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Moulded polyethylene water storage tank — Specification

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WDUS 1560: 2020

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Foreword

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Draft Uganda Standards adopted by the Technical Committee are widely circulated to stakeholders and the general public for comments. The committee reviews the comments before recommending the draft standards for approval and declaration as Uganda Standards by the National Standards Council.

The committee responsible for this document is Technical Committee UNBS/TC 04, Mechanical Engineering and Metallurgy

This second edition cancels and replaces the first edition (US 1560: 2013), which has been technically revised.

Moulded polyethylene water storage tank — Specification

1 Scope

This Working Draft Uganda Standard specifies the requirements and methods of sampling and test for moulded polyethylene water storage tanks (closed and open top tank).

This draft standard is not applicable to underground tanks, mobile water tanks and horizontal cylindrical water tanks.

2 Normative references

The following referenced documents referred to in the text in such a way that some or all of 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 18872, *Plastics — Determination of tensile properties at high strain rates*

ISO 6964, *Polyolefin pipes and fittings — Determination of carbon black content by calcination and pyrolysis — Test method*

ISO 18553, *Method for the assessment of the degree of pigment or carbon black dispersion in polyolefin pipes, fittings and compounds*

US ISO 1209-1, *Rigid cellular plastics — Determination of flexural properties — Part 1: Basic bending test*

US ISO 1209-2, *Rigid cellular plastics — Determination of flexural properties — Part 2: Determination of flexural strength and apparent flexural modulus of elasticity*

ISO 1183-1

ISO 18872

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
net capacity (actual)
net total volume of water contained between the lowest level of the overflow and lowest level of outlet (see Figure 1 and Figure 2)

3.2
gross capacity (nominal
total enclosed volume of the tank including any space, which may not be capable of being filled with water

3.3
mould parting
circumferential line visible only on the external surface of the tank corresponding to a parting joint of the mould required for rotational moulding (see Figure 1 and Figure 2)

3.4
overall height
height of the finished empty tank at its highest point, including the top rim of the manhole and lid of the tank (see Figure 1 and Figure 2)

3.5
effective height
height of the finished empty tank from its base to the point where overflow connection is provided for the purpose of limiting water storage capacity (see Figure 1 and Figure 2)

3.6
overall diameter
maximum outer diameter of finished empty tank measured at its base (see Figure 1and Figure 2)

3.7
man-hole/hand-hole
hole of suitable internal diameter provided at the top of the tank for the purpose of inspection of internal surface and entry into the tank (see Figure 1)

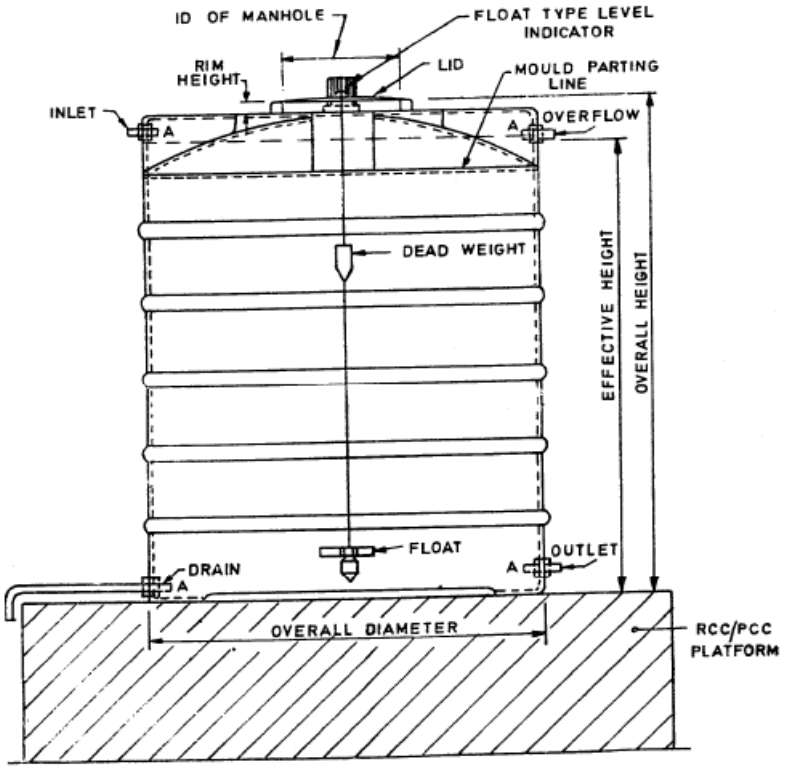
3.8
internal diameter of man-hole/hand-hole
internal diameter of the rim of the manhole measured as the mean of two perpendicular diameters (see Figures 1 and 2)

3.9
closed tank
tank moulded as a single piece with the top as an integral part (see Figure 1)

3.10
open top tank
tank where the body and top moulded separately and assembled after moulding (see Figure 2)

3.11
rotational moulding
three-stage commercial process consisting of loading the mould with powdered resin, fusing the resin by heating while rotating the mould about more than one axis, and cooling and removing the moulded article

3.12
blow moulding
method of forming hollow objects by inflating a parison into a mould with compressed gas



Key

RCC Reinforcement

PCC Pre-cast cement concrete

NOTE The requirements for the construction of the reinforced cement concrete or pre-cast cement concrete depend on the capacity of the tank and location.

Civil engineering will establish the viability of the geology that the water tank will be placed on and this will dictate site preparation and cost.

The choice of materials of construction will be impacted by the whether the tank is located indoors, outdoors or underground.

Figure 1 — Typical perspective view of closed top tank

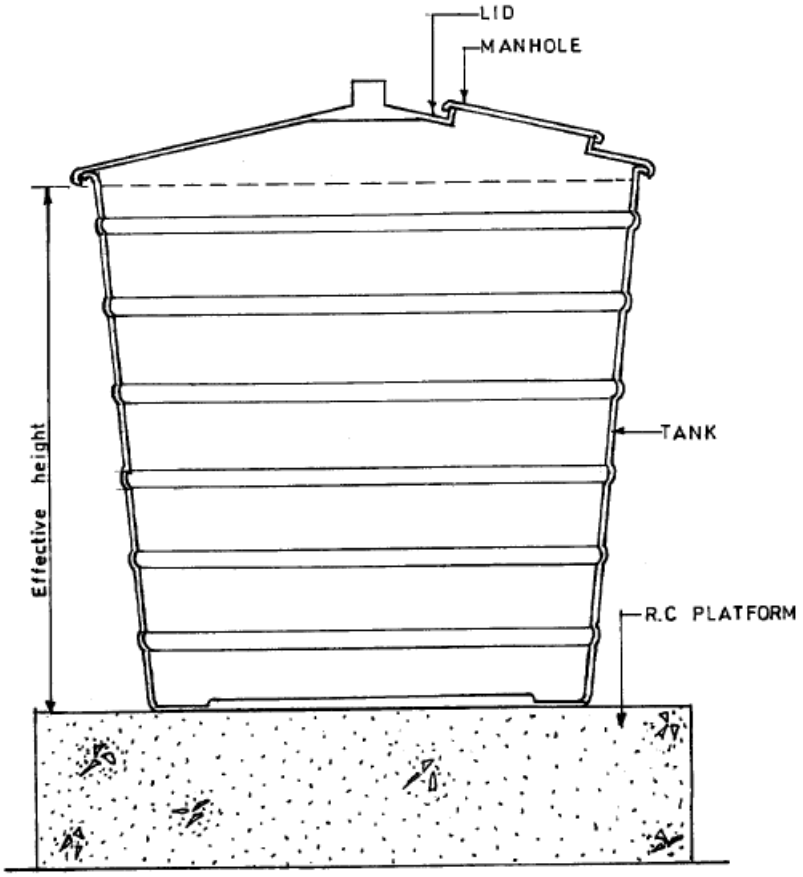


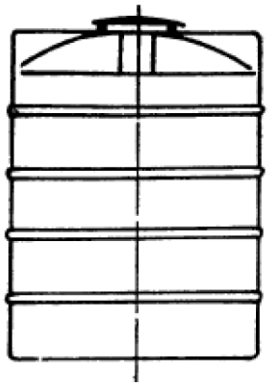
Figure 2 — Typical view of open top tank

4 Types

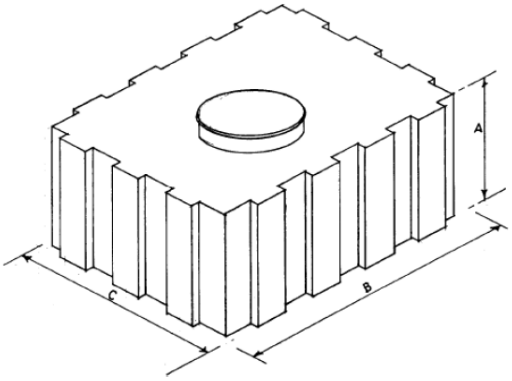
There shall be two types of tanks namely:

a) cylindrical vertical tanks (closed and open-end); and

b) rectangular loft tanks (see Figure 3 a) and b)).



a) Cylindrical vertical closed top tank



b) Rectangular loft tank

Figure 3 — Types of water storage tanks

5 Requirements

5.1 General

5.1.1 The following two conditions apply to both open-top and closed-top water storage tanks:

a) own hydrostatic head of water; and

b) uniform flat base support

5.1.2 The nominal service temperature shall be 1 °C - 50 °C

5.2 Materials

5.2.1 The materials for construction of the tank and lid that come into contact with water shall be of food grade and shall meet the material requirements given in Table 1.

5.2.2 Water tanks meant for outdoor use shall be manufactured from virgin polyethylene materials. The outer layer of the tank, however, shall be made from virgin and 10 % reusable material. The inside layer shall be made of 100% virgin material.

5.2.3 All polyethylene resin material shall contain a minimum of a U.V 8 stabilizer as compounded by the resin manufacturer.

5.2.4 The material for construction of the tank and lid, which comes into contact with water, shall not impart any taste, colour or odour to water; they shall neither have any toxic effect nor contaminate water thereby making it unpotable.

5.2.5 The life span for the tank shall not be less than 15 years under normal use.

Table 1 — Requirements of material

Material type	Property	Requirement	Test method
Blow-moulded polyethylene	Density [a]	shall not be less than 938 kg/m^3	ISO 1183-1
	Melt flow rate [b]	shall be less than 12 g/10 min at 190 ºC, 21.6 kg maximum increase of the melt flow rate of the moulded tank shall not be greater than 15 % of the value determined on the raw material	ISO 1133-1
	Tensile strength [c]	tensile strength at yield shall not be less than 21 MPa	ISO 18872
		elongation at yield shall not be more than 15 % elongation at break shall not be less than 200 %	
Rotationally moulded polyethylene	Density [a]	shall not be less than 930 kg/m3	ISO 1183-1
	Melt flow rate [b]	shall be 4.0 g/10 min ± 3.0 g/10 min at 190 ºC, 2.16 kg. Maximum variation of the melt flow rate of the moulded tank shall not be greater than 20 % of the value determined on the raw material	ISO 1133-1
	Tensile strength [c]	tensile strength at yield shall not be less than 15 MPa elongation at yield shall not be more than 25 % elongation at break shall not be less than 200 %	ISO 18872
Blow-moulded polyethylene and rotationally moulded polyethylene	Stress cracking resistance	either: After 28 days immersion the tensile strength shall not be less than 85 % of the reference sample without pin impression or the time to 50 % failure shall not be less than 500 h or the time to failure at reference stress 9 MPa shall not be less than 20 h	ISO 23667
	Weather resistance[c]	For external installations after exposure to global irradiance of 34 GJ/m^2 (corresponding to an irradiance of 2.3 GJ/m^2 for the band from 300 nm to 400 nm) the elongation at break shall be greater than 50 % of the initial value. For internal installations the elongation at break after exposure to global irradiance of 3.4 GJ/m^2 (corresponding to an irradiance of 0.23 GJ/m^2 for the band from 300 nm to 400 nm) shall be greater than 50 %	ISO 4892-2

Material type	Property	Requirement	Test method
		of the initial elongation at break.	
	Weather resistance [c]	For external installations after exposure to global irradiance of 34 GJ/m2 (corresponding to an irradiance of 2.3 GJ/m² for the band from 300 nm to 400 nm) the elongation at break shall be greater than 50 % of the initial value. For internal installations the elongation at break after exposure to global irradiance of 3.4 GJ/m2 (corresponding to an irradiance of 0.23 GJ/m² for the band from 300 nm to 400 nm) shall be greater than 50 % of the initial elongation at break.	ISO 4892-2
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[a] Test to be carried out on raw material.
[b] Test to be carried out on raw material and on tank.
[c] Test to be carried out on tank.

5.3 Carbon black content

5.3.1 For tanks intended to be used outdoors, carbon black pigment shall be added to the moulding material for the outer layer or the exposed layer and shall be 2.5 % ± 0.5 % when tested in accordance with Annex A.

5.3.2 The carbon black or any other pigment added shall be uniformly dispersed in the material, when tested in accordance with Method A in ISO 23900-3.

5.4 Catalyst

The total amount of inorganic material present in polyethylene shall not exceed 0.2 % (m/m) when tested by the atomic absorption method and in accordance with Annex B. An alternative method of testing for the metals shall be by X-ray fluorescence, where the atomic absorption method may not be applicable or just non-operational.

5.5 Fillers and pigments

The plastic shall not contain any filler. Pigments may be added as desired by the customer, or as designated by polymer processing companies, but shall not exceed 0.5 % dry blended, and 2 % compounded in, of the total weight.

5.6 Fittings

It shall be the prerogative of the manufacturer to provide as much information as is possible to the consumer regarding fittings.

5.7 Sizes

Tank sizes will vary in accordance with the customer's requirements and shall be as given in 5.10.

5.8 Net capacity (actual)

When filled to the lowest level of overflow, and the volume attained measured, tanks shall discharge the capacity marked on it.

5.9 Design requirements

5.9.1 Cylinder shell (unsupported portion of tanks)

5.9.1.1 The minimum wall thicknesses of the tanks shall be as provided in tables 2, 3, and 4.

5.9.1.2 The hydrostatic design stress that is used to determine the minimum wall thickness at any fluid level shall be based on hoop stress data for the polyethylene materials. The hydrostatic design-basis shall be reduced by a service factor to determine the actual hydrostatic design stress. The maximum service factor shall be 0.5 for wall thicknesses less than 9.5 mm. For thicknesses equal to or greater than 9.5 mm, the maximum service factor shall be 0.475.

5.9.1.3 Tank hoop stresses shall be derated for service above 23 °C.

5.9.2 Cylinder shell (externally supported tanks)

The minimum required wall thickness for the cylinder straight shell shall be sufficient to support its own weight in an upright position without any external support. The tolerance indicated in 5.10.3 applies to these dimensions.

5.9.3 Top head

The top head shall be integrally moulded with the cylinder shell. The minimum thickness of the top head shall be equal to the top of the straight wall.

5.9.4 Bottom head

The bottom head shall be integrally moulded with the cylinder shell.. The radius of the bottom knuckle of a flat-bottom tank shall not be less than 25.4 mm for tanks with a diameter less than 1.8 m and 38.1 mm for a

diameter greater than 1.8 m. The minimum thickness of the radius shall not be less than the maximum thickness of the cylinder wall.

5.9.5 Open-top tanks

The top edge of open tanks shall be reinforced by design to maintain its shape after installation.

5.10 Dimensions and tolerances

5.10.1 General

All dimensions shall be taken with the tank in the vertical position, unfilled. Tank dimensions shall represent the exterior measurements. The thickness shall be as specified in Table 2 for rotational moulded tanks and Table 3 for blow-moulded tanks.

Table 2 — Dimensions of rotational moulded cylindrical vertical tank

Volume, L	Diameter, mm	Height, mm	Minimum thickness, mm	Mass, kg
100	490	710	2.3	3
150	580	750	2.5	4.5
250	690	840	2.7	7.0
500	860	1 040	2.8	11
750	1 080	1 000	3.0	16.5
1000	1 080	1 270	3.7	21
1500	1 260	1 420	3.8	29
2000	1 380	1 580	4.0	35
2500	1 480	1 690	4.1	45
3000	1 580	1 780	4.2	55
4000	1 760	2 100	4.5	73
5000	1 850	2 050	4.8	85
6000	2 520	1 460	5.0	108
6000	1 980	2 230	5.0	108
8000	2 190	2 430	6.0	159
10000	2 850	1 890	10.0	205
10000	2 380	2 710	10.0	205
16000	2 900	2 800	15.0	325
24000	3 560	2 800	18.0	550

Table 3 — Recommended dimensions of rotational moulded rectangular loft tanks

Volume, L	Length, mm	Width, mm	Height, mm	Mass, Kg

250	1 000	700	550	15
500	1 200	880	620	23
1 000	1 270	1 270	870	50

Table 4 — Recommended dimensions of blow-moulded cylindrical vertical tank

Volume, L	Minimum thickness, mm			Mass, kg
	Top wall	Side wall	Bottom wall	
250	1.6	2.0	2.2	6
500	2.0	2.1	2.3	9
1000	2.2	2.5	2.8	16
1500	2.3	2.8	3.2	24
2000	2.6	3.0	3.8	32
2500	2.8	3.0	4.0	40
3000	3.1	3.4	4.3	48
4000	3.5	3.7	5.3	64
5000	3.5	3.9	5.5	80
8000	3.5	4.0	5.8	130
10000	4.5	5.0	5.8	170

5.10.2 Outside diameter

The tolerance for the outside diameter, including out of roundness, shall be ± 3 %.

5.10.3 Shell wall and head thickness

The tolerance for average thickness at each elevation shall be - 10 % of the design thickness on the low side and shall be unlimited on the high side. The tolerance for individual audit readings shall be limited to - 20 % of the design thickness. The total amount of surface area on the low side of the tolerance shall not exceed 10 % of the total surface area.

5.10.4 Placement of fittings

The tolerance for fitting placements shall be 12.7 mm in elevation and 2° radial at ambient temperature.

5.11 Mechanical properties

5.11.1 The flexural modulus of the wall of the water tank shall be not less than 400 N/mm2 when determined in accordance with US ISO 1209-1 and US ISO 1209-2

5.11.2 When the cylindrical vertical water storage tank is tested in accordance with Method 1 in Annex C, the difference between the circumferential measurements shall be not greater than 2 % of the original measurements.

6 Finish

6.1 The internal surface of the water storage tank shall be smooth to the extent that nothing sticks to it and easily cleanable, clean and free from other hidden internal defects, such as air bubbles, pits and metallic or other material inclusions.

6.2 The mould parting line near the top rim of the tank shall be cut and finished to the required level. Defects like air bubbles and pits at the parting line and at the top of the manhole shall be repaired.

6.3 The finished tank wall shall be free, as commercially practicable, of visual defects such as foreign inclusions, air bubbles, pinholes, pimples, crazing, cracking and delamination that will impair the serviceability of the vessel.

6.4 All cut edges where openings are cut into the tanks shall be trimmed smooth.

7 Test methods

7.1 Resistance to deformation test

7.1.1 The resistance to deformation test shall be determined in accordance with Method 1 in Annex C.

7.1.2 When rectangular loft tank is tested in accordance with Method 2 in Annex C, the difference between the longitudinal measurements shall be not greater than 3 % of the original measurements.

7.2 Tensile strength test

The tensile strength at yield shall be determined in accordance with ISO 18872.

7.3 Flexural strength test

The flexural modulus of the wall of the water tank shall be determined in accordance with US ISO 1209-1 and US ISO 1209-2

7.4 Hydrostatic pressure head test

The tank shall be filled with water up to the nominal capacity. Thereafter it shall be fitted with a pump with a pressure gauge. The pump shall then be started and run till the nominal pressure level is attained and examined for leakage. There shall be no leakage observed. A hydrostatic water test will be conducted if ordered by the customer.

8 Sampling

8.1 Lot

8.1.1 All the water storage tanks of same raw material, same type, size and produced under relatively uniform conditions of manufacture shall constitute a lot.

8.1.2 The sample size shall be determined in accordance with Table 5

Table 5 — Scale of sampling and criteria for conformity for tanks

Lot size	Sample size	Maximum permissible failure
Up to 50	1	0 Failure
200	2	0 Failure
300	3	0 Failure
500	5	0 Failure
501 and above	8	1 Failure

8.1.3 Tanks shall be selected at random from the lot. In order to ensure randomness of selection, tables of random numbers shall be used.

8.1.4 Each tank selected in accordance with Table 5 shall be tested for the requirements in Table 6.

Table 6 — Routine test parameters

SL No.	Test	Clause
i)	Resistance to deformation	7.1
ii)	Hydrostatic pressure head test	7.4
iii)	Carbon black content	Annex A
iv)	Carbon black dispersion	ISO 23900-3

8.2 Routine tests

The routine tests listed in Table 6 shall be carried out to ensure that satisfactory quality is maintained during a production run.

9 Marking

9.1 Plastic water storage tanks shall be marked legibly and indelibly with the following information;

a) manufacturer's name and address;

b) net capacity, in litres;

c) lot number and/or batch number;

d) country of origin;

e) manufacture date;

f) material code; and

g) recyclable symbol

9.2**The method of marking shall be at the discretion of the manufacturer.Annex A**
(normative)

Determination of carbon black content

A.1 Apparatus

A.1.1 Combustion boat, made of porcelain or silica, having minimum dimensions of 15 mm length, 9 mm width and 8 mm height

A.1.2 Combustion tube, made of hard glass of approximately 30 mm diameter and 400 mm ± 50 mm length

A.1.3 Gas flow meter, for measuring and controlling the rate of flow of nitrogen within 1.7 L/s ± 0.3 L/s

A.1.4 Thermometer, in the range of 250 °C - 550 °C

A.1.5 Furnace, to accommodate the combustion tube to give temperatures up to at least 500 °C

A.2 Reagents

A.2.1 Nitrogen, as technical grade

A.2.2 Trichloroethylene

A.3 Procedure

A.3.1 Assemble the apparatus as shown in Figure A.1. Both cold traps following the combustion tube shall contain trichloroethylene, but only the first need be cooled with solid carbon dioxide. Alternatively, the entire apparatus may be placed in a fume hood and the two traps following the combustion tube omitted. Fill the dry tube with anhydrous $CaCl_2$ or other suitable desiccant. Hold between loose plugs of glass wool.

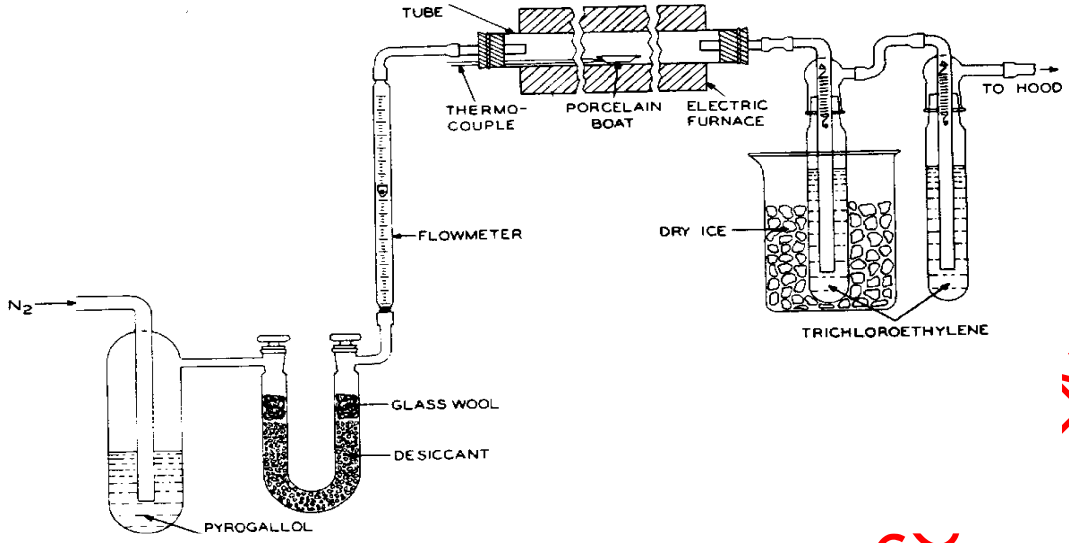

Figure A.1 — Assembly of apparatus for carbon black determination

A.3.2 Heat a clean combustion boat to red heat in a Bunsen flame; transfer the boat to the desiccant and allow it to cool over fresh desiccant. Hold between loose plugs of glass wool.

A.3.3 Remove the boat from the desiccant and weigh it to the nearest 0.000 1 g. Immediately place 1.0 g ± 0.1 g of the ethylene plastic under test in the boat and quickly weigh to the nearest 0.000 1 g.

A.3.4 Heat the furnace to a constant temperature of 600 °C. Adjust the rate of nitrogen flow to 1.7 L/min ±0.3 L/min. Open the inlet end of the 2.9-cm diameter tube, quickly place the combustion boat with the sample into the tube at the centre of the furnace, and adjust the thermocouple so that the weld is touching the boat. Insert a copper plug, if this is used. Quickly close the furnace and allow heating to proceed for at least 15 min.

A.3.5 Move the tube or furnace so that the boat is no longer in the heated zone of the furnace and allow 5 min for cooling, while maintaining the flow of nitrogen. Remove the copper plug, if present and the boat through the inlet end of the tube and allow it to cool for at least 30 min. Take care that the boat does not become contaminated from any deposits on the walls of the tube. Then quickly reweigh the boat and its contents to the nearest 0.000 1 g.

A.3.6 Make all determinations in duplicate.

A.4 Calculation

The carbon black content shall be expressed as follows:

$$W = \frac{W_r}{W_s} * 100\%$$

Where;

W is carbon black content by percent weight

Wr is the mass, in grams, of the boat before heating in air; and

Ws is the mass, in grams, of the boat after heating in air

Annex B
(normative)

Determination of effect of heavy metals on water quality

B.1 Test specimen

Three test specimens of approximately 500 mm^2 in surface area shall be taken from tank.

B.2 Method of extraction

B.2.1 Each test specimen shall be pre-washed for a period of 6 hours using tap water with pH of 7 to 8. The water shall be passed through the specimen at a velocity of 50 mm/s while the specimen is kept fully immersed with water. After washing, the specimen shall be filled with fresh solution of the distilled water acidified to pH of 4.5 ± 0.1 by bubbling a current of carbon dioxide through it, and both ends sealed with a material that does not contain any toxic substances nor interfere with the determinations of such constituents in the aqueous samples.

B.2.2 After maintaining the specimens at room temperature for 48 hours, the solution shall be decanted into a suitable container for analysis as the first extraction.

B.2.3 The procedure shall be repeated a second and a third time. Retain these samples for the determination of the amount of metals and other toxic substances as second and third extractions.

B.2.4 The first extraction and the third extraction shall be analysed for lead. The third extraction shall also be analysed for dialkyl tin (C4 and above) as tin.

B.2.5 When calcium and mercury are present; all three extracts shall be analysed.

B.3 Method of analysis

Analysis for lead, tin, cadmium and mercury shall be carried out using atomic absorption.

Annex C
(normative)

Deformation test

C.1 Method 1 for cylindrical vertical tank

C.1.1 The water tank shall be placed on a flat level base. A circumferential measurement shall be made parallel to the base at a distance of one third the effective height from the bottom. The tank shall be filled up to the effective height at a minimum rate of 23 L/min with water at temperature of not less than 15 °C.

C.1.2 A continuous film of polyethylene shall be floated over the whole of the surface of water in tank to prevent evaporation.

C.1.3 The temperature of the tank and water shall be maintained at a temperature not less than 15 °C and after seven days a circumferential measurement shall be made at a level referred to in C.1.1. The difference between the two circumferential measurements shall be expressed as a percentage of the original circumferential measurement.

C.2 Method 2 for rectangular loft tank

C.2.1 The rectangular tank shall be placed on a level base. The internal length and width of the tank shall be measured on the centrelines, as shown in Figure C.1 at the centre of effective height.

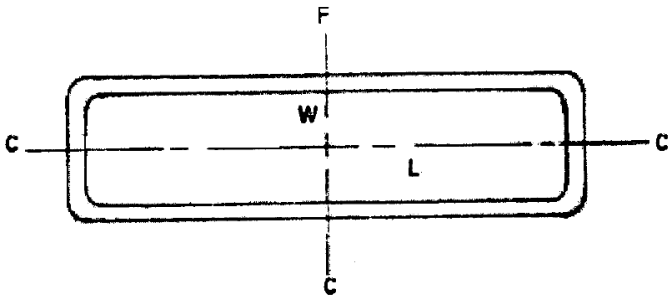

Figure C.1 — Centreline measurements

C.2.2 The tank shall be filled up to the effective height at a minimum rate of 23 L/min with water at a temperature not less than 15 °C. The lid shall close after filling the loft tank.

C.2.3 The temperature of the tank and water shall be maintained at not less than 15 °C and after seven days measurements of length and width shall be made at previously determined centrelines.

C.2.4 The deformation in each direction shall be calculated as follows:

$$D_W = \frac{L_2 - L_1}{2W_1} * 100$$

Where;

D_1 is the deformation of the longer side;

D_w is the deformation of the shorter side;

W_1 is the width at the start of the test;

W_2 is the width at the end of test;

L_1 is the length at the start of the test; and

L_2 is the length at the end of test.

Bibliography

[1] US 1560:2013, *Rotational moulded polyethylene water storage tank — Specification*

[2] BS EN 13575:2012, *Static thermoplastic tanks for the above ground storage of chemicals — Blow moulded or rotationally moulded polyethylene tanks — Requirements and test methods*

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ICS 23.020.10

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