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Pneumatic fluid power — Compressed air pressure regulators and filter-regulators —

Part 2: Test methods to determine the main characteristics to be included in literature from suppliers

Transmissions pneumatiques — Régulateurs de pression et filtres-régulateurs pour air comprimé —

Partie 2: Méthodes d'essai pour déterminer les principales caractéristiques à inclure dans la documentation des fournisseurs

Reference number
ISO 6953-2:2015(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.

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 on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: Foreword — Supplementary information.

The committee responsible for this document is ISO/TC 131, *Fluid power systems*, Subcommittee SC 4, *Connectors and similar products and components*.

This second edition cancels and replaces the first edition (ISO 6953-2:2000), which has been technically revised.

ISO 6953 consists of the following parts, under the general title *Pneumatic fluid power — Compressed air pressure regulators and filter-regulators*:

— *Part 1: Main characteristics to include in supplier's literature and product-marking requirements*

— *Part 2: Test methods to determine the main characteristics to be included in literature from suppliers*

— *Part 3: Alternative test methods for measuring the flow-rate characteristics of pressure regulators*

Introduction

In pneumatic fluid power systems, power is transmitted and controlled through a gas under pressure within a circuit.

When pressure reduction or pressure regulation is required, regulators and filter-regulators are components designed to maintain the pressure of the gas at an approximately constant level.

It is therefore necessary to know the performance characteristics of these components in order to determine their suitability in an application.

Pneumatic fluid power — Compressed air pressure regulators and filter-regulators —

Part 2: Test methods to determine the main characteristics to be included in literature from suppliers

1 Scope

This part of ISO 6953 specifies test procedures and a method of presenting the results concerning the parameters which define the main characteristics to be included in literature from suppliers of regulators and filter-regulators conforming to ISO 6953-1.

The purpose of this part of ISO 6953 is the following:

— to facilitate the comparison of pressure regulators and filter-regulators by standardizing test methods and presentation of test data;

— to assist in the proper application of pressure regulators and filter-regulators in compressed air systems.

The tests specified are intended to allow comparison among the different type of regulators and filter-regulators; they are not production tests to be carried out on each pressure regulator or filter-regulator manufactured.

NOTE 1 The tests related to electro-pneumatic pressure control valves are specified in ISO 10094–2.

NOTE 2 Use ISO 6953-3 for an alternative dynamic test method for flow-rate characteristics using an isothermal tank instead of a flow meter. However, this method measures only the decreasing flow rate part of the hysteresis curve of forward flow and relief flow characteristics.

2 Normative references

The following documents, in whole or in part, are referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 1219-1, *Fluid power systems and components — Graphical symbols and circuit diagrams — Part 1: Graphical symbols for conventional use and data-processing applications*

ISO 3448, *Industrial liquid lubricants — ISO viscosity classification*

ISO 5598, *Fluid power systems and components — Vocabulary*

ISO 6358-1, *Pneumatic fluid power — Determination of flow-rate characteristics of components using compressible fluids — Part 1: General rules and test methods for steady-state flow*

ISO 6953-1:2015, *Pneumatic fluid power — Compressed air pressure regulators and filter-regulators — Part 1: Main characteristics to be included in literature from suppliers and product-marking requirements*

ISO 10094-1, *Pneumatic fluid power — Electro-pneumatic pressure control valves — Part 1: Main characteristics to include in the supplier's literature*

ISO 10094-2, *Pneumatic fluid power — Electro-pneumatic pressure control valves — Part 2: Test methods to determine main characteristics to include in the supplier's literature*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 6953-1, ISO 6358-1, ISO 10094-1, and ISO 5598 apply; in the order shown.

4 Symbols and terms

4.1 Symbols and units

The symbols and units shall be in accordance with ISO 10094-2. See Table 1.

Table 1 — Symbols and units

Description	Symbol	SI unit	Practical unit
Reference atmosphere	p_{atm}	Pa	kPa (bar)
Inlet pressure	p_1	Pa	kPa (bar)
Regulated pressure	p_2	Pa	kPa (bar)
Forward volumetric flow rate at standard reference atmosphere	q_{vf}	m^3/s (ANR)	dm^3/min (ANR)
Relief volumetric flow rate at standard reference atmosphere	q_{vr}	m^3/s (ANR)	dm^3/min (ANR)
Reference temperature	T_0	K or °C[a]	°C
Inlet temperature	T_1	K or °C[a]	°C
Temperature at the regulated port	T_2	K or °C[a]	°C

[a] emperature in K is used for calculations; temperature in °C is used for test conditions.

NOTE 1 bar = 100 kPa = 0,1 MPa = 10^5 Pa = 10^5 N/m^2.

4.2 Graphical symbols

The graphical symbols used in this part of ISO 6953 are in accordance with ISO 1219-1.

5 Test conditions

5.1 Gas supply

Unless otherwise specified, testing shall be conducted with compressed air. If another gas is used, it shall be noted in the test report.

5.2 Temperature

The ambient fluid and the component under test shall be maintained at 23 °C ± 10 °C during all the tests.

5.3 Pressures

The specified pressures shall be maintained within ±2 %.

5.4 Inlet pressure

The inlet pressure used for testing shall be the lower of the following pressures:

— the maximum regulated pressure, $p_{2,max}$, plus 200 kPa (2 bar);

— the specified maximum inlet pressure, $p_{1,max}$.

5.5 Test pressures (regulated pressure)

The preferential test pressures are chosen as approximately equal to 25 %, 40 %, 63 %, and 80 % of the upper limit of recommended adjustable pressure range.

6 Test procedure to verify rated pressure

6.1 Perform this test on three random samples if a single-rated pressure is proposed for the entire product or on six random samples if separate ratings are proposed for the inlet and outlet sections. If the product uses a diaphragm, modify or replace it to withstand the pressure applied (diaphragms are excluded from the test criteria, but not the diaphragm support plates or any piston). Other product sealing means can be modified to prevent leakage and allow structural failure to occur during the test, but modifications shall not increase the structural strength of the pressure-containing envelope. For relieving regulators, the relieving system shall be blocked.

6.2 Prepare the test samples as follows:

— If a single pressure rating is proposed for the entire product, remove the control spring and replace it with a solid spacer whose length maintains the poppet in its approximately half-open position. Close the gauge ports and the inlet port with plugs, and perform all testing by applying pressure to the outlet port. For relieving regulators, the relieving system shall be blocked.

— If a separate pressure rating is proposed for the inlet and outlet sections of the regulator, relieve the control spring force on three of the samples. Using a proposed pressure rating for the inlet, perform testing on the inlet port, allowing the poppet to be closed and keeping the outlet port open. Prepare the other three samples as described in previous indent and test them using a proposed pressure rating for the outlet port.

6.3 The test should be done with a liquid which does not exceed ISO VG 32 (according to ISO 3448) or with compressed air. Maintain the temperature given in 5.2. When using a compressible medium, exercise safety precautions to contain an explosive failure.

6.4 After stabilizing the temperature, slowly pressurize to a level of one-half its proposed rated pressure. Hold at this level for 2 min and observe for leakage or failure, as defined in 6.5.

6.4.1 For products constructed of light alloys, brass, and steel, continue raising the pressure as above until a level of four times the proposed rated pressure has been reached.

6.4.2 For products constructed of zinc, die cast alloys, or plastics

— with design operating temperatures of up to 50 °C, continue raising the pressure as above until a level of four times the proposed rated pressure has been reached.

— with design operating temperature between 50 °C to 80 °C, continue raising the pressure as above until a level of five times the proposed rated pressure has been reached.

6.5 The criterion for a failure is a fracture, separation of parts, or a crack, or that which can allow enough liquid to pass across the pressure-containing envelope to wet the outer surface. Leakage across the port threads shall not constitute a failure, unless caused by a fracture or a crack.

6.6 The proposed rated pressure is verified if all three samples pass their respective tests.

6.7 Where a unit or sub-assembly in the unit (for example, reservoir sight glass) is constructed of different materials, the higher appropriate factor should be used. The applied pressure can be restricted to the area of the interface between the different materials.

6.8 Where the pressure-containing envelope design is covered by a pressure vessel code in the market of sale, the requirements of that code take precedence over the requirements stated in this part of ISO 6953.

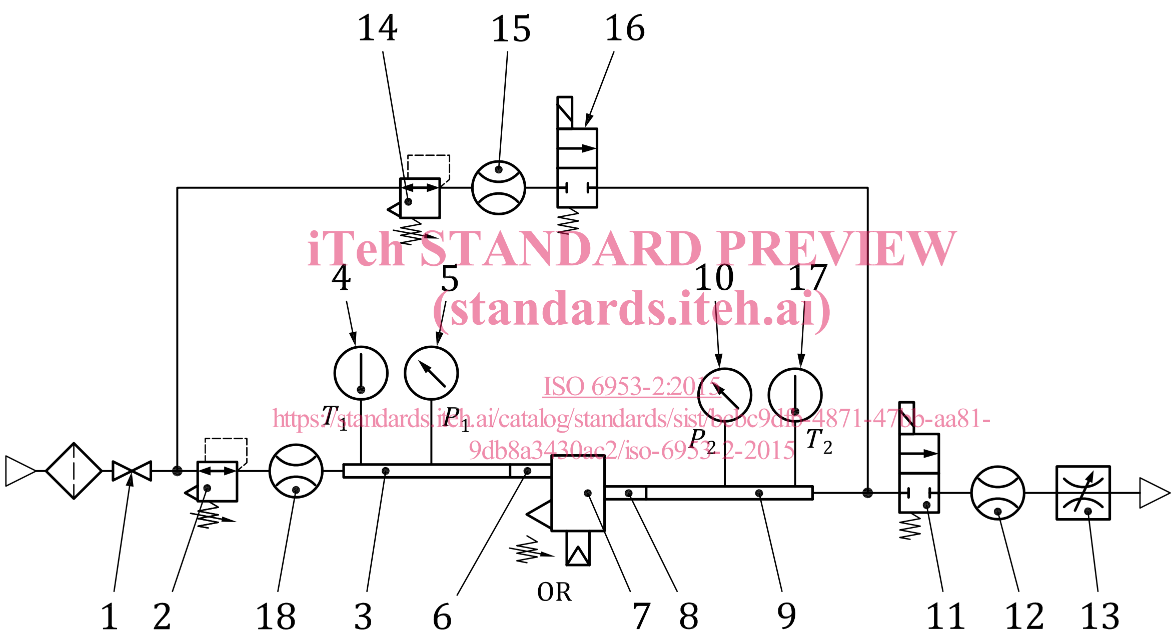
7 Flow characteristics tests

7.1 Test installation

A suitable test circuit as shown in Figure 1 shall be used for measuring forward or relief flow rates. This test circuit combines

— the constant upstream pressure (in-line) test circuit, as described in ISO 6358-1 for characterizing the components with upstream and downstream pressure-measuring tubes and transition connectors (used for forward flow rate measurements), and

— the variable upstream pressure (exhaust-to-atmosphere) test circuit, as described in ISO 6358-1 (used for relief flow rate measurements).



Key

1 inlet shut-off valve
2 inlet pressure regulator
3 pressure-measuring tube
4 inlet temperature, T_1, measuring-element
5 inlet pressure, p_1, gauge or transducer
6 transition connector
7 component under test
8 transition connector
9 pressure-measuring tube
10 regulated pressure, p_2, gauge or transducer
11 solenoid valve
12 forward flow meter
13 flow control valve (for forward flow rates)
14 pressure regulator (for relief flow rates)
15 relief flow meter
16 solenoid valve
17 temperature, T_2, measuring-element (for relief flow rates)
18 flow meter

NOTE Item 18 is optional for measuring forward flow rates but only for non-bleeding regulators.

Figure 1 — Test circuit for flow rate — pressure characterization

7.2 General requirements

7.2.1 The component under test 7 shall be located in the test circuit so as to connect its inlet port to the upstream transition connector and pressure-measuring tube. Its outlet port is connected to a transition connector and a pressure-measuring tube enabling a measurement of the regulated pressure, p_2. For the relief flow test, air passes through the vent passages to the atmosphere.

7.2.2 Pressure-measuring tubes 3 and 9 and transition connectors 6 and 8 shall be in accordance with ISO 6358-1.

7.2.3 Components 1, 2, 3, 4, 5, and 6 correspond to the upstream part of the test circuit used for forward flow measurements. These components shall remain in-place for the relief flow rate measurements, and the inlet port of the component under test shall be pressurized from the supply circuit.

7.2.4 Components 8, 9, 10, 11, 12, and 13 correspond to the downstream part of the test circuit used for forward flow rate measurements.

7.2.5 Components 14, 15, 16, 9, 10, 17, and 8 correspond to the upstream part of the test circuit used for relief flow rate measurements.

7.2.6 The sonic conductances of the pressure regulator 2 and solenoid valve 11 should each be at least twice the forward sonic conductance of the component under test. The sonic conductances of the pressure regulator 14 and solenoid valve 16 should each be at least twice the relief sonic conductance of the component under test.

7.3 Test procedures

7.3.1 Initial test procedure

7.3.1.1 Install the regulator according to Figure 1, with shut-off valve 1, solenoid valves 11 and 16, and flow control valve 13 closed.

7.3.1.2 Open shut-off valve 1 and adjust pressure regulator 2 to apply an inlet pressure, p_1, chosen according to 5.4. During every measurement concerning the static tests described in 7.3.2, 7.3.3, and 7.3.4, the inlet pressure shall be maintained within the tolerance specified in 5.3 (this might require constant readjustment of regulator 2).

7.3.1.3 Increase the set pressure on the component under test until it reaches the regulated pressure value, p_2, corresponding to 25 % of the regulated pressure full scale.

7.3.1.4 Follow successively the procedure described in 7.3.2 for forward flow rates and then the procedure described in 7.3.3 for relief flow rates.

7.3.2 Forward flow rate — pressure characteristics test

7.3.2.1 Open the solenoid valve 11. Then, slowly open the flow control valve 13 and let a low flow rate of air pass through the component under test.

7.3.2.2 When the flow is steady, measure the forward flow rate using the flow meter 12, the corresponding regulated pressure, p_2, using the pressure transducer 10 and the inlet temperature, T_1.

7.3.2.3 Continue the measurements by gradually increasing the flow rate in steps, recording data after conditions in each step are stable. Continue this process until the maximum flow rate is achieved in the test circuit. Measure additional data for a decreasing forward flow rate, also in steps, until the flow is near zero (item 13 is closed). During the variations of the forward flow (increasing and decreasing), keep the inlet pressure, p_1, within the tolerance specified in 5.3.

7.3.3 Relief flow rate — pressure characteristics test

7.3.3.1 Set the pressure regulator 14 at the same pressure value as the regulated pressure value of the component under test, obtained without flow at the end of the procedure described in 7.3.2.3. Close the solenoid valve 11 and open the solenoid valve 16 to apply this pressure on the outlet side of the component under test. Air can (but might not) begin to flow through the relief outlet of the test regulator.

7.3.3.2 Increase the regulated pressure slightly using the pressure regulator 14. When the flow is steady, measure the relief flow using the flow meter 15, the corresponding regulated pressure, p_2, using the pressure transducer 10 and temperature, T_2.

7.3.3.3 Continue the measurements by gradually increasing the flow rate in steps (by increasing the pressure using pressure regulator 14). Record data after conditions stabilize after each step. Continue this until the pressure reaches a level of the inlet pressure according to 5.4. Measure additional data for a decreasing pressure until the flow rate reaches zero. During variations of the relief flow (increasing and decreasing), keep the inlet pressure, p_1, within the tolerance of 5.3.

7.3.3.4 Close solenoid valve 16 before continuing to the next step.

7.3.4 Procedure for other regulated pressure values

Repeat the procedures for measuring forward flow rate (7.3.2) and relief flow rate (7.3.3) for regulated values corresponding to about 40 %, 63 %, and 80 % of the regulated pressure full scale. Make these settings without flow, gradually adjusting the regulator by increasing values only, until reaching these values. If a pressure setting needs to be adjusted downwards, reduce the pressure well below the desired value and increase the pressure to the desired setting.

7.4 Calculation of characteristics

7.4.1 Characteristic curves

7.4.1.1 For the regulated set pressure equal to 25 % of the regulated pressure full scale, for each forward flow rate value, calculate the mean value of the two corresponding regulated pressures, p_2, measured according to the procedure described in 7.3.2 respectively with increasing and decreasing forward flow rates.

Plot a graph of the mean regulated pressure values as a function of the forward flow rate, as shown in the first quadrant of Figure 2.

7.4.1.2 For the regulated set pressure equal to 25 % of the regulated pressure full scale, for each relief flow rate value, calculate the mean value of the two corresponding regulated pressures, p_2, measured according to the procedure described in 7.3.3 respectively, with increasing and decreasing relief flow rates.

Plot a graph of the mean regulated pressure values as a function of the relief flow rate, as shown in the second quadrant of Figure 2.

7.4.1.3 Repeat the procedure of calculation and layout for the three other regulated set pressure values: 40 %, 63 %, and 80 % of the full scale.

7.4.2 Flow rate — pressure hysteresis

For each forward flow rate or relief flow rate value, calculate the difference between the regulated pressure values measured respectively with increasing and decreasing flow rates. These values are measured according to the procedures described in 7.3.2 and 7.3.3.

Determine the maximal difference, $\Delta p_{2h,max}$.

$$H = \frac{\left|\Delta p_{2h,max}\right|}{p_{2,max}} \times 100 \qquad (1)$$

Use Formula (1) to calculate the hysteresis characteristic value expressed as percentage of the regulated pressure full scale.

7.4.3 Maximum forward sonic conductance

7.4.3.1 Graphically determine the maximum forward flow rate, $q_{vf,max}$, as the intersection of an extension line of forward flow rate-pressure characteristic curves obtained in 7.4.1 with the abscissa (regulated pressure is null in relative value), according to Figure 2.

7.4.3.2 Calculate the value of the maximal forward sonic conductance, $C_{f,max}$, by dividing this flow rate value by the inlet pressure according to ISO 6358-1, using Formula (2):

$$C_{f,max} = \frac{q_{vf,max}}{p_1 + p_{atm}} \sqrt{\frac{T_1}{T_0}} \qquad (2)$$

NOTE The square root is necessary to take into account the test upstream temperature, T_1, deviation from the reference temperature, T_0, according to ISO 6358-1.