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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

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

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

This second edition cancels and replaces the first edition (ISO 23309:2007) which has been technically revised.

The main changes compared to the previous edition are as follows:

— identifies the shortfall of the Reynolds formula when it's used in isolation;

— identifies the importance of flushing oil velocity, temperature, and viscosity;

— identifies to the practitioners who perform flushing procedures that if they only consider the *Re* value the flushing velocity could be much less than the system oil flow within the system and what it will be subjected to in normal service;

— raises awareness and importance of the factors other than the *Re* valve that affect the effectiveness, efficiency and reliability of any flushing process.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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 manufacturing, assembly, component failure and repair 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 needs 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 should not be the sole method for cleaning such systems unless other methods are impractical.

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

1 Scope

This document specifies the procedures for flushing particulate contamination from the hydraulic lines and components of hydraulic fluid power systems which is:

— residual in the components after manufacture;

— introduced into the system during the assembly of a new system; or

— introduced into the system after system failure, maintenance or modification of an existing system.

The aim of flushing the system is to quickly remove this contamination to reduce the amount of wear and damage that results if these particles are allowed to circulate around the system.

This document is not applicable to:

— the chemical cleaning and pickling of hydraulic tubes;

— the cleaning of major system components (this is covered in ISO/TR 10949).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 4406, *Hydraulic fluid power — Fluids — Method for coding the level of contamination by solid particles*

ISO 4407, *Hydraulic fluid power — Fluid contamination — Determination of particulate contamination by the counting method using an optical microscope*

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

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

ISO 12669, *Hydraulic fluid power — Method for determining the required cleanliness level (RCL) of a system*

ISO 16431, *Hydraulic fluid power — System clean-up procedures and verification of cleanliness of assembled systems*

ISO 16889, *Hydraulic fluid power — Filters — Multi-pass method for evaluating filtration performance of a filter element*

ISO 18413, *Hydraulic fluid power — Cleanliness of components — Inspection document and principles related to contaminant extraction and analysis, and data reporting*

ISO 21018-1, *Hydraulic fluid power — Monitoring the level of particulate contamination of the fluid — Part 1: General principles*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

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

3.2
flushing level
the cleanliness level to be achieved after *flushing* (3.1) which shall be cleaner than the *required cleanliness level (RCL)(3.3)*

Note 1 to entry: A cleanliness level of one ISO code cleaner than the *RCL* (3.3) is suitable (see ISO 4406).

3.3
required cleanliness level
RCL
liquid cleanliness level specified for a system or process

Note 1 to entry: See ISO 16431.

3.4
Reynolds number
Re
dimensionless ratio of the internal flow forces to the viscous forces within a fluid which is an indicator of the flow characteristics (laminar or turbulent) of a moving fluid

4 Principle of flushing

The purpose of flushing is to quickly remove surface particulate contamination to both limit the amount of damage to the components and to quickly achieve the RCL by the customer. This is achieved by circulating clean fluid under conditions of high fluid velocity, temperature and turbulence that are higher than that experienced in normal service and that will pick up the particles from the surfaces and transport them to a clean-up or flushing filter.

The RCL is usually specified by the customer, but for the case where the RCL is not stated, Annex A provides selection guidelines. Component suppliers shall be able to specify the cleanliness level of their components. ISO/TR 10949 and ISO 18413 specify methods of evaluating and documenting the cleanliness level.

5 Flushing lines in a hydraulic system

5.1 Initial factors to consider

Some factors to be considered for the achievement of a satisfactory cleanliness level for lines in a hydraulic 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) service or flushing fluid, which is cleaned to a level that, when added, is cleaner than the final flushing level, see 3.2;

d) selection of suitable line-mounted filters that have a rating capable of achieving the RCL within an acceptable time period;

e) the establishment of a high fluid velocity and turbulent flow regime that will pick up the particles and transport them to the filters.

5.2 System layout

5.2.1 Designers of hydraulic systems shall 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 flushed out.

5.2.2 Circuits should preferably be connected in series as the fluid velocity and *Re* of each single circuit can be calculated when the overall flow is given. Parallel connection of line sections however, is acceptable provided that turbulent flow can be achieved, maintained and monitored via flow meters.

5.2.3 Components that can prevent a high flow velocity being achieved or that can themselves be damaged by high velocities of particulate contamination shall be disconnected from the circuit or by-passed.

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

5.2.5 The rating of any flushing filter shall be equal to or finer than the rating of any built-in filter elements, and any built-in filter shall be replaced for flushing, if required. The original specified and new filters may be reinstated after flushing.

5.2.6 Connectors and conductors shall be of uniform inside diameter to avoid trapping any particles for possible release later. They shall also be suitably sized to avoid large pressure losses.

5.3 Component cleanliness level

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

NOTE The effect of component cleanliness on the whole system cleanliness level can be assessed using ISO/TR 10686. In order to estimate the component cleanliness level after flushing, in reciprocal approach, the final system flushing level could be redefined to the individual cleanliness of each component of the system. This requires knowledge of the whole system volume and each component of the system.

5.4 Anti-corrosion agents

If the components contain anti-corrosion agents that are not compatible with the flushing or system fluid, the components shall be flushed before assembly using a degreasing agent that is compatible with the intended system fluid. The degreasing agent shall not affect component seals. The degreasing agent shall be of a suitable cleanliness, ideally to the RCL selected.

6 Treatment of lines

6.1 Preparation of lines during fabrication

Tube or pipe 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 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 clean protection liquid and be suitably capped immediately after treatment. Corrosion protection measures will be required during storage.

6.3 Storage of lines and connectors

Cleaned and surface-treated assembled lines and connectors shall be blanked off and capped immediately with clean caps and shall be stored under dry controlled conditions. If this is not possible, the assembled lines and connectors shall be protected against moisture, e.g. rain. If assembled lines and connectors are not stored under adequate conditions, additional cleaning and surface treatment may be necessary.

7 Installation of piping systems

7.1 During installation of piping systems, welding, soldering or heating the lines shall be avoided to prevent scaling. If this is not possible, the relevant lines shall be cleaned and re-protected according to ISO/TR 10949.

7.2 Flanges or approved connectors shall be used. All protection items fitted to lines and components, e.g. blanking plugs and caps, shall be removed as late as possible in the installation process, see ISO/TR 10949.

8 Flushing requirements

8.1 Flushing document

A project-specific document ('flushing document') shall be produced to identify the lines that shall be flushed, in which order they shall be flushed and any additional equipment that is needed. Each identified flushing line should also show the highest flow rate the lines will be subjected to in normal service and what the minimum flushing flow rate should be. To record the cleanliness level that is achieved, see 8.6.1. This shall be signed by the customer and the system co-ordinator.

8.2 Flushing criteria

A flushing procedure shall be adapted to suit the requirements of the system concerned. The following criteria shall be met to ensure that a satisfactory result is obtained:

— if a portable flushing power pack is used, its reservoir shall be cleaned to a level at least matching that of the specified system cleanliness, see Clause 4;

— the fluid used to fill the system shall pass through a suitable filter, see 8.6.2 c). Air shall not be brought into the system during filling with hydraulic fluid. If necessary, the system shall be topped up and re-bled;

— if additional pumping equipment is used, it shall be located as close as possible to the supply end of piping systems to minimise the flow resistance and pressure losses;

— hydraulic flow and temperature measuring devices shall be installed to monitor the flushing fluid and to verify the flushing parameters;

— the flushing filter shall be located at the end of the circuit just before the reservoir. Additional filters may be used, see 8.4.2;

— a sampling valve for extracting samples or sample taps for the connection of field contamination monitors shall be positioned at the end of the section being flushed in a line, before the reservoir, or both.

8.3 Flushing parameters

8.3.1 To effectively flush particulate contamination from hydraulic lines, the system shall be subjected to a combination of all the main flushing elements (a, b and c) at the same time.

a) *Re* shall be greater than that which exists in the system during operation or greater than 4 000, whichever is higher;

b) The flow rate in the pipe lines should be at least 1,5 times the actual flow rate in service.

c) The oil temperature is greater than the minimum temperature likely to be experienced in service, but should be at least 40 °C.

In practice, it is not always possible to achieve all of these parameters. In the event of a conflict, e.g. *Re* can be achieved but the 1,5 times flow rate condition cannot, priority should be placed upon achieving the highest possible *Re*.

The importance of these factors is shown in Annex C.

8.3.2 *Re* and the required flow rate (q_v) can be calculated using Formulae (1) and (2):

$$Re = \frac{21\,220 \times q_v}{v \times d} \quad (1)$$

$$q_v = \frac{d \times Re \times v}{21\,220} \quad (2)$$

where

q_v is the flow rate in L/min;

v is the kinematic viscosity at the flushing fluid temperature in mm²/s;

d is the inside diameter of the line in mm.

If there is difficulty in obtaining *Re* greater than 4 000, *Re* should be raised by either reducing the viscosity or increasing the flow rate. Reduction of viscosity is the preferred method. Viscosity can 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 to ensure that the fluid properties or the 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.

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 measured 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.

8.3.3 The use of vibration, high frequency sound, or a change in flow direction can contribute to a faster removal of particles. This is a supplement and not an alternative to high velocity and turbulent flow.

