*भारतीय मानक* *मसौदा*

##### Draft Indian Standard

*भारतीय मानक मसौदा*

प्रघात नलिका अधिस्फोटकों – विशीष्टि

Draft *Indian Standard*

**SHOCK TUBE DETONATORS – SPECIFICATION**

 ICS 71.100.30

© BIS 2024

भा र ती य मा न क ब्यू रो

**B U R E A U O F I N D I A N S T A N D A R D S**

मानकभवन, 9बहादुरशाह ज़फर मार्ग, नई दिल्ली - **110002**

MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG

NEW DELHI 110002

[www.bis.org.in](http://www.bis.org.in) [www.standardsbis.in](http://www.standardsbis.in)

 *September* 2024  **Price Group**

Explosives and Pyrotechnics Sectional Committee, CHD 26

FOREWORD

(Formal clauses shall be added later)

A detonator is a device used to trigger an explosive. Detonators are usually initiated by mechanical or electrical means or with a shock wave.

A shock tube detonator is a non-electric initiating explosive device in the form of small-diameter hollow plastic tubing used to transport an initiating signal to an explosive by means of a shock wave traveling the length of the tube. Shock tube is used to convey a detonation signal to a detonator.

In the formulation of this standard, assistance has been derived from the following publications:

EN 13763 Series ‘Explosives for civil uses — Detonators and relays.

BS 7765: 1994 ‘Specification for Detonators for civil use.

There is no ISO specification for the product.

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 : 2022 ‘Rules for rounding off numerical values (second revision)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

*Draft Indian Standard*

**SHOCK TUBE DETONATORS - SPECIFICATION**

**1 SCOPE**

This standard prescribes the requirements, methods of sampling, and tests for shock tube detonators used for blasting purposes.

**2 REFERENCES**

The standards listed below contain provisions which through reference in this text, constitute provisions of and necessary adjuncts to this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated.

|  |  |
| --- | --- |
| *IS No.* | *Title* |
| IS 1260 (Part 1): 1973 | Pictorial Marking for Handling and Labelling of Goods: Part 1 Dangerous Goods (*first revision*) |
| IS 4905: 2015 | Random Sampling and Randomization Procedures (*first revision*) |
| IS 6609 (part 3): 2023 | Methods of Test for Commercial Blasting Explosives and Accessories Part 3 Detonators, General and Permitted (*first revision*) |
| IS 10081: 1981 | Terms Relating to Commercial Explosives, Pyrotechnics and Blasting Practices |

**3 TERMINOLOGY**

For the purpose of this standard, the terms and definitions given in IS 10081, in addition to the following shall apply.

**3.1 Shock tube** – A tube usually containing a dusting of explosive charge on the inner wall capable, on activation, of transmitting a shock wave from one end of the tube to the other at a constant velocity and having no external explosive effect.

**4** **REQUIREMENTS**

**4.1 Drop Test**

When subjected to drop test as laid down in **4.2** of IS 6609 (Part 3), none of the detonators connected to the shock tubes shall detonate. At the end of drop test, all the test samples shall fire in the functioning test.

NOTE: Cut the shock tube such that 10 cm length left instead of 20 cm.

**4.2** **Vibration Test**

Whensubjected to vibration test as laid down in **4.4** of IS 6609 (Part 3) and examined visually, there shall neither be any loose composition inside the tubes nor it shall come out of the tube during the testing and the shock tube detonators shall not explode during the test.

**4.3** **Strength of detonators**

**4.3.1** *By sand bomb method (optional test) -* Whenthe shock tube detonators are tested in sand bomb as prescribed in **4.5** of IS 6609 (Part 3), the percentage of crushed sand passing through 500-micron and 250-micron IS Sieves shall be as follows:

|  |  |
| --- | --- |
| **Strength of detonator** | **Percentage of sand passing through** |
| **500 micron IS sieve** | **250 micron IS sieve** |
| No.6 | ≥ 35 | ≥ 30 |
| No.8 | ≥ 50 | ≥ 45 |

**4.3.2** *By lead plate method**-*When the shock tube detonators are subjected to the test as prescribed in **4.6** of IS 6609 (Part 3), they shall produce dent on the lead plate corresponding to at least B-3 class [**4.6.3.3** of IS 6609 (Part 3)].

Note: Strength test is applicable for down-the-hole shock tube detonators only. For surface shock tube detonators, refer to 4.8.

**4.4** **Water Resistance**

Whenthe shock tube detonators are subjected to water resistance test as prescribed in **4.1** of IS 6609 (Part 3) using a pressure of 3kg/cm2 for 4 h, the detonators shall satisfy the following requirements:

1. After being subjected to the test, all the test samples shall fire.
2. All single values of their delay times shall be within the defined delay values.
3. All the surface connectors and non-electric detonators intended to be connected/combined with surface connectors shall detonate and all single values of their delay times shall be within the defined delay values.

NOTE: The sealed end part of the shock tube shall be kept outside the water.

**4.5** **Delay Time Measurement** (*for delay detonators only*)

Themanufacturer shall declare the nominal and delay interval for each delay of shock tube detonators.

Delay time shall be measured as prescribed in 4.10.3.1 of IS 6609 (Part 3). In delay time measurement, the scatter of any particular delay number shall be such that not more than 10% of the shock tube detonators tested shall have delay timing overlapping with the delay timing of the adjacent numbers.

**4.6 Determination of shock wave velocity**

When shock tubes are tested according to the method prescribed in **Annex A**, the individual shock wave velocities shall be within ±10% of the shock wave velocity declared by the manufacturer.

* 1. **Mechanical strength of shock-tube detonators**

When tested as per the method prescribed in **Annex B**, no detonator shall detonate, no shock-tube shall break, and the plug/shock tube shall not be pulled out of the shell during the test and all detonators shall fire correctly after the test.

**4.8** **Determination of transfer capability of surface connectors**

All the test specimen shall pass the test for transfer capability when tested as per the procedure specified in **Annex C**.

1. **TYPE TESTS**

**5.1 Immersion in hot oil**

The shock tube detonator shall pass the test as prescribed in **Annex D**.

**5.2 Thermal stability test**

When the shock tube detonators are subjected to thermal stability test asprescribed in**Annex E**, there shall be no detonation.

**5.3 Impact test for shock tube**

The shock tubes shall not be initiated when tested according to the method prescribed in **Annex F** and shall subsequently function normally when initiated according to the manufacturer’s manual.

**5.4 Resistance to abrasion**

When tested as per the method prescribed in **Annex G**, all the test specimens shall be initiated and shall propagate the detonation along the entire length of the shock tube.

**5.5 Resistance of detonators to bending**

When tested as per the method prescribed in **Annex H**, none of the shock tube detonators shall initiate. Also, there shall be no cracks or breaks in any of the shells.

**6 PACKING AND MARKING**

**6.1 Packing**

The shock tube detonators shall be packed as agreed to between the purchaser and the supplier. The packing shall conform to the provisions of *Explosives (Amendment) Rules*, 2019.

**6.2** **Marking**

**6.2.1** Eachpackage shall be marked with the followinginformation:

a) Name of the material / Product.

b) Number of pieces in the package;

c) Manufacturer’s name and/or his recognized trade-mark, if any; and

**6.2.2** The package shall also be marked with the appropriate symbol specified in IS 1260 (Part 1).

**6.2.3** The marking shall further be in conformity to the provisions of *Explosives (Amendment) Rules*, 2019.

**6.3 BIS Certification Marking**

The product(s) conforming to the requirements of this standard may be certified as per the conformity assessment schemes under the provisions of the *Bureau of Indian Standards Act*, 2016 and the Rules and Regulations framed thereunder, and the products may be marked with the standard mark.

**7 SAMPLING**

**7.1 Lot**

**7.1.1** Cases of Shock tube detonators of same grade, same type and belonging to the same batch of manufacture shall be grouped together to constitute a lot.

**7.1.2** Detonators constituting the sample shall be drawn from each lot separately for deciding the conformity of the lot to the requirements of the specification.

**7.2 Scale of Sampling**

Number of detonators to be selected at random from the lot shall depend on the lot size and shall be in accordance with co1 3 of Table 1. In order to ensure randomness of selection, procedures given in IS 4905 may be followed.

**Table 1 Scale of sampling of Shock tube detonators**

**(Clause 7.2)**

|  |  |  |
| --- | --- | --- |
| **Sl No.** | **No. of detonators in the lot** | **Sample size** |
| (1) | (2) | (3) |
|  | Up to 10 000 | 100 |
|  | 10 001 to 25 000 | 200 |
|  | 25 001 and above | 250 |

**7.3 Number of Tests**

The number of detonators to be selected from the sample size for the determination of each characteristic shall be as given in the Table 2.

**Table 2 No. of Tests**

**(Clause 7.3)**

|  |  |  |
| --- | --- | --- |
| **Sl No.** | **Test/ Characteristic** | **No. of detonators to be tested** |
| (1) | (2) | (3) |
|  | Water resistance | 5 |
|  | Drop test | 5 |
|  | Vibration test | 14 |
|  | Strength test by lead plate or sand bomb method | 5 |
|  | Mechanical strength test | 5 |
|  | Delay time measurement | 10 |
|  | Transfer capability | 5 |

**7.4 Criteria for conformity -** For deciding the conformity of the lot to the requirements of this specification, the test results of each characteristic shall meet the corresponding requirements specified in the relevant clauses.

**ANNEX A**

(*Clause* 4.6)

**DETERMINATION OF SHOCK WAVE VELOCITY**

**A-1** **APPARATUS**

**A-1.1** An initiating device (percussion cap, spark, etc.) or an initiating detonator provided that the shock tube and measuring equipment are protected against the fragments from the initiated detonator.

**A-1.2** System equipped with two optical sensors (e.g. optical fibers, see A and B in Figure 1) and capable of measuring the time taken for the shock wave to travel between the two sensors, to an accuracy of 1 µs.

**A-1.3** Conditioning chamber

**A-2 TEST PIECES**

Select 20 lengths of shock tube, each at least 2.4 m long. If the shock tubes are assembled with detonators, the lengths shall be taken from 20 detonators of the same specific type. If the detonators form part of a series with different delay times select detonators with delay times distributed as evenly as possible throughout the series

**A-3 PROCEDURE**

**A-3.1** Cut the required lengths of shock tube and immediately seal the cut ends, e.g. by adhesive tape or other suitable means. Condition the sealed lengths for at least 2 h at (20 ± 2) °C prior to testing.

**A-3.2** Install the two sensors in contact with the shock tube as in Figure 1. The distance between the sensors dAB shall be at least 1000 mm, measured to an accuracy of ± 5 mm. Remove the seal if necessary and initiate the shock tube.

 

Key

1 Initiator location

2 Shock tube

3 Optical sensors (A and B)

4 Direction of shock wave propagation

**Figure 1 Test arrangement**

**A-4 CALCULATION**

**A-4.1** Record the time tAB of the shock-wave propagation from A to B.

**A-4.2** Record the individual values of dAB and tAB for each of the 20 determinations.

**A-4.3** Calculate the shockwave velocity, $v$ expressed in meters per second (m/s), for each determination, from the following equation. Round the value in m/s to the nearest whole number.

$$v = \frac{d\_{AB}}{t\_{AB}}$$

**A-4.4** Calculate the mean value of $v$ in m/s and report this value, rounded to the nearest whole number, as the result of the test.

**ANNEX B**

(*Clause* 4.7)

**MECHANICAL STRENGTH OF SHOCK-TUBE DETONATORS**

**B-1 GENERAL**

During normal use on site, the crimps/closures of detonators and their shock tubes can be subjected to pulling forces. Such forces can cause a pullout of internal components of the detonator. A pullout would either cause the detonator to explode, or would render it incapable of functioning. This method determines the ability of detonator shock tubes, and their connections into the crimp/closure or sealing arrangement, to withstand a pullout when subjected to a pulling force.

**B-2 APPARATUS**

The apparatus consists of the following parts as given in Fig. 2:

**B-2.1** Fixing point for the detonator

**B-2.2** Moveable support table

**B-2.3** Weights that are to be attached to the shock tubes, capable for applying forces of 40 N.



FIG 2 TEST APPARATUS

Key

1. Detonator
2. Fixing point for detonator
3. Shock tubes
4. Weights
5. Moveable support table

**B-3 TEST PIECES**

**B-3.1** Select 5 assemblies, each one of particular type, having shell material, construction, shock tube, dimensions and crimp/closure of the similar design but delay composition and primary charge/base charge may vary.

**B-4 PROCEDURE**

The test is to be carried out at the highest operational temperature as claimed by the manufacturer.

**B-4.1** Test for 5 assemblies. To the fixing point, the detonator shell is attached and to the weights of total mass corresponding to the force of (40±0.1) N, the shock tube is attached. Allow the weights to rest on the supporting table, in such a way that a small amount of tension of about 5 N is applied and such that the distance between the attachment to the weights and the detonator is (500±50) mm. The weights are released such that the entire load is applied instantly and the load is maintained for (120±5) sec.

Keep the record if or not the detonator fires during the test. Record if or not the shock tube breaks and/or if a pullout has occurred.

**B-4.2 Functioning test**

After carrying out the test as given in **B-4.1**, fire out each of the remaining detonators of which the shock tube is intact and no pullout has occurred, according to the instructions given by the manufacturer. Record the detonators fire or not.

**ANNEX C**

(*Clause* 4.8)

**DETERMINATION OF TRANSFER CAPABILITY OF SURFACE CONNECTORS**

**C-1 GENERAL**

When using shock tube based non-electric initiation systems, there is a need to transfer the shock-wave from one unit to another and/or to delay the signal. This can be done by means of surface connectors.

**C-2 APPARATUS**

Witness papers, initiating device for the donors, shock tubes (for use as receptors or donors).

**C-3 TEST PIECES**

Make a selection of 5 items of similar type with similar construction and materials.

**C-4 PROCEDURE**

**C-4.1** Condition the surface connector by submerging the assembly at a pressure of 3kg/cm2 for 4 hr in water. The temperature should be kept at (25±5)oC.

NOTE: The sealed end part of the shock tube shall be kept outside the water.

**C-4.2** After the conditioning step, take out the connector from the water.

**C-4.3** Connect the maximum number of receptors (no. of shock tubes that the connector can be connected to) that are claimed by the manufacturer to the surface connector as per the instructions given by the manufacturer.

**C-4.4** Now initiate the test piece by making use of an appropriate initiating system and then check the successful transfer to each receptor.

**C-4.5** Record if shockwave has successfully transferred to all receptors or not.

**C-5 TEST REPORT**

It shall clearly indicate the following information:

1. Number of receptors that did not initiate during the test

**ANNEX D**

(*Clause* 5.1)

**IMMERSION IN HOT OIL TEST**

**D-1 GENERAL**

The purpose of this test is to determine the performance of shock tube detonators when used in bulk emulsions or cartridge emulsions.

**D-2 APPARATUS AND REAGENTS**

**D-2.1 Water bath**.

**D-2.2 Stainless steel vessel with lid**, having a capacity of 2 l.

**D-2.3 Thermometer**, having a range of 0 to 110°C.

**D-2.4 Fresh lubricant or furnace oil having medium viscosity** – 1000 ml.

**D-3 PROCEDURE**

**D-3.1** Take 5 test specimens of 2 m length, duly sealed at both the ends.

**D-3.2** Coil the test specimens so as to fit into the vessel.

**D-3.3** Pour the oil (*see* **D-2.4**) into the vessel (*see* **D-2.2**) till the coil of shock tube is completely dipped except the two sealed ends.

**D-3.4** Cover the vessel with lid, ensuring that the two sealed ends of the test specimens are outside.

**D-3.5** Place the vessel with oil on the water bath and turn on the water bath electrically.

**D-3.6** Keep the temperature of the thermostat at 65°C.

**D-3.7** Note the time of switching on the water bath.

**D-3.8** Maintain the water bath temperature in the range of 60 ± 5°C for 8 h.

**D-3.9** Remove the shock tube and let it cool to ambient temperature.

**D-3.10** Cut both sealed ends of the test specimens and attach the detonator and fire them. The detonator shall be initiated.

**ANNEX E**

(*Clause* 5.2)

**THERMAL STABILITY TEST**

**E-1 GENERAL**

The method describes the determination of the thermal stability of shock tubes for use with non-electric detonators by providing the heat treatment to the test pieces.

**E-2 APPARATUS**

Oven/heating cabinet which is capable of maintaining a prescribed temperature within ± 2 0C

Note: *The apparatus should be of such a design that it can ensure the prevention of sympathetic detonation.*

**E-3 TEST PIECES**

For each particular type having similar materials of construction, dimensions and chemical composition, selection of 25 pieces of shock tube is made, each with a length of (1.00±0.05) m.

**E-4 PROCEDURE**

In the heating cabinet, store the test pieces for 48 h at a temperature of (25±2) 0C higher than the maximum safe operating temperature as given by the manufacturer but should be at least (75±2) 0C.

12 of the test pieces are to be placed in a rack while keeping the base upwards and other 13 of the test pieces are to be placed in a rack while keeping their base downwards. Record any kind of incident of detonation or any evidence of reaction inside the tube (which may be audible or visible) during the test.

**ANNEX F**

(*Clause* 5.3)

**IMPACT TEST FOR SHOCK TUBES**

**F-1 GENERAL**

The shock tube resistance to initiation or damage by impact gives an indication of its safety in handling, transportation and use.

**F-2 TEST PIECES**

Select 10 pieces, each with a length of at least 10 m of a specific type of shock tube.

**F-3 PROCEDURE**

**F-3.1** Place a shock tube on a horizontal steel plate. Drop a 5kg steel ball from a height of 1 m onto each test piece. Cut each tube at the point of impact to remove any damaged part and then subject each portion (20 pieces) to normal functioning.

**ANNEX G**

(*Clause* 5.4)

**RESISTANCE TO ABRASION**

**G-1 GENERAL**

During usage, the plastic tubing of shock tube can experience abrasive forces when drawn over a rough surface which may result in gradual wearing of the plastic material. This method determines the ability of shock tube to resist the abrasive forces that are likely to be experienced in the normal use.

**G-2 PRINCIPLE**

The test piece is subjected to abrasion by an abrasive surface, moving on a particular speed, while applying a particular load then its functioning is tested after immersion in water.

**G-3 APPRATUS**

**G-3.1 ABRASION TEST APPARATUS**

The apparatus comprises of the setup as shown in the Fig. 3.

It consists of a motor driven drum 35mm ± 1mm in diameter with its faces at right angles to shock tube under test so that the drum perimeter bears on the shock tube with provision for anchoring the shock tube at one end and suspending a mass of 1kg from the free end after passing the shock tube over a pulley. The motor driven drum should be at a distance between 1 and 2 meters from the anchorage point. Firmly attach to the drum perimeter at 20mm long piece of new abrasive cloth of grade P100. The drum shall be capable of being rotated at 23 ± 1 rpm for the desired time.

Weight (1 kg)

Pulley

Anchorage

Rotating drum with abrasive cloth

Shock tube under test

FIG. 3 TEST APPRATUS FOR ABRASION

**G-3.2** **IMMERSION TEST APPARATUS**

It should consist of the following components:



Key

1. Shock tube
2. Water
3. Cylindrical bending rig
4. Rod with a diameter equal to the diameter of the shock tube
5. Abraded surface of the shock tube on the outer radius



FIG. 4 WATER TANK AND BENDING RIG

**G-3.2.1** **Tank of water:** It should be deep enough to permit the abraded surface of shock tube to immerse to (0.50 ± 0.05) m.

**G-3.2.2** Cylindrical bending rig: It should be capable of maintaining and bending the test pieces of shock tube in a U form with the radius of bending region around (1.6 ± 0.1) times the diameter of the shock tube.

**G-4 TEST PIECES**

Make a selection of 10 lengths of shock tube, with each one being (3.0±0.5) m long.

**G-5 PROCEURE**

**G-5.1** Take one piece and mount it on the test apparatus as shown in fig. 3. Attach the 1 kg mass to the free end and rotate the drum in contact with the shock tube at 23 ± 1 rpm for 10 ± 1 sec.

**G-5.2** Remove the shock tube from the test apparatus after marking the abraded portion.

**G-5.3** To the U shaped bending ring, attach the shock tube such that the surface which is abraded is on the outer radius of the bend.

**G-5.4** Into the tank of water, put the shock tube and the bending rig such that the free ends are above water and the surface that is abraded is (0.50 ± 0.05) m below the water (as illustrated in fig. 4).

**G-5.5** At a temperature of (25±5) 0C, store for 2 h inside the tank.

**G-5.6** After storage in water, remove the shock tube and initiate it using the manufacturer’s recommended initiating device.

**G-5.7** Record if the tube initiates or not. In case the tube initiates, record if it propagates along its entire length or not.

**ANNEX H**

(*Clause* 5.5)

**RESISTANCE OF DETONATORS TO BENDING**

**H-1 GENERAL**

During use on site, detonators shells can be subjected to bending during the loading of boreholes. This test determines the ability of detonator shell to resist the bending forces likely to be experienced in normal use.

**H-2 APPARATUS**

**H-2.1** **Weights** that have the capability of applying a force of (50±0.1) N with a wire attachment.

**H-2.2 Steel block:** as given in fig. 5, has a hole (A) of at least 30 mm in length. The hole diameter should not exceed the detonator diameter by higher than 0.1 mm. The radius of the hole edge shall be (2±0.1) mm.



FIG. 5 STEEL BLOCK

Key

**A** the diameter of the hole

**L** the length of the hole, minimum 30 mm

**H-2.3 Steel rings:** They are tightly fitted to each end of the detonator. Illustration has been given in fig. 6.



FIG. 6 RING

Key

**B** the inner diameter of the ring, tightly fitting each end of the detonator

**H-2.4 Removable support table** that is capable of supporting the weights. The illustration has been given in fig. 7.



**FIG. 7** ASSEMBLY WITH DETONATOR SUPPORTED AT THE BASE

Key

1. Steel Block
2. Detonator (shown as an electric detonator)
3. Ring
4. Weight
5. Support table
6. Approx. position of the end of the delay element or the base charge
7. Diameter of the hole

**H-3 TEST PIECES**

Select 13 detonators having a longest shell form a particular type with the similar compositions and design.

**H-4 PROCEDURE**

**H-4.1 General**

Determine the weakest point of the detonator as shown in the fig. 8.

**Note:** *It is the point from where the outer shell will break when subject to a 90 degree angle pulling force.*

**

FIG. 8 PRINCIPLE OF FINDING WEAKEST POINTS OF THE DETONATOR

Key

1. Delay element
2. Primary charge cap

 The weakest points

**H-4.2 Non electric detonators at the base:**

Take 13 detonators for the test and mark the weakest point at its base (using fig. 8). Insert the detonator by keeping its base first into the steel block to the weakest point. On the support table, rest the weight such that no force is applied on the detonator. Now, to the end of the protruding part of the detonator, attach the ring and the wire as given in fig. 7. Lower the support table gradually such that a downward force is applied. Continue to lower down the table till the detonator is completely supporting the weight. The load is maintained for a minimum of 5 seconds. Record any cracking or breaking of the shell and any initiation of the detonator.