StAR
SOCIETY OF ASIAN ROTOMOULDERS

Tank Standards By StAR

(Prepared by Ad hoc Committee on Tanks Standards

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1. SCOPE AND LIMITATIONS

1.1 Scope

This standard specifies requirements for the design and manufacture of polyethylene storage tanks that are rotationally molded in one piece seamless construction. The tanks are flat bottomed and are meant for non-buried, vertical installation and capable of containing water, liquids used in foods and beverage manufacture and chemical solutions at atmospheric pressure.

1.2 Limitations

This standard does not provide design criteria for-

a) Liquid contents heated above their flash points;
b) Liquid contents with service temperatures above-
  i) 50 degrees C; or
  ii) The rated service temperature of the tank material.
c) Superimposed pressure exceeding 0.25m head of water, or 2.5 kPa above the maximum recommended fill level; and
d) Superimposed mechanical forces, such as seismic forces, wind load or agitation.

Where criteria in Items (a) to (d) apply, special design consideration shall be given.

The tank material supplier shall be consulted where the anticipated service temperature of the liquid stored within the tank exceeds 50 degrees C.

This Standard does not apply to portable tanks for the transport of liquids.

2. OBJECTIVE

The objective of this standard is to-

(a) Ensure secure storage of water and other liquids or chemicals;
(b) Ensure performance and workmanship of the finished tank is adequate for the intended application.

3. DEFINITIONS

For the purpose of this Standard, the definitions given below apply.

3.1 Polyethylene 'base resin'

A polyethylene base resin is an un-pigmented virgin polyethylene polymer as supplied by the polyethylene producer. It may be in UV stabilized or non- UV stabilized form.

3.2 Polyethylene 'compound'

A polyethylene compound is a hot melt mixed blend of virgin polyethylene polymer, additives and pigments as required.

3.3 Service (design) factor

A derating value that takes into consideration reasonable material and process variation that is applied to long term resin provide a design safety margin.

3.4 Service Temperature

The maximum expected temperature of the contents of the tank or ambient temperature, whichever is greater.

4. MATERIALS

4.1 The material of construction of tank, lid and fittings which come in contact with water shall be such that it does not impart any taste, color or odor to water, nor have any toxic effect, and it shall not contaminate water thereby making it un-potable.

4.2 Polyethylene resin to be used for the manufacture of water tanks shall be of rotational molded grade and duly stabilized with anti-oxidants. The anti-oxidants used, not exceeding 0.3% of mass of finished resin, should be selected from the list given in IS 10141:1982. In addition, the material shall also meet the requirements given in 4.2.1 to 4.2.3.

4.2.1 The density of resin (base material) at 23 degrees C when tested in accordance with IS 7328:1992 shall be within 932 to 943 kg per cubic meter.

4.2.2 The melt flow rate (MFR) of the resin when tested under the test condition D (temperature 190 degrees C and nominal load of 2.16 kg) and in accordance with IS 2530:1963 shall be within 2.0 to 6.0 g/10 minutes.

4.2.3 The addition of not more than 10 percent of the manufactures own reworked material resulting from the manufacture of tanks only according to this standard is permissible. No other reworked or recycled waste material from any source or filler shall be used in the manufacture of the tanks

4.3 UV resistance

4.3.1 In case, Carbon black is used for UV stability, the carbon black content and carbon dispersion test shall be carried out in accordance with the procedure described in IS 2530:1963 and shall meet the following requirements:

(a) The percentage of carbon black content in the material shall be within 2.0 and 3.0, and

(b) The dispersion of carbon black shall be satisfactory.

4.3.2 In case of coloured tanks, the requirements of this Clause shall apply to base resins where base resins are UV stabilized. Where UV stabilizers are added at the final compounding stage, this Clause shall apply to natural (un-pigmented) powders.

All UV testing shall be performed on natural (non-pigmented) base resin material to establish a minimum performance level for the material being tested.

When tested in accordance with ASTM D2565, the polyethylene compound for tanks, fusion-bonded fittings and welding rods shall contain UV stabilizers such that the natural compound will retain 50% tensile elongation after 8000 hrs of exposure in a Xenon-Arc weather-o-meter.

Alternatively, UV testing in accordance with ISO 4892-2 may be conducted. When testing in accordance with ISO 4892-2, the testing authority shall provide certified evidence to demonstrate that the amount of exposure hours in accordance with ISO 4892-2 is equivalent (or higher) in total energy output, to the total energy output of 8000 hrs exposure in accordance with ATSM D2565.

4.4 DISPERSION OF ADDITIVES AND PIGMENTS

4.4.1 General

Compounded powders for rotational molding that exhibit a uniform color distribution after the master-batch has been compounded into the polymer will also exhibit uniform distribution of all other additives including UV light stabilizers that have been compounded into the masterbatch simultaneously with the pigments. The addition of UV light stabilizer additives only, via masterbatch into a non-UV stabilized base resin is not permitted.

A sample for visual inspection of between 0.5-1 mm in thickness and a minimum of 40 mm diameter shall be rotational or compression molded, or melted down from production powder to provide a sample sufficiently large to allow inspection under a light source. Colour shall be given through the specimen, without any evidence of agglomeration, blotching or other visual evidence of uneven dispersion.

4.4.2 Non –UV stabilized resins

Non-UV stabilized base resins, anti-oxidants, ultraviolet light stabilizers and pigments, including carbon black, shall be evenly dispersed in the compound. The compounded resin shall be tested for uniformity of dispersion of additive via visual inspection of a specimen manufactured in accordance with Clause 4.4.1.

Anti-oxidants, pigments and ultra violet stabilizers shall be pre-compounded with a small percentage of a suitable polyethylene resin into a masterbatch, before this masterbatch is compounded with the (non-UV stabilized) base resin at the prescribed ratio/percentages to ensure the final compound complies with Section 4 of this Standard. Pigment content, other than carbon black, shall not exceed 2% of the total mass.

4.4.3 Pigmented UV-stabilized base resins

For UV-stabilized base resins, the compounded resin shall be tested for uniformity of dispersion of the pigments by visual inspection of a specimen manufactured in accordance with Clause 4.4.1.

Anti-oxidants and pigments shall be pre-compounded with a small percentage of a suitable polyethylene base resin, into a master-batch compound, before this master-batch is compounded with the UV stabilized base resin at the prescribed ratio/percentages to ensure the final compound complies with Section 5 of this Standard. Pigment content, other than carbon black, shall not exceed 2% of the total mass.

4.5 Stress-cracking resistance

The polyethylene base resin used in compounds that are intended for use in tanks shall have a stress-cracking resistance of 500 hrs minimum F50 in accordance with ASTM D1693, Condition A, full-strength stress cracking agent. The test specimens shall be compression molded and shall meet the requirements of ASTM D4703 with a minimum platen temperature of 177 degrees C.

NOTES:

a) Advice on the tendency of a chemical to cause stress cracking should be sought from the material supplier.
b) The stress-cracking test is not used as an indicator of general chemical resistance of a polyethylene. The polyethylene supplier's or molder's chemical resistance chart should be referred to for information on the polyethylene to specific chemicals or products, or testing of specific products or chemicals should be conducted.

4.6 Chemical resistance

The suitability of a polyethylene base resin used n compounds that are intended for the use in chemical storage tanks shall be based on relevant chemical resistance data from base resin manufacturers. The suitability of the data shall be agreed between the base resin supplier and the compound supplier, the tank manufacturer and other parties, as required. Such agreement shall be based on relevant documented field experience, published chemical resistance reference texts or laboratory analysis.

For each chemical storage tank, the manufacturer shall maintain the relevant chemical resistance data demonstrating the tank's suitability for the intended application.

When specified, the compound shall be tested with the intended chemical in accordance with ASTM D543. Specimen dimensions and testing for mechanical properties shall be in the form for tensile testing in accordance with ASTM D638, Type IV.

NOTES:

1. Due to the wide range of materials, service conditions and chemical reagents, the suitability of a reagent to be stored in a polyethylene tank should be by agreement between parties.
2. Specimens should be cut from compression-molded plaques. If doubt exists as to the effect of the rotational molding process (i.e. porosity), rotationally molded specimens may also be tested.

5. DESIGN

5.1Hydrostatic design stress

The hydrostatic design basis shall be determined in accordance with ASTM D2837 with test conditions at 23 deg. The hydrostatic design basis shall be multiplied by the service factor to determine the hydrostatic design stress.

The maximum service factor shall be 0.5 for wall thickness less than 9.5 mm. For wall thickness equal to or greater than 9.5 mm, the maximum service factor shall be 0.475.

Note: For example if the hydrostatic design basis for the resin is 7.2 Mpa, the hydrostatic design stress for a tank of wall thickness 5mm will be 3.6 Mpa.(At 23 deg centigrade)

In absence on availability of the value of hydrostatic design basis from the supplier of the base resin the hydrostatic design basis of the base resin can be calculated as 20 % of the tensile strength at yield when tested in accordance with IS 8543 (part 4/sec 1):1984.

5.2 Tank design

5.2.1 The manufacturer has to design the tank taking into consideration the additional stresses and strains which may be imposed on certain areas such as outlet/inlets, anchor points and access openings. Usage of finite element analysis is highly recommended.

5.2.2 Wall thickness at Cylindrical Shell: The minimum wall thickness of the cylindrical shell at any fluid level shall be determined by the following equation, but shall not be less than 3.5 mm at any location

T=P*OD/2S

where

T=wall thickness ,in mm

P=Pressure in mega pascal, calculated as .0098*SG*H (Mpa)

SG=Specific gravity of fluid to be stored in tank

H=Height of the fluid to be stored in tank ,in meters

OD= outside diameter of tank, in millimeters

S=hydrostatic design stress , in megapascals

5.2.3 Wall thickness at the top: The minimum thickness of the top head shall be equal to the top of the straight wall and shall be designed to prevent buckling or collapse under specified loadings and conditions as stated by the manufacturer, or as specifically agreed between the manufacturer and the customer, for special applications. It should pass the test for top load resistance when tested according to clause 7.3.1 of IS 12701 : 1996

5.2.4 Wall thickness at floor and knuckle radius: The minimum floor thickness of a tank designed to be installed on a fully supporting floor (base) shall be not less than 3mm within a radial distance of 65% of the radius of the floor (measured from the centre of the floor). The balance of the floor shall gradually increase in thickness to the same as the thickness at the knuckle radius of the floor/wall intersection. Floor thickness of tanks designed for installation in other than a fully supporting floor shall be determined by the design engineer.

The radius of the external surface bottom knuckle of a flat-bottom tank shall be not less than 25mm for tanks with a diameter less than 1.8mm, and 38mm for tanks with diameter greater than 1.8m. The minimum thickness of the radius shall be not less than the maximum thickness of the cylinder wall. Bottom knuckles that are not a single radius shall be designed using appropriate engineering design methods, which may include finite element analysis. Floor thickness design for tanks with fittings located in the tank floor shall be determined to ensure the service life of the tank is not affected.

5.3 Dimensions

All volume and outside dimensions shall be taken at the time of manufacture with the tank in the operating upright position, unfilled. Tank dimensions shall represent the exterior measurement

5.4. Tolerances

5.4.1 Outside dimensions

The tolerance for outside dimensions, including out of roundness shall be within 3% of the specified outside dimensions

5.4.2 Tank wall, floor and roof thickness

Wall, floor and roof thickness shall be design thickness -10% to + 30%

Wall, floor and roof thickness shall be measured by ultrasonic equipment capable of measuring to an accuracy of 0.1 mm. The inability or difficulty in obtaining a reading with an ultrasonic gauge may indicate a high level of porosity in the part wall. This may be an indication of an under-cured part.

6.TANK CAPACITY

The tank capacity shall not be less than the stated capacity. The tank capacity shall be the internal volume calculated with the tank in the vertical position and unfilled. The height of the tank shall be from the base to the invert level of the overflow of the tank.

Alternatively, the tank capacity may be determined by filling the tank with water and measuring the quantity to fill the tank to the invert level of the overflow.

The useable volume in a storage tank will be dependent on the placement of the outlet.

7.FINISH

The internal and external surface of the water storage tank shall be smooth, clean and free from other hidden internal defects, such as air bubbles, pits and metallic or other foreign material inclusions. The mould parting line and excess material near the top rim of the tank shall be cut and finished to the required level. Defects like air bubbles and pits at mould parting line and at top rim of the main-man-hole shall be required by hot-air filler rod welding method.

NOTE: As far as is practically possible, internal air or internal surface temperature measurements should be made consistently either throughout the moulding and cooling cycles or at predetermined intervals during these cycles. Internal air temperature traces are normally very producible and variances from optimum can provide a good insight into what may have occurred during the moulding and cooling.

The cooling sequence of the cycle can have a significant effect on final product performance.

8. MAN-HOLE HAND-HOLE LIDS

8.1: Materials

Man-hole hand-hole lids shall be moulded from polyolefins of minimum thickness 3mm and shall have sufficient ribs to provide adequate stiffness. It shall also satisfy all the requirements of clause 4.3 and 4.4

8.2: The lid shall fit securely over the top rim of the tank and it shall rest evenly on it (with or without threaded arrangement) in order to prevent the ingress of foreign matter such as insects, mosquitoes or dust through the top of the tank. The lid shall also be provided with suitable locking arrangement.

9. PERFORMANCE REQUIREMENTS

9.1 Tensile strength

9.1.1: Tensile strength at yield shall be determined in accordance with IS 8543(part 4/sec 1) : 1984. The tensile strength of the wall of water tanks shall not be less than 12 N/sq. millimeter.

9.1.2: The test specimens shall be cut from the flat portion of the top of the water tank at a temperature not exceeding 50 degree Celsius and then machined.

9.2 Overall migration: When the tank is meant for food or water storage, then this test needs to be carried as a type test.

9.2.1:The polyethylene compound shall meet the specified limits of overall migration of constituents as specified in IS 10146 : 1982 when tested according to 6 of IS 9845 : 1986.

9.3: Rotational moulding process evaluation (Low temperature impact test):When tested in accordance with Appendix A, a tank(batch) shall not fail when subjected to the impact energy specified in Table A2 of Appendix A.

10. HANDLING STORAGE AND PACKING

Handling, Storage and packaging of the tanks prior to dispatch shall be carried out in a manner that ensures the compliance of performance and workmanship requirements of this standard are not compromised.

11. INSTALLATION

The manufacturer shall provide detailed installation instruction with each tank. The instruction shall be based on the design and end use of the tank and shall provide the following minimum information:

a. Site selection criteria.
b. Site preparation instructions
c. Plumbing connection instructions

12. MARKING REQUIREMENTS

The tank shall be legibly marked on the outer surface of vertical wall , or where it can be seen in it's normally installed position, with the following information

a. Manufacturer's name or trade mark
b. Tank Capacity ,based on fluid level used in the design criteria
c. Maximum specific gravity of contents of tank
d. Maximum design service temperature
e. Date of manufacture

13. REVIEW AND AMENDMENTS

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that the changes are needed, it is taken up for revision.

APPENDIX A

LOW TEMPERATURE IMPACT TEST

A1 .Scope: This Appendix sets out a method for determining the impact property of rotationally moulded polyethylene tanks.

A2 .Principle: Test specimens are cut from available areas on the tank and conditioned at -40 degree celcius after not less than 24h have elapsed. The specimens are then placed, inside-surface down, in the specimen holder and immediately impacted with a dart, of specified weight and tip radius, from a prescribed height. The specimen is observed for failure on both surfaces. The test prescribes a minimum impact value, which the specimen has to pass.

A3. Relevance: The dart impact test at -40 degree celcius produces a value that is used as an indication of the quality of the tank. If the moulding conditions were inadequate and a homogenous melt was not obtained, the impact energy absorbed before failure will likely be low. Higher impact energy values are obtained with ideal moulding conditions indicating that a quality part with good impact resistance has been moulded

A4. Definitions: For the purpose of this appendix, the definitions below apply.

A4.1 BRITTLE FAILURE: Signified by the part physically coming apart or cracking at the point of impact. Specimen has no, or very little, elongation.

A4.2 DUCTILE FAILURE: Signified by the dart leaving a hole or rupture through the full thickness of the specimen, rather than cracking outwardly from the point of failure. The area under the dart is elongated and thinned at the point of failure.

A.4.3 DROP HEIGHT: Dimension between impact tip of dart and surface of specimen to be tested .

A5. Apparatus: The following apparatus is required:

a)A test rig with sample, guide shaft, rope and pulley as illustrates in figure A1.

b)Darts as described in figure A2.

c)Specimen holder mounted on a rigid base(concrete or similar).

A6. Conditioning: Test specimens shall be cooled in air at ambient temperature for a minimum of 12 h from the time of manufacture. After cooling at ambient temperature, the test specimen shall be conditioned -40 plus or minus 5 degree celcius in accordance with table A1 and with sufficient time for the specimens to equilibrate at -40 plus or minus 5 degree celcius, depending upon the cooling equipment.

TABLE A1

MINIMUM CONDITIONING TIME AT -40 PLUS OR MINUS 5 DEGREE CELCIUS

Wall thickness Mm	Minimum residence time in air at -40 plus or minus 5 degree celcius hours
Less than or equal to 7.5	2
Greater than 7.5 up to and including 15.0	6
Greater than 15.0	12

A7. Procedure:

A7.1: TEST SPECIMEN

Cut the specimen for a loose fit in a 127mm X 127mm specimen holder. Test specimens shall be flat. Test specimens may be square 125 X 125 plus or minus 2mm or circular 125 plus or minus 2 mm.

Test specimens shall be labeled using a permanent marker. Marking with stickers shall not be permitted.

A7.2: PROCEDURE

The procedure shall be as follows:

a) Place a conditioned specimen in the specimen holder with the outside surface facing up.

b) Within 10 seconds of removal from the conditioned environment, release the dart and impact each specimen on the outer surface(use the impact energy specifies in table A2 as calculated by multiplying the dart weight by the drop height (see figure A1).

A7.3 ACCEPTANCE CRITERIA

The specimen shall not fail the specified impact energy. Where a specimen does fail, a further 2 specimens from the same tank may be tested and the tank accepted as having passed the test, if two out of three specimens pass at the specified impact energy.

NOTES:

1. Internal porosity through the wall cross-section should be noted. A low level of small bubbles limited to the inner third of the part wall indicates a close to optimum part cure. A greater level of porosity indicates an under-cured part while no porosity could indicate an over-cured part.

2. Whenever possible, choose a dart weight that permits the drop height to be between 0.8 and 2.3m, in order to minimize the effect of velocity on the result of the test.

TABLE A2

MINIMUM IMPACT ENERGY

Wall thickness Mm	Minimum impact energy J
3.5 to and including 6.4	122.0
Greater than 6.4 to and including 12.9	135.5
Greater than 12.9 to and including 19.3	203.2
Greater than 19.3	271.0

Impact energy= Height(in metres) X Weight (in kilograms) X Gravity(9.8m/s^2)

A8.Report: The following shall be reported:

a)Identification of the tank.

b)Date of test

c)Impact energy (J) used for the test

d)Whether the batch passed or failed in accordance with paragraph A7.3