, the **up** and **down** hydraulic lines are connected together and to the **hydraulic reservoir**. The pressures in these hydraulic lines then tend to equalize at a very low value. At this time, the load on the hoist cable will try to fall. As the load tries to fall, the **hydraulic motor** will attempt to rotate in the **down** direction as the load drives the drum. For this rotation to occur, fluid must escape past the **dynamic brake valve**. This escape of fluid or reverse flow is prevented by both the **check valve** and the **throttling spool**, which is in its normal or closed position.

- When the **directional control valve** spool moves into the **down** or lowering position, the **pump** attempts to force fluid to flow from the **directional control valve** through the **hydraulic motor**; however, the **hydraulic motor** cannot rotate in the **down** direction because of the **check valve** and the position of the **throttling spool**. The pressure in the **down** side of the circuit increases and is then transmitted through small pilot line connecting the **down** side of the circuit to the **pilot orifice**. This **pilot orifice** permits this pressure signal to push on the end of the **throttling spool**, which attempts to open the **dynamic brake valve** by compressing the **return spring**. As the **throttling spool** moves, the fluid trapped in the spring chamber flows to the low-pressure side of the circuit through the **spring cavity vent**. As the **throttling spool** opens, the load on the hoist cable rotates the **hydraulic motor** in the **down** direction, which permits the load to lower. The speed of this rotation increases as the load tries to fall. As this happens, the load will try to overrun the system by attempting to force more fluid through the **hydraulic motor** than is being supplied through the **directional control valve** by the **pump**. This action causes the pressure in the **down** side of the circuit to decay as the **hydraulic motor** tries to suck more fluid than supplied. This reduction in pressure allows the **return spring** to move the **throttling spool** toward its **closed** position, which slows the rotation of the **hydraulic motor** by reducing the fluid flow from the

dynamic brake valve and causes the rate of descent of the load to decrease.

- This modulation action of the **dynamic brake valve** then keeps the load's speed of descent in step and proportional to the flow rate of the fluid passing through the **directional control valve**. The energy absorbed by slowing the speed of descent of the load is converted to heat in the hydraulic fluid as fluid is forced past the **throttling spool**. This heat is then removed from the hydraulic fluid by the **oil cooler**.

- The **dynamic brake valve** is **fail-safe** because it bolts directly to the port of the **hydraulic motor** without the use of pipes, tubes or hoses. If the pressure in the down side of the circuit is lost for any reason, the **return spring** closes the **throttling spool** and stops the descent of the load.

This means that the load will stop if any of the following events occur in any combination:

- The **spool** in the **directional control valve** returns to the **neutral** position.
- The **prime mover** stops, which stops fluid flow from the **pump**.
- A hose or pipe ruptures. This applies to all hoses, pipes and tubes in the system.
- A pressure-containing device, other than the **hydraulic motor** or the **dynamic brake valve**, ruptures.
- If the **dynamic brake valve** or other system components are contaminated by dirt or other foreign materials.
- The design and construction of the **dynamic brake valve** also makes it impervious to changes in temperature and fluid viscosity.

Seatrax hoists are also furnished with a **static parking brake**. This brake is a **fail-safe**, spring-applied, pressure-released, non-self energizing, external band type of brake, which acts directly on the **hoist drum**. This brake will hold more torque, even with wet and oil soaked linings, than the hoist drive can develop. This brake system consists of the following major components:

- **Brake band** lined with conventional, non-asbestos lining and constructed with a rotary bearing on the low tension end and a threaded anchor on the high tension end.
- One-piece **camshaft** used to apply force to the low tension end of the **brake band**.
- **Lever arm** applies torque to the **cam shaft**.
- **Link bar** connects the **lever arm** to the **output rod** of the brake **actuator**.
- **Brake actuator** consists of a **conical spring**, an **output rod** and a **hydraulic release cylinder**.
- Three-position, spring-centered, pilot-operated, **shuttle valve** controls the operation of the **brake actuator**.

This **static parking brake** functions as follows:

- When the **directional control valve** spool is in the **neutral** or **stopped** position, the **up** and **down** sides of the circuit connect together and to the **hydraulic reservoir**. At this time, the pressures in both sides of the circuit will be roughly equal and of a low value. The pilot sections of the **shuttle valve** are connected one to the **up** and one to the **down** side of the circuit. The approximately equal pressures, acting in combination with the **centering springs**, hold the spool of the **shuttle valve** in the **center** position, thereby connecting the pressure side of the **hydraulic release cylinder** to the **hydraulic reservoir**. The **conical spring** can then apply its full force to the **output rod** and the **lever arm**. This applies torque to the **cam shaft** resulting in a tension load being applied to the low tension end of the **brake band**, which sets the brake.

- When the **directional control valve** spool moves to the **up** or **down** positions, the difference in pressures between the two sides of the circuit causes the spool in the **shuttle valve** to shift to one side or the other. This shift causes fluid to flow from the higher pressure side of the circuit to the **hydraulic release cylinder**. This cylinder will retract and cage the **conical spring** and release the **static parking brake**.

- The pressure required to release the **static parking brake** is normally less than that required to open the **dynamic brake valve**. This ensures the **static parking brake** will release first and set last. Therefore, in normal operation, this **static parking brake** does not operate against a moving drum, so there is little or no lining wear.

- However, this **static parking brake** can stop a runaway load in the unlikely event that a failure in the drive train connecting **the drum** to the **hydraulic motor** occurs. Because this brake is not self-energizing, it can perform this function in a controlled manner without inducing undue shock loads into the crane structure.

- This **static parking brake** is also **fail-safe** because the **conical spring** automatically sets the brake whenever positive pressure is not present in the **hydraulic release cylinder**.

Seatrax hoists have **dual load paths**. Note that the two **fail-safe** braking devices on Seatrax hoists operate through two distinctly separate load paths. The **dynamic brake** connects to the **hoist drum** through the drive train. The **static parking brake** acts directly on the **hoist drum**. This means that there is no mode of failure that can render both braking systems inoperative at the same time.

Certifying Authority and Regulatory Compliance:

- The above **fail-safe** braking systems fully comply with API Specification 2C, Seventh Edition, 2012.

- The U.S. Coast Guard, Eighth District, reviewed this system and concluded it would be classified as **fail-safe**, so our **hydraulic system** and all attendant **hydraulic plumbing** can be classified as a “Miscellaneous fluid power system” under the requirements of 46 CFR Subchapter F.