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Hydraulic spin-on filters with finite lives — Method for verifying the rated fatigue life and the rated static burst pressure of the pressure-containing envelope

bsi.

National foreword

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Hydraulic spin-on filters with finite lives — Method for verifying the rated fatigue life and the rated static burst pressure of the pressure-containing envelope

Filtres hydrauliques à visser ayant une durée de vie spécifiée — Méthode de vérification de la durée de vie nominale en fatigue et de la pression statique d'éclatement nominale de l'enveloppe sous pression

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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).

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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 an enclosed circuit. A basic requirement of hydraulic fluid power components is that they should be capable of adequately containing the pressurized fluid.

The pressure to which an individual component can normally be subjected has a relationship with the rated fatigue pressure and minimum burst pressure. This relationship can be estimated and used as a basis of total life expectancy for the component in an individual application. Such an estimate is applied by the user. Factors such as shock, heat, misuse, etc., are to be judged by the user in each application. Selection of a specific pressure and life expectancy for a component in a particular application can be based upon the rated fatigue pressure and burst pressure as described in Figure 1. This finite life pressure rating test procedure differs from the (NFPA)T2.6.1 R2 infinite life pressure rating document (which is referred to in ISO/TR 10771-2) and can be visualized from the S-N diagram in Figure 1. (NFPA) T2.6.1 R2 is a rating system along the vertical axis, with its fatigue strength distribution and assurance level in the vertical direction at a defined life. The finite life method described in this document is a rating system along the horizontal axis, with its fatigue life distribution and assurance level in the horizontal direction at a defined stress (pressure).

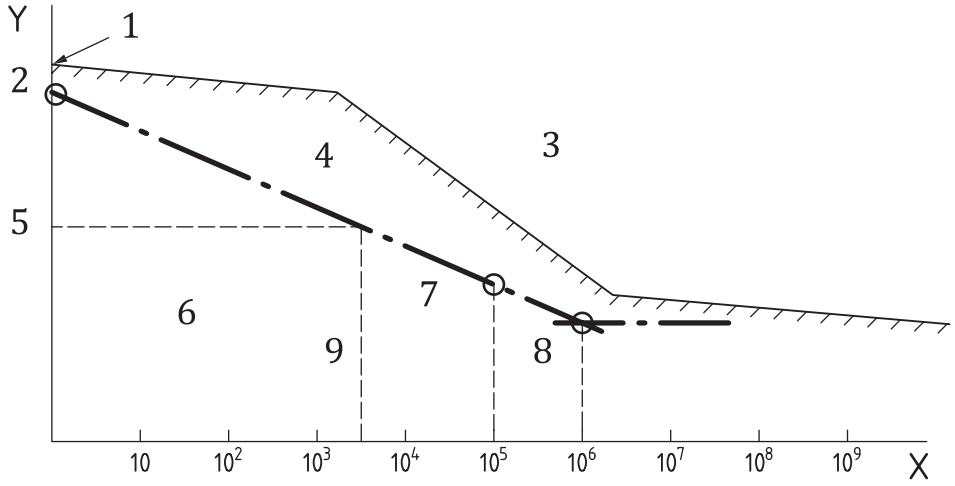


Figure 1 — Possible S-N curve method for estimating finite life rating

Because the service life of the element container for a finite life spin-on hydraulic filter is relatively short, a fatigue life of 100 000 cycles is judged sufficient for common industrial ratings. Ratings at levels other than 100 000 cycles are permitted; this document may be applied for those cases. The method of rating includes both pressure and minimum life. The pressure rating of the filter head or mounting base can be subjected to the full 10^6 fatigue cycles established by (NFPA)T2.6.1 R2.

The spin-on housing, because of its construction, can be tested and evaluated as an elastic body with specific pressure cycle test times and pressure rise rate conditions.

It needs to be noted that this document deals only with verifying the pressure ratings of spin-on filters. Separate from this verification procedure, manufacturers have the continuing responsibility to use managerial controls necessary to test spin-on filters that are representative of production.

Hydraulic spin-on filters with finite lives — Method for verifying the rated fatigue life and the rated static burst pressure of the pressure-containing envelope

WARNING — The use of this document can involve hazardous materials, operations and equipment. This document does not purport to address all of the safety concerns associated with its use. The user of this document is responsible, prior to its use, to establish appropriate safety and health practices and to determine the applicability of regulatory limitations.

1 Scope

This document specifies methods for verifying the rated fatigue life and the rated static burst pressure of the pressure-containing envelope (i.e. the filter housing) of a spin-on hydraulic filter with a disposable filter element and a finite life.

Because the service life of housings for these types of filters is relatively short, a rated fatigue life of 100 000 cycles is judged sufficient for typical industrial applications.

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 19972-1, *Hydraulic fluid power — Methods to assess the reliability of hydraulic components — Part 1: General procedures and calculation method*

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:

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

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

3.1
rated fatigue life
N_f
minimum life, expressed in cycles, with a specified assurance level, that a filter housing can sustain at a rated pressure

3.2
rated fatigue pressure
p_{fr}
pressure that a filter housing can sustain for a specific number of cycles without failure

3.3
rated static burst pressure
p_{Br}
pressure that the pressure-containing envelope of a component can sustain without failure

3.4
spin-on filter
filter assembly of which the filter element, housing and means of attaching are unitised into one inseparable part

4 Samples

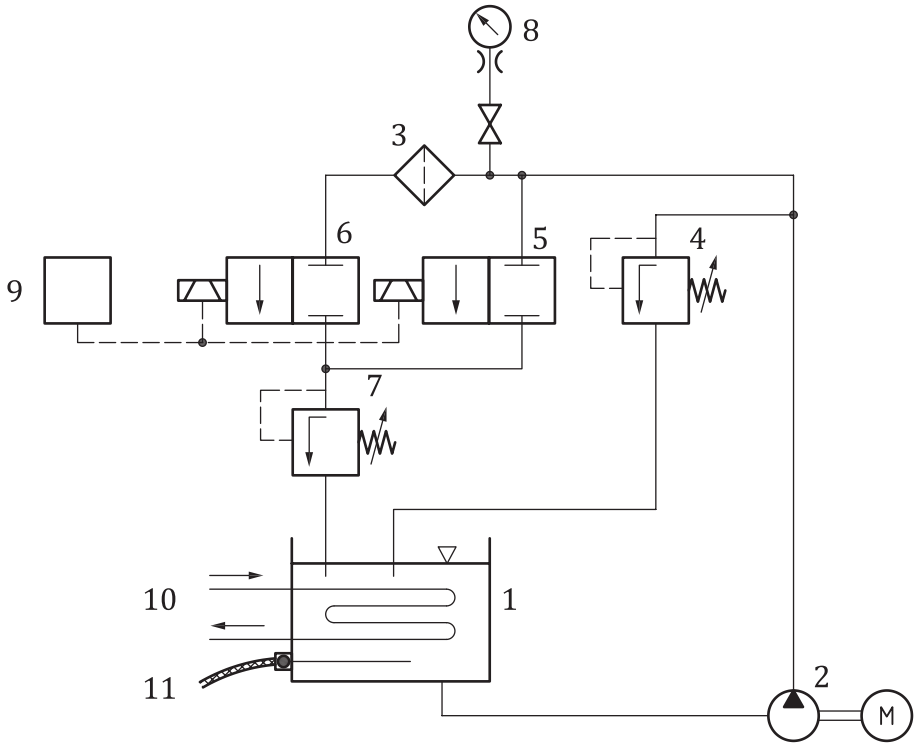
Two samples, each consisting of a minimum of six filters under test that are representative of normal production, shall be prepared. One of these samples shall be subjected to the cyclic endurance test and the other to the burst test.

5 Cyclic endurance test to verify the rated fatigue life at a rated fatigue pressure

5.1 Test equipment

5.1.1 Hydraulic test stand, that is capable of producing repeatable pressure impulses that conform to the requirements of 5.3.4. Figure 2 shows a circuit diagram of a typical test stand that can be used for this procedure.

NOTE The actual cyclic test pressure exceeds the measured test pressure if the frequency response of the measurement system or its components is insufficient to reproduce the actual waveform, thereby penalizing the component under test.



Key

1	reservoir	7	outlet pressure control valve
2	pump	8	pressure gauge
3	filter under test	9	component controls
4	inlet pressure control valve	10	heat exchanger
5	solenoid valve	11	thermostat
6	solenoid valve		

Figure 2 — Circuit diagram of typical test stand

5.1.2 Test liquid, MIF-PRF-5606H or a suitable non-corrosive hydraulic fluid.

5.1.3 Oscilloscope computerized recording system or **light beam recorder with sufficient speed,** to properly record the test waveform.

5.1.4 Pressure-measuring instrument, mounted directly into, or as close as possible to, the filter head or base through a pressurized port that is not being used to supply the test liquid. The pressure-measuring instrument shall not be installed in the line that supplies the test liquid to the test filter and shall be set up and maintained so that pressure measurements are accurate within the limits specified in Table 1. If the test setup allows multiple filters to be tested simultaneously, pressure shall be measured at each filter under test, to ensure that each filter is subjected to the pressure impulsing.

5.1.5 Thermometer, set up and maintained so that the temperature measured is accurate within the limits specified in Table 1.

5.2 Test conditions

5.2.1 Unless otherwise specified, the rated fatigue life for filters tested in accordance with this document is a minimum of 100 000 cycles.

5.2.2 The test equipment shall maintain a uniform test fluid temperature of 50 °C ± 10 °C, unless otherwise specified.

5.2.3 The instruments used to measure test parameters shall provide the reading accuracy specified in Table 1. Variations in test conditions shall be maintained within the tolerances specified in Table 1.

Table 1 — Instrument accuracy and test condition variation

Test condition	SI unit	Instrument accuracy — tolerance on reading	Allowed test condition variation
Pressure	kPa	±2 %	±3 %
Test fluid temperature	°C	±3 °C	±10 °C
Cycle rate	Hz	—	±10 %

5.3 Test procedure

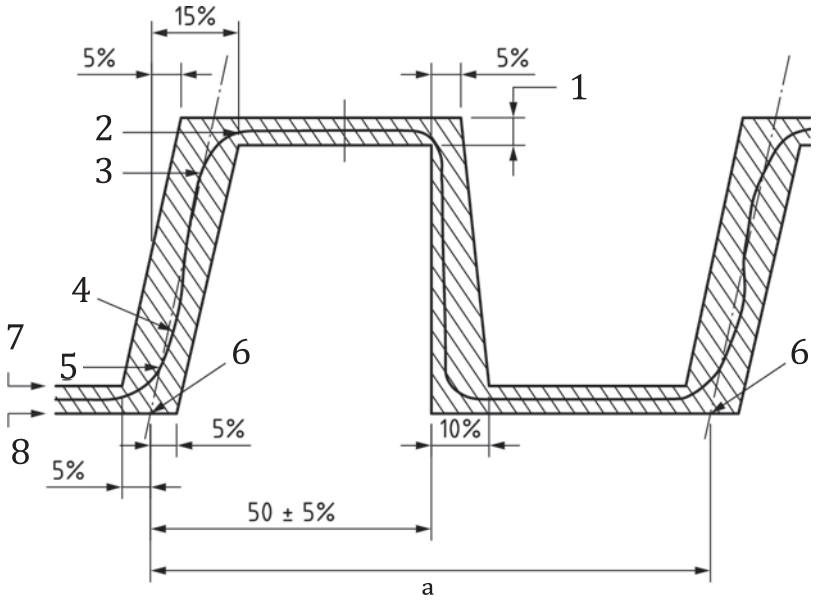
5.3.1 Apply torque to all threaded items in accordance with the manufacturer's recommendations. Document the torque installation value on the test report.

CAUTION — Torque, gasket lubrication and other factors have major effects on tests of the filter's structure.

5.3.2 Bleed entrapped air from the circuit and from the filters being tested.

5.3.3 Ensure that the temperature of the test liquid meets the requirements of 5.2.2, and record the temperature.

5.3.4 Apply a pulsating pressure to the filter under test with a pressure cycle that falls within the shaded area of Figure 3, which is taken from ISO 4548-5, at a rate between 0,5 Hz and 0,66 Hz; record the frequency used. A frequency higher than 0,66 Hz may be used if satisfactory experience of testing at higher frequencies exists; any such experience shall be stated in the test report. The cyclic test pressure shall be the rated fatigue pressure at the proposed rated fatigue life.



Key

1	test pressure ±5 %	5	15 % cyclic test pressure
2	cyclic test pressure	6	point "0" – the intersection of the secant pressure rise with zero pressure
3	85 % test pressure	7	5 % cyclic test pressure
4	secant pressure rise	8	0 kPa
a	One impulse cycle.		

Figure 3 — Test waveform

5.3.5 Test each filter under test to failure (see 5.4), and record the number of cycles at failure. When several filters are tested simultaneously in one setup and one filter fails, the failed filter shall be replaced with a new one, until all original test filters have failed.

5.4 Failure criteria

Any of the following occurrences shall be considered a failure:

a) any change from original shape;

b) external leakage of any amount caused by fatigue;

c) material separation (e.g. cracks).

5.5 Calculation of rated fatigue life at rated fatigue pressure

5.5.1 Report all test values and the modes of failure.

5.5.2 Use data from a minimum of six filters under test (see 5.3.5) as the sample, but if more than six filters under test failed, all data from all failed filters under test shall be evaluated.

5.5.3 Use Weibull analysis, as specified in ISO/TR 19972-1, to calculate the β_{10} life, N_f, at the 95 % confidence level.

5.6 Verification

If the calculated rated fatigue life, N_f, exceeds the proposed rated fatigue life (100 000 cycles, unless otherwise specified), the rated fatigue life and rated fatigue pressure of the spin-on filter shall be considered verified.

6 Burst test to verify the rated static burst pressure

6.1 Test equipment

6.1.1 **Hydraulic test stand**, that provides a stable and controllable hydrostatic fluid pressure.

6.1.2 **Test liquid,** any suitable non-corrosive liquid.

6.1.3 **Pressure-measuring instrument,** mounted directly into, or as close as possible to, the filter head or base through a pressurized port that is not being used to supply the test liquid. The pressure-measuring instrument shall not be installed in the line that supplies the test liquid to the test filter and shall be set up and maintained so that pressure measurements are accurate within ±2 %.

6.1.4 **Thermometer**, set up and maintained so that the temperature measured is accurate within ±3 °C.

6.2 Test conditions

6.2.1 The rated static burst pressure to be verified shall be selected.

6.2.2 The test equipment shall maintain a uniform test fluid temperature of 30 °C ± 10 °C.

6.3 Test procedure

6.3.1 Apply torque to all threaded items in accordance with the manufacturer's recommendations. Document the torque installation value on the test report.

CAUTION — Torque, gasket lubrication and other factors have major effects on tests of the filter's structure.

6.3.2 Bleed entrapped air from the circuit and from the filters being tested.

6.3.3 Ensure that the temperature of the test liquid meets the requirements of 6.2.2, and record the temperature.

6.3.4 Apply pressure to each filter under test, then increase it slowly to 0,5 times the rated static burst pressure selected in 6.2.1 and maintain this pressure for 60 s.

6.3.5 Increase the pressure in intervals of 5 % of the rated static burst pressure selected in 6.2.1 or of 100 kPa (1 bar), holding the pressure for 60 s between each increase in pressure.

6.3.6 Continue the incremental pressure increases until failure, as defined in 6.4, occurs. Record the pressure at failure.

6.3.7 Use data from a minimum of six filters under test as the sample, but if more than six filters under test failed, all data from all failed filters under test shall be evaluated.

6.4 Failure criteria

Any of the following occurrences shall be considered a failure:

a) any structural failure;

b) any crack produced by internal static pressure, as verified by magnetic particle or fluorescent penetrant techniques after testing;

c) any leakage at seals or sealing surfaces;

d) any permanent deformation that interferes in any way with the proper functioning of the pressure-containing envelope.

6.5 Calculation of rated static burst pressure

6.5.1 Use data from a minimum of six filters under test (see 6.3.7) for the sample.

6.5.2 Use Weibull analysis, as specified in ISO/TR 19972-1, to calculate the rated static pressure, p_{Br}, at the 95 % confidence level.

6.6 Verification

If the calculated lower pressure limit exceeds the selected rated static burst pressure, then the rated static burst pressure shall be considered verified.

7 Presentation of data

7.1 The following minimum information shall be included in test reports referencing this document:

a) rated fatigue life, N_f, and the rated fatigue pressure, p_{fr}, and the cycle life on which these values are based;

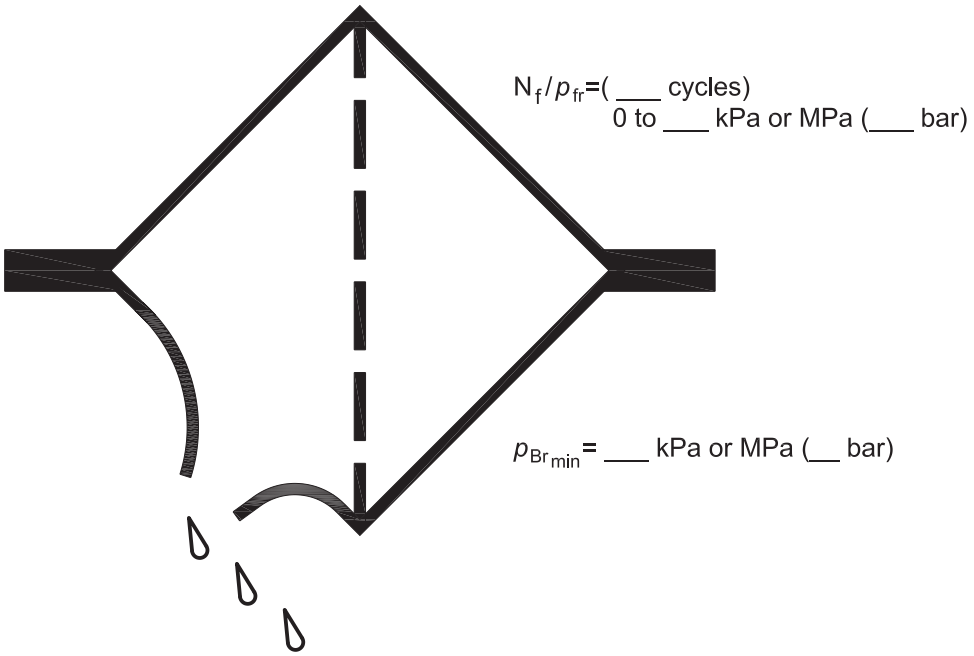
b) rated static burst pressure, p_{Br}, and the number of filters under test on which the rated static burst pressure is based.

7.2 This information may be presented in one or both of following ways:

a) as text

For example, a filter element with a rated fatigue life of 100 000 cycles verified at a rated fatigue pressure of 0 kPa to 1 000 kPa (0 to 10 bar), based upon a (–3σ) confidence level is designated as follows: “Rated fatigue life of 100 000 cycles at a rated fatigue pressure of 0 kPa to 1 000 kPa (10 bar)”;

b) using the relevant symbol from ISO 27407 to communicate the rated fatigue life, rated fatigue pressure and the rated static burst pressure of a spin-on filter, as shown here:



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8 Verification of rated fatigue life, rated fatigue pressure and rated static burst pressure by similarity

It is not necessary to test all designs of a family of spin-on filter housings if all designs have identical configurations except for variations in the lengths of cylindrical sections, elements or filter media. If the variation is in the length of a cylindrical section, the rated fatigue life, rated fatigue pressure and rated static burst pressure shall be verified by testing the longest and shortest designs in the family.

9 Similarity between filters under test and production components

All necessary managerial controls shall be used to maintain substantial similarity between filters under test and production components.

10 Identification statement (reference to this document)

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

"Method of verifying rated fatigue life, rated fatigue pressure and rated static burst pressure of a spin-on hydraulic filter housing in accordance with ISO 12829, *Hydraulic spin-on filters with finite lives — Method for verifying the rated fatigue life and the rated static burst pressure of the pressure-containing envelope*."

Annex A
(informative)

Results of the round robin test program conducted to verify the procedure specified in this document

A.1 Burst test

A.1.1 Results

Table A.1 shows the results of round robin burst pressure tests conducted to evaluate the procedure specified in this document. Five test facilities participated in the evaluations. The test specimens were spin-on hydraulic filters with an outside diameter of 92 mm from a single manufacturing batch.

Table A.1 — Results of burst pressure tests on spin-on hydraulic filters

Values in MPa (bar)

	Test facility					
	1	**2**	**3**	**4**	**5**	
Test data	1,90 (19,0)	2,07 (20,7)	1,90 (19,0)	1,79 (17,9)	1,96 (19,6)	
	1,79 (17,9)	1,90 (19,0)	1,92 (19,2)	1,86 (18,6)	1,90 (19,0)	
	2,21 (22,1)	1,93 (19,3)	1,94 (19,4)	1,90 (19,0)	1,85 (18,5)	
	1,90 (19,0)	2,21 (22,1)	2,00 (20.0)	1,94 (19,4)	1,99 (19,9)	
	2,00 (20.0)	2,21 (22,1)	1,90 (19,0)	1,86 (18,6)	1,86 (18,6)	
	2,00 (20,0)	1,90 (19,0)	1,86 (18,6)	1,73 (17,3)	1,89 (18,9)	
Mean	1,97 (19,7)	2,03 (20,3)	1,92 (19,2)	1,85 (18,5)	1,90 (19,0)	1,94 (19,4)[a]
Standard deviation	0,14 (1,4)	0,15 (1,5)	0,04 (0,4)	0,08 (0,8)	0,05 (0,5)	0,09 (0,9)[a]
Rated static pressure at 95 % confidence level	1,74 (17,4)	1,83 (18,3)	1,86 (18,6)	1,73 (17,3)	1,82 (18,2)	

[a] The means in the last column are the means of the means from each test facility data set and their five corresponding standard deviations.

A.1.2 Conclusions and supplemental information

A.1.2.1 In all reported cases, the failure mode was that the gasket (seal) blew out.

A.1.2.2 Statistically, test results are from one lot. There is no significant difference between results from different test facilities.

A.2 Cyclic endurance test

A.2.1 Results

Table A.2 shows the results of round robin cyclic endurance pressure tests conducted to evaluate the procedure specified in this document. Five test facilities participated in the evaluations. The test specimens were spin-on hydraulic filters with an outside diameter of 92 mm from a single manufacturing batch.

Table A.2 — Results of cyclic endurance tests on spin-on hydraulic filters, in number of cycles when tested at a rated fatigue pressure of 0 to 1,21 MPa (0 to 12,1 bar)

	Test facility										
	1	FM[a]	2	FM[a]	3	FM[a]	4	FM[a]	5	FM[a]	
Test data	56 815	S	66 500	T	66 591	G	51 569	T	74 498	T	
	89 832	T	86 300	T	67 891	G	97 727	T	90 142	T	
	115 096	S	90 800	T	71 990	G	97 772	G	132 629	S	
	119 498	T	104 500	T	72 560	S	108 410	T	136 287	S	
	119 853	T	119 200	T	76 898	T	126 258	T	144 472	S	
	124 297	S	133 400	S	77 115	T	134 132	G	161 000	G	
Mean	104 231,8		100 116,7		72 174,2		102 644,7		123 838,0		100 600,7[b]
Standard deviation	26 280,9		24 078,8		4 391,5		29 116,8		32 342,5		18 477,3[b]
$\beta 10$	78 386		70 104		65 523		70 745		87 752		–

[a] FM = failure mode. The key to the abbreviations in the columns is: G = gasket or seal blew out; T = tap plate broke; S = housing seam cracked.

[b] The mean and standard deviations in the last column are the means of the means from each test facility data set and their five corresponding standard deviations.

A.2.2 Conclusions and supplemental information

A.2.2.1 The test facilities reported three distinctly different failure modes.

A.2.2.2 Statistically, test results are not from one lot. There is a significant difference even within individual test facilities.

A.2.2.3 The test procedure proves that the filters under test had not been subjected to adequate manufacturing control for a fatigue pressure range of 0 to 1,21 MPa (0 to 12,1 bar). The manufacturer confirmed the defects and inconsistencies from historical comparison. The test procedure worked, as it proved that the sample lot should be disqualified.

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