IS 7332-1 (1991): Spherical Valves for Hydropower Stations and Systems, Part 1: Criteria for Structural and Hydraulic Design [WRD 12: Hydraulic Gates and Valves]

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भारतीय मानक

जलशक्ति केन्द्रों और तंत्रों के लिए गोलाकार वाल्व

भाग 1 संरचनात्मक तथा द्रवचालित डिजाइन के मापदण्ड

(पहला पुनरीक्षण)

Indian Standard

SPHERICAL VALVES FOR HYDROPOWER STATIONS AND SYSTEMS

PART 1 CRITERIA FOR STRUCTURAL AND HYDRAULIC DESIGN

(First Revision)

UDC 621·646·22 : 621·224 - 225·12

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

November 1991

Price Group 3

AMENDMENT NO. 1 APRIL 2003
TO
IS 7332 (Part 1) : 1991 SPHERICAL VALVES FOR HYDROPOWER STATIONS AND SYSTEMS
PART 1 CRITERIA FOR STRUCTURAL AND HYDRAULIC DESIGN

(First Revision)

(*Page* 1, *clause* **5.1**) — Substitute the following for the existing text:

'The body of the valve should be designed for various loading conditions given in IS 11639 (Part 1), IS 11639 (Part 2) and IS 11639 (Part 3).'

(*Page* 4, *clause* **6.4.1**, *para* 2) — Delete.

(*Page* 5, *Annex* A) — Delete 'IS 226 : 1975 Specification for structural steel (standard quality) (*fifth revision*)'.

(*Page* 5, *Annex* A) — Substitute 'IS 1030 : 1998 Specification for carbon steel castings for general engineering purposes (*fifth revision*)' *for* 'IS 1030 : 1982 Specification for steel castings for general engineering purposes (*fourth revision*)'.

(*Page* 5, *Annex* A) — Substitute 'IS 2002 : 1992 Specification for steel plates for pressure vessels for intermediate and high temperature service including boilers (*second revision*)' *for* 'IS 2002 : 1982 Specification for steel plates for pressure vessels for intermediate and high temperature service including boilers (*first revision*)'.

(*Page* 5, *Annex* A) — Substitute 'IS 2004 : 1991 Specification for carbon steel forgings for general engineering purposes (*third revision*)' *for* 'IS 2004 : 1978 Specification for carbon steel forgings for general engineering purposes (*second revision*)'.

(*Page* 5, *Annex* A) — Substitute 'IS 2062 : 1999 Specification for steel for general structural purposes (*fifth revision*)' *for* 'IS 2062 : 1984 Specification for weldable structural steel (*third revision*)'.

(*Page* 5, *Annex* A) — Substitute 'IS 2708 : 1993 Specification for 1.5 percent manganese steel castings for general engineering purposes (*third revision*)' *for* 'IS 2708 : 1984 Specification for 1.5 percent manganese steel castings for general engineering purposes (*second revision*)'.

(*Page* 5, *Annex* A) — Insert the following at the end:

IS No.	*Title*
'IS 11639 (Part 1) : 1986	Criteria for structural design of penstocks : Part 1 Surface penstocks
IS 11639 (Part 2) : 1995	Criteria for structural design of penstocks : Part 2 Buried/embedded penstocks
IS 11639 (Part 3) : 1996	Criteria for structural design of penstocks : Part 3 Specials for penstocks'

[*Page* 6, *Annex* B, *Sl No.* (i)(a), *col* 3] — Substitute 'IS 1030 : 1998' *for* 'IS 1030:1982'.

[*Page* 6, *Annex* B, *Sl No.* (i)(b), *col* 3] — Substitute 'IS 2062 : 1999 or IS 2002 : 1992' for the existing.

[*Page* 6, *Annex* B, *Sl No.* (i)(c), *col* 3] — Substitute 'IS 2708 : 1993' *for* 'IS 2708 : 1984'.

[*Page* 6, *Annex* B, *Sl No.* (ii)(a), *col* 3] — Substitute 'IS 1030 : 1998' *for* 'IS 1030 : 1982'.

[*Page* 6, *Annex* B, *Sl No.* (ii)(b), *col* 3] — Substitute 'IS 2062 : 1999' *for* 'IS 2062 : 1984 and IS 226 : 1975' .

[*Page* 6, *Annex* B, *Sl No.* (ii)(c), *col* 3] — Substitute 'IS 2708 : 1993'*for* 'IS 2708 : 1984'.

[*Page* 6, *Annex* B, *Sl No.* (iii)(a) , *col* 3] — Substitute 'IS 1030 : 1998' *for* 'IS 1030 : 1982'.

[*Page* 6, *Annex* B, *Sl No.* (iii)(b), *col* 3] — Substitute 'IS 2708 : 1993' *for* 'IS 2708 : 1984'.

[*Page* 6, *Annex* B, *Sl No.* (iv)(a) , *col* 3] — Substitute 'IS 1030 : 1998' *for* 'IS 1030 : 1982'.

[*Page* 6, *Annex* B, *Sl No.* (iv)(b), *col* 3] — Substitute 'IS 2004 : 1991' *for* 'IS 2004 : 1978'.

(WRD 12)

Reprography Unit, BIS, New Delhi, India

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Hydraulic Gates and Valves Sectional Committee had been approved by the River Valley Division Council.

Spherical valve is a shut-off device most commonly used in Hydro-power stations for a head 200 m and above. These valves may be used at lower heads also if desired by the designer. Its use is favoured at high heads as there is no hydraulic loss due to valve itself when valve is open and provided a better tight sealings when valve is closed.

It serves the following purposes:

a) Stops the water entry to the turbine when the latter is stopped to decrease the water leakages and to protect the guide vanes against slit cavitation and silt erosion;

b) Stops the water entry in case of emergency, that is, non-closure of guide apparatus or in the event of low oil pressure in the system;

c) Unit isolation in multi-unit plants where one penstock feeds more than one unit; and

d) To facilitate inspection of water path passages.

Basically spherical valve consists of spherical shaped body air valve and water/oil pressure system or any other control system are required for operation of spherical valves.

This standard covers only the guidelines (criteria) for structural and hydraulic design of valves so as to permit necessary flexibility in their detailed design as per requirements of the designer.

These guidelines are based on the available expertise and the practices prevaling in this field at present so that the same could be utilized. As and when some more information is available the same will be incorporated in the standard. Therefore these are expected to be used by those designers who have sufficient knowledge in this field.

This standard is being published in parts. Part 1 deals with structural and hydraulic aspects of design. Part 2 deals with the guidelines for design and selection of the control equipment used in spherical valves. Part 3 deals with the operation and maintenance of spherical valves.

This standard (Part 1) was first published in 1974. This revision is being done on the basis of experience gained during the use of this standard for the last 16 years as well as the experience gained during this period in the operation of these valves at the various power stations. The principal modifications made in this revision are as below:

a) In the construction provision of conical shape body has also been made;

b) The provision of rubber type seals has been deleted;

c) Self-lubricated bushes have been added;

d) Permissible bearing stress level has been increased to 35 N/mm^2; and

e) Clauses for, (1) hydraulic condition of design, (2) design criteria for by pass valve, sealing valve and air valve, (3) permissible leakages have been added.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

SPHERICAL VALVES FOR HYDROPOWER STATIONS AND SYSTEMS

PART 1 CRITERIA FOR STRUCTURAL AND HYDRAULIC DESIGN

(First Revision)

1 SCOPE

1.1 This standard (Part 1) lays down the guidelines (criteria) for the structural and hydraulic design of spherical valves for hydropower stations.

2 REFERENCES

The Indian Standards listed in Annex A are necessary adjuncts to this standard.

3 STANDARD SIZES

3.1 As far as possible, the valves should be designed in any of the following sizes (in mm):

500, 600, 700, 800, 900, 1 000, 1 100, 1 200, 1 300, 1 400, 1 500, 1 600, 1 800, 2 000, 2 200, 2 400, 2 600, 2 800, 3 000, 3 200, 3 400, 3 600, 3 800, 4 000 and 4 200.

3.2 Size of the valve should normally be the same as that of inlet dia of the spiral case/distributor. However reduction in the size if any can be considered by user taking into consideration the extra head loss in the reducer and expander.

4 TYPE OF VALVES AND THEIR USE

4.1 Normally two types of valves are designed:

a) Valve with service seal only, and

b) Valve with service and repair seals.

Typical details of valves with disc type and piston type seals (for service and repair seals) are shown in Fig. 1 and 2.

4.1.1 For a station having long penstock or requiring unit isolation it is recommended to use the valve with both the seals, that is service as well as repair seals. Repair seal gives possibility of changing the service seal without draining the long penstock which may take more time or may require closing of gates.

5 Hydraulic Conditions for Design

5.1 The body of the valve should be designed for the condition of dynamic head, which is the head attained after closure of the turbine.

$$\text{Dynamic head} = Max\ \text{Static head} + \text{Pressure rise head}$$

5.2 The rotor and trunnions of the valve should be designed for the condition of head being attained after its closure or for the head which is 1·10 times the maximum static head whichever is more.

6 DESIGN OF MECHANICAL PARTS

6.1 Valve Body

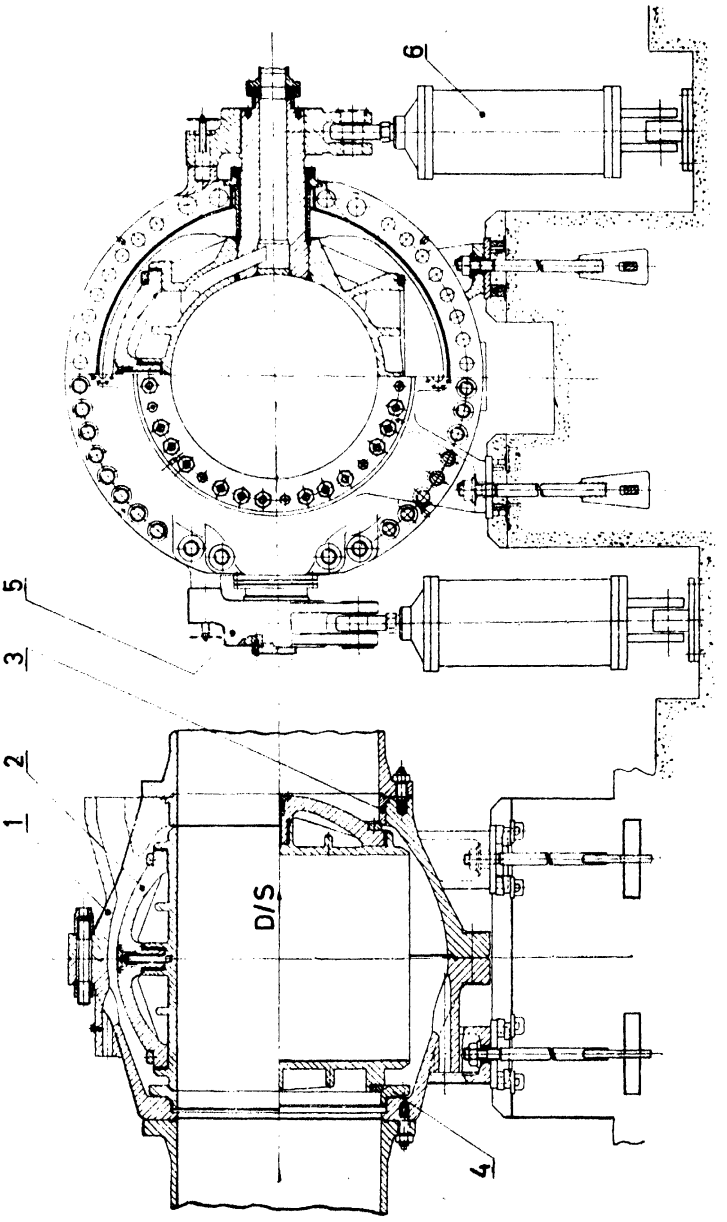
6.1.1 The valve body may be cast or fabricated or cast fabricated from materials recommended in Annex B. The body should have two holes for trunnion bearing housings and suitable bosses for by-pass connection, drainage, air release and for mechanical locks if necessary. Flanges for connecting to penstock should be at right angle to the axis of the bore and concentric with the bore and the faces should be parallel. The flanges should have tapped or through holes. In case repair seal has been provided, it should have a boss on upstream side for connection of a pipe for equalizing pressure and on inlet side a cylindrical surface lined with stainless steel should be provided where movable ring of repair seal slides. This may be provided only in case valve has got repair seal arrangement. On the outlet side it should have a cylindrical surface for fitting the service seal.

6.1.2 The body should be made in two parts from assembly point of view. The joint may be vertical, horizontal or diagonal according to the suitability of assembly and transport. For large valves the body may be made in more than two parts having joint in vertical as well as in the horizontal plane. The joint in horizontal plane gives possibility of assembling the valve directly at the place of installation. Two halves should have necessary spigots and sockets, seal provision, locating arrangement and should be held together by means of sufficient number of bolts and studs.

6.1.3 The fasteners of parting flanges and two end flanges should be tightened with specified initial tightening by heating or slogging or by hydraulic bolt tensioner to have controlled total stresses developed in the fasteners.

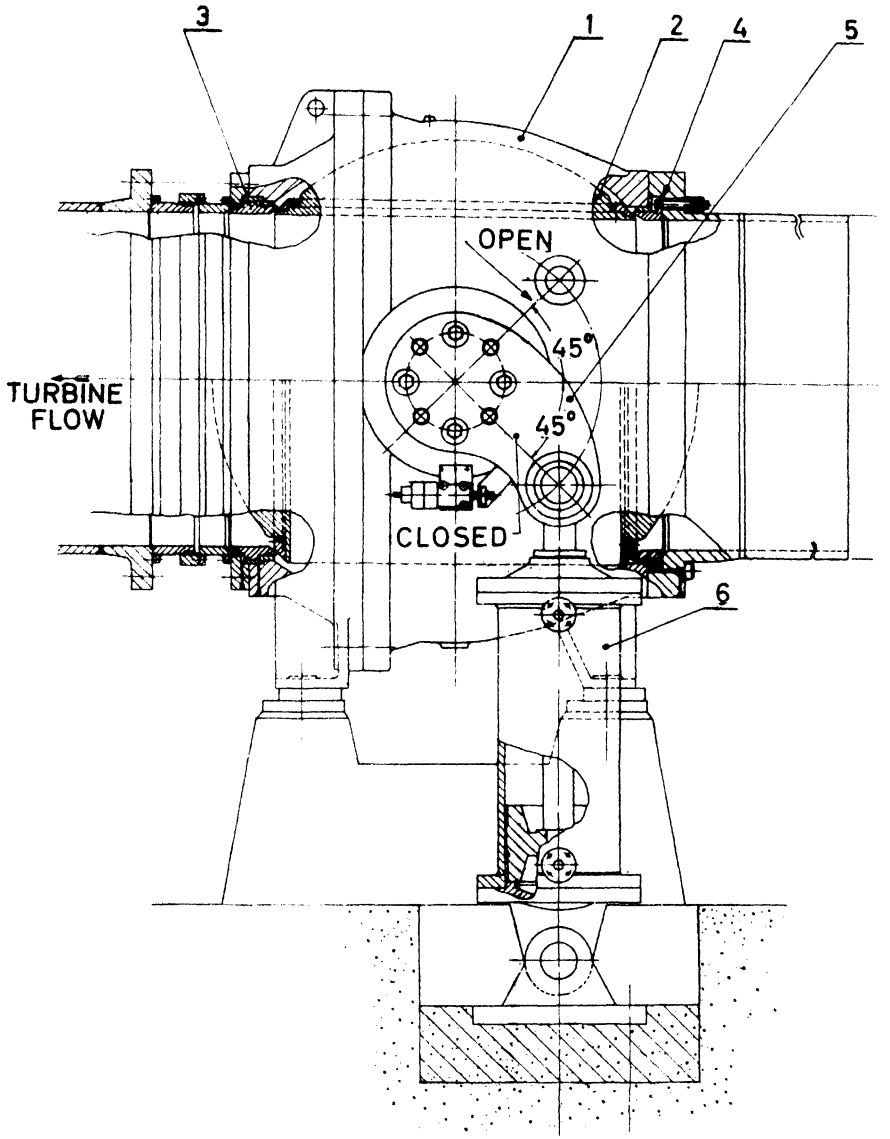
6.1.4 The body should be designed, such as to sustain maximum pressure including water hammer. Supporting feet for installing the valve on foundation should be provided. These feet, or part thereof, are to be integral with the valve body, and may not extend beyond the flange faces of the valve. These supporting feet should have holes bigger than the diameter of foundation bolts to allow for axial movement of valve thus avoiding axial load on foundation.

6.1.5 Suitable means of adequate strength for lifting the valve should be provided.



1 Body 2 Door 3 Main Seal 4 Maintenance Seal 5 Lever 6 Servomotor

FIG. 1 TYPICAL DETAILS OF SPHERICAL VALVE — DISC SEAL TYPE



1 Body 2 Door 3 Main Seal 4 Maintenance Seal 5 Lever 6 Servomotor

FIG. 2 TYPICAL DETAILS OF SPHERICAL VALVE — POSITION SEAL TYPE

6.2 Rotor and Trunnions

6.2.1 Rotor and trunnions should be joined together by means of welding or bolts or should be integrally cast, cast-fabricated or fabricated from materials recommended in Annex B. Bolted connection should be used in case dimension of rotor does not permit machining or transportation of rotor together with trunnions or it is necessary from assembly point of view, when body is split vertically but away from the trunnion centre lines, that is bodies are off-set split. Rotor should have necessary provision to accommodate service seal and repair seal, if provided.

6.2.2 Trunnions should be made of material as given in Annex B and of forged steel or cast steel when integral with rotor. Levers may be fixed by means of wedge pins, parallel pins or keys. The split of the pin may be perpendicular to the shearing planes. The levers should further be connected to the servomotor.

6.2.3 The angular travel of rotor should be 90° from open to close position.

6.2.4 Cylinder of the rotor should be horizontal when valve is open and vertical when valve is closed. Intermediate position for allowing partial flow should not be allowed.

6.2.5 There should be provision for movement to open and close the service seal.

6.2.6 The design of rotor and trunnions should be such that they will safely sustain maximum differential pressure including any surge pressure across the closed valve, and the maximum forces due to the servomotor.

6.3 Bearings

6.3.1 Valve should have bush bearing made from material given in Annex B. Self-centering bearings may be used in case of valve where deflection of trunnions is considerable. It should be designed for the maximum load imposed by the rotor.

6.3.2 Suitable provision should be made for lubricating the bearings unless bearings are of self lubricating type.

6.3.3 There should be provided for limiting the movement of rotor along its axis of rotation.

6.3.4 Bearing should be provided with suitable seal for stopping the leakage of water and grease.

6.4 Seal

6.4.1 *Service Seal*

The service seal should be manufactured using the material as mentioned in Annex B under para 'Seal Rings'. The design should have provision for movement of the seal. It may be metallic of materials given in Annex B and should have provision of movement.

6.4.2 *Repair Seal*

It should consist of movable and fixed rings and mechanism for movement of movable ring. Fixed ring should be fixed on the rotor and movable ring should slide on the valve body. Mechanism for movement of movable ring should be designed such that ring should move in axial direction very smoothly and should give a good tightness when repair seal is closed. Clearance between movable ring and valve body should be sealed by suitable design rubber seal or cord. A by-pass connection should be provided to equalize the pressure to enable smooth opening of the repair seal. This by-pass connection should be provided with a hand operated stop valve.

6.4.3 Lapping of seal rings may be carried out for better water tightness.

6.4.4 Seal should be made from material recommended in Annex B.

6.5 Dismantling Joint

In order to facilitate dismantling and also for taking care of certain amount of correction of errors in erection, suitable dismantling joint may be provided. The dismantling joint may be designed either to transmit the hydraulic thrust in the penstock to the upstream of valve or may act as dismantling-cum-expansion joint depending upon whether the thrust is required to be transmitted downstream of valve or sustained on the upstream by some means.

6.6 Foundations

The valve foundations should be designed to cater for complete tensile and compressive forces produced by operating gear occurring during worst conditions of its operations. No hydraulic thrust will be taken on the foundations of the valve in closed position. The purchaser should provide a suitable means to sustain thrust in the penstock design or on the downstream of the valve (by providing a thrust collar or brackets) as agreed by the purchaser and the supplier.

6.7 Bypass Valve

The size of the by-pass valve should be sufficient to balance the downstream pressure at least by 60 percent of the upstream pressure, considering the maximum leakages through the guide vanes.

6.8 Sealing Valves

The size of the sealing valve should be sufficient to drain pressurized water behind the disc to withdraw the disc instantaneously.

6.9 Air Valve

The size of the air valve should be sufficient to release or admit air according to rate of filling or draining of water in the spiral casing/distributor.

7 PERMISSIBLE LEAKAGES

7.1 Maximum permissible leakage from main (operating) seal should not exceed 1 litre/min/metre periphery of seal, when valve is new or reconditioned.

7.2 Maximum permissible leakages from repair/maintenance seal should not exceed 3·0 litres/min/metre periphery of seal. If required by the user in consultation with manufacturer the maximum permissible leakages can be reduced.

8 PERMISSIBLE STRESS LEVELS

8.1 The permissible stress levels at the designed head for the materials used are given below:

For design head refer 5

a) *Steel* :

Tensile stress = $\frac{1}{4}$ of ultimate tensile stress or $\frac{1}{2}$ of yield strength, whichever is less.

Shear stress = 60 percent of tensile stress.

b) *Bronze Bushings* :

Bearing stress $\leq$ 35 N/mm^2.

c) *Self-Lubricated Bushes* :

Bearing stress $\leq$ 35 N/mm^2

9 TESTING

9.1 The tests to be performed after final assembly of the valve are given in Annex C.

10 SPECIAL CLEANING, PROTECTION AND PAINTING

10.1 Before transportation all unfinished surfaces of ferrous material should be thoroughly cleaned, wire-brushed to remove all loose scale, smoothed and painted with black bitumen paint or red lead/steel gray paint or any other paint agreed between the supplier and the purchaser.

10.2 All material should be carefully boxed, crated or otherwise protected for transportation. Flanges should be protected and exposed finish surface should be thoroughly preserved before transportation.

ANNEX A

(*Clause* 2.1)

LIST OF REFERRED INDIAN STANDARDS

IS No.	*Title*
28 : 1985	Specification for phosphor bronze ingots and castings (*fourth revision*)
226 : 1975	Specification for structural steel (standard quality) (*fifth revision*)
318 : 1981	Specification for leaded tin bronze ingots and castings (*second revision*)
1030 : 1982	Specification for steel castings for general engineering purposes (*fourth revision*)
1570 (Part 5) : 1985	Schedules for wrought steels : Part 5 Stainless and heat resisting steels (*second revision*)
2002 : 1982	Specification for steel plates for pressure vessels for intermediate and high temperature service including boilers (*first revision*)
2004 : 1978	Specification for carbon steel forgings for general engineering purposes (*second revision*)
2062 : 1984	Specification for weldable structural steel (*third revision*)
2708 : 1984	Specification for 1·5 percent manganese steel castings for general engineering purposes (*second revision*)
2856 : 1987	Specification for carbon steel castings for pressure containing parts suitable for high temperature service (fusion welding quality) (*third revision*)

ANNEX B

(*Clauses* 6 1 1, 6 2 1, 6 2 2, 6 3 1, 6 4 1 *and* 6 4 4)

RECOMMENDED MATERIALS FOR VARIOUS COMPONENTS

Sl No	*Materials*	*Conforming to*
(1)	(2)	(3)
i)	*Valve Body*	
	a) Cast steel	IS 2856 : 1987 or IS 1030 1982
	b) Mild steel	IS 2062 1984 or IS 226 1975 IS 2002 1982
	c) Manganese steel	IS 2708 1984
ii)	*Rotor*	
	a) Cast steel	IS 2856 1987 or IS 1030 1982
	b) Mild steel	IS 2062 1984 or IS 226 1975
	c) Manganese steel	IS 2708 1984
iii)	*Seal*	
	a) Cast steel	IS 2856 1987 or IS 1030 1982
	b) Manganese steel	IS 2708 1984
	c) Stainless steel	IS 1570 (Part 5) 1985
iv)	*Trunnion*	
	a) Cast steel	IS 2856 1987 or IS 1030 1982
	b) Carbon steel	IS 2004 1978
	c) High tensile steel	IS 1570 (Part 5) 1985
	d) Stainless steel lining	IS 1570 (Part 5) 1985
v)	*Bushes*	
	a) Bronze	IS 28 1985
	b) Gunmetal	IS 318 1981
	c) Self-fabricated	
vi)	*Seal Rings*	
	Stainless steel	IS 1570 (Part 5) 1985

NOTE — Any other material not mentioned in this Annex may be used if found suitable by the designer

ANNEX C

(*Clause* 9 1)

TESTS TO BE PERFORMED ON THE SPHERICAL VALVE AND ITS PARTS

C-1 PERFORMANCE TEST

C-1.1 After final assembly, each valve should be shop operated three times or as agreed by the purchaser from the fully closed to the fully open position and vice versa under no flow condition to demonstrate that the assembly is workable

C-2 PRESSURE TESTS

C-2.1 All tests should be carried out with water as the test medium but other media may be used as agreed by the purchaser

C.2 2 Valve subjected to the following tests

a) *Body Test* — With both ends closed a hydro static pressure of one and a half times the specified pressure including pressure rise or as agreed by the purchaser should be maintained at least for a period of 15 minutes Under this test, there should be no leakage from the interior of the valve body to the atmosphere due to porosity blow-holes, cracks or any other defects

b) *Rotor or Closing Disc Test* — Rotor or disc should be tested for strength at a pressure one and a half times the specified pressure including pressure rise This pressure should be maintained at least for a period of 15 minutes No leakage through the disc or rotor or structural damage should be permitted

c) *Seal Test* With one end open to atmosphere and the valve in closed position, test for leakage should be carried out to a pressure equivalent to maximum closing pressure This test should be carried out for service as well as repair seal For permissible leakages refer 7

Standard Mark

The use of the Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act, 1986* and the Rules and Regulations made thereunder. The Standard Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well defined system of inspection, testing and quality control which is devised and supervised by BIS and operated by the producer. Standard marked products are also continuously checked by BIS for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

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Indian Standards are reviewed periodically and revised, when necessary and amendments, if any, are issued from time to time. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition. Comments on this Indian Standard may be sent to BIS giving the following reference :

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