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FOREWORD

(Formal clause shall be added later)

The requirements of stationary type electric water heaters were first covered in IS 2082 : 1985 'Specification for stationary storage type electric water heater'. That standard was first issued in 1962 and is currently in its third revision which covers water heaters having inner tanks made of copper and stainless steel. The vitreous enamelled inner tank has started coming in use in the recent past and some manufacturers are already in the market with this product. In view of the increasing demand of the product, the Committee decided to formulate an Indian Standard on the subject.

In the formulation of this standard, assistance had been derived from U.S. Commercial Standard CS 115 : 1960, 'Porcelain enamelled (glass lined) tanks for domestic hot water service' and ISO/DP 4528, 'Vitreous and porcelain enamel finishes—Guide to international standards for the selection of test methods for vitreous and porcelain enamelled areas of articles' issued by the International Organization for Standardization (ISO).

In this revision thickness of the base metal has been removed. Additionally, new test method has been incorporated for Hydrostatic test by superseding the test method prescribed in the earlier version of the standard.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated 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.

Indian Standard VITREOUS ENAMELLED INNER TANKS FOR STORAGE WATER HEATER – SPECIFICATION

1 SCOPE

This standard prescribes requirements methods of sampling and tests for vitreous enamelled inner tanks for use in stationary storage type electrical water heaters.

2 REFERENCES

The standards listed below contain provisions which through reference in this text, constitute provision of 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 below:

IS No.	Title
IS 513 (Part 1) : 2016	Cold Reduced Carbon Steel Sheet and Strip Part 1 Cold Forming and Drawing Purpose
	(Sixth Revision)
IS 2082 : 2018	Stationary storage type electric water heaters - Specification (fifth revision)
IS 2500 (Part 1) :	Sampling procedure for inspection by attributes Part 1 Sampling schemes indexed by
2000/ISO 2859-1 :	Acceptance Quality Limit (AQL) for lot-by-lot inspection (third revision)
1999	
IS 2717 : 1979	Glossary of terms relating to vitreous enamelware and ceramic-metal systems (first
	revision)
IS 3972 (Part 1) :	Methods of Test for Vitreous Enamelware Part 1 Production of Specimens for Testing
2020	(second revision)
IS 3972 (Part 2/Sec 1)	Methods of Test for Vitreous Enamelware Part 2 Test Methods Section 1 Resistance to
: 2020	corrosion by dilute acids at room temperature (second revision)
IS 3972 (Part 2/Sec 2)	Vitreous Enamelware — Method of Test Part 2 Test Methods Section 2 Low and High
: 2023	Voltage Tests for Detecting and Locating Defects (second revision)
IS 12038 : 1987	Permissible limits and test methods for toxic materials released from enamelware in
	contact with food

3 TERMINOLOGY

For the purpose of this standard, the definitions given in IS 2717 and the following shall apply.

3.1 Burn Off

It is a term used to designate a condition caused by saturation of the enamel layer by iron oxide during the firing operation. The condition usually occurs on areas where the enamel has been applied very thin. It can be recognized by:

- a) a complete lack of glossiness, and
- b) a reddish brown or black appearance of the enamel over the affected area.

4 TEST SPECIMEN

The test specimen shall be prepared in accordance with IS 3972 (Part 1).

5 REQUIREMENTS

5.1 Materials

5.1.1 Base Metal

The base metal and the component used for the fabrication of enamelled inner tank shall be made of steel sheet of a quality that is suitable for enamel coating by the manufacturer's process and equipment, so that the tanks will consistently meet the requirements of the standard.

5.1.2 Fitting Components

The base plate of all pipes and fittings on the enamel tank shall conform to IS 2082.

5.2 Welding

The welding of the steel tank shall be done with low hydrogen type electrode to minimise enamelling defects. In case gas welding is used for welding the steel tank, the filling material shall be of the same composition as the parent metal.

5.3 Enamel

5.3.1 All surfaces of the tank that are exposed to hot water shall have a continuous coating of vitreous enamel. The outside of the tank shall also be projected with a thin enamel coat.

5.3.2 The composition of the enamel shall be such as to meet the requirements given in 5.3.2.1 to 5.3.2.5.

5.3.2.1 Release of toxic material

The enamel shall pass the permissible release limits of 0.5 mg/dm^2 for lead (as Pb) and 0.05 mg/dm^2 for cadmium (as Cd) when tested by the methods given in Annex B of IS 12038.

5.3.2.2 *Resistance to citric acid*

The enamel shall pass the resistance to citric acid test at room temperature for 'AA' or 'A' class when tested by the method prescribed in 5 of IS 3972 (Part 2/Sec 1).

5.3.2.3 Solubility test

The enamel when tested by the procedure given in Annex A shall not suffer a weight loss of more than 4 mg/cm².

5.3.2.4 *Resistance to thermal shock*

The enamel shall pass the resistance to thermal shock test when tested by the procedure given in Annex B.

5.3.2.5 Impact resistance test

The enamel coating shall not show any instantaneous chipping at the impact point when subjected to an impact force of 3.4 kg/cm^2 . This impact force is achieved by making a steel ball weighing 43 ± 1 g to fall freely from a height of 80 cm at a plain segment of the inner part of the tank having a flat area larger than the cross sectional area of the ball.

NOTE — For the purpose of this testing, chipping shall be considered as those fractures of enamel coating, which result in spontaneous removal/breaking away of the damaged enamelled flake. Any delayed chipping or chipping on the opposite side of the impact face shall not be taken into account for evaluating the test result of the sample.

5.3.3 Thickness

The thickness of the enamel coating shall be between 0.2 mm to 0.4 mm.

5.3.4 Coverage

In order to be considered a continuous coating, the enamel shall have the minimum defects or discontinuities.

NOTE — Any break in the coating that is sufficient to expose the surface of the steel base shall be a cause of rejection (see 5.6).

5.3.4.1 Cathodic protection

If there is any discontinuity in the enamel coating more than the maximum limit prescribed in **5.6** then cathodic protection shall be provided. Each enamelled tank shall be furnished with a cored magnesium anode having a surface density of magnesium not less than 275 g/m² of the inner tank area. The anode shall be electrically grounded to the tank.

5.3.4.2 *Exceptions to cathodic protection*

For use in areas where experience has shown that cathodic protection shall not be used, the enamelled tanks may be furnished without anodes, if (a) the tanks are so labelled, and (b) the enamel is applied in such a way so as to ensure the complete coverage of the steel.

5.3.5 *Edges and Fittings*

All edges and fittings, welded or otherwise, shall be coated with enamel except sharp edges, threadings and small areas immediately adjacent to various fittings. A slight burn-off of enamel, that does not extend more than 6.25 mm back from the sharp edges, shall be permitted.

5.4 Storage Capacity

The storage capacity of each tank shall be within ± 5 percent of the rated capacity marked on the tank.

5.4.1 The tank shall be fixed in its working position. The drain plug and all outlets except the top most outlet shall be plugged. The container is filled with water through its inlet until water starts flowing at the top most outlet. The inlet is closed and when the overflow ceases completely, the water is drained out through the drain plug and the volume of water determined either by measuring or weighing. The capacity so measured is called the storage capacity.

5.5 Hydrostatic Test

5.5.1 The enamelled tank shall withstand the water pressure occuring in normal use. Compliance is checked by subjecting the tank to water pressure as given in **22.47** of IS 302-2-21.

5.6 Enamel Coverage Test

After completing the hydrostatic test (*see* **5.5**), the tanks shall be cut into four or more segments using a saw. Each segment shall be visually inspected for the presence of exposed metal areas except the cracked areas of the enamel caused by the cutting operation. If any exposed area of the metal shows a diameter of more than 3.5 mm, the tank shall be regarded as failing to meet the requirement of the test.

5.6.1 If a large number of exposed metal areas of smaller diameter are observed, the average diameter of such exposed metal areas shall be computed and from that the total exposed metal area shall be calculated. If this area exceeds 7 cm^2/m^2 of the inner tank surface, the sample shall be regarded as failing to meet the requirement of the test.

5.7 Low Voltage Test for Verifying Continuity of Enamel

The enamel shall pass the low voltage test when tested by the method prescribed in 4 of IS 3972 (Part 2/Sec 2).

6 PACKING AND MARKING

6.1 Packing

Each enamelled tanks shall be packed as agreed to between the manufacturer and the purchaser.

6.2 Marking

Each enamelled water tank shall be marked permanently and legibly with the following information:

- a) Indication of the source of manufacture;
- b) Name of the material, that is, enamelled water tank;
- c) Code or serial number to enable the lot to be traced from records;
- d) Storage capacity;
- e) Rating pressure; and
- f) Exceptions to cathodic protection (*see* **5.3.4.2**), if any.

6.2.1 BIS Certification Mark

The enamelled water tank may also be marked with the Standard Mark.

6.2.1.1 The use of the Standard Mark is governed by the provisions of *Bureau of Indian Standards Act*, 1986 and Rules and Regulations made thereunder. The details of conditions under which the licence for the use of Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

7 SAMPLING AND CRITERIA FOR CONFORMITY

7.1 Lot

A lot shall consist of vitreous enamelled tanks manufactured under same condition and not more than 500 in number.

7.2 Representative samples of the enamelled tank shall be drawn at inspection level I of IS 2500 (Part 1)/ISO 2859-1 and all the tests shall be conducted on these samples.

7.3 No defect shall occur at the end of the tests.

ANNEX A

(Clause 5.3.23)

DETERMINATION OF SOLUBILITY

A-1 APPARATUS

The apparatus required for determining the solubility of enamel is illustrated in Fig. 1 to 5. The cylinder assembly shall be constructed of 1.5 mm (16 guage) AISI type 304 stainless steel. The ends shall be ground so as to conform with the curvature of the tank to be tested. The gaskets shall be of neoprene rubber. The apparatus shall be heated with a gas burner of electric heater placed outside the cylinder assembly.



FIG. 1 TEST CELL FOR SOLUBILITY TEST OF ENAMEL



All dimensions in millimetres. FIG. 2 BACKING PLATE



All dimensions in millimetres. FIG. 4 CLAMPING ASSEMBLY



All dimensions in millimetres. FIG. 5 CYLINDER ASSEMBLY

A-2 SPECIMENS

The specimen for the solubility test shall comprise of four section pieces each of size $100 \text{ mm} \times 100 \text{ mm}$ cut from the wall of the enamelled tank approximately midway between the ends.

A-3 PREPARATION OF SPECIMEN

The specimen shall be buffed to remove rough edges and enamel fragments. The specimen shall be scrubbed on both sides using nylon brush and a mild abrasive detergent powder, rinsed with distilled water, dried for one hour in a drying oven and cooled in a desiccator.

A-4 THE INITIAL MASS

The specimen shall be weighed to an accuracy of 0.1 mg.

A-5 CALIBRATION OF TEST CELL

Each test cell shall be calibrated before it is used following the procedure given below:

Assemble the cell as it is to be opened. Fill with water to just below where the condenser tube is welded to the tank. Adjust the input to the heat source to give a slow rolling boil. If the water rises in the condenser, remove small amounts of water until the cell operates without surging. Switch off the heat and check it to see if the water level is completely covering the panels. Cool to room temperature, then measure the volume of water contained in the cell. Record this volume in the cell and use this amount of test solution in all subsequent tests.

A-6 TEST SOLUTION

The test solution used for each cycle shall consist of 400 mg of sodium bicarbonate dissolved in one litre of distilled water.

A-7 TEST PROCEDURE

A-7.1 Assemble the test cell using weighed panels of the same enamel on each end of the test cell. Pour the correct volume of the test solution into the cell. Adjust the input to the heater to give a consistent slow, rolling boil. After boiling for 18 hours, dismantle the cell and discard the used test solution. Clean the specimen using soft cloth and store in a desiccator between solution treatments. After 8 cycles of 18 hours each, clean specimen as before rinse with distilled water and dry at 107°C for 1 hour. Place the specimen in a desiccator while hot and after cooling to room temperature weigh to an accuracy of 0.1 mg.

A-8 CALCULATIONS

The loss of mass per unit area of the enamelled surface (M) after treatment with boiling water is calculated as follows:

$$M = \frac{M_1 - M_2}{A}$$

where

 M_1 = mass, in g, of the test specimen before the test;

 M_2 = mass, in g, of the test specimen after the test; and

A =area, in m², of the exposed surface of the test specimen.

ANNEX B

(Clause 5.3.2.4)

DETERMINATION OF RESISTANCE TO THERMAL SHOCK

B-1 OUTLINE OF THE METHOD

The test for thermal shock resistance consists of heating the specimen to $140 \pm 3^{\circ}C$ and then chilling with water at room temperature.

B-2 APPARATUS

Hot air oven capable of maintaining temperature of at least 150°C.

B-3 PROCEDURE

Heat the specimen in the oven to $140^{\circ}C \pm 3^{\circ}C$ at the rate of $5^{\circ}C - 10^{\circ}C$ per minute. As the required test temperature is attained, maintain the sample at this temperature for 30 minutes Switch off the oven and remove the sample and quench it in water at room temperature. At least two samples shall be tested. Examine the samples for any cracking, flaking or blistering. The samples which show occurence of any chipping of the enamel shall be considered as not being in conformity with the standard.