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Hydraulic filter element test methods — Thermal conditioning and cold start-up simulation

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National foreword

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Hydraulic filter element test methods — Thermal conditioning and cold start-up simulation

Méthodes d'essai des éléments filtrants hydrauliques — Conditionnement thermique et simulation de démarrage à froid

Reference number
ISO 16908:2014(E)

Contents

Foreword

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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).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is 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 a closed circuit. Filter elements maintain fluid cleanliness by removing insoluble contaminants.

Filter elements, particularly those intended for mobile hydraulic applications, are designed to withstand a range of thermal stresses, such as low and high temperature extremes, and system demands at low temperature (cold starts) whereby hydraulic fluid passes through the element under test at a greatly increased viscosity. These cold starts test the ability of the filter element to withstand the high differential pressures without subsequent loss of integrity or performance.

Stresses due to cold starts can be encountered within the lifetime of a filter element fitted in a mobile hydraulic system. It is therefore necessary to check that, having been subjected to such conditions, the filter element shall continue to provide adequate filtration while also maintaining structural integrity.

This International Standard provides a procedure by which to introduce stresses due to cold start and to condition a filter element prior to any subsequent performance qualification testing, such as multi-pass, collapse, flow fatigue, etc. This enables the purchaser of the filter element to be secure in the knowledge that the product can withstand cold starts and still maintain performance as intended.

Hydraulic filter element test methods — Thermal conditioning and cold start-up simulation

1 Scope

This International Standard specifies a test procedure to thermally condition a hydraulic filter element and simulate cold start, such as that which can be encountered in mobile machinery applications. It is intended to provide a procedure that yields reproducible results and can be used prior to other filter element performance tests, such as those specified in ISO 11170.

2 Normative references

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

ISO 1219-1, *Fluid power systems and components — Graphical symbols and circuit diagrams — Part 1: Graphical symbols for conventional use and data-processing applications*

ISO 2942, *Hydraulic fluid power — Filter elements — Verification of fabrication integrity and determination of the first bubble point*

ISO 2943, *Hydraulic fluid power — Filter elements — Verification of material compatibility with fluids*

ISO 3968, *Hydraulic fluid power — Filters — Evaluation of differential pressure versus flow characteristics*

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 5598, *Fluid power systems and components — Vocabulary*

ISO 11500, *Hydraulic fluid power — Determination of the particulate contamination level of a liquid sample by automatic particle counting using the light-extinction principle*

3 Terms and definitions

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

3.1
cold soak
prolonged immersion of a component or part in stationary fluid at 5 °C below the stated minimum temperature of use

3.2
cold start
application of a rapid increase in flow and differential pressure with cold fluid at a high viscosity

3.3
differential pressure
Δp
difference between the tested component inlet and outlet pressure as measured under the specified conditions

3.4
hot soak
prolonged immersion of a component or part in stationary fluid at a temperature 15 °C above the manufacturer's recommended operating temperature

3.6
material safety data sheet (MSDS)
specification sheet defining physical aspects, characteristics, and health and safety data for a substance

4 Symbols

The graphical symbols used in this International Standard are in accordance with ISO 1219-1.

5 Test equipment and materials

5.1 Soak test fluid, which shall be either the same as the system operating fluid or another compatible fluid agreed upon between the supplier and purchaser.

5.2 Cold start test fluid, which can be either the same as the soak test fluid or an alternative with a higher cold temperature viscosity to minimize the volume of fluid required to conduct the cold start test and to standardize the fluid required for testing of additional filters. If an alternative fluid is chosen, it shall be fully compatible with the filter element material and with the soak test fluid.

5.3 Differential pressure transducer, which shall be

— positioned such that the upstream and downstream connections are close to the filter housing, with no bends or restrictions included in the measurement, and with pressure taps in accordance with ISO 3968 and

— connected to a calibrated data recording system.

5.4 Temperature transducer, which shall be

— located so that the sensor part is located in the internal fluid volume,

— positioned so that it measures the temperature of the test fluid as close as possible upstream of the test element,

— connected to a calibrated data recording system, and

— positioned so that the sensor part does not touch the filter element or any part of the filter element container.

5.5 Environmental chamber, which shall be capable of achieving and maintaining the required temperature within the stated limits and capable of containing the test equipment (see 5.6). The chamber shall have suitable thermal controls with a calibrated feedback loop to allow precise control of the chamber temperature.

5.6 Cold start test equipment. See Annex A for a list of typical equipment necessary to perform the cold start test.

6 Accuracy of measuring instruments and test conditions

The accuracy of measuring instruments used and variations in test conditions shall be maintained within the limits given in Table 1.

Table 1 — Accuracy of measuring instruments and test conditions

Test parameter	SI unit	Instrument accuracy (±of actual value)	Permitted variations in test conditions (±of target value)
Differential pressure	kPa [a]	2 %	+5 % / -0 %
Gauge pressure	kPa [a]	2 %	5 %
Flow rate	L/min	2 %	
Temperature	°C	0,1 °C	5 °C

[a] 100 kPa = 1 bar

7 Summary of information required prior to testing

Prior to applying the requirements of this International Standard to a particular hydraulic filter element, the following shall be established:

— fabrication integrity test pressure (see ISO 2942);

— required maximum element differential pressure for the cold start test.

NOTE 1 For filter elements protected by a bypass valve within the filter housing, the maximum test differential pressure is generally set as the maximum differential pressure across the bypass valve at maximum flow rate and viscosity at the minimum expected temperature. For filter elements without such bypass, the maximum test differential pressure is generally set as the maximum operating system pressure.

NOTE 2 The maximum test differential pressure is normally limited to the maximum permissible collapse or burst pressure of the filter element. If this pressure is exceeded, it can result in damage to the test filter element.

8 Thermal conditioning test

8.1 Visually inspect the filter element for any damage. If it is damaged, reject the filter element and start over with a new filter element.

8.2 Carry out a fabrication integrity test on the element in accordance with ISO 2942. Reject the filter element if it is damaged as a result of testing or fails to meet the required minimum bubble point pressure. If either of these occurs, start over with a new filter element.

8.3 Drain fluid and dry the filter element thoroughly.

8.4 Conduct heat soak and cold soak tests as required in accordance with ISO 2943. The following requirements enhance the safe conduct of these tests.

a) If the material safety data sheet for the test fluid states that inhalation of its vapours is harmful, ensure that any vapour from the fluid is extracted externally from the workplace when testing with the fluid at above ambient temperatures.

b) If external extraction of the vapour is unavailable, the test shall be conducted in an enclosed vessel or housing with suitable pressure rating.

9 Cold start test

9.1 Preliminary preparation

9.1.1 Housing

9.1.1.1 Determine whether the designated housing for the filter element is fitted with a bypass valve. If a bypass valve is fitted as standard, then the bypass valve shall be disabled, or the cold start test procedure shall be conducted using an alternative housing that does not have a bypass valve. If the bypass valve is integral to the filter element, it shall be included in the test.

9.1.1.2 If the designated housing is not available, fit the filter element within an alternative housing that has an internal diameter at least as large as that of the designated housing and either does not have a bypass valve or whose bypass valve has been disabled.

9.1.1.3 The alternative housing shall not be smaller in internal diameter than the designated housing, as this can cause bias to the flow direction, thereby causing an uneven distribution of pressure stress in the filter element medium in the biased area.

9.1.2 Cold test equipment

9.1.2.1 A suggested test equipment and circuit are shown in Annex A.

9.1.2.2 Shut all sampling valves.

9.1.2.3 With a piece of pipe or test block replacing the test housing, run the hydraulic power circuit pump to empty test fluid from the transfer cylinders at a suitable flow rate. Install the test housing onto the cold start test rig. If the test circuit was previously used with a different fluid, all components of the test circuit should be drained, flushed with a compatible solvent, and then flushed with a volume of the new test fluid being used in order to prevent cross-contamination of test fluids.

9.1.2.4 Fill the test housing with test fluid. The clean-up filter element in the cold start test circuit should be replaced with a new filter element.

9.1.2.5 Run the cold start test circuit pump to refill the transfer cylinders with filtered test fluid and to filter the hydraulic power circuit fluid. Circulate the fluid at a suitable flow rate that does not cause the clean-up filter to exceed its rated differential pressure

9.1.2.6 Extract a sample from upstream of the test housing with a recommended minimum volume of 250 ml.

9.1.2.7 Analyse the contamination level of the test fluid sample in accordance with ISO 11500 and verify that its solid contamination level, expressed in accordance with ISO 4406, is 15/12/10 or cleaner.

9.1.2.8 If the fluid's solid contamination level is dirtier than 15/12/10, continue to cycle the transfer cylinders and clean the test fluid until it meets this requirement.

9.1.2.9 If it is necessary to determine if the cold start flow rate cycle can be achieved, an optional trial element can be installed so that a cold start dummy run can be conducted. If such a dummy run is successful, a new test filter element shall be installed into the test housing for the actual test (see 9.1.2.10).

9.1.2.10 Install the test filter into the test housing.

9.1.2.11 Run the hydraulic power circuit pump briefly to cycle the transfer cylinders in order to bleed any air pockets in the test housing and surrounding piping to the cold start test circuit reservoir.

9.1.2.12 Run the cold start test circuit pump to refill the transfer cylinders with filtered test fluid.

9.1.3 Filter assembly differential pressure waveform

9.1.3.1 Control the pump so that it provides the filter assembly differential pressure waveform specified in 9.1.3.2 to 9.1.3.7 and in Figure 1.

NOTE This can be accomplished by either using a programmable pump controller or controlling the pump outlet manually.

9.1.3.2 Increase the flow rate in the hydraulic power circuit so that the filter assembly differential pressure increases to the required maximum (+5 %, −0 %) within 2 s to 4 s (see Clause 7).

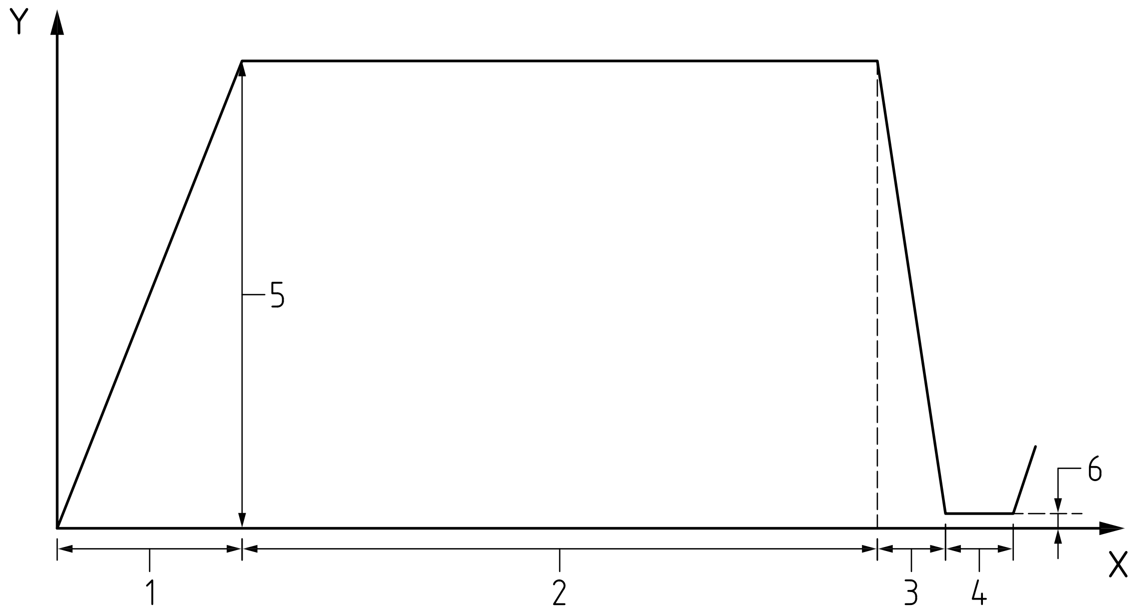
9.1.3.3 Maintain the maximum differential pressure for 10 s to 11 s.

9.1.3.4 Reduce the flow rate so that the filter differential pressure reduces to 1 % to 3 % of the maximum differential pressure within 1 s to 2 s.

9.1.3.5 Maintain the differential pressure at 1 % to 3 % of the maximum differential pressure until the next cycle starts, or a minimum of 2 s.

9.1.3.6 The filter differential pressure waveform for the test shall be in accordance with Figure 1.

9.1.3.7 The overall cycle time (rise, hold, and fall) shall be 15 s ± 1 s.



Key

X test time s

Y filter differential pressure

1 differential rise time = 2 s to 4 s

2 time at maximum differential pressure = 10 s to11 s

3 differential pressure fall time = 1 s to 2 s

4 time at minimum differential pressure = at least 2 s

5 maximum filter differential test pressure (+5 %, −0 %)

6 differential pressure between cycles = 1 % to 3 % of maximum differential pressure

Figure 1 — Differential pressure waveform for cold start test

9.2 Procedure

9.2.1 Ensure that the test fluid temperature in the cold start test circuit has stabilized at the designated minimum test temperature for at least 4 h.

9.2.2 Start the data recording system and continuously record

— differential pressure across the filter assembly,

— temperature transducer reading, upstream of the test filter, and

— system flow rate (optional).

9.2.3 Set the hydraulic power circuit pump to run the differential pressure waveform in accordance with Figure 1. Complete 10 cycles, unless otherwise agreed between the manufacturer and user, while maintaining the test fluid temperature within the designated limits. The number of cycles shall be recorded on the report sheet.

9.2.4 After completion of the cycles, remove the test filter element from the housing and allow both the housing and filter element to drain. If desired, the test chamber temperature can be allowed to increase to the ambient temperature prior to removing the element.

9.2.5 When the filter element has drained, remove all traces of test fluid from the filter element using a compatible solvent and allow the filter element to dry in a fume extraction cabinet or similar environment.

9.2.6 Ensure that the filter element is dry.

9.2.7 Visually inspect the filter element for any physical damage.

9.2.8 Package the conditioned element carefully to prevent any damage, and store at ambient conditions for subsequent testing.

10 Pass/fail criteria

Filter elements that exhibit any physical damage shall be deemed to have failed. Filter elements that do not exhibit any physical damage from the thermal conditioning and cold start tests should be subjected to subsequent tests to determine their performance after cold start. Use ISO 16889 (multi-pass performance test) or see ISO 11170 for a list of other pertinent performance tests, such as collapse/burst or flow fatigue. Alternatively, specification requirements agreed between the manufacturer and purchaser can be used; any such requirements shall be noted on the report sheet.

11 Data reporting

The results of testing conducted in accordance with this International Standard shall be reported on a data sheet containing, at a minimum, the information shown in the example test data reporting sheet in Annex B. A trace of the 10 differential pressure waveforms shall also be included in the report.

12 Identification statement (reference to this International Standard)

Use the following statement in test reports, catalogues, and sales literature when electing to comply with this International Standard:

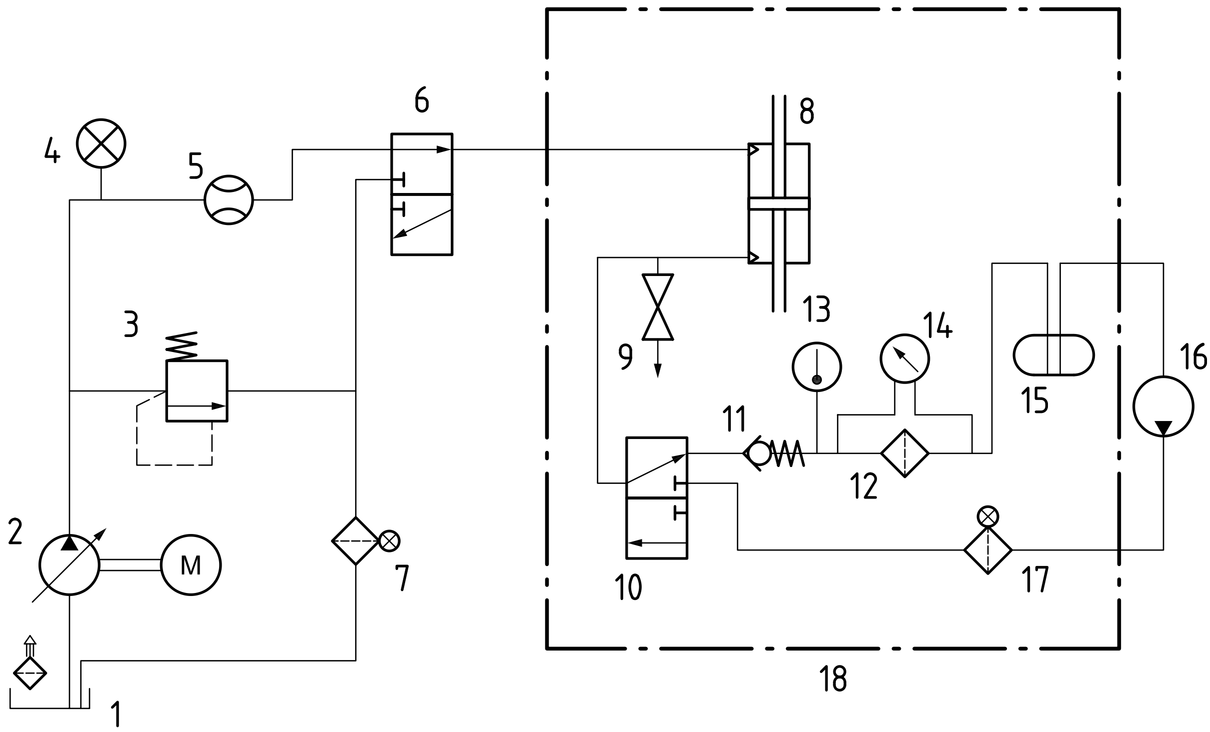
"Filter elements tested in accordance with ISO 16908."

Annex A
(informative)

Cold start test equipment

A.1 Test circuit

A suggested test circuit diagram for the entire cold start test rig is given in Figure A.1. Other circuits may be used as long as the filter assembly differential pressure waveform of Figure 1 is achieved.



Key

1	hydraulic power circuit reservoir	10	three-port directional valve
2	hydraulic power circuit pump and drive	11	non-return (check) valve
3	system pressure relief valve	12	test filter
4	system pressure transducer or pressure gauge	13	temperature transducer
5	flowmeter	14	differential pressure transducer
6	three-port directional valve	15	cold circuit reservoir
7	power circuit filter	16	cold circuit pump
8	transfer cylinder	17	cold circuit clean-up filter
9	sampling valve	18	cold test chamber

Figure A.1 — Suggested cold start test circuit

The circuit in Figure 1 consists of two sections. The power supply circuit is used for generating precisely controlled flow rate and pressure under ambient conditions to drive the transfer cylinder within the cold chamber. The test circuit within the cold chamber uses cold hydraulic fluid from the transfer cylinder to generate the differential pressure required across the filter, with the hydraulic fluid then collected in a cold circuit reservoir.

During the recharge cycle, valves 6 and 10 are shifted, and the cold circuit pump is used to drive cold hydraulic fluid back into the transfer cylinders, thereby forcing power circuit fluid back into the power supply reservoir. In both circuits, the fluid is forced through clean-up filters to maintain fluid cleanliness.

A.2 Test circuit components

A.2.1 Hydraulic power circuit pump and drive

The pump should be capable of providing sufficient fluid displacement to drive cold hydraulic fluid through the test filter at the flow rate and pressure required to achieve the waveform of Figure 1. A servo-controlled variable displacement pump is recommended, which uses the test filter differential pressure as the feedback loop control.

A.2.2 Hydraulic power circuit reservoir

A.2.2.1 A reservoir suitable for containing fluid in a clean environment, fitted with a lid to stop particulate or contaminant from entering the fluid, should be used.

A.2.2.2 The reservoir should be fitted with high- and low-fluid level sensors and the fluid lines should be located below the low-fluid level sensor to prevent aeration of the fluid.

A.2.2.3 The reservoir should be large enough to charge the hydraulic power circuit and the transfer cylinders without causing the reservoir's low-fluid level sensor to operate.

A.2.3 System pressure relief valve

The system pressure relief valve should be set to relieve pressure at a suitable system pressure in order to protect the parts of the equipment with the lowest rated pressure.

A.2.4 System pressure transducer or pressure gauge

A calibrated gauge-type pressure transducer or gauge that has a suitable range and that can be connected to a data recording system to continuously record the system pressure should be used.

A.2.5 Flowmeter

A flowmeter capable of measuring the flow rate through the hydraulic circuit is recommended, with an electronic signal output for continuous logging and display of the flow rate with a data recording system. Note that in Figure 1, the flowmeter is installed in the pressure line. In this location, the flowmeter shall be capable of withstanding the full pump pressure.

A.2.6 Three-port directional control valves

Three-port directional control valves are recommended for changing the mode of operation from normal testing to recharging mode for refilling the transfer cylinders in preparation for another test. The three-port valves can have either automatic or manual controls.

A.2.7 Clean-up filters

A.2.7.1 The circuit should contain clean-up filters capable of filtering the fluid to a solid contamination level of 13/11/09 or cleaner, expressed in accordance with ISO 4406.

A.2.7.2 The clean-up filter fitted in the cold circuit should be suitably sized to handle the high-viscosity conditions at the location chosen and to provide adequate life.

A.2.7.3 It is suggested that a differential pressure transducer or gauge be fitted across the clean-up filters to ensure the rated differential pressure for the filters is not exceeded.

A.2.8 Transfer cylinder

A cylinder or accumulator with two compartments separated by a sealing piston or diaphragm is recommended to isolate the higher temperature power supply fluid from the test fluid in the cold chamber. The transfer cylinder should be able to transmit the required flow rate and pressure at the minimum test temperature, without internal leakage.

A.2.9 Sampling valve

A sampling valve should be included upstream of the test filter to enable a sample of fluid to be taken from the system. The valve should be designed and fitted in accordance with ISO 4021.

A.2.10 Temperature transducer

A calibrated temperature transducer suitable for the required thermal range of the temperature conditioning and cold start test should be fitted in the line directly upstream of the filter housing.

A.2.11 Differential pressure transducer

A.2.11.1 A calibrated differential pressure transducer with a suitable range should be used to measure the differential pressure across the test filter housing. The transducer should give an electronic signal output for continuous logging and display of the differential pressure and include a data recording system.

A.2.11.2 The differential pressure transducer should be connected with pressure taps in accordance with ISO 3968.

A.2.12 Cold circuit reservoir

A.2.12.1 A reservoir suitable for containing fluid in a clean environment, fitted with a lid to stop particulate or contaminant from entering the fluid, should be used.

A.2.12.2 The reservoir should be fitted with high- and low-fluid level sensors and the level sensors should be capable of operating at ambient temperatures down to the minimum test temperature.

A.2.12.3 The fluid lines should be located below the low-fluid level sensor to prevent aeration of the fluid.

A.2.12.4 The reservoir should be large enough to contain the volume of fluid from the transfer cylinders without the reservoir high-fluid level sensor operating and should be filled adequately so that the low-fluid level sensor does not operate when the transfer cylinders are filled.

A.2.13 Cold circuit pump

A.2.13.1 The cold circuit pump is used for recharging the transfer cylinder. A low recharge rate is important, so the pump should be capable of providing low pressure and flow rate with cold oil at high viscosity.

A.2.13.2 The cold circuit pump is shown mounted outside the cold chamber, but it can be located within the cold chamber if it can withstand the temperature.

A.2.14 Piping

Piping, particularly within the cold chamber, should be suitable for continuous usage at the minimum test temperature and should not create any undue restriction to fluid flow.

Annex B
(informative)

Test data reporting form

<table>
<tr><td colspan="11">General test information</td></tr>
<tr><td>Test laboratory_______________</td><td colspan="4">Test date ____________</td><td colspan="6">Test operator_________________</td></tr>
<tr><td colspan="11">Filter and element identification</td></tr>
<tr><td colspan="3">Filter element part number__________________</td><td colspan="8">Filter housing part number ________________</td></tr>
<tr><td colspan="3">Filter element lot number ___________________</td><td colspan="8">Filter housing serial number _______________</td></tr>
<tr><td colspan="3">Filter element rated flow rate _______________ L/min</td><td colspan="8">Filter housing rated pressure ___________ MPa</td></tr>
<tr><td colspan="3">Filter element terminal differential pressure ______ MPa</td><td colspan="8"></td></tr>
<tr><td colspan="11">Test conditions</td></tr>
<tr><td colspan="3">Thermal conditioning</td><td colspan="8">Cold start test</td></tr>
<tr><td colspan="3">Test fluid type__________________________</td><td colspan="8">Test fluid type __________________________</td></tr>
<tr><td colspan="3">Test fluid cleanliness (ISO 4406 code) ________</td><td colspan="8">Required system pressure _____________ MPa</td></tr>
<tr><td colspan="11">Test results</td></tr>
<tr><td colspan="11">Thermal conditioning (if performed prior to cold start test)</td></tr>
<tr><td>High temperature ________ °C</td><td colspan="10">Time at high temperature ___________ h</td></tr>
<tr><td>Low temperature ________ °C</td><td colspan="10">Time at low temperature ___________ h</td></tr>
<tr><td colspan="11">Cold start test</td></tr>
<tr><td rowspan="2">Test parameter</td><td colspan="10">Test cycle</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td></tr>
<tr><td>Cold circuit fluid temperature (°C)</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Maximum power circuit flow rate (L/m) (optional)</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Maximum filter differential pressure recorded (MPa)</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Time at maximum filter differential pressure (s)</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="11">Attachment: Trace of the 10 differential pressure waveforms</td></tr>
</table>

Bibliography

[1] ISO 11170, *Hydraulic fluid power — Sequence of tests for verifying performance characteristics of filter elements*

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

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