INTERNATIONAL STANDARD

ISO 9644

Second edition
2008-07-01

Agricultural irrigation equipment — Pressure losses in irrigation valves — Test method

Matériel agricole d'irrigation — Pertes de pression dans les vannes d'irrigation — Méthode d'essai

Reference number
ISO 9644:2008(E)

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

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.

ISO 9644 was prepared by Technical Committee ISO/TC 23, *Tractors and machinery for agriculture and forestry*, Subcommittee SC 18, *Irrigation and drainage equipment and systems*.

This second edition cancels and replaces the first edition (ISO 9644:1993), which has been technically revised. It also incorporates the Amendment ISO 9644:1993/Amd 1:1998.

Agricultural irrigation equipment — Pressure losses in irrigation valves — Test method

1 Scope

This International Standard specifies a test method for determining the pressure loss in agricultural irrigation valves under steady-state conditions when water flows through them. The scope and accuracy of the valve performance specifications presented will assist agricultural irrigation system designers in comparing pressure losses through various types of valves.

The measurement of pressure losses provides a means for determining the relationship between pressure loss and flow rate through the valve.

This International Standard also describes the method of reporting pertinent test data.

No attempt is made to define product use, design or applications.

The test method is suitable for valves with equal inlet and outlet nominal sizes.

NOTE Unless otherwise specified, the equations are expressed in the SI units recommended by ISO 1000.

2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

2.1
nominal size
DN
conventional numerical designation used to indicate the size of an irrigation valve

NOTE It is expressed in millimetres, or in metres according to ISO 1000.

2.2
volume flow rate
flow rate
q_V
volume of water flowing through the valve per unit time

NOTE It is expressed in litres per second (l/s), cubic metres per hour (m^3/h), or in cubic metres per second (m^3/s) according to ISO 1000.

2.3
pressure loss
Δp
difference in pressure due to water flow between two specified points in a system or in part of a system

NOTE It is expressed in pascals (Pa) according to ISO 1000, in kilopascals (kPa) or in bar[1)].

2.4
piping pressure loss
Δp_{p}
pressure loss in the upstream and downstream portions of the test bench piping between the pressure taps, but excluding the pressure loss in the valve tested

2.5
bench pressure loss
Δp_{b}
pressure loss in the test bench between the pressure taps upstream and downstream of the valve tested

2.6
valve pressure loss
Δp_{v}
pressure loss in the valve tested

2.7
reference velocity
v_{ref}
velocity of flow through the valve calculated from the actual flow rate through the valve divided by the reference cross-sectional area of the valve

NOTE It is expressed in metres per second (m/s), in accordance with ISO 1000.

2.8
steady-state flow
state of flow where the flow rate through a cross-section does not vary with time

2.9
valve flow coefficient
K_{v}
number equal to the flow rate of water, in cubic metres per hour, that will flow through a fully open valve with a one bar pressure loss across the valve

NOTE It is expressed as

$$\text{m}^3/\text{h}\sqrt{\frac{1}{\text{bar}}}$$

2.10
flow resistance coefficient
ζ
coefficient used in non-dimensional presentation of valve loss

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1) 1 bar = 0,1 MPa = 10^5 Pa; 1 MPa = 1 N/mm^2.

3 Test installation

3.1 Permissible deviation of measuring devices

The permissible deviation of the reading indicated on the measuring devices from the actual value shall be as follows:

Flow rate:	± 2 %
Differential and actual pressure:	± 2 %
Temperature:	± 1 °C

The measuring devices shall be calibrated according to the existing calibration rules in the country concerned.

3.2 Test equipment

3.2.1 Piping

Upstream and downstream piping shall be the same diameter as that of the test valve connection. The lengths of the straight, uniform-bore pipe shall be as specified in Figures 1 and 2. The inside surface of the piping shall be free of flaking rust, mill scale and irregularities which might cause excessive turbulence.

In that part of the test apparatus shown within the frame, in Figures 1 and 2, the order of the fittings/devices shown in the key and the distances between them shall be adhered to, with the exception that the lengths indicated as $5d$ and $10d$ shall be understood to be the minimum allowable length.

3.2.2 Throttling valve

A downstream throttling valve shall be used to control the flow through the test specimen. There are no restrictions on the size or type of this valve. The throttling valve shall be located downstream of the downstream pressure tap (used for measuring bench pressure).

3.2.3 Flow measuring device

Any device that can be used to measure flow with acceptable accuracy may be used. If a closed measuring device (such as a rotameter, Venturi meter or similar device) is used, it shall be located either upstream of the upstream pressure tap or downstream of the downstream pressure tap.

If an open measuring device (such as a calibrated volumetric tank) is used, it shall be located at the downstream end of the assembly, i.e. downstream of the downstream throttling valve.

The flow-measuring device shall be installed in accordance with the specific installation instructions and, where applicable, shall be installed with the required length of straight piping before and after the device.

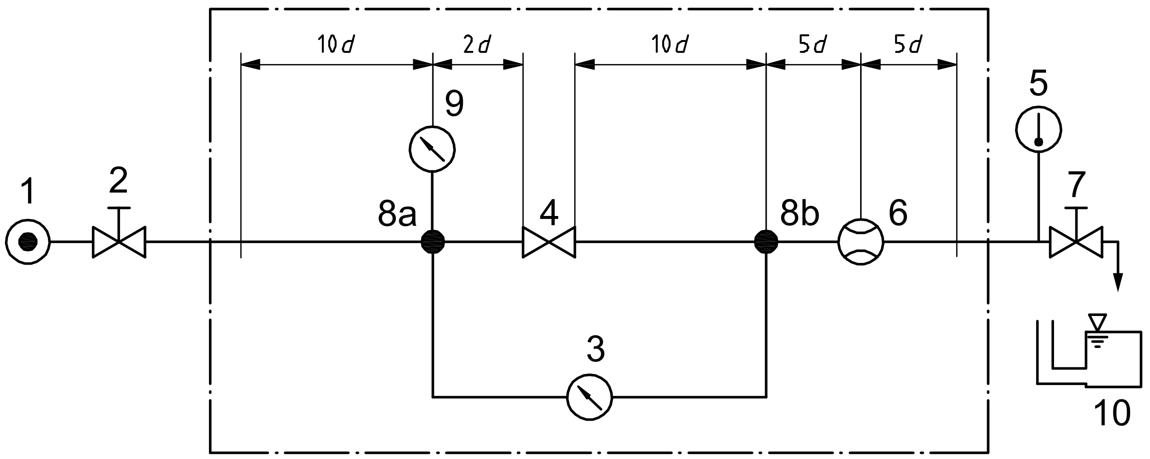
3.2.4 Pressure differential measuring device

Any device capable of measuring pressure differential with acceptable accuracy may be used.

3.2.5 Pressure taps

Pressure taps (see Figure 3) shall be provided on piping for measurement of static pressure, and spaced as shown in Figures 1 or 2. The drilling centreline of the taps shall intersect the centreline of the pipe perpendicularly, as shown in Figure 3. The taps shall have a diameter, d_1, of no less than 2 mm and no greater than 9 mm. The length, l, of the tap bore shall be not less than twice the diameter of the bore. For thin-walled pipes where the wall thickness is less than $2d_1$, a boss may be added to the pipe wall where the pressure taps are to be located (see Figure 3).

Pressure taps shall be free of burrs and other irregularities and the inside wall of the piping shall be machine-finished. For pipes of 50 mm diameter and larger, four taps shall be made, situated 90° ± 5° apart on the circumference so that no tap is located on the lowest point of the pipe circumference. For pipe diameters of less than 50 mm, two taps will suffice. All taps, whether two or four in number, shall be connected by a conduit whose bore shall not be less than two pressure-tap cross-sections. The pressure taps shall provide appropriate values of d_1 and l, and may be made as illustrated in Figure 3.



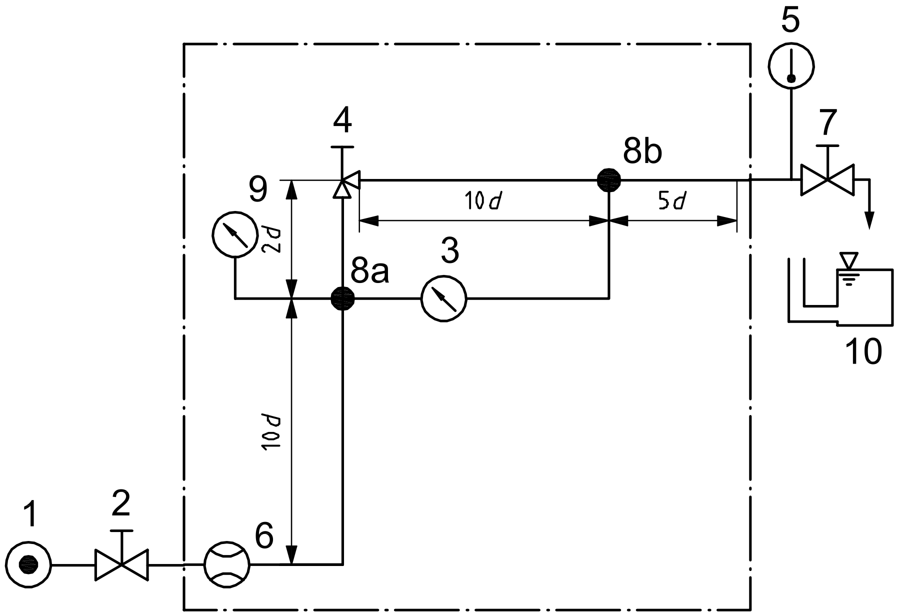
Key

1 controllable water supply
2 shut-off valve
3 pressure differential measuring device
4 test specimen, in-line valve
5 temperature sensor
6 flow measuring device, closed type (if used)
7 throttling valve
8a pressure tap
8b pressure tap
9 pressure gauge
10 calibrated water tank (if used)

d Nominal pipe diameter.

NOTE Dimensions $5d$ and $10d$ are minimal values.

Figure 1 — Test circuit diagram for in-line valves



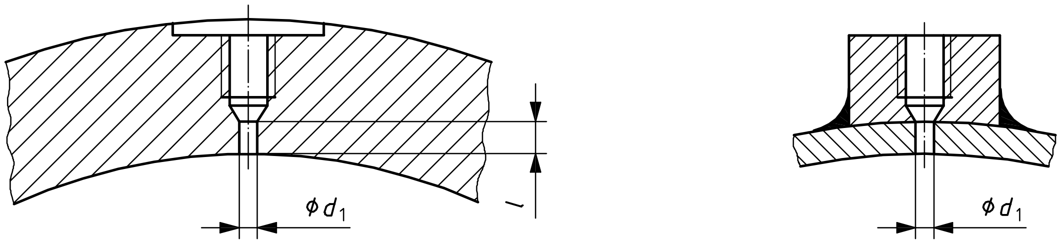
Key

1 controllable water supply
2 shut-off valve
3 pressure differential measuring device
4 test specimen, angle valve
5 temperature sensor
6 flow measuring device, closed type (if used)
7 throttling valve
8a pressure tap
8b pressure tap
9 pressure gauge
10 calibrated water tank (if used)

d Nominal pipe diameter.

NOTE Dimensions 5*d* and 10*d* are minimal values.

Figure 2 — Test circuit diagram for angle valves



a) Thick wall **b) Thin wall**

Figure 3 — Static pressure taps in thick and thin-wall piping

3.2.6 Temperature sensors

Any temperature-sensing device that is capable of measuring water temperature with acceptable accuracy (see 3.1) may be used. The device shall be located upstream of the throttling valve.

3.2.7 Filtration

If the valve manufacturer recommends the use of filtered water, a manufacturer-recommended filter shall be installed upstream of the test circuit.

4 Test procedure

4.1 Test installation

Install the test specimen on a suitable test bench for testing valves, as shown in Figure 1 or 2. Ensure that the water temperature during the test is between 5 °C and 35 °C.

4.2 Test conditions

4.2.1 Permissible fluctuations in measurements

For each quantity to be measured, the permissible amplitude of reading fluctuations is given in Tables 1 and 2.

If fluctuations of greater amplitude are present, measurements may be carried out by providing a damping device. The installation of the damping device shall not affect the accuracy of the readings. Symmetrical and linear damping devices shall be used.

Table 1 — Differential pressure fluctuation

Flow resistance coefficient [a] ζ	Δp **fluctuation** %
$\zeta > 20$	± 6
$4 < \zeta \leqslant 20$	± 10
$1 < \zeta \leqslant 4$	± 17
$0,1 \leqslant \zeta \leqslant 1$	± 26

[a] See 5.2.2.

Table 2 — Flowrate and pressure fluctuations

Quantity	**Fluctuation** %
Flow rate, q_V	± 3,5
Upstream pressure, e_p	± 3,5

4.2.2 Steady conditions

Test conditions are steady if the variations of each quantity, observed at the test operating point for at least 10 s, do not exceed a value of 1,2 % (the difference between the largest and the smallest readings of the quantity related to the mean value).

If this condition is met and if the fluctuations are less than the permissible values given in 4.2.1, only one set of readings of individual quantities is to be recorded for the test point considered.

Record all readings only after steady flow conditions have been reached, and the flow is free from pulsations.

4.2.3 Unsteady conditions

Test conditions are unsteady when variations exceed the limits of 4.2.2, when the following procedure shall be followed:

At each test point, repeated readings of the measured quantities shall be made at random intervals of time, but not less than 10 s. A minimum of three sets of readings shall be taken at each test point, with more sets required as the fluctuation increases, as indicated in Table 3.

Table 3 — Minimum reading set requirements

Number of sets	Permissible difference between largest and smallest values of readings of each quantity, related to mean value %
3	1,8
5	3,5
7	4,5
9	5,8
13	5,9
> 30	6,0

The arithmetic mean of all the readings for each quantity shall be taken as the actual value for the purposes of the test.

In the case where the excessive variation cannot be eliminated, the limits of error may be calculated by statistical analysis.

4.3 Test bench pressure loss

Measure the bench pressure loss, Δp_b, at the fully open position of the test specimen, unless specified otherwise in a specific standard, or as recommended by the manufacturer in the installation and operation instructions.

The bench pressure loss measured shall include the loss through the valve, Δp_v, and the loss through the piping, Δp_p, of the test set-up:

$$\Delta p_b = \Delta p_v + \Delta p_p \quad (1)$$

4.4 Test of valve

4.4.1 The test specimen shall be energized, opened or operated as in normal agricultural irrigation practice.

4.4.2 Record pressure-loss readings for at least five flow rates. Ensure that these readings include pressure losses for the maximum and minimum flow rates, $q_{V\text{1max}}$, and $q_{V\text{1min}}$ (as specified by the manufacturer), and at least three intermediate flow rates at approximately equal intervals between $q_{V\text{1max}}$ and $q_{V\text{1min}}$. The flow rate at approximately the midpoint of the range between $q_{V\text{1min}}$ and $q_{V\text{1max}}$ is referred to as the *median flow rate*, $q_{V\text{1med}}$. Conduct these tests at a pressure approximately two-thirds of the nominal pressure (as specified by the manufacturer) of the valve.

4.4.3 Tests of pressure loss shall be conducted successively in progressive steps — first, with increasing flow rates, followed by decreasing flow rates.

4.4.4 Calculate the valve pressure loss, Δp_v, of the test specimen by subtracting the piping pressure loss, Δp_p, from the bench pressure loss, Δp_b, measured by the differential pressure measuring device:

$$\Delta p_\text{v} = \Delta p_\text{b} - \Delta p_\text{p} \qquad (2)$$

The piping pressure loss, Δp_p, is determined by the following method. Remove the test specimen from the test assembly and connect pipe sections either directly or by means of a fitting that does not introduce significant pressure losses, and measure the piping pressure loss separately.

4.4.5 When the test specimen is supplied together with special fittings for connection to the water line, the connecting fittings are considered part of the valve.

5 Test results

5.1 Presentation of test results

The pressure loss of the valve, Δp_v, measured and calculated as described in Clause 4, shall be presented by one or both of the following:

a) by means of a table listing values of pressure loss and other coefficients at corresponding flow rates, q_V (see Table 4);

b) by means of a graph showing pressure loss, Δp_v, as a function of flow rate, q_V.

If only one of the above means in presented, b) is the one that is recommended.

If the results from the increasing and decreasing flow rate tests are substantially the same (within a tolerance range up to 5 % of the higher value), then only one column of pressure loss values shall be tabulated [a)], or only one curve shall be shown [b)].

If the results from the increasing and decreasing flow rate tests differ by more than the specified tolerance range of up to 5 % of the higher value, then two columns of pressure loss values labelled for increasing and decreasing flow rates shall be tabulated [a)], or two curves labelled for increasing and decreasing flow rates shall be shown [b)].

5.2 Calculated valve coefficients

5.2.1 General

For valves with fixed internal geometry, i.e. valves whose internal cross-section remains unchanged by pressure or discharge variations, the following coefficients may be calculated from the data given in the table or graph according to 5.1.

5.2.2 Flow resistance coefficient, ζ

The flow resistance coefficient, represented by the symbol zeta (ζ), is calculated using Equation (3):

$$\zeta = \frac{2\Delta p_{\mathrm{v}}}{\rho \cdot v_{\mathrm{ref}}^{2}} \tag{3}$$

where

Δp_{v} is the valve pressure loss;

ρ is the mass density;[2)]

v_{ref} is the reference velocity calculated from Equation (4):

$$v_{\mathrm{ref}} = \frac{q_V}{A_{\mathrm{ref}}} \tag{4}$$

where

q_V is the flow rate, in cubic metres per hour;

A_{ref} is the reference cross-sectional area, in square metres, calculated from Equation (5):

$$A_{\mathrm{ref}} = \frac{\pi}{4}\left(\frac{\mathrm{DN}}{1\,000}\right)^{2} \tag{5}$$

where DN is the nominal size of the valve, in millimetres.

This designation equals the nominal diameter or thread size of the pipe to which the valve can be connected without intermediate fittings.

NOTE A single number designation is adequate if the inlet and outlet ports are the same size.

The value of ζ for the valve tested shall be the arithmetic mean of the three flow resistance coefficient values, ζ_1, ζ_2 and ζ_3, calculated using Equation (3), with the three valve pressure loss values, $\Delta p_{\mathrm{v,min}}$, $\Delta p_{\mathrm{v,max}}$ and $\Delta p_{\mathrm{v,med}}$, inserted respectively, and using the corresponding measured values of q_V to calculate v_{ref} for insertion in the equation. The three Δp_{v} values are obtained from the table or graph according to 5.1 a) or b).

The presentation of the valve pressure loss by means of the flow resistance coefficient, ζ, is valid only if the values of ζ_1, ζ_2 and ζ_3 do not vary by more than 2,5 % of the calculated average value of ζ.

5.2.3 Valve flow coefficient, K_{v}

It is customary to compare the performance of different valves on the basis of their flow capacity which can be defined by the valve flow coefficient, K_{v}, which indicates the flow rate required to create a unit pressure loss across the valve.

2) For the purposes of this International Standard, it is expressed in kg/m^3, in accordance with ISO 1000. It can also be expressed in kg/l.

For water flow, K_v is calculated from Equation (6):

$$K_\mathrm{v} = q_V \sqrt{\frac{\rho}{\Delta p_\mathrm{v} \cdot \rho_0}} \quad (6)$$

where

q_V is the flow rate in m^3/h;

ρ is the mass density of the water at the temperature used during the test;

ρ_0 is the mass density of the water at 15 °C;

Δp_v is the valve pressure loss, in bar.

The value of K_v for the valve tested shall be the arithmetic mean of the three values of K_v as obtained when inserting in Equation (6) the measured values of q_V and Δp_v ($\Delta p_\mathrm{v,min}$, $\Delta p_\mathrm{v,max}$ and $\Delta p_\mathrm{v,med}$), obtained from the table or graph as specified in 5.1 a) or b).

The permissible difference between the maximum and the minimum value of the flow coefficient shall not exceed 4 % of the maximum.

5.3 Test report

The test report shall include

a) a description of the valve (manufacturer's name, type and model of valve, valve size, and special information and identification),

b) confirmation that the valve has been installed for the test in accordance with the direction of flow indicated on the valve body,

c) confirmation that the valve has been set to its normal fully open position,

d) confirmation that the valve test was conducted in accordance with this International Standard,

e) temperature and pressure of the water used during the test,

f) presentation of test results in accordance with 5.1,

g) a statement to the effect that the test was performed with filtered water (if its use is recommended by the manufacturer),

h) a graph showing the pressure losses obtained in the test, as recommended in 5.1 b), and/or

i) a table showing the pressure losses obtained in the test, such as Table 4.

Table 4 — Example of tabular presentation of test results

Flow rate q_V m^3/s	**Pressure loss** Δp_v kPa	**Flow resistance coefficient** ζ	**Valve flow coefficient** K_v $m^3/h\sqrt{\frac{1}{bar}}$

Bibliography

[1] ISO 1000:1992, *SI units and recommendations for the use of their multiples and of certain other units*

[2] EN 1267:1999, *Valves — Test of flow resistance using water as test fluid*

ICS 65.060.35

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