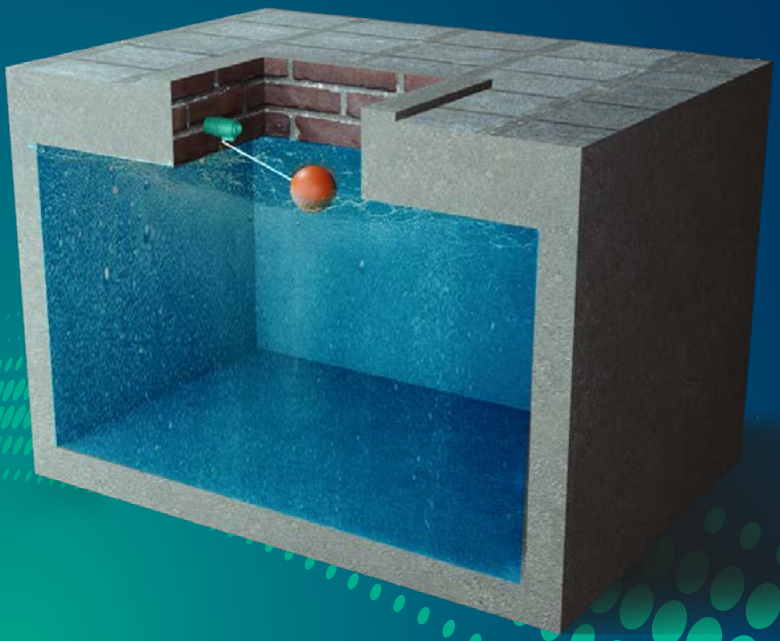
شركة المياه الوطنية
National Water Company

Guidelines for Waterproofing

of Underground Water Tanks

«Saving – Rationalization - Sustainability»



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Introduction

Within the efforts of the National Water Company (NWC) to preserve water, rationalize its use, ensure its sustainability, and mitigate the harms clients are bearing due to high water bills triggered by large water consumption, and based on the results of the field studies carried out by NWC within the Rasshid (rationalize) Project to detect leakages inside the buildings and real estate properties owned by clients, these indicated the existence of considerable leakages from the underground tanks in properties owned by the majority of clients participating in the project.

These leakages in turn lead to wastage of water and high-water consumption, as shown by the water bills for clients.

To solve the problems of leakages from underground tanks, NWC conducted a study on the various alternatives for solving this issue. The study concluded that the solution lies in resorting to the waterproofing options/alternatives mentioned in the guidelines.

(The Saudi Building Code (SBC) should be implemented in case of a clash between the requirements/prerequisites of these guidelines and the Code).

The Field

These guidelines shall be implemented on tanks meant for collecting potable drinking water and constructed in homes, real estate properties, and housing compounds or residential units, which have been carried out while fulfilling the requirements of the Saudi Building Code (SBC) and the technical conditions stipulated in the Saudi/GCC standards and specifications. The size of the facility should meet the requirements of its beneficiaries. This does not apply to the public tanks.

Definitions and terminology

TERM	DEFINITION
The company	National Water Company
Client	Owner of residential or commercial building or real estate
Guidebook	Guidelines on waterproofing of underground tanks that are constructed in houses, real estate properties, and housing compounds and units.
Tanks	Underground water tanks (It is an underground structure that is used to collect and store water, and feed the building with potable drinking water)
Standards and Specifications (SASO)	The Saudi Standards, Metrology and Quality Organization (SASO)
SBC	The Saudi Building Code
GSO/SASO	Saudi / GCC standards and specifications
BS	British Standards
EN	European Standards
ASTM	American Society for Testing Materials (ASTM)
NSF International	National Sanitation Foundation
ANSI	The American National Standards Institute (ANSI)

REFERENCE SPECIFICATIONS

The following Reference Specifications are essential and cannot be done without when implementing these Guidelines. For the dated references, only the mentioned editions apply. As to the undated references, the latest edition of the reference specifications (including any amendments) should be applied.

SPECIFICATION NUMBER	NAME OF SPECIFICATION
SASO-GSO-1831: 2007	Water tanks made of polyethylene formed into shape by spinning.
SASO-GSO-2450 EN 13280/11-2001	Water tanks made of Glass Reinforced Plastic (GRP)
SASO-2882	Solvent-free epoxy paints for potable drinking water tanks and pipes
SASO-826 EN 13280/11-2001	Drinking water horizontal tanks made of polyester resins and glass reinforced plastic (GRP)
SASO-GSO-2443: 2014	Potable drinking water tanks made of glass reinforced plastic with polyester resins
GSO 2311: 2013	Lining of concrete water tanks
NSF 61	The health effects of materials on drinking water
ASTM D 5199 ASTM D 792	Standard Test Method for Measuring the Nominal Thickness of Geosynthetics Standard Testing Methods for Density and Specific Gravity (Relative Density)
EN 1186-1	Non-metallic products for use in contact with water intended for human consumption

The Importance of Insulating Tanks

The insulation of tanks is greatly important due to the following reasons:

- To preserve water from wastage and rationalize consumption.
- To protect the foundations of buildings and real estate properties from harm by water leaking to the reinforcement materials.
- To protect the roads in the vicinity of the tanks from the harms of water leakages and their adverse effects on the soil.
- To protect the water from pollution due to water leakages from and to the underground tanks.
- To reduce the economic burden on the consumer by lowering the quantity of consumption as reflected by the water bills.

The most important types of tanks

- **Underground tanks made of reinforced concrete** carried out at the site (which are the most common) or prefabricated (prefab) and insulated from the inside and outside – depending on the insulation/waterproofing options and alternatives mentioned in these guidelines. The concrete tanks should be designed according to Chapter Six (A) of the Residential Building Code for buildings not exceeding three stories. As to the tanks of bigger capacity, they ought to be designed in line with ACI 350.
- **Prefab underground tanks made of synthetic materials harmless to man's health (fiberglass - High Density Polyethylene (HDPE), etc.)**

General conditions for executing tanks:

- To obtain approval of the authorities concerned for the site and the size of the underground tank, according to the engineering design of the building, as per the construction permit.
- The tank site should be clean and not inundated by water of whatever source. Hence, it should be drained of any water pools. It should be far away from foul odors, smoke, dust, and pollutants.
- All surfaces to be insulated should be free from moisture, and all irregular surfaces due to solidified cement, oils, and grease ought to be scraped off and cleaned before carrying out the insulation. One must make sure the surfaces are clean, dry, and dust-free, and all cracks and flaws likely to affect the efficiency of the insulation materials to be used, must be repaired before starting the internal insulation process. In general, the surfaces should be in the condition required by the insulation materials manufacturing company.
- In new tanks, an appropriate external insulation must be carried out and an internal insulation suitable for potable drinking water, in addition to installing PVC sheets at the construction joints with a width of at least 25 cm.

- All the internal insulation materials must be approved against toxicity, and they should have obtained the WRAS Certificate approving the material's suitability to be in contact with potable drinking water. This is in addition to certificate of conformity with the Specification No. ANSI /NSF 61 that is concerned with the components of drinking water system – the health effects of these materials on potable drinking water.
- The tank should be tightly insulated and waterproofed to prevent any water leakage into and out of the tank or any mixing of the water with other external sources (according to the details given in these guidelines).
- The parts of the tanks made of iron or tin must be treated with an anti-rust substance, provided it is free from anything causing toxicity, and it should not affect the properties of water or consumers' health.
- The insulation works should be carried out by a licensed and qualified technician, trained, and certified by the insulation material manufacturing company. It is important that the guidelines of the manufacturing company must be followed precisely.
- The tank site should be easily accessible for carrying out maintenance or cleaning.
- There should be appropriate ports for filling and cleaning.
- During the tank's design, ease of removing sediments during the washing and sterilizing of the tank must be taken into consideration by draining out the water from the tank's floor to remove the sediments and other deposits.
- The tank should be capable of being tightly closed to prevent the entry of dust, soil, and other pollutants. The manhole should be higher than the ground level by a height of 10 - 25 mm. The opening should be inclined outwards from the tank in such a way that it prevents rainwater or water from other sources to reach the tank port.
- A safe manhole cover should be used to cover the tank port meant for entering the tank, according to the Saudi / GCC standard specifications for manhole covers.
- The tank must have two ports – one for feeding and the second for draining out the water during washing and sterilization. A floater must also be provided to control the quantity of water in the tank.
- Sufficient continuous lighting and ventilation must be provided to protect all the workers during execution of the insulation works, while taking into consideration all the rules and conditions for health and safety during execution, in line with the Civil Defense safety conditions.
- To clean and sterilize tanks at least once every six months and carry out regular periodic inspections of tanks to ensure their safety in terms of construction and health.
- The tank shall be filled with water from the public network or from a reliable and approved source, which will confirm the water is fit for human consumption.
- The maximum load of the tank, according to its design, must not be exceeded during and after completion of works.

Options for insulating tanks

There is a variety of options for waterproofing and insulating underground tanks, due to the diverse insulation materials, which should be obtained from a source that has accreditation from the Saudi Standards, Metrology and Quality Organization (SASO), and their equivalent when importing from abroad.

This guideline is enhanced by the variety of insulation options, beginning with the currently existing practice of giving a finish to the tank's floor and walls from within using a cement plastering machine, while adding an anti-filtration agent (like silica) or coating the walls and floors of tanks with epoxy or other materials used as a waterproofing to prevent water leakage.

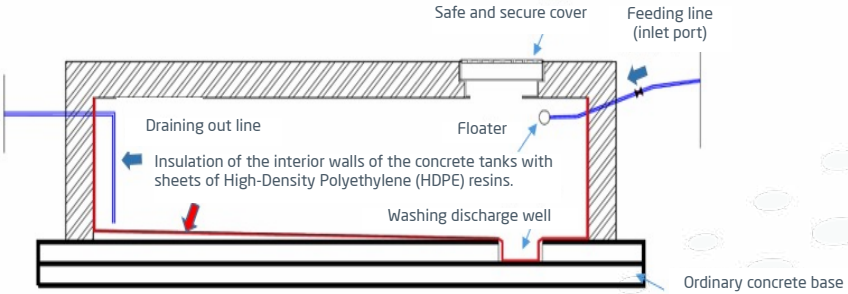
To the company's visions on insulation work, as summarized in the following points:

- Lining the (new / existing) concrete underground water tanks with High Density Polyethylene (HDPE).
- Lining the (new / existing) concrete underground water tanks with fiberglass (FRP/GRP).
- Lining the (new / existing) concrete underground water tanks with one of the waterproofing materials (epoxy insulation - penetron insulation – polyurea insulation).
- Installing prefabricated concrete underground water tanks made of High-Density Polyethylene (HDPE).
- Installing prefabricated fiberglass (FRP/GRP) underground water tanks.

The options for insulation of water tanks can be shown as follows:

First: Lining the (new / existing) concrete underground water tanks with High Density Polyethylene (HDPE).

The existing concrete tanks are rehabilitated and treated by mending the cracks and removing the deposits, oil smears and surficial flaws, and cleaning the tank walls from within. All the concrete surfaces ought to be free from moisture before starting the rehabilitation and treatment processes. It must be ensured that the surface to be lined is smooth, free from sharp objects and strange substances or materials that prevent the strong adhesion of the insulation material. Then it is insulated with High Density Polyethylene (HDPE), in line with the following diagram and conditions:

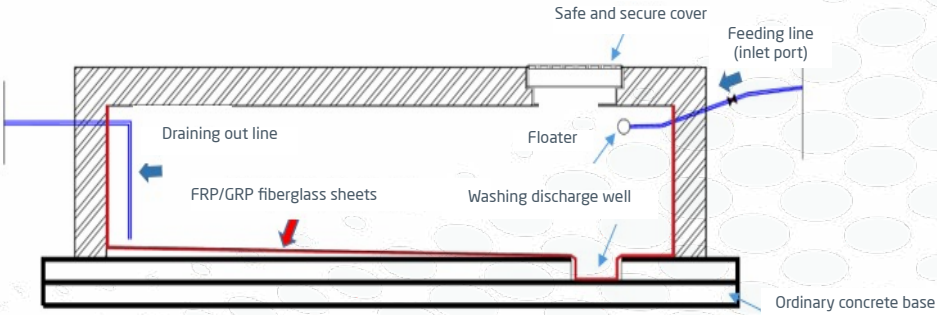


Insulation of the interior walls of the concrete tanks with sheets of High-Density Polyethylene (HDPE) resins.

1. The tank interior is lined with High Density Polyethylene (HDPE) resins to cover all the concrete surfaces that will be in contact with the water.
2. The insulation membranes should be made of High-Density Polyethylene (HDPE) resins that are in conformity with the technical standards and conditions of the Saudi/GCC Standard Specifications No. GSO 2311: 2013 on lining concrete water tanks.
3. The standard no. ANSI / NSF 61 that is concerned with the components of the drinking water system – the health effects of the materials on drinking water.
4. The insulation material made of High-Density Polyethylene (HDPE) resins must be fixed manually and it should be ensured that the resins are fixed around pipe openings. All the tools, machinery, equipment, workers, and materials necessary for executing, checking, and testing insulation works must be used.
5. To distribute the insulation material on the surface intended for insulation in line with the recommendations for preparing surfaces. The segments must be placed according to their numbers and proper places in the execution design. The insulation membrane sheets must be distributed in a way causing the least wrinkling.
6. The High-Density Polyethylene (HDPE) is welded using the welder vertically from top to bottom. A horizontal line should be drawn at least 1.5 meters from the likely stress focal points at the corners and engineering locations of various shapes. The number of welds should be reduced to the minimum, and the overlap between sheets ought to be in the range of 10 to 12 cm for fusion welding (by melting), and 7.5 cm for extrusion welding. Before starting the welding, it should be ensured all the sheets are dry and clean.
7. Fitting the insulation sheets should be in tandem with the welding machine being used, such that this overlap, in general, must not exceed 15 cm. In addition, the welding machine must be adjusted according to the speed, temperature, and thickness of the membrane prior to starting the welding process.
8. The tanks must be cleaned of all the waste resins after completing the insulation process, in line with the recommendations of the insulation material manufacturing company.

Second: Lining the (new / existing) concrete underground water tanks with fiberglass (FRP/GRP)

The existing concrete tanks are rehabilitated and treated by mending all the cracks and fissures, removing sediments, oils, surface defects and cleaning the interior walls of the tank. All the concrete surfaces should be free from moisture before executing. The surface to be lined should be smooth, free from sharp objects, and all strange substances that can prevent the insulation material from adhering strongly to the surface. Then all the concrete surfaces that will be in contact with water are insulated with fiberglass (FRP/GRP), in line with the following diagram and conditions:

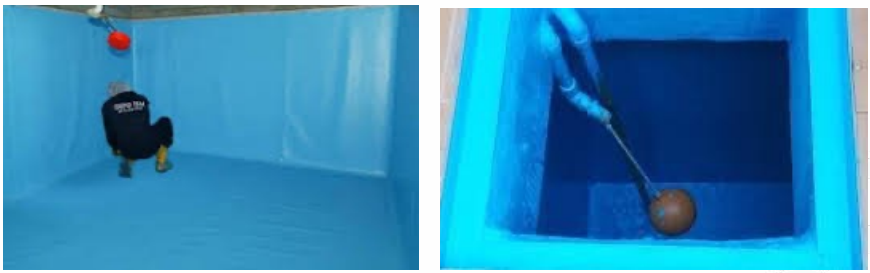


FRP/GRP fiberglass sheets

1. The lining resins and all their components should be manufactured of Fiber-Reinforced Plastic (FRP), in conformity with the standards and technical conditions of the Saudi / GCC Standard Specifications No. GSO 2311:2013 on lining concrete water tanks.
2. The Standard No. ANSI / NSF 61 concerned with the components of the potable drinking water system and the health effects of materials on drinking water.

Third: Lining of (new/existing) concrete underground water tanks with one of the waterproofing/insulation materials (epoxy insulation - penetron insulation - polyurea insulation).

Rehabilitation and treatment of existing concrete tanks of all shortcomings; scraping the sediments, oils and surface flaws and cleaning the tank interior walls; and making sure they are free from moisture before executing. It must be ensured that the tank's concrete surface to be lined is smooth and free from sharp, pointed objects and stones and is devoid of all strange materials that prevent strong adhesion of the insulation material. Then the insulation processes are carried out using one of the permitted waterproofing insulation materials in conformity with the health conditions, as follows:

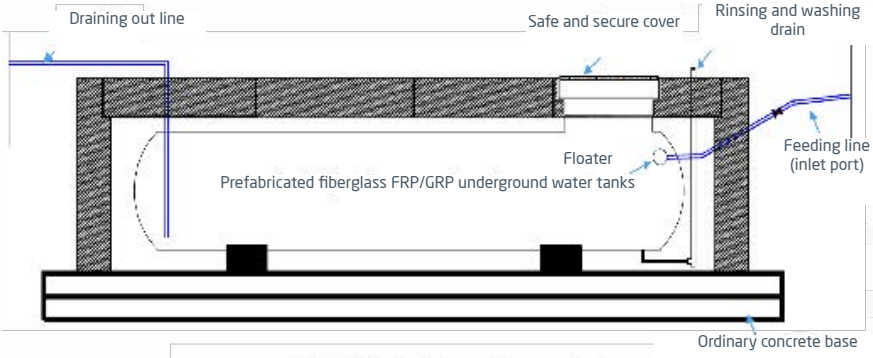


Waterproofing/insulation

1. The waterproofing is carried out internally for all the concrete surfaces in contact with water, provided the waterproofing material is in conformity with the technical specifications and conditions stipulated in the specification no. SASO-2882 on solvent-free epoxy paint meant for potable drinking water tanks and pipes.
2. The specification no. ANSI / NSF 61, which is concerned with the components of the potable drinking water system – the health effects of materials on drinking water, shall be implemented.
3. The insulation process shall be carried out manually and it must be ensured that all the areas and the pipe openings in contact with water, are covered, and all the required tools, machinery, equipment, workers, and the materials necessary for executing, inspecting, and testing are used.
4. The insulation should be distributed evenly on the surface, in line with the recommendations of the manufacturing company to prepare the surface to be insulated.

Fourth: Installing prefab High-Density Polyethylene (HDPE) underground water tanks

The tanks are manufactured of High-Density Polyethylene (HDPE) via a process known as Roto-molding technique for producing water tanks in one piece without any joints for more strength and durability. The tanks are designed for underground use (inside an already prepared underground chamber). The tanks are fitted vertically or horizontally for the storage of potable drinking water, in sizes that suit the needs of the building or real estate property users, in line with the technical conditions and standards of the Saudi/GCC specification no. SASO-GSO-1831, as per the following diagram and details:



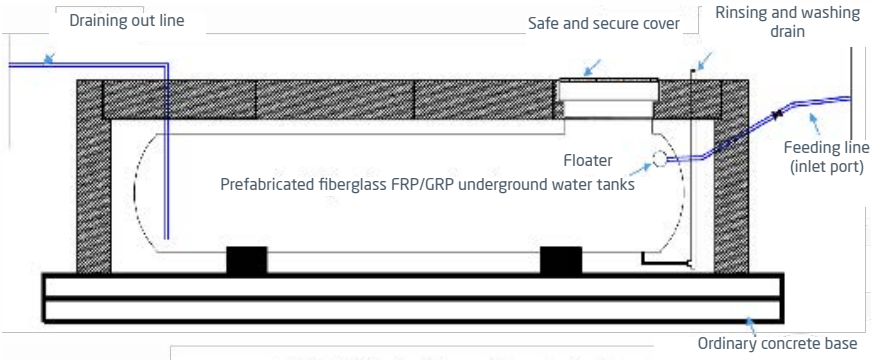
Caption: Prefabricated fiberglass FRP/GRP underground water tanks

1. The tanks must be manufactured of 3 to 4 layers, with a solid outer layer to bear the biggest loads and harshest climatic conditions, with a layer for protection from ultra-violet (UV) rays, thermal insulation for maintaining the water temperature in the tank at a lower temperature than the outside temperature, and a smooth internal layer that prevents and resists the growth of microorganisms including bacteria and algae.
2. The materials for construction and lining – whether for the tank, manhole cover, and fittings in contact with water – must be safe such that they do not cause any taste, color, or odor in the drinking water, nor do they leave any toxic effects causing the water to be polluted and become unfit for drinking. The specification no. ANSI / NSF 61 that applies to components of the potable drinking water system – the health effects of materials on drinking water – must be implemented.
3. The minimum thickness of the tank's cylindrical outer layer at whatever fluid level in the tank, will be determined by the manufacturing company.
4. The thickness of the wall should be sufficient to support the tank's weight in the upright position, without the need for any outside support.
5. Flat, level areas should be provided to permit placing big fitting pieces on the upright cylindrical outer casing.
6. The tank's crest is integrated with the cylinder casing through a molding process. The minimum thickness of the upper crest should be the same as that of the upper portion of the vertical wall, while the lower head should be molded in an integrated fashion with the cylindrical wall.
7. The tanks of 10 cubic meters capacity or more, must each have three handles for lifting it. The handles should have been poured fully integrated into the upper crest of the tank. The lifting handles should be designed in a way allowing lifting and installing the empty tanks.
8. The tank should be designed in such a way that it will have at least four handles molded in an integrated fashion into the upper head. The handles ought to be designed such that they confine the tank to its site during conditions of seismic and wind loads, without any damage to the tank's body.
9. The tank final wall should be visually flawless; like being free from strange impurities, air bubbles, holes, swellings, cracks, fissures, and peeling, which decrease the suitability of the tank for service, its life expectancy, and its expected long life in service as a storage vessel. All the edges that were cut while making holes in the tank, must be smoothened out.
10. Double flanged joints and fittings are made of virgin polyethylene. The bolts are welded to a common support ring and coated with polyethylene to prevent liquid contact with the metallic material. The connection flanges are fitted with a sealing ring to ensure sealing the surface on the side of the coupling flange, and tank top.
11. The tank covers should be of the threaded type, provided with air vents and a suitable diameter that will allow the entry of workers and maintenance and cleaning equipment.

12. The tank shall be provided with an inlet port, an overflow drain, a rinsing and washing drain, and a vent hole with HDPE resin pipes as per the required sizes and measurements, with connecting flange with nominal pressure PN 16 bar, in addition to the internal connecting flange at the inlet side suitable for fitting float valves and a floater to control the water level inside the tank.
13. The waterproofing filling materials and gaskets should be made of rigid polyethylene closed cell foam or Python or Ethylene Propylene Diene Monomer (EPDM) rubber. In addition, suitable air vents must be provided to facilitate air circulation.
14. The tanks must be provided with glass fiber reinforced plastic ladders when needed, and the design of all the ladders should be in conformity with the safety and occupational health standards in force.
15. The tanks should be suitable for use in an atmosphere where humidity reaches 100%, and temperatures reach 60 degrees Celsius. The tanks must be resistant to corrosion and Ultraviolet (UV) rays, and should be stable, nontoxic, nonpolluting, and resistant to microorganisms like bacteria and algae. They should be suitable for potable drinking water applications, and in conformity with the Saudi Standards, Metrology and Quality Organization (SASO), or its equivalent.

Fifth: Installing prefabricated fiberglass (FRP/GRP) underground water tanks

The prefabricated fiberglass (FRP/GRP) underground water tanks should be cylindrical in shape having a uniform and unified wall thickness. It should be manufactured in a process using a spinner to spin fiber threads. The tank should have a lining resistant to chemical substances and the growth of microorganisms – bacteria and algae. It should be fitted vertically or horizontally for water storage. The tanks should be of sizes that suit the needs of the beneficiaries using the building or real estate property, and in line with the technical conditions and stipulations of the Saudi/GCC Standard no. SASO-GSO-1831, and according to the following diagram and details:



Caption: Prefabricated fiberglass FRP/GRP underground water tanks

1. The inner lining thickness ought to be around 1 mm and should be reinforced with a Grade "C" glass surface membrane, with a rear support mat of Grade "E" granulated glass. All these are saturated with high quality isophthalic vinyl ester resins (insoluble in water). The constructed wall of the water tank is made of a Grade "E" glass reinforcement saturated with high quality isophthalic polyester resins.
2. The casing should be of uniform and regular thickness and composition, and of a corresponding minimum thickness that is in conformity with the technical requirements of the Saudi/GCC Specifications no. SASO-GSO-2443. The outer surface crust should be rich in resins and hardened with a Grade "C" glass cover.
3. The terminal covers of the tank are manufactured on a mold by a combination of manual application and Grade "E" fiberglass reinforcement spray and high quality isophthalic polyester resins. The minimum thickness and diameter of the tank covers should be in line with the design requirements in force.
4. The tank casing and the terminal covers are joined together using alternating layers of woven and resin impregnated atomized glass mat, hence ensuring a strong weld and cohesion of all the surfaces requiring a strong bond.
5. The width of each segment should be at least 250 mm. The inner lamination should have three layers of a rolled granulated glass mat that is impregnated with the final resin coating.
6. The construction of the tank should include reinforcement flanges to give the tank the sufficient hardness. The horizontal tanks should be provided with supports for loading them. Meanwhile, vertical tanks should lie on a flat base placed on concrete slabs.
7. The tank will have an inlet port (feeding line), surplus drainage outlet (draining line), rinsing and washing drain, air vents for ventilation through glass reinforced plastic (FRP/GRP) pipes (according to the required sizes) with a linking flange that can bear a nominal pressure of PN 16 bar, in addition to an interior linkage flange on the side of the inlet, suitable for fitting the safety valves and a floater to control the water level inside the tank.
8. The tank will be provided with a ladder made of glass reinforced plastic (FRP/GRP) when needed. The tanks will be provided with one inlet port with an internal diameter of at least 600 mm and the inlet port should be provided with a cover having hinges and can be closed or it can be fixed with threaded screws to prevent the entry of rainwater and dust that collect at the inlet port.
9. The tank should be provided with a mechanical floater, an indicator to show the water level inside the tank, of the tape type with a local reading at the bottom of the tank, or an electronic water level indicator with a device for controlling the water level.

10. The tank should be fixed with at least four clamps so that it does not rise when water leaks into its surroundings.

11. All the materials used in the tanks and the fitting parts and the like, should be non-toxic and suitable for use with potable drinking water. The FRP/GRP tanks, and their fittings and parts used to install them must not cause any taste, odor, or color in the drinking water. They should be in conformity with the Saudi Standards, Metrology and Quality Organization (SASO) or with other recognized standards organizations.

12. The tanks should be suitable for use in climates where the humidity reaches 100%, and temperatures reach 60 degrees Celsius. They should be resistant to corrosion, and Ultraviolet (UV) rays. They ought to be stable, nontoxic, unpolluted, and resistant to the growth of microorganisms including bacteria and algae. They should be suitable for potable drinking water applications and in conformity with the technical standards for Specification no. SASO-GSO-1831 of the Saudi/GCC Standard Specifications or the international standards BS EN 13121 / BS EN 13280, or their equivalent.

Tests for waterproofing/insulation of tanks

To ensure the waterproofing/insulation has been carried out properly, there are some tests to be carried out to verify the success of the waterproofing/insulation works, including:

- The insulation surface is checked with the bare eyes after installation to make sure there are no perforations or gaps, any detected flaw must be mended. The insulated surface must also be checked using the air pressure test to make sure the weld is leakproof.
- In the case of waterproofing/insulating the new tanks, a test is conducted by filling the tank with water and leaving it full for 24 hours, and the surroundings adjacent to the tank's concrete wall is not filled with layers of soil fill, until the test proves successful, and it is confirmed there is no water leakage.
- As to prefab tanks, the waterproofing/insulation tests to make sure the tanks are leakproof should be carried out in line with the manufacturer's directives, or according to the standards of the Saudi Standards, Metrology and Quality Organization (SASO), if available, or in line with the standards of the American Society for Testing and Materials (ASTM) specifications (ASTM D 5199) and (ASTM D 792).
- In the case where a leakage occurs on filling the tank, the leakage points must be pinpointed, and it must be treated by injecting the points with one of the waterproofing materials suitable for potable drinking water. The test must be repeated once more.

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