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Group standard

PV 3336

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Cleanliness of Lines and Circuit Parts

Determining Residual Particle Quantities

Previous issues

PV 3336: 2000-02

Changes

The following changes have been made to PV 3336: 2000-02:

– Technical responsibility changed
– Standard completely revised
– Title changed
– Class. no. changed

Contents

Technical responsibility	The Standards department
	I/EZ-3 Reinhold Eitelhuber
G/GQ-P35 Mr. Gyula Kerekes Tel.: +36 96 66 1183	Tel.: +49 841 89 32120

1 Scope

This Test Specification (PV) is used for determining the residual particle quantities and particle size distribution for lines (e.g., fuel lines, brake hoses) and circuit parts (e.g., evaporators, radiators) and is applicable together with the component-specific test specification.

The stipulations in PV 3336 take precedence over recommendations in VDA volume 19.1 , which provides supplementary information on individual items described in PV 3336.

In each case, a component-specific test specification must be prepared on the basis of PV 3336 (section 7.3).

2 Designation

Determining the residual particle quantity for lines and circuit parts as per PV 3336

3 General information

The function of an engine depends on a variety of factors, including the cleanliness of the individual parts and sub-assemblies that are used in the assembly (ASSY) and in especially sensitive engine areas.

4 Definitions

Definitions as per VDA volume 19.1

5 Purpose

The purpose of this standard is to standardize Group-wide cleanliness analyses and make them comparable so as to help achieve the overriding goal of improving cleanliness.

6 Testing equipment

6.1 Test bed and auxiliary equipment

– Component-specific rinsing adapter

Preventing component damage, e.g., due to threaded connections, metal-on-metal contact

- Collecting tank with inclined base, abrasion-resistant and corrosion-resistant; preferably closed testing system (circuit) with suction
- Component holder, e.g., bracket or clips
- Test fluid supply with pressure regulator and pressure indicator or volumetric flow regulator and volumetric flow indicator
- Spray device (e.g., spray nozzle) for post-rinsing, cleaning of the equipment
- Test fluid pre-filtering (filter mesh size smaller than 1 µm, absolute)
- Vacuum tank with vent valve and connection to vacuum pump
- Filter cascade consisting of 2 filter elements
- Sealing rings, e.g., made of fluoropolymers – PTFE, FKM, FPM (for sealing the filter cascade)
- Spray bottles
- Lint-free cloths
- Petri dishes

The test bed and the auxiliary equipment must meet the following conditions:

- Clear view of the device under test (DUT)
- 100% worker safety against spraying test fluid
- No ambient load during the extraction process (without evaporation)
- Corrosion resistance
- The test fluid must flow onto the analysis membrane in a direct path without spaces where particles might become trapped.
- The filter cascade/the membrane holder must be designed in such a way that the membrane filters cannot be contaminated as a result of the filter holder being opened

Recommendation:

- Pulsation

6.2 Chemicals

Cold-cleaning agent for cleanliness analysis

- Flash point between 55 °C and 100 °C (former VbF hazard class AIII (Verordnung über brennbare Flüssigkeiten (German Flammable Liquids Ordinance)))

or

- Flash point between 21 °C and 55 °C (former VbF hazard class AII)

Recommendation:

Pfinder AP 760 cold-cleaning agent, Kluthe ISOPAR G[1)] or HAKU 1025.920[1)] cold-cleaning agent, or equivalent

It must be ensured that the selected cold-cleaning agent is compatible with the components. It must be ensured that the test results cannot be distorted by the component's decomposition or partial dissolution.

If it is expected that the components' function will be impaired, either a suitable post-treatment must be performed or the tested components must be scrapped.

1) Company designations specified in this in-house standard are provided for information only and do not mean that the corresponding products have been approved by the Volkswagen Group. Equivalent products may be used if they verifiably lead to the same results.

Note: VDA volume 19.1

6.3 Filter

The fineness of the filter is specific to the component; it must be max. 1/5 to 1/10 of the smallest specified particle size, wherein 1/10 must be applied in the range of larger particles and 1/5 for the smaller particles.

If the gravimetric value is specified for the component cleanliness, a fabric filter must be used, with a filter mesh width of max. 20 µm.

Filter material: Made from polyester, PET, or polyamide or cellulose nitrate (caution: influence on the gravimetric values due to greater absorption of air humidity)

Diameter: Approx. (47 – 50) mm

Note: VDA volume 19.1 section: Analysis filtration

6.4 Drying oven

Approx. capacity 50 l

Temperature of up to 105 °C without recirculated air

6.5 Analytical balance, desiccator

Analytical balance: Display accuracy of 0.1 mg (recommended accuracy: 0.01 mg), sealable side walls.

Note: Regular calibration as necessary, but at least once every 2 years.

Desiccator with desiccant (recommendation: Humidity indicator)

Desiccant: Silica gel with an indicator showing the silica gel's moisture content

6.6 Test equipment for visual examination and evaluation

- Microscope
- Optical particle counting microscope: Minimum requirement: Resolution of (1 – 7) µm per pixel (depending on the specified smallest particle sizes to be measured).

  Polarized light must be used with the particle counting microscope in order to be able to identify metallic and nonmetallic particles.
- Endoscope

Recommendation:

- Scanning electron microscope (SEM)/energy dispersive X-ray analysis (EDX) (is only allowed to be used under specific circumstances for particle counting if the software makes it possible to correctly measure particle sizes; this must be verified in advance by means of a comparison test with an optical microscope).
- Regular inspection based on the analysis of prepared sample filters

7 Cleanliness analysis procedure

7.1 Sampling the components

The sampling of the components to check the cleanliness requirements is performed after the entire manufacturing process has been completed. The cleanliness check is performed on the individual parts or assemblies ready for assembly or delivery.

The entire process chain is checked by means of random component sampling:

– Directly after completion/in the as-received condition if applicable (purchase parts)
– Or upstream of the assembly line/the assembly system

The test frequency is determined in agreement with the purchaser after determining the corresponding trends, and is the responsibility of the component manufacturer.

The location where the samples are taken must always be documented. The traceability of the components must be ensured (e.g., production line, production date, test date).

The cleanliness analysis is performed immediately after sampling. It must be guaranteed that the parts are protected from dust during transport. The devices under test (DUT) must be transported by a suitable means of transport.

The random sample includes at least 5 parts. Deviations must be specified in consultation with the Quality Assurance department of the plant using the parts. The testing frequency must be defined in a component-specific manner in the test specification or in the test plan. The process stability of manufacturing must be taken into account within this context; see section 7.5.4.

The appropriate process instructions or work instruction must be followed if a target value is exceeded.

7.2 Cleanliness of the analysis system; determination of blank value

The goal of determining the blank value before the analysis starts is to evaluate all possible influences on the analysis results from the beginning of the analysis to the particle evaluation.

The blank value after the analysis ensures that the post-rinsing after extraction is adequate. The blank value measurement must be performed directly after a cleanliness test, but without thoroughly cleaning the test setup first. Thoroughly cleaning the testing equipment is not equivalent to a blank value measurement.

The blank value must be determined on a regular basis. The frequency of this process must be defined in a work instruction.

The following are examples of possible influences:

– Environmental influences (dust, air, moisture, personnel, handling)
– The design of the extraction equipment (test setup, adapter, lines, valves, etc.)
– Analysis fluid (cold-cleaning agent)
– Residual foreign matter from a previous test which has not been removed completely

A dummy run without components must be conducted in order to ensure that these influences do not significantly affect the analysis result. The blank value is determined throughout the whole analysis process, starting with the rinsing out of the extraction equipment with a specific volume of post-rinsing fluid appropriate for the extraction device, using the finest membrane filters used as standard, and ending with the analysis. If component holders, adapters, etc. are subject to the cleanliness analysis, their soiling must also be included when determining the blank value.

The blank value must be ≤ 10% of the current or planned gravimetric and particle quantity target values for the component. For the blank value for the maximum permissible particle size and particle quantity, additional conditions apply (see VDA volume 19.1 – section: Blank value, table: Blank value criterion and examples). The appropriate Process Standard or work instructions must be followed in case the target value is exceeded. The complete testing equipment must be cleaned thoroughly. Its cleanliness must be verified by means of a subsequent blank value measurement.

Recommended: Use of test particle recovery (e.g., for testing equipment acceptance).

Please note:

– If there is no target value for the component yet, the blank value can be examined in relation to the actual value from the analysis.
– If the analysis fluid is being used several times, it might contain foreign matter, e.g., preservatives, so that the cleaning effect is reduced.

Blank values for the gravimetric values, particle quantity, and particle length must be documented in German or English, as must be the resulting measures.

7.3 Extraction method: Rinsing

The test conditions applying to each component or to each component family must be specified in a separate test specification. The extraction conditions (test parameters, post-rinsing parameters of the test setup) must be subject to qualification tests by means of decay measurements as per VDA volume 19.1 . Exceptions to this rule may be defined by the responsible Quality Assurance department of the engine manufacturing plant. The qualification examination (the test conditions, extraction parameters, results, decay series) must be documented in German or English.

The component manufacturer is responsible for creating the test specification. The test specification must be presented prior to the start of series production and released by the Quality Management of the engine plant.

The components must be tested by rinsing them in a system with adapters.

– Rinsing in a closed system (adapters on both ends of lines)
– Rinsing by adapters on a purge line (unpressurized outlet)

A decay curve must be used to determine the rinsing volume on the basis of the inner line surface area that needs to be wetted for each line. The minimum rinsing volume must be 1.5 l. The minimum volume flow rate is 3.8 l/min.

The rinsing of the components must be performed in accordance with the flow direction during operation.

The extraction process (including post-rinsing) must be carried out as per the released test specification applicable to the component.

Post-rinsing must be carried out in such a way as to ensure that the blank value requirement will be met. Post-rinsing ensures that all particles are extracted from the test setup and onto the filter. The post-rinsing volume depends on the test setup and must be determined with a decay measurement. During the post-rinsing process, the entire test setup surface (incl. e.g., component-specific adapters) must be rinsed.

7.4 Handling and analysis of the filter membrane; test

Step 1: Clean all equipment required for testing (e.g., adapters)

Step 2: Dry the filters until they reach a constant weight (e.g., 30 min at 105 °C)

Step 3: Cool the dried filters in the desiccator until they reach a constant weight (e.g., 30 min)

Step 4: Weigh the dried and cooled filters

Step 5: Replace the filters and the sealing rings in the filter cascade

Step 6: Parts test washing

Step 7: Draw the analysis fluid through the filter cascade

Step 8: Remove and dry the filters until they reach a constant weight (e.g., 30 min at 105 °C)

Step 9: Cool down (e.g., 30 min) in the desiccator and then determine the weight

Step 10: Loosen (but do not remove) stuck particles from the component and transfer them to the inserted filter

Notes:

- Post-treatment of cleaned components:
  After the cleaning process, the components are degreased due to the use of cold-cleaning agent. The components might corrode within a short time. Conservation measures must be taken, if necessary, depending on the manufacturing environment, humidity, etc.
- Equipment grounding:
  The cleaning areas and measuring equipment components that come into contact with the analysis fluid or its gases must be grounded. Fire protection measures must be taken.
- Occupational safety regulations must be taken into consideration when designing the test set-up (e.g., extraction or completely sealed extraction areas).
- Visual examination:
  Chips sticking to the part (e.g., in holes) must be visually inspected by suitable means (e.g., using an endoscope).
- For components with a target value < 5 mg per part:
  Parts can be analyzed one after the other or together in order to obtain measurement values that provide meaningful information.

7.5 Assessment

7.5.1 Determination of the particle quantity for the entire component

The weight difference must be calculated with the following formula: $\Delta G = G_a - G_b$

ΔG = weight difference (mg)

G_a = filter weight after cleaning (mg)

G_b = filter weight before cleaning (mg)

7.5.2 Determining the particle size

The particle sizes and particle types (metallic, non-metallic, fibrous) on the entire filter must be determined with the use of an optical microscope with particle analysis software. Trained personnel must manually check and release the results from the software analysis.

The entire filter must be systematically examined for irregularities (e.g., function-critical particles that cannot be automatically detected by the software).

Note:

Certain destructive particles are smaller than the particle size target values (e.g., corundum, sand). Since these particles are destructive, they must be included in the report.

7.5.3 Handling

When handling the filters, it must be ensured that no particles detach from the filter, especially when the filters are being moved (with tweezers) and transported.

7.5.4 Cleanliness requirements

Cleanliness requirements are specified in separate documents (e.g., Process Performance Specification for engines, "cleanliness" module, component drawing, and standards).

Note: When a target value is exceeded, the probability of a failure will be higher. Therefore, parts and component cleanliness must be checked at defined intervals. The cleanliness analysis is a preventive and process-assuring measure that is used to track trends and must be documented.

The cleanliness test must be performed at least once per quarter. The interval between the cleanliness tests depends not only on the production process and the batch size, but also on the cleanliness test results obtained for the relevant components. It must be ensured that only components that meet the specified technical cleanliness requirements as per the drawing are delivered.

8 Documentation

The results must be stored in a database.

The test specification and the results (blank value, decay test, test results) must be documented in German or English.

Archiving:

- Either the filters for which a particle analysis has been carried out, or the corresponding high-resolution images, must be archived.
- Filters must be archived if the specified limits are exceeded (e.g., laminated or in a slide frame).
- All images and archived filters must be stored for 3 months.
- The test report must include the extraction and analysis parameters, the test conditions, the test results, and the pictures or the types (e.g., metallic glossy and non-metallic glossy particles) for at least the 5 largest relevant particles.

9 Applicable documents

The following documents cited in this standard are necessary to its application.

Some of the cited documents are translations from the German original. The translations of German terms in such documents may differ from those used in this standard, resulting in terminological inconsistency.

Standards whose titles are given in German may be available only in German. Editions in other languages may be available from the institution issuing the standard.

VDA volume 19.1 Testing of Technical Cleanliness