TECHNICAL SPECIFICATION

ISO/TS 24817

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Petroleum, petrochemical and natural gas industries — Composite repairs for pipework — Qualification and design, installation, testing and inspection

Industries du pétrole, de la pétrochimie et du gaz naturel — Réparations en matériau composite pour canalisations — Conformité aux exigences de performance et conception, installation, essai et inspection

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Foreword

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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.

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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/TS 24817 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*.

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Introduction

The objective of ISO/TS 24817 is to ensure that composite repairs to pipework when qualified, designed, installed and inspected using ISO/TS 24817 will meet the specified performance requirements. Composite repairs are designed for use in oil and natural gas industry processing and utility service applications. The main users of this Technical Specification will be owners of the pipework, design contractors, suppliers contracted to deliver the repairs, certifying authorities, installation contractors and maintenance contractors.

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Petroleum, petrochemical and natural gas industries — Composite repairs for pipework — Qualification and design, installation, testing and inspection

1 Scope

This Technical Specification gives requirements and recommendations for the qualification and design, installation, testing and inspection for the external application of composite repairs to corroded or damaged pipework used in the petroleum, petrochemical and natural gas industries.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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ISO 75-3, *Plastics — Determination of temperature of deflection under load — Part 3: High-strength thermosetting laminates and long-fibre-reinforced plastics*

ISO 527-1, *Plastics — Determination of tensile properties — Part 1: General principles*

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ISO 527-4, *Plastics — Determination of tensile properties — Part 4: Test conditions for isotropic and orthotropic fibre-reinforced plastic composites*

ISO 868, *Plastics and ebonite — Determination of indentation hardness by means of a durometer (Shore hardness)*

ISO 10952, *Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes and fittings — Determination of resistance to chemical attack on the inside of a section in deflected condition*

ISO 11357-2, *Plastics — Differential scanning calorimetry (DSC) — Part 2: Determination of glass transition temperature*

ISO 11359-2, *Plastics — Thermomechanical analysis (TMA) — Part 2: Determination of coefficient of linear thermal expansion and glass transition temperature*

ISO 14692 (all parts), *Petroleum and natural gas industries — Glass-reinforced plastics (GRP) piping*

ANSI/API RP 579, *Recommended Practice for Fitness-for-Service*

ASME B31G, *Manual for Determining the Remaining Strength of Corroded Pipelines: a Supplement to B31, Code for Pressure Piping*

ASTM C581, *Standard Practice for Determining Chemical Resistance of Thermosetting Resins Used in Glass-Fibre-Reinforced Structures Intended for Liquid Service*

ASTM D543, *Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents*

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ASTM D696, *Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics Between − 30 °C and 30 °C with a Vitreous Silica Dilatometer*

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-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing, and Fittings*

ASTM D2583, *Standard Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor*

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

ASTM D3039, *Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials*

ASTM D3165, *Standard Test Method for Strength Properties of Adhesives in Shear by Tension Loading of Single-Lap-Joint Laminated Assemblies*

ASTM D3681, *Standard Test Method for Chemical Resistance of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe in a Deflected Condition*

ASTM D5379/D5379M-05, *Standard Test Method for Shear Properties of Composite Materials by the V-Notched Beam Method*

ASTM D6604, *Standard Practice for Glass Transition Temperatures of Hydrocarbon Resins by Differential Scanning Calorimetry*

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ASTM E831, *Standard Test Method for Linear Thermal Expansion of Solid Materials by Thermomechanical Analysis*

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ASTM E1640, *Standard Test Method for Assignment of the Glass Transition Temperature by Dynamic Mechanical Analysis*

ASTM E2092, *Standard Test Method for Distortion Temperature in Three-Point Bending by Thermomechanical Analysis*

ASTM G8, *Standard Test Methods for Cathodic Disbonding of Pipeline Coatings*

BS 7910, *Guide to methods for assessing the acceptability of flaws in metallic structures*

EN 59, *Glass reinforced plastics — Measurement of hardness by means of a Barcol impressor* (BS 2782-10: Method 1001, *Methods of testing plastics. Glass reinforced plastics. Measurement of hardness by means of a Barcol impressor*)

EN 1465, *Adhesives — Determination of tensile lap shear strength of rigid-to-rigid bonded assemblies*

3 Terms and definitions

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

3.1
anisotropic
exhibiting different physical properties in different directions

3.2
Barcol hardness
measure of surface hardness using a surface impressor

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3.3
composite
thermoset resin system that is reinforced by fibres

3.4
cure
curing
setting of a thermosetting resin system, such as polyester or epoxy, by an irreversible chemical reaction

3.5
delamination
separation of layers within a repair laminate or between a repair laminate and the substrate

3.6
differential scanning calorimetry
DSC
method of determining the glass transition temperature of a thermosetting resin

3.7
glass transition temperature
temperature at which a resin undergoes a marked change in physical properties

3.8
hardener
component added to a thermosetting resin to effect cure

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3.9
heat distortion temperature
HDT
temperature at which a standard test bar deflects by a specified amount under a given load

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3.10
in-fill material
material used to repair external surface imperfections prior to the application of the composite laminate

3.11
laminate
repair laminate
that part of a repair system that is the composite

NOTE Most composites considered in this Technical Specification are composed of discrete lamina or layers which are wrapped or stacked one on top of the other. This stacked construction is the laminate.

3.12
leak
condition of a substrate wall that can allow the contents to make contact with, and act directly upon, the (composite) repair laminate

NOTE This does not refer to a fluid leaking through a hole or breach in the substrate.

3.13
occasional load
load that occurs rarely and during a short time

NOTE Occasional loads typically occur less than 10 times in the life of the component and each load duration is less than 30 min.

3.14
owner
organization that owns or operates the substrate to be repaired

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3.15
pipeline
pipe with components subject to the same design conditions used to transport fluids between plants

NOTE Components may include, for example, bends, flanges, valves.

3.16
pipework
interconnected piping subject to the same set or sets of design conditions

3.17
piping
piping system
assemblies of piping components used to convey fluids within a plant

NOTE Components may include pipe, fittings, flanges, gaskets, bolting, valves. A piping system is often above ground but sometimes buried.

3.18
ply
single wrap or layer (lamina) of a repair laminate

3.19
post cure
additional elevated-temperature cure

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3.20
qualification application procedure
application procedure used to apply the repair system for the qualification tests

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3.21
qualification test temperature
test temperature at which qualification testing of the repair system is performed

3.22
reinforcement
fibre embedded in the resin system

NOTE Possible fibre materials include aramid, carbon, glass, polyester or similar materials. Reinforcement results in mechanical properties superior to those of the base resin.

3.23
repair system
system comprised of the substrate, composite material (repair laminate), filler material, adhesive and including surface preparation and installation methods used for repair of pipework

3.24
repair system supplier
company that supplies and installs the repair system

3.25
resin system
all of the components that make up the matrix portion of a composite

NOTE Often this includes a resin, filler(s), pigment, mechanical property modifiers and catalyst or hardener.

3.26
risk
term describing an event encompassing what can happen (scenario), its likelihood (probability) and its level or degree of damage (consequences)

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3.27
substrate
surface on which a repair is carried out

NOTE The surface may belong to original pipework, a pipework component, pipeline, tank or vessel.

3.28
Shore hardness
measure of surface hardness using a surface impressor or durometer

3.29
thermoset resin system
resin system that cannot be resoftened following polymerization

4 Symbols and abbreviated terms

4.1 Symbols

α_a repair laminate thermal expansion coefficient, axial direction, expressed in millimetres per millimetre degree Celsius

α_c thermal expansion coefficient of the repair laminate for either the axial or circumferential directions

α_s thermal expansion coefficient of substrate

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c crack length

D external diameter

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D_a external attachment equivalent diameter

D_b external branch, tee, nozzle diameter

D_d external diameter end dome

D_r external reducer diameter (smaller diameter)

d diameter (or diameter of the equivalent circle) of the through-wall defect

ΔT difference between operation and installation temperatures

E_c tensile modulus of the composite laminate in the circumferential direction

E_a tensile modulus of the composite laminate in axial direction

E_{ac} combined tensile modulus $\sqrt{E_a E_c}$

E_s tensile modulus of substrate

ε_c circumferential design strain

ε_{c0} allowable circumferential strain

ε_a axial design strain

ε_{a0} allowable axial strain

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ε_t	thermal strain
ε_{short}	short-term failure strain of the composite laminate
F_{ax}	applied axial load
F_{eq}	equivalent axial load
F_{sh}	applied shear load
f_c	service factor for cyclic fatigue
f_D	degradation factor for the long-term performance of repairs to through-wall defects
f_{leak}	service factor for repairs to through-wall defects
f_{perf}	service factor for performance data
$f_{th,overlay}$	repair thickness increase factor for reduced available overlap length
$f_{th,stress}$	repair thickness increase factor for piping system or vessel component
f_{T1}	temperature de-rating factor for composite allowable strains
f_{T2}	temperature de-rating factor for through-wall defect repair design
ϕ	angle subtended by axial slot
G	shear modulus of the composite laminate
γ	toughness parameter (energy release rate) for the composite steel interface
γ_{LCL}	95 % confidence limit of energy release rate
h	burial depth
I	second moment of area
l	total axial extent of repair
$l_{available}$	available landing area (axial extent) of undamaged substrate
l_{over}	axial extent of design thickness of repair
l_{defect}	axial length of defect
l_{taper}	axial length of taper
N	number of cycles
M_{ax}	applied axial moment
M_{to}	applied torsional moment
n	number of observed data points
n_W	number of wraps or layers of repair laminate
p	design internal pressure

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p_{after}	internal pressure after repair system is applied
p_e	external design pressure
p_{eq}	equivalent design pressure
$p_{ext,soil}$	external soil pressure
p_{live}	internal pressure within the substrate during application of the repair
p_{min}	minimum (internal pressure) load (or stress) of the load cycle
p_{max}	maximum (internal pressure) load (or stress) of the load cycle
p_{mthp}	medium-term hydrostatic test pressure
p_s	maximum allowable working pressure (MAWP)
p_{sthp}	short-term hydrostatic test pressure
p_0	initial test pressure
$\dot{p}$	fixed linear increase in test pressure
q	tensile stress
R_c	cyclic loading severity, defined as: $R_c = \frac{p_{min}}{p_{max}}$
s	allowable stress of the substrate material
s_a	measured yield stress of substrate or mill certification yield stress
s_{lt}	lower confidence limit of the long-term stress determined by performance testing
T_d	design temperature
T_g	glass transition temperature
T_m	maximum operating temperature of repair system
T_{amb}	ambient temperature
T_{test}	qualification test temperature
t	wall thickness of substrate
$t_{lifetime}$	design lifetime
t_{layer}	thickness of an individual wrap or layer of repair laminate
t_b	wall thickness of branch, tee
t_f	wall thickness of flange
t_{design}	design thickness of repair laminate
t_{min}	minimum thickness of repair laminate
t_s	minimum remaining substrate wall thickness

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τ lap shear strength

ν Poisson's ratio for the repair laminate

w (axial) width of circumferential slot defect

W_{soilg} specific weight of soil

4.2 Abbreviated terms

ASME American Society of Mechanical Engineers

ASTM American Society for Testing and Materials

API American Petroleum Institute

AWWA American Water Works Association

BS (BSI) British Standards Institute

CFRP carbon-fibre-reinforced plastic

COSHH regulations for control of substances hazardous to health

CSWIP certification scheme for welding inspection personnel

DSC differential scanning calorimetry

FRP fibre-reinforced plastic

GRP glass-reinforced plastic

HDT heat distortion temperature

MAWP maximum allowable working pressure

MSDS materials safety data sheet

NDT non-destructive testing

OSHA Occupational Safety and Health Act

PCC post-construction committee

SMYS specified minimum yield strength

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5 Applications

The qualification and design, installation, testing and inspection procedures for repair systems in this Technical Specification cover situations involving the repair of damage commonly encountered in oil, gas and utility pipework systems. The procedures are also applicable to the repair of pipelines, caissons, storage tanks and vessels with appropriate consideration.

Procedures in this Technical Specification cover the repair of metallic and GRP pipework, pipework components, pipelines originally designed in accordance with a variety of standards, including ISO 15649, ISO 13623, ISO 14692, ASME B31.1, ASME B31.3, ASME B31.4, ASME B31.8 and BS 8010.

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Repair systems are applied to achieve a satisfactory level of structural integrity.

The following repair situations are addressed:

— external corrosion, where the defect is or is not through-wall; in this case the application of a repair system will usually arrest further deterioration;

— external damage such as dents, gouges and fretting (at supports);

— internal corrosion, erosion, where the defect is or is not through-wall; in this case corrosion and/or erosion can continue after application of a repair system, and therefore the design of the repair system shall take this into account;

— structural strengthening in local areas.

As a general guide, Table 1 summarizes the types of defect that can be repaired using repair systems.

Table 1 — Guide to generic defect types

Type of defect	Applicability of repair system
General wall thinning	Y[a]
Local wall thinning	Y
Pitting	Y
Gouges	R[b]
Blisters	Y
Laminations	Y
Circumferential cracks	Y
Longitudinal cracks	R
Through-wall penetration	Y

[a] Y implies generally appropriate.

[b] R implies can be used, but requires extra consideration.

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Services that are covered within the scope of this Technical Specification include all services normally found on an oil and gas production or processing installation. These include:

— utility fluid, diesel, seawater, air;

— chemicals (liquids);

— production fluids, including liquid hydrocarbons, gaseous hydrocarbons and gas condensates.

The upper pressure and temperature limits are dependent on the type of damage being repaired and the type of repair system being used. These limits are determined from the qualification testing results presented in Clause 6.

The lower temperature limit is dependent on the type of repair laminate being used. This limit is determined by the design requirements presented in Clause 6. The lower pressure limit, e.g. vacuum conditions, is determined by the design requirements presented in 6.5.9.7.

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