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SURFACE VEHICLE DRAFT TECHNICAL REPORT

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Engine Intake Air Water Separation Test Procedure

***Foreword*—**The purpose of this Draft Technical Report is to give the technical community the opportunity to review, comment on, and use the Draft Technical Report prior to its final approval by SAE.

This Draft Technical Report represents the current thinking of the sponsoring Technical Committee. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringements arising therefrom, is the sole responsibility of the user.

Comments on this Draft are welcome and should be submitted in writing to Secretary, Technical Standards Board, SAE Headquarters, 400 Commonwealth Drive, Warrendale, PA 15096.

1. ***Scope*—**This water separation section has been established to cover heavy-duty engine intake filter systems. It may also be applicable to some automotive and industrial air inlet systems where water separation is an issue.

1.1 **Purpose—**The purpose of this document is to establish and specify uniform testing procedures, conditions, equipment and guidelines, to permit a general evaluation of the water separation performance of engine intake systems.

The performance and reliability of internal combustion engines and other equipment employing intake air filtration or separation systems, is affected by the performance of the intake system in removing contaminants including water from the intake airflow. Water vapor or pure liquid in small quantities is not generally considered detrimental to an engine. Water vapor or liquid in sufficient quantities however, can reduce the quality and reliability of the intake filtration system in at least two ways. First, it can cause the pressure drop to increase across the filter. This increases the restriction to the engine and may reduce filter life or capacity. Secondly, water in sufficient quantities can facilitate the passing of fine particles in suspension and salt and other contaminants in solution, through the filter. Once on the clean side of the filter, the contamination particles, precipitates, or consequential corrosion residue are able to enter the engine and cause damage to the engine and engine management systems.

Experience has shown that systems, which perform on the order of 80% or higher efficiency, as measured by this procedure, will usually avoid water ingestion problems.

It is therefore desirable to provide a procedure for uniformly evaluating the effectiveness of intake systems in separating or otherwise removing water from the intake system.

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Actual field conditions will vary widely, and are difficult to duplicate. The intent of this procedure is to specify the most important variables involved, which will promote uniform laboratory evaluation and comparison of the water separation performance of intake filter systems and components.

2. ***References—***The following publications provide ancillary information regarding additional test procedures and recommended practices for the filter systems included in the scope of this document. These documents provide guidelines and requirements for air cleaner testing that shall apply to this water separation test procedure. This information includes environmental condition requirements and airflow and pressure drop measurement corrections and requirements.

2.1 Applicable Publications—The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest version of SAE publications shall apply.

2.1.1 SAE PUBLICATION—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J/ISO 5011—Inlet air cleaning equipment for internal combustion engines and compressors—Performance testing

2.2 Related Publications—The following publications are provided for information purposes only and are not a required part of this specification.

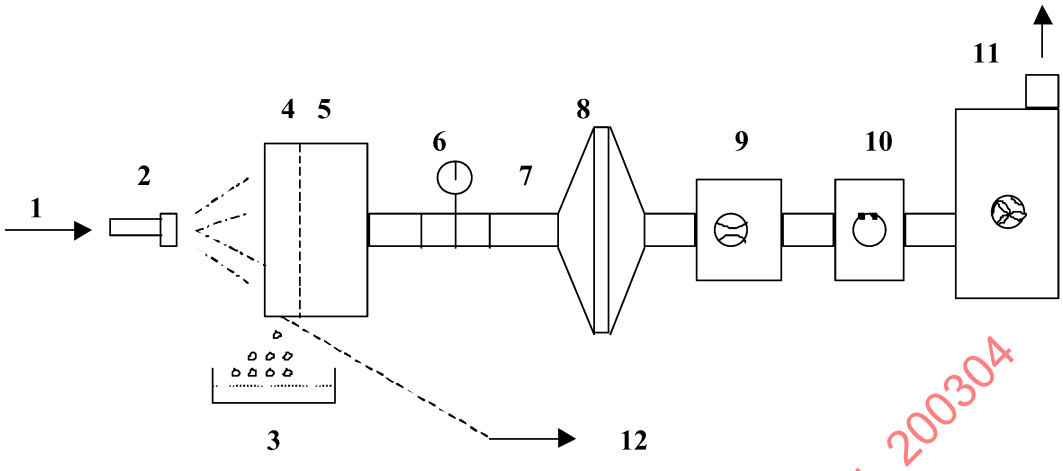
2.2.1 ISO PUBLICATION—Available from ANSI, 25 West 43rd Street, New York, NY 10036-8002.

ISO TS 11155-1—Road vehicles—Air filters for passenger compartment

3. ***Additional Equipment—***A typical test arrangement is shown in Figure 1. Test setups described in Figures 14, 17, and 24 of SAE J/ISO 5011 also generally apply, with the replacement of the dust feed system by a water feed and collection system. In addition to the airflow test equipment required in SAE J/ISO 5011, the following test equipment is required to conduct water separation tests.

3.1 Water Feed System—The water feed system shall consist of a pump or other means of supplying water at a controlled flow and/or pressure, to the spray nozzle(s).

3.2 Water Collection System—A system of collection containers, and/or other means shall be provided to quantify the water separated by the inlet system under test. For most tests, the water collection system will consist of containers placed at all locations where collected or separated water is drained or removed. This will vary with the design of the system under test. Scavenged air cleaner or precleaner systems will require more elaborate means of collecting the separated water.



1 AIR AND WATER SUPPLY SYSTEM
2 SPRAY NOZZLE(S)
3 WATER COLLECTION SYSTEM
4 PRECLEANER OR SEPARATOR
5 MAIN CLEANER
6 RESTRICTION MEASURING DEVICE
7 OUTLET TUBE (FIG 4, IS0 5011)
8 ABSOLUTE FILTER
9 AIR FLOW METER
10 AIR FLOW CONTROL
11 EXHAUSTER
12 SCAVENGE SYSTEM IF ANY

FIGURE 1—WATER SEPARATION EFFICIENCY TEST SETUP

3.3 Water Injection Spray Nozzles—Water injection is accomplished with a spray nozzle system. Test results will be sensitive to the droplet size distribution produced by the spray nozzle. Droplet sizes generated are controlled by the nozzle design and operating parameters (e.g., air and/or water supply pressure). For direct comparison, the same spray nozzle(s) and pressure conditions should be used. Rain droplets can generally range in size from 0.05 to 5 mm in diameter. Road spray from other vehicles, or fog conditions, can expand droplet size range both smaller and larger. Since a wide range of conditions exists, there may be interest in water separation performance at various conditions for various applications. Droplet sizes for most frequently encountered conditions are listed below in Table 1. Instrumentation for the precise measurement and control of water droplet size is not readily available. Nozzle manufacturers can usually provide general droplet size information at specific operating conditions of flow and pressure. Nozzle wear, corrosion, or buildup of mineral deposits can alter nozzle performance. It should be recognized that inspection, maintenance and replacement of nozzles or affected parts is necessary. Spray patterns and nozzle position relative to the inlet should be guided by a preference toward attempting to cover as much of the inlet area with challenge spray as possible. It is recognized that inlet locations vary widely on vehicles, and depending on wind and vehicle speed and directions, it may be desirable to run tests with the spray nozzle oriented in directions other than being aligned with an extension of the inlet. It has been suggested that an array of nozzle positions might be used to simulate a range of operating conditions. Multiple nozzles may be used for better coverage, if total flow rate and water droplet size effects are considered and accounted for.

TABLE 1—WATER DROPLET SIZE

CONDITION	DROPLET SIZE RANGE
Fog and Mist	2 - 100 micrometers
Drizzle and Rain	100 - 10 000 micrometers

4. ***Measurement Accuracy—***Measurement accuracy specified in section 4 of ISO DIS 5011, shall apply with the following additions.

4.1 Measure water flow rate within 5% of the actual value.

4.2 Measure spray nozzle pressures within ±1 kPa.

4.3 Measure weight of water, fed or separated and collected, to within ±1 g.

5. ***Test Conditions and Materials***

5.1 Water used for testing, should have minimal mineral content to reduce maintenance and variation in performance of the spray nozzle. Water temperature shall be maintained within ±2 °C of the temperature of the air entering the test system.

5.2 **Temperature and Humidity—**This procedure currently does not attempt to account for water evaporation. Since evaporation of water entering the system under test will have an effect on results, the temperature and humidity of the test airflow should be maintained for consistent results. All tests shall be conducted with the air entering the air cleaner or separator system at a temperature of 23 °C ± 5 °C and a relative humidity of 55% ±15%. This condition should be understood to prevail only before water injection spray is begun, or in the ambient airstream before mixing with the water spray.

6. ***Test Procedure—***The intent and scope of this procedure, is primarily to evaluate inertial separation, and coalescing devices in the inlet ductwork or filter housing entrance. Therefore most testing would be conducted with a clean filter element. Other variations of this procedure where a field element or dust and water feeding might be done are briefly described in item 6.14.

6.1 Set up the air cleaner intake system as shown in Figure 1.

6.2 Adjust the water feed system to deliver a feed rate to the nozzle of (a) 500 ml/min for airflows up to and including 2540 m^3/h, or (b) 1000 ml/min for airflows above 2540 m^3/h.

6.3 Adjust the airflow through the test system to the desired rate. (Tests may be run at several flow rates to establish performance at less than system rated airflow).

6.4 With the system running, adjust the placement of the injection nozzle relative to the inlet so that the water spray covers as much of the inlet cross section as possible without over spray. Inlets which have long narrow cross sections should be tested with the nozzle placed at a variety of locations to determine potential sensitivity to spray inlet location. Multiple nozzles, or nozzles with accommodating spray patterns may be used to cover the area, if care is taken to insure that the droplet size generated is within the recommended range.

6.5 For applications where overspray is desirable to approximate actual field condition, the overspray needs to be collected and subtracted from the amount fed before calculating the water separation efficiency.

6.6 Place adequate containers at all locations where collected or separated water is to be removed. This will vary with the design of the system under test. Scavenged systems will require a secondary water removal system.