FRP Asset Manual

Introduction and Scope

Contents

References, Standards and Bibliography

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Summary This preface document outlines the scope, the overall contents and general bibliography for the FRP Asset Manual.

Author JMC Composites Ltd

Introduction and scope

This suite of documents has been prepared to assist Asset Managers who inherit or acquire composite fibre reinforced polymer (FRP) assets on their work sites to achieve a better understanding of the materials, manufacturing processes, installation and maintenance involved in the cost effective life management of those assets. Such assets will typically be pipes, tanks, access and support structures, manhole and trench covers, tank covers and moulded items such as sumps and underground enclosures.

These documents aim to provide information in a straightforward manner which will provide users and Asset Managers with a simple explanation of the properties and potential benefits of composites components and assist them in the specification, procurement, installation, inspection, maintenance, repair and end of life disposal of industrial composite FRP equipment and components.

Composites are a valuable complementary engineering material in many industrial applications which can offer specific benefits to the user – they are not an automatic replacement for established materials such as steel or aluminium and their use must be correctly specified and implemented. Composites are not an 'exotic' or 'high tech' solution and there is no need for any mystique in their application or use. There has been a conscious decision in the preparation of this suite of documents to try to avoid the use of jargon, all too common in the composites industry, which is often a cause of misunderstandings.

Throughout these documents the term FRP has been used. FRP can be defined as Fibre Reinforced Polyester/Plastic/Polymer etc., but there is a problem within the composite materials industry that numerous, frequently undefined acronyms are used which can lead to significant confusion for users of fibre reinforced composite materials. Typically references will be found in literature from the industry suppliers referring to GRP, FRP, GRE, RTRP,GRVE, CFRP etc., etc.. All of these acronyms refer to different composite materials with different types of reinforcement and resins, and it is imperative that there is total clarity and agreement between suppliers, designers and users as to precisely what is meant when these abbreviations are used.

The authors have many years of direct hands-on experience with materials, design, manufacture, installation and maintenance of composite FRP pipes, tanks and structural assemblies, and have recognised the fact that many asset managers are given responsibility for FRP composite components of which they perhaps have very limited experience and understanding.

These documents do not set out to be 'in depth' technical manuals covering the design, specification, installation and use of composite pipes, tanks and structural assemblies. There are plenty of specialist textbooks to serve this need. These documents highlight issues which are of immediate significance to users, managers and specifiers and provide caveats to help those acting in these roles to better understand the materials and components with which they have to deal.

Contents

This suite of documents is sub-divided into 4 main sectors with a 5th sector dedicated to a directory of suppliers of materials, equipment and services. The main sections and sub-sections are shown below with a brief overview of each section detailed overleaf.

Section overview

Section 1 Introduction to Fibre Reinforced Plastics

This document is designed to familiarise the Asset Manager with the materials and processes used in the manufacture of FRP components and the properties, both mechanical and physical, which the Asset Manager can expect of FRP components.

Section 2 Pipes, consists of 3 subsections

Section 2A is a narrative document which gives the user an understanding of the special considerations needed when managing the installation and operation of FRP pipes and p i p e systems both above-ground and buried. These pipe systems would typically be used in the transportation of fluids such as potable, clean, and grey water, cooling water, chemical process fluids, dosing systems and industrial effluent. Pipes of this type would be typically, but not exclusively, manufactured by either continuous or discontinuous filament winding or by centrifugal casting.

Sections 2B and 2C detail inspection and maintenance procedures for above-ground and buried pipes respectively.

Section 3 Tanks, consists of 3 subsections

Section 3A is a narrative document which gives the user an understanding of the special considerations needed when managing the installation and operation of FRP storage and process tanks and tankage systems, both above-ground and buried. Such tanks would be used for storage of water, fuels and light oil and process chemicals. Tanks of this type would be manufactured either by discontinuous filament winding, hoop or tape winding, contact moulding, hand or spray lamination.

Sections 3B and 3C detail inspection and maintenance procedures for above-ground and buried tanks respectively.

Section 4 Access and Support Structures, Structural Panels and Covers consists of 3 subsections

Section 4A is a narrative document which gives the user an understanding of the special considerations needed when managing the installation and use of FRP access and support structures, structural panels and covers. Access and support structures, including ladders, walkways, stairs and handrails, tank and pipe supports, are predominantly assembled from pultruded section with flooring manufactured from pultruded section or moulded gratings. Structural panels and covers include tank roofing, manhole and access covers, trench covers, sumps and underground enclosures and are generally manufactured by hand or spray layup, vacuum bagging or vacuum infusion, resin transfer moulding (RTM) or compression moulding.

Sections 4B and 4C detail inspection and maintenance procedures for access and support structures, structural panels and covers respectively.

Section 5 Supplier Directory

References, standards and bibliography

The documents listed below do not comprise an exhaustive summary of the standards or test procedures relevant to FRP assets. The list is however, sufficiently comprehensive to cover all normal requirements for the assets considered in this suite of documents. In some cases compliance with other local or national standards equivalent to those listed may be demanded.

General background bibliography

Recommended practice for the in-service inspections of above-ground atmospheric fiberglass reinforced plastic (FRP) tanks and vessels. Fiberglass Tank and Pipe Institute FTPI RP 2007-1

FRP Inspection Guide. An Inspection Guide for Fiber-Reinforced Plastic (FRP) Equipment. Reichold Inc.

Glass Reinforced Plastic Vessels and Tanks – Advice to Users. HSE Guidance Note PM75 (Third Edition).

The mechanical integrity of plant containing hazardous substances – A guide to periodic examination and testing. EEMUA Publication 231-Ed 1 (SAFed Publication IMG 1).

Corrosion Resistant Plastic Composites in Chemical Plant Design. John H. Mallinson

Recommended guidelines for NDT of GRP Pipe Systems and Tanks. Norwegian Oil Industry Association (OLF)

Fiberglass Pipe Handbook. Composites Institute of the Society of the Plastics Industry Inc. (SPI).

ASCE 1984	Structural Plastics Design Manual, ASCE Manuals and Reports on Engineering Practice 63, American Society of Civil Engineers.
Eurocomp 1996	"Structural Design of Polymer Composites" Eurocomp Design Code and Handbook (J. Clarke, ed.), E&FN Spon, London
Composites Handbook	Published by Scott Bader Co UK www.scottbader.com/
Composites : Design Manual	Published by James Quinn Associates Ltd www.jqal.co.uk/
Design Manual	Strongell Corporation Design with Pultruded Profiles www.strongwell.com/

Relevant national and international standards

BS 4592-0:2006 Flooring, stair treads and handrails for industrial use. Common design requirements and recommendations for installation.

BS 4592-4:2006 Industrial type flooring and stair treads - glass reinforced plastics (GRP) open bar gratings. Specification.

BS 4592-5:2006 Industrial type flooring and stair treads - solid plates in metal and glass reinforced plastics (GRP). Specification

BS 4592-6:2008 Industrial type flooring and stair treads - glass reinforced plastics (GRP) moulded open mesh gratings and protective barriers. Specification

BS 4994 Specification for design and construction of vessels and tanks in reinforced plastics.

This standard has been internationally accepted for many years and is regarded as safe and conservative. It is officially obsolete under European Standards requirements, being superseded by BS EN ISO 13121. However this standard is still extensively used due to problems with the introduction of the replacement standard.

BS 7159 Code of practice for design and construction of glass-reinforced plastics (GRP) piping systems for individual plants or sites.

This standard is largely regarded as obsolete having been superseded by BS EN ISO 14692. It is however still well regarded and used by piping system designers and specifiers.

ISO 10467:2004 Plastic piping systems for pressure and non-pressure drainage and sewerage - glass-reinforced thermosetting plastics (GRP) systems based on unsaturated polyester (UP) resin.

The standard is applicable to GRP-UP piping systems, with flexible or rigid joints under uniaxial or biaxial loading, primarily intended for use in buried installations. It is applicable to pipes, fittings and their joints of nominal sizes from DN 50 to DN 4000 which are intended to be used for the conveyance of surface water or sewage at temperatures up to 50ºC, with or without pressure.

ISO 10639: 2004 Plastic piping systems for pressure and non-pressure water supply - glass reinforced thermosetting plastics (GRP) systems based on unsaturated polyester (UP) resin.

The standard specifies the properties of piping system components made from glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resin (UP) for water supply with or without pressure, as well as the properties of the system itself. The standard is applicable to GRP-UP piping systems, with flexible or rigid joints with or without end thrust load-bearing capability, primarily intended for use in buried installations.

This International Standard is applicable to pipes, fittings and their joints of nominal sizes from DN 50 to DN 4000 which are intended to be used for the conveyance of water at temperatures up to 50ºC, with or without pressure.

BS EN ISO 13121 GRP tanks and vessels for use above ground.

This standard is published in 4 parts and is intended to replace the now obsolete BS4994. However there were numerous substantive and typographical errors in the original publications of this standard and it was opposed by large sections of the industry until fully corrected.

BS EN 13121 - 1 GRP tanks and vessels for use above ground – Part 1 - Raw materials specification conditions and acceptance conditions

BS EN 13121 - 2 GRP tanks and vessels for use above ground – Part 2 - Composite materials. Chemical resistance.

BS EN 13121 - 3 GRP tanks and vessels for use above ground – Part 3 - Design and workmanship.

BS EN 13121 - 4 GRP tanks and vessels for use above ground – Part 4 - Delivery, installation and maintenance.

BS EN 13706 Reinforced plastics composites. Specifications for pultruded profiles

1. Designation
2. Method of test and general requirements
3. Specific requirements

BS EN ISO 14122 Safety of machinery. Permanent means of access to machinery –
Part 1) Choice of a fixed means of access between two levels
Part 2) Working platforms and walkways
Part 3) Stairs, stepladders and guard-rails
Part 4) Fixed ladders

BS EN ISO 14692 Petroleum and natural gas industries. Glass-reinforced plastics (GRP) piping

BS 8010-2.5 Code of practice for pipelines. Pipelines on land: design, construction and installation. Glass reinforced thermosetting plastics.

This is the most commonly applied standard for the installation and testing of buried composite piping systems.

BS 6464 Specification for reinforced plastics pipes, fittings and joints for process plants.

Dating originally from 1984 this standard is not frequently used today.

BS EN 13923:2005 Filament-wound FRP pressure vessels. Materials, design, manufacturing and testing.

AWWA C-950 Fiberglass Pressure Pipe

AWWA M45 Fiberglass Pipe Design

This is probably the most widely used design method worldwide for FRP pipe systems, both buried and above-ground.

AWWA D120 Thermosetting Fiberglass-Reinforced Plastic Tanks

This standard is rarely used in Europe but is reliable and popular in US and international markets.

ASME RTP-1 Reinforced Thermoset Plastic Corrosion-Resistant Equipment

This is a very widely adopted, rigorous and respected standard for process equipment and vessels.

WIMES 8.05 Water Industry Mechanical and Electrical Specification 8.05- Odour control equipment. Appendix G – GRP cover specification

Test procedures

ASTM test procedures are adopted and used worldwide for composite material pipes, vessels and structures. They specify controlled methods for determining performance and quality of laminates. The majority of these ASTM procedures are not directly relevant for users of finished products as they are intended for validation of products and processes at the manufacturing stage. Some tests are however extremely useful for users to check condition or long term performance of laminates in service conditions. Alternative, similar test procedures are indicated in some of the standards referenced above.

ASTM D2563 Standard Practice for Classifying Visual Defects in Glass Reinforced Plastic Laminate Parts

ASTM D2992 Standard Practice for Obtaining Hydrostatic or Pressure Design Basis for Fiberglass (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Fittings.

This test is a key requirement for providing laminate data for design of piping systems as it determines the maximum allowable stress conditions that can be used in the long term design – typically for 50 year life.

ASTM D3299-10 Standard Specification for Filament-Wound Glass-Fiber-Reinforced Thermoset Resin Corrosion-Resistant Tanks.

This specification covers cylindrical tanks fabricated by filament winding for above-ground vertical installation, containing aggressive chemical media at atmospheric pressure. This document covers vessels made with polyester or vinyl ester resins.

ASTM D4097 Standard Specification for Contact-Molded Glass-Fiber-Reinforced Thermoset Resin Corrosion-Resistant Tanks

This specification covers cylindrical tanks fabricated by contact moulding for above-ground vertical installation, containing aggressive chemical media at atmospheric pressure. This document covers vessels made with polyester or vinyl ester resins.

ASTM D792 Test methods for density and specific gravity (relative density) of plastics by displacement.

ASTM D1598 Standard test method for time-to-failure of plastic pipe under constant internal pressure.

ASTM D1599 Standard test method for resistance to short-term hydraulic pressure of plastics pipe, tubing and fittings.

ASTM D2105 Standard test method for longitudinal tensile properties of 'Fiberglass' (Glass-fibre reinforced, thermosetting-resin) pipe and tube.

ASTM D2143 Standard test method for cyclic pressure strength of reinforced thermosetting plastic pipe.

ASTM D2290 Standard test method for apparent hoop tensile strength of reinforced thermosetting plastic pipe by split disc method.

ASTM D2310 Standard classification for machine made 'Fiberglass' (Glass-reinforced thermosetting-resin) pipe.

ASTM D2412 Standard test method for determination of external loading characteristics of plastic pipe by parallel plate loading.

ASTM D2444 Test method for determination of the impact resistance of thermoplastic pipe and fittings by means of a tup (falling weight).

An adaptation of this test is suitable for testing impact resistance of reinforced thermoset pipe. An alternative impact test procedure is contained in BS5480.

ASTM D2583 Standard test method for indentation hardness of rigid plastics by means of a Barcol impressor.

This is the easiest and most widely used standard test to check the degree of cure of a thermoset resin, or degradation of resin condition by use of a simple hand held tool.

ASTM D2584 Standard test method for ignition loss of cured reinforced resins.

This test permits the determination of glass/resin/filler ratios in cured composite laminates, and allows for examination of the type and orientation of each reinforcement layer in a laminate.

ASTM D2924 Standard test method for determination of external pressure resistance of 'Fiberglass' (Glass-reinforced thermosetting-resin) pipe.

ASTM D2925 Standard test method for beam deflection of 'Fiberglass' (Glass-reinforced thermosetting-resin) pipe under full bore flow.

ASTM D2992 Standard practice for obtaining Hydrostatic or Pressure Design Basis for 'Fiberglass' (Glass-reinforced thermosetting-resin) pipe and fittings.

ASTM D2996 Standard specification for filament wound 'Fiberglass' (Glass-reinforced thermosetting-resin) pipe.

ASTM D2997 Standard specification for centrifugally cast 'Fiberglass' (Glass-reinforced thermosetting-resin) pipe.

ASTM D3262 Standard specification for 'Fiberglass' (Glass-reinforced thermosetting-resin) sewer pipe.

ASTM D3517 Standard specification for 'Fiberglass' (Glass-reinforced thermosetting-resin) pressure pipe.

ASTM D3567 Standard practice for determining dimensions of 'Fiberglass' (Glass-reinforced thermosetting-resin) pipe and fittings.

ASTM D3681 Standard test method for chemical resistance of 'Fiberglass' (Glass-reinforced thermosetting-resin) pipe in a deflected condition.

This procedure commonly called 'strain corrosion' testing is critical to the use of composite material pipes and fittings in extreme corrosive environments.

ASTM D3754 Standard specification for 'Fiberglass' (Glass-reinforced thermosetting-resin) sewer and industrial pressure pipe.

ASTM D3840 Standard specification for 'Fiberglass' (Glass-reinforced thermosetting-resin) pipe and fittings for non-pressure applications.

ASTM D4024 Standard specification for machine made 'Fiberglass' (Glass-reinforced thermosetting-resin) flanges.

ASTM D4161 Standard specification for 'Fiberglass' (Glass-reinforced thermosetting-resin) pipe joints using flexible elastomeric seals.

ASTM D4385-10 Standard Practice for Classifying Visual Defects in Thermosetting Reinforced Plastic Pultruded Products.

ASTM D5365 Standard test method for long-term ring-bending strain of 'Fiberglass' (Glass-reinforced thermosetting-resin) pipe.

ASTM D5421 Standard specification for contact-moulded 'Fiberglass' (Glass-reinforced thermosetting-resin) flanges.

ASTM D5685 Standard specification for 'Fiberglass' (Glass-reinforced thermosetting resin) pipe fittings.

ASTM D6041 Standard specification for contact-moulded 'Fiberglass' (Glass-reinforced thermosetting-resin) corrosion-resistant pipe and fittings.

ASTM F1173 Standard specification for thermosetting-resin fiberglass pipe systems to be used for marine applications.

ASTM F477 Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

ASTM E84 Flame spread of 25 (On a scale of 1-100, asbestos cement board = 0, red oak flooring = 100).

UK fire performance standards

BS476 Part 3:1958 Class AA (Fire penetration and spread of flame)

BS476 Part 6:1968 Class 0 (Fire propagation)

BS476 Part 7:1971 Class 1 (Surface spread of flame)

BS476 Part 20:1987 Describes the general procedures and equipment required to determine the fire resistance of elements of construction.

BS476 Part 21:1987 Describes the specific equipment and procedures for determining the fire resistance of load bearing elements.

BS476 Part 22:1987 Describes the procedures for determining the fire resistance of non-load bearing elements.

BS476 Part 23:1987 Describes the specific equipment and procedures for determining the contribution made by components to the fire resistance of structures.