Contamination Control

Contamination is a prime enemy of industrial hydraulic systems. Controlling it could mean elimination of more than half of all hydraulic system failures.

Generally, the same basic principles of contamination control apply to both ordinary hydraulic control systems and servo systems. The difference comes in degree. As servo systems continue to grow in industrial importance, the need for additional knowledge about effective contamination control will also increase.

Contaminants in a hydraulic system may consist of solids, liquids, or gases, or combinations of these. Solid insoluble contaminants—grit, dust, metal particles—pose the greatest problem since they are the most prevalent and the most damaging.

There are numerous sources of contamination, but they all fall into three basic categories—built-in, generated, and externally introduced. Built-in contamination is the largest single source, stemming largely from equipment manufacture. It may be caused by core sand from casting, weld spatter, metal chips, or lint and abrasive dust. Oxide scale may remain from heat treating or forging. In some cases, filter media particles may break loose and flow through the system. Varnish is a common problem of contamination which results from high heat and the presence of black mineral salt compounds.

Generated contamination results from the tendency from existing contamination to breed new contamination.

External contaminants may enter a system in new hydraulic oil, new filters, piping compounds, lapping compounds and the like. Airborne particles can also infiltrate through breathers. Lint is a common problem, introduced during cleaning and maintenance.

How Contaminants Compound Problems

Whatever their source, contaminants tend to multiply in a chain reaction, compounding the problem. Two soluble substances may combine to form a gummy sludge or an acid that corrodes a port. Tiny grit may score off particles within the system. These in turn, grind off more. Uncontrolled, contamination multiplies rapidly. It is best to start with a very clean system and then maintain it to prevent the start of the contamination generating cycle.

Damage due to contamination is costly and can endanger lives and equipment. Often, it is difficult to monitor. Too often the first clue is failure.

Many elements are susceptible to contamination. Dirty oil can cause pumps to wear more quickly than normal and can cause solenoids to stick. Basically, contaminants cause trouble by wearing and clogging internal passages—detracting from system performance and serviceability.

Sizes of contaminants as well as their density are important. In fact, the smaller particles often do the most damage because of their erosive action and the difficulty encountered in removing them. This is especially serious in the system where the use of servovalves is involved.

In extreme cases, contamination can cause sudden failure or loss of control. When hydraulic systems are controlling more massive equipment, there is more danger of servocontrol failures.

Wear on internal parts can increase pump and system leakage, and degrade operating efficiency. In hydraulic servo systems, erosion of critical metering surfaces has a substantial effect on accuracy. Silting—buildup of fin particles at metering ports—can destroy system stability.

Setting levels of cleanliness to match the application is perhaps the most difficult part of contamination control. Industry standards now evolving should help considerable. Component manufacturers have developed standards for their equipment, but these, too, must be molded to meet the economics of individual systems.

Measuring contamination presents problems of its own. Generally, the particle count method gives the clearest picture and will probably form the basis for industry standards. The method involves forcing a 100 ml sample through a porous membrane filter marked with grid liners. Counting particles by sized for one square and repeating this for other squares gives a representative contamination level for the entire system. The resulting distribution is then related to set standards to arrive at a cleanliness classification.

The membrane test can also serve as a filtration quality check. Contamination level in the system should drop after the initial flush period. An increase might indicate inadequate filtration or a component failure. After several months operation, the contamination level will start to rise—indicating the need for filter change. Employing this technique can help to establish a filter change schedule.

Pressure Drops May Be Measured

An alternative to the membrane test is to measure pressure drops across the filter, and correlate them with contamination levels tables supplied by the filter manufacturers.

In setting cleanliness standards for an individual system, first look at its characteristics and the reliability needed. Cleanliness required for the most critical component offers a good clue. Generally, the better the response needed, the cleaner the system must be.

General-duty hydraulic systems will perform well with 25 micron filtration. Servo systems will, of course, need higher cleanliness levels. For optimum performance, we recommend 10 micron absolute (75 Beta Ratio) filtration, and fluid samples falling in classes 3-4.

In systems up to 10 gpm, all servovalves should be protected by full-flow 10 micron absolute pressure filters. In higher flow systems these might be impractical. Here, 5 micron depth type cellulose filters should be installed in the system where they will handle total sump volume at least once an hour. In contaminated atmospheres, pressurize the reservoir, if possible. This will prevent the entrance of dirty or moist air through the breather.

These are guidelines only. Heavily contaminated systems have worked well and will probably continue to do so in many applications. Employing a 10 micron filtration system, for instance, does not necessarily mean that larger particles will not pass through the filter. But these recommendations will help ensure maximum reliability where it is required.

Invariably, system cleanliness will

hinge on filtration. Because of this, some filter myths should be dispelled. It is not true, for instance, that a filter needs to be dirty to clean properly. Nor are “permanent” filters really permanent—or is any filter fully effective. By the same token, the pore-size rating of a filter by no means ensures that it will trap all particles that happen to be larger. Most filters will release particles several times larger than their rated pore size. Pore size is only an indication of filtration—it is not an absolute.

The best assurance against being misled by such myths is to understand basically how a filter works and what it can do. Filters operate through a combination of trapping and screening to remove both large and small particles. Diameter of the pore or screen limits, to some extent, control the size of particles that can pass into the filter. There are tiny folds and semi-permeable openings within the filter that trap many of the smaller particles that have entered.

As the filter becomes saturated, however, some passages clog, forcing higher flows through other passages and increasing the pressure drop across the filter. This, in turn, may enlarge the passage and dislodge particles that might have been trapped earlier. Contamination is thus released back into the system. Frequent replacement is therefore essential.

Several types of filters are available, varying in material, characteristics, and function. Cellulose elements give good filtration at low cost, especially for small particles. But they can withstand only relatively small pressure drops or flow surges.

Porous metal elements, on the other hand, can take more punishment but can hold less contaminant and are less effective against small particles. Effectiveness also decreases with higher flows. Screen-type filters are rugged and effective against larger particles—but pass anything smaller than their screen opening.

Filter Selection Guidelines

Degree of filtration and system parameters—pressure, flow, temperature, type, and fluid—must be carefully considered in determining the best filter for a particular job. Manufacturers’ recommendations will also narrow the choice, and can be important aids in system design. Whatever the particular system or filtration problems, however, certain general principles apply. We suggest these three general guidelines for filter selection and sizing:

A. Plan on the worst and design for it. Size filters on the basis of maximum possible flow through the dirtiest possible filter. Remember, fluids may be more viscous at startup than during operation. Frequently, filters have been designed for operating conditions, only to fail during startup.

B. Use as large a filter as practical. Filters operating at less than rated flow and pressure will remove more contaminant with less maintenance.

C. Set multiple filters up in parallel, rather than cascading them. This reduces flow through each individual filter, improving over-all system cleanliness. A good rule of thumb is to de-rate filter capacity by one-third to account for flow variations through different filters.

In addition to proper design and operation of the system, regular maintenance substantially affects cleanliness. Filters do only part of the job. Here are some hints for getting the most performance out of a hydraulic servo control system.

1. Use tubing, not pipe. Tubing is cleaner and has better geometry for fit-up. Avoid threaded connections, pipe dope, and tape.

2. Minimize flexible lines. Particles can break off inside as tubing flexes, introducing serious contamination threats. If a flexible line is absolutely necessary, use Teflon or nylon lining.

3. Provide a means of monitoring the pressure drop across filters to warn when it is time for cleaning. In critical systems, tie in a shutoff switch to the pressure-sensing system.

4. Use totally closed reservoirs, unpainted sumps. Pressurized reservoirs are effective in contaminated atmospheres.

5. Keep painted and cadmium-plated parts away from hydraulic fluid.

6. Before assembly, clean all components thoroughly. Remove all burrs. If necessary, disassemble new parts to clean them properly. Welds, sumps, castings, threads and blind holes are particularly likely sources of dirt.

7. Seal all parts after cleaning unless they will be used immediately.

8. Filter new oil for at least 24 hours before adding it to a system. For servo systems, use 5 micron filters or better, changing them several times during the process.

9. Remember: new parts are dirty parts; new filters are dirty filters; new oil is dirty oil.

10. Use no wiping rags. Lint can be a serious problem.

11. After cleaning a filter, check its pore size. Replace it if pores have grown oversize during use or cleaning. We recommend our cleaning process which includes “Bubble Point” testing.

12. When starting up a new servo system, run it for 2 hours before installing critical components. After routine maintenance, bypass all servovalves for the first 10 minutes of operation.

We hope this bulletin will help you to obtain and keep a clean servo system. Remember: the reliability of your system is directly traceable to contamination control.