APPLICATION NOTE

Contamination Control in the Hydraulic Industry

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Abstract

It is estimated that between 70 to 90 percent of hydraulic system failures happen due to fluid contamination. If businesses want to get the most out of hydraulic system(s) they should develop a fluid cleanliness plan that monitors microscopic particles in their hydraulic fluid. The goal of a fluid cleanliness plan within a hydraulic system is to maximize productivity and enhance equipment reliability.

There are many parts and components susceptible to contamination within a hydraulic system. For the sake of time, we will focus most this paper on a hydraulic cylinder, how it can be contaminated, how contamination effects performance and ways to monitor contamination.

A hydraulic cylinder (Fig A) is made up of piping, body, rod and piston. The goal of a hydraulic system is to generate power by transmitting fluid. In Fig B fluid is transmitted through piping to the body so the rod extends (work). As the rod extends, fluid in the body that is not used for work exits the body through piping. In order to retract the rod, the operator would change direction of flow, (Fig C) and fluid pressure is used to lower the piston and rod.

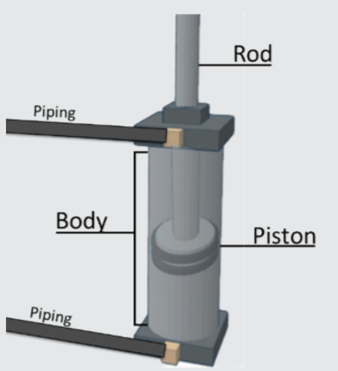


Figure A

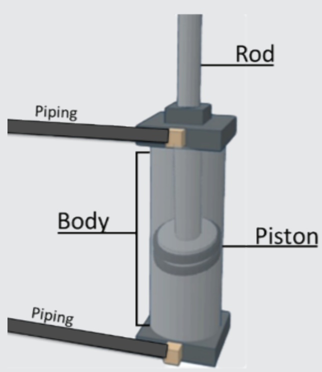


Figure B

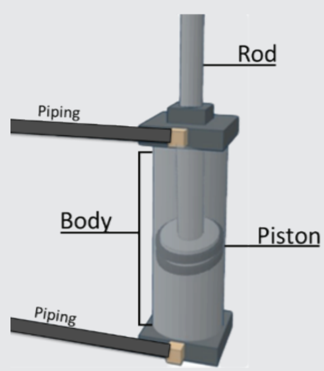


Figure C

Some wood splitters use a hydraulic cylinder in which the rod pushes on the backside of a log, pushing the log through a wedge, creating enough force between the wedge and log so the log will split. A wood splitter is a great example of a hydraulic system that uses a rod to transmit power (work).

Contamination Entering the System

Contamination entering a hydraulic system is inevitable; small damaging particles will find their way into any system. Gradual wear and tear within a hydraulic system will build up enough contamination that damaging particles will eventually damage components (pumps, valves, cylinders). Degradation to a hydraulic system will happen at a faster rate if its fluid is dirty, or above cleanliness levels.

Common Contamination Issues

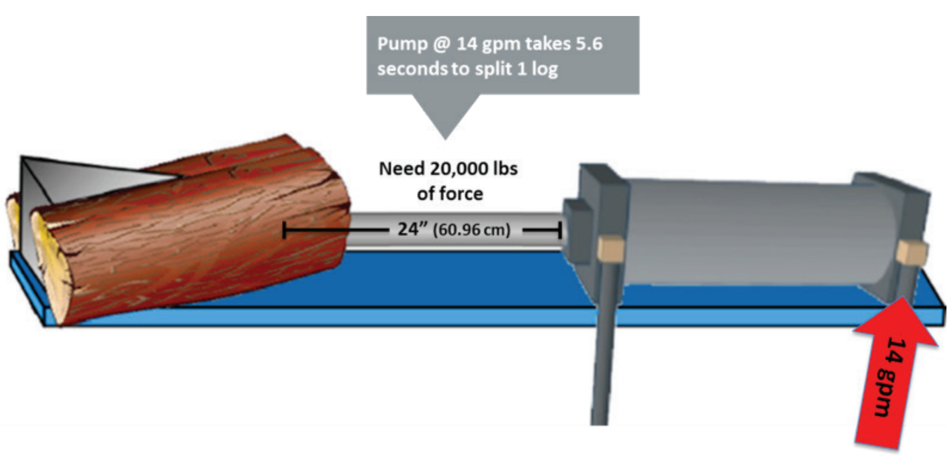
- When equipment is built, residue from hoses, cutting pipe and tubing, and poor assembly practices can be left in piping, manifolds and components.
- Brand new hydraulic fluid may contain contamination and adding it to your system may introduce particles into the system.
- Every time a cylinder extends, the fluid level in the reservoir drops. As the fluid level drops, outside air rushes into the reservoir, often bringing in contamination.
- Moisture (water) is considered one of the most common contaminates in a hydraulic system. Moisture can enter the system by invasion, or by condensation build up in the reservoir.

Contamination Entering the System

The speed of work within a hydraulic cylinder is dependent on the amount fluid (flow rate) that enters the cylinder over a period of time. Gallons per minute (gpm) is a common flow rate unit of measurement that is used to determine how much fluid enters the cylinder. The more gallons per minute (gpm) entering the cylinder will decrease the time it takes to split a log; thus, increasing productivity by allowing the operator to split more logs over time. Below is a made up example of how a log splitter loses performance over a three year period due to contamination.

Year One

The log splitter worked at optimal performance the entire year. The pump pushed 14 gpm into the cylinder; splitting logs every 5.6 seconds. In 5.6 seconds 20,000 lbs of force was created (amount needed to split a log), to fully extend the rod 24 inches, the length needed to split a log. At this work rate the operator was able to split 5,141 logs in an 8 hour work day, 25,705 logs in a 40 hour work week and 1,336,660 over a work year.

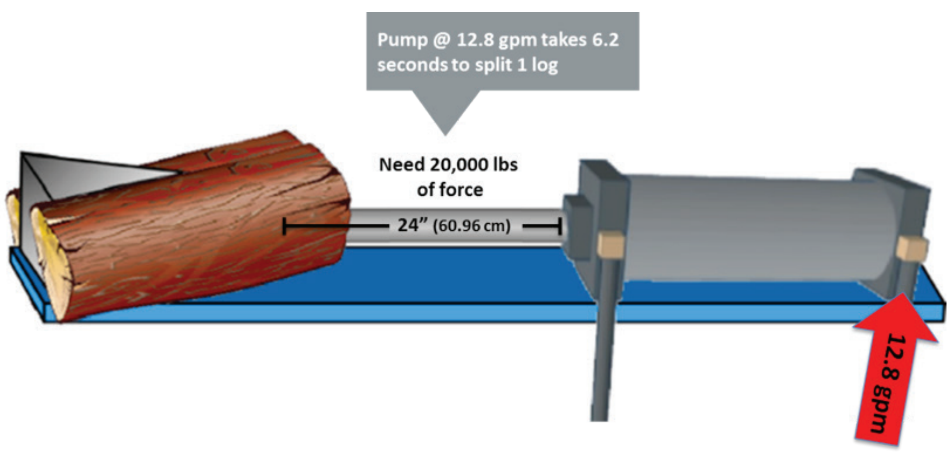


Year Two

Over the course of the second year the hydraulic cylinder's fluid cleanliness was not monitored nor tracked. Without knowing it, microscopic particles in the hydraulic fluid started to damage the pump and control valves. Fluid within the log splitter's hydraulic system now leaks internally. It was impossible for operators notice the leaking because it happened inside the hydraulic system. The business recognized a problem because the wood splitter productivity was way down after year one.

Year Three

The log splitter did NOT work at optimal performance in year three because the pump could only push 12.8 gpm into the cylinder; now splitting a log every 6.2 seconds. What used to take 5.6 seconds now takes 6.2 seconds to split the log. At this rate an operator can only split 4,641 logs in an 8 hour work day, 23,205 logs in a 40 hour work week, and 1,206,660 logs a year.



Year One vs Year Three

	Year One	Year Three
Duration	14 gpm	12.8 gpm
1 minute	10.71 logs	9.67 logs
1 hour	642.6	580.2
1 day (8 hours)	5,141	4,641
1 week (40 hours)	25,705	23,205
1 month (160 hours)	102,820	92,820
1 year (2,080 hours)	1,336,660	1,206,660

In year one the log splitter was able to use 14 gpm for the entire year and it generated 130,000 more logs when compared to year three. The 10% loss of productivity is a direct result of contaminated fluid and it could have been prevented.

Controlling Contamination

There are two general types of damage associated to fluid contamination.

1. Sandpaper Effect

a. Small pieces of contamination rub against internal parts and wear them down, much like rubbing a surface with coarse grit sandpaper.

b.Just like sanding a piece of wood creates sawdust, the sandpaper effect creates small particles and those small particles create more small particles.

2. Big Bang Effect

a. Larger pieces of contamination get caught between moving internal parts and gouge, break or slice the parts.

b. Similar to hitting a concrete block with a hammer; pieces will either break off or gouges will occur.

It is vital that hydraulic fluid is regularly monitored, analyzed, and recorded. Monitoring contamination at the "micron" level is very important because certain sized particles that cannot be seen with the human eye will create mass amounts of damage to a hydraulic system if not maintained. Particle size and particle counts are two very important variables when analyzing fluid because contamination creates more contamination. Controlling contamination levels in fluid will help reduce unnecessary maintenance expense and, more importantly, costly downtime. The chart below identifies parts of a hydraulic system that are susceptible to particle size damage.

Valves	Servo	1 - 4 µm
	Proportional	1 - 6 µm
	Directional	2 - 8 µm
Variable Volume Piston Pumps	Piston to Bore	5 - 40 µm
	Valve Plate to Cylinder Block	0.5 - 5 µm
Vane Pumps	Tip to Case	0.5 - 1 µm
	Sides to Case	5 - 13 µm
Gear Pumps	Tooth Tip to Case	0.5 - 5 µm
	Tooth to Side Plate	0.5 - 5 µm
Ball Bearings	Film Thickness	0.1 - 0.7 µm
Roller Bearings	Film Thickness	0.4 - 1 µm
Journal Bearings	Film Thickness	0.5 - 125 µm
Seals	Seal and Shaft	0.05 - 0.5 µm
Gears	Mating Faces	0.1 - 1 µm

*Data from STLE Handbook on Lubrication & Tribology (1994)

Interpreting Particle Counting Results

Over the last 30 plus years liquid particle counters have been used to monitor contamination levels in hydraulic fluids in military aircrafts, oil refineries, power plants and manufacturing plants that use hydraulic systems. Because of the variety of applications, many different standards have been developed to judge test results. One of the most commonly used standards today is ISO 4406. This standard looks at the particle count data from the 4 Qm, 6 Qm and 14 Qm channels and assigns a three digit cleanliness code. This code quickly tells users if their fluid meets their cleanliness levels or if there is a potential fluid contamination issue.

HIAC Particle Counters

Beckman Coulter manufactures HIAC particle counters for use in testing hydraulic fluids, oils, fuels, organics, glycols, and water. HIAC offers a complete line of particle counters for all applications.

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