FOREWORD BY

SECOND MINISTER OF RESOURCE PLANNING AND ENVIRONMENT

Sarawak has achieved tremendous economic growth during the last few decades. This growth has brought about some unavoidable environmental issues such as the generation, treatment and disposal of domestic sewage in our urban centres.

For other areas in Sarawak where there is no centralised sewerage system, package plants are opted for the treatment of domestic sewage. Therefore, there is a need to properly regulate these package plants to ensure their performance and durability.

The Sarawak Sewerage Services Department, in line with the powers and functions conferred upon it under the Sewerage Systems and Services Ordinance, 2005 shall adopt fully the following Technical Specifications published by National Water Services Commission (SPAN) for use in Sarawak:

Sewage Treatment System

Part 1 : Prefabricated Tanks - Package Plants (SPAN TS 1401 : 2010)

Part 2 : Construction and Installation – Package Plants (SPAN TS 1401:2010 (A1 : 2013))

The Ministry of Resource Planning and Environment, Sarawak and the Sarawak Sewerage Services Department would like to thank the Ministry of Energy, Green Technology and Water, Malaysia for allowing us to adopt these Technical Specifications for use in Sarawak.

YB DATUK AMAR HAJI AWANG TENGAH BIN ALI HASSAN
SECOND MINISTER OF RESOURCE PLANNING AND ENVIRONMENT

Date : 18th August 2015

SEWERAGE SYSTEMS AND SERVICES ORDINANCE 2005

These Guidelines are issued under Section 4 and Section 9 of the Sewerage Systems and Services Ordinance, 2005.

Dated this 18th day August 2015.

URBAN SEWERAGE SYSTEMS AUTHORITY

TECHNICAL SPECIFICATION

SPAN TS 1401:2010

SEWAGE TREATMENT SYSTEM

Part 1: Prefabricated Tanks - Packaged Plants



Technical Standards and Compliance Division

Sewerage Regulatory Department

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October 2010

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FOREWORD

National Water Services Commission (SPAN) was established in 2008 to regulate the water services industry in Malaysia. SPAN envisions a sustainable, reliable and affordable water services for all by regulating the water services industry through fair, effective and transparent implementation of the Water Services Act (Act 655). Since inception in 2008, SPAN has been striving to institute improvements in term of standards and performance in the country's water and sewerage services sector.

SPAN aims to enhance efforts towards improving standards, quality and operational efficiency of water and sewerage services industry to ensure sustainability. One of the approaches is to achieve higher standards and quality by developing technical specifications for products and systems used in the industry. Hence Technical Working Groups (TWG) had been formed by Sewerage Regulatory Department to formulate technical and performance specifications for adoption in sewerage industry.

This publication of Technical Specification for Sewage Treatment System, Part 1: Prefabricated Tanks - Packaged Plants is a result of joint effort by members from various relevant stakeholders of the industry. The specification contains key criteria on packaged plants made of prefabricated tanks covering operational requirements, performance criteria, test methods, marking and evaluation of conformity for packaged plants used for the treatment of domestic sewage with population equivalents between 150 and 5000.

The continual development of technical and performance specifications is crucial in moving the industry towards higher standards which will uplift the image of local sewerage industry. With the publication of this Technical Specification, it is hoped that it will contribute towards a better planned and well organized development of new sewerage systems to fulfil whole life infrastructure obligations.

As more than 50% of the systems installed on the ground are packaged plants using prefabricated tanks, hence the best practices, quality and performance measurement standards must be established to ensure its long lasting performance and durability.

Dato' Teo Yen Hua
Chief Executive Officer
National Water Services Commission (SPAN)

ACKNOWLEDGEMENT

Todate SPAN had published 3 volumes of Malaysian Sewerage Industry Guideline which are used extensively nationwide. Meanwhile this publication is the first effort by SPAN to produce technical specification. It would not had been possible without the joint effort of industry stakeholders namely representatives from Association of Environmental Consultants and Contractors of Malaysia (AECCOM), Jabatan Perkhidmatan Pembetungan (JPP), Indah Water Konsortium (IWK) and SIRIM Berhad. TWG reports to the Commission via System, Product, Material and Research & Development Committee to seek endorsement for implrementation of Technical Specification in the industry. The commitment and cooperation showed by the members of TWG must be applauded. We also would like to record our utmost appreciation for stakeholders whom had participated in the publication of the technical specification draft for public comments. We are planning for many more technical specifications publication with such continuous support for industry players.

The System, Product, Material and Research & Development Committee of National Water Services Commission (SPAN) comprises of representatives from:

Department of Standards Malaysia (DSM)
Ministry of Science, Technology and Innovation (MOSTI)
National Water Services Commission (SPAN)
Public Works Department Malaysia (PWD)
Sewerage Services Department (JPP)
Water Supply Department (JBA)

The Technical Working Group for Technical Specification of Sewage Treatment Systems, Part 1: Prefabricated Tanks-Packaged Plants consists of representatives from:

Association of Environmental Consultants and Companies of Malaysia (AECCOM)
Indah Water Konsortium Sdn. Bhd. (IWK)
National Water Services Commission (SPAN)
Sewerage Services Department (JPP)
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1 Scope

This Specification enumerates operational performance requirements, performance criteria, test methods, marking and evaluation of conformity for packaged sewage treatment plants made of prefabricated tanks using Glass Fibre Reinforced Plastics (FRP) and Polyethylene (PE) (hereafter called packaged plants) used for population equivalents between 150 and 5000. Packaged plants according to this Specification are used for treatment of raw sewage generated from domestic activities.

The subjects in Specification deal with features such as functional design, material, construction, installation and testing as means of compliance with overall requirements of the plants. The focus is on prefabricated components and operational systems of the plants comprising piping, aeration, pumping, flow distribution, control and other ancillaries.

This Specification applies to packaged plants where all prefabricated components are off site assembled in the factory by one supplier or manufacturer and tested as a whole for tanks made of FRP and PE.

The test methods specified establish the performance of packaged plants at the condition of which plants are normally installed for use whereby it is buried in the ground with no vehicles loads are applied to the product. The testing is also to ascertain if the prefabricated tanks achieve the effective operational performance, reliability and durability under normal operating conditions along its serviceable life span.

This Specification does not consider the design of treatment process, mechanical and electrical components and control and instrumentation needs. All these components shall be designed to the best engineering practice in compliance with the Guidelines and Standards recognised by the Commission, by-laws, regulations and other regulatory agencies' requirements relevant to the aspects.

2 Normative references

The documents and publications that are requisite for the application of this Specification are listed in Annex A. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

3 Terms and definitions

For the purposes of this Specification, the terms and definitions given in MS 1228, EN 1085:2007 and the following apply:

3.1 anchorage

device or technique for holding the tank in the ground against hydrostatic uplift pressure

3.2 assembly

component or equipment that can be removed and replaced as a whole

Note Example of an assembly is a pump, an air blower, a diffuser etc

3.3 desludging

removal of accumulated sludge from sludge holding tank

3.4 extension shaft

component(s) or structure used to bring the inspection opening and cover to finished ground level or slightly above the ground surface

Note Extension shaft permits maintenance work and observation

3.5 equipment

any component which is installed in, mounted on, attached to, or operated on structures in the performance of their intended function

3.6 factor *α*

Ratio of the initial deformation of material under load and the deformation under the same constant load, extrapolated to a given period

3.7 factor *β*

Ratio between the beam stiffness after storage in water of 50°C for 1000 hours and the initial beam stiffness determined in dry condition at 23 °C after post-curing of the sample

3.8 inspection opening

opening in top surface of prefabricated tank fitted with a cover to allow access for visual inspection of interior and contents of the tank, maintenance work, but not intended for man entry

3.9 initial type test

an examination which confirms the required technical utility properties and usability, performed before launching the product on the market and for usage

3.10 laboratory

body capable of testing a domestic sewage treatment plants under controlled conditions

3.11 laminate

for glass fibre manufacturing, the layer or layers of reinforcement impregnated with polyester or other resin forming a thick structural membrane, excluding the gel-coat

3.12 lateral load

load applied sideways onto a buried tank due to the combined effects of soil, water and traffic

3.13 operational performance

functions that a system has to perform in order to operate as defined

3.14 packaged plant

prefabricated factory-built tanks and components of sewage treatment installation assembled off site by one supplier or manufacturer, which accepts domestic sewage and treats it to a declared quality

3.15 partition wall

internal wall within a prefabricated tank

3.16 performance criteria

qualitative or quantitative description of the operational performance

3.17 production batch

clearly identifiable collection of units, manufactured consecutively or continuously under the same conditions, using material to the same specification

3.18 range

group of products in which, for the purpose of evaluation, the selected property(s) is/are similar for all products within the group

Note The definition of range takes into account at least similar shape, equipment, materials and conditions of use and ensures the minimum level of performance (hydraulic efficiency and structural behaviour) for all the products in the range

3.19 sample

one or more units of product drawn from a batch, selected at random without regard to quality, the number of units of product in the sample being the sample size

3.20 serviceable life span

period of time in which under normal conditions and with routine maintenance, the packaged plants and associated fittings and equipment perform satisfactorily without failure

Note Serviceable life span is different from both the warranty time and average service life of use, as used for cost efficiency calculations

3.21 structure

any construction and its components built for the accommodation of equipment

3.22 unit process

any structure including any related equipment which is used as a process stage and which can be isolated from other parallel, upstream or downstream structures

Note Examples for a unit are a screen chamber, an aeration tank, a clarifier, a sludge holding tank.

4 Declaration of information

4.1 Nominal designation

The nominal influent parameters expressed in milligram per litre (mg/l) and the nominal hydraulic daily flow for both average and peak values expressed in cubic metres per day (m^3/day) shall be declared for each model of packaged plants.

4.2 Operation and maintenance instruction

The supplier shall provide, with each installation of packaged plants, clear and comprehensive operation and maintenance instructions including declaration for desludging frequency.

5 Requirements

5.1 General

The requirements in this Specification shall be in addition to those specified in Malaysian Sewerage Industry Guidelines (MSIG).

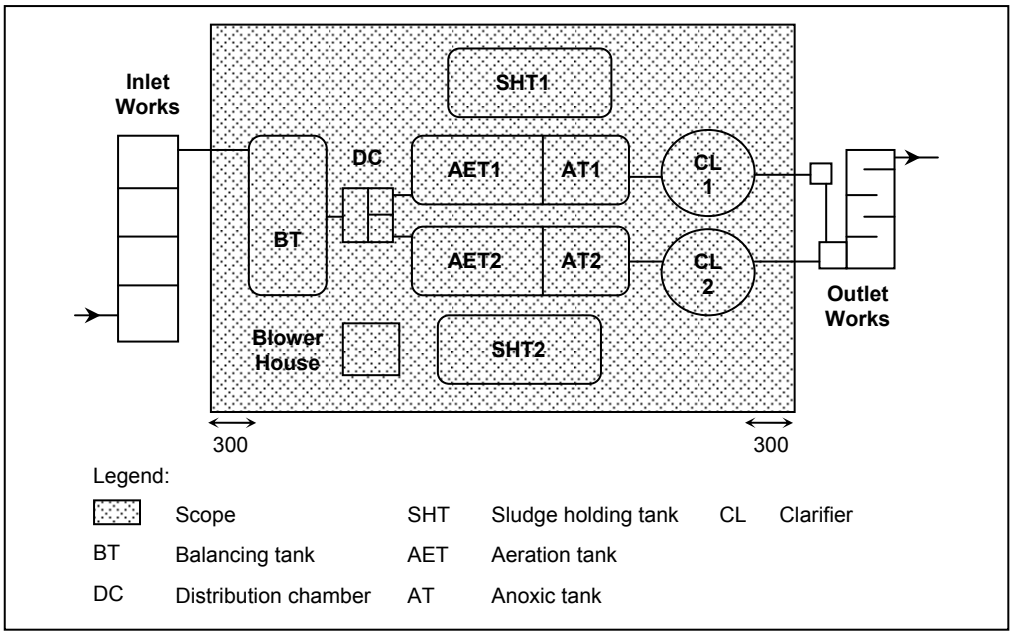
5.2 Endorsement

Calculations, engineering design and drawings for prefabricated tanks and components of the packaged plants shall be duly endorsed by qualified person appointed by the supplier or manufacturer covering process, structural and operational behaviour of the components.

The entire packaged plant inclusive of inlet works, outlet works, treatment system, process and structural components as well as ensuring installation and construction at site conformance to the design intent and any rules prescribed must be validated and endorsed by the Professional Engineers.

5.3 Packaged and site assembled components of packaged plants

Biological treatment system in which the scope extends 300 mm from inlet pipe of first prefabricated tank or chamber to 300 mm from outlet pipe of final prefabricated tank or chamber as shown in Figure 5.1 shall be packaged in terms of treatment process with the dimensions of each prefabricated tank fixed.



Note: This layout is an indicative view of a typical packaged plant arrangement for reference

Figure 5.1 Scope of biological treatment system for packaged plants

Site conditions for the installation must be taken into consideration for the layout and arrangement of site assembled components of packaged plants, comprising tanks and systems of piping, pumping, aeration and air lift together with the size, type and number of mechanical equipment, electrical, control and instrumentation equipped in the treatment system.

5.4 Serviceable life span

The minimum serviceable life span against defects, deterioration and total failure of the components for packaged plants shall be as Table 5.1 below.

Table 5.1 Minimum serviceable life span for packaged plant components

Component	Standards	Serviceable life span
Prefabricated FRP tank	EN 12566-3, EN 976-1, EN 978	> 50 years
Prefabricated PE tank	EN 12566-3, EN ISO 9967	
Other structures	BS 8110-1	> 50 years
Mechanical and electrical	BS EN 12255-1	10 years
Control and instrumentation	BS EN 12255-12	10 years
Corrosion resistance coating	BS EN ISO 12944-1 to 8	10 years

5.5 Design

5.5.1 Arrangement of tank

Provided that it is proven in both process and hydraulic design, the prefabricated tanks arranged in series to meet the loading requirements of one unit process tank can be considered as one tank.

5.5.2 Flow splitting and distribution

When the process line in packaged plants involve splitting the flow to multiple lines or parallel units, the incoming flow shall be distributed by an adjustable distribution

device (e.g. valve, gate, stop-log) that can also be used to isolate each treatment unit. This device shall provide the required flow distribution over the range of flow rates considered. The concept is as typically shown in Figure 5.2.

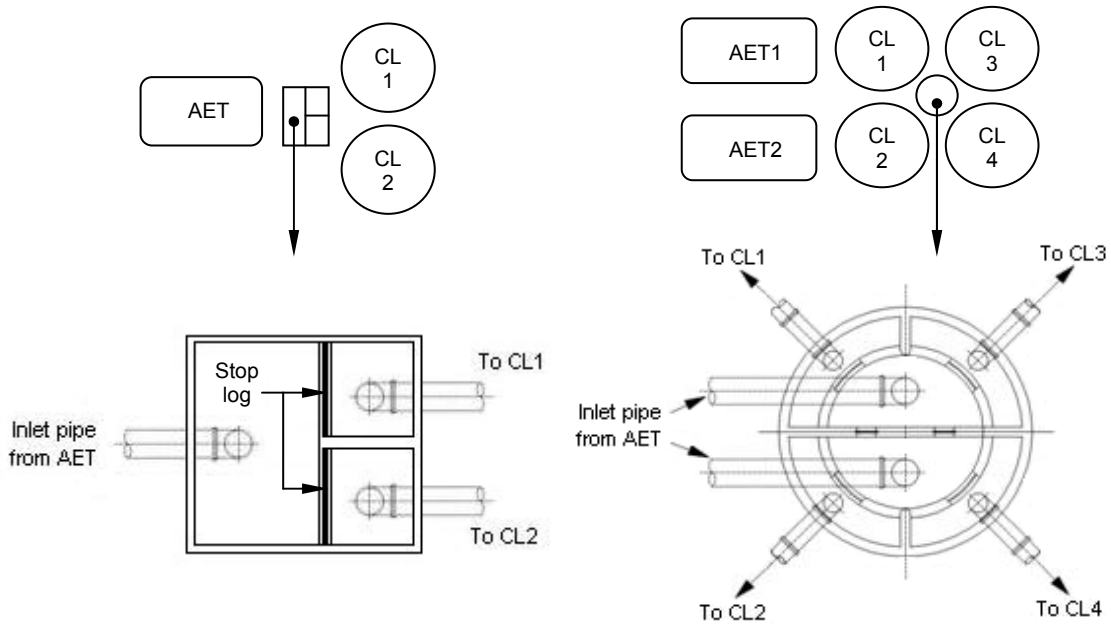


Figure 5.2 Typical concepts of flow splitting and distribution

5.6 Operational performance

5.6.1 Process

The packaged plants shall demonstrate compliance with sewage treatment efficiency performances in accordance with Malaysian Sewerage Industry Guideline (MSIG) and Environmental Quality (Sewage) Regulations 2009, Environmental Quality Act, 1974. It shall also be capable:

a. to encourage and provide sufficient amount of mixed liquor suspended growth (MLSS) in the treatment system;
b. to provide minimum dissolved oxygen concentration of 2 mg/l to prevent oxygen diffusion limitation from hindering substrate removal by the microorganism;
c. to provide sufficient mixing to keep the sludge in suspension without causing any settlement of sludge in any part of the unit process tanks which require mixing;

d. to provide good quality of sludge with normal settling characteristics indicated by sludge volume index (SVI_{30}) and sludge settled volume (SSV_{30}) of the respective treatment system adopted;
e. to avoid likelihood of blockage in sewage and sludge transfer system within the boundary of packaged plants during its serviceable life span.

5.6.2 Hydraulic

The hydraulics of equipment, internal pipe work and connections shall ensure no back-flow, blockage or surcharging occur during normal operation. The hydraulic design of packaged plants shall allow entry of sewage with minimum of disturbance to surface layers by maintaining consistent hydraulic flow and pattern throughout the treatment system without causing any increment in surface loading and velocity.

5.6.3 Civil and structure

5.6.3.1 General

Civil and structural components of the packaged plants shall be designed by a Qualified Professional Engineer. The design shall be based on appropriate calculations, design methodologies and relevant standards to best engineering practice. The structures and construction of packaged plants shall be:

a. stable, able to bear and resist all loads and stresses resulting from handling, installation, construction and use, including operation and maintenance throughout their serviceable life span. These shall take into account of water pressures, static and dynamic forces being induced by equipment and desludging,
b. able to prevent likelihood of damage from superimposed loads or normal ground movement;
c. resistant against corrosion, chemical and biological attack from wastewater, sludge, air and gas components and against temperature changes as appropriate;

d. durable, watertight and able to retain structural integrity including alignment, orientation, levelling and function properly with normal maintenance over their serviceable life span.

5.6.3.2 Design basis

Packaged plants and their foundation shall be designed to achieve the required serviceable life span and long term structural integrity and shall meet the worst-case conditions not limiting to:

a. when the prefabricated tanks are fully emptied; and
b. during high groundwater conditions.

The structural design of packaged plants shall consider all factors that can affect particularly the strength and integrity of prefabricated tanks such as soil conditions and area of installation to ensure the entire structure of tanks and its associated components are integrally sound.

5.6.3.3 Foundation work

Foundation works for the installation of major and auxiliary components for packaged plants shall be designed and constructed so that components such as inspection chambers shall be secured to avoid disruption to the operation and maintenance works and process of the system. The foundation shall be able to prevent the possibility of sludge settlement, differential settlement between structures on top of between structures and equipment such as pipeline.

5.6.3.4 Backfill material

The backfill material for packaged plants shall be of particle size and grading that allows the specified relative compaction to be achieved with the intended compaction methods. The material shall not contain organic material which will affect backfill material performance and free of materials that are physically and chemically harmful to prefabricated tanks. The support and overlay material shall be placed in

layers of appropriate thickness for the method of compaction used to achieve the relative compaction or soil modulus.

5.6.3.5 Anchorage

The anchor system consisting of straps, cables, turnbuckles and anchor hooks shall have strength of at least 1.5 times of maximum uplift force of an empty tank without backfill in place. All the anchor system components shall be made of Grade 304 stainless steel complying with ASTM A240/ A240M. The anchorage design shall comply with BS 7777.

Details shall be provided by prefabricated tanks manufacturer with the installation instructions, which shall show the recommended relationship between levels in the tank, groundwater levels surrounding the tank, and anchorage requirements.

5.6.3.6 Retaining wall

The retaining wall shall be designed and checked by taking into account all possible factors involved contributing to the lateral earth pressure. The wall components shall also be capable of meeting serviceability requirements at site condition.

5.6.3.7 Load bearing capacity

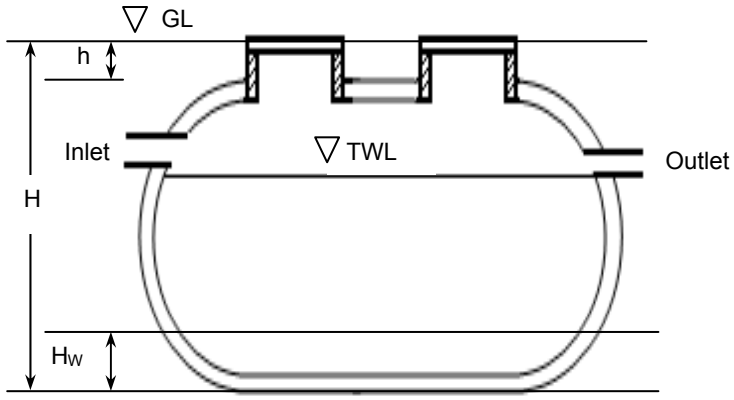
The load bearing capacity for fully equipped packaged plants shall be determined through both appropriate tests and calculations made to prove the structural adequacy. For calculations, loads at the maximum installed depth shall be taken into account including consideration of the following loads:

a. Backfill load – the load that shall take into account effect of ground conditions, backfill materials and tank shape factor.
b. Hydrostatic loads – where the highest level of groundwater table is above bottom of the tank, stability conditions of the plants in relation to water pressure shall be taken into account.
c. Pedestrian loads – when the depth of cover is more than 1000 mm, pedestrian loading is assumed to be negligible against other action.

5.7 Prefabricated tank

5.7.1 Design basis

All prefabricated tanks shall be structurally designed to withstand the maximum earth load equivalent to an overburden depth of 1000 mm at maximum depth of cover of 1000 mm. Figure 5.3 illustrated definition of parameters that shall be considered to determine the structural strength of the tanks.



H total depth of the plants

H_W height of exterior water level (groundwater)

K coefficient of horizontal soil pressure

h depth of cover from the top of the tank to ground level

Figure 5.3 Definition for parameters of loads

The prefabricated tanks shall be capable of withstanding loads imposed on its roof and walls i.e. top and lateral loads during and after installation. Account shall be taken of any load imposed on tank structure as a result of the technique used to anchor the tanks in the ground. The resistance to transport and installation loads shall also be considered in the structural design of the tanks.

The construction and installation of prefabricated tanks shall resist hydrostatic uplift pressures i.e. uplift loads from groundwater and be protected against floatation in areas of high water table level or when the tank is emptied. The bottom of an excavation for prefabricated tanks shall provide a uniform base to support the tanks in a level position.

5.7.2 Integrity

The integrity of prefabricated tanks shall be such that no full penetration crack of a width greater than 0.1 mm shall be developed during any stage of production.

Further widening or lengthening of any crack shall not occur during subsequent handling, installation or use.

5.7.3 Hydrostatic uplift

An installed prefabricated tanks shall not move when subjected to uplift forces generated by surrounding groundwater or be stressed to such an extent that cracks in excess of those permitted in section 5.7.2 is developed.

5.7.4 Lifting system loading

The lifting system of prefabricated tanks shall comply with at least one of the following requirements:

a. When submitted for 6 minutes to a vertical force equal to five (5) times the weight of the tank, breaking shall not occur.
b. When lifted using the manufacturer's nominated lifting method, there shall be no structural failure or visible cracking after being lifted and remained in lifted position for one hour.

5.7.5 Integrity during handling or installation

There shall be no structural failure when the tank is lifted, or is moved during installation. Any cracking shall be limited to that permitted by 5.7.2.

5.7.6 Structural strength

5.7.6.1 General

The structural strength of prefabricated tanks shall be determined by crushing resistance or maximum load deformation by at least one of test methods specified herein.

5.7.6.2 External hydrostatic pressure test

With the structural design as specified in 5.7.1, there shall be no damage, structural failure, undue distortion, leakage or in surface cracking in excess of that permitted by 5.7.2 due to external hydrostatic groundwater and soil loading of 18 kPa/m depth acting on an empty tank.

Prefabricated tanks shall comply with at least one of the following requirements when tested according to the methods described in Annex B.

a. Hydraulic test
   When tested according to B3.1 in Annex B, there shall be no leaks affecting integrity of the tank and there shall be no deflection in the tank exceeding reference value in the test.

b. Pit test
   When tested according to B3.2 in Annex B, the tank shall not leak, fail or has permanent damage of other means after holding superimposed hydrostatic pressure during the testing duration.

5.7.6.3 Vacuum test

As an alternative for FRP prefabricated tanks, vacuum test can be carried out to test external earth and hydrostatic pressure for the purpose of monitoring in the plants quality control. For vacuum test defined in Annex C, there shall be no damaged and no visual deterioration internally or externally following the test. Tank shall also withstand the vacuum pressure selected without rupture.

5.7.6.4 Top loading test

As an alternative test for PE prefabricated tanks, when tested according to Annex D, the tank shall not deform wider than specified in the method. The tank, lid, and access opening cover shall be free of fractures and cracks wider than specified in

5.7.2 and from other defects arising from faulty materials or faulty methods of manufacture.

5.7.7 Water tightness

Prefabricated tanks when assembled and ready for use, shall be watertight up to the height declared by the manufacturer together with the fittings and covers. The height of tank is equivalent to the minimum declared height that shall be top of the tank as shown in Figure E.1. Prefabricated tanks shall comply with at least one of the following requirements when tested according to methods described in Annex E.

a. Hydrostatic pressure test
   When tested according to E3.1 in Annex E, no leakage and no damp patches shall occur for the prefabricated tanks complete with the attachments.

b. Pneumatic pressure test
   When tested according to E3.2 in Annex E, the prefabricated tanks complete with the attachments shall be deemed watertight when the pneumatic pressure selected (equal to effective internal pressure) that shall not be less than 20 kPa does not deviate by more than 10% during 30 seconds testing duration.

5.7.8 Compartmentalization

When a single prefabricated tank is divided into different compartments by partition walls, assumptions regarding the arrangement of liquid loading shall cause critical effects. Hence the following concerns must be addressed:

a. Particular attention shall be paid to possible sliding and overturning of the partition walls due to differential in moment.
b. The partitions shall be structurally sound and fixed without diminishing the integrity of tank.
c. The content of tank shall be able to be pumped-out without the partition wall collapsing, permanently deforming or leaking according to a verification test describe in Annex F.

The partition walls shall be permanently fastened in place or form an integral part of the prefabricated tanks structure.

5.7.9 Joints

The joints between fittings and the wall of prefabricated tanks as well as between tank components such as the wall and lid, shall have a durable watertight seal, and have sufficient integral strength and flexibility to maintain a sound structure. The prefabricated tanks shall comply with at least one of the following requirements when tested according to the methods described in Annex G.

a. Low hydrostatic pressure test
   When tested according to G3.1 in Annex G, the tank shall have no leakage, and no damp patches. It is assumed the fitting installation is watertight in this test for both water ingress and egress.

b. Bending and torsion moments on fittings test
   When tested according to G3.2 in Annex G, the tank shall show no visual deterioration and shall not leak when submitted to leakage tests according to Annex E.

5.7.10 Impact resistance

The following impact resistance tests shall be conducted for tanks made of FRP:

a. Internal impact resistance test
   When tested in accordance with H3.1 of Annex H, no cracking of the internal surface or a surface change visible with the unaided eye shall occur.

b. External impact resistance
   When tested in accordance with H3.2 of Annex H, the tank shall show no visual deterioration.

5.7.11 Mechanical characteristics

The mechanical characteristics of prefabricated tanks shall be determined to estimate serviceable design life span of the tanks as specified in 5.4.

a. For FRP prefabricated tank, *α* factor and *β* factor for the material as defined in 3.6 and 3.7 respectively, shall be determined in accordance with EN 978. When tested, the *α* factor shall be ≥ 0.5 and the *β* factor shall be ≥ 0.6.
b. For PE prefabricated tank, mechanical characteristics of the material shall be determined in accordance with method specified in BS EN 12556-3.

5.8 Construction and physical properties

5.8.1 Glass Fibre Reinforced Plastic (FRP)

5.8.1.1 Materials

The material of FRP tank shall be constructed using resins, reinforcement materials, processing agents and other materials in accordance with EN 976-1, Clause 3.

5.8.1.2 Composition

The laminate shall contain not less than 30% w/w of glass fibre content. No fillers or pigments shall be included in the laminate. Any parts or surfaces that are exposed to the sun shall be constructed with ultraviolet-light inhibitors added to the laminate.

5.8.1.3 Dimensions

Internal diameter of the tank shall be within the tolerances of at most ± 1 %.

The minimum cylindrical wall and end panel thickness for cylindrical tanks shall be 8.0 ± 0.5 mm. For differentially shaped tank, the minimum thickness of the structural tank wall shall be 8.0 ± 0.5 mm. The thickness of partition wall and all other internal components shall be at least 5.0 ± 0.5 mm.

A verification test shall be in accordance with Annex J.

5.8.1.4 Surface finish and appearance

The internal surface and all mating surfaces of joints shall be smooth. Both internal and external surfaces shall be free from irregularities which would impair the ability of the tank or joint. The surface shall not be tacky.

The exterior surface shall be relatively smooth with no sharp projections and be free of blisters larger than 15 mm in diameter, delaminating, and fibre show.

The interior surface shall be resin rich with no exposed fibres. The surface shall be free of crazing, delamination, blisters and wrinkles of 3.5 mm or greater in depth.

5.8.1.5 Durability

In addition to the tests specified in 5.7, the criteria as specified in Table 5.2 shall be tested to verify durability of the tanks at 27ºC ± 5ºC using test specimens prepared in accordance with ISO 1268-4.

Table 5.2 Durability criteria of FRP tank at 27ºC ± 5ºC

Criteria	Properties	Testing standards
Flexural strength	≥ 110 MPa	ISO 14125
Modulus of elasticity	≥ 4830 MPa	ISO 14125
Barcol hardness	≥ 35	BS EN 13923
Water absorption	≤ 0.75%	ISO 62
Glass fibre content	≥ 30% w/w	ISO 1172
Tensile strength	≥ 65 MPa	ISO 527-4
Tensile elongation	≥ 1.5%.	ISO 527-4
Tensile modulus	≥ 7000 MPa	ISO 527-4
Specific gravity	≥ 1.5	ISO 62
Fire rating	< 25s, Class 1	ASTM E84, BS 476

5.8.2 Polyethylene (PE)

5.8.2.1 Materials

Polymer resin used shall be suitable in the form of powders, granules or pellets with no more than 10% of recycled materials so that the finished product meets the performance requirements as set out in this technical specification. The materials shall be as uniform in composition and size and as free of contamination.

5.8.2.2 Composition

PE tanks shall be constructed with ultraviolet light inhibitors added to the material. Polyethylene material shall comply with ASTM D1238, Class B that requires an ultraviolet stabiliser or Class C that requires a minimum 1% carbon black.

5.8.2.3 Thickness

Internal diameter of tank shall be within the tolerances declared by the manufacturer, which shall be at most ± 1 %.

Minimum thickness of tank walls, partition wall, other internal components, base and access opening covers shall be 6.0 ± 0.5 mm.

A verification test shall be in accordance with Annex J.

5.8.2.4 Surface finish and appearance

Exterior surface shall be ribbed, relatively smooth and impervious to liquid.

Interior surface shall be smooth and of even texture. The surface shall be free from surface imperfections, which detract from the performance of the tank in use.

5.8.2.5 Durability

In addition to tests specified in 5.7, the criteria as specified in Table 5.3 shall be tested to verify durability of the tanks at 27ºC ± 5ºC. The test specimens prepared shall reflect manufacturing process and typical cross section of the tank, which shall be manufactured at the same time as the tanks produced for installation.

Table 5.3 Durability criteria of PE tank at 27ºC ± 5ºC

Criteria	Properties	Testing Standards
Flexural modulus	640 MPa to 1200 MPa	ISO 178
Charpy impact	45 KI	ISO 179
Shore hardness	≥ 62	ISO 868
Tensile strength	17 to 28 MPa	ISO 527-4
Tensile elongation	≥ 200%	ISO 527-4
Tensile stress at yield	≥ 23 MPa	ISO 527-4
Tensile modulus	22 MPa	ISO 527-4
Vicat softening temperature	80 °C	ISO 306
Melt index	0.58	ISO 306
Thermal conductivity	0.4 W/m°C	ASTM E1225

6 Marking and labelling

6.1 Permanence and visibility

All marking and labelling shall be permanent, legible and clearly visible at time of installation. The marking and labelling shall be stencilled, laminated or embossed to the products. Manufacturer is responsible for affixing of the marking and labelling.

6.2 Prefabricated tank

Each prefabricated tank shall be marked at least with the following information.

a. Manufacture's name or trademark.
b. Manufacturing serial number.
c. Manufacturing date (MM/YY).
d. Diameter and capacity.
e. Standards number.
f. Certification number.

6.3 Inspection cover

Each inspection cover shall be properly marked and labelled as typically shown in Figure 6.1 with the following information to ease identification of the unit process for treatment system.

a. Model of the packaged plant.
b. Unit process for the tank.
c. Dimension of the tank (Length x Width x Diameter/ Height).
d. Standards number.
e. Certification number.

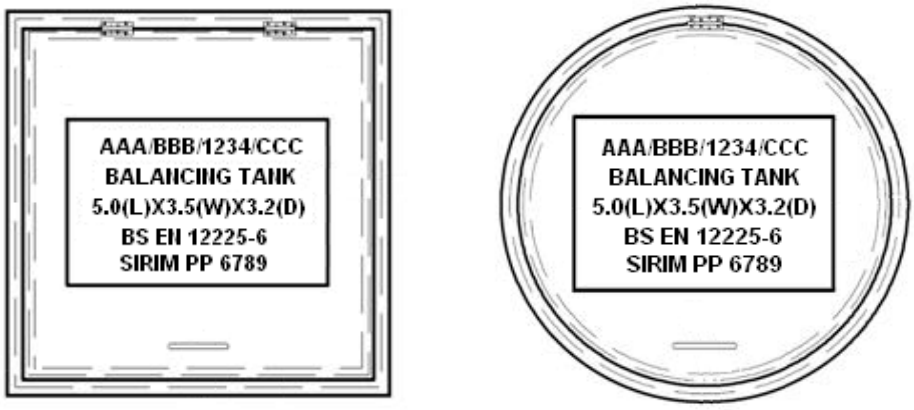


Figure 6.1 Typical marking and labelling for inspection covers

7 Code and model

Coding requirements to name the model of packaged plant as a product shall follow the sequence code of identification with maximum characters as shown below.

AAA/BBB/1234/CCC Example: XXS/HKA/3000/CAS

whereby; AAA - Name of company
BBB - Brand / Model
1234 - Actual population equivalent of package plants
CCC - Type of treatment process

The model shall be limited to the range of population equivalents with minimum intervals as Table 7.1.

Table 7.1 Range of model for packaged plants

Model Range	Interval
150 P.E ~ 1000 P.E	50
1001 P.E ~ 5000 P.E	100

8 Performance criteria

8.1 Unit process

8.1.1 Effluent weir

The weir in sedimentation tank shall be accessible without causing obstruction and not posing any health and safety issues. The weirs shall always be levelled for even distribution of flow. Slots in the weir shall be provided to allow for level adjustment during the installation stage. Flow through over the weir shall be calculated based on the actual type of weir used.

8.1.2 Sludge treatment

The amount of wasted sludge, Q_{waste} shall be used to size the sludge holding tank. The amount of wasted sludge in mass shall be balanced with sludge accumulation rate in reference to computed sludge age.

An adequate air mixing mechanism and air supply shall be provided in the sludge holding tank to ensure sewage content is sufficiently mixed to keep it in suspension, without causing any hardened sludge settled at the bottom of the tank during desludging periods of 30 days.

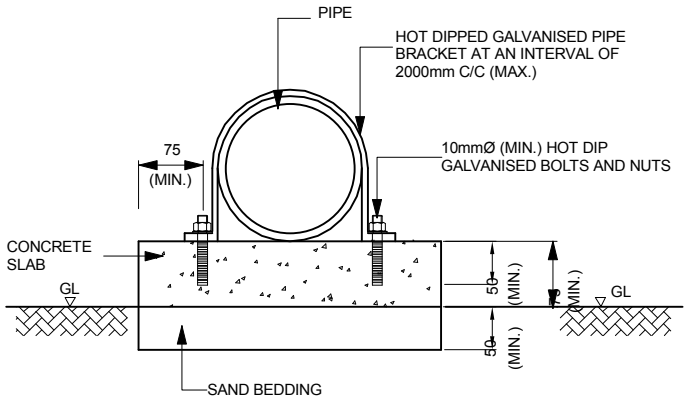
The sludge treatment by anaerobic digester shall not be allowed as it require intensive health and safety requirements and control system, which is not suitable for operation and maintenance of plants within the serving population equivalent.

8.2 Piping system

8.2.1 General

The piping system for packaged plants shall comply with following criteria:

a. The arrangement of piping system and interconnection pipes in prefabricated tanks shall not obstruct maintenance work of the equipment in the tanks;
b. All the buried piping shall be properly bedded and supported with the selected compacted fill material;
c. All the above ground piping shall have a minimum distance of 75 mm from the ground level. It shall be provided with a proper pipe support and bracket. The bracket shall be made steel coated with hot dipped galvanised in compliance with BS EN ISO 12944. The typical pipe support and bracket is shown in Figure 8.1;



NOTES :-

1. ALL DIMENSIONS ARE IN MILIMETERS UNLESS OTHERWISE STATED.

Figure 8.1 Typical pipe support and bracket

d. The arrangement of the above ground piping shall minimise obstruction and manoeuvrability;
e. Any on-site installation or assemblies of pipe support that is attached to the prefabricated tank shall not be allowed;
f. No bending shall be allowed at any sewage distribution pipe excluding the force main piping. Instead, a chamber shall be provided to cater for any change of direction in sewage flow.

8.2.2 Inlet and outlet pipe

All openings for pipes connection of the prefabricated tanks shall be pre-fitted at the factory with a socket, a spigot, a flange or a 300 mm length short piece of pipe. On-site drilling of openings for pipe connection is prohibited.

8.2.3 Air pipe

Air pipes consisting of air distribution pipes from blower, header pipes, drop leg/down pipes and other pipes to convey air for aeration, mixing or air lift purposes shall be:

a. able to withstand maximum air temperatures generated by the blower and pressures of 25% more than the design pressure of the blower;
b. painted in green with the air flow direction is painted in white at maximum interval of 3 m;
c. above ground for the air distribution pipes from the blower to the unit processes;
d. properly bracketed with Grade 304 stainless steel U-bolt in compliance with BS EN 10088-1:2005 for the down pipes to limit the movement of diffusers;
e. designed to provide even and adequate air distribution to all relevant unit processes;
f. provided with instruments such as air gauge or pressure gauge for the pipes conveying air for mixing and air lift purposes. The points to allow calibration shall be provided for the fixed instrument, while points to allow measurement shall be provided for the portable instrument.

8.2.4 Sludge transfer pipe

All jointing to connect the sludge transfer pipes shall be double flange with Grade 304 stainless steel bolts and nuts in compliance with ISO 3506-1 to ISO 3506-3. No thread union or coupling shall be allowed in any jointing part of the pipes.

8.2.5 Effluent pipe

The effluent discharge piping system that passes through or by-passes the disinfection treatment facility shall be designed so as not to cause any nuisance.

The invert level of effluent pipe shall be at a minimum of 300 mm from the top water level of receiving watercourse.

8.3 Pumping system

8.3.1 Pump

Minimum control mechanism for the pumps installed within packaged plants shall be:

a. automatic by float switch for sewage transfer pump;
b. automatic by timer and interlock with solenoid valve for return and waste sludge pump in sedimentation tank;
c. manual by push button for sludge transfer pump to remove sludge from sludge holding tank.

In event non-submersible pumps are used, sufficient cover for weather protection shall be provided.

8.3.2 Duck foot, transfer pipe and guide rail

All pumps shall be completely installed with duck foot, guide rail and lifting chain complying with the following requirements:

a. Duck foot shall be installed and assembled in the factory. No installation or assemblies at site shall be allowed except for the connection of transfer pipe and guide rail.
b. The guide rail shall be properly bracketed with U-bolt to secure the movement of the pump.
c. All fasteners of the duck foot shall be watertight.
d. Guide rail, lifting chain and U-bolt bracket shall be made of Grade 304 stainless steel in compliance with BS EN 10088-1.

8.4 Air lift system

The solenoid valves shall be provided for intermittent air lift system for both return and waste sludge and scum skimmer.

8.5 Diffuser

All diffusers shall be supported from the tank base and shall not be bolted to the bottom of the tank. The diffusers shall be removable and easy to re-install onto the diffuser support.

The support for diffusers shall be made of non-corrosive material and shall be designed to suit the application. The support shall be capable to prevent buoyancy of the diffuser.

8.6 Valve

All valves shall be accessible and not obstructed for maintenance work. The valves of 100 mm diameter and above shall be installed in the inspection chamber.

Selection of materials to be used in the construction of body and seal of the valves shall be in accordance with the application in order to optimize functional reliability, fluid compatibility, serviceable life and cost.

8.7 Inspection opening and cover

The design and arrangement of inspection cover in reference to the inspection openings shall be consistent with operational requirements of packaged plants. The inspection cover shall be installed at any location on top of the tank except at assembly joints, rib or reinforced ring location.

The inspection cover shall have a size of 600 mm x 600 mm or 600 mm diameter and shall be equipped with a frame support together with hinge and handle made of Grade 304 stainless steel. For inspection opening bigger than size of inspection cover, bracing to support the cover made of Grade 304 stainless steel shall be provided. All stainless steel Grade 304 shall comply with BS EN 10088-1.

The inspection covers shall be securely fitted and attached to the opening and shall have the mechanism preventing it from being accidentally shut. The collar of the opening to place the inspection covers shall be raised to a minimum height of 150 mm above ground level. The typical inspection cover is shown in Figure 8.2.

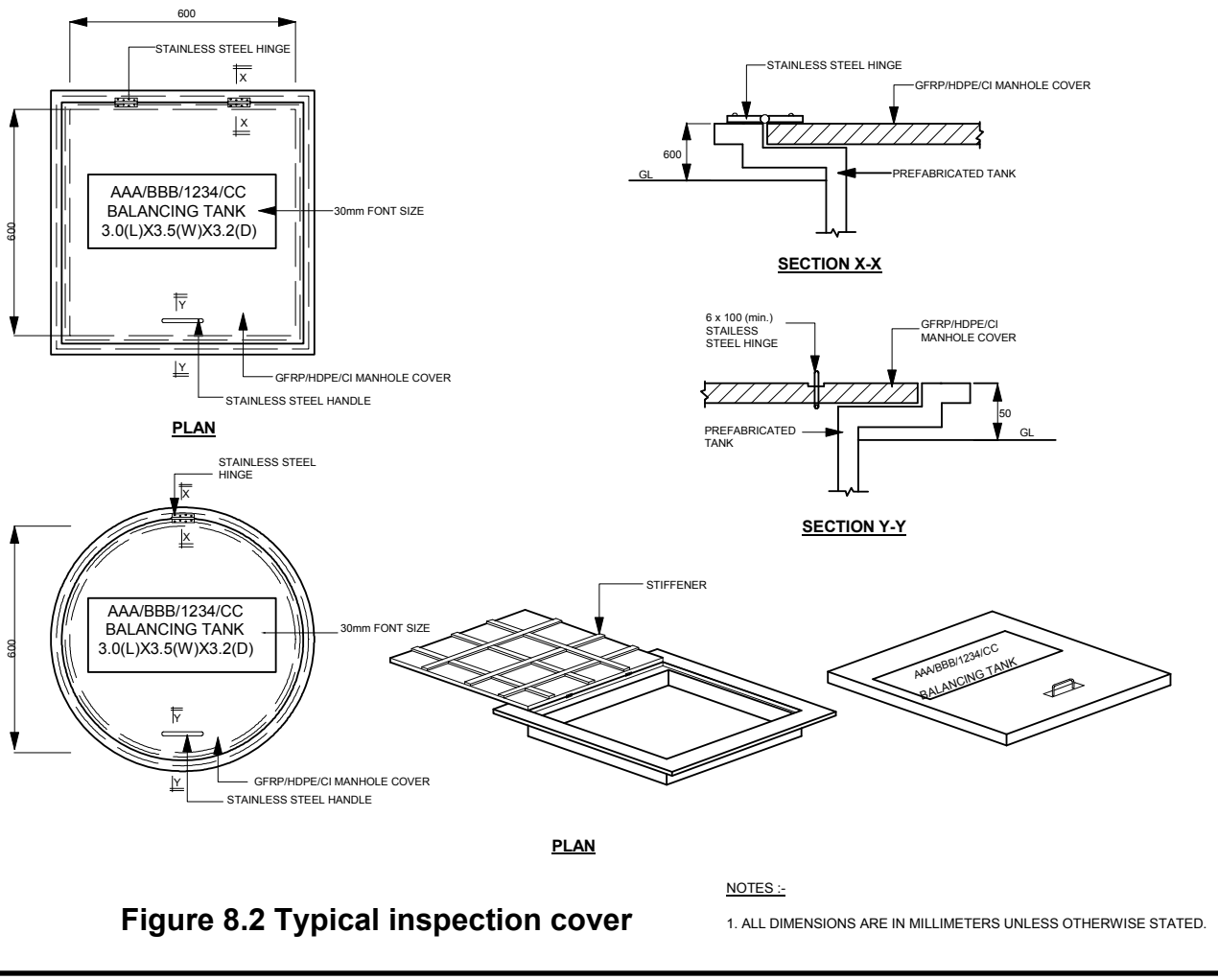


Figure 8.2 Typical inspection cover

The inspection cover shall provide an effective, durable and watertight seal and be able to withstand superimposed loads at operating temperature of 27°C to 35°C with incorporation of thermal expansion and contraction complying with the requirements as shown in Table 8.1 below.

The inspection cover shall be sufficiently protected during its serviceable life, which similar to the prefabricated tanks against degradation due to exposure to UV light and corrosion due to exposure to corrosive sewage environment.

Table 8.1 Performance criteria for inspection cover

Parameter	Standards	Performance criteria
Load bearing capacity	BS EN 12255-1	$\geq$ 3.5 kN/m^2
Maximum deflection limit	BS EN 12255-1	10 mm or the span divided by 200, whichever is smaller
Design safety factor	ANSI/ASCE 7-98	4:1 for allowable stresses shall be met for all load combinations

8.8 Flow distribution chamber

Design and construction of flow distribution chamber shall prevent any sedimentation. The adjustable features shall be provided within flow distribution chamber and shall be constructed using one of the following material:

a. Reinforced concrete with a minimum of Grade C30 in compliance with BS 8007;
b. FRP with minimum thickness of 5.0 $\pm$ 0.5 mm in compliance with BS EN 4994, BS EN 13923 or ASTM D4097;
c. Steel plate coated with hot dipped galvanised of 140 μm or high build tar epoxy coating of 200 μm minimum dry film thickness. The steel plate and coating shall comply with the requirements in EN 10163-2 and BS EN ISO 12944-1 to BS EN ISO 12944-8 respectively;
d. Stainless steel of minimum Grade 304 in compliance with BS EN 10088-1;
e. Any other material that is approved by the Commission to be used for this purpose.

8.9 Lifting device

Lifting device shall be installed to avoid direct loading to the structure of prefabricated tanks. Where fixed lifting device is provided, it shall be supported by the spread footing to ensure even distribution of loads exerted by the weight of the devices.

8.10 Control and instrumentation

Necessary measuring and control equipment shall be specified taking into account the installation conditions. This applies to its location within the packaged plants, layout and size of structures in compliance with BS EN 12255-12.

9 Delivery and installation

Manufacturer/supplier shall properly plan delivery route so as not to cause any damage to road facilities and harm to road users.

Packaged plants shall be installed and constructed under the supervision of a Professional Engineer and in accordance to detailed plans approved by the Commission. An inventory list of every item to be installed shall be provided and to be checked against the approved construction drawings. The list shall be endorsed by the Professional Engineer.

No fabrication or moulding of any part of the prefabricated tanks and pipe holes drilling shall be allowed at the site. All jointing and pipe holes connection shall be factory fabricated and moulded.

10 Evaluation of conformity

10.1 General

Conformity of the prefabricated tanks to the requirements in this Specification shall be demonstrated by:

a. Initial type tests;
b. Factory production control, including finished product tests.

The results of every test conducted as specified in the following Sections shall be recorded and available for inspection, and shall be kept for at least 15 years after the date of last production of the prefabricated tanks to which they relate. All test equipment shall be calibrated and verified and the procedure, frequency and criteria of testing shall be documented.

10.2 Initial type tests

Table 10.1 sets out the requirements for initial type tests to confirm that the final properties of the prefabricated tanks conform to the requirements of this Specification. When a new prefabricated tank outside an existing range is developed, the initial type tests shall be carried out for that particular tank.

The initial type tests shall be repeated if a modification is carried out involving any change in design, process or material that is likely to alter the functional properties, performance or requirement of the finished prefabricated tank.

10.3 Factory production control

10.3.1 General

A factory production control system shall be established and documented. The control system shall consist of procedures for the internal control of production to ensure that prefabricated tanks placed on the market conform to this Specification.

10.3.2 Raw materials and components

The specifications of incoming raw materials and components shall be verified.

10.3.3 Production process

The relevant features of packaged plants and production process of prefabricated tanks shall be defined giving the frequency of inspection checks and tests, together

with criteria required for controlling the manufacturing process. The action to be taken when control values or criteria are not met shall be given. All production equipment shall be calibrated and the procedure, frequency and criteria of the production shall be documented.

10.3.4 Finished product testing

Testing plan for finished product of the prefabricated tanks shall include:

a. On-going test
   As sets out in Table 10.2, the tests shall be carried out in accordance with an agreed testing plan, at least once per each batch of tanks production to demonstrate its compliance with this Specification on an on-going basis.

b. Periodic test
   The periodic test comprises tests as set out in initial type tests shall be performed.

10.3.5 Stock control

The stock control of finished prefabricated tanks, together with procedures for dealing with non-conforming tanks, shall be documented.

10.4 Treatment efficiency testing

The treatment efficiency testing shall be mandatory for all packaged plants. At least a minimum of three (3) assessments on different days shall be conducted for packaged plant that had been installed for more than two (2) years. All data and samples collected for this testing shall be verified by operator of the plant. Table 10.3 sets out core parameters that shall be monitored in the plant.

The test reports on treatment efficiency shall be submitted to the Commission on a yearly basis containing at least the information specified below.

a. Information on the conformity of plants tested with the information provided prior to testing.
b. Data obtained during testing with analysis on the efficiency ratios of the loading parameters.
c. Information on all maintenance and repairs carried out during the test period, including details of desludging frequency, quantity and the volume removed.
d. Information on any problems, physical or environmental occurring during the test period. Deviations from the manufacturer's maintenance instructions shall be reported in this section.
e. Information detailing any physical deterioration of the plants that has occurred during the testing.
f. Information concerning deviations from the test procedure.

10.5 Conditions of testing

10.5.1 General

Conditioning of the test specimens is not required unless otherwise specified by the test method. The tests are to be conducted at ambient conditions without any special controls on temperature or relative humidity unless otherwise specified by the test method. All tests and samplings for the testing shall be conducted by a laboratory accredited to ISO/IEC 17025.

10.5.2 Prefabricated tank

In event of a test failure, further test shall be conducted on prefabricated tanks within the production batch. If the first two randomly selected additional tanks meet the requirements, the batch shall be deemed to meet the test requirements. If one of the additional tanks fails, the batch shall be rejected or every tank subjected to the relevant test.

10.5.3 Treatment efficiency

The quantity of packaged plants to be tested shall be calculated based on 5% installed units on all ranges of models. For packaged plants installed with less than 20 units, the performance of minimum three (3) installed units shall be tested.

10.5.4 Test record

For each test specimen, the report shall record, not limiting to the following data:

a. Identification of person and organisation carrying out the test.
b. Identification of the sample tested.
c. Date of test.
d. The test result.
e. Reference to the test method.

Table 10.1 Requirements for initial type test

No.	Requirement	Reference clause	Model to be tested		Test Method
			Each model in a range	Representative model in a range	
1.	Overall dimensions	5.8.1.3, 5.8.2.3	x		Annex J
2.	Inlet and outlet pipe	8.2.2	x		Design review
3.	Inspection opening and cover	8.7	x		Design review
4.	Hydrostatic uplift	5.7.3	x		Design review
5.	Lifting system loading	5.7.4	x		5.7.4
6.	Integrity during handling and installation	5.7.5	x		Design review
7.	Structural strength	5.7.6		x_a	Annex B to Annex D
8.	Water tightness	5.7.7	x		Annex E
9.	Compartmentalisation	5.7.8	x		Annex F
10.	Joints	5.7.9	x		Annex G
11.	Impact resistance	5.7.10	x		Annex H
12.	Mechanical characteristics	5.7.11		x_a	Design review
13.	Marking and labelling	6	x		Design review
14.	Material	5.8.1.1, 5.7.2.1	x_b		Design review
15.	Composition	5.8.1.2, 5.8.2.2	x_b		Design review
16.	Surface finish and appearance	5.8.1.4, 5.8.2.4	x		Design review
17.	Durability	5.8.1.5, 5.8.2.5		x_a	5.8.1.5, 5.8.2.5

Note:

x_a *The biggest size will normally be selected assuming this size represents the worst structural behaviour.*

x_b *Evidence by way of appropriate manufacturer documentation of approvals or tests.*

Table 10.2 Requirement for on-going test

No.	Requirement	Reference Clause	Model to be tested		Test Method
			Each model in a range	Representative model in a range	
1.	Overall dimensions	5.8.1.3, 5.8.2.3	x		Annex H
2.	Inlet and outlet pipe	8.2.2	x		Design review
3.	Inspection opening and cover	8.7	x		Design review
4.	Hydrostatic uplift	5.7.3	x		Design review
5.	Lifting system loading	5.7.4	x		5.7.4
6.	Integrity during handling and installation	5.7.5	x		Design review
7.	Water tightness	5.7.7	x		Annex E
8.	Compartmentalisation	5.7.8	x		Annex F
9.	Joints	5.7.9	x		Annex G
10.	Impact resistance	5.7.10	x		Annex H
11.	Treatment efficiency	10.4		x_c	Table 10.3
12.	Marking and labelling	6	x		Design review
13.	Material	5.8.1.1, 5.8.2.1	x_b		Design review
14.	Composition	5.8.1.2, 5.8.2.2	x_b		Design review
15.	Surface finish and appearance	5.8.1.4, 5.8.2.4	x		Design review

Note:

x_b *Evidence by way of appropriate manufacturer documentation of approvals or tests.*

x_c *Refer to 10.5.3 for sampling requirements.*

Table 10.3 Core parameters for treatment efficiency testing

Criteria	Description/ Results
Date/ Time	
Weather condition	
Condition of plants	
Status of mechanical equipment	
Current hydraulic daily flow	
Average	
Peak	
Influent characteristics	
- BOD_5	
- COD	
- TSS	
- Oil and grease	
- pH	
- Temperature	
- Total nitrogen	
- Ammonical nitrogen	
- Phosphorus (if applicable)	
Aeration tank characteristics	
- MLSS	
- Dissolved oxygen	
- Sludge settleability (SSV_{30})	
- Sludge volume index (SVI_{30})	
- Sludge settlement	
- pH	
- Temperature	
Clarifier characteristics	
- Sludge settleability (SSV_{30})	
- Sludge volume index (SVI_{30})	
- Sludge blanket	
Return sludge characteristics	
- TSS	
- Recirculation ratio (Q_{RAS}/Q_{INFLOW})	

Table 10.4 Core parameters for treatment efficiency testing (cont.)

Criteria	Description/ Results
Effluent characteristics	
- BOD_5	
- COD	
- TSS	
- Oil and grease	
- pH	
- Ammonical nitrogen	
- Nitrate nitrogen	
- Phosphorus (if applicable)	

Note: Testing methods shall be in accordance with "Standard Methods for the Examination of Water and Wastewater", a joint publication by American Public Health Association, the American Water Works Association and the Water Environment Federation of the United States of America

ANNEX A

NORMATIVE REFERENCE

AS 3750.2	*Paints for steel structure-ultra high-build paint*
AS/NZS 1546.1	*On-site domestic wastewater treatment units Part 1: Septic Tank*
AS/NZS 1546.2	*On-site domestic wastewater treatment units Part 3: Aerated wastewater treatment systems*
AS/NZS 4766	*Polyethylene storage tanks for water and chemicals*
ANSI/ASCE 7-98	*Minimum Design Loads for Buildings and Other Structures*
ASTM A240/A240M	*Standard specification for chromium and chromium-nickel stainless steel plate, sheet and strip for pressure vessels and for general applications*
ASTM D3029	*Test method for impact resistance of flat, rigid plastic specimens by means of a tup (falling weight)*
ASTM D4097	*Standard specification for contact moulded glass fibre reinforced thermoset resin corrosion resistant tanks*
ASTM E84	*Standard test method for surface burning characteristics of building materials*
ASTM E1225	*Standard test method for thermal conductivity of solids by means of the guarded-comparative-longitudinal heat flow technique*
BS 4994	*Specification for design and construction of vessels and tanks in reinforced plastics*
BS 5150	*British Standard Specification for cast iron gate valve*
BS 8007	*Code of practice for design of concrete structures for retaining aqueous liquids*
BS 8110-1	*Structural use of concrete. Code of practise for design and construction*
BS EN 124	*Gully tops and manhole tops for vehicular and pedestrian areas – Design requirements, type testing, marking, quality control*
BS EN 976-1	*Underground tanks of glass-reinforced plastics (GRP) – Horizontal cylindrical tanks for the non-pressure storage of liquid petroleum based fuels – Part 1: Requirements and test methods for single wall tanks*
BS EN 978	*Underground tanks of glass-reinforced plastics (GRP) – Determination of factor α and factor β*
BS EN 10088-1	*Stainless steels. List of stainless steels*
BS EN 10088-2	*Stainless steels. Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for general purposes.*
BS EN 12334	*Industrial valves – Cast iron check valves*
BS EN 12255-1	*Wastewater Treatment Plants – Part 1: General construction principles*
BS EN 12255-11	*Wastewater Treatment Plants – Part 11: General data required*
BS EN 12255-12	*Wastewater Treatment Plants – Part 12: Control and automation*

BS EN 12566-3	*Small wastewater treatment systems for up to 50 PT – Part 3: Packaged and/ or site assembled domestic wastewater treatment plants*
BS EN 13923	*Filament wound FRP pressure vessels. Materials, design, manufacturing and testing*
BS EN ISO 1461	*Hot dipped galvanised coatings on fabricated iron and steel articles. Specifications and test methods.*
BS EN ISO 12944-1	*Paints and varnishes. Corrosion protection of steel structures by protective paint systems. General introduction.*
CSA B66-05	*Design, material and manufacturing requirements for prefabricated septic tanks and sewage holding tanks*
ISO 62	*Plastics – Determination of water absorption*
ISO 75-2	*Plastics – Determination of temperature of deflection under load – Plastics and ebonite*
ISO 75-3	*Plastics – Determination of temperature of deflection under load – High strength thermosetting laminates and long fibre reinforced plastics*
ISO 179-1	*Plastics – Determination of Charpy impact properties – Non-instrumented impact test*
ISO 179-2	*Plastics – Determination of Charpy impact properties – Instrumented impact test*
ISO 306	*Plastics – Thermoplastic materials – Determination of Vicat softening temperature*
ISO 868	*Plastics and ebonite – Determination of indentation hardness by means of a durometer (Shore hardness)*
ISO 3506-1	*Mechanical properties of corrosion resistant stainless steel fasteners – Part 1: Bolts, screw and studs*
ISO 3506-2	*Mechanical properties of corrosion resistant stainless steel fasteners – Part 2: Nuts*
ISO 3506-3	*Mechanical properties of corrosion resistant stainless steel fasteners – Part 3: Set screws and similar fasteners not under tensile stress*
ISO 527-1	*Plastics – Determination of tensile properties – General principles*
ISO 527-2	*Plastics – Determination of tensile properties – Test conditions for moulding and extrusion plastics*
ISO 527-4	*Plastics – Determination of tensile properties – Test conditions for isotropic and orthotropic fibre reinforced plastics composite*
ISO 14125	*Fibre reinforced plastics composites – Determination of flexural properties*
ISO/IEC 17025	*General requirements for the competence of testing and calibration laboratories*
ISO/IEC GUIDE 7	*Guidelines for drafting of standards suitable for use for conformity assessment*

ANNEX B

DETERMINATION OF RESISTANCE TO EXTERNAL PRESSURE
(EXTERNAL HYDROSTATIC PRESSURE TEST)
(Normative)

B1 SCOPE

This Annex sets out a method for testing the resistance of a prefabricated tank to external pressure due to soil in a fully or partially saturated state and hydrostatic groundwater.

B2 PRINCIPLE

The tank is subjected to a circumferential load applied to the wall of the tank.

B3 TESTING

B3.1 Hydraulic Test

The lateral (side loading) forces on a tank due to soil in a fully or partially saturated state, together with any accidental (incidental) additional loading due to the presence of earth-moving equipment adjacent to the tank wall may be represented by a circumferential load applied to the wall of the tank. These forces equate approximately to the forces applied to an empty tank held submerged in water. The test method requires that forces due to any anchorage technique normally used with the septic tank are simulated during the test.

The testing procedures shall be as follows:

a) Level the container base.

b) Install the empty test tank in the container and restrain it as necessary. If it is necessary to reproduce anchorage compression, weights shall be placed on the upper rim of the tank cylinder.

c) Holding down the tank in a manner that does not provide any lateral stability to the tank in excess of that provided by the lid, when installed.

d) Fill the outer container of the test tank with water up to the designed depth of cover, including risers.

e) Maintain the tank under test for a minimum of 7 days.

B3.2 Pit Test

The test shall be carried out on an empty tank equipped with pipe connections (inlet, outlet and interconnection pipes), its cover(s) and any extension and/or maintenance shaft(s). The tank shall be installed in a watertight test excavation. The size of testing excavation shall be calculated to avoid side effects. The tank shall be fixed on the base of excavation, according to manufacturer's installation instructions. The excavation shall be backfilled with rounded gravel (size from 3 mm to 8 mm). To test in wet ground conditions, add water to the top of the plant, as defined in Figure B.1.

The testing procedures shall be as follows:

a) Measure the initial internal dimensions of the tank.

b) Place the tank in the test excavation.

c) Backfill with gravel up to the level of pipe connections and simultaneously fill the tank with water up to the top, after sealing the inlet and outlet pipe connections. The volume of water shall be measured.

d) After that, discharge the water in the tank by using the following procedure.

   - For a tank made of FRP, the volume of water in the tank shall be measured; after that, discharge the water in the tank.

   - For a tank made of PE, measure the volume of water in the tank one day later and discharge the water.

e) Check the position of inlet and outlet pipe connections.

f) Complete backfill up to the maximum depth of cover as specified in 5.7.1, including the pedestrian load (2.5 kN/m^2) converted to a uniform backfill load.

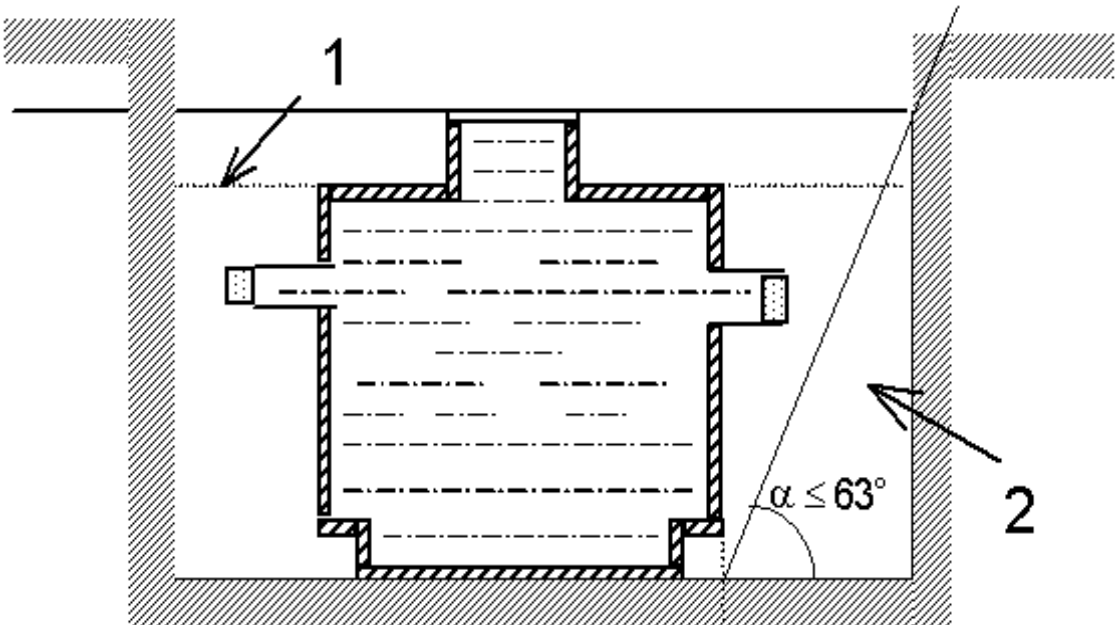
g) Seal inlet and outlet pipe connections and, for a wet ground test, add water in the excavation to the top of the tank.

h) For a tank made of FRP, maintain the test conditions for 24 h. For a tank made of PE, maintain the test conditions for 3 weeks.

i) In wet condition, examine inside of the tank to ensure water tightness is maintained. Discharge water from the excavation. If the tank is watertight, refill with water, and measure any change in the capacity of the tank.

j) In dry condition, examine inside of the tank. Refill with the volume of water required to fill the tank and measure any change in the capacity of the tank.

k) Check the position of inlet and outlet pipe connections and the internal dimensions of the tank.



(Ref: BS EN 12566-3)

Key 1 = water table level 2 = backfill

Figure B.1 Scheme of the principle for the pit test

B4 TEST CRITERIA

B4.1 Hydraulic test

Inspection shall show that there have been no leaks and that the integrity of the tank has no permanent damage as specified in 5.7.2. Inspection shall show that the deflection measured in the tank wall does not exceed:

a) The wall thickness at that point; or

b) The deflection predicted by calculation.

B4.2 Pit test

For a tank made of FRP:

a) No failure shall occur during the test; and

b) No lack of water tightness shall be recorded.

For a tank made of PE:

a) Variation of the volume of tank (expressed in m^3) shall be lower than 20 % of the internal volume of the tank; and

b) Movement of inlet, outlet and interconnecting pipe works shall not lead to loss of water tightness.

ANNEX C

DETERMINATION OF RESISTANCE TO EXTERNAL LOAD (VACUUM TEST)
(Normative)

C1 SCOPE

This Annex sets out an alternative method to determine structural strength of Glass Fiber Reinforced Plastic (FRP) prefabricated tank to withstand external earth and hydrostatic pressure by testing its resistance to an applied vacuum pressure.

C2 PRINCIPLE

The tank shall be tested for designed external load in any conditions, using the following formula:

$$p = (½ D + H) \times 10$$

where; p = negative pressure, kPa

H = maximum depth of earth cover as specified in 5.7.1, m

D = internal tank diameter, m

10 = action resulting from the specific weight of water, kN/m^3

WARNING: Failure implosion in a negative pressure test can release large quantities of energy. Adequate precautions shall be taken to protect personnel and facilities.

C3 TESTING

The test procedures for vacuum test shall be conducted as follows:

a) Support the tank uniformly. Bed an empty tank in dry sand to a depth not exceeding 100mm, with the tank oriented as in service.

b) Seal all openings in the tank and apply the required internal vacuum pressure calculated by the formula in C2.

c) Hold the vacuum for 60±5 min and check for deformation or damage to the tank. Ensure the hatches and inlet and outlet fittings have not lost their seal or been distorted.

C4 TEST CRITERIA

For vacuum tests defined above, the tank shall not be damaged nor has any visual deterioration internally or externally. The tank shall withstand the vacuum pressure selected without rupture.

ANNEX D

DETERMINATION OF RESISTANCE TO TOP LOAD (TOP LOADING TEST)
(Normative)

D1 SCOPE

This Annex sets out an alternative method to determine structural strength of polyethylene (PE) prefabricated tank by testing its resistance of to an applied top load.

D2 PRINCIPLE

The tank is subjected to a load that is applied to the top segment of the tank. Testing shall be carried out at the temperature of (25 + 5) °C. This test method is applicable for use in dry conditions only. The test shall be carried out on an empty tanks equipped with its cover(s).

D3 TESTING

The test procedures for the top loading testing for PE tank shall be conducted as follows:

a) Bed an empty tank in dry sand to a depth not exceeding 100 mm, with the tank oriented as in service, and record the width of the tank (w_0).

b) Determine the maximum plan area of the tank.

c) Load the top segment of the tank with sandbags (or equivalent) to a total mass calculated by the formula below.

$$W = 2000 \times A \times H$$

where; W = mass, kg

A = plan area, m^2

H = maximum depth of earth cover as specified in section 5.7.1, m

d) Load the top of the tank with sandbags up to the total load, W as calculated in item (c), by taking care that the load is uniformly distributed. Completion of loading shall be considered time zero for the purposes of this tests.

e) Check the tank for cracking or other damage and measure the width at 1 h (w_1) and 48 h (w_{48}) after time zero.

f) At the end of 48 hours period under load W, reduce the load to 10% of W. At the end of 24 hours under the load of 10% of W, measure the tank width (w_{72}) and remove the remainder of the load.

D4 TEST CRITERIA

The deformed width (w) of the tank under load shall be as follows:

a) w_1 shall not exceed 1.07 w_0;

b) w_{48} shall not exceed 1.12 w_0; and

c) w_{72} shall not exceed 1.05 w_0.

If fractures or cracks occur they shall be checked by means of the test crack measuring gauge. The load shall than be released and the surface again examined to check whether all test cracks have closed.

ANNEX E

DETERMINATION OF WATERTIGHTNESS (LEAKAGE TEST)

(Normative)

E1 SCOPE

This Annex outlines a method of testing the water tightness by leakage test for prefabricated tanks. The tank shall be tested after the strength tests specified in Clause 5.7.6 have been conducted.

E2 PRINCIPLE

The tank is subjected to a hydrostatic or pneumatic pressure and is then examined for signs of leakage. The tanks shall be placed on a level surface and laterally supported. Horizontal tanks shall be supported sufficiently so as to counter any bending and induced tension.

E3 TESTING

E3.1 Hydrostatic Pressure Test

For this test, tank shall be secured in place so as to enable inspection of the base of the tank. No saturation period is necessary before the test starts. The procedure shall be as follows:

a) Seal all the inlet and outlet connections.
b) Fill the tank with water to the declared height of water tightness, which is a minimum height equal to top of the tank (see Figure E.1).
c) Maintain this water level for 30 minutes and then observe and inspect for any leakage.

E3.2 Pneumatic Pressure Test

For this test, tank shall be subjected to an effective internal pressure equal to the maximum working pressure, but not less than 20 kPa (gauge pressure). The value of pressure variation is measured using a pressure gauge capable of being read to the nearest 0.5 kPa. The procedure shall be as follows:

a) Seal all the inlet and outlet connections and tank openings.

b) The required pneumatic pressure is gradually imposed on the tank and held for 3 min to allow the tank to absorb deformation. Do not start the leakage test until the pressure settles and the tank holds the pressure.

c) While the tank is holding the required pressure level, cover the entire external surface of the tank with soapy water solution or leak test fluid. Soap the entire tank and fittings.

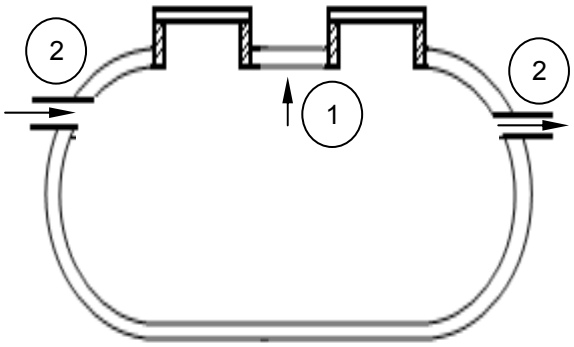
d) Check the tank visually for leaks, giving special attention to tank openings.

e) Measure the pressure variation in the tank during the test period of 30 seconds.

E4 TEST CRITERIA

Under pneumatic pressure testing for tanks complete with attachments, the tank shall not leak and pressure selected for the test shall not deviate by more than 10% during 30 seconds testing duration.

Under hydrostatic pressure testing, tanks shall have no leakage and no damp patches.



1 top of the tank
2 connections

Figure E.1 Height for filling

ANNEX F

DETERMINATION OF THE RESISTANCE OF A PARTITION WALL TO A HYDROSTATIC HEAD (PUMP-OUT TEST)
(Normative)

F1 SCOPE

This Annex outlines a method for testing the resistance of a partition wall dividing the prefabricated tank into compartments to the effects of pumping-out fluid from one side of the partition wall.

F2 PRINCIPLES

When the fluid is removed from one side of a compartmentalised tank during pump-out, the partition wall will be subjected to a hydrostatic pressure head. This test reproduces those conditions and then checks for any signs of weaknesses or failure of the partition wall.

F3 TESTING

This test may be carried out in conjunction with the hydrostatic pressure testing for water tightness as specified in E3.1 of Annex E. The test procedure shall be as follows:

a) Seal all the inlet and outlet connections and flow opening in the partition walls;

b) Fill the tank with water up to its outlet or overflow level;

c) Pump out water from one side of the partition wall. If the partition wall is situated so that there is a greater quantity or head of water on one side as compared to the other, the water shall be pumped-out from the side that has the least quantity or head;

d) Observe the reaction of partition wall to the effect of pump-out process and check the partition wall for leaks over a period of at least 1 hour.

F4 TEST CRITERIA

The partition wall shall not collapse or permanently deform when the water in the tank is pumped-out and no leakage shall occur in the partition wall.

ANNEX G

DETERMINATION OF THE INSTALLATION OF FITTINGS IN A SOUND STRUCTURE AND WATERTIGHT MANNER

(Normative)

G1 SCOPE

This Annex outlines a method for testing for the installation of fittings in a sound structure and watertight manner, whether the fittings are installed in the factory or on-site.

G2 PRINCIPLES

The fittings attached to the prefabricated tank are subjected to a low hydrostatic pressure from inside the tank, or are subjected to a moment of bending and torsion.

G3 TESTING

G3.1 Low hydrostatic pressure test

The test procedure shall be as follows:

a) Set up the tank as for the leakage test in determining water tightness as required by Annex E.
b) Install fittings in accordance with manufacturer's instruction.
c) Seal openings in the fittings to allow water to build up behind the fitting during the test.
d) Fill the tank with water until to the top of the tank.
e) Allow the tank to stand for at least 10 minutes.
f) Observe the tank and fittings for any leakage.

G3.2 Bending and torsion moments on fittings test

Carry out the test on the tank which has been restrained. The test procedure shall be as follows:

a) Apply successively a 500 N.m moment of bending and a 500 N.m moment of torsion on piping sections fixed on each of the pipe fittings attached to the tank.
b) Maintain these moments for 1 min.
c) Inspect the tank visually.
d) Submit the tank to a leakage test in accordance with Annex E.

G4 TEST CRITERIA

Under low hydrostatic pressure test, no leakage and no damp patches shall occur in the tanks.

Under bending and torsion moments on fittings test, no visual deterioration shall occur in the tank. Subsequently, no leakage shall occur when the tank is submitted to leakage tests.

ANNEX H

DETERMINATION OF IMPACT RESISTANCE FOR GLASS FIBER REINFORCED PLASTIC (FRP) PREFABRICATED TANK

(Normative)

H1 SCOPE

This Annex sets out a method of determining the impact resistance of FRP prefabricated tank.

H2 PRINCIPLES

The test allows the mean energy to cause the tank failure to be calculated after a weight of solid steel ball is allowed to fall vertically onto the test tank.

H3 TESTING

H3.1 Internal impact resistance test

The test procedure shall be as follows:

a) Drop a (0.5 ± 0.005) kg solid steel ball from the upper edge of the inspection opening onto the protection plate of the tank.
b) Observe and inspect for any damage and surface change.

H3.2 External impact resistance test

The test procedure shall be as follows:

a) Drop a (0.5 ±0.005) kg solid steel ball from a height of (1 ± 0.01) m onto the structural tank wall of the tank.
b) If the wall contains ribs, carry out the test by dropping the ball centrally between ribs and on the crown of a rib.
c) Observe and inspect for any deterioration.

H4 TEST CRITERIA

Under internal impact resistance test, no cracking of the internal surface or a surface change visible with the unaided eye shall occur.

Under external impact resistance test, the tank shall show no visual deterioration.

ANNEX J

DETERMINATION OF DIMENSIONS (DIMENSIONAL TEST)

(Normative)

J1 SCOPE

This Annex outlines a method for testing and measuring all dimensional parameters of importance for finish product of the prefabricated tank i.e. diameter, thickness, rib spacing and length.

J2 PRINCIPLES

The tanks are subjected to non-uniform dimensional parameters during the manufacturing process and are then examined to ensure that each part complies with the dimensional tolerance and required minimum reference value.

J3 TESTING

a) Measure all dimensional parameters of importance, i.e. diameter, thickness, rib spacing and length with a suitable instrument.
b) Measure the dimensions other than thickness to the nearest 1 mm. An average of two (2) perpendicular measurements for internal diameter of the tank and two (2) parallel measurements for rib spacing and length of the tank shall be taken.
c) Measure the minimum required thickness of structural tanks wall, end panel, partition wall and internal components for finish product of prefabricated tank to the nearest 0.1 mm. The thickness shall be measured at certain parts of the determining components.

J4 TEST CRITERIA

The internal diameter, rib spacing and length of the tank shall be within tolerances of at most ± 1 %.

The thickness of all determining components shall not be less than the reference value of the minimum thickness specified in 5.8.1.3 and 5.8.2.3.

TECHNICAL SPECIFICATION

SPAN TS 1402:2010 (A1:2013)

SEWAGE TREATMENT SYSTEM

Part 2: Construction and Installation - Packaged Plants

Technical Standards and Compliance Division

Sewerage Regulatory Department

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FOREWORD

National Water Services Commission (SPAN) was established in 2008 to regulate the water services industry in Malaysia. SPAN envisions a sustainable, reliable and affordable water services for all by regulating the water services industry through fair, effective and transparent implementation of the Water Services Act (Act 655). Since inception in 2008, SPAN has been striving to institute improvements in term of standards and performance in the country's water and sewerage services sector.

SPAN aims to enhance efforts towards improving standards, quality and operational efficiency of water and sewerage services industry to ensure sustainability. One of the approaches is to achieve higher standards and quality by developing technical specifications for products and systems used in the industry. Hence, Technical Working Groups had been formed by Sewerage Regulatory Department to formulate technical and performance specifications for adoption in sewerage industry.

This Technical Specification is a result of joint effort by members from various relevant stakeholders of the industry. This series of Technical Specification consists of the following parts, under the general title *Sewage Treatment System*:

Part 1: Prefabricated tanks – Packaged Plants

Part 2: Construction and Installation - Packaged Plants

The specification contains key criteria on packaged plants made of prefabricated tanks covering operational requirements, performance criteria, test methods, marking and evaluation of conformity for packaged plants used for the treatment of sewage with population equivalents between 150 and 5000.

The continual development of technical and performance specifications is crucial in moving the industry towards higher standards which will uplift the image of local sewerage industry. With the publication of this Technical Specification, it is hoped that it will contribute towards a better planned and well organized development of new sewerage systems to fulfil whole life infrastructure obligations.

As more than 50% of the systems installed on the ground are packaged plants using prefabricated tanks, hence the best practices, quality and performance measurement standards must be established to ensure its long lasting performance and durability.

ACKNOWLEDGEMENT

To date SPAN had published 3 volumes of Malaysian Sewerage Industry Guideline which are used extensively nationwide. Meanwhile this publication is the first effort by SPAN to produce technical specification. It would not had been possible without the joint effort of industry stakeholders namely representatives from Association of Environmental Consultants and Contractors of Malaysia (AECCOM), Jabatan Perkhidmatan Pembetungan (JPP), Indah Water Konsortium (IWK), SIRIM Berhad and IKRAM QA Services Sdn. Bhd.. TWG reports to the Commission via System, Product, Material and Research & Development Committee to seek endorsement for implementation of Technical Specification in the industry. The commitment and cooperation showed by the members of TWG must be applauded. We also would like to record our utmost appreciation for stakeholders whom had participated in the publication of the technical specification draft for public comments. We are planning for many more technical specifications publication with such continuous support for industry players.

The System, Product, Material and Research & Development Committee of National Water Services Commission (SPAN) comprises of representatives from:

Department of Standards Malaysia (DSM)
Ministry of Science, Technology and Innovation (MOSTI)
National Water Services Commission (SPAN)
Public Works Department Malaysia (PWD)
Sewerage Services Department (JPP)
Water Supply Department (JBA)

The Technical Working Group for Technical Specification of Sewage Treatment Systems, Part 2: Construction and Installation - Packaged Plants consists of representatives from:

Association of Environmental Consultants and Companies of Malaysia (AECCOM)
Indah Water Konsortium Sdn. Bhd. (IWK)
National Water Services Commission (SPAN)
Sewerage Services Department (JPP)
SIRIM QAS International Sdn. Bhd.
IKRAM QA Services Sdn. Bhd.

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Ir. Cho Hock Tin	AECCOM
Ir. Norman Wong	AECCOM

Contents Page

1 Scope

Part 2 of this Technical Specification specifies the construction and installation requirements for packaged sewage treatment plant (hereafter called packaged plant) consisting prefabricated tanks made of glass fibre reinforced plastics (FRP) or polyethylene (PE) to serve between 150 and 5000 population equivalents that are in compliance with Part 1 of the Technical Specification.

The specification covers operational requirements and performance criteria that deal with features such as functional design and material as means of compliance with overall requirements of the packaged plant. The focus is on operational systems of the plant comprising piping, aeration, pumping, control and other ancillaries. The specification also includes treatment efficiency testing to ascertain if the plant achieve the effective and reliable operational performance under normal operating conditions throughout its serviceable life span.

The specification excludes the design of treatment process, mechanical and electrical components and control and instrumentation needs. All these components shall be designed to the best engineering practice in compliance with the Guidelines and standards recognised by the Commission, by-laws, regulations and other regulatory agencies' requirements relevant to the aspects.

2 Terms and definitions

For the purposes of this Specification, the terms and definitions given in MS 1228, EN 1085:2007 and the following apply:

2.1 anchorage

device/technique for holding the tank in the ground against hydrostatic uplift pressure

2.2 assembly

component or equipment that can be removed and replaced as a whole

Note. Example of an assembly is a pump, an air blower, a diffuser etc

2.3 desludging

removal of accumulated sludge from sludge holding tank

2.4 equipment

any component which is installed in, mounted on, attached to, or operated on structures in the performance of their intended function

2.5 laboratory

an organisation accredited under Skim Akreditasi Makmal Malaysia (SAMM) by Department of Standards Malaysia as testing and calibration laboratories

2.6 operational performance

functions that a system has to perform in order to operate as defined

2.7 packaged plant

prefabricated factory-built tanks and components of sewage treatment installation assembled off site by one manufacturer, which accepts sewage and treats it to a declared quality

2.8 performance criteria

qualitative or quantitative description of the operational performance

2.9 serviceable life span

period of time in which under normal conditions and with routine maintenance, the packaged plant perform satisfactorily without failure

Note. Serviceable life span is different from both the warranty time and average service life of use, as used for cost efficiency calculations

2.10 structure

any construction and its components built for the accommodation of equipment

2.11 testing agency

an organisation accredited as a third party quality management certification body or an accreditation body recognised by Department of Standards Malaysia.

2.12 unit process

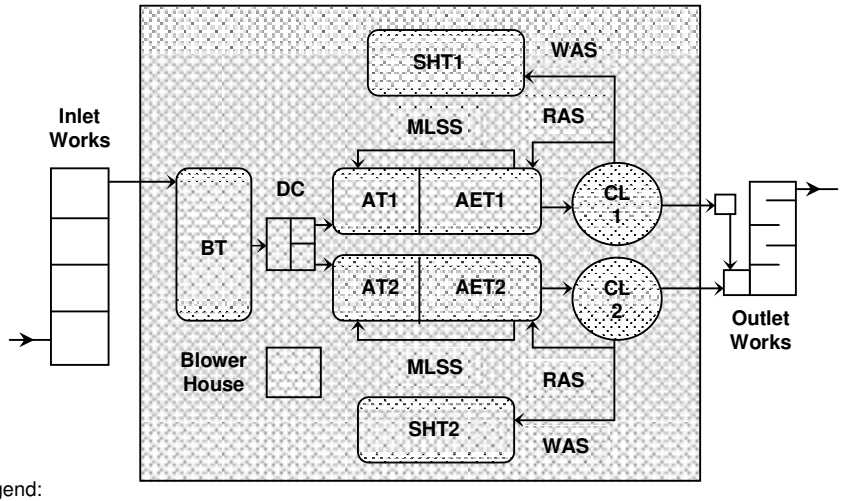
any structure including any related equipment which is used as a process stage and which can be isolated from other parallel, upstream or downstream structures

Note. Examples for a unit are a screen chamber, an aeration tank, a clarifier, a sludge holding tank

3 General requirements

3.1 Packaged and site assembled components of packaged plant

Biological treatment system in which the scope is from inlet pipe of first prefabricated tank or chamber to outlet pipe of final prefabricated tank or chamber as shown in Figure 3.1 shall be packaged in terms of treatment process with the dimensions of each prefabricated tank fixed.



Legend:

	Scope	SHT	Sludge holding tank	CL	Clarifier
BT	Balancing tank	AET	Aeration tank	RAS	Return activated sludge
DC	Distribution chamber	AT	Anoxic tank	WAS	Waste activated sludge
MLSS	Mixed liquor suspended solids				

Note: This layout is an indicative view of a typical packaged plant arrangement for reference purposes

Figure 3.1 Scope of biological treatment system for packaged plant

Site conditions for the installation must be taken into consideration for the layout and arrangement of site assembled components of packaged plants such as tanks and systems of piping, pumping, aeration, air lift and air blower together with the size, type and number of mechanical equipment, electrical, control and instrumentation equipped in the treatment system.

3.2 Arrangement of unit process tank

Provided that it is proven in both process and hydraulic design, the prefabricated tanks arranged in series to meet the loading requirements of one unit process tank can be considered as one tank.

3.3 Flow splitting and distribution

When the process line in packaged plants involves splitting the flow to multiple lines or parallel units, the incoming flow shall be distributed by an adjustable distribution device (e.g. valve, gate, stop-log) that can also be used to isolate each treatment unit. This device shall provide the required flow distribution over the range of flow rates considered. The concept is as typically shown in Figure 3.2.

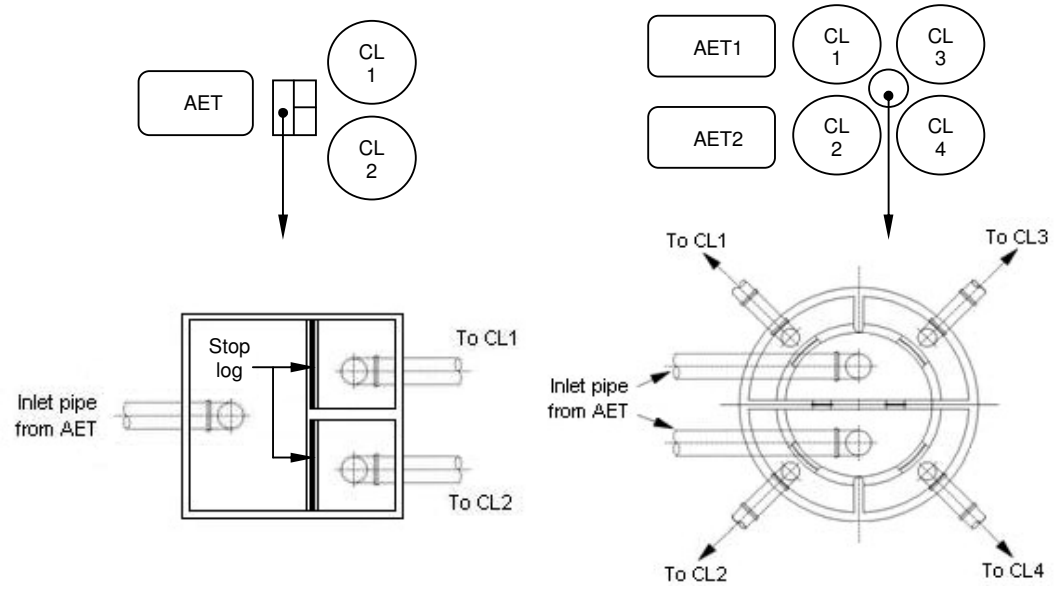


Figure 3.2 Typical concepts of flow splitting and distribution

3.4 Manufacture's guidelines

The supplier or manufacturer shall provide with each installation of packaged plant with endorsement of a Professional Engineer:

a. A clear and comprehensive operation and maintenance instructions including declaration for desludging frequency;
b. A manufacture's guidelines which give details on installation instructions showing the recommended relationship between levels in the tank, groundwater levels surrounding the tank, and anchorage requirements.

3.5 Code and model

Coding requirements to name the model of packaged plant as a product shall follow the sequence code of identification with maximum characters as shown below.

AAA/BBB/1234/CCC Example: XXS/HKA/3000/CAS

whereby; AAA - Name of company
BBB - Brand / Model
1234 - Actual population equivalent of package plants
CCC - Type of treatment process

The model shall be limited to the range of population equivalents with minimum intervals as Table 3.1.

Table 3.1 Range of model for packaged plants

Model Range	Interval
150 P.E ~ 1000 P.E	50
1001 P.E ~ 5000 P.E	100

4 Operational requirements

4.1 Process

The packaged plants shall demonstrate compliance with sewage treatment efficiency performances in accordance with Malaysian Sewerage Industry Guideline (MSIG) and Environmental Quality (Sewage) Regulations 2009, Environmental Quality Act, 1974. It shall also be capable:

a. to encourage and provide sufficient amount of mixed liquor suspended growth (MLSS) in the treatment system;
b. to provide minimum dissolved oxygen concentration of 2 mg/l to prevent oxygen diffusion limitation from hindering substrate removal by the microorganism;
c. to provide sufficient mixing to keep the sludge in suspension without causing any settlement of sludge in any part of the unit process tanks which require mixing;

d. to provide good quality of sludge with normal settling characteristics indicated by sludge volume index (SVI_{30}) and sludge settled volume (SSV_{30}) of the respective treatment system adopted;
e. to avoid likelihood of blockage in sewage and sludge transfer system within the boundary of packaged plants during its serviceable life span.

4.2 Hydraulic

The hydraulics of equipment and interconnecting pipes shall ensure no back-flow, blockage or surcharging occur during normal operation. The hydraulic of the packaged plants shall allow entry of sewage with minimum of disturbance to surface layers by maintaining consistent hydraulic flow and pattern throughout the treatment system without causing any increment in surface loading and velocity.

The distance between the top water level and the top of interconnecting pipe shall not exceed 150 mm.

Any pipe carrying sludge must be designed and installed to allow for self cleansing and preventing sludge settlement inside the pipe.

4.3 Civil and structure

4.3.1 General

Civil and structural components of the packaged plants shall be designed by a Professional Engineer. The design shall be based on appropriate design methodologies and relevant standards. The structures and constructions of packaged plants shall be:

a. stable, able to bear and resist all loads and stresses resulting from installation, construction, handling and use, including operation and maintenance throughout the serviceable life span. These shall take into account of water pressures, static and dynamic forces being induced by equipment and desludging;
b. able to prevent likelihood of damage from superimposed loads or normal ground movement;
c. resistant against corrosion, chemical and biological attack from sewage, sludge, air and gas components and against temperature changes as appropriate;

d. durable, watertight and able to retain structural integrity including alignment, orientation, levelling and function properly with normal maintenance over their serviceable life span of minimum 50 years.

4.3.2 Design basis

Packaged plants and their foundation shall be designed to achieve the required serviceable life span and long term structural integrity and shall meet the worst-case conditions not limiting to:

a. when the prefabricated tanks are fully emptied;
b. during high groundwater conditions; and
c. traffic loading due to close proximity of vehicle to the tank.

The structural design of packaged plants shall consider all factors that can affect particularly the strength and integrity of prefabricated tanks such as soil conditions and area of installation to ensure the entire structure of tanks and its associated components are integrally sound.

4.3.3 Foundation work

Foundation works for the installation of major and auxiliary components for packaged plants shall be designed and constructed so that components such as inspection chambers shall be secured to avoid disruption to the operation and maintenance works and process of the system. The foundation shall be able to prevent the possibility of sludge settlement, differential settlement between structures on top of between structures and equipment such as pipeline.

4.3.4 Backfill material

The backfill material for packaged plants shall be of particle size and grading that allows the specified relative compaction to be achieved with the intended compaction methods. The material shall not contain organic material which will affect backfill material performance and free of materials that are physically and chemically harmful to prefabricated tanks. The support and overlay material shall be placed in layers of appropriate thickness for the method of compaction used to achieve the relative compaction or soil modulus.

4.3.5 Retaining wall

The retaining wall shall be designed and checked by taking into account all possible factors involved contributing to the lateral earth pressure. The wall components shall also be capable of meeting serviceability requirements at site condition.

4.3.6 Prefabricated tanks

The construction and installation of prefabricated tanks shall resist hydrostatic uplift pressures i.e. uplift loads from groundwater and be protected against floatation in areas of high water table level or when the tank is emptied. The bottom of an excavation for prefabricated tanks shall provide a uniform base to support the tanks in a level position.

4.3.7 Anchorage

A corrosion-resistant means of anchorage system consisting straps, cables, turnbuckles and anchor hooks shall have strength of at least 1.5 times of maximum uplift force of an empty prefabricated tank without backfill in place.

5 Performance criteria

5.1 Effluent weir

The weir in sedimentation tank shall be accessible from top for manual cleaning without causing obstruction and not posing any health and safety issues. The weirs shall always be levelled for even distribution of flow. Slots in the weir shall be provided to allow for level adjustment during the installation stage. Flow through over the weir shall be calculated based on the actual type of weir used.

5.2 Sludge treatment

The amount of wasted sludge, Q_{waste} shall be used to size the sludge holding tank. The amount of wasted sludge in mass shall be balanced with sludge accumulation rate in reference to computed sludge age.

An adequate air mixing mechanism and air supply shall be provided in the sludge holding tank to ensure sewage content is sufficiently mixed to keep it in suspension, without causing any hardened sludge settled at the bottom of the tank during desludging periods of 30 days.

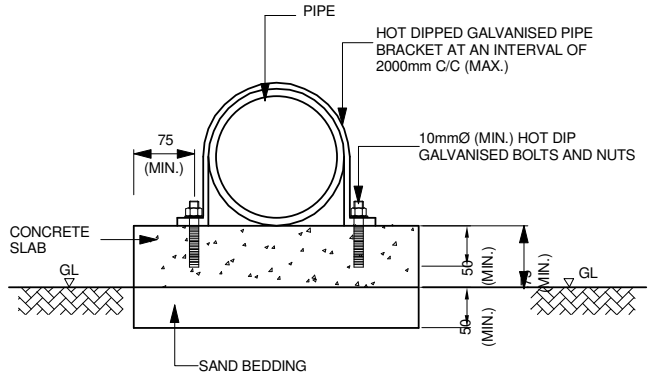
The sludge treatment by aerobic or anaerobic digester shall not be allowed as it require intensive health, safety and control system requirements, that is not suitable for operation and maintenance of plants within the serving population equivalent.

5.3 Piping system

5.3.1 General

The piping system for packaged plants shall comply with following criteria:

a. The arrangement of piping system and interconnection pipes in prefabricated tanks shall not obstruct maintenance work of the equipment in the tanks;
b. All the buried piping shall be properly bedded and supported with the selected compacted fill material;
c. All the above ground piping shall have a minimum distance of 75 mm from the ground level. It shall be provided with a proper pipe support and bracket. The bracket shall be made of or be coated with corrosion-resistance material. The typical pipe support and bracket is shown in Figure 5.1;



NOTES :-

1. ALL DIMENSIONS ARE IN MILIMETERS UNLESS OTHERWISE STATED.

Figure 5.1 Typical pipe support and bracket

d. The arrangement of the above ground piping shall minimise obstruction and manoeuvrability;
e. Any on-site installation or assemblies of pipe support that is attached to the prefabricated tank shall not be allowed;
f. No bending shall be allowed at any sewage distribution pipe excluding the force main piping. Instead, a chamber shall be provided to cater for any change of direction in sewage flow.

5.3.2 Inlet and outlet pipe

On-site drilling of all openings or holes for pipe connections at the prefabricated tanks is not allowed. All jointing and pipe holes connection shall be factory fabricated and moulded.

5.3.3 Air pipe

Air pipes consisting of air distribution pipes from blower, header pipes, drop leg/down pipes and other pipes to convey air for aeration, mixing or air lift purposes shall be:

a. able to withstand maximum air temperatures generated by the blower and pressures of 25% more than the design pressure of the blower;
b. painted in green with air flow direction is painted in white at maximum interval of 3 m;
c. above ground for the air distribution pipes from the blower to the unit processes;
d. properly bracketed with corrosion-resistance U-bolt or other means of bracketing the down pipes to limit the movement of diffusers and to withstand the buoyancy effect.
e. designed to provide even and adequate air distribution to all relevant unit processes;
f. provided with instruments such as pressure gauge for the pipes conveying air for mixing and air lift purposes;
g. points to allow calibration shall be provided for the fixed instrument;
h. points to allow measurement using portable instrument shall be provided such as for air flow measurement.

5.3.4 Sludge transfer pipe

All jointing to connect the sludge transfer pipes shall be double flange with corrosion-resistance bolts and nuts. No thread union or coupling shall be allowed in any jointing part of the pipes.

5.3.5 Effluent pipe

The effluent discharge piping system that passes through or by-passes the disinfection treatment facility shall be designed so as not to cause any nuisance. The invert level of effluent pipe shall be at a minimum of 300 mm from the top water level of receiving watercourse.

5.4 Pumping system

5.4.1 Pump

Minimum control mechanism for the pumps installed within packaged plants shall be:

a. automatic by float switch for sewage transfer pump;
b. automatic by timer and interlock with solenoid valve for return and waste sludge pump in sedimentation tank;
c. manual by push button for sludge transfer pump to remove sludge from sludge holding tank.

In event non-submersible pumps are used, sufficient cover for weather protection shall be provided.

5.4.2 Duck foot, transfer pipe and guide rail

All pumps shall be completely installed with duck foot, guide rail and lifting chain complying with the following requirements:

a. Duck foot shall be installed and assembled in the factory. On-site installation or assemblies is not allowed except for connection of transfer pipe and guide rail;
b. The guide rail shall be properly bracketed with U-bolt or other means of bracket to secure the movement of the pump;
c. All fasteners of the duck foot shall be watertight;
d. Guide rail, lifting chain and U-bolt bracket shall be made of non-corrosive material.

5.5 Diffuser

All diffusers shall be supported from the tank base and shall not be bolted to the bottom of the tank. The diffusers shall be removable and easy to re-install onto the diffuser support.

The support for diffusers shall be made of non-corrosive material and shall be designed to suit the application. The support shall be capable to prevent buoyancy of the diffuser.

5.6 Valve

All valves shall be accessible and not obstructed for maintenance work. The valves of 100 mm diameter and above shall be installed in the inspection chamber.

Selection of materials to be used in the construction of body and seal of the valves shall be in accordance with the application in order to optimize functional reliability, fluid compatibility, serviceable life and cost.

5.7 Inspection opening and cover

The design and arrangement of inspection cover in reference to the inspection openings shall be consistent with operational requirements of packaged plants.

5.8 Flow splitting and distribution chamber

Design and construction of flow splitting and distribution chamber shall prevent any sedimentation. The adjustable features shall be provided within flow distribution chamber and shall be constructed using one of the following material:

a. Reinforced concrete with a minimum of Grade C30;
b. FRP with minimum thickness as declared by the manufacturer in compliance with TS 1401:2010 (A1:2013);
c. Steel plate coated with corrosion resistance coating such as hot dipped galvanised or high build tar epoxy;
d. Stainless steel of minimum Grade 304;
e. Other material that is approved by the Commission to be used for this purpose.

5.9 Lifting device

Lifting device shall be installed to avoid direct loading to the structure of tanks. Where fixed lifting device is provided, it shall be supported by the spread footing to ensure even distribution of loads exerted by the weight of the devices.

5.10 Control and instrumentation

Necessary measuring and control equipment shall be specified taking into account the installation conditions. This applies to its location within the packaged plants, layout and size of structures in compliance with Malaysian Sewerage Industry Guidelines (MSIG) Volume IV.

6 Delivery and installation

Manufacturer/supplier shall properly plan delivery route so as not to cause any damage to road facilities and harm to road users.

Packaged plants shall be installed and constructed under the supervision of a Professional Engineer and in accordance to detailed plans approved by the Commission. An inventory list of every item to be installed shall be provided and to be checked against the approved construction drawings. The list shall be endorsed by the Professional Engineer.

No fabrication or moulding of any part of the prefabricated tanks shall be allowed at the site. These parts shall be factory fabricated and moulded.

7 Treatment efficiency testing

7.1 General

The treatment efficiency testing shall be mandatory for packaged plants with reference to 7.3. At least a minimum of three (3) assessments on different days shall be conducted for packaged plant that had been installed for more than two (2) years.

All data and samples collected for this testing shall be verified by operator of the plant. Table 7.1 sets out core parameters that shall be monitored in the plant.

The manufacturer or supplier shall submit the test reports to the Commission on a yearly basis containing at least the information specified below:

a. Information on the conformity of plants tested with the information provided prior to testing;
b. Data obtained during testing with analysis on the efficiency ratios of the loading parameters;
c. Information on all maintenance and repairs carried out during the test period, including details of desludging frequency, quantity and the volume removed;
d. Information on any problems, physical or environmental occurring during the test period. Deviations from the manufacturer's maintenance instructions shall be reported in this section;
e. Information detailing any physical deterioration of the plants that has occurred during the testing;
f. Information concerning deviations from the test procedure.

7.2 Conditioning of test specimen

Conditioning of the test specimens is not required unless otherwise specified by the test method. The tests are to be conducted at ambient conditions without any special controls on temperature or relative humidity unless otherwise specified by the test method. All tests and samplings for the testing shall be conducted by a laboratory accredited to ISO/IEC 17025.

7.3 Sampling requirement

The quantity of packaged plants to be tested shall be 5% from the total installed units of more than two (2) years. If the total installed units are less than 50 units, a minimum three (3) installed units shall be tested.

7.4 Test record

For each test specimen, the report shall record, not limiting to the following data:

a. Identification of person and organisation carrying out the test.

b. Identification of the sample tested.
c. Date of test.
d. The test result.
e. Reference to the test method.

Table 7.1 Core parameters for treatment efficiency testing

Criteria	Description/ Results
Date/ Time	
Weather condition	
Condition of plants	
Status of mechanical equipment	
Current hydraulic daily flow	
Average	
Peak	
Influent characteristics	
- BOD_5	
- COD	
- TSS	
- Oil and grease	
- pH	
- Temperature	
- Total nitrogen	
- Ammonical nitrogen	
- Phosphorus (if applicable)	
Aeration tank characteristics	
- MLSS	
- Dissolved oxygen	
- Sludge settleability (SSV_{30})	
- Sludge volume index (SVI_{30})	
- Sludge settlement	
- pH	
- Temperature	
Clarifier characteristics	
- Sludge settleability (SSV_{30})	
- Sludge volume index (SVI_{30})	
- Sludge blanket	
Return sludge characteristics	
- TSS	
- Recirculation ratio (Q_{RAS}/Q_{INFLOW})	

Table 7.1 Core parameters for treatment efficiency testing (cont.)

Criteria	Description/ Results
Effluent characteristics	
- BOD_5	
- COD	
- TSS	
- Oil and grease	
- pH	
- Ammonical nitrogen	
- Nitrate nitrogen	
- Phosphorus (if applicable)	

Note: Testing methods shall be in accordance with:

a) The 21st edition of "Standard Methods for the Examination of Water and Wastewater", published jointly by the American Public Health Association, the American Water Works Association and the Water Environment Federation of the United States of America; or'

b) "Code of Federal Regulations, Chapter 40, Subchapter D, part 136" published by the Office of the Federal Register, National Archives and Records Administration, United States of America.

Bibliography

[1] Water Services Industry Act 2006 (Act 655)

[2] Malaysian Sewerage Industry Guidelines, Volume IV, Sewage Treatment Plants – 3rd Edition

[3] AS/NZS 1546.2 On-site domestic wastewater treatment units Part 3: Aerated wastewater treatment systems

[4] BS EN 12566-3 Small wastewater treatment systems for up to 50 PT – Part 3: Packaged and/ or site assembled domestic wastewater treatment plants

[5] ISO/IEC 17025 General requirements for the competence of testing and calibration laboratories

[6] ISO/IEC GUIDE 7Guidelines for drafting of standards suitable for use for conformity assessment