March - April 2003

Machinery Lubrication

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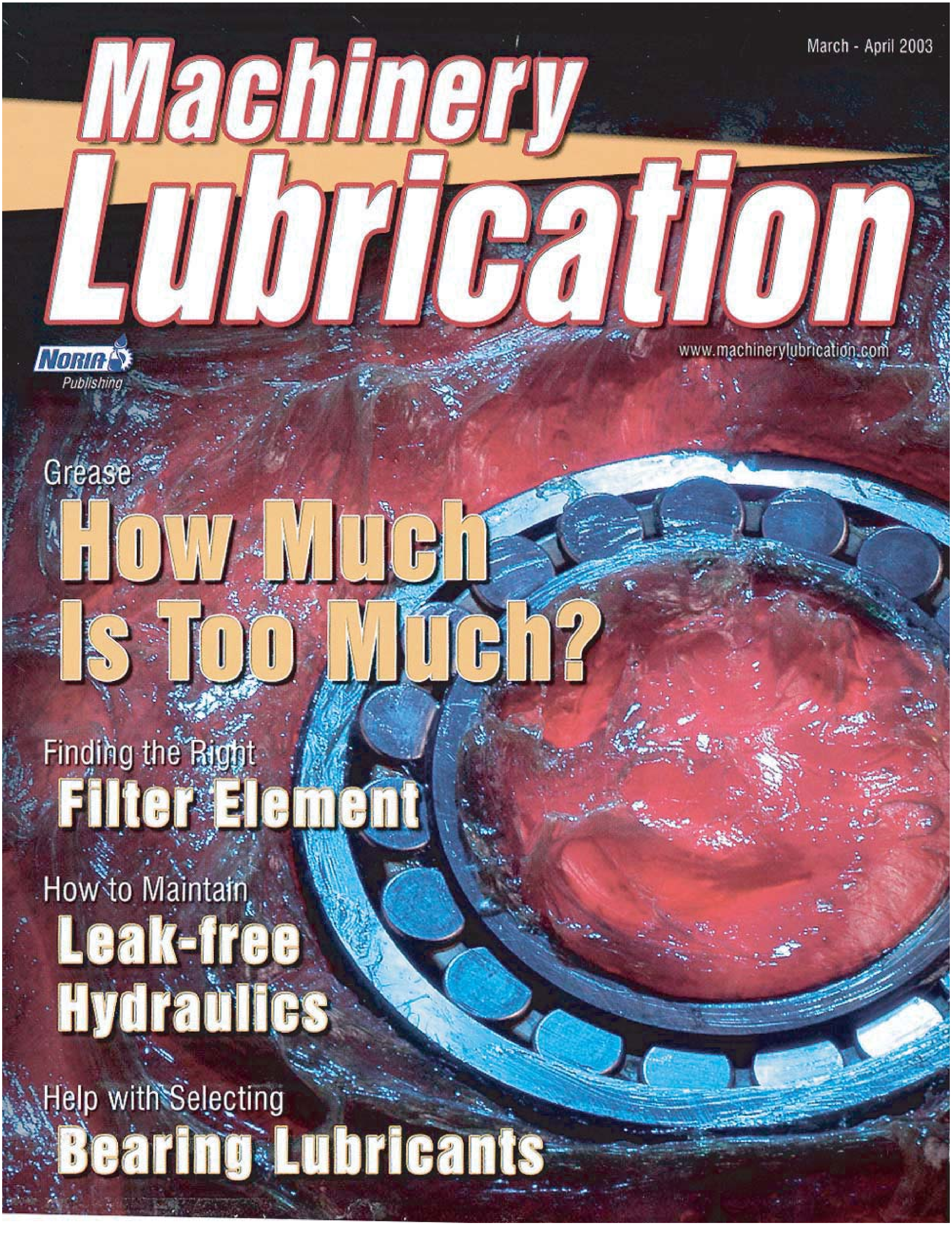

Grease
How Much Is Too Much?

Finding the Right
Filter Element

How to Maintain
Leak-free Hydraulics

Help with Selecting
Bearing Lubricants

Leak-free Hydraulic Plumbing

By Mark Reaves

Until recently, leaks were considered to be inherent to industrial hydraulic systems. Sealing technologies developed for reliable aviation and mobile hydraulic systems are now finding their way into industrial plants. Environmental and cost reduction demands are causing manufacturing facilities to take action to reduce or eliminate fluid leaks, with the biggest culprit usually being hydraulic plumbing leaks.

When one sums up the total expense of fluid leakage - downtime, fluid consumption, clean-up and safety risk - then the argument to upgrade the hydraulic system may look quite attractive. Often the payback can occur in less than one year.

The total cost of hydraulic system leaks is much more than the cost of the replenishment fluid and absorbent pads. Depending on a company's cost of downtime, leaks that can cause an unscheduled shutdown result in losses that significantly exceed the annual fluid and clean-up costs. The potential costs of safety and environmental liabilities stemming from leakage onto and into the floor should also be considered.

The root causes of hydraulic plumbing leaks must be addressed to achieve optimum reliability (such as leak-free plumbing). In order to maintain a leak-free system, all system plumbing must be analyzed and repaired or upgraded. Otherwise, new leaks will develop at the next weakest seal or connection. This article addresses options that are widely available, with a long history of proven effectiveness.

Total Cost of Leakage

Fluid Consumption

Fluid consumption rates are rarely measured on individual machine centers. Typically, the only measurement available is how much of each type of fluid is purchased annually. Equipment that has significant leakage can be easily identified by the severity of leakage, but the cost per machine is sometimes difficult to quantify. To obtain the cost per machine, keep a service log next to the equipment to record consumption for a month, and then multiply by 12 for annual cost. These hard expense numbers are often needed to justify investment capital to upgrade hydraulic systems to a leak-free state. Be sure to include in the expense calculation the cost of labor to monitor fluid levels and service the reservoirs.

Repair, Clean-up and Disposal Costs

There is often no data for the total costs per machine associated with leakage costs. The labor expense can include wiping down the machine, locating the source of the leak, repairing the leak, draining the drip pan, changing the absorbent pads and cleaning the floor. If one can estimate the amount of time spent on these tasks monthly, then an annual estimate can be extrapolated. These annual costs can be quite significant even for machines with only moderate leaks.

Anyone who has purchased absorbent pads, pigs and "kitty litter" knows that the cost of these materials is high. Unless these saturated pads can be wrung out, EPA compliance requires that they be disposed of as hazardous waste in many states. Again, a month's worth of record-keeping can be useful to calculate an annual estimate of disposal costs.

Downtime

A nuisance leak can quickly turn into a shutdown situation if a seal or line fails. Suddenly, the hydraulic system reliability gets plenty of attention. Fortunately, these costs may be the easiest to capture on each machine, depending on the reporting and record-keeping systems utilized.

Potential Liability

Excessive leakage raises long-term safety and environmental risk. Safety issues range from employees slipping and falling to fire hazards. Environmental concerns stem from the leakage migrating into the soil and water systems, or simply the lack of information regarding the final disposition of lubricants. One possibly frightening piece of data would be a comparison of the amount of fluid purchased annually to the amount of waste fluid disposed and absorbed. The difference is the amount that went down into the floor somewhere.

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Causes of Hydraulic System Leaks

Pipe Threads

Many of the hydraulic systems in service today were built and installed decades ago using threaded pipe. Originally, most hydraulic components had NPT ports. This type of connection is the least reliable for high-pressure fluids as the thread itself provides a leak path. Because pipe threads are deformed when tightened, any subsequent movement, either loosening or tightening, increases the potential for leaks. To achieve leak-free reliability, all pipe thread connections must be eliminated and replaced with soft seal connections.

Hardened Seals

A single over-temperature event of sufficient magnitude can permanently damage all the seals in an entire hydraulic system resulting in numerous leaks. Also, prolonged operation at above-normal temperatures can produce the same results. Before replacing seals, system temperatures must be brought under control by addressing the generation and dissipation of heat or by installing a heat exchanger (in the system) before replacing seals. Also, it is necessary to replace all hardened seals at the same time, otherwise incremental leakage remains.

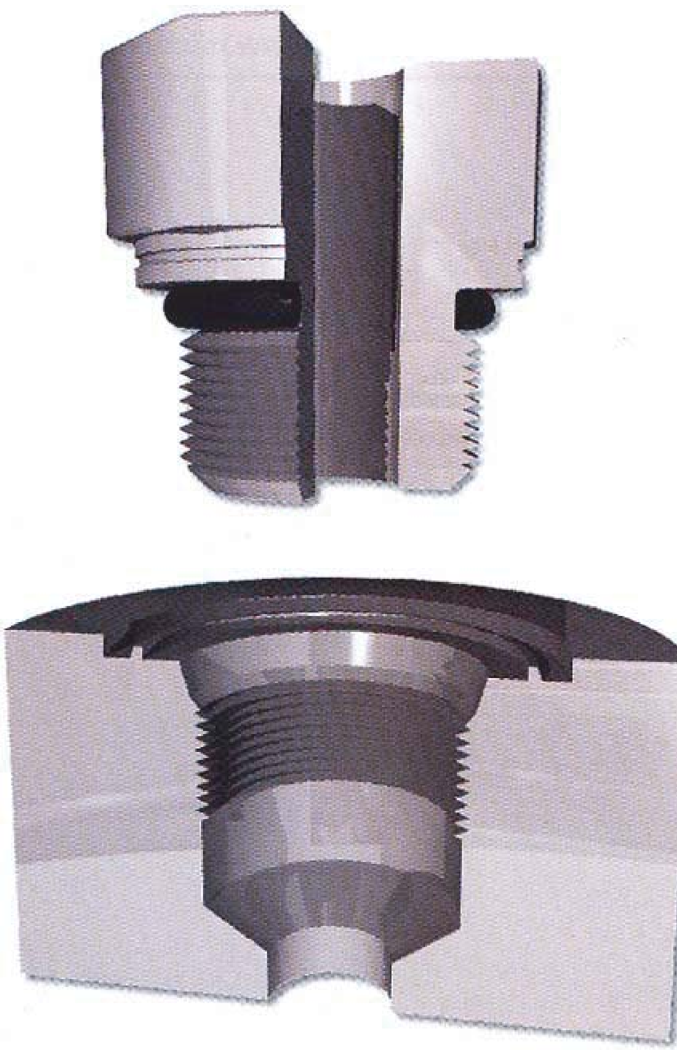

Figure 1. Straight Thread

Vibration

Fluid power is used to provide actuator movement. The resulting vibration can affect the torque on plumbing connections and cause metal fatigue. The root cause of the vibration should be addressed if possible, but unfortunately, this is not always practical. An understanding of the source of movement, and the stiffness of the plumbing and connections is the key to addressing the problem. Sometimes the problem can be solved by properly securing the equipment to the floor. In some cases, the hydraulic power unit is mounted on a nonvibrating surface while the work end is mounted to a vibrating surface, which results in stress on the interconnecting plumbing.

Proper design, routing and supporting of plumbing lines will assist in accomplishing leak-free service, even in the most severe applications. One method to isolate movement is to install a well-secured junction block between a moving hose and a rigid tube or pipe. Rigid lines should be supported with vibration dampening clamps. Hoses should be wrapped with protective guards and supported to minimize or control movement.

Improper Torque on Fittings

All metal-to-metal connections, such as compression and flared type, are sensitive to excessive torque. Proper torque loading requires using the correct torque setting and keeping a back-up wrench close at hand during the job process. Tubing and fittings can be easily damaged if the two metal faces are cold-worked against each other. Flared tubing is created through cold forming. Cold forming tends to cause metal to become less elastic. Subsequent tightening of these connections to try to stop a leak often aggravates the problem.

Leak-free connections require a soft seal, such as an O-ring. Soft seals provide good forgiveness for insufficient torque and good stress resistance for excessive use of torque.

Improper Installation and Maintenance

Tube bending and fabrication require proper training and experience to produce properly routed, supported and aligned connections. Typically, the general maintenance technician lacks the required expertise to install a reliable tube run. Misalignment causes strain on the tubing, which can lead to leakage or line failure once in service. Improper deburring and flaring during fabrication can eventually lead to stress cracks after the lines have been installed.

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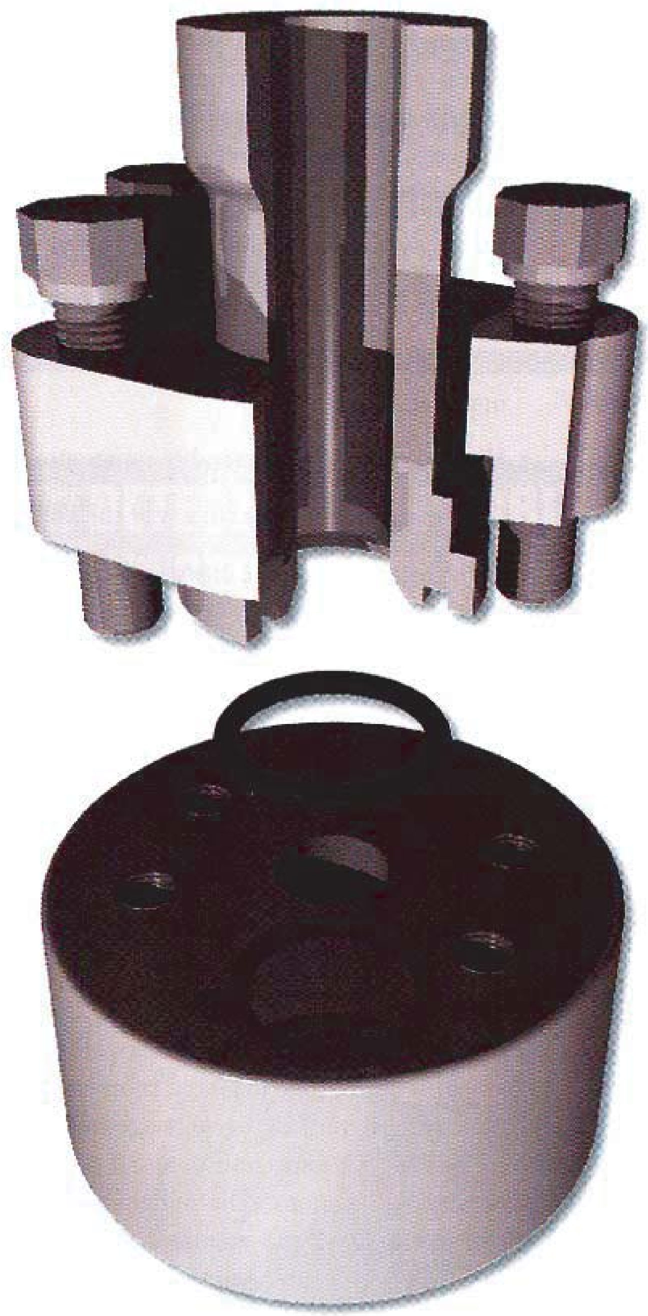

Figure 2. Four-Bolt Flange

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Reliable Sealing Technology

The common ingredient in each of the following types of connections is an O-ring seal. It is the author's opinion that the two most reliable port connections are the SAE J1926 straight thread (Figure 1) and SAE J518 four-bolt flange (Figure 2). The most reliable tube end connection is the J1453 O-ring face seal (Figure 3). In addition, a circuit manifold eliminates plumbing by mounting valves directly onto the manifold block (Figure 4).

SAE J1926 / ISO 6149 Straight Thread

This common connector design uses an O-ring at the top of the threads, just under a seating shoulder. The top of the female port is chamfered to accommodate the O-ring. Proper torque is needed to obtain the appropriate amount of squeeze on the O-ring.

SAE J518 / ISO 6162 Four-Bolt Flange

This type of connector uses a flange with the O-ring face seal design and four maintenance-friendly bolts. These types of connections are found on socket weld pipe and on hose ends. Hoses have a separate flange (often split in half). This style eliminates the need for large wrenches that must be used on large-diameter hoses, thus allowing the connections to be spaced close together. This flange design has the added benefit of allowing zero clearance; drop-in installation of components for improved maintainability.

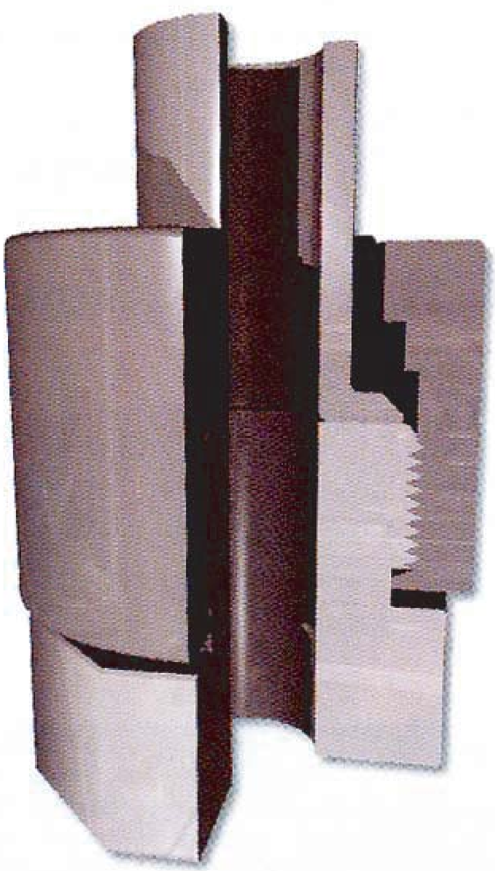

Figure 3. O-ring Face Seal Tube Connector

SAE J1453 / ISO 8434-3 O-ring Face Seal Fittings

These tube end connectors use an O-ring face seal against the end of the tube. The tube end is formed using a 90° flanging machine. An alternate method is to braze a flange onto the tube end. The O-ring is contained in a groove on the end of the port connector.

When compared to compression and JIC fittings, which have a metal-to-metal seal, O-ring face seal tube connections outperform in every category:

- Highest pressure capability
- Highest seal reliability
- Highest tolerance to minor sealing surface imperfections
- Highest tolerance to assembly variations
- Can be used with most tube wall thickness
- Zero clearance; no tube entry space required.

The reliability of the connection does not deteriorate each time it is disconnected and reconnected. The inexpensive O-ring can be easily changed. When installing from the finger-tight position, one short pull on the wrench gives the connection a quick high rise to required torque. O-ring face seal fittings have a solid "make-up feel" and excellent over-torque resistance.

Circuit Manifolds

Custom circuit manifold blocks allow the flow paths of manifold mounted components to be connected via internal passageways, thus eliminating the associated external plumbing and their connections. The plumbing connections mount onto the manifold using either SAE four-bolt flange connections or SAE straight thread O-ring connections.

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Implementing an Upgrade

Because an upgrade requires nearly all plumbing and many components to be replaced, upgrading usually requires a capital investment as opposed to a repair expense.

The equipment being evaluated needs to be audited by an experienced hydraulic technician while it is running at normal temperatures and again during shutdown. The auditor needs to interview the maintenance management about repair history, the production management about machine output needs, and the machine operator for general information, to develop a broad assessment of the machine's performance. The auditor will generate a list of problems and recommendations. A systems specialist or engineer may need to get involved with design issues.

The next phase is to plan the logical steps to implement the upgrade during an outage. Outside contractors with onsite plumbing capabilities can usually provide the quickest upgrade. The ideal situation is to perform the entire upgrade during one shutdown so the machine can then be cleaned and monitored for any remaining leaks.

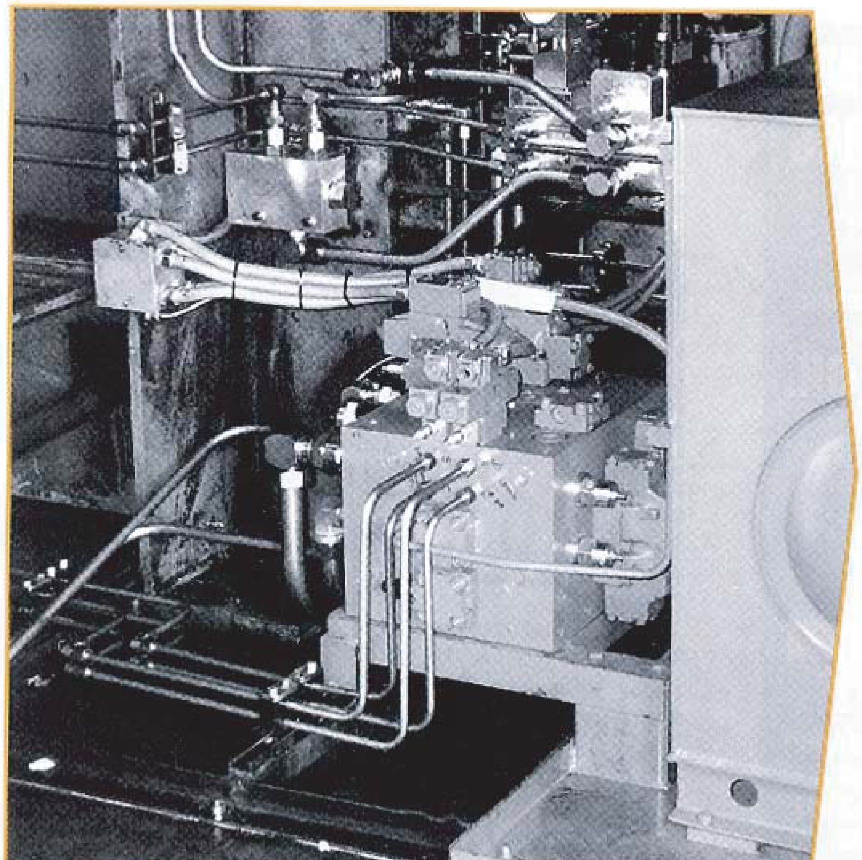

Figure 4. Circuit Manifold

This planning phase allows for labor costs to be estimated and a materials list to be generated. The total project cost can then be compared to the estimated annual cost savings in a payback calculation.

Once funds are approved, scheduling can be based on deliveries of repair parts and production planning. Actual implementation typically requires that the existing hydraulic power unit be replaced to save precious downtime. The new power unit would come with components that use soft-seal connections, which allows for leak-free plumbing to be installed.

A leak-free hydraulic system operation is possible, but requires that all causes of the leaks be addressed. Fluid leaks do not have to be "the nature of the beast". Yesterday's manufacturing facilities utilize mostly metal-to-metal sealing technologies because those type connections were the previous industry standard. Hydraulic systems can be made extremely reliable when properly designed, installed and maintained.

The total cost of leakage should be estimated for each piece of equipment that is in need of an upgrade. The machine should be audited by a professional hydraulic technician so that a list of problems can be generated and reviewed. A planning phase can then be conducted which will reveal the cost of the upgrade. Finally, this investment cost can be compared to the expected savings.

Onsite upgrades using qualified contractors and portable equipment allow for the shortest possible downtime and least disruption to the equipment. This is often an excellent option to minimize production losses.

Lastly, environmental responsibility will likely drive the need for leak-free systems more than any other single factor, even machine reliability. As industry begins to upgrade to O-ring face seal technology, specified now on most new equipment, zero leakage can become the standard. ML

Editor's Note

This article originally appeared in the *SMRP 2001 Conference Proceedings.*