TECHNICAL REPORT

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Hydraulic fluid power — Methods for cleaning and for assessing the cleanliness level of components

Transmissions hydrauliques — Méthodes de nettoyage et d'évaluation du niveau de propreté des composants

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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 main task of technical committees is to prepare International Standards. In exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types:

— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;

— type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;

— type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 10949, which is a Technical Report of type 2, was prepared by Technical Committee ISO/TC 131, *Hydraulic fluid power,* Subcommittee SC 8, *Product testing and contamination control.*

On consideration of this document for circulation as a draft International Standard, it was concluded that standard practice had progressed beyond the recommendations presented herein. It was therefore decided to stop work and publish the document as a Technical Report of type 2, allowing interested bodies to refer to it, and as the basis for conversion into an International Standard.

Introduction

To ensure long life and satisfactory performance of hydraulic fluid power systems, the cleanliness of the system is of paramount importance. One factor affecting that cleanliness is the degree of contamination which is present in the system components after manufacture.

This Technical Report has been prepared to give guidance to manufacturers for producing clean components and to select the most appropriate of three alternative procedures for assessing the level of cleanliness as delivered to the user.

As it is not always clear what level and type of cleanliness would be beneficial for improved performance and life on a cost-effective basis, the actual quantitative levels can only be set in relation to other parameters and should be agreed between the manufacturer, supplier and user.

Hydraulic fluid power — Methods for cleaning and for assessing the cleanliness level of components

1 Scope

This Technical Report recommends methods of cleaning hydraulic fluid power components and describes alternative procedures for assessing the cleanliness of the components as delivered by the manufacturer to a system constructor or user.

It is not intended to cover complete systems or procedures for cleaning and assessing solid pipework.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Technical Report. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Technical Report are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 3722:1976, *Hydraulic fluid power — Fluid sample containers — Qualifying and controlling cleaning methods.*

ISO 3938:1986, *Hydraulic fluid power — Contamination analysis — Method for reporting analysis data.*

ISO 4021:1992, *Hydraulic fluid power — Particulate contamination analysis — Extraction of fluid samples from lines of an operating system.*

ISO 4402:1991, *Hydraulic fluid power — Calibration of automatic-count instruments for particles suspended in liquids — Methods using classified AC Fine Test Dust contaminant.*

ISO 4405:1991, *Hydraulic fluid power — Fluid contamination — Determination of particle contamination by the gravimetric method.*

ISO 4406:—[1], *Hydraulic fluid power — Fluids — Code for defining the level of contamination by solid particles.*

ISO 4407:1991, *Hydraulic fluid power — Fluid contamination — Determination of particulate contamination by the counting method using a microscope.*

ISO 5598:1985, *Fluid power systems and components — Vocabulary.*

ISO 6072:1986, *Hydraulic fluid power — Compatibility between elastomeric materials and fluids.*

3 Definitions

For the purposes of this Technical Report, the definitions given in ISO 5598 apply.

4 Contamination control

Creating and maintaining a clean component is primarily a manufacturing responsibility but the customer or user must also accept responsibilities.

Care with cleanliness is needed by the manufacturer at all stages of production.

1) To be published. (Revision of ISO 4406:1987)

The manufacturer is responsible for:

— cleaning component parts prior to assembly;

— assembly in a clean area;

— flushing, if this operation is needed;

— cleanliness during testing;

— preparation for packing, corrosion prevention, port sealing etc.;

— adequate packaging.

On receipt of the component, the customer or user is responsible for:

— care in unpacking;

— keeping the component clean after removing protective plugs, etc.;

— installing the component in the system in a clean condition.

5 Cleaning and assembly of components and parts

5.1 Cleaning

To ensure that an adequate standard of cleanliness of finished units is achieved, it is essential that all parts which make up a component are thoroughly cleaned before assembly.

An appropriate procedure shall be implemented, for each component or component element, to remove such residues as chips, sand, filings, rust, weld spatter and slag, elastomers, sealants, water, aqueous products, chlorine, oil, acid, detergent, etc.

This cleaning procedure is essential to ensure that no damage to the finished component will occur during flushing or testing.

The cleaning procedure can be carried out as follows:

— shot blast or chemically clean castings to remove casting sand and scale prior to machining, and then carefully deburr and wash them before assembly;

— remove manufacturing residues, burrs, etc. by mechanical, ultrasonic, vibratory, chemical means, etc.;

— remove cleaning residues using chemical means, solvents, dry filtered compressed air, etc.;

— wipe with lint-free cloths;

— oven-dry or dry with dry filtered compressed air.

When cleaning components, special care should be taken to ensure that cored passages and deep holes are cleaned, and it should be remembered that items with designed sharp edges, such as grooved spools, can collect quantities of "finger dirt". Assembler's hands and benches should be kept clean and cleaning materials should be lint-free.

Ultrasonic cleaning of components can be very effective, providing the manufacturer's instructions for the ultrasonic cleaner are carefully followed. This process relies mainly on the effect of vapour bubbles imploding on the surface of components; it is important that the bath and component temperature are correct for this action to be fully effective. Adequate time shall, therefore, be allowed for components to reach working temperature after immersion. The design of containers and spacing of components is also critical and adequate flow paths shall be allowed for the sonic waves to reach all parts of all components. Baskets made of perforated sheet may tend to attenuate the sound waves, as will tightly packed parts. Open wire mesh baskets are normally satisfactory.

A further important point is that if the bath fluid is even slightly contaminated with oil or dissolved preserving agent (grease for example), traces of this grease may be left on the components. Components which require subsequent treatment, such as plating or the use of some sealants, should be cleaned in a vapour bath. It should be noted that some vapours, particularly some chlorinated hydrocarbons, can promote very rapid corrosion even if the components are subsequently coated with oil soon after cleaning.

5.2 Assembly

Components should, ideally, be assembled immediately after cleaning as even short storage periods can allow corrosion to start or airborne dust to settle on them. Components which are not required for immediate assembly should be adequately protected.

Assembly should be done in a clean area, well away from contaminant-generating operations such as grinding, welding and machining. Air jets used for cleaning in the vicinity of the assembly should be avoided as these jets can project contaminant many metres.

If adhesives or PTFE tape are used during assembly, care should be taken to avoid entrapment within the unit. If grease is used, it is important that it be kept clean and it should be used sparingly as it may not be soluble in the system fluid and may block filters.

After assembly, all joint surfaces and ports should be covered unless the unit is to be tested immediately. Cover plates and other closures, such as plastic plugs, should be as clean as the unit. Closures which have been used for this purpose will probably be oily and should be cleaned before re-use.

A list of some of the means of protecting a component is given in table 1. If further cleansing of an assembled component is required, the component should be flushed on a specifically designed flushing rig prior to testing.

WARNING — Test plant should not be used as a primary cleaning station.

Table 1

Nature of protection	Cleaned components[1)]
Pressed-on metallic plug or cap	T
Screwed cylindrical metallic plug with seal	R
Flanged plate with seal	R
Pressed-on plastic plug	T
Screwed male plastic plug	R
Self-cutting plastic plug	F
Anti-corrosive Kraft paper	F
Plastic packaging	R
Filling with clean compatible hydraulic fluid	R
Contact corrosion volatile inhibitor for spare parts	R By agreement
Vacuum-tight envelope[2)]	R
Pressure-tight envelope[2)]	R

1) R = recommended; T = tolerated; F = forbidden.
2) In addition to port plugs.

6 Flushing

6.1 Principle

The principle of flushing is to apply sufficient energy to the contaminants in order to dislodge them and to wash them away from the component for subsequent collection in a filter.

6.1.1 Fluid-conveying components

The preferred procedure involves circulating a fluid through the component under defined conditions of flow and temperature.

The fluid flow shall be turbulent ($Re > 4\,000$) and calculated from the nominal diameter of the component supply ports:

$$Re = \frac{Vd}{\nu} \times 10^3$$

where

Re is the Reynolds number;

d is the nominal diameter of the ports, in millimetres;

V is the linear velocity of the fluid, in metres per second;

ν is the kinematic viscosity of the fluid, in centistokes (cSt) [2)].

For the flowrate to achieve a Reynolds number of 4 000, the flowrate, in litres per minute, must be greater than 0,189 νd.

6.1.2 Non fluid-conveying components

Flushing may be carried out by filling the components with a suitable fluid, and by flushing them completely several times until the fluid cleanliness, as measured at regular intervals, reaches the required level.

6.2 Flushing installation

In order to achieve satisfactory conditions, it is recommended that an installation which meets the requirements given in 6.2.1 to 6.2.4 is used.

CAUTION — Special care shall be taken when mounting the component onto the flushing installation to check that the fluid sample taken for cleanliness determination is the same fluid as that conveyed by, or stored in, the component during the flushing operation.

2) 1 cSt = 1 mm²/s

6.2.1 The flushing fluids shall have the following properties:

— they shall be compatible with the components, the seals and the fluid for final use;

— they shall have a viscosity which minimizes wall effects. Empirically, such effects are acceptable as long as viscosity does not exceed 40 cSt.

6.2.2 The tank shall be sealed to prevent ingress of external contamination and shall include a breather with a filtration efficiency compatible with the required cleanliness class.

6.2.3 The filter shall:

— allow the maximum flowrate, as defined in 6.1.1, to pass through it;

— have a filtration efficiency which easily allows the required cleanliness class to be reached;

— include a blocking indicator.

6.2.4 A sampling valve or contamination monitoring port shall be fitted downstream of the component to be flushed.

6.3 Flushing procedure

The time required for flushing is dependent on the component complexity, on the required cleanliness and on the equipment performance.

Flushing should be continued until

— either the contamination level reaches the required value, or

— a specified time is reached, determined experimentally for a given installation and a given component when developing the method.

The moving parts of the component shall be operated for the whole duration of the flushing process. In addition, pumps, motors and cylinders shall be operated at their maximum permissible continuous speed or stroke.

7 Measurement methods

7.1 General

As appropriate, the following three methods should be used to assess the level of contaminant remaining in components or sub-assemblies:

a) monitoring the contamination level of fluid in a production test rig (see 7.2);

b) the flush test method to determine contaminant level flushed out (see 7.3);

c) the strip-wash test method to determine contaminant removed (see 7.4).

One or more of these methods should be used by component manufacturers as part of their quality assurance programme.

It is not recommended that these tests be performed by customers. If a customer considered it essential to conduct either the flush or strip-wash test, he should only do so by prior agreement with the manufacturer, as tests of this nature will certainly invalidate the warranty on the units concerned.

Monitoring the component test fluid will give a very good average indication of the level of fine particulate remaining in all components, but the flush and strip-wash tests will demonstrate the quantity and nature of larger particles present in a component.

7.2 Production test rig method

7.2.1 Commentary

This method is suitable for most components and sub-assemblies, such as gasket-mounted modules and multiple valves, provided adequate fluid flow is directed through all active flow paths, if possible in both directions during test, and that sufficient time is allowed for thorough flushing.

There are limitations to this method as some units contain blind passages which will not be cleaned out by this process, e.g. passages between a pilot valve and the ends of a second stage spool. The housings of piston pumps and motors may also contain additional contaminant which may not be removed due to the flows into these cavities.

This test gives an indication of the level of cleanliness of the flow passageways of components in production.

Units that use the test rig to cut themselves in, for example gear pumps, can be checked by this method.

NOTE 1 It is recommended that the specified level of cleanliness be established after consultation between the customer and the manufacturer due to the special conditions that exist.

7.2.2 Procedure

a) By this method, the oil in a suitable final rig is used to quantify the cleanliness level of the complete unit by using oil which is cleaner than the contaminant level stated in the catalogue or the "as-shipped" specification of the unit. The contaminant level should be stated in accordance with ISO 3938 and ISO 4406.

b) The test rig should not be used as a means of cleaning the parts that make up the final assembly.

c) Monitoring of the fluid condition should be recorded in order to optimize the frequency of checking and predict the probable deterioration of cleanliness levels to a point where other actions may be needed in the rig.

d) Oil samples should be taken from sampling valves positioned in an active part of the circuit to give a realistic contaminant count and in a manner that does not introduce outside contaminants to the sample, or the sample containers; i.e. in accordance with ISO 4021.

e) Satisfactory methods of monitoring the levels of contamination include automatic particle counters, gravimetric analysis, comparison membranes and several other proprietary methods. Related standards are ISO 3722, ISO 4402, ISO 4405 and ISO 4407.

7.3 Flush test method

7.3.1 Commentary

In this method, the outside of the component is first thoroughly cleaned, then the internal surfaces are carefully flushed with a suitable solvent whilst being agitated as strongly as possible. The solvent is subsequently filtered to separate out the contaminant for inspection.

It is a simple and easy-to-perform quality control test and will give a good indication of the quantity and nature of the larger particles remaining in the component. However, it is unsuitable for very large components and suffers from the disadvantage that some components have cavities which cannot be adequately flushed.

It is, however, essential to take extreme care to prevent external contamination being added to the sample. After flushing, all surfaces should be rewetted with clean hydraulic oil or preservative to prevent corrosion or damage during initial use.

7.3.2 Procedure

a) Clean all external surfaces with solvent to remove extraneous contaminant from the sample.

b) Remove shipping plugs carefully to prevent adding contaminant such as plastic plug shavings. Clean each port, if necessary, with a bottle brush. Do not remove permanent plugs which remain in the component during service.

c) Place the component in a clean collecting tray. This tray, and all other apparatus used, should be pre-cleaned to a level such that any contamination released from it should have no significant effect on the final test result.

d) Select a solvent which is compatible with all the materials used in the components, including seals and the working fluid (see ISO 6072) and filter to better than the required cleanliness level of the component. The required level should be stated in accordance with ISO 4406 and ISO 3938.

e) Valves, hoses and similar components should have their lower ports plugged, half filled with solvent and the remaining plugs refitted. Thoroughly agitate the half-filled component. Valves with manually operated spools should, where practicable, be agitated with the spool in each position. Hoses should be flexed 10 times during agitation.

Remove shipping plugs and drain solvent into the collecting tray. Ideally, this entire procedure should be repeated two or three times.

f) Pumps and motors should have all shipping plugs removed, and the inlet port filled with solvent. The drive shaft should then be rotated 1,5 times in the correct direction. Repeat this three times. After the fourth filling, rotate the shaft three times.

Pumps and motors with a separate case cavity should have this cavity rinsed as for valves.

Remove any remaining shipping plugs and drain all remaining solvent into the collecting tray.

g) Pour the contents of the collecting tray into a funnel containing a suitable filter paper or membrane. Wash the tray with solvent and pour the contents into the funnel.

h) Dry the filter paper or membrane and remove it for inspection, either visually, gravimetrically (ISO 4405) by electronic particle counting, or by microscope.