INTERNATIONAL STANDARD

ISO 8984-1

Second edition
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Diesel engines — Testing of fuel injectors —

Part 1:
Hand-lever-operated testing and setting apparatus

Moteurs diesels — Essais des porte-injecteurs de combustible complets —

Partie 1: Appareillage d'essai et de réglage à levier de commande manuel

Reference number
ISO 8984-1:1993(E)

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 8984-1 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 7, *Injection equipment and filters for use on road vehicles*.

This second edition cancels and replaces the first edition (ISO 8984-1:1987), subclause 3.2.4 of which has been technically revised.

ISO 8984 consists of the following parts, under the general title *Diesel engines — Testing of fuel injectors*:

— *Part 1: Hand-lever-operated testing and setting apparatus*

— *Part 2: Test methods*

Annexes A and B of this part of ISO 8984 are for information only.

International Organization for Standardization
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Introduction

An assessment of the functional performance of individual fuel injectors has proved necessary. A form of hand-lever-operated testing and/or setting equipment for injectors has evolved over the years; it has been found in principle effective and adequate to perform the test. Differences in certain physical values between equipment from different manufacturers and of different designs have however resulted in lack of correlation of results. This International Standard consists of two parts (apparatus and method respectively), which together specify the relevant requirements to establish common test conditions.

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Diesel engines — Testing of fuel injectors —

Part 1:
Hand-lever-operated testing and setting apparatus

1 Scope

1.1 This part of ISO 8984 specifies minimum requirements for hand-lever-operated testing and setting apparatus to perform certain tests on fuel injectors for diesel (compression-ignition) engines. These tests are detailed in ISO 8984-2 and are

— nozzle opening pressure;

— chatter (atomization);

— spray pattern;

— seat leakage;

— back-leakage.

This International Standard concerns fuel injectors having a spring-loaded nozzle valve actuated by fuel pressure. It is intended that the specifications form a standard basis. The injector is connected to the apparatus by an adaptor specified by the injector manufacturer.

1.2 This part of ISO 8984 primarily applies to apparatus for testing the injectors of fuel injection equipment for diesel (compression-ignition) engines requiring fuel delivery of up to 300 mm^3/(injection × cylinder) at full load.

1.3 No distinction is made between apparatus used in different locations, e.g. laboratories, factories or service stations.

1.4 It is up to the injector manufacturer to specify which tests are to be selected from those listed in 1.1, together with any additional requirements for a particular injector.

NOTE 1 The terms used in this part of ISO 8984 are in accordance with ISO 7876-2 [6].

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 8984. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 8984 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 2974:1990, *Road vehicles — High-pressure fuel injection pipe end-connections with 60 degree female cone.*

ISO 4010:1977, *Road vehicles — Calibrating nozzle, delay pintle type.*

ISO 4020-1:1979, *Road vehicles — Fuel filters for automotive compression ignition engines — Part 1: Test methods.*

ISO 4113:1988, *Road vehicles — Calibration fluid for diesel injection equipment.*

ISO 8984-2:1993, *Road vehicles — Testing of fuel injectors — Part 2: Test methods.*

3 Mandatory features of equipment

3.1 Mandatory components

NOTE 2 Numbers given in parentheses relate to figure 1.

3.1.1 This part of ISO 8984 covers those components within the dashed line (1) in figure 1 which comprise

— Operating handle (2)

— Pump (3)

— Filter (4)

— Fluid container and lid (5)

— Non-return valve (6)

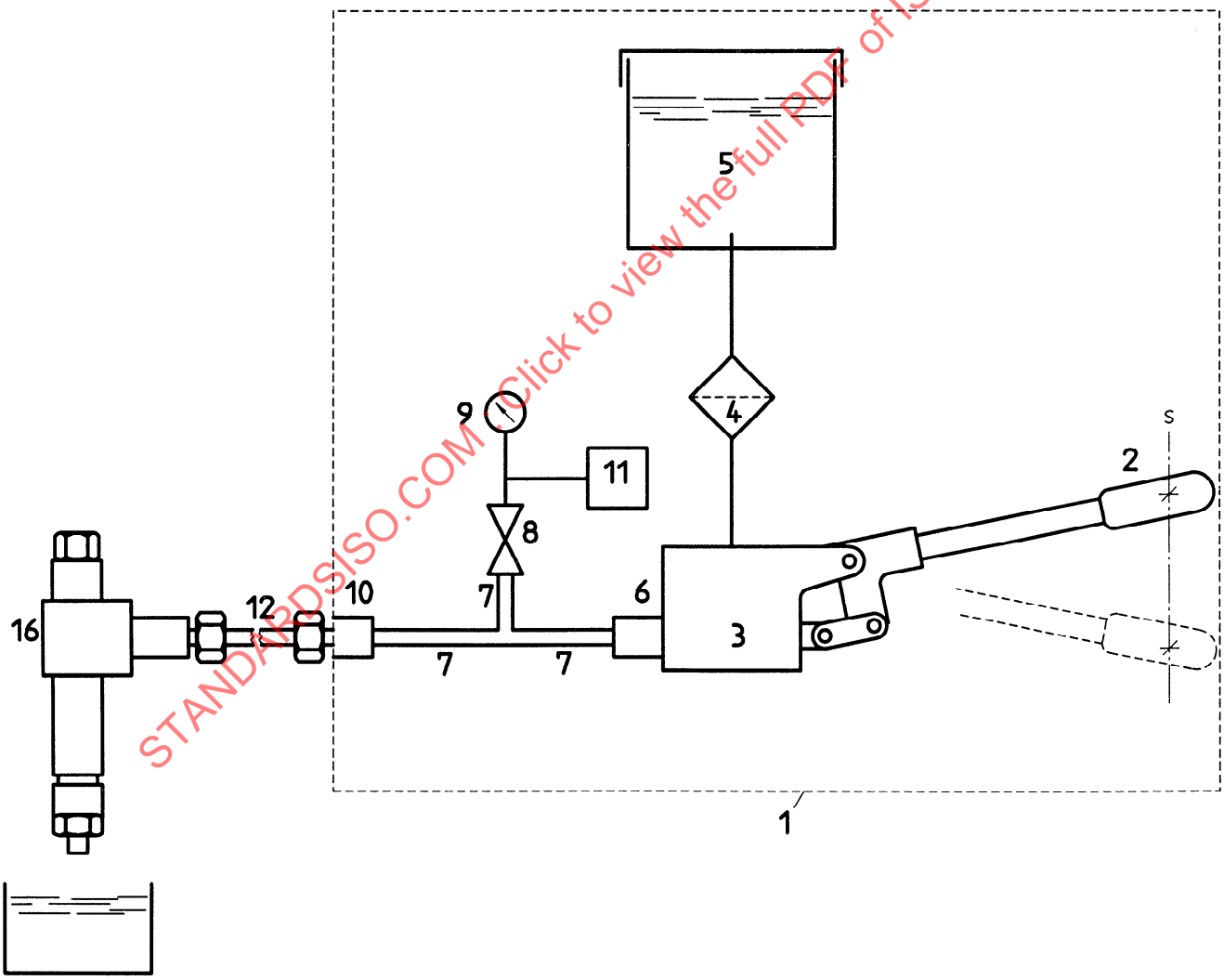
— Ducts (7)

— Isolating valve (8)

— Pressure gauge (9)

— Outlet connection (10)

— Variable volume device (11)



NOTE — Components (13), (14), (15) not illustrated (see 3.1.2).

Figure 1 — Mandatory components

3.1.2 Certain components are not covered by this International Standard. They are however essential to testing:

— Adaptor (12)

— Blank (13)[1)]

— Reference pressure gauge (14)[1)]

— Volume measuring device (15)[1)]

— Injector (16)

3.2 Specification of components

3.2.1 The whole mechanism [within the dashed line (1)] shall be of self-contained stiff construction capable of being rigidly mounted; items (4) and (5) may be separate if desired.

3.2.2 The operating handle (2) shall have a vertical plane of action; the line of action, S, drawn between the positions of the centrepoint of the hand-grip at extremes of stroke shall be approximately vertical.

3.2.3 The pump (3) shall incorporate a piston and lever system such that the following parameters are achieved.

a) The stroke of the operating handle along the line of action, S, which produces geometric delivery, shall be between 125 mm and 325 mm.

b) Specific delivery (at atmospheric conditions) shall be between 4,5 mm^3 and 6 mm^3 per millimetre of stroke along the line of action, S.

c) The hydromechanical stiffness of the apparatus, with the isolating valve (8) closed and the outlet connection (10) closed off, shall not be less than 0,2 MPa/mm (2 bar/mm), measured in the range 5 MPa to 35 MPa (50 bar to 350 bar) and along the line of action, S.

3.2.4 The element of the pump inlet filter (4) shall be replaceable without risk of any foreign matter entering the pump.

The element shall have an initial and average efficiency of more than 80 % using grade 2 test dust[2)] at a flowrate of 10 l/h when tested in accordance with ISO 4020-1:1979, subclause 6.4.

3.2.5 The fluid container (5), and filter container (4) where applicable, shall have a smooth and corrosion-resistant internal finish with a sufficiently large opening to give ample access for cleaning. The container lid (and breather) shall prevent ingress of foreign matter.

3.2.6 The pump shall discharge through a non-return valve (6) which seals against return flow and has no unloading feature.

3.2.7 The ducts (7) connecting the non-return valve (6) to the outlet connection (10) and the isolating valve (8) shall be constructed so that at no point is the cross-section less than 2 mm in diameter.

3.2.8 A manually operable isolating valve (8) shall prevent communication with pressure gauge (9) and variable volume device (11), if applicable. It shall be capable of sealing completely in both directions. The valve spindle seal shall be on the pressure gauge side of the sealing interfaces. Change of internal trapped volume due to valve spindle axial movement need not be zero but shall be kept to a minimum.

3.2.9 The pressure gauge (9) (and external damper if fitted) shall be of robust construction with the following specification:

a) Range: 0 (nominal) to 40 MPa $^{+2}_{0}$ MPa (400 bar $^{+20}_{0}$ bar).

b) Accuracy in fitted attitude (including hysteresis): within $\pm$ 0,6 % of full-scale deflection from 10 % to 90 % full-scale deflection. The needle shall lie within 1 mm to 2 mm in front of a flat scale.

c) Scaling:

— length 300 mm minimum;

— graduation pitch of 0,2 MPa (2 bar) graduation, to commence at approximately 5 % full-scale deflection.

d) Damping characteristic that shall protect the gauge from damaging shocks due to injector action but shall not reduce the rate of response to a step change to less than 90 % in 200 ms.

1) Not illustrated.

2) *Grade 2 test dust.* This is a product delivered by MIRA (Motor Industry Research Association). This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

NOTE 3 Although this specification describes an analogue-type Bourdon tube pressure gauge, other methods of pressure measurement are acceptable provided they allow equivalent assessment of the injector.

3.2.10 The outlet connection (10) shall be a connection end complying with ISO 2974, with M14 × 1,5 thread.

3.2.11 A variable volume device (11) shall be included as shown in figure 1, to permit compensation of variations in internal volume elasticity of individual pressure gauges. This item may be omitted if the requirements of 3.3 are fulfilled.

3.2.12 The adaptor (12) shall be specified by the injector manufacturer. (It is not covered by this part of ISO 8984.)

3.2.13 A suitable blank (13) to seal the outlet connection (see 3.2.10) from the atmosphere shall not alter the system volume (see note 4).

3.2.14 A reference pressure gauge (14) shall be capable of measuring (with or without reference to a test certificate) to an accuracy of at least ± 0,2 % full-scale deflection, over a range similar to that of the apparatus pressure gauge (9).

3.2.15 A suitable means of measuring internal volume (15) is described in annex A; the outlet connection (10) is the feed connection in annex A.

3.3 Additional requirements: internal volume elasticity

3.3.1 The total internal trapped volume of the system (see note 4) at 23 °C ± 5 °C shall be such that it releases fluid at the rate of 20 mm^3/MPa ± 0,5 mm^3/MPa (2,0 mm^3/bar ± 0,05 mm^3/bar), in the pressure range 10 MPa to 7 MPa (100 bar to 70 bar) using ISO 4113 calibration fluid.

NOTE 4 The system comprises the volume between the sealing face of the non-return valve (6) and the plane of the small end of the cone of the outlet connection (10) including the pressure gauge (9) [and variable volume device (11) if applicable].

3.3.2 With the pressure gauge (9) [and variable volume device (11) if applicable] isolated from the system by closing the valve (8), the remaining trapped volume at 23 °C ± 5 °C shall be such that it releases fluid at the rate of 4 mm^3/MPa ± 1 mm^3/MPa (0,4 mm^3/bar ± 0,1 mm^3/bar), in the pressure range 10 MPa to 7 MPa (100 bar to 70 bar) and using ISO 4113 calibration fluid.

4 Validation

WARNING — The spray from an injector can penetrate human skin. To avoid injury keep clear of the spray.

4.1 Preparation

Fill the system with fluid and then flush it. Fit an injector and operate the pump through at least 10 full strokes after the injector first sprays at its normal opening pressure with the isolating valve open. It is important that any air in the system is expelled or dissolved before commencement of the following validation procedure, for example by maintaining a pressure of 10 MPa (100 bar) for 1h.

4.2 Tightness of whole system

Fit the blank (13) and operate the pump to raise the pressure to full-scale reading with the isolating valve open. If the gauge reading falls slightly after releasing the handle, it is permissible to re-establish the full-scale reading a sufficient number of times over a period of 30 min to dissolve any remaining free air into the fluid.

Then release the handle: the gauge reading shall not fall more quickly than 0,1 MPa/min (1 bar/min).

4.3 Pump plunger (and inlet valve or port) leakage

Apply the load necessary to produce a full-scale reading. Release the blank and allow the gauge reading to fall to zero. Retighten the blank, lift the handle fully and apply the same load again.

The handle shall not fall at a rate greater than 10 mm/min measured along the line of action, S (see 3.2.2).

4.4 Leakage of gauge isolation valve and non-return valve

Replace the blank (13) with a certified reference pressure gauge (14).

NOTE 5 In fitting the reference gauge, a short length of steel pipe (6 mm outer diameter, 2 mm bore) may be used to permit it to be set at its correct attitude. This pipe should first be fitted to the outlet connection (10) and purged of air before fitting the gauge.

Close the gauge isolating valve (8). Raise the pressure to the full-scale value and release the handle. If the gauge reading falls slightly after releasing the handle, it is permissible to re-establish the full-scale reading a sufficient number of times over a period of 30 min to dissolve any remaining free air into the fluid.

The reference gauge reading shall not fall by more than 0,1 MPa/min (1 bar/min) and the apparatus gauge reading shall not rise at all.

4.5 Gauge integrity

Open the gauge isolating valve (8) and release and retighten the reference gauge fitting. Raise and lower the pressure in small increments and compare gauge readings throughout the range.

The apparatus shall meet the requirements of 3.2.9.

4.6 Internal volume elasticity using volume measuring device (15)

4.6.1 Check that the total internal elasticity with the isolating valve open, e_3, conforms to the values specified in 3.3.1. Record this value.

4.6.2 With the pressure gauge and variable volume device (if applicable) isolated from the system, check that the internal volume elasticity, e_c, conforms to the value specified in 3.3.2. The following method may be used.

4.6.2.1 Fit the reference gauge used in 4.4 to one leg of a "T" piece. Fit the second leg to the outlet connection (10) and the volume measuring device (15) to the third leg.

4.6.2.2 Measure the volume elasticity of the whole system with the isolating valve (8) open, e_1, and including the reference gauge.

4.6.2.3 Measure the volume elasticity with the isolating valve (8) closed, e_2, using the reference gauge to indicate the pressure change.

4.6.2.4 Deduce the value of the internal volume elasticity, e_c, in cubic millimetres per megapascal (per bar), using the value for e_3 recorded in 4.6.1, with the equation:

$$e_c = e_2 + e_3 - e_1$$

4.7 Hydromechanical stiffness

With the isolating valve (8) open, and a blank (13) fitted to the outlet connection (10), apply a load of 50 N to the handle (2) and record the pressure, p_1. Increase the load to 150 N and record the pressure, p_2. Release the handle (2), release and retighten the blank (13), close the isolating valve (8) and record the vertical movement of the handle S_d along the line of action, S, as the load applied to the handle is increased from 50 N to 150 N. The hydromechanical stiffness, in megapascals (bars) per millimetre, is then determined as follows:

$$\text{Stiffness} = \frac{p_2 - p_1}{S_d}$$

4.8 Function

Fit the previously validated calibrating injector fitted with pintle nozzle complying with ISO 4010. The apparatus shall perform all tests listed in 1.1, and detailed in ISO 8984-2.

5 Information to be supplied by manufacturer

5.1 With the apparatus, the test equipment manufacturer shall provide proper organization, installation and maintenance instructions in conformity with this part of ISO 8984, including the specific values required in 3.2.3 a) and b).

5.2 The fuel injector manufacturer shall state the applicable tests as detailed in ISO 8984-2 in test instructions for a particular fuel injector or range of fuel injectors.

6 Maintenance

Certain validation tests shall be carried out periodically to ensure functional conformity of the equipment with this part of ISO 8984. In the absence of specific instructions by the apparatus manufacturer, the tests detailed in table 1 shall be applied.

Table 1 — List of validation tests to be performed on apparatus as part of maintenance schedule

Test	Interval	Special apparatus
Preparation of the equipment (see 4.1)	Prior to all validation tests	Injector (any)
Tightness of whole system (see 4.2)	Every 6 months	Blank (13)
Pump plunger (and inlet valve or port) leakage (see 4.3)	Every 6 months	Blank (13)
Leakage of gauge isolation valve and non-return valve (see 4.4)	Every 3 months	Reference pressure gauge (14)
Gauge integrity[1] (see 4.5)	Every 3 months	Reference pressure gauge (14)
Internal volume elasticity[1] (see 4.6)	As detailed by the manufacturer	Reference pressure gauge (14) and volume measuring device (15)

1) Replacement of the pressure gauge is likely to change the internal volume elasticity (see 3.3.1) of the apparatus significantly, with a detrimental effect on the back-leakage test. The equipment manufacturer shall indicate whether the internal volume elasticity should be checked and if the variable volume device (if applicable) requires adjustment to achieve the values specified in 3.3, when gauge replacement proves necessary.

Annex A
(informative)

Volume measuring device

[corresponds to (11) in 3.1.1 and figure 1]

The following text is reproduced from Issue 6 of Technical Services Bulletin No. 107/4 of Leslie Hartridge Ltd, Buckingham, United Kingdom.

It is given for the convenience of users of this part of ISO 8984 and does not constitute endorsement of the product by ISO.

PRODUCT: INJECTOR TESTERS

SUBJECT: VOLUME MICROMETER

This Bulletin is a supplement to issue 5

A. General

The Volume Micrometer has been designed to measure the internal volume elasticity of calibrating fluid (test oil) trapped within the system of injector testers.

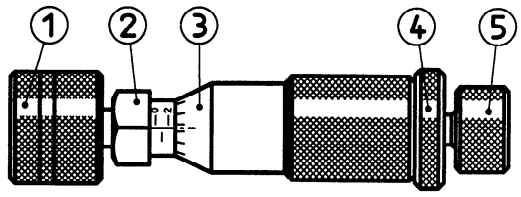


Figure 1 — Volume micrometer

Micrometer HJ034 is calibrated in mm^3. It is recommended for checking to ISO standards and fits directly onto the test equipment feed connection.

B. Operating instructions

1. Fit the volume micrometer to the nozzle tester feed connection.
2. De-aerate the system by operating the tester with the micrometer slack on the feed connection. Tighten the connection (1) when all air has been expelled.
3. Close the pressure gauge isolating valve and then open it a quarter of a turn. If the injector tester has other controls, refer to the appropriate maintenance instructions.
4. Slacken the locknut (4), set the gap between the zeroing screw (5) and this locknut to approximately 0.2 inch (5 mm), with no gap between (3) and (4). Set the micrometer scale so that both (2) and (3) zero graduations coincide.
5. Raise the pressure to 100 bar exactly. Wait 30 seconds. Carefully reset the pressure if necessary, whilst maintaining the zero reading between (2) and (3). (If the pressure is too high it should be reduced by bleeding at the feed connection.) Continue re-setting until the pressure holds steadily at 100 bar. (If setting takes longer than 2 minutes there is a leak in the system which must be rectified.) Small adjustments in gauge reading may be made by turning screw (5) by up to one turn. Tighten locknut. Neither the screw (5) nor the locknut (4) may be disturbed.
6. Turn the micrometer thimble (3) until the pressure gauge reads 70 bar exactly and wait for 30 seconds. Re-set the thimble if necessary until the gauge reading holds.
7. Turn the micrometer thimble back to zero. Check that the pressure gauge reading returns to 100 bar exactly. If it neither settles nor returns in under 30 seconds:
   a) there is a leak in the system, or
   b) all the air was not expelled.
8. Turn the micrometer thimble until the gauge reads 70 bar exactly.
9. The micrometer reading, divided by 30, is the internal volume elasticity of the test equipment.

C. Maintenance

Occasionally unscrew thimble (3) completely and grease the threads with Shell Alvania Grease No. 2. Always replace the protective cap and keep the micrometer in the case when not in use.

Issue 6, March 1982