



SURFACE VEHICLE STANDARD

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Automatic Transmission Intake Filter Test Procedure

RATIONALE

This document has been revised for clarity, simplification, and inclusion of the latest advances in transmission intake filter validation testing.

1. SCOPE

This test procedure is intended to apply to hydraulic pump suction filters and strainers used in automotive automatic transmissions that include hydraulic power pumps. The various paragraphs of Section 5 include a variety of tests and alternative tests that are not applicable to all filters and applications, so the engineer must specify which tests are to be performed for a particular application. These test procedures are intended to evaluate filter functional performance characteristics only, durability is not evaluated under this standard.

Filter design requirements must be specified by the engineer on the filter assembly drawing, an applicable engineering specification, or summarized on an application data sheet similar to that found in this recommended practice. See Figure 6.

Pressure circuit filters, both barrier and system contamination control types, are not covered under this standard. They are similar in design and construction to filters used in many hydraulic and lubricating applications. Testing for pressure filters are covered by the ISO and SAE standards listed under references in Section 2.

1.1 Purpose

The purpose of this standard is to establish test methods to evaluate critical performance characteristics of automatic transmission intake (suction) filters. These filters need ratings for flow capacity, temperature range, contaminant capacity, filter efficiency, and other critical functional characteristics. These characteristics should be representative of a production feasible design and are to be applied to the filter assembly. Pressure side filters are covered by other existing test standards and practices.

Prior use of “nominal” and “absolute” filter ratings as applied to a filter’s ability to capture particles of a given size have been deprecated. This standard predicates the use of “filtration ratios” (efficiency) or “beta ratios” to describe the capture effectiveness under reproducible test conditions using a known test contaminant.

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Documents

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2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE HS-806-2009, SAE Oil Filter Test Procedure ISBN 978-0-7680-2155-4, Discontinued, limited availability.

2.1.2 ISO Publications

Copies of these documents are available online at <http://webstore.ansi.org/>.

ISO 1219-1	Fluid Power Systems and Components - Graphic Symbols and Circuit Diagrams - Part 1: Graphic Symbols for Conventional Use and Data Processing Applications
ISO 3722	Hydraulic Fluid Power - Fluid Sample Containers - Qualifying and Controlling Cleaning Methods
ISO 3724	Hydraulic Fluid Power - Filter Elements - Determination of Resistance to Flow Fatigue Using Particulate Contaminant.
ISO 3968	Hydraulic Fluid Power - Filters - Evaluation of Pressure Drop Versus Flow
ISO 4021	Hydraulic Fluid Power - Particulate Contamination Analysis - Extraction of Fluid Samples from Lines of Operating Systems
ISO 4405	Hydraulic Fluid Power - Fluid Contamination - Determination of Particulate Contamination by Gravimetric Method
ISO 4406	Hydraulic Fluid Power - Method of Coding Level of Contamination by Solid Particles
ISO 5598	Fluid Power Systems and Components - Vocabulary
ISO 11171	Hydraulic Fluid Power - Calibration of Automatic Particle Counters for Liquids
ISO 11841-1	Road Vehicles and Internal Combustion Engines - Filter Vocabulary - Part 1: Definitions of Filters and Filter Components
ISO 11841-2	Road Vehicles and Internal Combustion Engines - Filter Vocabulary - Part 2: Definitions of Characteristics of Filters and Their Components
ISO 11943	Hydraulic Fluid Power - On-Line Liquid Automatic Particle Counting Systems - Method of Calibration and Validation
ISO 12103-1	Road Vehicle - Test Dust for Filter Evaluation - Part 1: Arizona Test Dust
ISO 16889	Hydraulic Fluid Power - Filters - Multi-Pass Method for Evaluating Filtration Performance of Filter Elements
ISO 16232	Road Vehicles - Cleanliness of Components and Systems

2.1.3 U.S. Government Publications

Copies of these documents are available online at <https://quicksearch.dla.mil>.

MIL-H-5606J Performance Specification - Hydraulic Fluid, Petroleum Base: Aircraft and Ordnance

MIL-DTL-8815D W/ Attachment 2 Filter and Filter Elements, Fluid Pressure, Type II Systems, General Specifications

2.1.4 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org

ASTM MNL32-5th Test Sieving Methods : Guidelines for Establishing Sieve Analysis Procedures, 5th Edition

ASTM C778-17 Standard Specification for Standard Sand

2.2 Other Publications - General Information References

2.2.1 Eleftherakis, J. and Khalil, A., "Advanced Filter Test Methods - Utilizing the Multi-Pass Test," TAPPI Press, 1993.

2.2.2 Eleftherakis, J. and Khalil, A., "Development of a Laboratory Test Contaminant for Transmissions," SAE Technical Paper 900561, 1990, <https://doi.org/10.4271/900561>.

2.2.3 Eleftherakis, J. and Khalil, A., "Test Methods for Automotive Filtration," SAE Technical Paper 930016, 1993, <https://doi.org/10.4271/930016>.

2.2.4 Hummel, P., "Advancements in Automotive Transmission Sump Filtration," SAE Technical Paper 960535, 1996, <https://doi.org/10.4271/960535>.

2.2.5 Chapter 14 in "Design Practices: Passenger Car Automatic Transmissions," (Warrendale, SAE International, 2012), doi:10.4271/AE-29.

2.2.6 Khalil, A., Eleftherakis, J., Parnell, D., Bill, P. et al., "Advances in Automatic Transmission Cleanliness," SAE Technical Paper 2001-01-0372, 2001, <https://doi.org/10.4271/2001-01-0372>.

3. TERMS AND DEFINITIONS

For the purpose of this document, the terms and definitions given in ISO 5598, ISO 11841-1, and ISO 11841-2 together with the following apply.

3.1 FILTER

A device whose primary function is to capture and retain insoluble contaminants from a fluid.

3.2 FILTER COMPONENTS

The parts that make up a filter.

3.2.1 BAFFLE

A device to prevent direct flow impingement or to guide the flow. Can be used inside the filter housing to prevent tunneling and channeling through the media by distributing the flow. When used on the outside of the filter, a baffle can prevent air ingestion during maneuvering or it can be used to guide spent fluid to the filter inlet.

3.2.2 BY-PASS VALVE

Used to allow fluid to by-pass the media, usually to give adequate flow under extreme cold conditions or where the filter is blocked by contamination. May be temperature or pressure regulated.

3.2.3 COLD FLOW PATCH

A woven screen welded or otherwise placed over a by-pass opening in the filter media to improve fluid flow under extreme cold conditions.

3.2.4 FILTER FEET

Risers on the bottom of the filter to keep the filter housing off the sump pan and allow fluid flow to the filter inlet.

3.2.5 MEDIA GROOVING

Shallow ridges in the filter medium perpendicular to the roots of the pleats.

3.2.6 FILTER HOUSING

A ported enclosure which directs the flow of fluid through the filter element.

3.2.7 INTERNAL SUPPORT

A permeable structural part which imparts rigidity to a filter element, and is primarily used to prevent filter element collapse.

3.2.8 FILTER MEDIA

The porous layer of material that performs the actual particle interception, i.e., does the filtering.

3.2.9 JET NOZZLE

A shaped port directed into the pump intake so as to supercharge the fluid entering the pump intake.

3.2.10 PLEATS

A series of folds in the filter medium of uniform or variable height and spacing, used to increase filter media area.

3.2.11 PLEAT ROOT

The inner fold of a pleat.

3.2.12 SEAL

A component or feature used to prevent cross media leakage or hydraulic short circuit thereby insuring leak free separation of hydraulic circuits.

3.2.13 SUPPORT RIBS

Part or feature used to provide support to the filter media so as to prevent collapse. May also be configured to act as a baffle to direct flow or prevent media damage from high velocity flow impingement.

3.3 FILTER ACCESSORIES

Auxiliary devices incorporated into a filter to enhance its usefulness.

3.3.1 MAGNET

A magnet integrated into the housing which attracts and holds ferromagnetic particles.

3.3.2 VALVE, INERTIAL SHUTTLE INLET

A valve that moves in response to the forces associated with maneuvering, switching the fluid intake between two possible inlet openings so the inlet used is always submerged in fluid thereby preventing air ingestion.

3.3.3 VALVE, THERMOSTATIC

A valve that operates in response to a change in temperature, usually installed in a by-pass circuit to open and provide enhanced flow under cold conditions where the increased viscosity of the fluid prevents the fluid from moving readily through the filter media.

3.4 FILTER ELEMENT TYPES

Classification of filter elements by construction, application, or method of filtration.

3.4.1 INTAKE FILTER ELEMENT

A filter element, which is installed in the pump intake line. Also known as a suction filter.

3.4.2 SERIAL FILTRATION MEDIA

Two or more media layers of different pore size used to capture and retain successively finer particles.

3.4.3 PARALLEL FILTRATION MEDIA

Two or more media grades of different pore sizes arranged in parallel flow pattern for capturing and retaining particles.

3.4.4 STRAINER

A coarse filter element typically constructed from woven screen mesh.

3.4.5 SURFACE ELEMENT

A filter element that uses a woven or punched single layer filter element material with uniform hole sizes. The particle capture and retention mechanism is by straining or sieving of particles larger than the nominal hole size.

3.5 FILTER MEDIA

The porous materials, which performs the actual process of filtration.

3.5.1 ABSORBENT MEDIA

A filter medium that holds contaminant by mechanical means.

3.5.2 BINDER

Material applied to media during process, usually by dipping or spraying, to prevent media fiber migration or shedding in use.

3.5.3 COMBI™ (COMBINATION) MEDIA

A filter composed of two or more types, grades, or arrangements of filter media to provide performance, which is not available in a single filter media.

3.5.4 DEPTH MEDIA

A thick media layer that uses adsorption and entanglement as the particle capture and retention mechanism.

3.5.5 MESH

The count or number of mesh opening per linear distance in a woven filter cloth, e.g., “250 mesh” indicates 250 wires per linear inch. Usually specified in inches, but may be specified in centimeters.

3.5.6 NON-WOVEN MEDIA

A filter media composed of a random mat of fibers.

3.5.7 WOVEN MEDIA

A filter medium made from strands of fiber, thread, or wire repetitiously interlaced into a cloth on a loom.

3.6 FILTER OPERATING CONDITIONS

Conditions that may occur during operation of the filter throughout its useful life.

3.6.1 FILTER LOADING

A filter element that is loaded with a controlled laboratory test contaminant.

3.6.2 BRIDGING

A condition of filter element loading in which contaminant particles span the filter media pore openings blocking a portion of the useful filtration flow area.

3.6.3 BURST

An outward structural failure of the filter element caused by excessive differential pressure.

3.6.4 CAKING

An accretion of contaminant or particulate that can result in reduced flow and at the same time increased filtration efficiency.

3.6.5 CLEAN FILTER

A new or properly cleaned filter element.

3.6.6 FILTER ELEMENT COLLAPSE

An inward structural failure of the filter element caused by excessive differential pressure.

3.6.7 CONTAMINATED FILTER

A filter element which contains foreign particles resulting from handling, storage, or fabrication.

3.6.8 DIRTY FILTER

A used filter element that is partially or completely loaded.

3.6.9 FATIGUED FILTER

A structural failure due to flexing caused by cyclic differential pressure.

3.6.10 LOADED (PLUGGED) FILTER

A filter element that has collected a sufficient quantity of insoluble contaminants such that it can no longer pass rated flow without excessive differential pressure.

3.6.11 PINCHED MEDIA PLEAT

A pleat partially or fully closed off by excessive differential pressure or crowding, thus reducing the effective area of the filter element.

3.6.12 RUPTURED MEDIA

Any tear or split in the filter medium.

3.6.13 SERVICE LOADED FILTER

A filter element, which is loaded from actual use.

3.6.14 TUNNELING (CHANNELING OR BYPASSING)

Breakdown of the filter media caused by focused fluid flow; a hole or tear caused by high energy (kinetic or thermal) fluid stream.

3.7 FILTER PERFORMANCE

The following describe the functions and attributes of a filter or filter element.

3.7.1 BETA RATIO (FILTRATION RATIO)

A value calculated by measuring particle size concentration upstream and downstream of the filter assembly, used as an indicator of filter efficiency.

$$\beta_x \beta_x = \frac{\text{Number of particles larger than X upstream}}{\text{Number of particles larger than X downstream}} \quad (\text{Eq. 1})$$

3.7.2 BUBBLE POINT

The differential gas pressure at which the first steady stream of gas bubbles are emitted from a wetted filter element under specified test conditions. It is used as a means to indicate the media pore size or to test the fabrication integrity (damage) of the filter.

3.7.3 BURST PRESSURE

The pressure which causes rupture. Also, the inside-out differential pressure that causes outward structural or filter medium failure of a filter element.

3.7.4 BURST PRESSURE RATING

The maximum specified inside-out differential pressure which can be applied to a filter element without outward structural or filter medium failure.

3.7.5 COLLAPSE PRESSURE

The outside-in differential pressure that causes structural or filter medium failure of a filter element.

3.7.6 COLLAPSE PRESSURE RATING

The maximum specified outside-in differential pressure which can be applied to a filter element without inward structural or filter medium failure.

3.7.7 CONTAMINANT CAPACITY

There are two measures for contaminant capacity in filter testing:

3.7.7.1 INJECTED CAPACITY

The weight of a specified artificial contaminant, which must be added to the influent to produce a given differential pressure across a filter at specified conditions.

3.7.7.2 RETAINED CAPACITY

The weight of particulate contaminant effectively retained by the filter element when terminal pressure is reached. This is an empirical value that can be calculated from test data by subtracting the weight of contaminant remaining in the test stand at the end of test from the injected capacity. The retained capacity may be used as an indication of the filter's relative service life.

3.7.8 CONTAMINANT MIGRATION (UNLOADING)

Contaminant, previously captured by the media, that has passed through the media, been released, and has proceeded downstream.

3.7.9 DIFFERENTIAL PRESSURE (PRESSURE DROP)

The difference in pressure between the filter inlet and outlet due to fluid flow.

3.7.10 EFFECTIVE MEDIA AREA

The total area of the porous medium in a filter element exposed to flow. Note that the flow through the media is usually not the same everywhere because of the proximity and configuration of the housing, flow distribution channels, media supports, and baffles and, as a result, some areas of the filter media may be less utilized than other areas.

3.7.11 EFFICIENCY

The ability, expressed as a percent, of a filter to remove a specified contaminant at a given contaminant concentration under specified test conditions.

3.7.12 FLOW FATIGUE

A structural failure of the filter medium due to flexing caused by cyclic flow forces.

3.7.13 LARGEST PARTICLE PASSED

The diameter of the largest hard spherical particle that will pass through a filter under specified test conditions (refer to MIL-DTL-8815D).

3.7.14 MEDIA MIGRATION

Contaminant, in the form of filter media that has separated from its substrate, or manufacturing debris left in the filter assembly, that is released and proceeds downstream.

3.7.15 OPEN AREA RATIO

The ratio of pore area to total area of a filter medium expressed as a ratio, fraction, or percent. This is applicable to woven or perforated filter media.

3.7.16 PERMEABILITY

The relationship of flow per unit area to differential pressure across a filter medium.

3.7.17 PORE SIZE DISTRIBUTION

The ratio of the number of holes of a given size to the total number of holes per unit area expressed as a percent and as a function of hole size.

3.7.18 POROSITY

The ratio of pore volume to total volume of a filter medium expressed as a percent. Applicable to depth media such as sintered or non-woven filter media.

3.7.19 PRESSURE FATIGUE

A structural failure of the filter medium due to flexing caused by cyclic differential pressure.

3.7.20 RESIDUAL CONTAMINANT CAPACITY

The contaminant capacity remaining in a service loaded filter element after use, but before cleaning, measured under the same conditions as the contaminant capacity of a new filter element.

3.7.21 SLOUGHING OFF

The release of contaminant from the upstream surface of a filter element to the upstream side of the filter enclosure.

3.7.22 TERMINAL PRESSURE

That differential pressure required to produce a specified flow rate at a specified viscosity when the filter has reached its specified contaminant capacity.

3.7.23 TORTUOSITY

The ratio of the average effective flow path length to minimum theoretical flow path length (thickness) of a filter medium.

3.7.24 TOTAL MEDIA AREA

The entire area of a porous media, whether effective or not, in a filter element.

4. TESTS AND EQUIPMENT

4.1 Hydraulic Test Circuits

The circuits illustrated in Figures 1A and 1B are based on approved practice outlined in ISO 16889 to test filters operating at pressures above atmospheric—"pressure mode." These circuits are suitable for completing all tests in this recommended practice except "pressure drop versus flow rating" at extreme cold temperatures, generally taken to mean temperatures below -20 °C. Figure 1A shows the preferred circuit for completing the 5.1.1 test, and Figure 1B shows the preferred circuit for completing the 5.1.2 test. This is because they permit direct measurement of particle size concentration and distribution by automatic particle counters. Figures 2A and 2B illustrate circuits appropriate when test filter flow is compelled via atmospheric—generally known as "suction mode." These circuits are likewise suitable for evaluating "steady state multi-pass efficiency" (see Figure 2A) and "pulsed flow efficiency" (see Figure 2B); however, this alternate method infers influent contaminant concentration via reservoir sampling in lieu of upstream and downstream particle counting. Both methods, "pressure mode" or "suction mode," require validation in accordance with procedures outlined below (see 4.4.7.3). For either method, the test stand supply must be capable of producing sufficient flow, controlling temperature, and pressure, and maintaining the test contamination in suspension throughout the test.

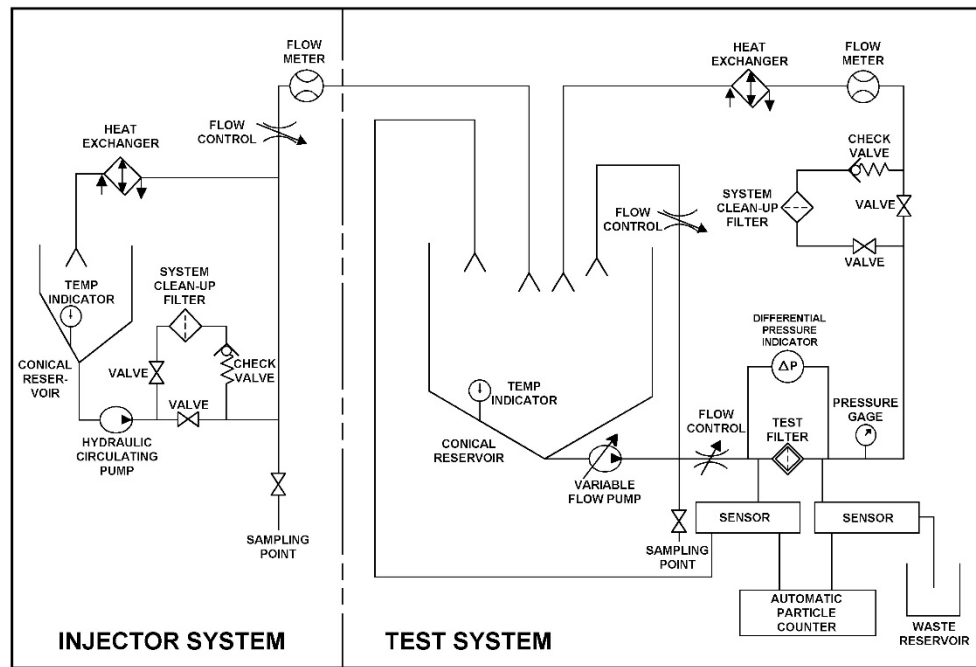


Figure 1A - Typical intake filter test circuit: pressure mode, steady state multi-pass test

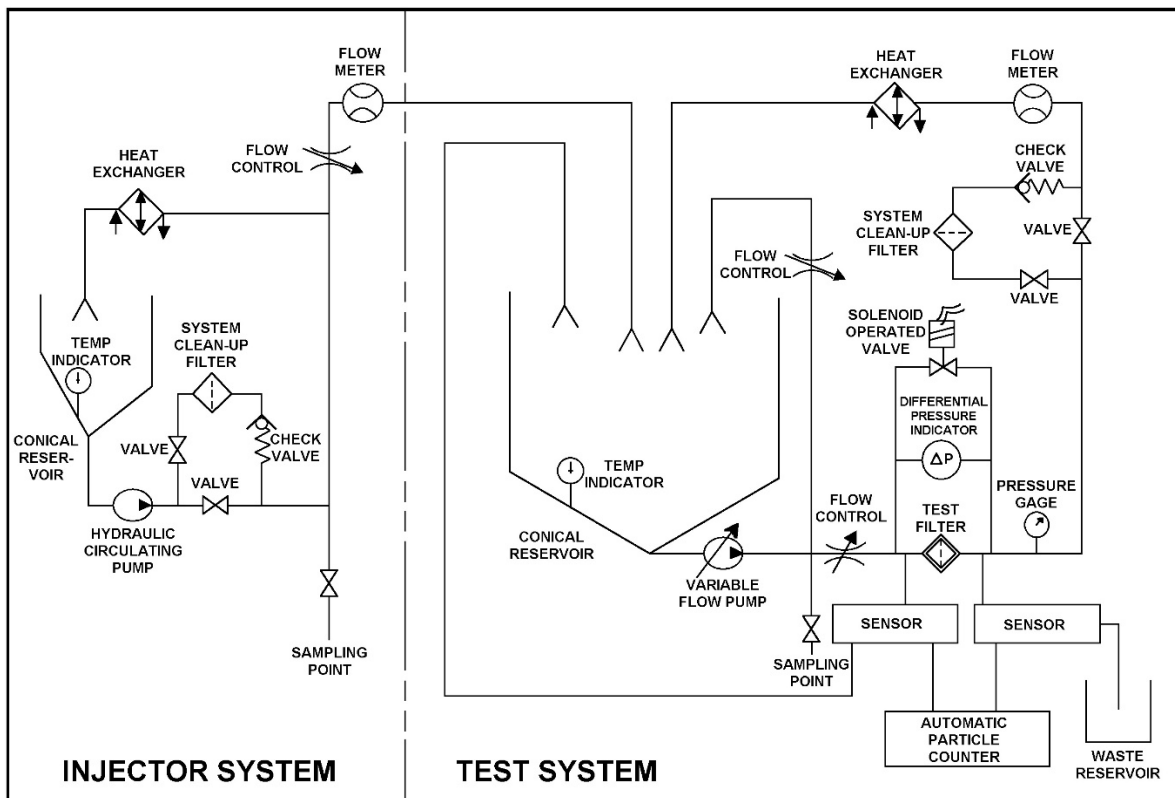


Figure 1B - Typical intake filter test circuit: pressure mode, pulsed flow efficiency test