Designing for smart load-sensing: Practical considerations

Though hydraulic systems have used load-sensing for some time, misconceptions have placed load-sensing out of reach of many applications which would benefit from power on demand. We dispel misconceptions and provide key questions for designing smart load-sensing systems that allow you to effectively balance efficiency and power.

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Load-sensing is more than pre-compensation and is cost-effective across a range of horsepower.

Designing for load-sensing becomes tricky with multiple demands on a hydraulic supply. Users typically must choose between valves that support pre-compensation or post-compensation. Under pump-saturation conditions, pre-compensation meters out oil to the lowest induced pressure-load first, according to predetermined parameters. The result is a loss of function on higher induced-pressure loads until flow is regained. Post-compensation under pump-saturation conditions decreases oil to all functions proportionally, resulting in a reduced speed of performance, but no loss in function.

How does one design a load-sensing system that prioritizes control under pump saturation conditions?

Why load-sensing?

Every industry searches for ways to cut fuel costs while maintaining the power needed to accomplish their tasks. Running hydraulic motors is no different and load-sensing has been a key answer to that question. Running motors at lower RPM conserves in fuel costs, among other benefits. Any pressure not used by an actuator is wasted, so manufacturers have great interest in gaining efficiencies wherever they can. Selecting and prioritizing the timing of that reduced RPM is critical- and difficult.

In the past there was a generally-accepted limit of 100HP for improving efficiency, so there was little incentive for load-sensing for engines below 100HP. But today, with increasing cost for fuels and increased pressure to get the most work from every stroke, new tools have emerged to help improve efficiency across a wider range of engines.

What Is load-sensing?

Load sensing provides the right amount of power to a hydraulic system when that power is needed. Just like changing the idle setting on an automobile: Set idle too low and you cannot speed away when the traffic light turns green. Set idle too high and you may speed away easily, but your engine will always be running fast and fuel consumption will be higher. The best idle is something between too-low and too-high.

Load-sensing works by sensing the load-induced pressure downstream at the actuator and communicating to the upstream orifice to increase or decrease pressure, which in turn optimizes the pressure drop across the spool for maximum efficiency and minimizes energy loss.

Typical load-sense choices

Load-sensing helps make a motor more efficient—but there are trade-offs. Typical load-sensing systems deal with saturation conditions by using pre-compensation or post-compensation (Figure 1).

- **Pre-compensation:** When the pump is saturated, pre-compensation routes upstream oil (from the pump) to a primary, priority function (lowest induced pressure-load) so control remains dependably intact. Other functions that use the system may experience a ceasing of function or loss of control (higher induced pressure-loads).
- **Post-compensation:** When the pump is saturated, post-compensation reduces downstream pressure (from the pump) to all the functions in the system. The result can be a slowing or reduced speed of performance, but no loss in function.

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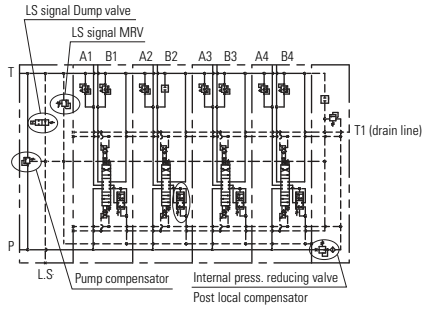
Typical load-sense choices have not allowed for setting priorities for functions using the system. Most hydraulic valves enforce a binary choice, since most hydraulic valves are equipped with either pre-compensation or post-compensation.

Post compensated system



Pre compensated system

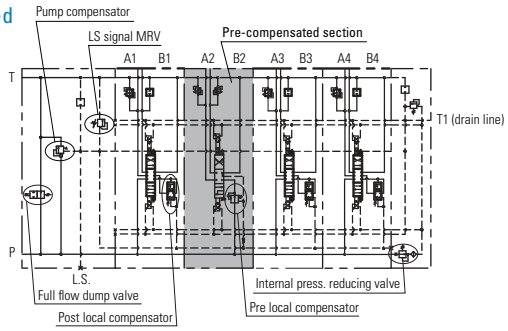


Figure 1. Eaton CLS100 Load Sense Sectional Mobile Valves E-VLVM-CC001-E1

The Eaton CLS Load Sense Sectional Mobile Valves can be configured with both pre- and post-compensation, which allows flow-sharing and priority-sharing, resulting in hydraulic functions that remain uncompromised under saturation conditions. Combining flow-sharing (post-comp) with priority sharing (pre-comp) allows you to maintain priority flow to the function of choice by assigning a pre-compensation section to that function while all other functions get post-compensation.

Establish general hydraulic design parameters

Pursuing load-sensing will always start with the general questions facing any hydraulic system project. What loads will your system lift? Does your system require more efficiency or more torque? A typical checklist may look something like this:

- Pressure requirement: _____
- Flow requirement: _____
- Number of actuators required: _____

	Requirement	
Actuator	**Pressure**	**Flow**
1		
2		
3		
4		
5		
6		
7		
8		

- Could application benefit from Pre-comp, Post-comp or both? _____
- How far is the pump from the valve? _____
- Length of load sense line (from valve to pump): _____ (If longer then XX, bump press by XX bar)
- Desired speed of spin: _____
- Does the system require any special features, like feedback, for instance?
- What is the duty cycle (will they all be used at the same time or at different times)?
- Will flow requirements apply to more than one pump?

Questions for designing smart load-sensing

Smart load-sensing uses downstream pressure (from the load) to inform upstream pressure—but that information commands both the pre- and post-compensation. This unique arrangement, available only on Eaton valves, allows for priority flow-sharing.

After dealing with the general hydraulic design considerations listed above, a few specific considerations get directly at the opportunities inherent in smart load-sensing.

Open-center or closed-center?

When it comes to the smart load-sensing design-specifics, the first question is how your hydraulic system handles neutral or 0 demand. Open-center systems deal with reduced demand by sending excess oil (at pressure) into the reservoir. Closed-center systems deal with reduced demand by blocking the flow of the pump and commanding the variable displacement pump to duct production of flow.

Flow-sharing or priority-only—or a combination?

Flow-sharing (post-compensation) helps ensure no vital functions are left without control. But in some cases priority sharing (pre-compensation) may be enough to accomplish your purpose. In your hydraulic design be sure to take into account those functions.

Secondary load-sense design questions

After determining open- or close-center and whether priority flow-sharing is needed, the design process follows the more general hydraulic design process:

- Does the system require:
  - Port relief?
  - Anti-cavitation valves?
- Number and types of functions/actuation required?
- Pressure capabilities should match with the valve types
- Flow rates per section?
- Kind of command signal used?
  - Need hydraulic remote control?
  - Need electro-proportional control?
  - Need manual actuation?

Other design questions will certainly also apply

Smart load-sensing balances efficiency and power

The Eaton CLS Load Sense Sectional Mobile Valve is able to accommodate an open- or closed-center system. And whether you need the full effect of flow-sharing, priority sharing or priority flow sharing, the CLS valve can accommodate each of those situations. By providing for pre- and post-compensation in a single valve, plus the ability to configure and control with Eaton's Pro-FX® technology, the CLS valve looks like the smart choice and the most versatile choice for whatever application you are designing for.

Learn more about the Eaton CLS Valve at www.eaton.com/CLS

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