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Hydraulik – Vätskors renhet – Allmänna principer och vägledning för val och användning av filter (ISO/TR 15640:2011, IDT)

Hydraulic fluid power contamination control – General principles and guidelines for selection and application of hydraulic filters (ISO/TR 15640:2011, IDT)

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Foreword

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ISO/TR 15640 was prepared by Technical Committee ISO/TC 131, *Fluid power systems*, Subcommittee SC 6, *Contamination control*.

Introduction

Hydraulic systems transmit power by means of a pressurized liquid in a closed circuit. Foreign materials or contaminants present in the fluid can circulate around the system, cause damage to the component surfaces, and reduce the efficiency, reliability and useful life of the system. Hydraulic filters are provided to control the number of particles circulating within the system to a level that is commensurate with the degree of sensitivity of the components to the contaminant, and the reliability and durability objectives of the hydraulic system.

The selection and application of filters takes into account the filter design and performance, the system design and function, the required cleanliness level (RCL), the severity of the system operation and the standard of maintenance. The only way to confirm whether the correct filter has been selected is to monitor the cleanliness level in the fluid, and the reliability and durability of the system.

These guidelines are intended to introduce the concepts of cleanliness management and filter selection and application to both system designers and users. Although this guide cannot make one an expert on filter selection and use, it does seek to educate and thereby assist the reader in making informed decisions about filtration, and to improve the communication process.

Hydraulic fluid power contamination control — General principles and guidelines for selection and application of hydraulic filters

1 Scope

This Technical Report is applicable to contamination control principles for hydraulic fluid power systems and includes guidelines for the selection and application of hydraulic filters. Although control of non-particulate contamination, e.g. air, water and chemicals, is important, and is briefly discussed, the primary focus of this Technical Report is the control of particulate contamination and the selection and application of filters for that function.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 5598, *Fluid power systems and components — Vocabulary*

NOTE The other documents mentioned and referenced in this document in a non-normative way are listed in the Bibliography.

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5598 and the following apply.

3.1

contaminant

any material or combination of materials (solid, liquid or gaseous) that can adversely affect the system

3.2

ingression

introduction of environmental contamination into the system

NOTE Contamination introduced through ingression is referred to as ingressed contamination.

3.3

filter medium

part of the filter structure that removes and retains contaminant

3.4

filter media

collective layers that make up a filter element

4 Types and sources of contamination

4.1 General

Contaminants in a hydraulic fluid are any material or combination of materials (solid, liquid or gaseous) that can adversely affect the system.

4.2 Solid contaminants

4.2.1 General

Solid contaminant particles come from four main sources as shown in Table 1 and can vary considerably in material, hardness, shape and size from sub-micrometre to millimetres.

Contaminant shape varies widely and debris can appear as granular (cube-shaped), acicular (rod-shaped), platelets (very thin, nearly two dimensional), irregular fragments and fibres. Shape affects the way that particles are aligned in the moving fluid and thus the likelihood of the particles becoming lodged in a small clearance or trapped within the filter medium. Although quite important, particle shape is rarely reported because of the difficulties involved in its determination.

Table 1 — Primary sources of particulate contamination

| Built-in (manufacturing debris) | Ingressed | | Generated | | Maintenance (service debris) |
|---------------------------------------|-------------------------------|------------------------------------|-------------------|--------------------------|--------------------------------------|
| | Process | Atmosphere | Surfaces | Fluid | |
| – burrs | – initial fluid fill | – ingestion via reservoir breather | – mechanical wear | – re-entrainment | – repairs |
| – machining swarf | – addition of incorrect fluid | – ingestion via seals | – corrosive wear | – filter desorption | – preventive maintenance |
| – weld spatter | – compressed air or gas | – reservoir opening | – cavitation | – additive precipitation | – new filter |
| – abrasives | – pulp | – rock dust | – exfoliation | – sludge | – new fluid |
| – drill turnings | – pulverized coal | – mill scale | – hose materials | – insoluble oxides | – dirty hose, connector, components |
| – filings | – ore dust | – quarry dust | – filter fibres | – carbonisation | – top-up containers |
| – dust | – aggregates | – foundry dust | – break-in debris | – coke | – incorrect fluid |
| – contaminated components | – cement | – slag particles | – elastomers | – aeration | – cleaning rags |
| – dust from grinding | – catalysts | – dust from welding and grinding | | – varnishes | – dust from welding and grinding |
| – incompatible fluids | – clays | | | | – dust from atmosphere and workplace |
| – paint chips | – process chemicals | | | | |

4.2.2 Built-in contaminant

All new systems contain some contaminant left during manufacture and assembly. This can consist of fibres (from rags, etc.), casting sand, pipe scale, cast iron or other metal particles, jointing material or loose paint. When a system is operated at an unusual load or if there are high pulsations in the flow, it is likely that built-in contaminant becomes dislodged.

4.2.3 Ingressed contaminant

Systems can also be contaminated during normal operation, through openings in the reservoir, inadequate air breather filters, through worn seals in vacuum conditions and by intrusion through the fluid film on piston rods. Worn seals increase the likelihood of ingress. These ingressed contaminants can be highly abrasive.

4.2.4 Generated contaminant

When a normal system has been run for a reasonable period of time, a quantity of solid contaminant can be present in the form of small metallic platelets, created by the normal wear process. For correctly designed

systems, which are provided with suitable filtration, the majority of these particles are smaller than 15 µm. If a filter blockage indicator is ignored, previously retained contaminant can be dislodged from the filter element (see 10.4.1). However, if abnormal wear occurs, both the size and quantity of particles increase and, if not detected by monitoring, wear rates can accelerate and the wear mode can change from benign fatigue wear to abrasive wear. With abrasive wear, substantial amounts of surface material can be removed.

4.2.5 Maintenance-induced contaminant

Contaminants can easily be introduced during routine system maintenance unless the maintenance is performed in a clean environment, and precautions are taken to prevent contaminant from getting on serviced items. For example, topping up the system with new fluid can add contaminants unless the fluid is filtered upon addition.

4.3 Liquid contaminants

After damage caused by solid particulate contamination, damage caused by the presence of liquid contamination is the next highest cause of contamination-related problems. This damage is caused either directly through corrosion or indirectly through the interaction of the liquid contamination with the hydraulic fluid. This either reduces the fluid's effectiveness and thereby increases component wear rates, or reacts with it to produce insoluble products that can block filters, clearances, etc. Blockage under these circumstances is often rapid and unless it is detected and rectified, filtration ceases.

Water is the most common liquid contaminant in systems using mineral or synthetic fluids. Water can enter the system from the atmosphere, leaking coolers and condensation. Although most hydraulic fluids are formulated to cause water to separate so that it can settle in the reservoir and be drawn off, it is essential that the water content is maintained at levels well below the solubility or saturation level of the fluid used, at the minimum operating temperature.

Contamination by even small amounts of water in the fluid significantly lowers the load-sustaining capabilities of the fluid. This deterioration of lubrication ability is of great importance to many components in hydraulic systems. One example is that of rolling-element bearings, in which very high pressures are generated. If water is present in the hydraulic fluid, even in dissolved form, the viscosity increase required for the form of lubrication required in the bearing might not be achieved, and wear can result.

4.4 Gaseous contaminants

Nearly all fluids contain some dissolved gases. At atmospheric pressure, hydraulic fluids normally contain about 8 % of their volume as dissolved air, which, at this pressure, causes no problem. Increasing the pressure in the hydraulic fluid causes an increase in the amount of air that can be dissolved, and in low-pressure parts of the system, some of this dissolved air can be liberated in the form of bubbles, a situation frequently found downstream of pressure relief valves.

The presence of air bubbles in a system almost always causes erratic operation of the system, as it affects the stiffness (bulk modulus) of the fluid and thereby system response. Air bubbles in an inlet (suction) line of a pump reduce the volumetric efficiency and cause damage to most kinds of pumps through cavitation. Another effect often seen in high performance systems is the sudden compression of the fluid in the high pressure section of the pump, which causes the air bubbles to implode, and causing the vapour to ignite momentarily. The very high temperatures generated cause thermal stress on the fluid, leading to oxidation and nitration. A similar condition can exist downstream of metering valves; the process is known as "dieseling" and leads to the formation of gums, varnishes and even microscopic "coke" particles. These in turn can lead to lacquering of valves and plugging of filters.

5 Effects of particulate contamination and the benefits of its removal

5.1 General

It has been demonstrated that, in the majority of hydraulic systems, the presence of solid contaminant particles is the main cause of failure and reduced reliability. The sensitivity of components to these particles depends