

PETRONAS TECHNICAL STANDARDS

DESIGN AND ENGINEERING PRACTICE

MANUAL

GLASS-FIBRE REINFORCED PLASTIC PIPELINE AND PIPING SYSTEMS

PTS 31.40.10.19

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1. INTRODUCTION

1.1 SCOPE

This revised PTS specifies requirements and gives recommendations for the purchase and use of glass-fibre reinforced plastic (GRP) pipeline and piping systems, both onshore and offshore. Its objective is to enable the purchase of GRP components with known and consistent properties from any source.

This PTS is not applicable to:

- (i) Pipe systems that incorporate internal thermoplastic or elastomeric liners;
- (ii) Fibre reinforced plastic (GRP) downhole tubing and casing.

Application of fibre reinforced thermoplastic lined GRP spoolable pipe is specified in PTS 31.40.10.20.

This PTS is a revision of a previous edition with the same number, dated November 2003; a summary of main changes from the previous edition is given in (1.6).

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by PETRONAS, the distribution of this PTS is confined to companies forming part of or managed by PETRONAS and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them.

This PTS is intended for use in exploration and production facilities.

When PTSs are applied, a Management of Change (MOC) process should be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this PTS, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this PTS which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this PTS as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project, or operation or maintenance of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Specific definitions

system design pressure

maximum operating pressure intended to be experienced by pipeline or piping system during its service life.

design temperature

maximum fluid temperature that can be reached during service.

E-glass

glass fibre, normally used to reinforce GRP pipes, consisting mainly of SiO₂, Al₂O₃ and MgO.

ECR or C-glass

glass fibre or synthetic veil having a better chemical resistance against acids than E-glass, used primarily as a reinforcement for the resin-rich internal liner.

fittings

pressure-tight fluid containing components with a geometry different from straight pipe (e.g. tees, elbows, reducers etc.).

hand lay-up

a process for fabricating a composite structure in which discontinuous reinforcements (woven mats, chopped strand mats) are impregnated with a matrix material and are manually applied on a mandrel.

intumescent coating

a passive fire protection coating which in the presence of fire expands to create an inert "char" layer.

lot

a production quantity. When referred to pipe manufacture, a lot shall be defined as 100 units. When used in connection with the manufacture of fittings or spools, a lot shall be defined as components manufactured from the same materials during a single shift.

pipeline system

pipe with component parts subject to the same design conditions and typically used to transport fluids between wells and field facilities, processing plants and storage facilities.

piping system

pipe with components subject to the same design conditions and typically used within a processing facility. The piping system also includes pipe supports, but does not include support structures.

pressure rating

a rating for a component relating to its long term resistance to failure when subjected to either static or cyclic internal pressure loading.

product family

defines a range of pipes, fittings and joints manufactured by the same Manufacturer, using the same method and having the same constituent materials.

product family representative

the component (normally pipe plus joint) that is taken to be representative of that particular product family.

product sector

sub-division of a product family that groups pipes (plus joints) and fittings into specific diameter and pressure ranges.

product sector representative

the component taken to be representative of that sector and upon which the basic qualification testing is performed.

synthetic

primarily polyester fibres, typically used as reinforcement material for the resin rich internal liner, i.e. chemical barrier.

winding angle

angle of main reinforcement to pipe longitudinal axis, can be either positive or negative.

1.4 ABBREVIATIONS

BTX

benzene, toluene, p-xylene and o-xylene

GRE	Glass-fibre reinforced epoxy
GRP	Glass-fibre reinforced plastic
GRUP	Glass-fibre reinforced unsaturated polyester
GRVE	Glass-fibre reinforced vinyl ester
IPD	Cyclo aliphatic amine
LCL	97.5 % confidence limit of the long-term hydrostatic pressure or stress based on a 20-year lifetime
LTHP	extrapolated long-term mean static (or cyclic) failure pressure of a component, tested with free ends, and based on a 20-year lifetime
MDA	Aromatic Amine
P_{min}	Minimum pressure during pressure cycle
P_{max}	Maximum pressure during pressure cycle
R	Ratio of minimum / maximum pressure during cyclic service
SLT	Standard laboratory temperature
TP_{1000hrs}	Test pressure to be used in 1000-hour qualification test
T_g	Glass transition temperature
UV	Ultraviolet

1.5 CROSS REFERENCES

Where cross-references are made, the number of the section or sub-section referred to is shown in brackets. All publications referred to in this PTS are listed in (13).

1.6 CHANGES FROM THE PREVIOUS EDITION

The previous edition of this PTS was dated November 2003; a summary of the main changes since the last edition is given below.

Section	Change
General	- The previous edition of this PTS was written as amendments of and supplements to ISO 14692. Although certain parts of ISO 14692 are still referenced in this PTS it was considered unsuitable to continue to use it as the basis, because too many areas required amendments, supplements and more prescriptive requirements. - Added: experience and lessons learned from several GRP projects within PETRONAS, both upstream and downstream.
Chapter 2	Added: guidance on GRP material selection.
Chapter 3	Added: details on manufacturing methods and requirements for GRP components, including piping, fittings, and flanges.
Chapter 4	- Reduction of number of product sectors. - Added: qualification requirements for gas service.
Chapter 7	Added: design requirements for buried pipe systems.
Chapter 9	Added: installation requirements for buried pipe systems.
Chapter 10	Additional specific requirements for GRP pipelines
Appendix 1	Added: qualification requirements for pipe jointer, supervisor, and inspector.

1.7 APPLICATIONS

This PTS is generally applicable to:

- Onshore pipeline and piping systems and offshore piping systems for non-hydrocarbon applications;
- Onshore pipelines transporting oil and associated gas;
- Pipeline and piping systems for chemicals.

It is anticipated that the application of GRP will expand further in areas such as:

- Onshore and offshore piping systems for hydrocarbon liquids;
- Onshore pipeline systems for gas transport; and
- Offshore pipelines.

Typical applications for the use of GRP pipe include:

Boiler feed water	Hydrochloric acid
Brine	Hydrogen chloride gas, wet
Condensate (water and gas)	Injection water
Chlorine, gas, wet	(sour) Oil plus associated gas
Cooling water, sweet, brackish- /seawater	Potable water
Demin water	Process water
Diesel fuel	Produced water
Hydrocarbon drains	Sewer (grey and red)
Water / oil mixtures	Sour water
Fire water (ring main & wet or dry deluge)	Sodium hydroxide
Formation water	Water disposal

GRP materials may be appropriate for use in sour oil and gas applications, however, Regulatory Authorities and the Principal shall be consulted where this may be considered.

This PTS is applicable in the pressure-diameter range indicated by Figure 1, which represents a compromise between the current Group experience envelope of GRP pipelines and piping systems and commercial availability.

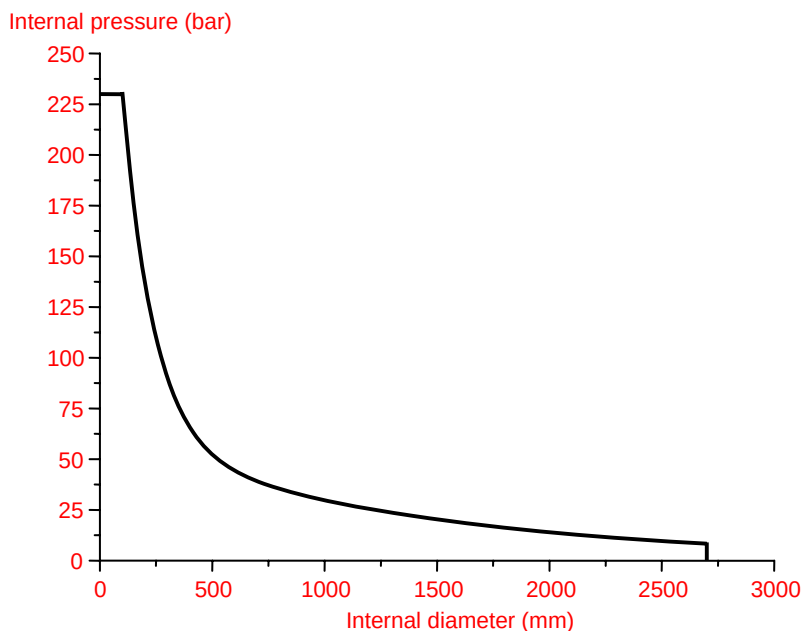


Figure 1 Current Group experience envelope of pressure/diameter range of GRP pipeline and piping systems

Current maximum diameter range for commercially available GRP pipe systems is the following:

- GRE (Epoxy): diameters up to 1600 mm;
- GRVE (vinyl ester) and GRUP (polyester): diameters up to 4000 mm;

The application of GRP piping classes for refining and chemicals is specified in PTS 31.38.01.12 , and includes cooling water, boiler feed water, fire fighting water, demineralised water, and hydrochloric acid.

The use of higher pressures or larger diameters outside the current experience envelope, i.e. diameter (mm) x pressure (MPa) greater than 2700, is permitted, subject to satisfactory qualification.

New applications are not specifically excluded from this PTS. However, in these cases an assessment should be made whether additional specifications and requirements are necessary. Such an assessment should show that safety and risk to personnel, the facilities and the environment will not be compromised by the application of a GRP pipeline or piping system.

1.8 PROJECT EXECUTION

Experience with GRP pipe systems shows that most problems (joints, leakages) are mainly caused by inadequate system design and poor installation, i.e. poor workmanship.

Therefore “single point” responsibility should be specified for GRP pipe installation projects, i.e. the Manufacturer of the GRP system shall carry out the following:

- System design;
- Product qualification and supply;
- Supervision of installation;
- Supervision of system hydro testing.

2. MATERIALS

2.1 GENERAL

The material selection process shall ensure that the material is compatible with the service fluids to which it is exposed over the full design temperature range so that the mechanical, physical and chemical properties of the GRP satisfy the design requirements throughout the intended lifetime.

2.2 RESINS

The resins selected shall be of a suitable commercial grade that complies with the technical requirements of the application.

The recommendations of the resin Manufacturer for the use of hardeners, catalysts and accelerators shall be followed.

The resin shall be compatible, over the full design temperature range, with the fluid being contained.

2.2.1 Epoxy resins

Epoxy resins are resistant to a wide range of moderately strong acids and alkalis, and most hydrocarbons. There are several types of base epoxy resins and associated curing agents.

Curing agents typically used for epoxy resin are:

- Aliphatic amine;
- Cyclo aliphatic amine (IPD);
- Aromatic Amine (MDA);
- Anhydride.

2.2.2 Polyester resins

For water services, e.g. sea-water cooling, Isophthalic polyester resin is typically used. Isophthalic polyester is a relatively low cost resin, with limited chemical resistance.

2.2.3 Vinyl ester resins

Compared to polyester, vinyl ester resin has very good chemical resistance, especially against acids. High temperature and chemical resistant vinyl ester based resins, e.g. Novolac vinyl ester, are also available.

2.2.4 Temperature limitations

The maximum allowable temperature is determined by the resin type and state of cure. Experience of typical GRP systems suggests the following maximum allowable temperatures (in air), depending on resin type (Table 1):

Table 1 Temperature limitations for GRP

Type GRP	Maximum allowable temperature	Typical T _g value of fully cured resin
Glass-fibre/epoxy (GRE) - Aromatic-amine cured (MDA) - Cyclo-aliphatic cured (IPD) - Aliphatic-amine cured - Anhydride cured	100 °C 100 °C 85 °C 85 °C	140 °C 140 °C 115 °C 115 °C
Glass-fibre/vinyl ester (GRVE) - Bisphenol A - Novolac	90 °C 100 °C	120 °C 140 °C
Glass-fibre/polyester (GRUP) - Isophthalic	60 °C	90 °C

The temperatures listed in Table 1 are for initial guidance only.

The maximum allowable temperature for GRP, however, may be considerably lower, depending on the aggressiveness of the specific fluid and its concentration.

The minimum recommended temperature for GRP regardless of the resin system is minus 40 °C although lower temperatures may be considered.

2.2.5 Chemical resistance

The resin Manufacturer shall supply chemical resistance data for the relevant service fluids and the specific resin material, quoting the highest known service temperature that the material has been subjected to and, if available, the service life that has been achieved under the service conditions.

The chemical resistance information shall state whether the material has been laboratory tested according to ASTM C 581 (or other equivalent standard). Guidance on the selection of GRP is given in Table 2:

Table 2 Chemical resistance of GRP material

Fluid type	GRE Aliphatic	GRE Aromatic	GRE Anhydride	GRVE Vinyl ester	GRUP Polyester
Acids	Poor	Poor	Good	Very good	Poor
Alkalis (caustic)	Very good	Very good	Poor	Good	Not resistant
Solvents (BTX)	Good	Good	Poor	Poor	Not resistant
Water sea/brackish	Good	Good	Good	Good	Good

The following aggressive chemicals may be transported in GRP piping or pipeline systems, with the following restrictions:

- Hydrochloric acid, up to 37 % concentration, e.g. used in demin units. GRE (epoxy) has limited resistance against hydrochloric acid (< 10 %) and therefore GRVE (vinyl ester) shall be used, lined with a resin rich layer (liner), reinforced with double C-glass veil;
- Sodium hydroxide (caustic), up to 50 % concentration, e.g. used in chemical plants. Glass-fibre is not resistant against sodium hydroxide, and therefore only "lined" GRE or GRVE shall be used. The resin rich liner shall be reinforced with double synthetic veil (e.g. Nexus), and thickness of the liner shall be minimum 1.5 mm;

- Sodium hypochlorite solution, e.g. used in chlorination units. Sodium hypochlorite, typically produced on-site using electrolytic cells, i.e. concentrations typically up to 1 %, and pH in the range 9 to 10, will attack all thermoset resins. However, UPVC lined GRVE is a proven option for the transport of sodium hypochlorite.

Further information about chemical resistance of resins typically used for GRP, in a variety of chemical environments, is given in PTS 30.10.02.13.

2.3 REINFORCING MATERIALS

The principal reinforcing material for the structural wall of GRP piping shall be a suitable grade of glass fibre having a glass finish compatible with the resin system used. Other types of reinforcement fibres may be used, to be agreed by the Principal.

Fibre reinforcement materials typically used for GRP pipeline and piping systems are:

- **E-glass**, the most commonly used type of glass. It is relatively inexpensive and has good mechanical properties. However, E-glass has limited chemical resistance and shall therefore be protected by the resin from direct exposure to the fluid;
- **C-glass** has a higher degree of chemical resistance than E-glass. It is used where the fluid may come into contact with the reinforcement, e.g. C-glass veil used in the liner of GRP pipe;
- **ECR glass** offers improved chemical resistance over C-glass. ECR-glass veil is often used as reinforcement material for the resin rich internal liner when severe corrosive conditions may occur.
- **Synthetic veil**, primarily polyester fibres, typically used as reinforcement material for the resin rich internal liner, in chemical service.
- **Carbon**. Single carbon fibre rovings may be included within the structural wall of GRP piping to achieve an electrically conductive wall to prevent build up and discharge of static electricity.

2.4 GASKET MATERIALS

The gasket material, e.g. used for flanges, shall match the pressure, temperature and chemical resistance capabilities of the piping system. Further information about the chemical resistance of non-metallic materials in a variety of chemical environments is given in PTS 30.10.02.13.

For chemical services, expanded PTFE flange gaskets, so-called e-PTFE should be used. Compared to the traditional full-density PTFE, expanded PTFE has excellent resistance against creep, cold flow, and blow-out.

2.5 INTERNAL SURFACE

For GRP pipe systems transporting non-aggressive fluids, e.g. water, crude oil, hydrocarbons, etc., an internal resin-rich liner with minimum thickness of 0.5 mm shall be applied, which may be reinforced with C glass or ECR glass veil.

For GRP pipe systems transporting chemicals, e.g. hydrochloric acid or caustic, an internal resin-rich liner, reinforced with veil of C glass, ECR glass, synthetic fibre, or other suitable material shall be used. Thickness of the liner shall be minimum 1.5 mm, and the fibre reinforcement content should be in the range 20 % to 30 % by weight.

2.6 UV PROTECTION

To protect the external GRP surface against weathering, sunlight, UV, etc., a resin-rich external layer shall be applied, with a thickness of at least 0.5 mm.

Exposure of GRP to intense sunlight, UV radiation, e.g. in tropical (desert) areas, may cause local resin degradation and fibre bloom, and it may result in loose fibres on the surface of the pipe wall. Generally, the degradation is skin deep and causes no significant loss in mechanical strength.

If specified by the Principal, the external resin layer may be pigmented to provide suitable resistance to UV degradation effects, e.g. using carbon black (3 % by weight) filler. To increase UV resistance, the application of an UV resistant coating may also be considered, e.g. white-pigmented polyurethane or epoxy.

2.7 FIRE RESISTANCE

Generally the fire resistance of GRP pipe is good, and can be further increased by the application of a fire retardant, intumescent coating.

GRP is acceptable for application in dry piping for fire protection systems provided that the water flow through the piping can be initiated before its dry survival time limit.

GRP piping is also an attractive option for tank farm fire piping, i.e. the dry riser piping and the main ring line for the foam sprinkler installation on tanks. There is already a significant track record for GRP pipe used in tank farm sprinkler installations.

3. MANUFACTURING

3.1 GENERAL

For manufacturing GRP pipe components, filament winding, and/or hand lay-up shall be used. Sand-filled GRP pipe and fittings shall not be used for pipeline and piping systems.

3.2 FILAMENT WINDING

Filament winding is the process of impregnating glass fibre reinforcement with resin, then applying the wetted fibres onto a mandrel in a prescribed pattern, and thickness. Chopped glass rovings may be used as additional reinforcement. Filament winding includes reciprocal and continuous filament winding.

▪ Reciprocal filament winding

Reciprocal filament winding is the most widely used manufacturing method for GRP pipe components. The winding angle of the component is controlled by the synchronised translation speed of the fibre/resin bath and the rotational speed of the mandrel.

▪ Continuous filament winding

Continuous filament winding is made using a continuously advancing mandrel. The pipe wall of the system consists of a combination of helical wound layers of glass-fibre reinforced resin, and additional layers of chopped glass-fibres reinforced resin.

3.3 PIPE

Pipe components shall be manufactured by filament winding. Glass-fibre reinforced epoxy (GRE) filament wound pipe is commercially available up to a diameter of maximum 1600 mm. Filament wound glass-fibre reinforced vinyl ester (GRVE) and polyester (GRUP) pipe are commercially available up to a diameter of 4000 mm. Standard length of GRP pipe manufactured by reciprocal filament winding is typically 9 to 12 meter.

Continuous filament wound pipe is commercially available up to a diameter of 4000 mm. For transportation purposes, standard length of the continuous filament wound pipe, type Drostholm, is restricted to approximately 12 meter.

3.4 FITTINGS

Bends (elbows) shall be manufactured by filament winding, or hand lay-up, or by joining standard GRP pipe sections, using laminated joints, to form so-called "mitered bends". Mitered bends are often used for relative large diameter pipe systems, typically greater than 1000 mm.

Tees, and reducing tees shall be manufactured by hand lay-up, or by joining standard GRP pipe sections, using laminated joints.

3.5 FLANGES

3.5.1 General

Flanges shall be manufactured by filament winding and/or hand lay-up. Filament winding is typically used for flanges smaller than 500 mm, and hand-lay up for larger diameter flanges.

The outside diameter and hole spacing of GRP flanges shall meet the requirements of ASME B16.5, and the flanges shall be flat face.

For flange diameters larger than 1000 mm, an O-ring based seal design may be selected, to be agreed by the Principal.

Flanges with an O-ring seal require special moulding and tooling (O-ring groove) and are typically fabricated by the filament winding process.

Two types of flanges are typically used:

- Integral-type flange, adhesive-bonded or laminated to the GRP pipe ends;
- Loose ring type flanges, with GRP collars adhesive-bonded or laminated to the pipe ends (stub-end) with loose backing flanges in GRP or steel.

3.5.2 Hand lay-up

Hand lay-up is the simplest manufacturing technique for flanges and involves applying layers of resin-impregnated mat or woven roving to a mould by hand. Manufacturing of hand lay-up flanges shall be in accordance with ASTM D 5421. For maximum mechanical properties and chemical resistance, flanges shall be post-cured.

3.5.3 Filament winding

Filament winding of flanges involves wrapping continuous roving wetted with resin over a mould. Manufacturing of filament wound flanges shall be in accordance with ASTM D 4024. For optimal mechanical properties and chemical resistance, flanges shall be post-cured.

Filament wound flanges are strong in the hoop direction but weak in axial bending. To prevent cracking in the flange during loading, e.g. during assembly, the neck area of the flange shall be reinforced with continuous fibres, e.g. mat or woven rovings.

4. QUALIFICATION

The qualification programme consists of standard methods for quantifying GRP pipe component performance with respect to internal pressure and elevated temperature.

Qualification of GRP pipe components shall be achieved through performance-based procedures. This effectively means that the GRP Manufacturer shall demonstrate, through testing, that its products will satisfy the design specifications.

The qualification programme includes testing of components in order to provide baseline data for quality control.

4.1 PRESSURE RATING

4.1.1 General

Manufacturers generally assign all components a nominal pressure rating (NPR), the rating given in the Manufacturers' brochures. This rating involves assumptions about the relationship between certain qualification tests, long-term hydrostatic pressure strength (LTHP), lower confidence limit (LCL), design life, operating temperature, transported fluids and safety factor(s) as well as certain pipeline or piping system design factors.

The rating methodology varies between Manufacturers as the NPRs are often based on different assumptions and test methods. The NPRs quoted by the Manufacturers, therefore, do not always allow an objective comparison between different products and it is not always clear whether the products will meet the specified performance.

To overcome this, a simplified product qualification process is used which requires that pipe and all components survive a 1000-h test (4.4) at the Principal's given system design pressure multiplied by an appropriate factor. The factors have been determined from extensive Group experience with the qualification of GRP piping and pipelines from projects over the past 10 years.

For product, piping and pipeline design, the Manufacturer shall establish the LCL_{static} and/or LCL_{cyclic} values for the product family (4.3) being made. This shall be determined in accordance with the requirements of ASTM D 2992, Procedure A and/or Procedure B, as appropriate, and at a minimum test temperature of 65 °C, or design temperature if higher, and with unrestrained ends. For GRUP, the maximum test temperature shall be 60 °C. For the test fluid, fresh water shall be used.

Where a Manufacturer has not established the LCL, a default value shall be used; see Table 3:

Table 3 Default LCL (hoop stress, reinforced wall) values for GRP pipe component

Type GRP	Default LCL_{static}	Default LCL_{cyclic}
Glass-fibre/epoxy (GRE) - Aromatic-amine cured (MDA) - Cyclo-aliphatic cured (IPD) - Aliphatic-amine cured - Anhydride cured	110 MPa (≤ 65 °C) 85 MPa (> 65 °C)	55 MPa (≤ 65 °C) 43 MPa (> 65 °C)
Glass-fibre/vinyl ester (GRVE) - Bisphenol A - Novolac	70 MPa (≤ 65 °C) 55 MPa (> 65 °C)	35 MPa (≤ 65 °C) 28 MPa (> 65 °C)
Glass-fibre/ Isophthalic polyester (GRUP)	70 MPa (≤ 60 °C)	35 MPa (≤ 60 °C)

4.1.2 Cyclic Service

When the number of pressure cycles during the design life of the pipeline or piping system exceeds 7000, and the pressure fluctuation ratio R is smaller than 0.8, then the service shall be considered cyclic.

R is defined as:

$$R = \frac{P_{\min}}{P_{\max}}$$

Where $P_{\min}$ and $P_{\max}$ are the minimum and maximum values of the pressure cycle.

NOTE: $R = 0$ corresponds to fully cyclic service whereas $R = 1$ corresponds to static service.

When cyclic pressure qualified components are not available, de-rated static pressure qualified components may be used, to be agreed by the Principal.

The cyclic pressure rating shall be calculated from the following relationship:

$$LCL_{\text{cyclic}} = \frac{LCL_{\text{static}}}{2}$$

4.2 TEST REQUIREMENTS

The Manufacturer shall demonstrate by pressure testing that all components, i.e. pipe + joint, fittings (tees, wyes, bends, reducers), instrument/small-bore connections, flanges, etc., are fit-for-purpose, i.e. are capable of meeting the typical 20 year design life requirement for the pipeline or piping system.

All tests shall be carried out, or witnessed and certified by an independent third party authority, to be approved by the Principal.

4.3 COMPONENT DEFINITIONS

In order to keep the total test burden within acceptable limits but at the same time to control the use of test data beyond their limits of applicability, the concept of a product family and its sub-divisions is used in the next sections.

A **product family** defines a range of pipes, fittings and joints manufactured by the same Manufacturer, using the same method and having the same constituent materials.

The **family representative** is the component that is taken to be representative of that particular product family. It is the family representative that is tested under ASTM D 2992 to determine the long-term behaviour and LCL, of the product. Testing shall be carried out on pipe product with a diameter of 50 mm or larger.

A **product sector** is a sub-division of a product family that groups pipes (plus joints) and fittings into specific diameter and pressure ranges.

The **product sector representative** for a product sector is the component that is representative of that sector and upon which the basic qualification testing (4.4) is performed.

Qualification of the product sector representative also qualifies similar components with smaller diameter which are part of that product sector.