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Industrial valves — Design validation-testing of valves

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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).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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 153, *Valves*.

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

The scope of this document is currently limited to ball and butterfly valves.

The objective of this document is to outline the requirements and methods for evaluating the performance of metallic industrial valves with respect to seat performance and operating torque capability. Fugitive emission performance was omitted, as it is covered by ISO 15848-1. The number of cycles (205) is consistent with the number in C01 of ISO 15848-1:2015. It serves to test the accuracy and dependability of the measurements and capabilities of a valve as published by the manufacturer in the valve's technical documentation.

Type validation is the most reliable method to validate a range of valve products, covering many aspects, such as its design, material selection and manufacturing processes. It will also serve as a guide for valve selection, allowing customers to compare different valve types, designs and brands.

Several major customers already require type tests, each having their own requirements and specifications. Introducing a defined International Standard will reduce manufacturer's costs by decreasing the number of qualifications, as well as decreasing end-user total cost-of-ownership, by eliminating the possibility of unintentional design flaws.

This validation will improve performance and safety in the plants by enabling any customer to specify durable type-tested industrial valves.

Industrial valves — Design validation-testing of valves

1 Scope

This document specifies requirements and acceptance criteria for type testing, in compliance with design conditions, of metallic butterfly and ball valves used for isolating services for all industrial applications, and serves to validate the product design over 205 cycles.

This document excludes testing for safety devices, control valves, thermoplastics valves, and valves for water supply for human consumption and sewage (e.g. the EN 1074 series).

This document defines the procedure for extending the qualification of the tested valve to untested sizes and pressure designations of the same product range.

The purpose of this type test is to validate the seat performance within manufacturer given pressure/temperature rating, provided by the manufacturer's technical documentation of the product. This type test verifies torque requirements and the maximum allowable stem torque (MAST), as given in the manufacturer's technical documentation. This type test validates the durability of seat performance and operating torque through mechanical and thermal cycles.

2 Normative references

The following documents are referred to in the text in such a way that some or all 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 5208, *Industrial valves — Pressure testing of metallic valves*

ISO 15848-1, *Industrial valves — Measurement, test and qualification procedures for fugitive emissions — Part 1: Classification system and qualification procedures for type testing of valves*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5208 and ISO 15848-1 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
asymmetric sealed valve
valve with an internal construction, which does not have a plane of symmetry perpendicular to the axis of the body ends

Note 1 to entry: This is a valve where both seat and sealing elements are not identical.

3.2
bidirectional valve
valve designed for blocking the flow in both downstream and upstream directions

3.3
maximum allowable stem torque
MAST
maximum torque that can be applied to a valve stem or shaft without causing permanent deformation or mechanical damage to the stem or any other components of the valve that prevent sealing or operation

3.4
minimum allowable temperature
minimum temperature for which the valve is designed

3.5
obturator
movable component of the valve whose position in the fluid flow path permits, restricts or obstructs the fluid flow

3.6
operating mechanism
mechanism which translates the motion of the manual- or power-operated device to the motion of the *obturator* (3.5)

3.7
post-test examination
disassembly, inspection and examination after completion of all the tests

3.8
qualified facility
independent test facility accredited and certified to perform valve type testing

3.9
room temperature
RT
temperature in the range of +5 °C to +40 °C

3.10
seating torque
torque applied to the shaft to move the *obturator* (3.5) into contact with the seat immediately prior to the closure test

3.11
seat performance
closure test over a range of mechanical, pressure and temperature cycles

3.12
symmetric sealed valve
valve with an internal construction which has a plane of symmetry perpendicular to the axis of the body ends

Note 1 to entry: This is a valve where both seat and sealing elements are identical.

3.13
torque measurement
measurement of *seating* (3.10) and *unseating torques* (3.14) using calibrated measuring equipment

3.14
unseating torque
torque applied to open the valve against the maximum differential pressure

3.15
design validation testing
protocol where valves are type tested at the maximum rated pressures and design temperature ranges as specified by the manufacturer

3.16
unidirectional valve
valve designed for blocking the flow in either downstream or upstream direction only

4 Type test

4.1 Test condition

4.1.1 General

The valve manufacturer shall issue a declaration of conformity that the valve to be tested is representative of the products that are being shipped to customers and is not specially prepared for this test. The valve to be tested may be externally coated or painted.

This declaration of conformity shall state that the valve components and the assembled valve have undergone all the manufacturing, assembly and hydrostatic shell test steps of the typical quality control plan provided by the manufacturer.

The allowable seat leakage rates, according to ISO 5208, shall be specified by the valve manufacturer before the start of the type test.

The test equipment shall be appropriately selected to assure it adheres to the specific type test operating conditions. This equipment should also be in accordance with the applicable health, safety and environmental management system.

All measuring instruments shall be calibrated and shall be within their period of validity at the date of testing.

4.1.2 Closure test

Pressure test for the purpose of validating leakage through a valve's closure mechanism shall be measured with dry air or other suitable gas using the mandatory closure test procedure given in ISO 5208 per the applicable product standard. Over 5 MPa (50 bars), self-ignition risks shall be considered when testing with dry air.

For a closure test performed at high or low temperature, the temperature of the exiting test gas shall be measured (before the flowmeter) and verified to be within the calibration range of the flowmeter. For volume flow measurement it is required to correct that measurement for the effect of temperature, or to bring the temperature of the exiting test gas within room temperature.

The perfect gas relationship assuming constant pressure shall be used to determine the equivalent flow rate at room temperature. See ISO 28921-1 for the detailed calculation.

$$Q_2 = \frac{Q_1 \times T_2}{T_1} \tag{1}$$

where

T_1 is the test gas temperature entering the flowmeter, in Kelvin (K);

T_2 is 298 K, the standard ambient temperature, in Kelvin (K);

Q_1 is the test gas flow exiting the flowmeter, in cubic millimetres per second (mm^3/s);

Q_2 is the corrected test gas flow exiting the flowmeter at room temperature, in cubic millimetres per second (mm^3/s).

Electronic mass flowmeters are not affected by pressure or temperature changes. When such flowmeter is used, test gas pressure and temperature measurements (as well as correction) at the flowmeter is not required.

For a closure test performed at high temperature, the test pressure shall be 1,1 × the maximum rated pressure at high temperature.

4.1.3 Torque measurement

Torque shall be measured by means of a calibrated torque wrench with maximum torque indicator, strain gauge sensor or other appropriate means. Torque measurement equipment shall have a tolerance accuracy lower than or equal to 5 % at the maximum torque measured.

4.1.4 Temperature measurement

The temperature of the test valve shall be measured at the following three locations, as shown in Figure 1 and recorded in a test report.

a) Measurement at location 1 shall be used to determine the test temperature.

b) Measurement at location 2 is for information; any use of insulation shall be detailed in the test report.

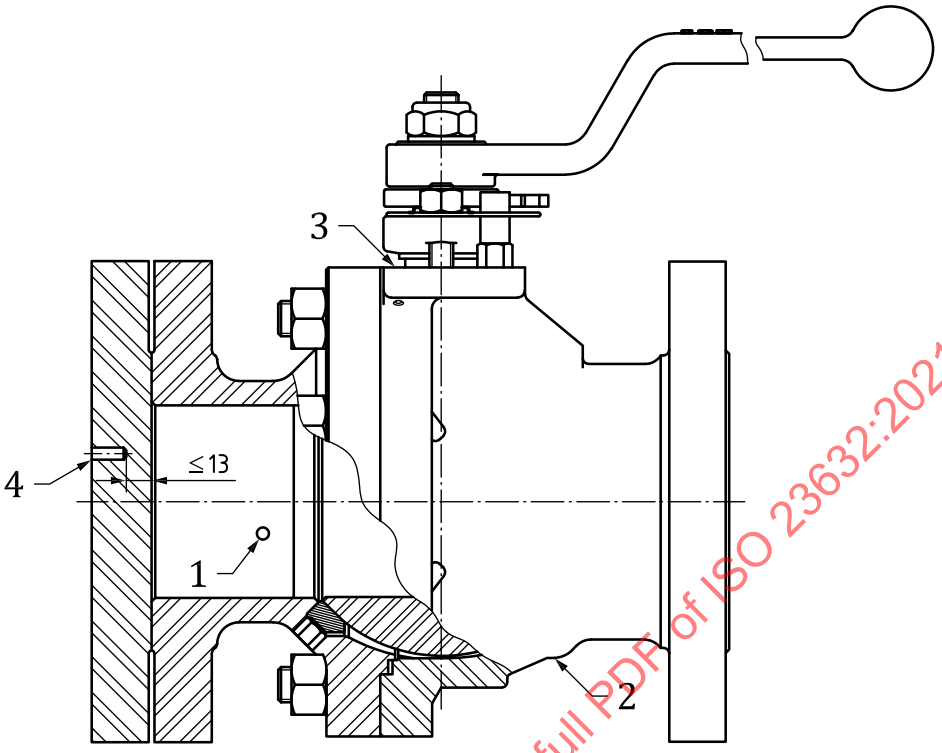
c) Measurement at location 3 is used to determine the external valve temperature adjacent to the stem (or shaft) seal(s) for information. For a valve provided with extended bonnet, the thermocouple shall be located on the stuffing box, at the top of the extension.

d) Measurement at location 4 is an option if the measurement location 1 is not possible (except in the case where heating elements penetrate the blind flanges).

All temperatures at location 1 (optionally 4), location 2 and location 3 shall be stabilized before leakage is measured. Temperature at location 1 (optionally 4) shall be stabilized for minimum 10 min prior to leakage measurement (see Figures 1 and 2).

Check if the temperature variation is within ± 5 %, or ± 15 °C, whichever is less.

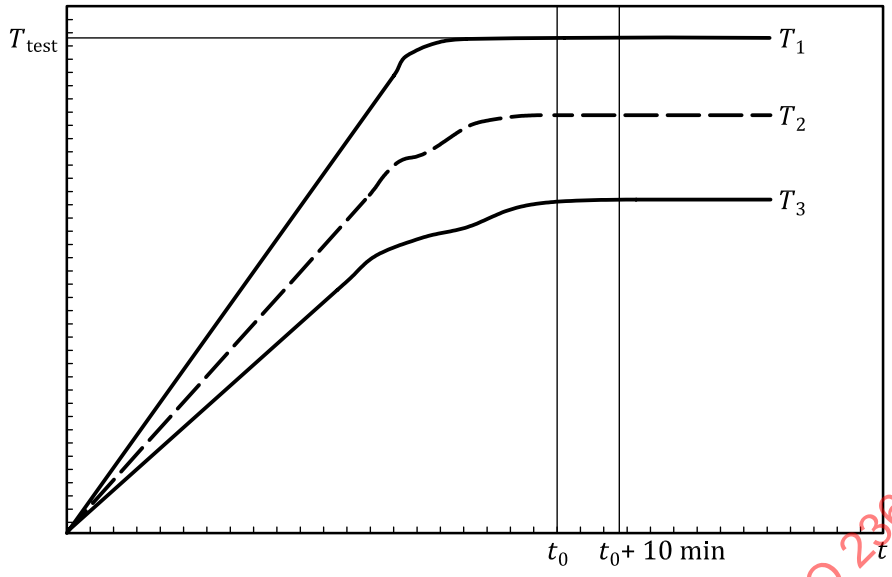
Dimensions in millimetres



Key

1 location 1: internal flow path (temperature T_1)
2 location 2: valve body, close to the seat (temperature T_2)
3 location 3: stuffing box (temperature T_3)
4 location 4: optional for flow path when location 1 is not possible (temperature T_4); maximum depth is 13 mm

Figure 1 — Temperature measurements



Key

T_{test}	test temperature, °C	t	time
T_1	stabilization temperature at location 1 (flow path)	t_0	stabilization of temperature at location 1 (flow path)
T_2	stabilization temperature at location 2 (valve body)		
T_3	stabilization temperature at location 3 (stuffing box)	t_0 + 10 min	start of mechanical cycles

Figure 2 — Stabilization of temperatures

4.1.5 Test facility and safety rules

The type tests may be carried out at the valve manufacturing facilities, at the customer facility or at an external qualified facility. However, a set of minimum requirements shall be established for the facility and shall be met for testing to take place at said location. These requirements may include, but are not limited to:

— demonstration of the capability to perform required tests, inspections, analysis and examinations, in terms of both personnel qualification and equipment availability;

— having a quality management system;

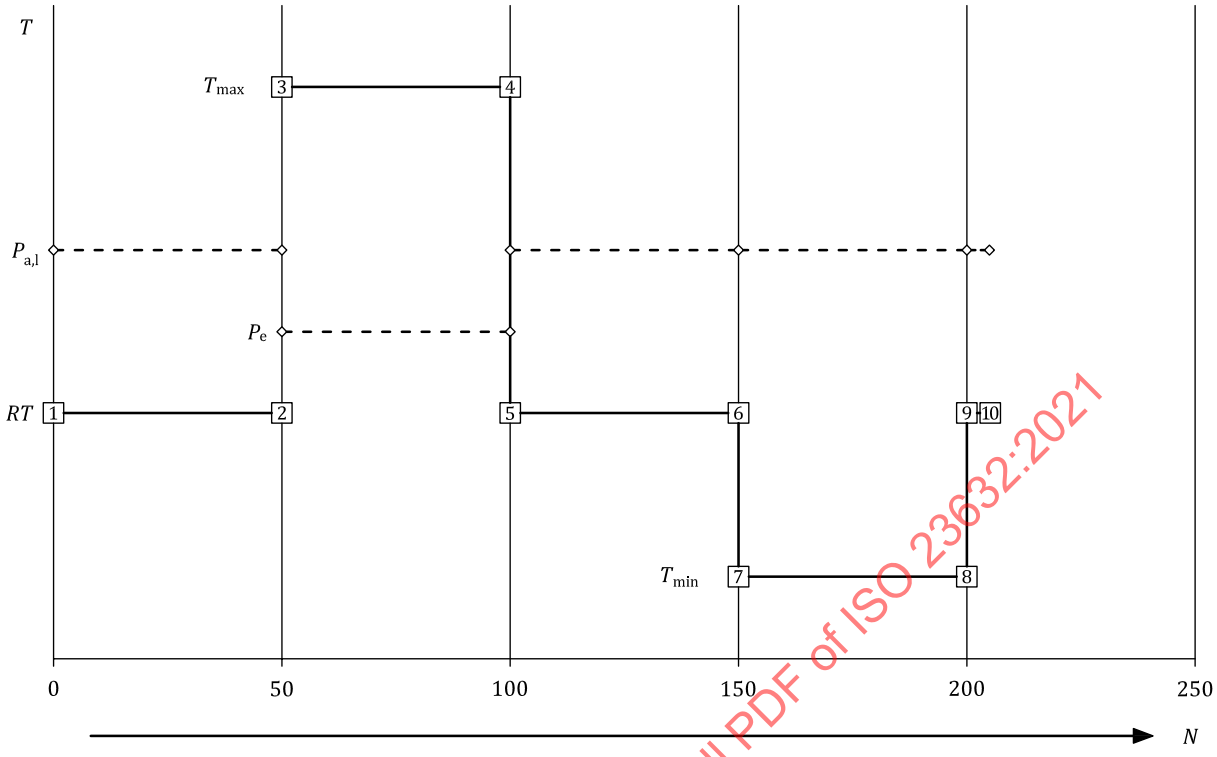
— a health, safety and environment management system;

— familiarity with the most common valve standards, as well as the reporting and certification of the test results (in appropriate formats).

CAUTION — Pressure testing using gas could be dangerous. Adequate shields or barriers shall be provided, with warning signs posted in the test area.

4.1.6 Mechanical-cycle classes

The mechanical cycle shall be in accordance with Figure 3.



Key

N	number of mechanical cycles
RT	room temperature
T_{max}	maximum allowable temperature (internal flow path)
T_{min}	minimum allowable temperature (internal flow path)
$P_{a,l}$	maximum rated pressure at ambient temperature and T_{min}
P_e	maximum rated pressure at T_{max}

NOTE 1 If P_e at T_{max} is less than 6 bar, T_{max} is equal to the temperature at 6 bar.

NOTE 2 The numbers 1 to 8 refer to the closure and torque tests to be performed at the beginning and the end of each temperature cycles, and as specified in 4.2.3 and 4.2.4. Number 9 refers to the post-test as specified in 4.2.5 and 4.2.6. Number 10 is the end of the test.

Figure 3 — Mechanical-cycle class for isolating valves

4.2 Test description

4.2.1 General

The test sequence shall follow Figure 3. Each numbered box is a measurement step.

The valve shall be opened against the maximum differential pressure at each mechanical cycle. The torque seated valve should be closed to the seating torque provided by the manufacturer at each cycle.

The closure test shall be carried out and the opening torque measured at steps 1 to 8 identified in Figure 3.

4.2.2 Test temperatures

The valve mechanical cycling is carried out at room temperature, maximum allowable and minimum allowable temperatures. Testing at maximum allowable and minimum allowable temperatures is required if these temperatures are outside the room temperature range.

The test temperature shall be recorded for each leakage and torque measurement.

4.2.3 Closure test

The closure test shall be performed in accordance with 4.1.2.

The obturator shall be moved to the closed position.

For torque seated valves, the seating torque shall be the one provided by the valve manufacturer. Some variation of the seating torque during cycling is allowed ±10 %.

Unidirectional valves shall be tested in one direction only. Symmetric sealed valves that are bidirectional may be tested in one direction only. Asymmetric sealed valves that are bidirectional shall be tested in both directions.

The closure test pressure shall be maintained for a period of time not less than the time specified in Table 1 before closure testing.

Table 1 — Minimum stabilisation time before closure testing

Valve NPS	Time (min)
DN 15 to DN 400 (NPS ½ to NPS 16)	5
DN 450 to DN 600 (NPS 18 to NPS 24)	10
> DN 600 (DN 24)	15

4.2.4 Unseating torque

After each closure test the unseating torque at the test temperature shall be measured and recorded.

The measured torque shall not be greater than the torque given by the manufacturer technical documentation.

4.2.5 Maximum allowable stem torque (MAST)

The MAST published by the manufacturer shall be applied to the valve at room temperature ensuring that the full operating mechanism is tested. For actuator and gearbox operated valves where the actuator or gearbox torque is less than the valve MAST, the maximum actuator or gearbox rated torque shall be applied. Actual applied torque shall be reported in the test report. In case of a ball valve, a set-up may be required to block the obturator (set-up shall avoid damaging the seats and obturator).

The valve shall then be operated from closed to full open and open to close once to confirm mechanical integrity. After the cycling, the seat integrity shall then be confirmed by a closure test as per 4.2.3.

4.2.6 Post-test examination

On completion of the type test sequence, the valve shall be disassembled, and each component visually inspected, to record any notable wear or any other significant observations. Any crack, important material removal or any degradation that would question the valve integrity or operability are not acceptable.

4.2.7 Qualification

Tested valves shall be qualified when:

— all steps of test procedures have been satisfactorily completed;

— all leakage measurements are verified to be equal or lower than the rates specified by the valve manufacturer;

— all torque measurements are verified to be within the manufacturer published torque values;

— nothing was found in the post-test examination that would question the valve integrity or operability.

4.3 Test report

A template of the test report is given in Annex A.

5 Extensions of qualification to the product range

Upon the successful completion of the test program, this qualification can be extended to untested size and pressure designation of valves of the same product range if the following criteria are met.

— Design standards are identical.

— Construction geometry, including seal design, tolerance classes and surface finishes specification affecting seat leakage and torque performance, are identical.

— Seat-to-closure material selection is from the same group. For example, metal-seated valves provided with a seat-to-closure material coating cannot qualify an uncoated component. PTFE test qualifies all grades of PTFE, a nylon test qualifies all grades of nylon, a HNBR test qualifies all grades of HNBR. Lip seals cannot be used to qualify O-rings and vice versa. Filled materials do not qualify unfilled materials. However, unfilled materials qualify filled materials up to the limit of the tests (pressures and temperatures) performed.

— When a valve has been successfully tested:

  — for sizes from DN 50 (NPS 2) up to DN 600 (NPS 24) it will qualify nominal valve sizes 3 sizes smaller and 2 sizes larger;

    EXAMPLE A successful testing of a DN 150 (NPS 6) valve size qualifies DN 50 (NPS 2) up to DN 250 (NPS 10). A successful testing of a DN 450 (NPS 18) valve size qualifies DN 300(NPS 12) up to DN 600 (NPS 24).

  — for sizes from DN 750 (NPS 30) up to DN 2 000 (NPS 80) it will qualify nominal valve sizes one size smaller and two sizes larger;

    EXAMPLE A successful testing of a DN 900 (NPS 36) valve size qualifies DN 750 (NPS 30) up to DN 1 200 (NPS 48). A successful testing of a DN 1 600 (NPS 64) valve size qualifies DN 1 400 (NPS 56) up to DN 2 000 (NPS 80).

  — for small size valves up to and including DN 50 (NPS 2), an exception has been made to allow any valve in that range to qualify the full range, e.g. a successful testing of a DN 25 (NPS 1) valve size qualifies all sizes through to DN 50 (NPS 2).

  — all based on the size of the internal flow bore diameter, see Table 2;

  — for valves of the same product range with a pressure designation less than Class 900 or PN160, the valve Class or PN designation, which is equal or lower than the tested Class or PN designation;

  — for valves of the same product range with a pressure designation greater than or equal to Class 900 or PN 160, the valve Class or PN designation, which is equal or lower than the tested Class or PN designation;

  — the required temperature falls between room temperature and the test temperature of the qualified valve;

  — the seat leakage required is equal to or less severe than that of the qualified valve;

  — where a single valve is qualified, assemblies incorporating multiple valves of the same functional components [obturator, seat(s), shaft/spindle/stem and associated sealing mechanism] sharing the same body are also qualified.

Table 2 — Qualification range

Nominal sizes				Pressure Classes (PN)						
Flanges	Bore	Bore		150	300	600	800	900	1 500	2 500
Inch		Inch	DN	(10,16)	(25,40)	(100)	(N/A)	(160)	(250)	(400)
½	FB	½	15							
¾	RB	½	15							
¾	FB	¾	20							
1	RB	¾	20							
1	FB	1	25			*T*				*T*
1 ½	RB	1	25							
1 ½	FB	1 ½	40							
2	RB	1 ½	40							
2	FB	2	50							
3	RB	2	50							
3	FB	3	80							
4	RB	3	80							
4	FB	4	100							
6	RB	4	100							
6	FB	6	150			*T*				*T*
8	RB	6	150							
8	FB	8	200							
10	RB	8	200							
10	FB	10	250							
12	RB	10	250							
12	FB	12	300							
14	RB	12	300							
14	FB	14	350							
16	RB	14	350							
16	FB	16	400							
18	RB	16	400							
18	FB	18	450			*T*				*T*
20	RB	18	450							
20	FB	20	500							
24	RB	20	500							
24	FB	24	600							
30	RB	24	600							
30	FB	30	750							
36	RB	30	750							
36	FB	36	900			*T*				*T*
42	RB	36	900							
42	FB	42	1 050							
48	RB	42	1 050							
48	FB	48	1 200							

NOTE 1 *T* is the suggested test valves to minimise number of tests.

NOTE 2 Any non-preferred sizes that are not included in Table 2 are considered qualified if the qualification range exceeds that of NPS.

Table 2 *(continued)*

Nominal sizes				Pressure Classes (PN)						
Flanges	Bore	Bore		150	300	600	800	900	1 500	2 500
Inch		Inch	DN	(10,16)	(25,40)	(100)	(N/A)	(160)	(250)	(400)
56	RB	48	1 200							
56	FB	56	1 400							
64	RB	56	1 400							
64	FB	64	1 600			*T*				*T*
72	RB	64	1 600							
72	FB	72	1 800							
80	RB	72	1 800							
80	FB	80	2 000							

NOTE 1 *T* is the suggested test valves to minimise number of tests.

NOTE 2 Any non-preferred sizes that are not included in Table 2 are considered qualified if the qualification range exceeds that of NPS.