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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*

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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](http://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](http://www.iso.org/patents)).

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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*.

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## 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.

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# 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*  
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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**

$\Delta p$

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 <sup>a</sup>	2 %	+5 % / -0 %
Gauge pressure	kPa <sup>a</sup>	2 %	5 %
Flow rate	L/min	2 %	
Temperature	°C	0,1 °C	5 °C

<sup>a</sup> 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

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**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  $15 \text{ s} \pm 1 \text{ s}$ .

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