Closed vs. Open Loop Configurations for Hoisting Applications

**General Background:**

Seatrax uses an open loop configuration for all of its variable displacement hydraulic systems, which are used for hoisting applications. These systems utilize the same type of variable displacement, high pressure, piston pumps that are used on the more familiar European closed loop systems. Seatrax’s open loop configuration for this same type of equipment provides equal or better infinitely variable speed control in both directions of movement and addresses well-known safety and maintenance concerns that continue to be a problem with the closed loop system configuration.

**Problems with Closed Loop Systems:**

The pump on a closed loop circuit discharges directly to the hydraulic motor. Flow from the motor is directed directly back to the pump. The fluid moves in a loop from which it does not escape. Directional control is accomplished by rotation of the pump swashplate. The position of this swashplate selects the direction of pump flow (up or down) or, if the swashplate is vertical, no flow occurs (neutral). The nature of this system creates certain problems in crane applications, which are described below:

**Dynamic braking** is accomplished by attempting to back drive the pump. The pumps and prime mover constitute the dynamic brakes. This has several disadvantages:

- In the event that the prime mover is a diesel engine, this engine must be develop sufficient power to drive all three primary crane motions at full load and full speed at the same time. Otherwise loss of dynamic braking capability can occur because of engine overload while lowering the boom and the hook simultaneously. For this reason, the engine must run at high speed when the crane handles any substantial load. Otherwise, the load may overrun and kill the engine. Prime mover failure can result in loss of control of the load.

- A hydraulic line rupture between the pump and motor will drop the load. This means that the hydraulic fluid conductors must be classified and treated as critical components.

- The servo controls that operate the pump swashplate all seem to have trouble holding an exact neutral position from time to time. This neutral shift permits the crane to move about unintentionally without input from the crane operator. Many accidents have resulted from this cause. Most crane specifications require one or more panic buttons or emergency stops to deal with this situation. Also, the controls on a crane with this type of system should never be left unattended with the prime mover running.

The fact that the flow of hydraulic fluid is primarily in a closed loop causes certain other problems, which include:
It is very hard to properly filter the hydraulic fluid because most of it does not escape from the closed loop. This means that contaminants are constantly circulated from the pump to the motor and back again. In many systems, high-pressure filters are placed in the loop to attempt to deal with this problem, but they can only operate in one direction and are prone to leakage. Also, they are easy to plug up.

It is very difficult to properly cool the hydraulic fluid in a closed loop system. These systems are efficient but generate a lot of heat. This heat can only be dissipated by cooling the flow from the charge pump circuit. This flow is a small percentage of the total flow through the loop, so this process is not effective. For this reason, cranes with closed loop systems have historically had overheating problems when used in tropical or semi-tropical applications.

**Advantages of Open Loop Systems:**

The pump on an open loop system draws fluid from a storage tank or reservoir and then discharges it to a directional control valve, which is used to select up, down or neutral. Flow from this valve goes to the motor and back to tank (up or down) or goes directly back to the tank when in neutral.

This configuration overcomes the problems associated with closed loop systems as described below:

**Dynamic braking** is accomplished by means of a motor control or counterbalance valve, which is normally fitted directly to the hydraulic motor. The energy of lowering the load at a controlled speed is converted into heat in the hydraulic fluid by forcing it to flow through a small orifice at high pressure, so the prime mover plays no role in dynamic braking. This means the prime mover need not be sized based on the potential full power requirements of the three primary crane motions. For this reason, a failure of the prime mover cannot and will not result in loss of control of the load.

If the prime mover is a diesel engine, it is not necessary to run it at high speed. Full-rated loads, on both the boom and the hook, can be lowered under full control with the engine operating at idle speed.

- A hydraulic line rupture cannot cause the load to drop because load holding is performed between the hydraulic motor pistons and the spool in the counterbalance valve. This means that the fluid conductors are not critical components in this type of system.

- Neutral creep in the pump swashplate servo cannot cause the crane to move unintentionally because the directional control valve will divert any unexpected flow directly to tank as long as the control handles are centered.

- It is very easy to filter the hydraulic fluid because the fluid passes through the tank whenever a hoist is in operation. This makes it practical to filter the oil on a continuous basis by means of a separate fluid conditioning circuit.

- It is also very easy to cool the hydraulic fluid by means of a large oil cooler fitted in the fluid conditioning circuit. This overcomes the overheating problem common with closed loop systems.