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Road vehicles — Dimethyl Ether (DME) fuel system components —

Part 2: Performance and general test methods

Véhicules routiers — Composants des systèmes de combustible Diméthyle Ether (DME) —

Partie 2: Performances et méthodes d'essai générales

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Foreword

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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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 41, *Specific aspects for gaseous fuels*.

A list of all parts in the ISO 20766 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

For the purposes of this document, all fuel system components in contact with Dimethyl Ether have been considered suitable for Dimethyl Ether as defined in ISO 16861. However, it is recognized that miscellaneous components not specifically covered herein can be examined to meet the criteria of this document and can be tested in accordance with the appropriate functional tests.

All references to pressure in this document are considered to be gauge pressures unless otherwise specified.

This document is based on a service pressure for Dimethyl Ether used as fuel of 1 500 kPa (15 bar) settled at 20 °C. Other service pressures can be accommodated by adjusting the pressure by the appropriate factor (ratio).

Road vehicles — Dimethyl Ether (DME) fuel system components —

Part 2: Performance and general test methods

1 Scope

This document specifies performance and general test methods for Dimethyl Ether (DME) fuel system components intended for use on the types of motor vehicles defined in ISO 3833.

This document is applicable to vehicles (mono-fuel, bi-fuel or dual-fuel applications) using Dimethyl Ether in accordance with ISO 16861 and ASTM D7901. It is not applicable to the following:

a) fuel containers;

b) stationary gas engines;

c) container-mounting hardware;

d) electronic fuel management;

e) refuelling receptacles.

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 188, *Rubber, vulcanized or thermoplastic — Accelerated ageing and heat resistance tests*

ISO 1431-1, *Rubber, vulcanized or thermoplastic — Resistance to ozone cracking — Part 1: Static and dynamic strain testing*

ISO 1817, *Rubber, vulcanized or thermoplastic — Determination of the effect of liquids*

ISO 9227, *Corrosion tests in artificial atmospheres — Salt spray tests*

ISO 22760-1:2019, *Road vehicles — Dimethyl Ether (DME) fuel system components — Part 1: General requirements and definitions*

ASTM D4814, *Standard Specification for Automotive Spark-Ignition Engine Fuel*

IEC 68-2-52, *Kb: Salt Spray Fog Test*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 22760-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

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

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

3.1
fill cycle
sequence of events performed on a filling system that has a defined beginning and ending

3.2
duty cycle
sequence of events performed on a component that has a defined beginning and ending

3.3
service pressure
settled pressure of the fluid at 20 °C

4 General

4.1 Unless otherwise stated, the tests shall be conducted at a room temperature of 20 °C ± 5 °C.

4.2 Components shall comply with the tests specified in this document as well as the relevant parts of ISO 22760, as applicable for each component.

NOTE Because of the peculiarities of some components, the list of tests given in this document (Clauses 5 to 15) is not exhaustive. Where additional tests are required, their provisions are given in other parts of ISO 20766.

4.3 Unless otherwise specified, all tests shall be conducted using dry air or nitrogen. Tests may also be conducted with Dimethyl Ether, provided appropriate safety measures are taken.

4.4 Unless otherwise specified, all pressures shall have a maximum tolerance of ±5 %. Unless otherwise specified, all temperatures shall have a maximum tolerance of ±5 %. Unless otherwise specified, all dimensions shall have a maximum tolerance of ±5 %.

5 Hydrostatic strength

5.1 General

A component shall not show any visible evidence of rupture when subjected to the following test procedure.

a) Plug the outlet opening of the component and have the valve seats or internal blocks assume the open position.

b) Apply, with a test fluid, the hydrostatic pressure specified in the applicable part of ISO 20766 to the inlet of the component for a period of at least 3 min.

c) The hydrostatic pressure shall then be increased at a rate of less than or equal to 1,4 MPa/s until component failure. The hydrostatic pressure at failure shall be recorded. The benchmark value for a specific component shall be determined by testing a component that has not undergone previous testing.

Previously untested sample shall withstand at least 2,25 times working pressure. Hydrostatic testing of components that have been subjected to previous testing shall result in an acceptable failure pressure that is at least 80 % of the benchmark value or at least 2,25 times the working pressure of the component.

The samples used in this test shall not be used for any other testing.

6 Leakage

6.1 General

6.1.1 Prior to conditioning, purge the component, then seal it at 30 % of the working pressure using nitrogen or dry air.

6.1.2 Conduct all tests while the device is continuously exposed to the specified test temperatures. The device shall either be bubble free or display a leakage rate of less than 15 cm^3 (normal)/h when subjected to the following test method.

If components are subjected to more than one working pressure, the test may be conducted in subsequent steps.

6.2 External leakage

6.2.1 Plug each device outlet into the appropriate mating connection.

6.2.2 Apply pressurized dry air or nitrogen to the inlet of the test device.

6.2.3 At all test temperatures, immerse the components in a suitable test medium for $2\,\text{min}\left(^{+30}_{0}\right)\text{s}$ or use a helium vacuum test (global accumulation method) or other equivalent method.

6.2.4 If there are no bubbles for the specified time period, the sample passes the test. If bubbles are detected, measure the leakage rate using an appropriate method; the leakage rate should not be more than that specified in 6.1.2.

6.3 Internal leakage

6.3.1 The internal leakage test is applicable only to devices that are intended to be leak-tight in closed position. The aim of this test is to check the pressure tightness of the closed system.

6.3.2 Connect the inlet or outlet (as applicable) of the device to the appropriate mating connection, leaving the opposite connection(s) open.

6.3.3 Apply the test pressure to the inlet or outlet (as applicable) of the device using dry air or nitrogen as the test fluid.

6.3.4 At all applicable test temperatures mentioned in 6.4, immerse the component in a suitable test medium for $2\,\text{min}\left(^{+30}_{0}\right)\text{s}$ or use any other equivalent method.

6.3.5 If there are no bubbles for the specified time period, the sample passes the test. If bubbles are detected, measure the leakage rate using an appropriate method; the leakage rate should not be more than that specified in 6.1.2.

6.4 Test conditions

6.4.1 The device shall be pressurized at 150 % of the working pressure and then conditioned until temperature equilibrium is achieved at room temperature, as applicable, and maintained at that temperature for at least 30 min.

6.4.2 The device shall be pressurized at 150 % of the working pressure and then conditioned until temperature equilibrium is achieved at a low temperature of −40 °C or −20 °C, as applicable, and maintained at that temperature for at least 30 min.

6.4.3 The device shall be pressurized at 150 % of the working pressure and then conditioned until temperature equilibrium is achieved at high temperature of 65 °C, 85 °C or 120 °C, as applicable, and maintained at that temperature for at least 30 min.

7 Excess torque resistance

A component designed to be connected directly to threaded fittings shall be capable of withstanding, without deformation, breakage or leakage, a torque effort equal to or greater than 150 % of the rated installation value, when tested in accordance with the following test procedure.

a) Test an unused component, applying the torque adjacent to the fitting.

b) For a component having a threaded connection or threaded connections, apply the turning effort for 15 min, release it, then remove the component and examine it for deformation and breakage.

c) Subject the component to the leakage test specified in Clause 6.

d) Subject the component to the hydrostatic strength test specified in Clause 5.

8 Bending moment

A component shall be able to operate without cracking, breaking or leaking when tested in accordance with the following procedure.

a) Assemble the connections of the component, ensuring that they are leak-tight, to one or several appropriate mating connection(s) representative of the design. After assembly, the length of the inlet tubing shall be greater than 300 mm (see Figure 1).

b) The outlet connection shall be rigidly supported at a distance of 25 mm from the component outlet, except in the following cases:

   — if the component has an integral mounting means that is independent of the inlet and outlet connections, the component shall be mounted using the integral mounting means specified by the manufacturer;

   — if the component is intended to be mounted using either the integral mounting means or the component outlet, the mounting means that produces the most severe test condition shall be used.

c) Check this assembly for leaks according to 6.4.1 before subjecting it to step d).

d) With the component in the closed position, pressurize the system to 5 kPa and apply a force in accordance with Table 1, at 300 mm from the inlet, maintaining it for 15 min. Without removing the force, check the component for leakage in accordance with the test method given in Clause 6, at room temperature.

   NOTE Depending on how this test is performed, it can be necessary to raise the load to compensate for buoyancy.

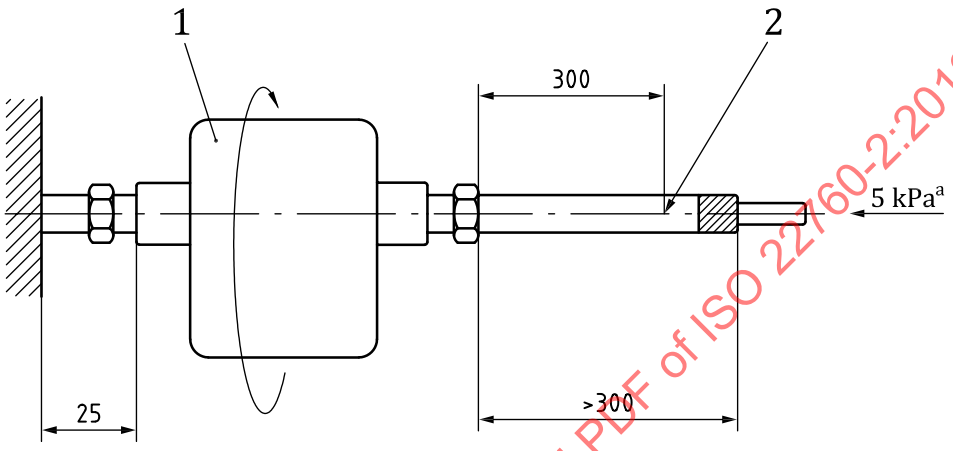
e) Perform step d) of the procedure four times, rotating the component by 90° around the horizontal axis between each test. Between tests, open and close (if applicable) the component three times with the bending moment removed.

f) At completion of the above tests, remove the component and examine it for deformation; then subject it to the leakage test specified in Clause 6 and the hydrostatic strength test specified in Clause 5.

Table 1 — Bending moment test force

Outside diameter of tubing mm	Force (minimum) N
6	3,4
8	9,0
≥12	17,0

Dimensions in millimetres



Key

1 component
2 force point
[a] 4 × 90° rotation.

Figure 1 — Bending moment

9 Continued operation

9.1 General

For details on test methods pertaining to particular components, see the respective parts of ISO 22760.

The method specified in this clause is general in nature and also applies to miscellaneous components.

Other components (those for which specific requirements are not specified) shall be subjected to the following continuous operation test for a total number of cycles to be determined by the testing agency. The determination of the total number of cycles shall be based on 15 000 fill cycles and/or 50 000 duty cycles.

9.2 Test methods

9.2.1 Test procedure

The component shall be installed as indicated and cycled using dry air, nitrogen or Dimethyl Ether, under all the appropriate loads.

Connect the component securely, using a suitable fitting, to a pressurized source of dry air, nitrogen or Dimethyl Ether, and subject it to the number of cycles specified in the ISO 22760 part corresponding to the specific component, as applicable. A cycle shall consist of one full operation and reset within an appropriate period as determined by the testing agency.

On completion of the cycling, the component shall be subjected to the leakage test specified in Clause 6, and to the hydrostatic strength test, as specified in Clause 5.

During the off cycle, the downstream pressure of the test fixture shall be lowered to a maximum of 50 % of the test pressure.

Unless otherwise specified, the test pressure shall be 100 % of the working pressure.

Unless otherwise specified, the conditions of 9.2.2, 9.2.3 and 9.2.4 shall apply.

9.2.2 Room temperature cycling

Operate the component through 90 % of the total cycles at room temperature and at working pressure. On completion of the room temperature cycles, the component shall comply with the requirements of Clause 6.

This test may be interrupted, if desired, at 20 % intervals for leakage testing.

9.2.3 High-temperature cycling

Operate the component through 5 % of the total cycles at the appropriate maximum temperature specified in ISO 22760-1:2019, 4.4, and at working pressure. On completion of the high temperature cycles, the component shall comply with the requirements of Clause 6 at the appropriate maximum temperature.

9.2.4 Low-temperature cycling

Operate the component through 5 % of the total cycles at the appropriate minimum temperature specified in ISO 22760-1:2019, 4.4, and at 100 % of the working pressure. On completion of the low temperature cycles, the component shall comply with the requirements of Clause 6 at the appropriate minimum temperature.

Immediately following the continued operation tests and leakage testing, perform the hydrostatic strength test in accordance with Clause 5.

10 Corrosion resistance

10.1 All components shall perform safely and in compliance with Clause 6 following exposure to salt spray in accordance with one of the following test methods. AISI series 300 austenitic stainless steels, or equivalent austenitic stainless steels, are exempt from corrosion resistance testing.

10.2 With the component supported in its normal installed position, expose it for 144 h to a salt spray (fog) test, as specified in ISO 9227. If the component is expected to operate, unprotected, in vehicle underbody service conditions, then it shall be exposed for 500 h to the salt spray (fog) test.

10.3 Maintain the temperature within the fog chamber between 33 °C and 36 °C.

10.4 The saline solution shall consist of 5 % sodium chloride and 95 % distilled water, by weight.

10.5 As option to the test described in 10.2, the metal DME component shall comply with the salt spray test according to IEC 68-2-52 as described in 10.6.

10.6 Test procedure:

Before the test, the component shall be cleaned according to the instructions of the manufacturer. All the connections shall be closed off. The component shall not be operated during the test.

Subsequently the component shall be submitted for 2 h to spraying with a solution of salt, containing 5 % NaCl (mass %) with less than 0,3 % contamination and 95 % distilled or demineralised water, at a temperature of 20 °C. After the spraying the component is stored at temperature of 40 °C and 90 % to 95 % relative humidity for 168 h. This sequence shall be repeated 4 times.

After the test, the component shall be cleaned and dried for 1 h at 55 °C. The component shall now be conditioned to reference conditions for 4 h, before submitting it to further testing.

10.7 Immediately following the corrosion resistance test, rinse the sample and gently clean it of salt deposits; then subject it to the leakage test according to Clause 6.

10.8 Immediately following the corrosion resistance test and leakage test, subject the sample to the hydrostatic strength test according to Clause 5.

11 Oxygen ageing

Non-synthetic or non-metallic parts of components that provide a fuel-containing seal shall crack or show visible evidence of deterioration after oxygen ageing when tested in accordance with the following procedure.

Expose representative samples to oxygen for a minimum of 96 h at a temperature of 70 °C ± 5 °C and a pressure of at least 2 MPa (20 bar), in accordance with ISO 188.

12 Ozone ageing

Non-metallic materials used in a component shall be subjected by the test agency to the tests described in this document, except where the applicant submits a test result declaration for tests carried out on the material provided by the manufacturer.

They shall not crack or show visible evidence of deterioration subsequent to ozone ageing as specified herein.

The test shall be in conformance with ISO 1431-1.

The test piece, which shall be stressed to 20 % elongation, shall be exposed to air at 40 °C with an ozone concentration of 50 parts per hundred million during 96 h.

No cracking of the test piece is allowed. After being subjected to the conditions of this procedure, samples shall show no evidence of cracking when examined at a magnification of 25x.

13 Electrical overvoltages

All electrical components or devices containing electrical subcomponents shall withstand the application of 1,5 times its rated operating voltage ±5 % for periods of 3 min without creating an unsafe condition. Failure to open is not considered an unsafe condition.

14 Non-metallic material immersion

14.1 Non-metallic material used in a component shall be subjected by the test agency to the tests described in 14.2 and 14.3, except where the applicant submits a test result declaration for tests carried out on the material provided by the manufacturer.

14.2 A part made of non-metallic material in contact with Dimethyl Ether shall not show excessive change in volume or weight when tested with proper test fluid according to ISO 1817 with the following conditions:

a) Temperature: 65 °C (tolerance according to ISO 1817).

b) Immersion period: 72 h.

c) Medium is DME.

d) After taking out the material, measure within 20 min, preferably as fast as possible.

— Prepare, measure, and weigh a representative sample or samples of each non-metallic synthetic material used in a component. Immerse the sample or samples according to the conditions above.

— Maximum change in volume 20 %.

— After storage in air with a temperature of 40 °C for a period of 48 h the mass compared to the original value may not decrease more than 5 %.

14.3 A part made of non-metallic material in contact with DME shall not show excessive change in volume or weight when tested in accordance with the following procedure.

a) Prepare, measure and weigh one or more representative samples of each non-metallic material used in a component, then immerse the sample or samples at room temperature in DME, at a pressure equal to its working pressure, but not less than 100 kPa, for a minimum of 70 h.

b) Immediately following this period of immersion, rapidly reduce the test pressure to atmospheric pressure without causing shredding or disintegration.

No tested sample shall exhibit swelling greater than 25 % or shrinkage greater than 1 %. The weight change shall not exceed 10 %.

It is recommended to read section 6.7 of the DME Handbook as generic background for using sealing material compatible with DME.

14.4 Non-metallic material used in a component that is likely to be exposed to ester-based or alpha-olefin- based synthetic compressor oils, including non-synthetic compressor oils, shall not show excessive change in volume or weight when tested in accordance with ISO 1817 or the following procedure.

a) Prepare, measure and weigh one or more representative samples of each non-metallic material used in a component, then immerse the sample or samples at room temperature in holders, each containing one of the test fluids, for a minimum of 70 h.

b) Following this period of immersion, remove and measure the test samples, within 1 h.

No sample shall exhibit swelling greater than 25 % or shrinkage greater than 1 %. The weight change shall not exceed 10 %.

15 Vibration resistance

Components with moving parts shall remain undamaged and shall continue to operate and meet the requirements of their leakage tests and hydrostatic strength test after the vibration test has been carried out in accordance with the following test procedure.

Vibrate the component for 30 min, pressurized to its working pressure with dry air, nitrogen or Dimethyl Ether, and sealed at both ends, along each of the three orthogonal axes at the most severe resonant frequency determined as follows:

— by an acceleration of 1,5 G;

— within a sinusoidal frequency range of 5 Hz to 500 Hz;

— with a sweep time of 10 min.

If the resonance frequency is not found in this range, the test shall be conducted at 500 Hz.

On completion of the test, the component shall not show any indication of fatigue or component damage and shall comply with the leakage test specified in Clause 6 and the hydrostatic strength test specified in Clause 5.

16 Brass material compatibility

All fuel-containing brass components or subcomponents, for which a satisfactory declaration of properties is not submitted by the applicant, shall be tested in accordance with the following procedure (component manufacturers able to provide documentation attesting to the field-worthiness of their products are exempted from this requirement).

a) Subject each test sample to the physical stresses normally imposed on, or within, a part as a result of its assembly with other components. Apply these stresses to the sample prior to testing and maintain them throughout the test. Samples with thread, intended to be used for installing the product in the field, shall have the threads engaged and tightened to the torque specified in the instruction manual of the sample or specified by the manufacturer. Polytetrafluorethylene (PTFE) tape or pipe compounds shall not be used on the threads.

b) Degrease three samples and expose them continuously for 10 d at a set position to a moist ammonia–air mixture, maintained in a glass chamber of approximately 30 l in capacity, with a glass cover. Aqueous ammonia having a specific gravity of 0,94 shall be maintained at the bottom of the glass chamber, below the samples, at a concentration of 21,2 ml/l of chamber volume. Maintain approximately 600 cm^3 of aqueous ammonia, with a relative density (specific gravity) of 0,94, at the bottom of the glass chamber, below the samples. Position the samples 40 mm above the aqueous ammonia solution, supported by an inert tray. Maintain the moist ammonia–air mixture in the chamber at atmospheric pressure and at a temperature of 34 °C ± 2 °C.

After being subjected to the conditions of this procedure, samples shall show no evidence of cracking when examined at a magnification of 25×.

17 Insulation resistance

This test is designed to check for a potential failure of the insulation between the component's power conductor and the component casing.

Apply 1 000 V DC between the power conductor and the component casing for at least 2 s. The minimum allowable resistance for the component shall be 240 kΩ.

18 Resistance to dry heat

The test shall be conducted in compliance with ISO 188 for rubber materials and in compliance with ISO 527 for moulding and extrusion plastics. The test piece shall be exposed to air at a temperature equal to the maximum operating temperature for 168 h.

The allowable change in tensile strength should not exceed +25 %.

The allowable change in ultimate elongation shall not exceed the following values:

— maximum increase 10 %;

— maximum decrease 30 %.

19 Creep

A non-metallic part containing liquid DME shall comply with the leakage tests mentioned in Clauses 5 and 6. This shall be done after having been submitted to a hydraulic pressure of 2,25 times the working pressure at a temperature of 120 °C during minimal 96 h. Water or any other suitable hydraulic fluid may be used as a test medium.

20 Temperature cycle test

A non-metallic part containing liquid DME shall comply with the leakage tests mentioned in Clauses 5 and 6. This shall be done after having been submitted to a 96 h temperature cycle from the minimum operating temperature up to the maximum operating temperature with a cycle time of 120 minutes, under working pressure.

21 Compatibility with heat exchange fluids of non-metallic parts

21.1 The test is applicable to non-metallic parts which potentially can become in contact with heat exchange fluids.

21.2 Test samples shall be submerged in heat exchange medium for 168 hours at 90 °C; then they shall be dried for 48 hours at a temperature of 40 °C. The composition of the heat exchange medium used for the test is water/ethylene-glycol fluid of 50 %/50 %.

21.3 The test is deemed to be satisfactory if the change in volume is less than 20 %, the change in mass is less than 5 %, the change in tensile strength is less than –25 % and the change in elongation at break is within –30 % and +10 %.

22 Automotive fluid exposure

22.1 General

External portions of components shall be able to withstand exposure to the following fluids without mechanical degradation. Resistance shall be determined by the test in 22.2 except when the manufacturer can demonstrate by other means that the material is resistant to these fluids.

22.2 Test method

The external surfaces of the component shall be exposed to the following test. The inlet and outlet connections of the component shall be connected or capped in accordance with the component manufacturers installation instructions. The test shall be performed at ambient temperature. The component shall be exposed by spraying the exterior of the component 24 times at one-hour intervals. The test shall either be performed over 24 straight hours or during a maximum of three consecutive days (e.g. 8 times a day over three days).

Alternatively, the component may be immersed in the solution for a period of 24 h. In the immersion method, the fluid shall be replenished as needed to assure complete immersion for the duration of the test.

An individual test shall be performed with each of the three fluids specified in 22.3. One component may be used for all three exposures sequentially.

22.3 Fluids

The following fluids shall be used for testing:

a) Sulfuric acid: 19 % solution by volume in water;

