

INTERNATIONAL STANDARD

ISO
7440-2

Second edition
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Road vehicles — Fuel injection equipment testing —

Part 2:

Orifice plate flow-measurement

*Véhicules routiers — Essai des équipements d'injection de
combustible —*

Partie 2: Mesurage du débit des pastilles à trou



Reference number
ISO 7440-2:1991(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 7440-2 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Sub-Committee SC 7, *Injection equipment and filters for use on road vehicles*.

This second edition cancels and replaces the first edition (ISO 7440-2:1985), of which it constitutes a complete revision.

ISO 7440 consists of the following parts, under the general title *Road vehicles — Fuel injection equipment testing*:

- *Part 1: Calibrating nozzle and holder assemblies*
- *Part 2: Orifice plate flow-measurement*

Annexes A and B of this part of ISO 7440 are for information only.

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Road vehicles — Fuel injection equipment testing —

Part 2:

Orifice plate flow-measurement

1 Scope

This part of ISO 7440 specifies the flow-measuring system, including the fixture, to be used for flow-testing the single hole orifice plates used in an orifice plate type nozzle and holder assembly (described in ISO 7440-1) which are intended for testing and setting diesel fuel injection pumps on test benches.

The flow-measuring system and fixture described in this part of ISO 7440 ensure accurate flow-testing of the entire range of orifices from 0,4 mm to 0,8 mm diameter as specified in ISO 7440-1. It is intended primarily for use by the manufacturers of single hole orifice plates.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 7440. 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 7440 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 4113:1988, *Road vehicles — Calibration fluid for diesel injection equipment*.

ISO 7440-1:1991, *Road vehicles — Fuel injection equipment testing — Part 1: Calibrating nozzle and holder assemblies*.

3 Orifice plate flow-measuring system

3.1 General description

Figure 1 shows an orifice plate flow-measuring system comprising:

- fluid supply circuit and flow-measuring device (an example is shown in annex A);
- orifice plate holding fixture;
- flow overcheck device (optional) [This device is for periodic overchecking of the accuracy of the primary flow-measuring device in a) and is specified in annex B.]

The system shall be designed and constructed with particular attention being given to the problems associated with fluid evaporation, contamination, aeration and instability of pressure and temperature.

Flow values obtained by alternative systems shall require correlation with values determined using the system shown in figure 1.

3.2 Orifice plate holding fixture

The functionally critical details and dimensions of the fixture are shown in figure 2. Dimensions not specified and construction techniques are left to the discretion of the manufacturer of the fixture, but shall be such that the fixture has unrestricted and undisturbed flow.

4 Flow-measuring procedure

4.1 General requirements

4.1.1 The orifice plates shall be clamped in a fixture conforming to the general layout in figure 2.

4.1.2 The following monitoring points shall be provided and the values measured or verified:

- a) orifice plate inlet temperature;
- b) orifice plate inlet pressure;
- c) orifice plate outlet pressure.

4.1.3 The fluid shall enter the orifice plate through the entry cone.

4.1.4 The flow through each orifice plate shall be measured individually.

4.1.5 The fluid in the flow circuit shall conform to ISO 4113. Viscosity and specific density shall be measured frequently and the fluid shall be discarded if it ceases to conform to ISO 4113.

4.2 Reference conditions

The orifice plate flow values stated in ISO 7440-1 refer to volumetric flow-rate measured at (or adjusted to) 40 °C. The other reference conditions shall be as follows:

- a) inlet pressure minus outlet pressure: 10 MPa (100 bar);
- b) outlet pressure: ambient pressure;
- c) inlet temperature of fluid: 40 °C;
- d) dynamic viscosity at 40 °C: $2,1 \times 10^{-3}$ Pa·s^{*)};
- e) density at 40 °C: 0,808 g/cm³.

NOTE 1 Dynamic viscosity at 40 °C is equal to kinematic viscosity at 40 °C $\times$ density at 40 °C.

4.3 Accuracy of measurement

4.3.1 Measurements shall be taken with the following accuracies:

- a) orifice volumetric flow-rate at 40 °C: $\pm 0,2$ % of reading;
- b) temperature of volume measured: $\pm 0,5$ °C;

*) $1 \text{ Pa}\cdot\text{s} = 1 \text{ N}\cdot\text{s}/\text{m}^2$

c) dynamic viscosity at 40 °C: $\pm 10^{-4}$ Pa·s;

d) density at 40 °C and at atmospheric pressure: $\pm 0,001 \text{ g}/\text{cm}^3$ (see note 2).

4.3.2 The following supply conditions shall be maintained taking into account gauge error:

- a) temperature of fluid at inlet: ± 1 °C;
- b) inlet pressure: $\pm 0,01 \text{ MPa}$ (0,1 bar);
- c) maximum cyclic fluctuation in inlet pressure: $\pm 0,1 \text{ MPa}$ (1 bar).

4.4 Correction procedure

To compensate for the effects of temperature, density and viscosity, the following empirical formula shall be used:

$$\text{Flow} = \text{flow}_{\text{measured}} \times \left[1,7 \sqrt{\frac{\rho_{m40}}{\rho}} \right] \times \left[1 - \left(\frac{\mu - \mu_{m40}}{\mu \times K} \right) \right] \times \frac{1}{1 + \gamma(t_m - t)}$$

where

- ρ is the reference density, equal to $0,808 \text{ g}/\text{cm}^3$;
- ρ_{m40} is the density of fluid in the circuit at 40 °C, in grams per centimetre cubed;
- μ is the reference dynamic viscosity, equal to $2,1 \times 10^{-3} \text{ Pa}\cdot\text{s}$;
- μ_{m40} is the dynamic viscosity of fluid in the circuit at 40 °C, in pascals per second;
- γ is the coefficient of volumetric expansion of the fluid, equal to $0,000 824 \text{ }^\circ\text{C}^{-1}$;
- t is the reference temperature, equal to 40 °C;
- t_m is the temperature of the fluid in the flow-measuring device, in degrees Celsius;

and

$K = 88$ for $\varnothing 0,4 \text{ mm}$ orifices;

$K = 100$ for $\varnothing 0,5 \text{ mm}$ orifices;

$K = 114$ for $\varnothing 0,6 \text{ mm}$ orifices;

$K = 134$ for $\varnothing 0,7$ mm orifices;

$K = \infty$ for $\varnothing 0,8$ mm orifices.

NOTE 2 Density is preferably measured at ambient temperature and is adjusted to 40 °C as follows:

$$\rho_{m40} = \rho_{\text{ambient}} - 0,000\,68\,(40 - t_{\text{ambient}})\,\text{g/cm}^3$$

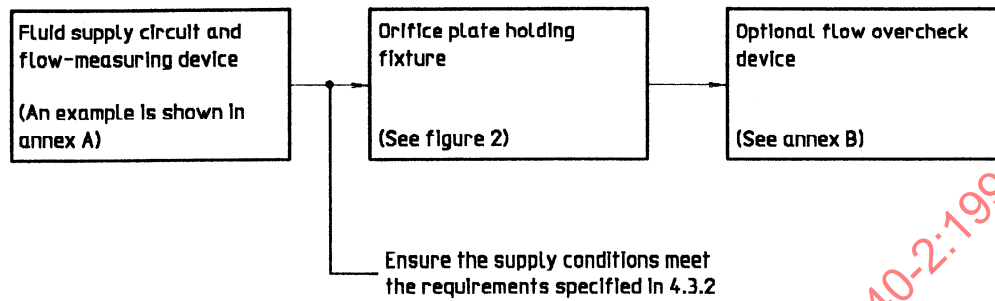


Figure 1 — Orifice plate flow-measuring system

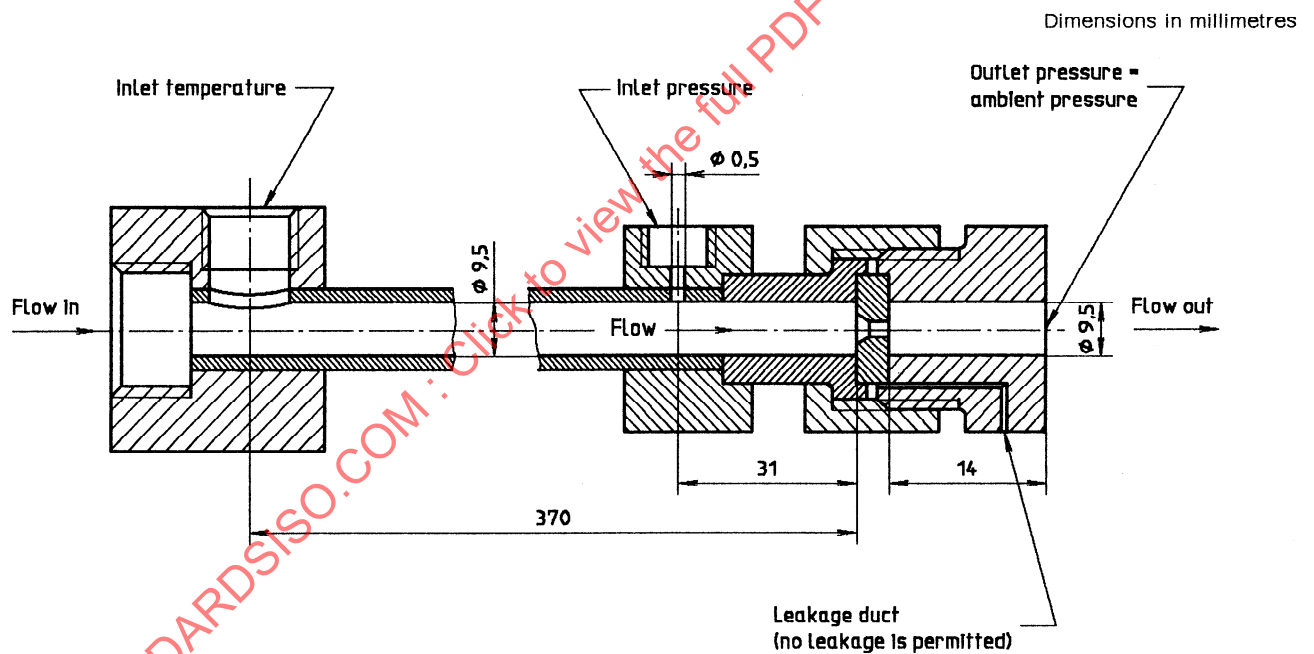


Figure 2 — Orifice plate holding fixture for flow-measurement

Annex A (informative)

Example of fluid supply circuit and flow-measuring device

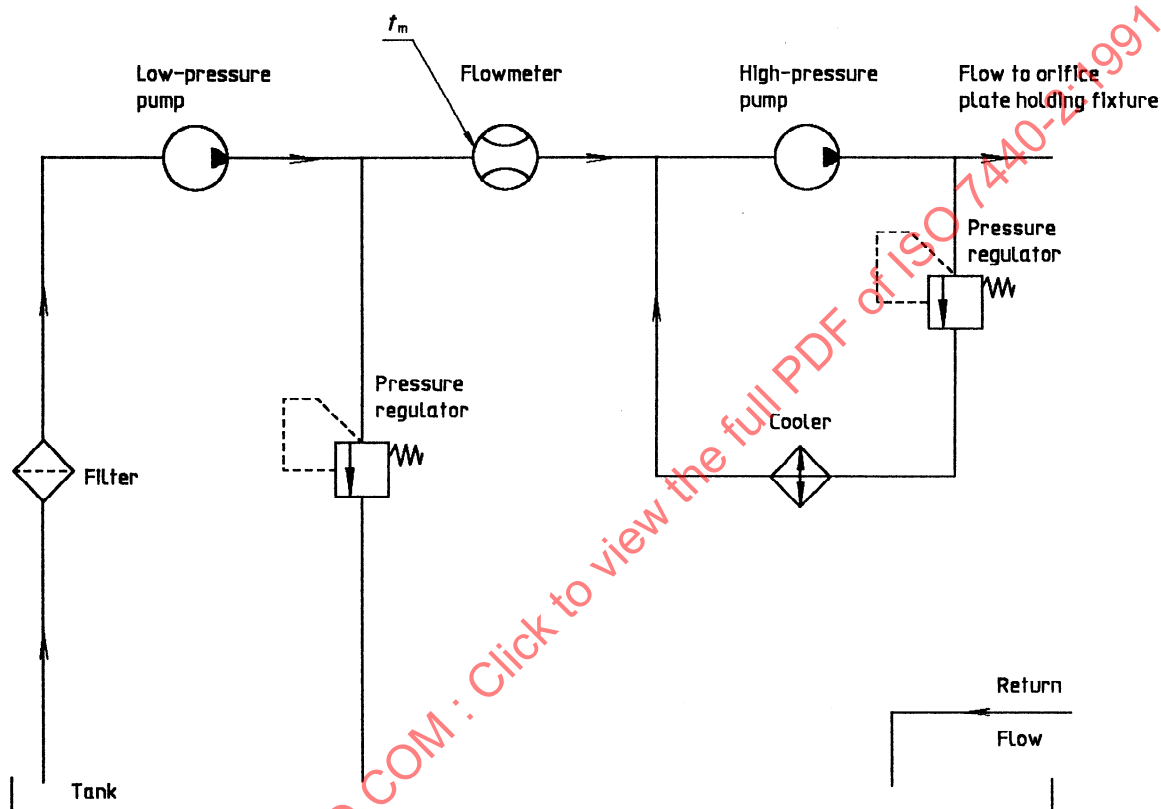


Figure A.1 — Fluid supply circuit with pressure and temperature control and flow-measuring device

Annex B (informative)

Overcheck device for flow-measuring system (optional)

B.1 Requirements

The device as illustrated in figure B.1 shall have the features described in B.1.1 to B.1.7 (where the bracketed numbers refer to figure B.1).

B.1.1 Measuring chamber (1)

The volume of the sample shall be measured in a chamber having:

- minimum 4 l capacity;
- minimum internal wetted surface;
- conical upper and lower surfaces;
- vertical graduated tube of maximum 25 mm, extending upward from the top surface of the chamber;
- this tube to have graduations in 1 ml increments and accurate at 50 °C to ± 2 ml after draining for 1 min;
- chamber to be made from low thermal expansion material, or appropriate allowance for differential expansion to be made in the measured flow correction formula (see 4.4);
- a 25 mm effective diameter drain valve in the centre of the base;
- independent upward-facing fluid inlet;
- the measuring chamber shall have a temperature sensor in a central position lying on the axis of the inlet connection.

B.1.2 Level sensor (2)

A level sensor looking through the graduate shall stop the sample collection and timer simultaneously.

B.1.3 Three-port valve (3)

A symmetrical power-operated three-port valve with nil leakage (or two separate similar two-port valves operating in "push-pull" mode) shall be arranged to connect the orifice outlet to either the measuring cylinder or to a separate chamber having the same

height. This valve shall have an equivalent port area of between 6 mm and 8 mm diameter and shall have fast response time (< 50 ms), equal in both directions.

B.1.4 "Slave" chamber (4)

The second "slave" chamber shall have an overflow at the same level as the sensor in 2 (see figure B.1) and the measuring chamber shall have an overflow at a higher level.

B.1.5 Drain return (5)

The drain return shall be separate from the overflow lines to ensure full and complete drainage.

B.1.6 Control unit (6)

A control unit shall incorporate a second timer with a six-figure display reading to three-decimal places and having an accuracy of $\pm 0,001$ s. Controls shall be provided to

- deliver the flow to the measuring chamber and start the timer simultaneously;
- drain and reset the timer;
- manually select and hold either direction of flow (to test for leakage).

The sensor shall reverse the valve mode and stop the timer simultaneously.

B.1.7 Fluid passageway (7)

This fluid passageway, because it must run downwards, shall have a bore size large enough to produce no back-pressure and small enough to carry entrained air downwards with the smallest orifice flow-rate, e.g. between 7 mm and 8 mm bore.

B.2 Schematic diagram

The diagram in figure B.1 shows the device for calibrating and checking a different type of faster-acting primary meter. The arrangement of overflow levels with respect to the orifice height and the arrangement of the fluid passageways shall be observed.

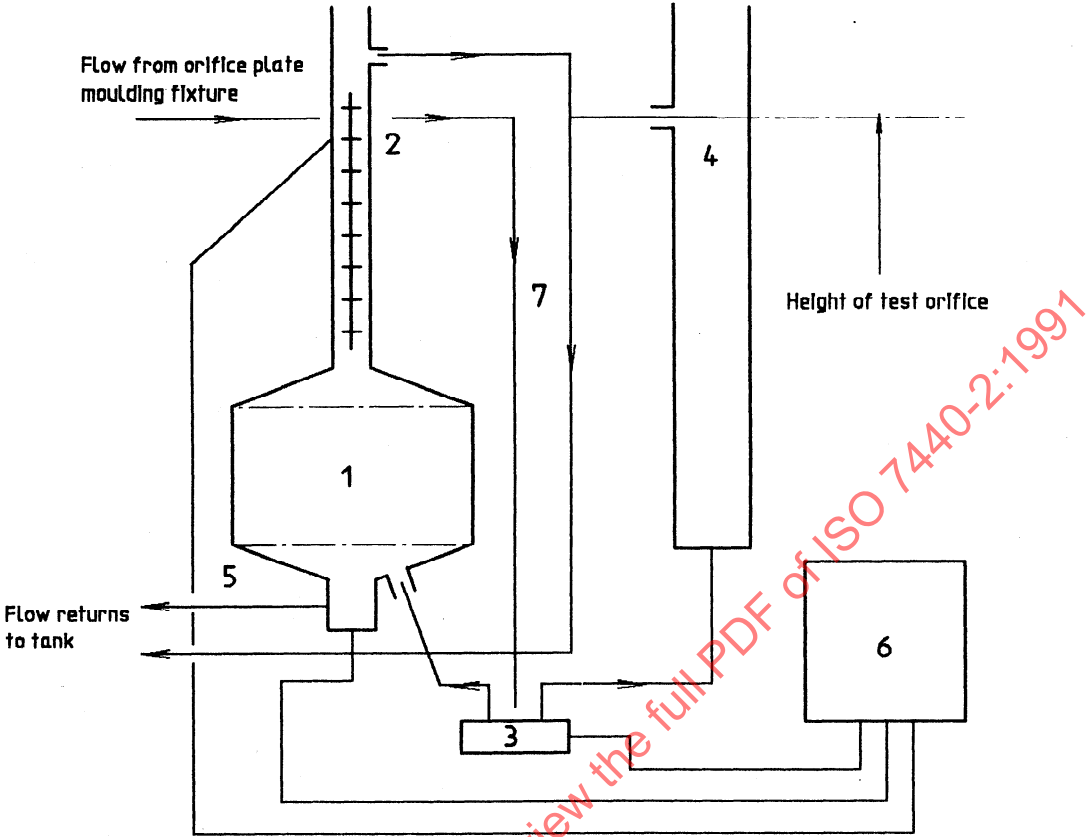


Figure B.1 — Schematic diagram of flow-checking device

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