DRAFT FOR DEVELOPMENT

DD CEN ISO/TS 24817:2011

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

ICS 75.180.20

NO COPYING WITHOUT BSI PERMISSION EXCEPT AS PERMITTED BY COPYRIGHT LAW

BSI Documents
Document Sharing Hub
British Standards

Full document details: DD CEN ISO/TS 24817:2011

National foreword

This Draft for Development is the UK implementation of CEN ISO/TS 24817:2011. It is identical to ISO/TS 24817:2006. It supersedes DD ISO/TS 24817:2006, which is withdrawn.

This publication is not to be regarded as a British Standard.

It is being issued in the Draft for Development series of publications and is of a provisional nature. It should be applied on this provisional basis, so that information and experience of its practical application can be obtained.

Comments arising from the use of this Draft for Development are requested so that UK experience can be reported to the international organization responsible for its conversion to an international standard. A review of this publication will be initiated not later than 3 years after its publication by the international organization so that a decision can be taken on its status. Notification of the start of the review period will be made in an announcement in the appropriate issue of *Update Standards*.

According to the replies received by the end of the review period, the responsible BSI Committee will decide whether to support the conversion into an international Standard, to extend the life of the Technical Specification or to withdraw it. Comments should be sent to the Secretary of the responsible BSI Technical Committee at British Standards House, 389 Chiswick High Road, London W4 4AL.

The UK participation in its preparation was entrusted by Technical Committee PSE/17, Materials and equipment for petroleum, petrochemical and natural gas industries, to Subcommittee PSE/17/-/6, Processing equipment and systems for petroleum and natural gas industries.

A list of organizations represented on PSE/17/-/6 can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

This Draft for Development was published under the authority of the Standards Policy and Strategy Committee on 31 January 2007

© BSI 2011

ISBN 978 0 580 72221 9

Amendments/corrigenda issued since publication

Date	Comments
30 June 2011	This corrigendum renumbers DD ISO/TS 24817:2006 as DD CEN ISO/TS 24817:2011

Documents
Document Sharing Hub

Full document details: DD CEN ISO/TS 24817:2011

TECHNICAL SPECIFICATION

SPÉCIFICATION TECHNIQUE

TECHNISCHE SPEZIFIKATION

CEN ISO/TS 24817

February 2011

ICS 75.180.20

English Version

Petroleum, petrochemical and natural gas industries - Composite repairs for pipework - Qualification and design, installation, testing and inspection (ISO/TS 24817:2006)

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 (ISO/TS 24817:2006)

Erdöl-, petrochemische und Erdgasindustrie - Reparatur von Rohrleitungen mit Verbundwerkstoffen - Bewertung und Ausführung, Montage, Test und Inspektion (ISO/TS 24817:2006)

This Technical Specification (CEN/TS) was approved by CEN on 27 December 2010 for provisional application.

The period of validity of this CEN/TS is limited initially to three years. After two years the members of CEN will be requested to submit their comments, particularly on the question whether the CEN/TS can be converted into a European Standard.

CEN members are required to announce the existence of this CEN/TS in the same way as for an EN and to make the CEN/TS available promptly at national level in an appropriate form. It is permissible to keep conflicting national standards in force (in parallel to the CEN/TS) until the final decision about the possible conversion of the CEN/TS into an EN is reached.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: Avenue Marnix 17, B-1000 Brussels

© 2011 CEN All rights of exploitation in any form and by any means reserved worldwide for CEN national Members.

Ref. No. CEN ISO/TS 24817:2011: E

Documents
Document Sharing Hub

Full document details: DD CEN ISO/TS 24817:2011

Foreword

The text of ISO/TS 24817:2006 has been prepared by Technical Committee ISO/TC 67 “Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries” of the International Organization for Standardization (ISO) and has been taken over as CEN ISO/TS 24817:2011 by Technical Committee CEN/TC 12 “Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries” the secretariat of which is held by AFNOR.

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

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to announce this Technical Specification: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

Endorsement notice

The text of ISO/TS 24817:2006 has been approved by CEN as a CEN ISO/TS 24817:2011 without any modification.

Documents
Document Sharing Hub
Full document details: DD CEN ISO/TS 24817:2011

Contents

Page

Foreword ... v

Introduction ... vi

1 Scope ... 1

2 Normative references ... 1

3 Terms and definitions ... 2

4 Symbols and abbreviated terms ... 5
4.1 Symbols ... 5
4.2 Abbreviated terms ... 8

5 Applications ... 8

6 Qualification and design ... 10
6.1 Risk assessment ... 10
6.2 Repair class ... 11
6.3 Repair lifetime ... 11
6.4 Required data ... 11
6.5 Design methodology ... 14
6.6 Requalification ... 35

7 Installation ... 35
7.1 General ... 35
7.2 Materials of construction ... 36
7.3 Storage conditions ... 36
7.4 Method statements ... 36
7.5 Installer qualifications ... 37
7.6 Installation guidance ... 37
7.7 Live repairs ... 38
7.8 Repair of clamps, piping components, tanks or vessels ... 38
7.9 Environmental considerations ... 38

8 Testing and inspection ... 39
8.1 General ... 39
8.2 Allowable defects for the repair system ... 39
8.3 Repair of defects within the repair system ... 41
8.4 Inspection methods ... 41
8.5 Repair system maintenance and replacement strategy ... 41

9 System testing ... 42

10 Future modifications ... 42

11 Decommissioning ... 42

Annex A (normative) **Design data sheet** ... 43

Annex B (normative) **Qualification data** ... 46

Annex C (normative) **Short-term pipe spool survival test** ... 48

Annex D (normative) **Measurement of γ_{LCL} for through-wall defect calculation** ... 50

Annex E (normative) **Measurement of performance test data** ... 53

Annex F (normative) **Measurement of impact performance** ... 56

Annex G (normative) **Measurement of the degradation factor** ... 57

Documents
Document Sharing Hub

Full document details: DD CEN ISO/TS 24817:2011

Annex H (informative) **Axial extent of repair look-up table** **59**
Annex I (normative) **Installer qualification** **61**
Annex J (normative) **Installation requirements and guidance** **64**
Bibliography **67**

Documents
Document Sharing Hub
Full document details: DD CEN ISO/TS 24817:2011

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.

In other circumstances, particularly when there is an urgent market requirement for such documents, a technical committee may decide to publish other types of normative document:

— an ISO Publicly Available Specification (ISO/PAS) represents an agreement between technical experts in an ISO working group and is accepted for publication if it is approved by more than 50 % of the members of the parent committee casting a vote;

— an ISO Technical Specification (ISO/TS) represents an agreement between the members of a technical committee and is accepted for publication if it is approved by 2/3 of the members of the committee casting a vote.

An ISO/PAS or ISO/TS is reviewed after three years in order to decide whether it will be confirmed for a further three years, revised to become an International Standard, or withdrawn. If the ISO/PAS or ISO/TS is confirmed, it is reviewed again after a further three years, at which time it must either be transformed into an International Standard or be withdrawn.

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*.

Documents
Document Sharing Hub
Full document details: DD CEN ISO/TS 24817:2011

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.

Documents
Document Sharing Hub
Full document details: DD CEN ISO/TS 24817:2011

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.

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*

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*

Documents
Document Sharing Hub

Full document details: DD CEN ISO/TS 24817:2011

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*

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

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

Documents
Document Sharing Hub
Full document details: DD CEN ISO/TS 24817:2011

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

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

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

Documents
Document Sharing Hub

Full document details: DD CEN ISO/TS 24817:2011

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

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

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)

Documents
Document Sharing Hub
Full document details: DD CEN ISO/TS 24817:2011

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

c crack length

D external diameter

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

Documents
Document Sharing Hub

Full document details: DD CEN ISO/TS 24817:2011

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

Documents
Document Sharing Hub
Full document details: DD CEN ISO/TS 24817:2011

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

AVA Documents
Document Sharing Hub

Full document details: DD CEN ISO/TS 24817:2011

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

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.

Documents
Document Sharing Hub
Full document details: DD CEN ISO/TS 24817:2011

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.

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.

AVA Documents
Document Sharing Hub

Full document details: DD CEN ISO/TS 24817:2011

The composite materials constituting the repair laminate considered within this Technical Specification are typically those with aramid (AFRP), carbon (CFRP), glass (GRP) or polyester (or similar material) reinforcement in a polyester, vinyl ester, epoxy or polyurethane matrix. Other fibre and matrix types are also permissible.

6 Qualification and design

6.1 Risk assessment

A risk assessment associated with both the defect and the repair method shall be completed by the owner prior to application of the repair system.

The following factors shall be considered within the risk assessment:

— assessment of the nature and location of the defects;

— design and operating conditions for the substrate and contents (including pressure, temperature, sizes and combinations thereof);

— repair lifetime (see 6.3);

— geometry of the substrate being repaired;

— hazards associated with system service;

— availability of personnel with the necessary skills;

— ease with which it is practicable to execute surface preparation operations;

— performance under upset and major incident situations, including impact, abrasion, fire, explosion, collision and environmental loading:

— operational measures, including (if relevant) permits, gas testing and fire protection requirements to ensure safety in the vicinity of the repair area;

— failure modes;

— inspectability (both visual and non-destructive);

— repair system materials.

For clarification, the risk assessment is not intended as a means to predetermine that the repair method is the appropriate strategy or remedial action, but rather to assess the risks associated with applying the repair method.

The information and data describing any hazards shall be included in the method statement (7.4) to be used on site.

Since the application of these repair systems typically changes the mode of failure from rupture of the substrate to a leak, the consequences of failure will therefore be reduced.

The objective of the assessment shall be to establish the class of the repair (6.2), which determines the detail of the design method (6.5) to be carried out, together with the requirements for supporting documentation. This also determines the design margin or factor of safety to be used in the design.

Guidance on performing a risk assessment can be obtained from Reference [36].

Documents
Document Sharing Hub
Full document details: DD CEN ISO/TS 24817:2011

6.2 Repair class

Each repair shall be allocated to a particular class following completion of the risk assessment. Repair classes are defined in Table 2.

Class 1 repairs cover design pressures up to 1 MPa (10 bar) and design temperatures up to 40 °C and are appropriate to the majority of the utility service systems. This class is intended for those systems that do not relate directly to personnel safety or safety-critical systems.

Class 2 repairs cover design pressures up to 2 MPa (20 bar) and design temperatures up to 100 °C but exclude hydrocarbons. This class is appropriate to those systems that have specific safety-related functions.

Class 3 repairs cover all fluid types and pressures up to the qualified upper pressure limit. This class is appropriate for systems transporting produced fluids.

Applications in which the service conditions are more onerous or not included in the above, shall be designated as Class 3.

Table 2 — Repair class

Repair class	Typical service	Design pressure	Design temperature
Class 1	Low specification duties, e.g. static head, drains, cooling medium, sea (service) water, diesel and other utility hydrocarbons	< 1 MPa	< 40 °C
Class 2	Fire water/deluge systems	< 2 MPa	< 100 °C
Class 3	Produced water and hydrocarbons, flammable fluids, gas systems Class 3 also covers operating conditions more onerous than described.	Qualified upper limit	Qualified upper limit

6.3 Repair lifetime

The lifetime (in years) of the repair system shall be defined in the repair data sheet, Annex A. It may be limited by the defect type and service conditions, e.g. internal corrosion.

The minimum lifetime of the repair shall be 2 years.

Short lifetimes (2 years) are intended to apply to those situations where the repair is required to survive until the next shutdown.

Long lifetimes (up to 20 years) are intended to apply to those situations where the repair is required to reinstate the substrate to its original design lifetime or to extend its design life for a specified period.

Once the lifetime of the repair has expired, the owner shall either remove or revalidate the repair system.

6.4 Required data

6.4.1 Background

The following data shall be supplied for each repair application. The detail to which these requirements are fulfilled is determined by the output of the risk assessment. Original equipment design data, maintenance and operational histories shall be provided by the owner and material qualification data shall be provided by the repair system supplier. The availability of relevant data shall feature as part of the risk assessment.

Documents
Document Sharing Hub

Full document details: DD CEN ISO/TS 24817:2011

6.4.2 Original equipment design data

Original equipment design data are required, consisting of:

a) piping line lists or other documentation showing process design conditions and a description of the piping class, including material specification, wall thickness, and pressure and temperature ratings;

b) piping isometric drawings and, if appropriate, the output of a piping flexibility calculation;

c) specification of all operating mechanical loads not included in the above, including upset conditions;

d) original design calculations.

6.4.3 Maintenance and operational histories

Maintenance and operational histories are required, consisting of:

a) documentation of any changes in service conditions, including pressure, temperature, internal fluids and corrosion rate;

b) past service conditions;

c) summary of all alterations and past repairs local to the substrate of concern;

d) inspection reports detailing the nature and extent of damage to be repaired.

6.4.4 Service condition data

Service condition data are required, consisting of:

a) lifetime requirements/expectation of the repair system life;

b) required design and operating pressures (internal and external)/temperatures;

c) expected future service conditions;

d) if applicable, MAWP as calculated according to the requirements of ASME B31G, API RP 579, BS 7910 or another applicable standard. This shall be carried out taking into account the current position and any possible further degradation in the future.

An example of a design data sheet is presented in Annex A.

6.4.5 Repair system qualification data

The documentation and qualification data related to repair systems that shall be provided by suppliers are shown in Table 3.

Details of the qualification data to be provided by the suppliers are given in Annex B.

Table 3 — Documentation and data requirements

Documentation requirement	Class 1	Class 2	Class 3
Material documentation and data	✓	✓	✓
Design capability		✓	✓
Surface preparation documentation	✓	✓	✓
Short-term test data	✓	✓	✓
Long-term test data		✓	✓

Documents
Document Sharing Hub
Full document details: DD CEN ISO/TS 24817:2011

Clarification of the terms used in Table 3 is as follows:

a) Material documentation and data

This shall include a statement of the resins and reinforcements used and any standards to which they are supplied. Basic data on material compatibility with the working environment shall also be available. It shall be ensured that any chemical interaction between the resin (and associated curing agents) and substrate will not cause further degradation of the substrate. Also attention shall be given to CFRP laminates and the potential for bimetallic (galvanic) corrosion of the substrate.

b) Design capability

Suppliers who offer a repair option for Class 2 and 3 repairs shall provide design calculations with supporting data.

c) Surface preparation

The durability of a bonded assembly under applied load is determined to a large extent by the quality of the surface preparation used. Details of the surface preparation procedure and how it is to be implemented shall be provided.

d) Short-term test data

These shall include tensile strength and modulus in both the hoop and axial directions and the strength of the (adhesive) bond between the repair laminate and the substrate.

e) Long-term test data

These shall include the strength of the adhesive bond between the repair laminate and substrate and optionally the ultimate tensile strain of the repair laminate. Long-term is defined as greater than or equal to 1 000 h.

Table 4 lists the data required to comply with Class 3 requirements. Annex B contains the full details of the qualification data requirements.

Table 4 — Qualification test requirements

	Material property	Test method
Mechanical properties	Young's modulus Poisson's ratio Shear modulus	ISO 527-1, ISO 527-4 (or ASTM D3039) ISO 527-1, ISO 527-4 (or ASTM D3039) ASTM D5379
	Thermal expansion coefficient	ISO 11359-2 (or ASTM D696)
	Glass transition temperature of resin or heat distortion temperature of resin	ISO 11357-2 (or ISO 75-3, ASTM D6604, ASTM E1640, ASTM E831), ASTM E2092
	Barcol or Shore hardness	ISO 868 or EN 59 (or ASTM D2583)
Adhesion strength	Lap shear	EN 1465 (or ASTM D3165)
Performance data	Long-term strength (optional)	Annex E
	Energy release rate (optional)	Annex D
	Short-term pipe spool survival test (optional)	Annex C

Documents
Document Sharing Hub
Full document details: DD CEN ISO/TS 24817:2011

6.5 Design methodology

6.5.1 Overview

There are two design cases.

a) Defect type A design case

The defect is within the substrate, not through-wall and not expected to become through-wall within the lifetime of the repair system, requiring structural reinforcement only. One of the following three design methods shall be used:

1) include allowance for the substrate (see 6.5.4);

2) exclude allowance for the substrate (see 6.5.5);

3) long-term performance test data (see 6.5.6).

b) Defect type B design case

The substrate requires structural reinforcement and sealing of through-wall defects (leaks). For substrates with active internal corrosion, the repair laminate shall be designed on the assumption that a through-wall defect will occur if the remaining wall thickness at the end of service life is expected to be less than 1 mm. Both of the following design methods shall be used:

1) the design method in 6.5.7;

2) the design method for the Defect type A design case.

The greater repair thickness from the Defect type A design case or the design method in 6.5.7 shall be taken as the repair laminate thickness, t_{design}.

Subclauses 6.5.9 and 6.5.10 shall be considered for each design case and applied where appropriate, with the largest thickness being taken as the repair laminate thickness, t_{design}.

6.5.2 Environmental compatibility

The suitability for use of the repair system in the service environment shall be based on the following considerations. The service environment is the environment that contacts the repair laminate. It may be either the external or internal environment.

The qualification of the repair system (6.4.5) demonstrates that the repair system is compatible with aqueous and hydrocarbon environments at the qualification test temperature. In general, thermoset resins are compatible with a wide range of environments, but consideration shall be given when the environment is strongly acidic (pH $<$ 3,5), strongly alkaline (pH $>$ 11) or is a strong solvent, e.g. methanol, toluene in concentration greater than 25 %.

Resistance to UV degradation and weathering (where appropriate) shall be provided by data from the resin supplier.

When the environmental compatibility of the repair system is unknown, then the repair system supplier shall provide one of the following to demonstrate compatibility:

— environmental compatibility data or experience of previous applications from the resin supplier, demonstrating that the environment is no more aggressive than aqueous or hydrocarbon environments at the design temperature;

Documents
Document Sharing Hub
Full document details: DD CEN ISO/TS 24817:2011

— if no compatibility data from the resin supplier are available, then specific environmental testing is required. One of the following test procedures – ISO 10952, ASTM D543, ASTM C581, ASTM D3681 or equivalent – comparing the exposure of the specific environment and aqueous environment to the repair laminate at the design temperature shall be performed. The repair system shall be considered compatible to the specific environment if the test results from the specific environment are no worse than for the aqueous environment.

When erosion is the cause of the degradation process of the substrate and the repair laminate is in contact with the eroding medium, then the repair laminate can suffer material loss. The repair system supplier shall calculate the survival of the repair system for the specified repair lifetime assuming a conservative estimate of the loss of laminate material. Alternatively, a metal plate can be placed over the affected area prior to application of the repair laminate to minimize material loss (of the laminate).

6.5.3 Design temperature effects

For a design temperature, T_d, greater than 40 °C, the repair system shall not be used at a temperature higher than the glass transition temperature (T_g) less 30 °C. For repair systems for which a T_g cannot be measured, the repair system shall not be used above the HDT less 20 °C. For repair systems which do not exhibit a clear transition point, i.e. a significant reduction in mechanical properties at elevated temperatures, then an upper temperature limit, T_m, shall be defined (or quoted) by the repair supplier.

For a repair system where the defect within the substrate is not through-wall, the temperature limit can be relaxed to T_g less 20 °C or HDT less 15 °C. T_g or HDT shall be measured in accordance with Table 4.

Table 5 summarizes the upper temperature limit of the repair.

Table 5 — Service temperature limits for repair systems

	Defect type B limit T_m	Defect type A limit T_m
T_g measured	T_g – 30 °C	T_g – 20 °C
HDT measured	HDT – 20 °C	HDT – 15 °C

For design temperatures ⩽ 40 °C (and Class 1 and Class 2 repairs), adequate cure of the field-applied repair laminate or adhesive shall be demonstrated by Barcol or Shore hardness testing. For these conditions, no acceptance criteria linked to T_g or HDT are stipulated. Adequate cure is defined as a measured hardness value, and shall be no less than 90 % of the minimum obtained from repair system qualification in accordance with Table 4.

The temperature de-rating factor, f_{T1}, to account for elevated design temperature application used in Equation (8) is given in Table 6, where T_m is the upper temperature limit for the system (as defined in Table 5), in degrees Celsius.

Table 6 — Temperature de-rating factor for composite allowable strains, f_{T1}

Design temperature T_d °C	Temperature factor f_{T1}
$T_d = T_m$	0,70
T_m – 20	0,75
T_m – 40	0,85
T_m – 50	0,90
T_m – 60	1,00

Documents
Document Sharing Hub

Full document details: DD CEN ISO/TS 24817:2011

Factors for intermediate temperatures shall be obtained by interpolation.

The additional requirements for repairs to through-wall defects are qualified through performance testing. To allow for higher design temperatures than the qualification test temperature, Table 7 defines the temperature de-rating factor, f_{T2}, that shall be applied to Equations (11), (12) and (13), where T_{amb} is the ambient test temperature, in degrees Celsius, and T_{test} is the qualification test temperature, in degrees Celsius.

Table 7 — Temperature de-rating factor for through-wall defects (type B defect), f_{T2}

Temperature °C	Temperature factor f_{T2}
$T_d - (T_{test} - T_{amb}) = T_m$	0,70
$T_d - (T_{test} - T_{amb}) = T_m - 20$	0,75
$T_d - (T_{test} - T_{amb}) = T_m - 40$	0,85
$T_d - (T_{test} - T_{amb}) = T_m - 50$	0,90
$T_d - (T_{test} - T_{amb}) = T_m - 60$	1,00

For Table 7 to be appropriate, the same post-curing regime between qualification test sample preparation and in-service application shall apply.

The split in requirement for service temperatures at 40 °C is to ensure consistency with ASME PCC-2 [11].

6.5.4 Design based on substrate-allowable stress (defect type A)

Use of the design method in this subclause is appropriate if the contribution of the substrate is to be included in the calculation for load-carrying capability.

For piping systems, Equations (1) and (2) shall be used. In the derivation of these equations it is assumed that the repair thickness is limited by the allowable stress in the substrate.

In the circumferential direction, the minimum repair laminate thickness, t_{min} (expressed in millimetres), due to internal pressure is given by Equation (1):

$$t_{\mathrm{min,c}} = \frac{D}{2s} \cdot \left(\frac{E_{\mathrm{s}}}{E_{\mathrm{c}}} \right) \cdot \left(p_{\mathrm{eq}} - p_{\mathrm{s}} \right) \tag{1}$$

In the axial direction, the minimum repair laminate thickness, t_{min} (expressed in millimetres), due to internal pressure, bending and axial thrust is given by Equation (2):

$$t_{\mathrm{min,a}} = \frac{D}{2s} \cdot \left(\frac{E_{\mathrm{s}}}{E_{\mathrm{a}}} \right) \cdot \left(\frac{2F_{\mathrm{eq}}}{\pi D^2} - p_{\mathrm{s}} \right) \tag{2}$$

where

E_a is the axial modulus of the repair laminate, expressed in megapascals;

E_c is the circumferential modulus of the repair laminate, expressed in megapascals;

E_s is the modulus of substrate, expressed in megapascals;

D is the external diameter, expressed in millimetres;

F_{eq} is the equivalent axial load, expressed in newtons [see Equation (3)];

Documents
Document Sharing Hub
Full document details: DD CEN ISO/TS 24817:2011