INTERNATIONAL STANDARD

ISO 14692-1

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Petroleum and natural gas industries — Glass-reinforced plastics (GRP) piping —

Part 1: **Vocabulary, symbols, applications and materials**

Industries du pétrole et du gaz naturel — Canalisations en plastique renforcé de verre (PRV) —

Partie 1: Vocabulaire, symboles, applications et matériaux

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 14692-1 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 6, *Processing equipment and systems*.

ISO 14692 consists of the following parts, under the general title *Petroleum and natural gas industries — Glass-reinforced plastics (GRP) piping*:

— *Part 1: Vocabulary, symbols, applications and materials*

— *Part 2: Qualification and manufacture*

— *Part 3: System design*

— *Part 4: Fabrication, installation and operation*

Introduction

ISO 14692 (all parts) for the use of glass-reinforced plastics (GRP) piping in oil and natural gas industries is based on the document *Specifications and recommended practice for the use of GRP piping offshore* published by the United Kingdom Offshore Operators Association (UKOOA) in 1994. The objective of ISO 14692 (all parts) is to provide the oil and gas industry, and the supporting engineering and manufacturing industry, with mutually agreed specifications and recommended practices for the design, purchase, manufacturing, qualification testing, handling, storage, installation, commissioning and operation of GRP piping systems.

ISO 14692-2, ISO 14692-3 and ISO 14692-4 follow the individual phases in the life cycle of a GRP piping system, i.e. from design through manufacture to operation. Each part is therefore aimed at the relevant parties involved in that particular phase. It is primarily intended for offshore applications on both fixed and floating topsides facilities, but it may also be used as guidance for the specification, manufacture, testing and installation of GRP piping systems in other similar applications found onshore, e.g. produced-water and firewater systems.

— *Part 1: Vocabulary, symbols applications and materials*. It defines terms and symbols, and identifies the applications that ISO 14692 (all parts) is intended to cover, together with anticipated end users. It also defines limits on the material used for the construction of components and describes the pressure terminology used throughout ISO 14692 (all parts). Main users are envisaged to include all parties in the life cycle of a typical GRP piping system. ISO 14692-1 should be used in conjunction with the part of specific relevance.

— *Part 2: Qualification and manufacture.* Its objective is to enable the purchase of GRP components with known and consistent properties from any source. Main users of the document are envisaged to be the principal and the manufacturer, certifying authorities and government agencies.

— *Part 3: System design.* Its objective is to ensure that piping systems, when designed using the components qualified in ISO 14692-2, meet the specified performance requirements. Main users of the document are envisaged to be the principal, design contractors, suppliers contracted to do the design, certifying authorities and government agencies.

— *Part 4*: *Fabrication, installation and operation.* Its objective is to ensure that installed piping systems meet the specified performance requirements throughout their operational life. Main users of the document are envisaged to be the principal, fabrication/installation contractors, repair and maintenance contractors, certifying authorities and government agencies.

Petroleum and natural gas industries — Glass-reinforced plastics (GRP) piping —

Part 1: Vocabulary, symbols, applications and materials

1 Scope

This part of ISO 14692 gives the terms, definitions and symbols used in the specification, manufacture, testing and installation of glass-reinforced plastics (GRP) piping installations associated with offshore applications on both fixed and floating topsides facilities for oil and gas industry production and processing. It also describes the philosophy and provides guidance on the range of suitable applications for such piping, and defines limitations to the materials of construction for these applications.

It is intended to be used in conjunction with the other parts of ISO 14692.

This part of ISO 14692 also describes the pressure terminology used in ISO 14692 (all parts).

2 Terms and definitions

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

2.1 General terms

2.1.1
authority having jurisdiction
third-party organization required to be satisfied with the standard of engineering proficiency and safety of a project

EXAMPLE A classification society, verification body or government regulatory body.

2.1.2
contractor
party which carries out all or part of the design, engineering, procurement, construction and commissioning for a project or operation of a facility

NOTE The **principal** (2.1.9) may undertake all or part of the duties of the contractor.

2.1.3
designer
party which carries out all or part of the design for a project or facility

2.1.4
installer
party which carries out all or part of the construction and commissioning of composite pipe installations and installation work for a project

2.1.5
installation inspector
person able to perform satisfactory and independent inspection of composite pipe installations and installation work

2.1.6
installation supervisor
tradesman able to perform practical supervision of the installation and joining of composite pipes

2.1.7
manufacturer
party which manufactures or supplies equipment to perform the duties specified by the contractor

2.1.8
operator
party which assumes ultimate responsibility for the operation and maintenance of the piping system

NOTE The operator may or may not be the same as the principal or principal's agent.

2.1.9
principal
party that initiates the project and ultimately pays for its design and construction

NOTE The principal generally specifies the technical requirements and is ultimately responsible for ensuring that safety and all other issues are addressed. The principal may also include an agent or consultant, authorized to act for the principal.

2.1.10
site
location where piping system is installed

2.2 Technical terms

2.2.1
accelerator
substance which, when mixed with a catalyst or a resin, will speed up the chemical reaction between catalyst and resin

2.2.2
active fire protection
method of extinguishing fire by application of substances such as halon, water, CO_2, foam, etc.

2.2.3
adhesive joint
adhesive bond
bonded joint
glued joint
socket joint
rigid type of joint between two components made using an adhesive

NOTE Generally consists of a slightly conical (tapered) bell end and a machined (cylindrical or tapered) spigot end.

2.2.4
anisotropic
exhibiting different properties when tested along axes in different directions

2.2.5
carbon fibre
fibre produced by the pyrolysis of organic precursor fibres, such as rayon, polyacrylonitrile or pitch, in an inert environment

2.2.6
cavitation
formation of pockets of vapour in a liquid that suddenly collapse, causing very high localized pressures which can lead to serious erosion of boundary surfaces

2.2.7
chemical-resistant glass
glass fibre or synthetic veil having a specific chemical resistance against acids

NOTE Such glass is used primarily as a reinforcement for the resin-rich internal liner of GRP pipe

2.2.8
collapse pressure
external pressure differential which causes buckling collapse of a component

2.2.9
component variant
individual component

2.2.10
composite
reinforcing fibres laid up in a resin matrix

2.2.11
composite pipe
pipe manufactured using fibre-reinforced thermoset plastics

NOTE Thermoplastic resins are excluded from ISO 14692 (all parts).

2.2.12
chopped strand mat
CSM
reinforcement structure in which short lengths of glass fibre tows, held together by an emulsion or powder binding agent, are dispersed in random directions within a single plane

2.2.13
cure
change irreversibly the properties of a thermosetting resin by chemical reaction

NOTE 1 Examples of such chemical reaction are condensation, ring closure and addition.

NOTE 2 Cure may be accomplished by the addition of a cross-linking agent, with or without heat and pressure.

2.2.14
cure cycle
time/temperature/pressure cycle used to cure a thermosetting resin system

2.2.15
curing agent
catalytic or reactive agent that, when added to a resin, causes polymerization

NOTE Also called hardener, for epoxies.

2.2.16
delamination
separation of two adjacent plies or layers of material in a laminate resulting from lack of adhesion

NOTE May occur either locally or covering a wide area.

2.2.17
design external pressure
maximum positive external pressure differential, i.e. external minus internal pressure, intended to be experienced by a component during its service life

2.2.18
design pressure
maximum positive internal pressure differential, i.e. internal minus external pressure, intended to be experienced by a component during its service life

2.2.19
design temperature
for each design condition, maximum fluid temperature that can be reached during service

2.2.20
differential scanning calorimetry
DSC
method for determining the glass transition temperature of a polymer

2.2.21
dynamic mechanical thermal analysis
DMTA
method for determining the glass transition temperature of a polymer or **FRP** (2.2.33) component

2.2.22
earth, verb, GB
ground, verb, US
provide electrical contact with earth

2.2.23
E-glass
glass fibre normally used to reinforce **GRP** (2.2.48) pipes, consisting mainly of SiO_2, Al_2O_3 and MgO

2.2.24
elastomeric bell-and-spigot seal lock joint
rubber seal lock joint
rubber sealed key lock joint
joint connection made up of a spigot end and a socket end with “O” or lip-sealing rings

2.2.25
electrically conductive
conductive
having a volume resistivity equal to or lower than 10^4 Ω·m

2.2.26
electrostatic dissipative
conductive
having a volume resistivity higher than 10^4 Ω·m but lower than 10^9 Ω·m or a surface resistivity less than 10^{10} Ω measured at ambient temperature and 50 % relative humidity

2.2.27
environmental stress cracking
ESC
formation of cracks in a polymer or composite caused by exposure to a chemical or environment under stress

2.2.28
epoxide
epoxy
compound containing at least two epoxy or oxirane rings

NOTE 1 Chemically, an epoxy ring is a three-membered ring containing two carbon atoms and one oxygen atom.

NOTE 2 The most widely used epoxy resin is termed DGEBA (diglycidyl ether of bisphenol A). Epoxy resins are always used in conjunction with curing agents or hardeners, i.e. substances that react with the epoxy rings, producing hydroxyl groups and other products, and linking the originally linear molecules into a rigid three-dimensional network.

2.2.29
factored qualified pressure
pressure to be used in determining the safe operating envelope of the GRP pipe or piping system

NOTE Factored qualified pressure is based on the qualified pressure and takes account of specific service conditions that could not be considered in the qualification programme, e.g. temperatures other than 65 °C and the effect of exposure to chemical environments other than water.

2.2.30
factored stress
hoop stress based on the **factored qualified pressure** (2.2.29)

2.2.31
failure
loss of structural integrity and/or transmission of fluid through the wall of a component or a joint

2.2.32
fibre
filamentary material with a finite length that is at least 100 times its diameter and prepared by drawing from a molten bath, spinning or deposition on a substrate

NOTE Filaments are usually of extreme length and very small diameter, usually less than 25 µm. Normally, filaments are assembled as twisted (yarn) or untwisted (tow) bundles comprising hundreds of filaments.

2.2.33
fibre-reinforced plastic
FRP
plastic-based composite that is reinforced with any type of fibre, not necessarily glass

2.2.34
filament winding
process for fabricating a composite structure in which continuous reinforcements, e.g. fibre tows, are either previously impregnated with a matrix material or impregnated during the winding

2.2.35
fire classification code
code designation of the fire performance of pipe component in terms of fire endurance and fire reaction properties

2.2.36
fire endurance
fire resistance
ability to maintain functional performance in a fire

2.2.37
fire-reaction property
material property which contributes to spread of fire, heat release and smoke/toxic emissions

2.2.38
fitter
jointer
pipe bonder
tradesman able to perform satisfactory and independent work in the installation and joining of composite pipes

2.2.39
fitting
pressure-tight fluid-containing components with a geometry different from straight pipe.

EXAMPLES Flanges, tees, elbows, reducers and fabricated branch.

2.2.40
flame retardant
chemical that is used to reduce or eliminate the tendency of a resin to burn

2.2.41
flange joint
mechanical joint with face flanges for which the bolt circle and face dimensions conform to a recognized standard

2.2.42
flexibility factor
ratio of the flexibility in bending of a component/fitting to that of the flexibility of a straight pipe of the same lamination, Young's modulus and thickness having a length corresponding to the developed length of the fitting

2.2.43
free-end testing
pressure-testing arrangement using pipe end closures of a type such that internal pressure produces axial, as well as hoop and radial, stresses in the component wall

cf. **axial load-free testing** (2.2.110)

2.2.44
function
ability of the piping system to perform its primary purpose, i.e. to deliver a minimum quantity of fluid above a minimum pressure

2.2.45
furnace test
test in a compartment furnace where the time-temperature curve to be followed is to a defined standard

2.2.46
gel coat
quick-setting resin applied to the surface of a mould and gelled before lay-up

NOTE The gel coat becomes an integral part of the finished laminate, and is usually used to provide specific service characteristics (see **liner**, 2.2.69).

2.2.47
glass-fibre-reinforced epoxy
GRE
epoxy resin-based composite that is reinforced with glass fibre

2.2.48
glass-fibre-reinforced plastic
GRP
fibreglass
composite
reinforced plastic
reinforced thermosetting resin plastic
RTR plastic
polymeric resin-based composite that is reinforced with glass fibre

NOTE 1 The predominant glass fibre is **E-glass** (2.2.23).

NOTE 2 ISO 14692 (all parts) is restricted to the use of **thermosetting** (2.2.120) resins.

2.2.49
glass transition temperature
T_g
temperature at which amorphous polymer undergoes a marked change in properties on passing from the rubbery to glassy state

NOTE This observed change in properties is associated with the virtual cessation of local molecular motion in the polymer. Below their glass-transition temperature, amorphous polymers have many of the properties associated with ordinary inorganic glasses, whilst above this temperature the polymers possess rubbery characteristics.

2.2.50
grounding clamp
metal fitting attached to the pipe component to provide an electrical connection to earth

2.2.51
hand lay-up
process for fabricating a composite structure in which discontinuous reinforcements, e.g. woven mats, chopped strand mats, are impregnated with a matrix material and are manually applied on a mandrel

2.2.52
hardener
substance or mixture added to a plastic composition to promote or control the curing action by taking part in it

2.2.53
hazardous area
three-dimensional space in which a flammable atmosphere may be expected to be present frequently enough to require special precautions for the control of potential ignition sources

2.2.54
heat-distortion temperature
temperature at which a standard test bar deflects a specified amount under a stated load

2.2.55
heat flux
density of heat flow rate
quantity of heat divided by area and time

2.2.56
hydrocarbon pool fire
fire caused by ignition of a pool of hydrocarbon liquid

2.2.57
hydrotest
pressure test to verify the pressure-retention integrity of a piping system after installation

cf. **mill hydrostatic test** (2.2.78)

NOTE Also used as a leak test.

2.2.58
impregnate
saturate the reinforcement with a resin

2.2.59
incendive discharge
electrostatic spark discharge of sufficient energy to ignite a flammable atmosphere

2.2.60
integrity
minimum structural capability required to enable the pipe system to fulfil its function

2.2.61
intumescent
passive fire-protection coating which, in the presence of fire, expands to create an inert “char” layer

2.2.62
jet fire
turbulent diffusion flame resulting from the combustion of a fuel continuously released with significant momentum in a particular range of directions

2.2.63
joint
means of connecting two or more components

EXAMPLE Plain pipe to a fitting, or plain pipe to plain pipe.

2.2.64
laminae
thin sheets of reinforcing fibres in a resin matrix built up into a flat or curved arrangement

2.2.65
laminate, verb
unite laminae with a bonding material, usually using pressure and heat

NOTE Normally used with reference to flat sheets, but can also refer to tubes. A product made by such bonding is referred to as a laminate.

2.2.66
laminated joint
butt-and-wrap joint
butt-and-strap joint
butt-welded joint
joint consisting of plain-ended pipe and fittings laminated together with reinforcing fibres and resin/hardener mixture

2.2.67
laying length
actual length of a line, corresponding to the initial length plus the increase afforded by the fitting or integral joint when installed

2.2.68
leak test
pressure test to determine the presence of leaks at joints

NOTE Usually carried out at a pressure lower than the hydrotest and for a longer period.

2.2.69
liner
continuous resin-rich coating on the inside surface of a pipe component, used to protect the laminate from chemical attack or to prevent leakage under stress

NOTE The liner may also be used to provide enhanced abrasion and erosion resistance.

2.2.70
long-term hydrostatic pressure
LTHP
extrapolated long-term mean static failure pressure of a component with free ends based on a 20-year lifetime

NOTE LTHP is determined in accordance with ASTM D2992 Procedure B.

2.2.71
long-term hydrostatic strength
LTHS
extrapolated long-term mean failure strength of a plain pipe with free ends based on a 20-year lifetime

NOTE LTHS is determined in accordance with ASTM D2992 Procedure B.

2.2.72
lower confidence limit
LCL
97,5 % confidence limit of the long-term hydrostatic pressure or stress based on a 20-year lifetime

2.2.73
mandrel
core tool around which resin-impregnated reinforcement is wound to form pipes, fittings and structural shell shapes

2.2.74
manufacturer's pressure rating
pressure rating given by manufacturer in product literature

2.2.75
matrix
homogeneous resin or polymer material in which the fibre system is imbedded in a laminar arrangement

2.2.76
mechanical joint
joint between GRP piping components which is not made by bonding

NOTE A mechanical joint typically involves use of proprietary devices.

2.2.77
megohmmeter
high-voltage instrument used for measuring electrical resistance

2.2.78
mill hydrostatic test
short-term hydrotest at the mill, or factory, used as a quality control check which is carried out at a pressure above the design pressure

2.2.79
modulated differential scanning calorimetry
MDSC
type of **DSC** (2.2.20) which enables reversible reactions to be distinguished from irreversible processes

2.2.80
nominal diameter
numerical designation of size that is common to all components in a piping system, other than components designated by outside diameters or by thread size

NOTE It is a convenient round number for reference purposes and is only loosely related to manufacturing dimensions.

2.2.81
operating pressure
normal or anticipated standard internal pressure difference, i.e. internal minus external pressure, to be experienced by the pipe or piping system which should not exceed the design pressure

2.2.82
ovality
irregularity of the circular section of a component, quantified by the difference in the largest and smallest cross-sectional axes

2.2.83
part factor f_1
ratio of the 97,5 % confidence limit of LTHP to the mean value of LTHP

2.2.84
part factor f_2
derating factor related to confidence in the pipework system, the nature of the application and the consequences of failure

2.2.85
part factor f_3
part factor that takes account of non-pressure-related axial loads, e.g. bending

2.2.86
passive fire protection
method of minimizing fire damage by use of sacrificial or non-combustible coatings

2.2.87
performance standard
defined limit placed on characteristics of materials, products or services

2.2.88
phenolic
class of polymer resins made from phenol and formaldehyde, and cured by air drying or heat baking

NOTE Chemical resistance can be further increased via heat and catalyst treatment.

2.2.89
pipe support
pipe fixture or structural attachment which transfers the load from the pipe or structural attachment to the supporting structure or equipment

NOTE 1 Fixtures include hanging-type fixtures such as hanger rods, spring hangers, sway braces, counterweights, turnbuckles, struts, chains, guides and anchors; and bearing-type fixtures such as saddles, bases, rollers, brackets and sliding supports.

NOTE 2 Structural attachments include elements which are bonded or moulded into the pipe, such as clips, lugs, rings, clamps, clevises, straps and skirts.

2.2.90
piping
assemblies of piping components used to convey, distribute, mix, separate, discharge, meter, control or restrict fluid flows

2.2.91
piping component
component
mechanical element suitable for joining or assembly into a pressure-tight fluid-containing piping system

EXAMPLES Pipe, fittings, flanges, gaskets, bolting, valves, and devices such as expansion joints, flexible joints, pressure hoses, liquid traps, strainers and in-line separators.

2.2.92
piping system
interconnected piping subject to the same set or sets of design conditions

NOTE The piping system also includes pipe supports, but does not include support structures.

2.2.93
pipeline system
pipe with components subject to the same design conditions and typically used to transport fluids between wells and field facilities, field facilities and processing plants, processing plants and storage facilities

2.2.94
Poisson's ratio
ratio of axial strain to the corresponding hoop strain below the proportional limit

2.2.95
proportional limit
greatest stress which a material is capable of sustaining without deviation from linear proportionality of stress and strain

2.2.96
postcure
additional elevated-temperature cure, usually without pressure, to improve final resin properties and/or complete the cure, or decrease the percentage of volatiles in the compound

NOTE In certain resins, complete cure and ultimate mechanical properties are attained only by exposure of the cured resins to temperatures higher than those of curing.

2.2.97
pot life
length of time that a catalysed thermosetting resin system retains a viscosity low enough to enable processing and sufficient reactivity to achieve specified properties after processing

2.2.98
pressure rating
rated pressure
rating for a component, relating to its long-term resistance to failure when subjected to either static or standardized cyclic internal pressure loading

2.2.99
pressure stress multiplier
PSM
fractional increase in hoop stress loading due to applied axial loads acting on a fitting

2.2.100
product family
component type all of whose variants have the same function

EXAMPLES Plain pipe, bend, tee, reducer, etc.

2.2.101
product family representative
component that is taken to be representative of that particular **product family** (2.2.100)

NOTE Examples include plain pipe, pipe plus joint, elbows and reducers, tees, and flanges. Also included are fabrication processes used in the factory or on-site, that are not qualified as part of the process for manufacturing stock items.

2.2.102
product sector
subdivision of a **product family** (2.2.100) that groups variants into specific diameter and pressure ranges

2.2.103
product sector representative
component variant taken to be representative of that **product sector** (2.2.102) and upon which the basic qualification testing is performed

2.2.104
qualification
process of demonstrating that a component is in accordance with the requirements of ISO 14692-2

2.2.105
qualified pressure
component pressure rating determined in accordance with qualification requirements given in 2.2.104

2.2.106
qualified stress
hoop stress based on the **qualified pressure** (2.2.105)

2.2.107
rated temperature
maximum design temperature at the factored pressure determined in accordance with ISO 14692-2 and ISO 14692-3

2.2.108
reducer
component that allows pipes of different sizes to be connected

2.2.109
reinforcement
strong material embedded into a matrix to improve its mechanical properties

NOTE Reinforcements are usually long fibres, whiskers, particulates, etc. The term should not be used synonymously with filler.

2.2.110
axial load-free testing
pressure-testing arrangement using a pipe-sealing device or mechanism such that internal pressure produces hoop and radial stresses only in the component wall

2.2.111
roving
number of strands, tows or ends collected into a parallel bundle with little or no twist

2.2.112
saddle
length of an arc of GRP material adhesively bonded to the outside of the pipe

2.2.113
short-term hydrostatic pressure
STHP
short-term burst pressure determined with free ends at **SLT** (2.2.116)

NOTE STHP is determined in accordance with ASTM D1599.

2.2.114
sizing agent
coating on glass fibres used to promote bonding of glass-reinforcement to resin

2.2.115
spoolpiece
permanent assembly of pipe and fittings fabricated in the factory using laminated or adhesive joints

2.2.116
standard laboratory temperature
SLT
temperature as defined by a recognized standard with standard tolerance

EXAMPLE 23 °C ± 2 °C.

2.2.117
stress intensification factor
SIF
ratio of the actual/effective stress in a component/fitting under external load to the nominal stress in that component/fitting as determined based on a straight pipe run with the same section modulus and Young's modulus

2.2.118
system
assembled section of piping consisting of a representative range of pipes, fittings, connections, attachments, supports, penetrations and associated coatings, e.g. for thermal insulation or fire protection, as would be found in service

2.2.119
thermoset
plastic which, when cured by application of heat and/or chemical reaction, changes into a substantially infusible and insoluble material

2.2.120
thermosetting polyester
thermosetting class of resin produced by dissolving unsaturated, generally linear, alkyd resins in a vinyl-type active monomer such as styrene, methylstyrene or diallyl phthalate

NOTE Cure is effected through vinyl polymerization using peroxide catalysts and promoters or heat to accelerate the reaction.

2.2.121
tow
untwisted fibrous bundle

2.2.122
tow tex
mass of a fibrous bundle expressed per unit length

2.2.123
tribocharging
generation of electrostatic charge caused by moving contact of one insulating material over another

2.2.124
type
components of common function

NOTE Pipes, prime connections, flanges, reducers, tees and elbows are examples of different component types.

2.2.125
type testing
exposure of a system to a fire insult to qualify the assembled system components for a defined range of service conditions

2.2.126
ultraviolet radiation
UV
electromagnetic radiation in the frequency band just above the visible spectrum

2.2.127
variant
component with a unique combination of nominal diameter, type and pressure rating

2.2.128
vinyl ester
class of thermosetting resin containing esters of acrylic and/or methacrylic acids, many of which have been made from epoxy resin

NOTE Cure is accomplished, as with unsaturated polyesters, by copolymerization with other vinyl monomers such as styrene.

2.2.129
water hammer
shock load or high-pressure surge caused by sudden halting of flow in a pipe

3.2.130
winding angle
angle of main reinforcement to pipe axial axis

NOTE The angle can be either positive or negative.

2.2.131
woven roving
WR
cloth reinforcement structure in which fibre bundle tows are woven together in a single plane to provide reinforcement which is usually orientated to provide strength in the orthogonal 0° and 90° directions

3 Symbols and abbreviated terms

3.1 Symbols

A_1 partial factor for temperature

A_2 partial factor for chemical resistance

A_3 partial factor for cyclic service

α_a coefficient of thermal expansion in the axial direction

α_h coefficient of thermal expansion in the hoop direction

b_1	width of the saddle support
C	capacitance
D	mean diameter of the reinforced wall of the component
D_i	internal diameter of the reinforced wall of the component
D_m	average optical density
D_n	nominal wall diameter
d_{ID}	internal diameter of component
d_{OD}	outside diameter of component
ΔT_{eff}	effective design temperature change to be used for stress analysis
ΔT_{pa}	temperature difference between ambient temperature and the process design temperature
δ_a	axial pressure correction factor
δ_h	hoop pressure correction factor
E_a	axial modulus
$E_{a,pipe}$	axial modulus of pipe
$E_{a,bend}$	axial modulus of bend
E_h	hoop modulus
$E_{h,bend}$	hoop modulus of bend
ε	strain
$F_{a,max}$	maximum axial compressive load
F_e	safety factor for external loading
F_{max}	maximum load (or stress) of the load (or stress) cycle
F_{min}	minimum load (or stress) of the load (or stress) cycle
f_{scale}	scale factor of ratio short-term to long-term failure envelope
f_1	part factor that provides a measure of the degree of scatter in the long-term pressure tests
f_2	part factor for loading (safety factor)
f_3	part factor to take account of limited axial load capability of GRP pipe
$f_{3,man}$	value of f_3 assigned by manufacturer for quotation purposes

G slope of static regression curve

$G_{default}$ default slope of static regression curve

G_{shear} shear modulus

γ shear strain

I_b second moment of area about an axis through the centroid normal to the bend axis

I_p second moment of area about an axis through the centroid normal to the pipe axis

I_t second moment of area about an axis through the centroid normal to the tee axis

K_s support type factor

k factor to take account of the low thermal conductivity of GRP

κ_b flexibility factor for GRP bends

κ_t flexibility factor for GRP tees

L length of pipe

L_{max} maximum overall length of fittings (bends, tees and reducers)

L_s support span

λ_b pipe factor for bends

M bending moment

M_i applied in-plane bending moment

M_o applied out-of-plane bending moment

M_T applied torsional moment

m_{psb} pressure stress multiplier for bends

m_{pst} pressure stress multiplier for tees

N total number of cycles during service life

p applied pressure

p_c external collapse pressure

p_d design pressure

$p_{d,max}$ maximum design pressure

p_{LCL} lower confidence limit

p_{LTHP} long-term hydrostatic pressure

p_{LTHS} long-term hydrostatic strength

p_{NPR} manufacturer's nominal pressure rating

p_{q} qualified pressure

p_{qf} factored qualified pressure

p_{STHP} short-term hydrostatic pressure

π pi = 3,141 59 (only to six significant figures)

θ total saddle angle

Q_{CFE} critical flux at extinguishment

Q_{sb} heat for sustained burning

Q_{t} total heat release

q_{p} peak heat release

R_{b} mean pipe bend radius

R_{c} design cyclic severity of the piping system

R_{i} inside radius

R_{o} outside radius

r short-term biaxial strength ratio at 0:1 and 2:1 stress ratios

ρ_{c} density of GRP

ρ_{L} density of fluid within the pipe

S_{f} stress intensification factor (SIF)

S_{ft} stress intensification factor for tees

$S_{\mathrm{fa,ib}}$ axial SIF under in-plane bending

$S_{\mathrm{fa,ob}}$ axial SIF under out-of-plane bending

$S_{\mathrm{fh,ib}}$ hoop SIF under in-plane bending

$S_{\mathrm{fh,ob}}$ hoop SIF under out-of-plane bending

σ_{a} axial stress

$\sigma_{\mathrm{al(0:1)}}$ idealized long-term axial (longitudinal) strength at 0:1 stress ratio

σ_{ab} non-pressure-induced axial stress

$\sigma_{a,bp}$ axial stress due to internal pressure and bending due to self-weight

$\sigma_{aeff,b}$ effective axial stress in bends

$\sigma_{aeff,t}$ effective axial stress in tees

σ_{ap} axial stress due to internal pressure

$\sigma_{a,sum}$ sum of all axial stresses

σ_{fs} factored stress

σ_{h} hoop stress

$\sigma_{heff,b}$ effective hoop stress in bends

$\sigma_{heff,t}$ effective hoop stress in tees

σ_{hb} hoop stress due to bending

σ_{hp} hoop stress due to internal pressure

$\sigma_{h,sum}$ sum of all hoop stresses (pressure plus system design)

σ_{qs} qualified stress

$\sigma_{sa(0:1)}$ short-term axial strength at 0:1 stress ratio

$\sigma_{sa(1:1)}$ short-term axial strength at 1:1 stress ratio

$\sigma_{sh(1:1)}$ short-term hoop strength at 1:1 stress ratio

$\sigma_{sa(2:1)}$ short-term axial strength at 2:1 stress ratio

$\sigma_{sh(2:1)}$ short-term hoop strength at 2:1 stress ratio

σ_{u} axial elastic buckling stress, for a cylinder in pure bending

t time

T_{g} glass transition temperature

T_{TD} ratio of the test pressure divided by the design pressure

$T_{P1\,000}$ test pressure to be used in 1 000-hour survival test

t nominal wall thickness

t_{b} reinforced wall thickness of the reference laminate of the bend

t_{br} average wall thickness of the branch laminate of the tee

t_d wall thickness of the reference laminate of the bend

t_{min} minimum wall thickness

t_{pipe} reinforced wall thickness of the reference laminate of the pipe

t_r average reinforced wall thickness of the component

t_t average wall thickness of the reinforced laminate of the tee

τ shear stress

τ_{max} maximum shear stress

ν_{ha} Poisson's ratio, axial to hoop strain resulting from a stress in the hoop direction

ν_{ah} Poisson's ratio, hoop to axial strain resulting from a stress in the axial direction

V electric potential

W electrical energy of a charged surface

w_o pipe and fluid dead mass per length of pipe

ξ torsional stress

Z factor to enable p_{LCL} to be derived from p_{STHP} such that $p_{LCL} = p_{STHP} / Z$

3.2 Subscripts

b bend

fr family representative

cv component variant

psr product sector representative

t tee

3.3 Abbreviated terms

ANSI American National Standards Institute

API American Petroleum Institute

ASME American Society of Mechanical Engineers

ASTM American Society of Testing and Materials

BSI British Standards Institution

DIN Deutsches Institut für Normung

HSE Health and Safety Executive (UK)

IMO International Maritime Organization

NDE non-destructive examination

NDT non-destructive testing

PTFE polytetrafluoroethylene

SLT standard laboratory temperature

4 Principle

ISO 14692 (all parts) advocates the use of a standard methodology for materials selection that is based on performance and not specification, called "performance-based material selection" (PBMS). PBMS reflects true functional needs, excludes arbitrary requirements and does not specify materials. The four key steps to PBMS are:

a) identification and documentation of all performance factors relevant to the application;

b) quantification of functional performance requirements;

c) qualification of materials for technical acceptability;

d) final selection.

The above methodology provides a standardized auditable approach to material selection.

5 Applications

5.1 Principal applications

ISO 14692 (all parts) applies to GRP piping installations associated with oil and gas industry processing and utility service applications. It is primarily intended for offshore applications on both fixed and floating topsides facilities, but it may also be used as guidance for the specification, manufacture, testing and installation of GRP piping systems in other similarly high-criticality applications found onshore.

Typical current and potential applications for the use of GRP piping are given in Table 1.

Applications to hydrocarbon service, including crude oil or condensate, diesel oil, solvent-based chemicals or hazardous drain systems, may also be considered subject to satisfactory results of a risk analysis. This risk analysis shall be designed to identify any risk inherent in the selection of GRP piping materials and to compare this risk with a metallic piping system operating under the same conditions. GRP may be selected where no significant potential of failure is identified or where the consequences of failure are determined to be of low significance.

High-pressure hydrocarbon applications require more rigorous consideration of fire engineering and fire performance requirements.

In the case of piping which is fully embedded within concrete, such as ballast piping in a concrete gravity-base structure, where the piping forms an impervious form within the concrete, alternative standards may be acceptable. However, it is recommended that specific attention be paid to loads that may be applied to the piping during construction and installation of the structure, including at penetrations and changes in section.

For floating installations, reference should be made to the design, construction and certification standards for the hull or vessel, since these may allow alternative codes and standards for GRP piping associated with marine and/or ballast systems. However, it is recommended that ISO 14692 (all parts) be used for such applications to the maximum degree attainable, and that attention be paid to specific design details, taking into account factors such as hull motions, differential displacements and bulkhead penetrations.

Whilst ISO 14692 (all parts) may be used as the general basis for specification of pipe used for pump caissons, stilling tubes, I-tubes, seawater lift risers and other similar items, it should be noted that such applications normally require consideration of combined internal pressure and structural loadings. These items should therefore be individually designed to accommodate all loading conditions.

Table 1 —Typical current and potential GRP piping applications

Alkyl chloride	Jet-A fuel
Ballast water	Mogas
Boiler feed water	Oil
Brine	Oil plus associated gas
Condensate (water and gas)	Potable water
Cooling water	Process water
CO_2	Produced water
Drains (non-hazardous)	Seawater
Emulsions (oil/water)	Service water
Inert gas	Sewer (grey water)
Injection water	Sewer (red water)
Fire water (ring main and wet or dry deluge)	Shallow gas
Formation water	Sodium hypochlorite
Fuel	Sodium hydroxide
Fresh water	Unstabilized oil
Gas (methane, etc.)	Vents
Glycol	Wastewater
HCl	Ballast piping systems
Hydrogen chloride gas	Pump caissons, stilling tubes, or seawater lift pump risers

5.2 Other applications

The broad range of other systems to which ISO 14692 (all parts) is applicable includes:

— onshore pipeline and piping systems transporting both oil and associated gas;

— pipeline and piping systems for chemicals.

NOTE ISO 14692 (all parts) is not specifically intended to be utilized for buried pipelines (onshore or offshore). However, much of the content may be adapted in the specification of qualification, manufacturing and installation requirements for pipeline applications.

6 Materials

Application of ISO 14692 (all parts) shall be limited to the manufacture of rigid components made from fibre-reinforced thermosetting resins. Typical resins are epoxy, polyester, vinyl ester and phenolic. Thermoplastic resins are excluded.

The principal reinforcement material of the component wall shall be glass fibre, e.g. continuous and woven rovings. Application of ISO 14692 (all parts) to pipes manufactured with other reinforcement fibres shall be done with caution and in agreement with the principal (2.1.9). See Note 1.

ISO 14692 (all parts) is not applicable to pipe systems that incorporate internal thermoplastic or elastomeric liners. This is because such materials may introduce significant changes in performance characteristics of the GRP piping. See Notes 2 and 4.

The maximum allowable temperature is determined by the resin type and state of cure. Suggested maximum allowable temperatures, based on experience with typical GRP pipe systems, are given in Table 2 as a function of resin type. The temperatures listed in Table 2 are for initial guidance only.

Table 2 —Temperature limitations

Resin type	Maximum temperature
Epoxy	110 °C
Vinyl ester	100 °C
Polyester	70 °C
Phenolic	150 °C

The maximum allowable operating temperature for a GRP pipeline or piping system may, however, be considerably lower, depending on the aggressiveness of the specific fluid and its concentration, and on the specific curing agent.

The minimum recommended temperature for GRP regardless of the resin system is –35 °C, although lower temperatures may be considered.

NOTE 1 The resins as listed are generic compounds. Their performance and properties of thermal, mechanical and chemical resistance vary significantly depending on the resin and curing agent used to cure them. The user is cautioned to ascertain that the resin and curing agent are known for the resin system planned to be used and that these have all the properties that ISO 14692 (all parts) requires for the resin system.

NOTE 2 Thermoplastic resins are excluded because of the lack of experience in piping applications covered by this part of ISO 14692.

NOTE 3 Glass fibre is the preferred reinforcement material because there is little information available about the long-term pressure retention, impact and fire performance of pipes manufactured from other reinforcement materials such as carbon or aramid fibre.

NOTE 4 The use of a thermoplastic liner will result in change of the failure mode for pressure retention. Such liners also have an influence on the fire endurance and electrostatic properties of the pipe.

7 Dimensions

For guidance purposes, the typical pressure-diameter range of pipes covered by ISO 14692 (all parts) is indicated by Figure 1, which represents a compromise between the current application experience envelope of GRP pipelines and piping systems and commercial availability.

The structural calculations given in ISO 14692 (all parts) are only valid for thickness-to-diameter ratios that are in accordance with Equation (1).

$$\left(\frac{t_r}{D}\right) \leqslant 0{,}1 \qquad (1)$$

where

t_r is the reinforced thickness of the wall, in millimetres, i.e. excluding liner and added thickness for fire protection;

D is the mean diameter, in millimetres, of the structural portion of the wall.

ISO 14692 (all parts) covers all the main components that form part of a GRP pipeline and piping system (pipe, bends, reducers, tees, supports, flanged joints) with the exception of valves and instrumentation.

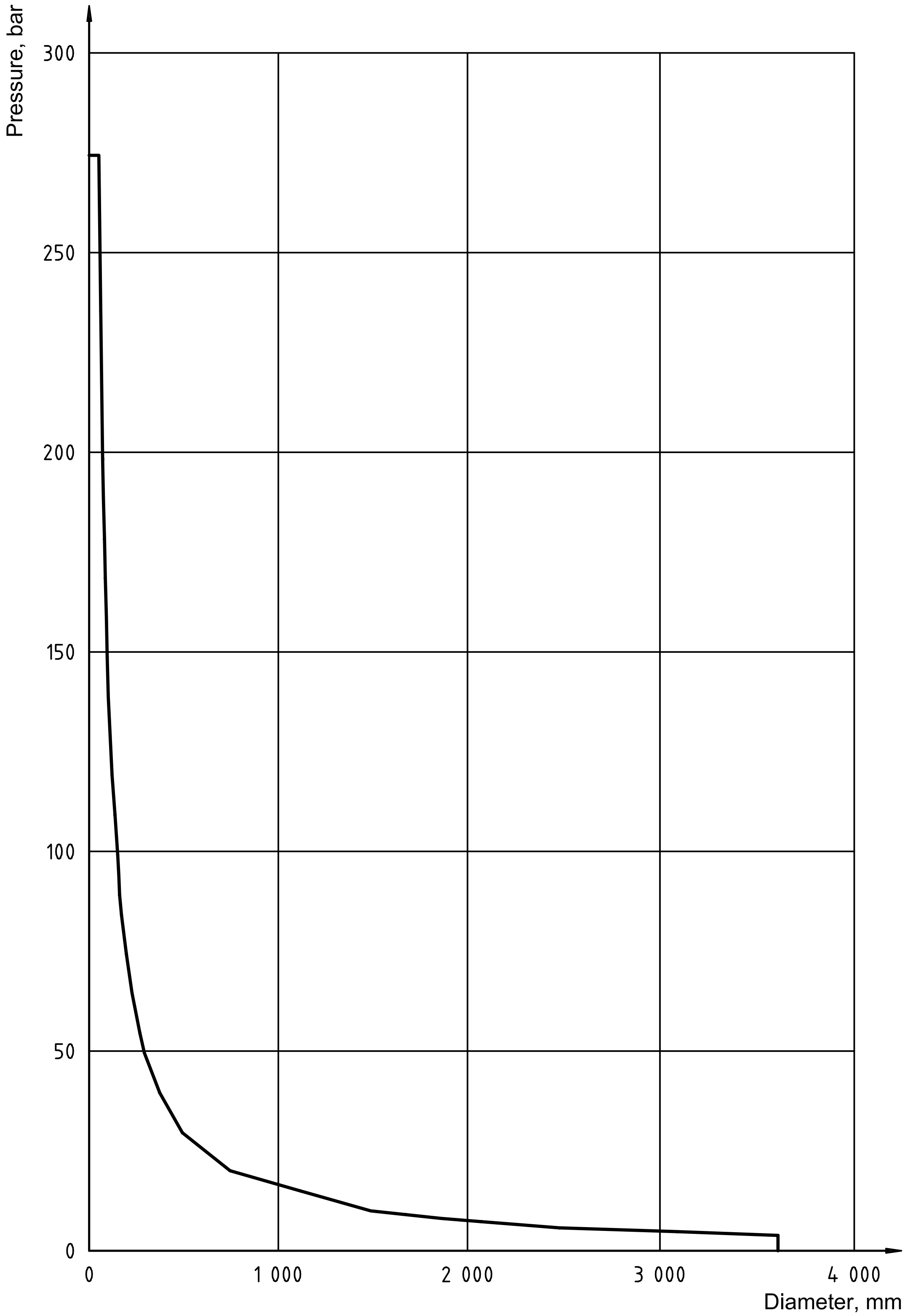

Figure 1 — Envelope of pressure/diameter range of GRP pipes and piping systems based on current experience

8 Pressure terminology

The pressure terminology used in this part of ISO 14692 is dependent on the context in which it is used. The term pressure rating, as quoted by the supplier, is avoided to prevent confusion as to whether it refers to a manufacturer's catalogue value, design pressure or operating pressure.

In ISO 14692-2, manufacturers assign all components a *qualified pressure,* p_q expressed in megapascals (MPa) (with equivalent provided in bars) which corresponds to a 20-year minimum long-term performance of the pipe subject to unrestrained ends, i.e. 2:1 pressure loading in the hoop and axial directions. The default design temperature is 65 °C. Factoring and interpolation of data to other temperatures is permitted depending on the availability of suitable test data. The qualified pressure is not the same as the *manufacturer's nominal pressure rating*, p_{NPR}, which includes a derating factor chosen by the manufacturer based on experience. Use of the manufacturer's rating shall only be for guidance purposes.

The *maximum design pressure* $p_{d,max}$ for the GRP pipe and joint/fitting is given by equation (2):

$$p_{d,max} = f_2 \cdot f_3 \cdot p_q \qquad (2)$$

where

p_q is the qualified pressure, in megapascals;

f_2 is related to confidence in the pipework system, the nature of the application and the consequences of failure. The default partial factor used for the evaluation of operational sustained loads, excluding thermal effects, is 0,67;

f_3 is not a fixed parameter and is used to take account of the limited axial load capability of GRP. The maximum allowable value of f_3 is 1,0 (which would normally only be applicable to a below-ground application).

The qualified pressure is factored to give the *factored qualified pressure,* p_{qf}, which takes account of the performance at temperatures other than 65 °C and the effect of exposure to chemical environments other than water.

In ISO 14692-3, the system design pressure p_d for a component is given by Equation (3):

$$p_d \leqslant f_2 \cdot f_3 \cdot p_{qf} \qquad (3)$$

The *system design pressure,* p_d, is limited by the component with the smallest value of f_3. Since the value of f_3 is dependent on the magnitude of axial stress, the component with the smallest f_3 cannot be determined until after the system stress analysis has been completed. If the stresses exceed the failure envelope, the designer is obliged to either redesign the system in order to reduce the stresses or else select pipe components with a higher value of qualified pressure.

The factored qualified pressure is used to determine the qualified stress, σ_{qs}. The qualified stress for plain pipe is the maximum hoop stress at which the system is designed to operate under sustained conditions. The qualified stress is used with other information provided by the manufacturer to produce a design failure envelope. It is the responsibility of the system designer to ensure that the system stresses do not fall outside the factored long-term design envelope, as described in 7.11 of ISO 14692-3:2002.

In ISO 14692-4, the installer requires knowledge of the system design pressure and the qualified pressure in order to construct and commission the piping system. The operator also requires knowledge of the qualified pressure in order to carry out repairs and modifications.

The *operating pressure* is the pressure at which a system is operated, which should not exceed the design pressure.

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