Contamination

There is a consensus that 70% to 90% of equipment wear and failure is attributed to contamination. Solid particles, such as dirt, are the chief culprits because of their ability to directly attack metal surfaces. The selection of a High quality filter is a cost effective way of reducing this contaminate. All hydraulic fluids contain dirt to some degree. Dirt in hydraulic fluid is the downfall of even the best designed hydraulic systems. Dirt particles can bring huge and expensive machinery to its knees.

Dirt vs Hydraulic Fluid

Dirt causes trouble in a hydraulic system because it interferes with the fluid which has four functions:

1. To act as a medium for energy transmission
2. To lubricate internal moving parts of hydraulic components
3. To act as a heat transfer medium
4. To seal clearances between close fitting moving parts

Dirt interferes with the transmission of energy by plugging small orifices in hydraulic components like pressure valves and flow control valves. In this condition pressure has a difficult time passing to the other side of the spool. The valve's action is not only unpredictable and nonproductive, but unsafe. Because of viscosity, friction, and changing direction, hydraulic fluid generates heat during system operation. When the fluid returns to the reservoir, it gives the heat up to the reservoir walls.
Dirt particles interfere with liquid cooling by forming a sludge which makes heat transfer to reservoir walls difficult.

Clean hydraulic systems run cooler than dirty systems. Probably the greatest problem with dirt in a hydraulic system is that it interferes with lubrication.

Dirt can be divided into three sizes with respect to a particular component's clearances; that is, dirt which is smaller than a clearance, dirt which is the same size, and dirt which is larger than a clearance.

Extremely fine dirt, which is smaller than a component's clearances, can collect in clearances especially if there are excessive amounts and the valve is not operated frequently. This blocks or obstructs lubricative flow through the passage. An accumulation of extremely fine dirt particles in a hydraulic system is known as silting.

Dirt which is about the same size as a clearance rubs against moving parts breaking down a fluid's lubricative film. Large dirt can also interfere with lubrication by collecting at the entrance and blocking fluid flow between moving parts.

A lack of lubrication causes excessive wear, slow response, erratic operation, solenoid burn out, and early component failure.

Dirt is Pollution

Dirt in a hydraulic system is pollution. It is very similar to bottles, cans, paper and old tires floating in your favorite river or stream. The difference is that hydraulic system pollution is measured using a very small scale. The micrometer scale is used to measure dirt in hydraulic systems.

Sources of Contamination

When engineering a complex hydraulic system, designers must consider the ways in which contaminants reach the fluid, as well as the quantity and size of the particles. Those factors influence the size, micron rating, and location of filters.

Built-In or From Maintenance

During manufacturing or maintenance, large quantities of particles and solid debris are introduced. Even the most thorough flushing doesn't eliminate all foreign matter, some of which dislodges once the system is put into operation. Also, there is no guarantee that all of the right procedures will be followed, so, as equipment can sustain significant wear in the first few days after start-up, high quality filtration is essential at this stage.

Tank Leakage

Loose inspection plates and other unsealed joints in a tank allow a great deal of dirt into the fluid, particularly when surrounding air is polluted.

Air Through Breather

Most hydraulic systems draw in and expel air as the oil level in the reservoir changes. Often, this is a main source of dirt ingestion, especially when filter breathers either are not installed or maintained.

Dirty Oil

New oil is seldom as clean as required for a modern hydraulic system, even when it is described as “clean” by the supplier. When stored improperly or not well filtered before filling the reservoir, it likely will be many times as contaminated as the system can tolerate.

Pump Wear

Pumps, especially when worn, are a key source of metal wear particles. Hard wear metals are of great concern for several reasons:

1. Potential for damage to valves, cylinders and motors immediately downstream.
2. Ability to generate large numbers of additional particles within the system.
3. Action as a catalyst in the fluid oxidation process.

Piping Slag

Older pipes can flake off quantities of larger particles, such as scale, rust and welding slag.

Dirt on Cylinder Rods

When sliding back and forth, cylinder rods can draw in large quantities of smaller particles, depending on the concentration of airborne dirt and quality of the rod seals. This is a particular problem in systems with numerous large cylinders.

System Design Consideration

The first line of defense against contamination is to exclude particles and moisture to the maximum extent possible. This effort entails a host of actions, such as careful manufacturing and maintenance, thorough flushing, sealed reservoirs and pipe joints, tight seals, and so forth.

Whatever the success in exclusion, though, top quality filters are necessary. Even if it were possible to keep out most contaminants, particle counts would grow rapidly in the fluid for this reason:

Any particles thrown off the pump or from other components will generate additional particles at a rapid rate.

Effects of Contamination

Abrasive Wear

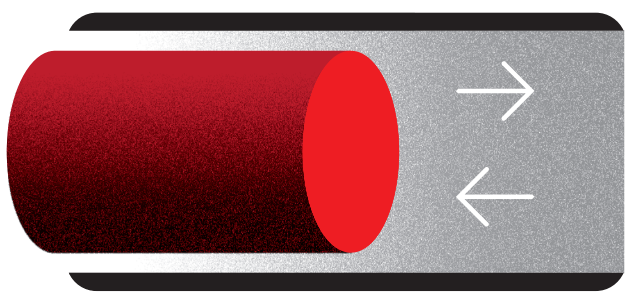
Anytime two metal surfaces move opposite to one another, they are subject to abrasive wear.

The amount of metal loss depends on the types of metals, quality of the lubricant, speed, tolerances, and other factors.

Abrasion results when hard particles about the width of the tolerance become embedded in one of the oppositely moving surfaces, then act like a cutting tool to gouge and scratch the other surface

Equipment designed with close tolerances to handle high pressure and speed is particularly subject to abrasion from particles well below 10 microns in size

Moreover, only a small loss of metal will reduce equipment performance and shorten its life.

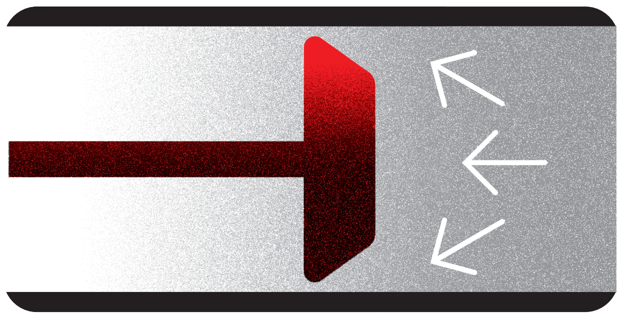


Abrasion is the leading cause of wear. Embedded hard particles scratch and gouge and most seriously affects close-tolerance, high speed and high pressure components such as pumps and motors.

Erosive Wear

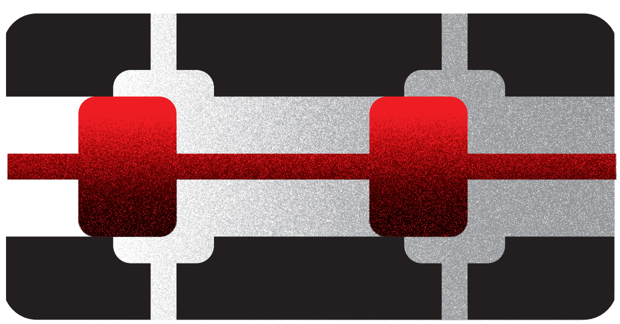
Erosion takes place when particles moving at high speed hit surfaces and pit or wear away the metal.

Control devices, such as flow controls and relief valves, are especially sensitive to this type of damage.



Silting

Spool valves, especially proportional and servo types, can lose responsiveness or bind completely because of silt buildup. Silt is composed of extremely fine particles, often under five microns in size, which are present in the environment; or which are generated within the system in large quantity. Such valves are also affected by abrasion, and, in some cases, particle blockage that leads to total failure.



Servo and proportional valves are subject to the following problems;

- close tolerances
- low operating forces
- requirement for accuracy

Silt build-up causes can also include; stiction, binding and poor response.

Fatigue Wear

Bearings and other components subject to heavy axial loading often suffer from metal fatigue.

Hard particles caught between two surfaces create cracks which continually expand and eventually, result in spalling.

The useful life of critical bearings can be prevented simply by improving cleanliness of the oil.

Analyses by bearing manufacturers and others have shown that the useful life of critical bearings can be greatly lengthened by means of improved dirt exclusion techniques and better filtration.

Costs of Contamination

When contaminants wear or destroy critical components, the result is an increase in several kinds of costs. It may be impractical to pinpoint the sum of such costs precisely, but not difficult to establish the general magnitude of the problem.

In a continuous process (Steel, aluminum, paper, etc.), an emergency shutdown may cost well in excess of $50,000 an hour. Repair work is often difficult and time-consuming, stretching maintenance resources.

Electrical energy is a key cost factor, therefore any loss of efficiency due to component wear and damage contributes to cost.

Components employed in systems that function at high speed and under heavy load carry replacement cost that is related to their size, precision and sensitivity to contamination. Fluid replacement cost varies widely.

In general, the higher the quality and more specialized the fluid, the higher the cost.

Bearing and gear wear diminishes the accuracy of equipment by causing chattering and vibration.
In some circumstances, product quality is reduced (and scrap increased). The end result is a lower quality product and lost income.

In all cases, an investment in quality filtration pays for itself very quickly. This is especially true when equipment must provide top performance for an extended period of time

Operating Costs	**Low**	**High**
Downtime	Intermittent Operation	Critical Continuous Process
Repair	Simple and Quick	Difficult and Time Consuming
Energy	Light Load	Heavy Load
Replacement Costs	**Low**	**High**
Components	Small and Dirt-tolerant	Large, Precision and Sensitive
Fluid	Standard	High quality special
Lost Business Costs	**Low**	**High**
Production Quality	Unaffected by process	Affected by process