

Standardization on zero leakage

By M. Horgan, contributing editor

Hydraulic systems have an image problem. Even the finest public relations spin doctors would have their hands full convincing the general public that hydraulic systems don't have to leak. But with advancements in sealing techniques, coupling designs and hose construction, building a leak-free hydraulic system is a definite reality.

With the marriage of electronic motion control and mechanical power transmission, the hydraulics industry must clean up its messy image to compete. There's no question that despite electromechanical advances, there are some applications that lend themselves to hydraulic power. However, motion system designers and maintenance engineers will not put up with the inconvenience, unsafe conditions, and high cleanup costs associated with leaky hydraulic systems if an electromechanical system could do the job just as well — or even almost as well.

Hydraulic component manufacturers are taking responsibility for leak-free components and systems. In fact, many manufacturers already offer guaranteed leak-free products. But the responsibility does not lie solely on the shoulders of the component manufacturers. The brunt of the responsibility has to fall on the shoulders of distributors and end users. Distributors must recommend leak-free components and systems, while end users must not tolerate leaky systems. The days of putting a pan under a connection to catch the intermittent leaks are gone — or should be.

"A colleague of mine puts it in perspective when he says, 'If an occasional spark (an electrical leak) is seen coming from an electric drive or control, things are shut down in a hurry,'" explains Phil Swisher, director of venture development, Vickers, Inc., Maumee, Ohio. Swisher is responsible for zero-leak technology research and development at the Vickers Advanced Technology Center in Rochester, Mich. "In the not-so-distant past, if the choice was between stop-

Some users have tolerated leakage of hydraulic fluid for so long, they no longer notice it. Now that zero-leakage technology is in place, it may require a new standard to bring it into general use.

ping production to fix a leak that was lowering the reservoir fluid level or adding fluid while letting production continue, adding fluid was the answer," says Swisher.

A fitting farewell

Customers are saying good-bye to leakage, in large part, because many fittings manufacturers have embraced the zero-leak attitude. Traditionally, fittings were one of the largest culprits of leakage, so new zero-leak designs give hydraulic fittings the greatest potential for controlling leakage.

Utilizing new seal technology, manufacturers are making fittings that stand up to the increasingly higher pressures mandated by today's hydraulic systems. And recognizing that improper installation is a large reason why fittings leak, several leading fitting manufacturers have developed easier crimping techniques to virtually ensure a leak-free connection between the hose and the fitting.

The variety of fitting options is almost endless, and some experts say this large variety has been a leading cause of leakage. Many large plants must stock dozens of fittings from several manufacturers to properly maintain machines throughout the plant. In many cases, one type of fitting is connected to a similar fitting simply because they seem to connect, which invites leakage.

Many industry experts relate the fitting leakage problem to the lack of a single fitting standard. Fittings can be specified based on any one of these standards: DIN, ISO, SAE, NPT, BSPT, BSPP, and JIS. Some industry analysts believe that implementing a singular metric global standard for fluid connection points will eliminate many of the problems caused by the existence of multiple standards. The leading standard appears to be ISO 6149, developed under ISO TC131. Recognized worldwide, ISO 6149 eliminates confusion on standard fittings, increases parts availability while decreasing costs, and increases fitting reliability leading to the realization of zero leakage.

Fluid leakage in a hydraulic fitting can come from two areas: the port side and the tube/hose

ZERO LEAKAGE

connector side. ISO TC131 standardized on five port connections and four tube/hose connections, but recommends only two port side and two tube-hose side connections for new designs. Round-robin testing between TC131 committee members in the U.S., Europe, and Japan concluded that ISO 6149 was a proven leak-free standard for the metric straight thread O-ring port with reasonable assembly torques. ISO 6162 for four-bolt flange connections is the TC131 recommended standard for large sizes and, again, is a metric standard to allow for global acceptability.

On the tube/hose side, ISO 8434-3 O-ring face seal design is the preferred connection for leak-free operation. It is compatible with inch or metric tubing, is rated to 9000 psi, and has a solid assembly feel. The other recommended tube/hose design is the ISO 8434-4 24° cone with elastomeric sealing.

Cylinders seal the deal

In addition to fittings and connectors, the piston rod on a hydraulic cylinder can also contribute to leakage. A typical piston rod assembly in a cylinder consists of a primary seal, a back-up washer to protect the seal from extrusion, and a wiper. All three of these components need to work together to prevent leakage. If any one doesn't do its job, leakage will result.

A piston rod must carry a thin film of hydraulic fluid on its surface as it extends for lubrication to reduce friction. Just how much fluid depends upon a variety of factors, but could be crucial in a zero-leak application. If the film is too thick, the wiper will shave off enough oil as the rod retracts to form a drop of oil.

A relatively simple option to decrease the likelihood of hydraulic leakage is the use of multiple glands. A venting hole or leakage oil line must be arranged between the glands for the oil to be returned to the cylinder. Another option is a dual-action scraper on the cylinder rod. While these solutions increase the initial cost of components, the cost advantages of longer service life and a leak-free hydraulic system greatly offset the initial cost differential.

Unclogged arteries

When selecting hose for your hydraulic system, it is imperative to pay attention to details. A hydraulic hose

Failure analysis finds sealing solutions

Leakage control depends more on sealing devices than any other component in a hydraulic system. That's why the analysis of seals and sealing systems at the initial design stage is critical. Equally important to a new design is the evaluation of any sealing device or system after it has either completed its life cycle or failed prematurely by allowing leakage.

Since 1991, we have conducted more than 1000 seal failure analysis projects. These represent sealing devices submitted by a wide variety of customers over a range of industries including those from 23 other manufacturers. A summary of the data compiled from these projects reveals the most frequent causes of leakage—seal failure. The table shows the causes and their frequency of occurrence from the data.

All of these types of failures are preventable! Steps to prevent these leaks must occur during the initial design and, of course, during manufacturing/assembly of the machine. In the design phase, the engineer must realize that no two applications are exactly the same. Therefore, all design and application parameters must be identified and evaluated for each seal within a sealing system. At this stage an ounce of prevention is worth gallons of cure. Too often designers are tempted to take short cuts in this vital process. Don't do it! Instead, pay close attention to applica-

tion requirements, operating environment, and operating expectations. Each of these major categories is further broken down into steps that must be considered in detail to arrive at the proper seal selection.

In manufacturing and assembly, *clean* and *careful* are the two most important guidelines. As can be seen in the chart, contamination and installation damage represent over one-third of the failures evaluated. Proper design and *clean* components manufactured to specification and assembled *carefully* using proper tools and techniques are the ingredients that produce a hydraulically powered machine with no leaks.

Submitted by E. Wayne Walden, director of engineering and P. Dennis Koontz, vice president, HPS, Inc.-Tech Center, Chambersburg, Pa.

consists of an inner tube that carries the fluid, a reinforcement layer, and a protective outer layer. Common factors contributing to hose failure (and ultimately leakage) include:

- flexing the hose to a radius smaller than the recommended minimum
- operating the system at too high a temperature or pressure
- intermixing hose and end fittings from different manufacturers, and
- twisting, pulling, or kinking the hose.

The inner tube must have some flexibility and needs to be compatible with the type of fluid it will carry. One detail you cannot overlook is that the fluid may be compatible with the hose, but the additives in the fluid may not. Additives in hydraulic fluid can extend the life of the fluid, help reduce

Causes of seal failure

Contamination	21.4%
Installation damage	14.3%
Extrusion	10.8%
Wear and abrasion	9.8%
Cold start-up	6.8%
Compression set	5.3%
Excessive heat	4.7%
Fluid incompatibility	4.3%
Surface finish	3.9%
Aging, weathering, or both	3.2%
Dithering	2.9%
Gland overfill	2.4%
Other*	10.4%

*Other causes include low temperatures, air entrainment, stability, dieseling, fluid jet erosion, and stress fatigue cracking.

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the effects of corrosion, and even enhance the fluid's performance. However, they can also affect hose life and seal life if the additives are not compatible with the hose or seal material.

A challenge issued

Manufacturers of hydraulic components have risen to the challenge and are now offering products that use zero-leak technology. For hydraulics to survive against other forms of power transmission, distributors and end users must follow suit. By using common sense, following fitting, seal, and hose specification guidelines set forth by new ISO standards, and adhering to proper installation instructions, you can ensure your fluid power system will operate efficiently and leak-free for years. **H&P**