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Hydraulic fluid power systems — Assembled systems — Methods of cleaning lines by flushing

Transmissions hydrauliques — Systèmes assemblés — Méthodes de nettoyage des canalisations par curage

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 23309 was prepared by Technical Committee ISO/TC 131, *Fluid power systems*, Subcommittee SC 6, *Contamination control*.

Introduction

In hydraulic fluid power systems, power is transmitted and controlled through a liquid under pressure within an enclosed circuit.

The initial cleanliness level of a hydraulic system can affect its performance and useful life. Unless removed, particulate contamination present after manufacture and assembly of a system can circulate through the system and cause damage to the system components. To reduce the probability of such damage, the fluid and the internal surfaces of the hydraulic fluid power system need to be flushed clean to a specified level.

Flushing of lines in a hydraulic system needs to be viewed as one means of removing in-built and residual contamination, and ought not be the sole method used for cleaning such systems.

Hydraulic fluid power systems — Assembled systems — Methods of cleaning lines by flushing

1 Scope

This International Standard specifies the procedures for flushing from the hydraulic lines of larger hydraulic fluid power systems solid particulate contamination that can be introduced during the initial build of a new hydraulic system or after maintenance or modification of an existing system.

This International Standard supplements, but does not replace, the requirements of the component supplier and customer, especially when those requirements are stricter than those specified by this International Standard.

This International Standard is not applicable to

a) the chemical cleaning and pickling of hydraulic tubes, or

b) the cleaning of major system components (see ISO/TR 10949).

Verification of the cleanliness of assembled systems is covered in ISO/TS 16431.

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 4021, *Hydraulic fluid power — Particulate contamination analysis — Extraction of fluid samples from lines of an operating system*

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

ISO/TR 10949:2002, *Hydraulic fluid power — Component cleanliness — Guidelines for achieving and controlling cleanliness of components from manufacture to installation*

ISO/TS 16431, *Hydraulic fluid power — Assembled systems — Verification of cleanliness*

3 Terms and definitions

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

3.1
flushing
process of cleaning a hydraulic piping system that involves the circulation of turbulent hydraulic system fluid within piping system loops to remove, transport and filter out particles that can have been introduced into the system during manufacture and build and after maintenance

3.2
outflushing
unrestricted discharge of sufficient fluid volume to an open container or bucket to remove contamination from a dead end in the piping

3.3
visible cleanliness
surface cleanliness that can be identified visually without magnification

3.4
clean work area
work area that is kept free from any activity that produces debris or particles

NOTE Activities such as welding, chipping, cutting, grinding or burning can produce debris and particles, and as a consequence ought not be carried out in the work area.

4 Cleanliness level

The main purpose of flushing is to achieve the cleanliness level required by the customer or the supplier of the system or component. For the case where the required cleanliness level is not stated, Annex A provides selection guidelines.

5 Flushing lines in a hydraulic system

5.1 Factors

Some factors to be considered for the achievement of a satisfactory cleanliness level for lines in a hydraulic fluid power system are

a) the selection of components that have been cleaned in accordance with ISO/TR 10949,

b) the initial cleanliness of the fitted lines,

c) the use of appropriate flushing procedures,

d) the selection of a suitable line-mounted filter having a rating capable of achieving the required cleanliness level within an acceptable time period, and

e) the establishment of a turbulent flow regime that will pick up the particles and transport them to the filter.

5.2 System layout

5.2.1 It is important for designers of hydraulic systems to plan for system flushing in the design phase. Dead ends without circulation shall be avoided. If there is a risk of particulate contamination moving from the dead end to the rest of the system, then the dead end shall be capable of being outflushed.

5.2.2 Circuits shall not be connected in parallel when flushing. Series connection of line sections may be acceptable if turbulent flow can be maintained. Parallel flow paths shall be avoided in piping loops unless instrumentation is provided to verify an adequate flow rate is present in each parallel flow path.

5.2.3 Components that can prevent a high flow velocity being achieved or which can themselves be damaged by high flow velocities or particulate contamination shall be disconnected from the circuit or bypassed. It shall be possible to interconnect each of the circuit line components for flushing.

5.2.4 Sampling valves in accordance with ISO 4021 shall be provided at strategic locations.

5.3 Component cleanliness level

Components and assemblies that are fitted into the system should be at least as clean as the specified system cleanliness. Component suppliers should be able to give information regarding component cleanliness levels.

5.4 Anti-corrosion agents

If the components contain anti-corrosion agents that are not compatible with the system fluid, the components may be flushed using a degreasing agent that is compatible with elastomers and the intended system fluid. The degreasing agent shall not affect component seals.

6 Treatment of lines

6.1 Preparation of lines during fabrication

Tubing or piping to be used as a hydraulic line shall be deburred in accordance with procedures agreed between the manufacturer and the user. Tubes or pipes with scale and/or corrosion shall be treated in accordance with procedures agreed between the manufacturer and user.

6.2 Surface treatment

To maintain cleanliness until installation, lines shall be treated with a suitable protection liquid. Corrosion-protection measures can be required during storage.

6.3 Storing of lines and connectors

Cleaned and surface-treated lines and connectors shall be capped immediately with clean caps and stored in a clean, dry place.

7 Installation of hydraulic lines

7.1 During the installation of hydraulic lines, it is important to avoid welding, soldering or heating the lines to prevent scaling. If this is not possible, the relevant lines shall be cleaned and re-protected (see ISO/TR 10949:2002, 5.3).

7.2 Flanges or recognized connectors should be used. All protection items fitted to lines and components (e.g. caps) shall be removed as late as possible in the installation process (see ISO/TR 10949:2002, 5.3).

8 Flushing requirements

8.1 General

8.1.1 A project-specific document shall be produced to identify the lines that shall be flushed and record the cleanliness level that is achieved.

8.1.2 A flushing procedure should be adapted to the practical conditions. However, certain main criteria shall be met to ensure that a satisfactory result is obtained.

a) The portable hydraulic power pack reservoir shall be cleaned to a level at least matching that of the specified system cleanliness (see Clause 4).

b) The fluid used to fill the system shall pass through a suitable filter [see 5.1 d)]. During filling with hydraulic fluid, air shall not be brought into the system; if necessary, the system shall be topped up and re-bled.

c) Pumping equipment shall be located as close as possible to the supply end of piping loops to minimize flow rate losses.

d) Flow-measuring and temperature-measuring devices shall be located near the return end of the piping loop.

e) Filters shall be located close to the return end of the piping loop. A supply-side filter may be used.

8.2 Removing particles from internal surfaces

8.2.1 For effectively removing particulate contamination from hydraulic lines, the main requirement is that the flushing fluid has turbulent flow. Turbulent fluid flow will also ensure transportation of the particulate contaminants out of the system and to the filters. A fluid with a Reynolds number (Re) greater than 4 000 shall be used to flush the system.

NOTE If the flushing is done with a fluid with a Re number less than 4 000, there could be sections of laminar flow within the lines.

8.2.2 Re and the required flow rate (q_V) can be calculated using Equations (1) and (2):

$$Re = \frac{21\,220 \times q_V}{\nu \times d} \tag{1}$$

$$q_V = \frac{d \times Re \times v}{21\,220} \tag{2}$$

where

q_V is the flow rate in litres per minute;

v is the viscosity in square millimetres per second;

d is the inside diameter of the line in millimetres.

8.2.3 It could be difficult to obtain a value of Re greater than 4 000. Re should be raised by either increasing the flow rate or reducing the viscosity. Reduction of viscosity should be used as the preferred method for achieving turbulent flow. Viscosity may be reduced by increasing the temperature or by using a compatible flushing fluid with a lower viscosity.

If the fluid temperature is increased, the temperature rise shall be limited so as to ensure that the fluid properties do not break down or that system components are not adversely affected. If a special flushing fluid is used, it shall be compatible with the intended system fluid. The preferred options are to use the system fluid for flushing or a lower viscosity grade of the same system fluid.

8.2.4 In a cold environment, the flushing fluid can suffer from heat loss. In such a case, in order to verify that Re is greater than 4 000, the temperature of the fluid shall be checked at the estimated coldest point of the system. Flushing shall only be accepted when the lowest temperature measured provides for Re greater than 4 000 (consult the manufacturer's data for the viscosity and temperature of the relevant flushing fluid). Under very cold conditions, the system shall be insulated to keep the temperature above the minimum necessary to provide for Re greater than 4 000.

8.2.5 Care shall be taken when considering a reduction in the diameter of the hydraulic lines that the necessary Re value is maintained, as this can have an impact on the flushing flow rate or low-pressure components.

8.2.6 The use of vibration, high-frequency sound, or a change in flow direction will contribute to a faster removal of particles. However, this is a supplement and not an alternative to turbulent flow.

8.2.7 Pressure in the piping system shall be monitored to ensure that it does not exceed the system's maximum allowable working pressure.

8.3 Filters and separation of particles

8.3.1 General requirements

8.3.1.1 The filters used for flushing determine the final cleanliness level and the clean-up time.

8.3.1.2 Choosing a filter with the optimum filtration ratio is important. If filters with a filtration ratio inadequate for the application are used, situations may arise where the specified cleanliness level cannot be achieved or is achieved after an extended flushing period.

The filtration ratio is determined according to ISO 16889.

8.3.1.3 Filters shall have a means to monitor blockage (e.g. a differential pressure indicator). Filter elements shall be replaced as necessary in order that the pressure drop is kept within the filter element's operating range.

8.3.2 Additional external flushing filters

8.3.2.1 Additional filters could be required during the flushing process in order that:

a) sensitive components are protected from the ingress of particles (e.g. when used in the suction line to protect the pump from contamination in the reservoir); the effects of an additional pressure drop should also be taken into account;

b) particles released from the component are captured immediately (e.g. when a return-line filter is used to prevent the particles from settling in the reservoir),

c) the flushing time is reduced.

8.3.2.2 Large flushing filters should be used when possible. The smallest acceptable flushing filter shall have a maximum pressure drop through a clean filter element of 5 % of the setting of the bypass valve or the indicator, calculated at the actual viscosity and maximum flow rate of the flushing fluid.

8.4 Minimum flushing time

8.4.1 The minimum required flushing time depends on the capacity and complexity of the hydraulic system. Even if fluid samples from the system indicate that the specified cleanliness level has been reached after only a short period of time, flushing at turbulent flow shall continue.

NOTE Continued flushing increases the possibility of removing particles that can adhere to the line's walls.

8.4.2 The recommended minimum flushing time, t, can be calculated from Equation (3):

$$t = \frac{20V}{q_V} \tag{3}$$

where

q_V is the flow rate in litres per minute;

V is the system volume in litres.

9 Verification of final cleanliness level

The final cleanliness level shall be determined in accordance with ISO/TS 16431 and shall be documented before the flushing operation may be considered as finished.

10 Identification statement (reference to this International Standard)

It is strongly recommended to manufacturers who have chosen to conform to this International Standard that the following statement be used in test reports, catalogues and sales literature:

"Method of cleaning lines in an assembled hydraulic system by flushing conform to ISO 23309, *Hydraulic fluid power systems — Assembled systems — Methods of cleaning lines by flushing*."