Hyster-Yale Group, Inc. **Title:** METHOD FOR GRAVIMETRIC DETERMINATION OF PART CLEANLINESS	**Document Control Number:** **K146**
Page 1 of **10** **Document Author:** Maurice Sifri / Bob Downey	**Effective Date:** 01-Feb-2016 **Revision No.** 2016-02

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1.0 OBJECTIVE: Defines the gravimetric method to determine the cleanliness of a part.

2.0 SCOPE: This method applies to gravimetric testing of HYG parts.

3.0 CITED: See Master Index for a complete list of Citing & Cited Documents.
For reference, cited documents are shown in Appendix 1.

4.0 DEFINITIONS: See Master Glossary for a complete list of definitions.
For reference, definitions specific to this document are shown in Appendix 1.

5.0 GENERAL: Overview

This procedure was established to assure consistency among gravimetric measurements. Listed methods are consistent with ISO 4405 and ISO 18413.

The gravimetric method involves measuring the mass (mg) of contaminant per surface area (m^2). This is done by:

- Weighing a filter element
- Washing the surface of a part with filtered test liquid
- Passing the test liquid (with included contamination) through the filter element
- Drying the contaminated filter element
- Weighing the contaminated filter element

The difference in mass between the first and second measurements is equal to the mass of contaminant washed from the part.

Magnetism

- Residual magnetic fields in parts attract and hold ferrous particles which will transfer to the next higher assembly. Although demagnetizing all parts is not required by this specification, it is good manufacturing practice to demagnetize magnetic parts and check for residual magnetic fields as part of a comprehensive cleaning program.

This procedure addresses the following measurement methods:

- Pressure Rinse Method
  Used for simple shapes and housings such as gears, plates, shafts, spools, rods, pistons, hardware, seals, reservoirs (tanks), etc.
- Agitation Method
  Used for hoses and tubes

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Test Liquid

- The test liquid should be compatible with all materials used in the part or component, as well as with the functional liquid of the final system. The test liquid should also be compatible with all test apparatus, including seals and filters, and filtered to a level suitable for the process. A low viscosity test liquid is recommended. Viscosity of the test liquid should be ≤ 5 mm2/s at the test temperature.

Appropriate test fluids (Aliphatic Hydrocarbons) such as:

Exxon D80 or D60, Ashland 140, Shell Sol 140, Acros Organics Product 23302 (Petroleum ether, extra pure, boiling range 100-140°C) or equivalent.
Citrikleen or equivalent (3% minimum concentration)*

* Use of Citrikleen is approved for wash down of hydraulic tanks and steer cylinders with loose end caps only. At completion of wash down, the process must finish with a minimum of two rinse cycle to remove Citrikleen emulsifiers and detergent residue. Citrikleen is not approved for use in closed assemblies such as valves, pumps and other cylinders. The residual emulsifiers, detergents, and water present in Citrikleen are not allowed in these assemblies due to potential seal compatibility issues, rust cause by residual water, and the potential for water to end up in the hydraulic systems.

WARNING – Exercise care when using test liquids with low flash points. Consult Material Safety Data Sheet for the product of use.

6.0 DESCRIPTION:

Pressure Rinse Method:

Summary of Method

Parts are washed with a clean test liquid using a pressurized spray. Rinsing should be performed with the highest practical liquid turbulence. The fluid and contaminant thus removed are collected and weighed to determine the amount of contaminant per part, and the cleanliness value is determined by dividing the contaminant weight by the washed surface area of the part.

The cleanliness level of a part as determined by this method depends greatly on test parameters (such as rinse pressure, liquid volume, spray nozzle, etc.). These parameters shall be stated in the inspection document and strictly followed by test personnel.

Equipment

Filter Membranes With nominal pore sizes less than 1.2 μm for test liquid cleaning and 5.0 μm for contaminant collection.

Filtration Equipment See Figure 1.

Collecting Pan	Stainless steel is preferred.
Vacuum pump	Capable of establishing a vacuum of 86 kPa (12.5 psi).
Filtered Test Liquid Sprayer	Capable of furnishing spray at 200-400 kPa (29-58 psi) pressure.
Probe	Stainless steel
Analytical Balance	With an accuracy of +/- 0.1 mg.
Drying Oven	Capable of maintaining a temperature of 80 +/- 2°C.
Clean Room	While a clean room is not required, good housekeeping and 5S auditing with records will be expected. This will be part of the audit process.
Magnetism Indicator	At discretion of the tech the magnetism can be checked and recorded on the test report. If magnetism gauge is used it is not required to be a calibrated unit and can be used for "reference only"
Microscope	With calibrated scale for sizing particles.
Desiccator	

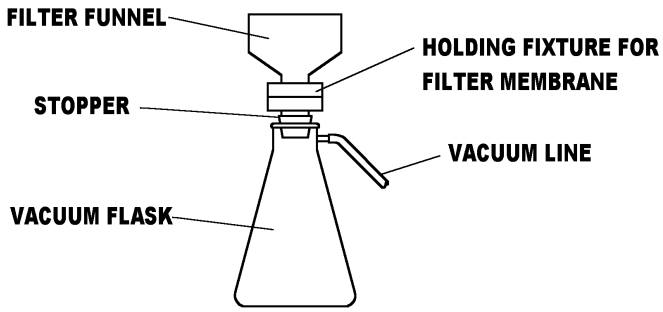


Figure 1, Filtration Equipment

Pressure Rinse Procedure

1. Prefilter test liquid through a filter membrane of less than or equal to 1.2 μm pore size.
2. Clean all collection apparatus to less than or equal to 5% of the allowable contamination level of the component. Any collection apparatus should be covered after cleaning and prior to use in order to prevent contamination from the environment. Sample containers shall be sufficiently clean so as not to affect results of the contaminant analysis.

Note: It is possible for contaminant remaining on the apparatus to be transferred to the sample, and included as part of the contaminant attributed to the component.

3. Assure that the benchtop to be used is clean and free from any visible contaminant.
4. Clean the drying oven. If static electricity is a problem, install a ground wire to the oven frame.

5. Measure and record magnetism of the part being checked. If magnetic field strength is greater than 5 gauss, demagnetize the part to a level less than 5 gauss and record the new level of magnetism. If the part cannot be demagnetized, the level of magnetism should be noted on the test report.
6. Dry all filter membranes in an oven at 80 +/- 2°C for a minimum of 15 minutes, then place filter membrane in desiccator and allow to cool to room temperature.
7. Weigh pre-dried filter membranes. Record mass to +/- 0.1 mg.
8. Install filter membrane in gravimetric filtration apparatus (Figure 1). If static electricity is a problem, install a ground wire to all metallic equipment.
9. Thoroughly wash all surfaces to be checked for cleanliness using pressurized 200 to 400 kPa (29 to 58 psi) test liquid. The test liquid collecting pan should be deep enough to collect the fluid effectively. The parts should be oriented to minimize splashing. Any grinding chips, heat treat scale, casting inclusions, or other particles which can be loosened from the part with the laboratory probe must be added to the collected test liquid.
10. Turn on vacuum pump. Pass all the collected test liquid through the pre-dried 5.0 μm filter membrane. Intermittent operation of the pump may be required to drain the funnel.
11. Thoroughly flush the collecting pan, allowing the flushing test liquid to pass through the filter membrane.
12. Without turning vacuum off, remove funnel assembly and gently rinse any residual contamination from the funnel base onto the filter disk using a squeeze bottle and prefiltere rinsing test liquid. Allow the vacuum pump to run for approximately 10 additional seconds.
13. Carefully remove filter membrane and place it in the drying oven set at 80 +/- 2°C for a minimum of 15 minutes. NOTE: The oven should be located as close as possible to the gravimetric equipment.
14. Place filter membrane in desiccator and allow to cool to room temperature.
15. Reweigh the filter membrane and record mass to +/- 0.1 mg.
16. Place filter membrane in a protective cover.

Calculation

Calculate the contaminant weight of the part as follows:

$$C = (Y-X) / A$$

Where: C = contamination of part, in mg/m^2
X = mass of clean membrane in mg (see item 7)
Y = mass of loaded membrane in mg (see item 15)
A = washed surface of area of part in m^2

Absolute Maximum Particle Size

Applies if the part drawing specifies an Absolute Maximum Particle Size.

- Place filter membrane under the microscope with a scale calibrated in micrometers.
- Scan the entire field of the membrane. Gauge large particles for size (>500µm) using eyepiece graticule; photograph and measure these particles and determine the number of particles larger than the maximum particle size, as specified on the part drawing, as well as the size of the largest particle observed. Particle size is the length of the longest dimension.
- Record the number of particles of each size over the maximum particle size specified (e.g., >500µm) and the maximum particle size.
- If possible, determine composition of largest particle size.

Generally, repeating the test twice on the same part ensures that contaminates are broken loose especially during the slosh test. The technician may, based on experience of tests, conduct double rinses for a single test.

At the discretion of the technician the Test Repeatability can be used as needed when evaluating new types of components.

Test Repeatability

In order to check the effectiveness of the part-washing step (see item 9), recheck one out of every ten parts by repeating steps 5 through 16 on parts that have just been checked for cleanliness.

If the calculated value of the results of the second measurement, divided by the results of the first measurement is greater than 0.10, a more thorough wash down of the part is required.

$$\frac{\text{mg Second Test}}{\text{mg First Test}} \leq 0.10$$

Report

Report the following information for each part tested:

- Contamination in mg/m^2
- Cleanliness classification per K144

If the part drawing specifies a critical particle size, report the following information:

- Absolute Maximum Particle Size observed in microns (µm)
- The size of particles and number of particles of each size exceeding the Absolute Maximum Particle Size specification on the part drawing.

Agitation Method: Summary of Method

Contaminant is collected by partially filling the test item with a known volume of test liquid, sealing the openings, and agitating the test item in order to remove the contaminant from the controlled surfaces and suspend it in the test liquid.

The cleanliness level of a part as determined by this method depends greatly on test parameters such as type of agitation, duration of agitation, choice of test liquid, etc. These parameters shall be stated in the inspection document and strictly followed by testing personnel.

WARNING – Exercise care when using test liquids with low flash points. Consult Material Safety Data Sheet for the product of use.

Desiccator

Agitation Procedure

1. Prefilter test liquid through a filter membrane of less than or equal to 1.2 μm pore size.
2. Clean all collection apparatus to less than or equal to 5% of the allowable contamination level of the component. Any collection apparatus should be covered after cleaning and prior to use in order to prevent contamination from the environment. Sample containers shall be sufficiently clean so as not to affect results of the contaminant analysis.

   Note: It is possible for contaminant remaining on the apparatus to be transferred to the sample, and included as part of the contaminant attributed to the component.
3. Assure that the benchtop to be used is clean and free from any visible contaminant.
4. Clean the drying oven. If static electricity is a problem, install a ground wire to the oven frame.
5. At the discretion of the technician, measure and record magnetism of the part being checked. If magnetic field strength is greater than 5 gauss, demagnetize the part to a level less than 5 gauss and record the new level of magnetism. If the part cannot be demagnetized, the level of magnetism should be noted on the test report.
6. Dry all filter membranes in an oven at 80 +/- 2°C for a minimum of 15 minutes, then place filter membrane in desiccator and allow to cool to room temperature.
7. Weigh pre-dried filter membranes. Record mass to +/- 0.1 mg.
8. Install filter membrane in gravimetric filtration apparatus (Figure 1). If static electricity is a problem, install a ground wire to all metallic equipment.

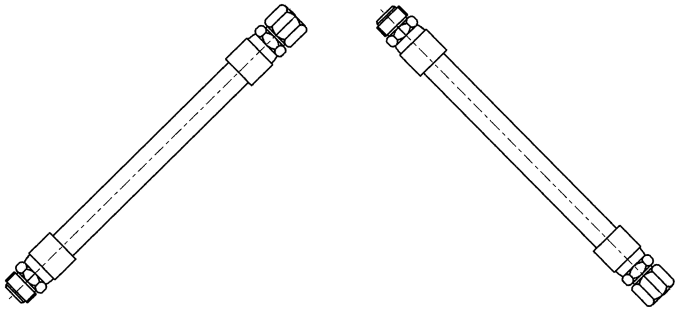
9. Calculate volume of test liquid (slosh fluid). This shall be 1/2 the internal hose volume.

   Fill an appropriately sized graduated cylinder, via filter nozzle, with the calculated amount of test liquid.

   Plug a single end of the sample hose or tube assembly, dispense contents of graduated cylinder into the open end, and then plug same.

   With calculated amount of test liquid contained within the hose or tube assembly, both ends must be sealed to prevent leakage regardless of position and / or movement of the sample.

   Slosh sample assembly per SAE J1227, section 5.5.3.1.
   Agitate 10 cycles by turning part end for end. Turn part 90 degrees between cycles. (see graphic) Allow enough time between each cycle for the test liquid to gravitate to the currently lower end.



   Immediately after completing the agitation process, remove a plug from sample assembly, and pour test liquid through the filter system. Pass 100% of test liquid through patch.

   Remove filter membrane and place in tin

   Place filter patch in pre heated oven and dry at 80 degrees Celsius, (temperature may be plus or minus 5 %), for a period of time not less than 10 minutes.

   Immediately weigh dried filter patch upon removal from oven, and record appropriately.

   Use gravimetric calculation to determine contaminant level, and record appropriately.

10. Turn on vacuum pump. Pass all the collected test liquid through the pre-dried 5.0 μm filter membrane. Intermittent operation of the pump may be required to drain the funnel.
11. Thoroughly flush the collecting pan, allowing the flushing test liquid to pass through the filter membrane.

12. Without turning vacuum off, remove funnel assembly and gently rinse any residual contamination from the funnel base onto the filter disk using a squeeze bottle and prefiltered rinsing test liquid. Allow the vacuum pump to run for approximately 10 additional seconds.
13. Carefully remove filter membrane and place it in the drying oven set at 80 +/- 2°C for a minimum of 15 minutes. NOTE: The oven should be located as close as possible to the gravimetric equipment.
14. Place filter membrane in desiccator and allow to cool to room temperature.
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Report

Report the following information for each part tested:

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If the part drawing specifies a maximum particle size, report the following information:

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7.0 RECORDS: Not Applicable

APPENDIX 1

CITED DOCUMENTS:

ISO 4405, Hydraulic Fluid Power Fluid Contamination – Determination of Particulate Contamination by the Gravimetric Method

ISO 18413, Hydraulic Fluid Power – Cleanliness of Parts and Components – Inspection Document and Principles Related to Contaminant Collection, Analysis and Data Recording

SAE J1227, Assessing Cleanliness of Hydraulic Fluid Power

DEFINITIONS:

The following definition is specific to this standard:

Aliphatic Solvents: A class of organic solvents which are composed of open chains of carbon atoms, derived from paraffin base crude oil. Aliphatics are relatively weak solvents. Among the typical aliphatic hydrocarbons are gasoline, mineral spirits, naphtha and kerosene.