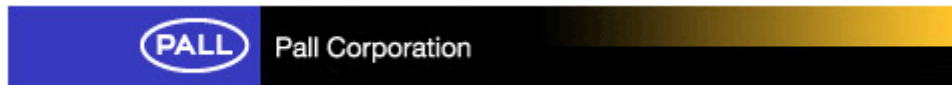


This company manufactures in-line & off-line filtration, designed to remove contaminant from the lubricant. So regarding their business it is not obvious to recommend stopping the main cause of contamination. However page 4 they recommend, to optimize maintenance and filtration's cost the use of vent dry (hygroscopic breathers).

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Service Life Extension of Hydraulic and Lubricant Fluids Through Contamination Control

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Abstract

The extension of service life of hydraulic and lubricant fluids can have a significant impact on pollution prevention due to the resulting reduction in serviced fluid disposal quantities. The economic benefits include reduced serviced fluid disposal costs as well as the resulting reduction in new fluid cost.

Particulate contamination and water can have serious adverse effects on the physical and chemical properties of hydraulic and lubricant fluids. They include accelerated oxidation of the fluid base stock and premature depletion of additives due to additive precipitation or chemical reactions involving additives. In many cases, the presence of free water in the fluid can be detrimental to proper system performance.

The importance of the removal of particulate contamination and water in fluid service life extension has been confirmed in laboratory studies and through experience in the field where factors of 4-6 in fluid service life extension are realized. Fine particulate control filters, water absorbing filters, and vent dryers to prevent ingress of moisture into the fluid system from the environment, in conjunction with fluid purifiers, provide effective means to control particulate contamination and water accumulation in hydraulic and lubricant fluids.

Introduction

The extension in service life of hydraulic and lubricant fluids has assumed prominence to all users in industry. A primary factor is the increasing awareness of protecting the environment from hazardous contaminants. This has resulted in stringent Federal and local regulations leading to higher costs and liabilities being involved in the disposal of serviced fluids. Major economic benefits associated with extended fluid service life include reduced serviced fluid disposal costs as well as the resulting reduction in new fluid cost. Other benefits include

reduced maintenance costs and machine downtime which, in many applications, can result in significant economic gains to the user.

Particulate contamination and water can have serious adverse effects on the physical and chemical properties of the fluids. The loss of crucial fluid properties, central to useful service life of the fluid, can result in inefficient system performance and accelerated mechanical and chemical wear processes.¹⁻³ In this paper, attention is focused on the degradation of hydraulic and lubricant fluids in the presence of particulate and water contamination, and on the extension of fluid service life via removal of particulates and water from fluids.

Degradation of Hydraulic and Lubricant Fluids

Hydraulic and lubricant fluids are carefully formulated for specific areas of application and are comprised of a base stock and an additive package.⁴ The additive package consists of chemical compounds designed to protect the base stock, as well as system components, to ensure proper performance of the system. Typical additives include dispersants and detergents, antioxidants, anticorrosion, antiwear and extreme pressure (EP) agents, and viscosity index improvers.

Particulate contamination and water affect both the base stock and additives adversely as discussed below.

Physical properties of the fluid

Water is a much less effective lubricant and can result in decreased viscosity, load carrying ability and dynamic film thickness when present in the fluid. This can lead to greater surface-to-surface contact at sliding, rolling dynamic clearances and hence, increased component wear.

The presence of free water in systems that could experience low temperatures, below the freezing point of water, can lead to degradation of system performance and malfunction due to 'icing'.

The presence of water can also lead to the agglomeration or precipitation of particles to produce viscous sludges or solids. This induces excessive stress on system components, especially in pumps, and the clogging of orifices, nozzles and jets.

In addition, particulate contamination and water can promote chemical reactions involving the base stock and additives resulting in reaction products that adversely affect viscosity and other properties of the fluid. Typical reactions include the oxidation of the base stock, producing corrosive organic acids, gums and sludges; see below.

Degradation of the fluid base stock

Oxidation: A primary chemical degradation process in many applications is the oxidation of the fluid base stock. The oxidation process proceeds through a series of chemical chain reactions and is self propagating, with the intermediate, reactive chemical species regenerating themselves during the process. The process results in the conversion of the fluid base stock to oxygenated compounds, such as organic acids in the case of hydrocarbon or poly-ol ester based base stocks, and eventually, high molecular weight polymeric compounds. The polymeric compounds often are insoluble and settle out of the fluid as gums, resins or sludges.

Oxidation is significantly accelerated by the presence of metals and water. Metals act as catalysts providing an alternate, favorable pathway for the reaction. In most cases the alternate pathway involves the participation of the metal surface. Fine metallic debris are especially ideal, in this respect, due to their large, effective surface area.

Table I summarizes data from tests carried out to determine the effect of metal catalysts and water on oil oxidation.⁵ The tests were conducted on turbine grade oil in pure oxygen according to the ASTM/D-943 oxidation test procedure. The neutralization number, tabulated in the last column, is a measure of the extent of oxidation.

The results show that the extent of oxidation is increased roughly 48 fold for iron/water and 65 fold for copper/water within 400 hours and 100 hours, respectively, compared to the baseline; Test Number 1, Table I. In these tests, the metal catalysts were present in the form of strips as opposed to silt size particles normally present in actual systems. The results would be expected to be even more dramatic in the latter case because of substantially increased metal surface area for oxidation.

Table I. Effect of Metal Catalysts and Water on Oil Oxidation⁵

Test Number	Catalyst	Water	Hours	Final Neutralization Number
1	None	No	3500+	0.17
2	None	Yes	3500+	0.90
3	Iron	No	3500+	0.65
4	Iron	Yes	400	8.10
5	Copper	No	3000	0.89
6	Copper	Yes	100	11.20

Hydrolysis of base stock: Fluid base stocks that are comprised of ester compounds, such as poly-ol ester turbo lubricants and phosphate ester hydraulic fluids, can undergo hydrolysis in the presence of free water under operating conditions in the system. This results in the formation of acidic compounds that can react with the materials of the system components and hence, corrode the components.

Additive Depletion

Depletion of additives can occur either by their physical removal from the fluid or by chemical reactions in which they are converted to non-functional products. Particulate contamination and water foster both types of processes.

The solubility of many additives is critically dependent on fluid composition. The presence of water can lead to the precipitation of these additives from the fluid.

A primary step in the action of additives such as anti-corrosion, anti-wear and extreme pressure agents is their adsorption on metal component surfaces to form a protective layer.⁶ The presence of particulate contamination, especially metallic debris, provides an alternate, effective surface for adsorption and causes premature depletion of the additives.

Particulate contamination and water can also chemically react with additives or promote chemical reactions among additives. The products of the chemical reactions, in addition to

being non-functional, often are solids or sludges which are detrimental to the system as **diskussed previously.**

Additives that protect the base stock can be depleted rapidly due to the enhanced degradation of the base stock in the presence of particulate contamination and water. A notable example is the depletion of antioxidants.

A summary of the above diskussion on the detrimental effects of particulate contamination and water on hydraulic and lubricant fluids is presented in Table II.

Table II. Effect of Particulate Contamination and Water on Hydraulic and Lubricant Fluids

Fluid Breakdown	Cause	Effect on System
Physical Properties	<p>a) Particulate contamination, agglomeration and precipitation</p> <p>b) Oxidation/hydrolysis</p> <p>c) Reactions involving additives - sludges and solids</p> <p>d) Free water</p>	<p>Component wear</p> <p>Clogging of jets, nozzles and orifices; valve jamming</p> <p>System malfunction due to icing (free water)</p>
Base Stock Degradation	<p>a) Oxidation</p> <p>b) Hydrolysis</p>	Corrosion
Additive Depletion	<p>a) Precipitation of additives</p> <p>b) Adsorption by particulates</p> <p>c) Reactions involving additives</p> <p>d) Abnormal base stock degradation</p>	<p>Loss of component protection</p> <p>Increased component wear and corrosion</p>

Removal of Particulate Contamination and Water

Several methods are available for removing particulate contamination and water from fluids.⁷ The method of choice depends both on the contamination level of the fluid and the specific area of application. Heavily contaminated fluids are best subjected to external purification prior to use. In-line contamination control in the system is conveniently achieved by in-line particulate contamination control filters and water absorbing filters, **and vent dryers to minimize ingress of water from the environment into the system.**

In-line particulate contamination control filters and water absorbing filters are important in maintaining particulate contamination and water at low, acceptable levels. Typically, water absorbing filters control the concentration of free water in the fluid. **In order to minimize the ingress of water into the system, it is convenient to utilize vent dryers at critical ingress points such as reservoir breathers in hydraulic systems.**

Field Experience

Experience in the field demonstrates the importance of particulate contamination and water removal in extending the service life of hydraulic and lubricant fluids. Some examples are enumerated below.

Table III. Contamination Control in Hydraulic Systems of Airline Ground Support Equipment⁸

Equipment Type	Initial Sample		30 Hours Operation with Silt and Water Control	
	Particulate Levels (ISO Code)	Water Conc. (ppm)	Particulate Levels (ISO Code)	Water Conc. (ppm)
Container Rotator	23/19	8000	13/11	200-400
Mobile Cargo Loader	19/13	2000	13/10	200-400
Aircraft Bridge	20/16	1000	13/11	200-400

A study was conducted in 1982 by Pall Corporation on the effect of particulate and water control on the performance of hydraulic systems in ground based airline cargo container handling equipment at the JFK International Airport, New York, in conjunction with United Airlines⁸. Equipment studied included aircraft bridge/nose docks, container rotators and mobile cargo loaders. The equipment is located outdoors and is exposed to dirt and weather extremes. Preliminary investigations revealed excessive contamination levels of particulates and water, necessitating frequent changes of hydraulic fluid, every 2-3 months. In spite of this, equipment failure was common, resulting in aircraft delays and associated cost overheads. A comprehensive program of contamination control was then initiated that included the incorporation of high efficiency fine particulate control filters and portable oil purification units in the hydraulic systems. Results are shown in Table III below.

A marked increase in service life of the hydraulic fluid, factors of 4-6, was realized with the fluid replacement interval exceeding 11 months. The level of water in the fluid was consistently maintained below the manufacturers recommended level of 200-400 ppm. Associated benefits included improved system performance and sharply reduced system downtime. Similar extensions in fluid service life have been achieved in many applications. In one instance, frequent fluid replacements, every 2-3 months, and machine downtime were severe problems in numerically controlled machine tools utilized in an aerospace manufacturing plant. Tests conducted in conjunction with Pall Corporation showed particulates to be a major contaminant in the hydraulic fluid. Subsequent installation of fine, 3 micron rated, filters resulted in annual fluid changes during maintenance work. In another instance excessive particulate and water contamination was encountered in the lubricant fluid used in the gearboxes of the mixing vats in a major pharmaceutical company. Incorporation of a fluid purification unit has led to a virtually indefinite extension in fluid life.

Conclusions

The extension of service life of hydraulic and lubricant fluids is gaining prominence due to many considerations including environmental pollution, conservation of natural resources and the economic benefits associated with extended service life.

Particulate contamination and water can degrade critical physical properties of fluids, promote oxidation/hydrolysis of the base stock, and induce depletion of additives. The resulting breakdown of fluid properties leads to increased chemical and physical wear processes.

The removal of silt and water is important in extending the service life of fluids. This is confirmed in laboratory tests as well as through experience in the field. Typically, factors of 4-6 in fluid service life extension are realized.

The incorporation of fine particulate control filters, water absorbing filters, and vent dryers to prevent ingress of moisture into the fluid system from the environment, in conjunction with fluid purifiers, provide effective means to control particulate contamination and water accumulation in hydraulic and lubricant fluids.

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