Any plant manager who oversees a manufacturing facility where hydraulics are used has undoubtedly been told that leaks in those systems are inevitable. A more accurate statement would be that leaks in poorly designed, inadequately maintained systems are inevitable. Leakage robs hydraulic systems of efficiency, increases costs and exposes workers and the environment to potentially harmful conditions. This paper will focus on leaks in one specific component, valves, and how leakage in valves can be minimized.

**Internal and External Leakage Explained**

There are two types of leakage in hydraulic systems, internal and external. External leaks are evidenced by the drips and puddles on plant floors or equipment. These leaks can be hazardous to workers, the general public and the environment, depending on the flow media. Even if the flow media does not contain substances that present an exposure risk, there is an added slip and fall risk, which according to OSHA, is among the top five causes of lost time injuries in the workplace. Additionally, the loss of flow media in a closed-loop system has a negative impact on the efficiency of that system. For instance, if a hydraulic press has a cycle time of one minute, but leakage is causing that cycle time to drop to two minutes, then the efficiency of that press has been cut in half. This is in addition to the possible detrimental effects associated with operating all of the system components at sub-optimal operating conditions. External leakage can result in lower operating pressure, which can lead to vibration that can cause excessive stress on system components. Of course, there is the obvious cost of having to replace the flow media that has leaked.

Internal leakage on the other hand, is sometimes designed into a valve to provide lubrication to various valve components. Without that lubrication, friction would prematurely age those components, such as seals, spools or pistons. Another form of intended leakage maintains the pressure within a system at a safe level. This is the case with some types of pressure reducing valves that may have an orifice designed to vent pressure to the tank as part of its ability to control pressure on the reduced circuit.

Unintentional internal leakage though, can be just as problematic as its more visible sibling, external leakage. Internal leakage through a valve can result in a system that operates inefficiently, as pressure, temperature, flow, velocity, as well as other parameters can be affected. This likely will result in equipment that is not operating as it was intended to operate, leading to inconsistency in the processes which rely on the hydraulic circuit. That unintended variation in the process leads to poor quality, which means that scrap is being produced and dollars are being lost. This is why internal leakage can be so destructive. Often the assumption is made that a machine that is running is a machine that is running at optimal performance. Internal leakage is a hidden culprit that discredits that line of thought.
How Much is Too Much?

How much leakage should be accepted as inevitable? That question will be answered differently by any entity that uses high-pressure hydraulics systems. An acceptable amount of external leakage in a forging operation will most likely be unacceptable in a food processing plant. Internal leakage in valves in a hydraulic system that is used to create high cost parts will be tolerated less than internal leakage in a system where a commodity item is being manufactured.

Industry standards have been developed to help quantify the acceptable amount of leakage for different applications. ANSI (American National Standards Institute), the Fluid Controls Institute (FCI) and MSS (Manufacturers Standard Society) have all created leakage standards for different types of valves:

**API Standard 527**: Developed specifically for pressure relief valves, API 527 specifies the methods for gauging seat tightness and defines acceptable leakage rates.

**API Standard 598**: Acceptable leakage in Butterfly, Ball, Gate, Globe and Plug valves is established by API 598.

**MSS Standard SP-61**: A standard intended for establishing allowable leakage in valves that operate as isolation or check valves.

**ANSI Standard 70-2**: Specifically established for control valves, ANSI 70-2 sets different leakage classifications, ranging from Class I, which allows an unspecified amount of leakage, to Class V which essentially allows zero leakage.

These standards were developed with the intention of establishing guidelines for valve manufacturers to adhere to when designing valves. But, it should be noted that the standards use a set of specific operating parameters, such as viscosity, pressure and temperature, when measuring leakage. These guidelines can be helpful in the valve selection process, but do not offer any guarantees of how a particular valve will operate in service conditions, where the actual operating parameters can exceed those that are set forth in the leakage testing protocol of a particular standard. So, if an engineer needs a zero leakage valve, it should not be assumed that he or she can select an ANSI Class V valve out of a catalog and be good to go. The valve will need to be tested under actual service conditions to verify that it is providing the desired leakage control.
Proper Valve Selection is Key

There is no understating the importance of taking the time to size and select the proper valve for the process, as this will result in a lower chance of that valve leaking. Oversizing of valves is a common practice, and is one of the most common causes of valve leakage. Flow velocities that are incompatible with an oversized valve will result in eventual leakage.

Of paramount importance is recognizing potential incompatibilities between the flow media and the materials of construction of the valve, especially the wetted areas. Additionally, additives in the flow media can wreak havoc on valve components. For instance, glycol added to a water based hydraulic system for fire resistance will degrade a polyurethane or polyester seal in short order, which will result in leakage through that seal. Incompatibility charts for materials are typically published by valve, seal and gasket manufacturers. This information is an essential tool for any engineer who is tasked with valve selection.

Put the Valve in a Position to Succeed

Assuming all of the necessary work has been done in selecting the correct valve and it has been installed into an operational system, leakage can be minimized by operating the valve within its design parameters. This is likely easier said than done, but it stands to reason that a spool valve that is designed to operate within a certain range of temperatures, pressures and flow velocities will not operate as intended if it asked to operate outside of that range. It is important to remember when tracking down a leak in a valve that the valve may be operating as intended. The problem may be that the system as a whole may be presenting conditions that are causing the valve to leak.

One of those conditions that will lead to leakage is contamination in the flow media. If there is dirt or unintended particles in the media, then this can cause a valve to leak for a couple of reasons. First, those particles will cause premature wear as they travel at high speed through the circuit. Secondly, these particles can prohibit the mating surfaces of the valve shut-off point to mate correctly, allowing gaps where leakage can occur. Contamination is a condition that feeds on itself; if flow media is capable of escaping the system in the form of a leak, then contaminants can enter the system though that same point. Cylinder rods are prime offenders in carrying dirt into the system as they extend and retract into unclean environments. Wiper seals on cylinder rods can help prevent this from happening, as they are designed specifically for this purpose. Contamination can best be controlled by filtering the flow media and by consistently monitoring it for cleanliness.
Another cause of leakage is misalignment between the valve stem and the actuator stem. If the two stems are misaligned there can be an uneven force applied to the valve shut-off surfaces, which can allow leakage to occur at that point. Any uneven force on the valve stem will also create issues with the packing surrounding the stem. The valve actuator also needs to be regularly inspected and tested to ensure that it is operating as intended. If it is not capable of mating the shut-off surfaces with the required seating load, then leaks will occur.

The majority of leakage causes can all be minimized by adhering to a regular preventative maintenance program. But, these types of programs are typically dictated by the organization’s tolerance of leakage or the eventual failure of a valve. Run to failure might be the method for one company, while complete intolerance of leakage may go hand in hand with a total predictive maintenance program at another. More companies are trending to the latter mindset, as industry studies have shown that predictive maintenance can be ten times less costly than reactive maintenance.

Internal and external leakage in valves can be minimized if there is a concerted effort on the part of the organization to not fall into the archaic mindset that leaks are inevitable. It all starts with sizing and selecting the right valve for the process. Once the valve has been installed into the system, it needs to perform under a consistent set of operating parameters. Lastly, valves need to be serviced regularly to keep them in their design condition. Maintaining a disciplined approach in all of these areas will lead to valves that function in a safe and efficient manner, with minimal leaks.

About Hunt Valve

Hunt Valve brings decades of fluid power engineering innovations and solutions to a wide range of industrial and military customers. It specializes in severe-duty valves and complementary engineered components and system solutions for applications that include primary metals (steel, aluminum), energy (nuclear, hydro, downstream oil & gas), process (chemical) and U.S. Navy nuclear-powered vessels, including all submarines and carriers in operation as well as the Virginia Class, Ford Class and soon-to-be-in-production Ohio Replacement. To learn more about the Experts in Extreme Engineering, visit www.huntvalve.com.
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Heestand’s leadership role at Hunt Valve includes oversight of the company’s welding and nondestructive test procedures, Welder Workmanship Training and Examination and contract engineering reports. He is also responsible for a portion of NDT Level II inspector training and testing. On June 23, 1998, Heestand was granted a U.S. inventor patent (US 5769123 A) for developing the cylinder actuated descale valve. This patent is owned by Hunt Valve. Prior to joining the company in 1986, Heestand worked at GM as a welder maintenance repair supervisor, gaining experience in hydraulics and control. He is an ASNT NDT Level III who is certified in several NDT methods (VT, PT and MT). He is also tested to meet HVC-specific requirements and certified by Hunt Valve as a NAVSEA Examiner. Heestand has a bachelor’s degree in mechanical engineering from Youngstown State University.