International Standard ISO 4572

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Hydraulic fluid power — Filters — Multi-pass method for evaluating filtration performance

Transmissions hydrauliques — Filtres — Évaluation du rendement par la méthode de filtration en circuit fermé

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up 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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 4572 was developed by Technical Committee ISO/TC 131, *Fluid power systems and components*, and was circulated to the member bodies in December 1978.

It has been approved by the member bodies of the following countries :

Australia
Austria
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Canada
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Hungary
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The member bodies of the following countries expressed disapproval of the document on technical grounds :

France
South Africa, Rep. of

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Hydraulic fluid power — Filters — Multi-pass method for evaluating filtration performance

0 Introduction

In hydraulic fluid power systems, power is transmitted and controlled through a liquid under pressure within an enclosed circuit. The ideal filter for a hydraulic system offers infinite restriction to the passage of particulate contaminants, exhibits zero resistance to the flow of fluid and provides unlimited capacity for retained contaminant.

An actual filter cannot exhibit such phenomenal performance characteristics. Therefore, test procedures must be available to establish its degree of ideality (filter capability).

The performance characteristics of a filter are a function of the element (configuration and material) and the housing (general configuration and seal design).

In practice, a filter is subjected to a continuous flow of contaminant entrained in the hydraulic fluid until a specified terminal pressure drop (relief valve cracking pressure) results.

Both the length of operating time (prior to reaching the terminal pressure drop) and the contaminant level at any point in the system are functions of the rate of contaminant addition (i.e. rates of contaminant ingression and generation) and the capability of the filter.

Therefore, a realistic laboratory test which establishes filter capability must provide the test filter with a continuous supply of ingressed contaminant and allow the periodic monitoring of the performance characteristics of the filter

The contamination level of the fluid immediately downstream of a filter is directly related to the contamination level of the upstream fluid. The contamination level of a fluid is given by the particle size distribution. This distribution can be accurately measured for particle sizes greather than 10 µm using currently available automatic particle counters. However, particle size distributions associated with an operating system always exhibit higher cumulative particle counts at 10 and 20 µm than at larger sizes. Therefore the separation characteristics of a filter can be most accurately determined statistically by using the particle counts at the lower µm sizes.

Experience shows that optimum discrimination and excellent repeatability are achieved using cumulative particle counts at 10 µm.

Fluid samples must be extracted from the test system to evaluate the filter element's particulate removal characteristics. To prevent this sampling from adversely affecting the test results, a lower limit is placed upon the rated flow of filter elements which may be tested with this procedure. Thus the current maximum flow rate is based upon the maximum gravimetric level of contaminant injection systems which have so far been qualified whilst the current maximum 10 µm filtration ratio is based on the highest ratio for filters which have been tested in more than one laboratory. It has been determined that this procedure is currently only applicable for filter elements meeting the requirements given in clause 1.

Since it is difficult to specify, achieve and verify a cyclic flow requirement that is both realistic and consistent with the flow variations occuring in actual systems, the compromise of a steady-state condition has been used for this test to enhance the repeatability and reproducibility of results.

Additional information and verification data are provided in the annex.

1 Scope and field of application

This International Standard establishes a multi-pass filtration performance test with continuous contaminant injection for fine hydraulic fluid power filter elements.

It also includes a procedure for determining the contaminant capacity, particulate removal characteristics and pressure loss.

It also includes a test currently applicable to hydraulic fluid power filter elements which exhibit a 10 µm filtration ratio of less than 75, a final reservoir gravimetric level of less than 200 mg/L and a rated flow between 4 and 600 L/min.

This International Standard provides a test procedure which yields reproducible test data for evaluating the filtration performance of a fine hydraulic power filter element.

2 References

ISO 1219, *Fluid power systems and components — Graphic symbols.*

ISO 2942, *Hydraulic fluid power — Filter elements — Determination of fabrication integrity.*

ISO 2944, *Fluid power systems and components — Nominal pressures.*

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

ISO 3938, *Hydraulic fluid power — Contamination analysis data — Reporting method.*[1]

ISO 3968, *Hydraulic fluid power — Filter elements — Evaluation of pressure drop versus flow characteristics.*

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

ISO 4402, *Hydraulic fluid power — Calibration of liquid automatic particle-count instruments — Method using Air Cleaner Fine Test Dust contaminant.*

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

3 Definition

multi-pass test : A test which requires the recirculation of unaltered effluent fluid through the filter element.

For definitions of other terms used, see ISO 5598.

4 Graphical symbols

Graphical symbols used are in accordance with ISO 1219..

5 General procedure

5.1 Set up and maintain apparatus per clauses 6 and 7.

5.2 Run all tests per clauses 8, 9 and 10.

5.3 Analyze data from clauses 8, 9 and 10 per clauses 11, 12 and 14.

5.4 Present data from clauses 10 and 12 per clauses 13 and 15.

6 Test equipment

6.1 Use a suitable timer for measuring minutes and seconds.

6.2 Use an automatic particle counter calibrated per ISO 4402, or any ISO-approved counting method. The accuracy of this filter test procedure is dependent upon the counting method used.

6.3 Use air cleaner fine test dust or any other ISO-approved equivalent contaminant dried at 110 to 150 °C for not less than 1 h for quantities less than 200 g.

NOTE — This standard test dust has been widely used for many years and has been shown to be consistent and suitable for use in this test procedure.[2]

6.4 Use sample bottles containing less than 1,5 particles greater than 10 µm per millilitre per bottle volume, as qualified per ISO 3722.

NOTE — This degree of cleanliness ensures a contamination contribution from the sample bottle of less than one-tenth of the minimum expected effluent level of any filter for which this test procedure is applicable.

6.5 Use petroleum base test fluid conforming to the following specifications :

6.5.1 Properties of petroleum base stock

— pour point not lower than	− 59,4 °C
— flash point (min.)	93,3 °C
— acid or base number (max.)	0,10
— precipitation number	0

6.5.2 Additive materials

— viscosity-temperature coefficient improver — not to exceed 10 % (*m*/*m*)

— oxidation inhibitors — not to exceed 2 % (*m*/*m*)

— triceresyl phosphate antiwear agent — in the amount of 0,5 ± 0,1 % (*m*/*m*)

Limit the free phenol content of the TCP agent to a maximum of 0,05 % (*m*/*m*).

6.5.3 Properties of finished oil

— viscosity (mm^2/s at 40 °C) (min.) [3]	10,0
— viscosity (mm^2/s at − 40 °C) (min.) [3]	500
— pour point not lower than	− 59,4 °C
— flash point (min.)	93,3 °C
— precipitation number	0
— acid or base number (max.)	0,20

6.5.4 Colour of finished oil

Use oil which is clear and transparent and which contains a red dye in a proprotion not greater than one part of dye per 10 000 parts of oil (*m*/*m*) (used for identification only).

NOTE — The use of test fluid conforming to these specifications ensures greater reproducibility of results and is based upon current practices and other accepted filter standards. Fluid conforming to these specifications is available worldwide.

1) At present at the stage of draft.

2) This is commercially available. Details may be obtained from the Secretariat ISO/TC 131 or from the ISO Central Secretariat.

3) 1 mm^2/s = 1 cSt

6.6 Use a filter performance test circuit comprising a "filter test system" and a "contaminant injection sytem". A typical layout is shown in figure 1.

6.6.1 The filter test system consists of :

6.6.1.1 A reservoir constructed with a conical bottom having an included angle of not more than 90° and where the oil entering is diffused below the fluid surface.

NOTE — This reservoir design avoids a horizontal bottom and thus minimizes containing settling whilst the sub-surface diffusion reduces the entrainment of air.

6.6.1.2 A hydraulic pump which is essentially insensitive to contaminant as the operating pressures.

WARNING — Pumps exhibiting excessive flow pulses will cause erroneous results.

6.6.1.3 A system clean-up filter capable of providing an initial system contamination level of less than 15 particles greater than 10 µm per millilitre.

NOTE — This initial cleanliness ensures that the test results are not significantly influenced.

6.6.1.4 Pressure gauges, temperature indicator and controller, and flow meter.

6.6.1.5 Pressure taps in accordance with ISO 3968.

6.6.1.6 A means for turbulent sampling upstream and downstream of the test filter. Sample in accordance with ISO 4021.

6.6.1.7 Interconnecting lines which ensure that turbulent mixing conditions exist throughout the filter test system and that contaminant traps, silting areas and combinations of cyclonic separation zones and quiescent chambers are avoided.

6.6.2 The contaminant injection system consists of :

6.6.2.1 A reservoir constructed with a conical bottom having an included angle of not more than 90° and where the oil entering is diffused below the fluid surface.

NOTE — This reservoir design avoids a horizontal bottom and thus minimizes contaminant settling whilst the sub-surface diffusion reduces the entrainment of air.

6.6.2.2 A sytem clean-up filter capable of providing an initial system contamination level of less than 1 000 particles greater than 10 µm per millilitre and a gravimetric level less than 2 percent of the calculated level at which the test is being conducted.

6.6.2.3 A hydraulic pump (centrifugal or of another type which does not alter the contaminant particle size distribution).

6.6.2.4 A sampling means for the extraction of a small injection flow from a point in the contaminant injection system where active circulation of fluid exists. Sample in accordance with ISO 4021.

6.6.2.5 Interconnecting lines which ensure that turbulent mixing conditions exist throughout the contaminant injection system and that contaminant traps, silting areas and combinations of cyclonic separation zones and quiescent chambers are not present. In particular, turbulent mixing conditions must exist throughout the length of the line carrying the injection fluid.

6.7 Use membranes and associated laboratory equipment suitable for carrying out the double membrane gravimetric method.

7 Test conditions accuracy

Set up and maintain equipment accuracy within the limits given in table 1.

Table 1 — Test conditions accuracy

Test condition	Unit	Maintain within (±) of true value
flow	L/min	2 %
pressure	bar	2 %
temperature	°C	40 ± 2 °C
volume	L	2 %

8 Filter performance test circuit validation procedures

NOTE — These validation procedures reveal the effectiveness of the filter performance test circuit in maintaining contaminant entrainment and/or preventing contaminant size modification.

8.1 Validation of filter test system

8.1.1 Validate at the minimum flow that the filter test system will be operated.

NOTE — Install a filter housing of alternatively a conduit during validation.

8.1.2 Adjust the total test system fluid volume to be numerically equal to one-fourth of the value of the minimum volume per minute.

NOTE — This is the volume to flow ratio required for the filter test procedure (see 9.3.3).

8.1.3 Contaminate the system fluid to the calculated gravimetric level of 5 mg/L using air cleaner fine test dust.

NOTE — This contamination level is below the saturation limitations of automatic particle counters.

8.1.4 Circulate the fluid in the test system for 1 h and extract the fluid samples at 15, 30, 45 and 60 min.

8.1.5 Analyze the four fluid samples and record three cumulative particle counts at 10 and 20 µm for each sample.

8.1.6 Accept the validation test only if :

8.1.6.1 The average of all three particle counts obtained for a given size from each sample does not deviate by more than 10 percent from the average particle counts for that size from all samples.

8.1.6.2 The average of all particle counts per millilitre at 10 µm is not less than 600 nor more than 900.

8.1.6.3 The particle counts per millilitre at 20 µm are not less than 100 nor more than 150.

8.2 Validation of contaminant injection system

8.2.1 Validate at the maximum gravimetric level and the maximum injection circuit volume to be used (see 9.2.2 and 9.2.3).

8.2.2 Add the required quantity of contaminant in slurry form to the injection system fluid and circulate for 2 h.

8.2.3 Extract fluid samples at the point where the injection fluid is discharged into the filter test system at 30, 60, 90 and 120 min and analyze each sample gravimetrically.

8.2.4 Accept the validation test only if the gravimetric level of each sample is within ± 10 percent of the average of the four samples and ± 10 percent of the known gravimetric value.

9 Preliminary preparation

9.1 Test filter assembly

9.1.1 Ensure that the test fluid cannot bypass the filter element to be evaluated.

9.1.2 Subject the test filter element to a fabrication integrity test in accordance with ISO 2942.

9.1.2.1 Disqualify the element from further testing if it fails to meet the designated test pressure.

9.1.2.2 Where applicable, allow the fluid to evaporate from the test filter element before installing it in the test filter housing.

9.2 Contaminant injection system

9.2.1 Using 10 mg/L as a base upstream gravimetric level, calculate the predicted test time (τ') in minutes by the following equation :

$$\tau' = \frac{\text{(apparent capacity of filter element, mg)}}{\text{(10 mg/L) (test flow rate, L/min)}}$$

NOTE — A second element may be tested for capacity analysis if the value of the apparent capacity of the test element is not supplied by the filter manufacturer.

9.2.2 Calculate the minimum volume required for operation of the injection system (σ, litres) which is compatible with the above predicted test time (τ') and a value for the injection flow of 0,5 L/min using the following equation :

$$\sigma = 1{,}2\ (\tau',\ \text{min.})\ \text{(injection flow, L/min)}$$

NOTES

1 The volume calculated above will ensure a sufficient quantity of contaminated fluid to load the test element plus 20 percent for adequate circulation throughout the test. Larger injection system volumes may be used.

2 The 0,5 L/min value of the injection flow ensures that the downstream sample flow expelled from the filter test system will not significantly influence the test results even at the lower flow rate given in clause 1. Lower injection flow rates may be used provided that the base upstream gravimetric level of 10 mg/L is maintained. An injection flow rate below 0,25 L/min is not recommended due to silting characteristics and accuracy limitation.

9.2.3 Calculate the gravimetric level (γ', mg/L) of the injection system fluid using the following equation :

$$\gamma' = \frac{\text{(10 mg/L) (test flow, L/min)}}{\text{(injection flow, L/min)}}$$

9.2.4 Calculate the quantity of contaminant (ω, g) needed for the contaminant injection system using the following equation :

$$\omega,\ \text{g} = \frac{(\gamma',\ \text{mg/L})\ \text{(injection system volume, L)}}{1\ 000}$$

9.2.5 Adjust the injection flow rate at stabilized temperature to within ± 5 percent of the value selected in 9.2.2 and maintain throughout the test.

9.2.6 Adjust the total volume of the contaminant injection system to the value determined in 9.2.2.

9.2.7 Circulate the fluid in the contaminant injection system through its system clean-up filter until a contamination level of less than 1 000 particles greater than 10 µm per millilitre and a gravimetric level of less than 2 percent of the value determined in 9.2.3 are attained.

9.2.8 Bypass the system clean-up filter after the required initial contamination level has been achieved (see 6.6.1.3).

9.2.9 Add in slurry form the quantity of contaminant (g) as determined in 9.2.4 to the injection system reservoir.

9.2.10 Circulate the fluid in the injection system for a minimum of 15 min to thoroughly disperse the contaminant.

9.3 Filter test system

9.3.1 Install the filter housing (without the test element) in the filter test system.

9.3.2 Circulate the fluid in the filter test system at the rated flow and a stabilized test temperature of 40 ± 2°C and record the pressure drop at the empty filter housing.

9.3.3 Adjust the total fluid volume of the filter test system (exclusive of the system clean-up filter circuit) such that it is numerically equal to one-fourth of the value of the minimum volume flow per minute through the filter.

NOTE — Repeatable results require that the system volume be held constant. The specified 1/4 volume to flow ratio minimizes the physical size of the system reservoir as well as the quantity of test fluid required and maximizes the mixing conditions in the reservoir.

9.3.4 Circulate the fluid in the filter test system through the system clean-up filter until a contamination level of less than 15 particles greater than 10 µm per millilitre is attained.

NOTE — The time required to achieve the contamination level is directly proportional to the particle separation capability of the clean-up filter used.

9.3.5 Select and install suitable lengths of capillary tubing upstream and downstream of the test filter such that the initial upstream sample flow is 0,3 ± 0,05 L/min and the downstream sample flow is within 5 percent of the injection flow. Maintain uninterrupted flow from the two sampling points during the entire test.

9.3.6 Return the upstream sampling flow of the test filter directly to the reservoir when sampling is not in progress.

9.3.7 Collect the sampling flow downstream of the test filter outside the filter test system in order to assist in maintaining a constant system volume which should be kept within 15 percent of the required system volume.

10 Filter performance test

10.1 Install the filter element in its housing and subject the assembly to the specified test conditions (test flow with test temperature of 40 ± 2 °C) and recheck fluid level.

10.2 Measure and record the clean assembly pressure drop. Calculate and record the clean element pressure drop (clean assembly pressure drop minus the housing pressure drop measured in 9.3.2). (For nominal pressures, see ISO 2944.)

10.3 Calculate the pressure drops corresponding to increases of 5, 10, 20, 40, 80 and 100 percent of the net presure drop (arbitrary terminal pressure drop minus the clean element pressure drop).

NOTE — These percentage values provide an adequate number of data points for meaningful results.

10.4 Obtain a sample upstream of the test filter element to determine the system initial contamination level.

NOTE — Take all samples in such a manner as to minimize the aeration of the fluid sample.

10.5 Obtain a fluid sample from the contaminant injection system.

10.6 Measure and record the injection flow rate.

10.7 Initiate the filter test as follows :

10.7.1 Bypass the system clean-up filter.

10.7.2 Allow the injection flow to enter the filter test system reservoir.

10.7.3 Start the timer.

10.7.4 Start the downstream sample flow.

10.8 Record the test time (minutes) required for the pressure drop across the filter assembly to increase by 5, 10, 20, 40, 80 and 100 percent of the net pressure drop.

10.9 Extract upstream and downstream samples simultaneously at 2 min from test initiation and when the pressure drop across the filter assembly has increased by 10, 20, 40 and 80 (± 1) percent of the net pressure drop.

NOTE — Use identical sample time of not more than 30 s for both upstream and downstream samples. Since the sampling procedure requires the sample volume to be within 50 to 90 percent of the sample bottle volume, more than one size sample bottle may be required.

10.10 Conclude the test by stopping the flow to the test filter.

10.11 Obtain a fluid sample from the contaminant injection system.

10.12 Measure and record the injection flow rate.

11 Data accuracy

Select and maintain instrumentation so that data accuracy is within the limits in table 2, unless otherwise specified.

Table 2 — Data accuracy

Quantity	Unit	Accuracy within (±) of true value
injection flow rate	L/min	5 %
base upstream gravimetric level	mg/L	1 mg/L

12 Calculations

12.1 Analyze the samples extracted from the filter test system by determining the number of particles greater than 10, 20, 30 and 40 µm per millilitre with an automatic particle counter calibrated per ISO 4402, or any ISO-approved counting method.

NOTE — Care should be taken to dilute samples appropriately to avoid exceeding the saturation limit determined by the approved calibration procedure for the particular counting method used.

12.1.1 Obtain a minimum of three particle counts for each fluid sample and calculate and record the arithmetic average for each size range counted.

12.1.2 Accept the test only if the number of particles greater than 10 µm per millilitre in the initial sample from the filter test system is less than 15.

12.2 Conduct a gravimetric analysis on the two samples extracted from the contaminant injection system and on the upstream sample extracted from the filter test system at the 80 percent sample point.

NOTE — The final sample is taken at the 80 percent point because it often overlaps the 100 percent point.

12.2.1 Record the 80 percent gravimetric value as the final system gravimetric level.

12.2.2 Calculate the average (γ) of the gravimetric levels for the two samples from the contaminant injection system.

12.2.3 Accept the test only if the gravimetric level of each sample is within ± 10 percent of this average.

12.3 Calculate and record the injection flow rate by averaging the measurements taken at the beginning and end of the test.

12.3.1 Accept the test only if this value is equal to the selected value ± 5 percent.

12.4 Calculate and record the actual base upstream gravimetric level by multiplying the average injection gravimetric level (γ, mg/L) by the average injection flow rate (L/min) per 12.3 and dividing by the test flow (L/min).

12.4.1 Accept the test only if this value is equal to 10 ± 1 mg/L.

12.5 Calculate the filtration ratio as defined in the annex.

12.5.1 Record these calculated ratios as shown in figure 3.

12.5.2 Record the minimum filtration ratio in figure 3.

13 Data presentation

13.1 Record the following minimum information for filter elements evaluated using this International Standard :

13.1.1 Present all test and calculation results as shown in figure 3.

13.2 Using the actual time (τ) required to reach the terminal pressure drop, the average gravimetric level (γ) of the injection stream and the injection flow rate, calculate the filter element air cleaner fine test dust capacity (α) using the following equation :

$$\alpha, \text{g} = \frac{(\gamma, \text{mg/L})\ (\text{injection flow rate L/min})\ (\tau, \text{min})}{1\ 000}$$

13.2.1 Record the air-cleaner fine test dust capacity as shown in figure 3.

13.3 Report the values of the gravimetric levels obtained in 12.2.

13.4 Have available a record of the following minimum test data in test reports referencing this International Standard :

a) all physical values pertaining to the test;

b) all additional provisions or modifications pertaining to the test;

c) record the counting method used.

14 Criteria for acceptance

14.1 Compare the minimum filtration ratio (β_{10}) with the designated value.

14.2 Compare the filter element air cleaner fine test dust capacity (α) with the designated value.

14.3 Check that there is no visual evidence of filter element damage as a result of performing this test.

15 Summary of designated information

The following designated information is needed when applying this International Standard to a particular application or use :

a) fabrication integrity test pressure (see ISO 2942);

b) filter element test flow;

c) terminal pressure drop;

d) the minimum acceptable filtration ratio (β_{10});

e) the minimum acceptable filter element capacity (α) for air cleaner fine test dust.

16 Justification statement

Justification is as set forth in the annex.

17 Test/production similarity

Apply the managerial controls necessary to maintain substantial similarity between test and production components or elements.

18 Justification 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 :

"Method for determining filtration performance data conforms to ISO 4572, *Hydraulic fluid fower — Filters — Multi-pass method for evaluating filtration performance*."

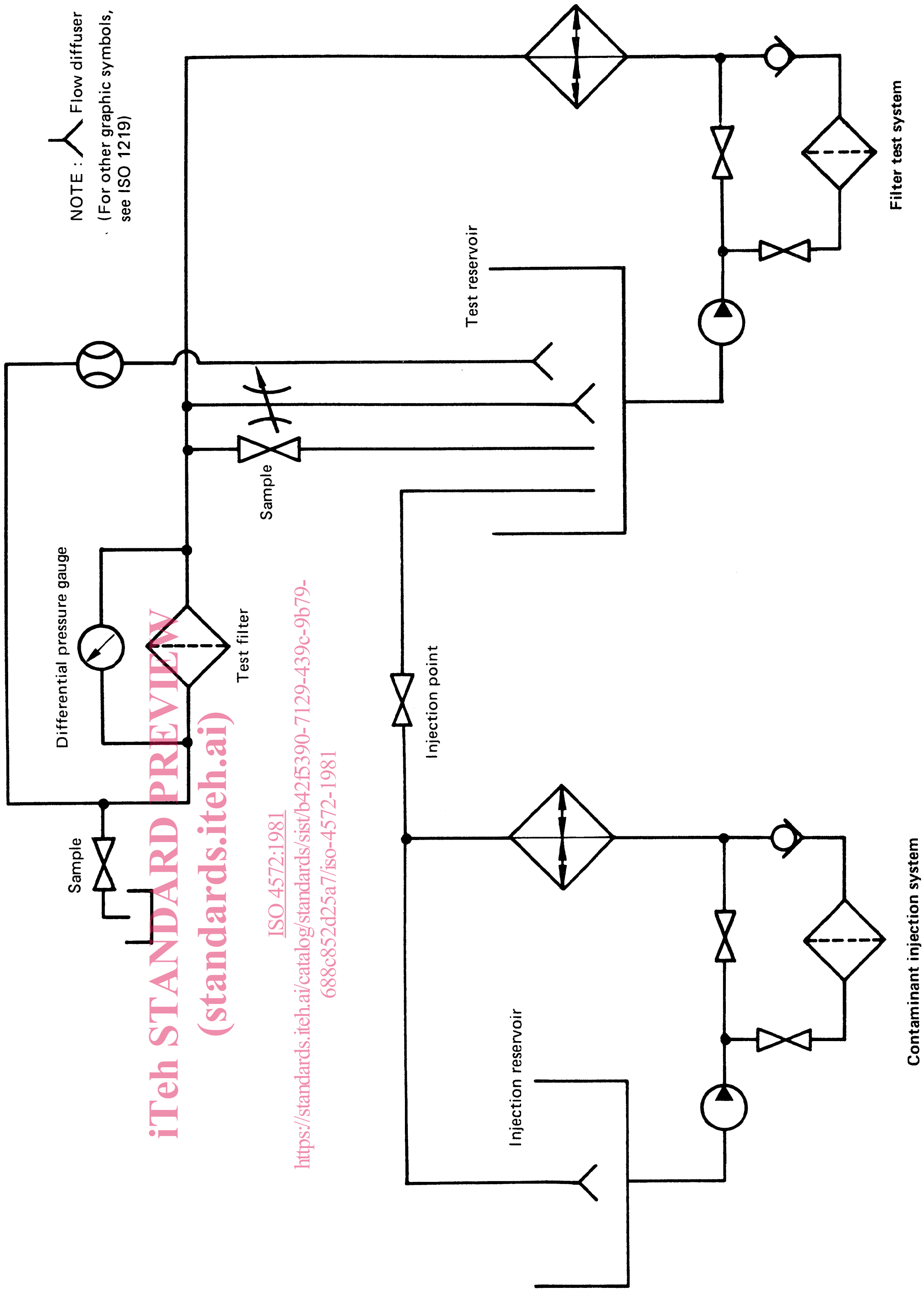

Figure 1 — Typical filter performance test circuit