

DIN EN ISO 24817

ICS 75.200

Ersatz für
DIN CEN ISO/TS 24817
(DIN SPEC 91240):2011-04

**Erdöl-, petrochemische und Erdgasindustrie –
Reparatur von Rohrleitungen mit Verbundwerkstoffen –
Bewertung und Ausführung, Montage, Test und Inspektion
(ISO 24817:2015);
Englische Fassung EN ISO 24817:2015**

Petroleum, petrochemical and natural gas industries –
Composite repairs for pipework –
Qualification and design, installation, testing and inspection (ISO 24817:2015);
English version EN ISO 24817:2015

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 24817:2015);
Version anglaise EN ISO 24817:2015

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DIN-Normenausschuss Erdöl- und Erdgasgewinnung (NÖG)

Nationales Vorwort

Dieses Dokument (EN ISO 24817:2015) wurde vom Technischen Komitee ISO/TC 67 „Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries“ Subkomitee SC 6 „Processing equipment and systems“ in Zusammenarbeit mit dem Technischen Komitee CEN/TC 12 „Materialien, Ausrüstungen und Offshore-Bauwerke für die Erdöl-, petrochemische und Erdgasindustrie“ (Sekretariat NEN, Niederlande) erarbeitet.

Für Deutschland hat hieran der Arbeitskreis NA 109-00-01-06 AK „Verfahrenstechnische Anlagen und Ausrüstungen“ im DIN-Normenausschuss Erdöl- und Erdgasgewinnung (NÖG) mitgearbeitet.

Diese europäische Norm enthält unter Berücksichtigung des DIN-Präsidialbeschlusses 1/2004 nur die englische Originalfassung der ISO Norm.

Diese Norm enthält neben den gesetzlichen Einheiten auch die Einheit „in (inch)“, die in Deutschland nicht zugelassen ist. Es wird ausdrücklich darauf hingewiesen, dass die Anwendung dieser Einheit im nationalen amtlichen und geschäftlichen Verkehr aufgrund des Gesetzes über Einheiten im Messwesen nicht zulässig ist. Die Angabe dieser Einheit dient lediglich als Hilfe im amtlichen und geschäftlichen Verkehr (z. B. bei Einfuhr und Ausfuhr) mit solchen Staaten, die diese Einheit anwenden.

Umrechnung:

Nicht-SI-Einheit	SI-Einheit	Umrechnung
in (inch)	mm	1 inch = 25,4 mm

Für die in diesem Dokument zitierten Internationalen Normen wird im Folgenden auf die entsprechenden Deutschen Normen hingewiesen:

ISO 75-3	siehe	DIN EN ISO 75-3
ISO 527-1	siehe	DIN EN ISO 527-1
ISO 527-4	siehe	DIN EN ISO 527-4
ISO 868	siehe	DIN EN ISO 868
ISO 11357-2	siehe	DIN EN ISO 11357-2
ISO 14692 (all parts)	siehe	DIN EN ISO 14692 (alle Teile)

Änderungen

Gegenüber DIN CEN ISO/TS 24817 (DIN SPEC 91240):2011-04 wurden folgende Änderungen vorgenommen:

- Änderung der Veröffentlichungsform von ISO/TS 24817 in ISO 24817;
- neuer Abschnitt 6 „Summary of key issues“;
- neuer informativer Anhang K „Design considerations“;
- neuer informativer Anhang L „Management of the integrity of composite repair systems to pipework and vessels“.

Frühere Ausgaben

DIN CEN ISO/TS 24817 (DIN SPEC 91240): 2011-04

Nationaler Anhang NA (informativ)

Begriffe, Symbole und Abkürzungen

Die Benummerung der folgenden Begriffe, Symbole und Abkürzungen ist identisch mit der Benummerung in der englischen Fassung.

3 Begriffe

Für die Anwendung dieses Dokuments gelten die folgenden Begriffe.

3.1

anisotrop

das Auftreten einer Richtungsabhängigkeit verschiedener physikalischer Eigenschaften

3.2

Barcol-Härte

Härteskala für die Oberflächenhärte unter Anwendung eines Eindringkörpers auf der Oberfläche

3.3

Blase

Luftloch zwischen den Schichten eines Laminats (Schichtstoffs), das auf der Oberfläche als erhabener Bereich sichtbar ist

3.4

Verbund(werk)stoff

Komposit(werk)(stoff)

Faserverbundwerkstoff

wärmehärtbares (duroplastisches) Harzsystem, das durch Fasern verstärkt ist

3.5

Riss

Spalt im Laminat, der (rechtwinklig zur Oberfläche) so verläuft, dass an der Außen(wand)fläche ein Durchbruch mit einander gegenüberliegenden Flächen eindeutig erkennbar ist

3.6

Aushärten

Aushärtung

Festwerden eines wärmehärtbaren Harzsystems, z. B. Polyester oder Epoxid, bei dem eine irreversible chemische Reaktion abläuft

3.7

Aushärtezeit

Zeit-Temperatur-Profil, das zur Erzeugung einer festgelegten T_g (Glasübergangstemperatur) oder HDT (Wärmeformbeständigkeitstemperatur) geeignet ist

3.8

Defekttyp A

Fehler innerhalb des Substrats, der nicht durch die Wand verläuft und erwartungsgemäß innerhalb der Auslegungslbensdauer des Reparatursystems auch zu keinem Wanddurchbruch führen wird

3.9

Defekttyp B

Fehler, der durch die Wand verläuft (d. h. mit Wanddurchbruch) oder Fehler innerhalb des Substrats, der am Ende der Nutzungsdauer zu einer Wandausdünnung mit einer verbleibenden Wanddicke von weniger als 1 mm führt

3.10

festgelegte Lebensdauer

tatsächliche Anwendungsdauer oder Nutzungsdauer des Reparatursystems

3.11

Delamination

Schichtentrennung

Reparatur-Laminat und Substrat, die miteinander verbunden sein sollten, lösen sich voneinander durch fehlenden Verbund (Versagen in der Klebschicht) an einer Stelle zwischen Reparatur-Laminat und Substrat, oder Trennung zwischen einzelnen Schichten des Reparatur-Laminats

3.12

Auslegungslbensdauer

die maximale Anwendungslbensdauer des Reparatursystems

3.13

dynamische Differenzkalorimetrie

DDK

(en: DSC)

Verfahren zum Bestimmen der Glasübergangstemperatur eines wärmehärtbaren Harzes

3.14

Dry-Spots oder nicht imprägnierte/trockene Fasern

nicht mit Harz getränkter Faserbereich, in dem die blanke, exponierte Faser sichtbar ist

3.15

planmäßige Reparatur

nach einem festgelegten, kontrollierten Vorgang so konzipierte und ausgeführte Reparatur, dass unter den Auslegungsbedingungen mit einem hohen Zuverlässigkeitsgrad die Beibehaltung der Integrität des Reparatursystems über die Auslegungslbensdauer zu erwarten ist

3.16

frei liegende Faser

exponierte Faser

Bereich der Faser, der nicht mit Harz getränkt ist und über den Reparaturaufbau hinausragt

3.17

Fremdstoff

alle Substanzen außer den Verstärkungsfasern oder den anderen Materialien, die Teil des Reparatursystems sind

3.18

Materialien für die Abschlusschicht

Deckschicht, die im Allgemeinen eine Polymer- oder eine Gewebeschicht ist und dazu beiträgt, dass das Laminat für Reparaturzwecke dichter anliegt

Anmerkung 1 zum Begriff: Diese Materialien sollten nach dem Aushärten des Reparatursystems und vor der Inspektion oder dem Aufbringen eines Anstrichs vollständig entfernt werden.

3.19**Glasübergangstemperatur**

Temperatur, bei der sich die physikalischen Eigenschaften eines Harzes deutlich verändern

3.20**Härter****Härtungsmittel**

Komponente, die einem wärmehärtbaren Harz zur Aushärtung zugefügt wird

3.21**Wärmeformbeständigkeitstemperatur****HDT**

Temperatur, bei der sich ein Standardprobekörper unter einer bestimmten Last um einen bestimmten Betrag durchbiegt

3.22**Reparateur****Anwender des Reparatursystems****Supervisor**

Person, die zur Anwendung des Verbundwerkstoff-Reparatursystems qualifiziert ist

3.23**Füllstoff**

Material, das zur Reparatur von Fehlern auf der Außenfläche vor Anwendung des Verbundwerkstoffsystems angewendet wird

3.24**Laminat****Schicht(press)stoff****Laminat für Reparaturzwecke****Reparatur-Laminat**

Teil eines Reparatursystems, der ein Verbundwerkstoff ist

Anmerkung 1 zum Begriff: Die meisten in dieser internationalen Norm erwähnten Verbundwerkstoffe bestehen aus eigenständigen dünnen Schichten oder Lagen, die auf das zu reparierende Rohr gewickelt oder anderweitig übereinander angeordnet werden. Diese geschichtete/gestapelte Anordnung ist das Laminat.

3.25**Lage****Schicht**

eine einzelne Lage oder spiralförmige Umwicklung innerhalb des Verbundwerkstoffsystems

3.26**Leck****undichte Stelle****Undichtheit**

Zustand der Wandung eines Substrats, der zulassen kann, dass der Inhalt eines Rohres/Behälters mit dem Reparatur-Laminat in Kontakt gelangt und direkt auf das Reparatur-Laminat einwirkt

Anmerkung 1 zum Begriff: Dieses Lecken bezieht sich nicht auf flüssige/gasförmige Medien, die durch ein Loch oder einen Durchbruch im Substrat sickern.

3.27**gelegentliche Last**

selten und nur kurzzeitig auftretende Last

Anmerkung 1 zum Begriff: Während der Nutzungsdauer eines Bauteils treten gelegentliche Lasten üblicherweise weniger als 10 Mal und über eine Dauer von weniger als 30 min auf.

3.28

Eigentümer

Organisation, die Besitzer oder Betreiber des zu reparierenden Substrats ist

3.29

Nadelstich

Pore

Krater

nadelstichfeines Loch in der harzreichen Oberfläche, das nicht bis in das Laminat hinein verläuft

3.30

Pipeline

Rohr(fern)leitung

Rohr und Zubehörteile, die den gleichen Auslegungsbedingungen unterliegen und zum Transport von gasförmigen/flüssigen Medien zwischen verschiedenen Anlagen verwendet werden

Anmerkung 1 zum Begriff: Zu den Zubehörteilen gehören Bogen, Flansche, Armaturen.

3.31

Leitungsanlage

Verrohrung

miteinander verbundene Leitungen, die den gleichen Auslegungsbedingungen unterliegen

3.32

Rohrleitungen

Rohrleitungssystem

System von Rohrleitungsbauteilen, die zum Transport von flüssigen/gasförmigen Medien innerhalb einer Anlage verwendet werden

Anmerkung 1 zum Begriff: Zu den Bauteilen gehören Rohre, Formstücke, Flansche, Dichtungen, Verschraubungen, Armaturen. Rohrleitungssysteme sind häufig oberirdisch verlegt, mitunter jedoch auch erdverlegt.

3.33

Grübchen

Krater

Narbe

Vertiefung auf der Oberfläche des Laminats

3.34

Lage

einzelne Umwicklung oder Lage (dünne Schicht) eines Reparatur-Laminats

3.35

Nachhärtung

thermische Nachbehandlung

nach dem Festwerden des Harzes zusätzliche Behandlung bei erhöhter Temperatur um sicherzustellen, dass die erforderliche Glasübergangstemperatur erreicht wird

3.36

Anmeldeverfahren für den Eignungstest

Antragsverfahren zur Anwendung des Reparatursystems bei Eignungstests

3.37

Temperatur beim Eignungstest

Temperatur bei Durchführung des Eignungstests für das Reparatursystem

3.38**Verstärkung
Armierung**

in das Harzsystem eingebettete Fasern

Anmerkung 1 zum Begriff: Mögliche Fasermaterialien sind Aramid, Kohlenstoff, Glas, Polyester oder ähnliche Materialien. Durch die Verstärkung sind mechanische Eigenschaften zu erzielen, die besser als die Eigenschaften des Basispolymers sind.

3.39**Reparatursystem**

das für die Reparatur von Rohrleitungen verwendete System umfasst das Substrat, den Verbundwerkstoff (das Reparatur-Laminat), Füllstoffe, Klebstoffe sowie die Verfahren zur Oberflächenvorbereitung und zur Montage

3.40**Installateur des Reparatursystems**

Firma, die das Reparatursystem installiert

3.41**Anbieter/Lieferer des Reparatursystems**

Firma, die das Reparatursystem konstruiert und liefert

3.42**Harzsystem**

alle Bestandteile, die den Matrixanteil eines Verbundwerkstoffs bilden

Anmerkung 1 zum Begriff: In der Regel gehören Harz, Füllstoff(e), Pigment, Mittel zum Modifizieren mechanischer Eigenschaften und Katalysatoren oder Härtungsmittel zum Harzsystem.

3.43**Risiko**

Ereignis, welches die Vorkommnisse erfasst, die auftreten können (Szenario), die Wahrscheinlichkeit des Auftretens dieser Vorkommnisse, ihr Schweregrad oder das Ausmaß des Schadens (Folgen)

3.44**Substrat**

Oberfläche, auf der eine Reparatur durchgeführt wird

Anmerkung 1 zum Begriff: Die Oberfläche darf zu der ursprünglichen Rohrleitung, zu Rohrleitungsteilen, zu Pipelines, Tanks oder Behältern gehören.

3.45**Supervisor**

erfahrener Anwender des Reparatursystems (Reparateur), der sich durch den erfolgreichen Abschluss einer Supervisor-Schulung qualifiziert hat

3.46**Shore-Härte**

Härteskala für die Oberflächenhärte unter Anwendung eines Durometers oder eines Eindringkörpers auf der Oberfläche

3.47**wärmehärtbares Harzsystem****duroplastisches Harzsystem**

Harzsystem, das nach der Polymerisation nicht mehr geschmolzen oder umgeformt werden kann

3.48

Falte

Furche

wellige Oberfläche oder einzelne Furche (Grat) im Laminat, bedingt dadurch, dass das Verstärkungsgewebe zerknittert eingebracht wurde

4 Symbole und Abkürzungen

4.1 Symbole

α_s	Wärmeausdehnungskoeffizient des Substrats
α_c	Wärmeausdehnungskoeffizient des Reparatur-Laminats, in Längs- oder in Umfangsrichtung
c	Risslänge
D	ursprünglicher Außendurchmesser
D_b	ursprünglicher äußerer Durchmesser eines Abzweigs, T-Stücks, Stutzens
d	Durchmesser (oder Durchmesser des äquivalenten Kreises) des Wanddurchbruch-Defekts
ΔT	Differenz zwischen Betriebs- und Installationstemperatur
E_c	Zugmodul des Verbundwerkstoffsystems in Umfangsrichtung
E_a	Zugmodul des Verbundwerkstoffsystems in Längsrichtung
E_{ac}	kombinierter Zugmodul $\sqrt{E_a E_c}$
E_s	Zugmodul des Substrats
ε_c	Auslegungsdehnung in Umfangsrichtung
ε_{c0}	zulässige Dehnung in Umfangsrichtung
ε_a	Auslegungsdehnung in Längsrichtung
ε_{a0}	zulässige Dehnung in Längsrichtung
σ_{lt}	untere Vertrauensgrenze der bei der Funktionsprüfung bestimmten Langzeitspannung
ε_t	Wärmedehnung
ε_{short}	kurzzeitige Bruchdehnung des Verbundwerkstoffsystems
F_{ax}	aufgebrachte Axiallast
F_{eq}	äquivalente Axiallast
F_{sh}	aufgebrachte Scherlast

f_c	Betriebsfaktor bei zyklischer Ermüdungsbeanspruchung
f_D	Abbaufaktor für das Langzeitverhalten der Reparatursysteme bei Wanddurchbruch-Defekten
f_{leak}	Betriebsfaktor für Reparatursysteme bei Wanddurchbruch-Defekten
f_{perf}	Betriebsfaktor für Leistungsdaten
$f_{\text{th,overlay}}$	Faktor zur Vergrößerung der Dicke des Reparatursystems für die reduzierte verfügbare Überlappungslänge
$f_{\text{th,stress}}$	Faktor zur Vergrößerung der Dicke des Reparatursystems für ein Rohrleitungssystem oder ein Behälterbauteil
f_{T1}	Faktor zur Verringerung der Temperatur der für ein Verbundwerkstoffsystem zulässigen Dehnungen
f_{T2}	Faktor zur Verringerung der Temperatur für die Konstruktion des Reparatursystems bei einem Wanddurchbruch-Defekt
ϕ	entgegengesetzt vom Axialschlitz liegender Winkel
G	Schermodul des Verbundwerkstoffs
γ	Zähigkeitsparameter (Energiefreisetzungsrate) für die Grenzfläche Verbundwerkstoffs/Stahl
γ_{soilg}	spezifisches Gewicht des Bodens
h	Erdverlegungstiefe
I	zweites Flächenträgheitsmoment
l	gesamte Länge der Reparatur in Längsrichtung
$l_{\text{available}}$	verfügbarer Landebereich des unbeschädigten Substrats (in Längsrichtung)
l_{over}	Auslegungsdicke der Reparatur in Längsrichtung
l_{defect}	Länge des Defekts in Längsrichtung
l_{taper}	Länge des Kegels in Längsrichtung
N	Anzahl der Schwingspiele
M_{ax}	aufgebrachtes axiales Moment
M_{to}	aufgebrachtes Torsionsmoment
n	Anzahl der Umwicklungen oder Lagen des Reparatur-Laminats

p	erforderlicher Auslegungs-Innendruck
p_{after}	Innendruck nach Aufbringen des Reparatursystems
p_e	Auslegungs-Außendruck
p_{eq}	äquivalenter Auslegungsdruck
$p_{\text{ext,soil}}$	Boden-Außendruck
p_{live}	Innendruck innerhalb des Substrats während der Aufbringung des Reparatursystems
p_{min}	kleinste (Innendruck-) Belastung (oder -spannung) des Schwingspiels
p_{max}	größte (Innendruck-) Belastung (oder -spannung) des Schwingspiels
p_{mthp}	hydrostatischer Prüfdruck mit mittlerer Dauer
p_s	maximal zulässiger Betriebsdruck (MAWP)
p_{sthp}	hydrostatischer Prüfdruck mit kurzer Dauer
p_0	Anfangs-Prüfdruck
p_1	feste lineare Zunahme des Prüfdrucks
q	Zugspannung
R_c	Schweregrad der zyklischen Beanspruchung, definiert als: $R_c = \frac{p_{\text{min}}}{p_{\text{max}}}$
s	zulässige Spannung des Substratmaterials
s_a	gemessene oder im Werk zertifizierte Streckspannung des Substrats
T_d	erforderliche Auslegungstemperatur
T_g	Glasübergangstemperatur
T_m	maximale Betriebstemperatur des Reparatursystems
T_{amb}	Umgebungstemperatur (beim Eignungstest)
T_{test}	Temperatur beim Eignungstest
t	ursprüngliche Wanddicke des Substrats
t_{lifetime}	Auslegungslebensdauer des Reparatursystems
t_{layer}	Dicke einer einzelnen Umwicklung oder Lage des Reparatur-Laminats
t_b	Wanddicke eines Abzweigs, eines T-Stücks

t_f	Wanddicke eines Flansches
t_{design}	Auslegungsdicke des Reparatur-Laminats
t_{min}	Mindestdicke des Reparatur-Laminats
t_s	Mindestwanddicke des verbleibenden Substrats
τ	Scherfestigkeit der Überlappung
ν	Poissonzahl des Reparatur-Laminats
w	(axiale) Breite des Schlitzdefekts in Umfangsrichtung

4.2 Abkürzungen

ASME	Amerikanischer Ingenieursverband (en: American Society of Mechanical Engineers)
ASTM	Amerikanische Normungsorganisation (en: American Society for Testing and Materials)
API	Amerikanisches Erdölinstitut (en: American Petroleum Institute)
AWWA	Amerikanische Wasserwerkvereinigung (en: American Water Works Association)
BS (BSI)	Britische Normungsorganisation (en: British Standards Institute)
CFRP	carbonfaserverstärkter Kunststoff (en: carbon fibre-reinforced plastic)
COSHH	Gesetz zur Kontrolle von gesundheitsgefährlichen Stoffen (en: regulations for control of substances hazardous to health)
CSWIP	Zertifizierung des Personals zur Sicherung der Schweißgüte (en: certification scheme for welding inspection personnel)
DSC	dynamische Differenzkalorimetrie (en: differential scanning calorimetry)
FRP	faserverstärkter Kunststoff (en: fibre-reinforced plastic)
GRP	glasfaserverstärkter Kunststoff (en: glass-reinforced plastic)
HDT	Wärmeformbeständigkeitstemperatur (en: heat distortion temperature)
MAWP	maximal zulässiger Betriebsdruck (en: maximum allowable working pressure)
MSDS	Materialsicherheitsdatenblätter (en: material safety data sheets)
NDT	zerstörungsfreie Prüfung (en: non-destructive testing)
OSHA	Arbeitsschutzbestimmungen (en: Occupational Safety and Health Act)
PCC	Post-Construction Committee
SMYS	angegebene Mindest-Streckgrenze (en: specified minimum yield strength)

Nationaler Anhang NB (informativ)

Literaturhinweise

DIN EN ISO 75-3, *Kunststoffe — Bestimmung der Wärmeformbeständigkeitstemperatur — Teil 3: Hochbeständige härtbare Schichtstoffe und langfaserverstärkte Kunststoffe*

DIN EN ISO 527-1, *Kunststoffe — Bestimmung der Zugeigenschaften — Teil 1: Allgemeine Grundsätze*

DIN EN ISO 527-4, *Kunststoffe — Bestimmung der Zugeigenschaften — Teil 4: Prüfbedingungen für isotrop und anisotrop faserverstärkte Kunststoffverbundwerkstoffe*

DIN EN ISO 868, *Kunststoffe und Hartgummi — Bestimmung der Eindruckhärte mit einem Durometer (Shore-Härte)*

DIN EN ISO 11357-2, *Kunststoffe — Dynamische Differenz-Thermoanalyse (DSC) — Teil 2: Bestimmung der Glasübergangstemperatur und der Glasübergangsstufen*

DIN EN ISO 14692(alle Teile), *Erdöl- und Erdgasindustrie — Glasfaserverstärkte Kunststoff-Rohrleitungen*

English Version

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

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European foreword

This document (EN ISO 24817:2015) has been prepared by Technical Committee ISO/TC 67 “Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries” in collaboration with 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.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by February 2016, and conflicting national standards shall be withdrawn at the latest by February 2016.

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Endorsement notice

The text of ISO 24817:2015 has been approved by CEN as EN ISO 24817:2015 without any modification.

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: [Foreword - Supplementary information](#)

The committee responsible for this document is ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 6, *Processing equipment and systems*.

This first edition cancels and replaces ISO/TS 24817:2006, which has been technically revised.

Introduction

The objective of this International Standard is to ensure that pipework, pipelines, tanks, and vessels repaired using composite systems that are qualified, designed, installed, and inspected using this International Standard will meet the specified performance requirements. Repair systems are designed for use within the petroleum, petrochemical, and natural gas industries and also within utility service applications. The main users of this International Standard will be plant and equipment owners of the pipework and vessels, design contractors, suppliers contracted to provide the repair system, certifying authorities, installation, maintenance, and inspection contractors.

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

1 Scope

This International Standard gives requirements and recommendations for the qualification and design, installation, testing, and inspection for the external application of composite repair systems to corroded or damaged pipework, pipelines, tanks, and vessels used in the petroleum, petrochemical, and natural gas industries.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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 the resistance to chemical attack for the inside of a section in a deflected condition*

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

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

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

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

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

ASTM D696, *Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics Between Minus 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 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, *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, *Methods of testing plastics — Glass reinforced plastics — Measurement of hardness by means of a Barcol impressor (BS 2782-10, Method 1001, 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 impresser

3.3

blister

air void between layers within the laminate visible on the surface as a raised area

3.4

composite

thermoset resin system that is reinforced by fibres

3.5

crack

split in the laminate extending through the wall (perpendicular to the surface) such that there is actual separation with opposite surfaces visible

3.6

cure

curing

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

3.7

cure schedule

time-temperature profile qualified to generate a specified T_g or HDT

3.8

defect type A

defect within the substrate, not through-wall and not expected to become through-wall within the repair design lifetime of the repair system

3.9

defect type B

through-wall defect or a defect within the substrate where at the end of service life the remaining wall thickness is less than 1 mm

3.10

defined lifetime

actual application or service lifetime of the repair

3.11

delamination

area between the repair laminate and the substrate which should be bonded together but where no bond exists, or an area of separation between layers in the repair laminate

3.12

design lifetime

maximum application lifetime of the repair

3.13

differential scanning calorimetry

DSC

method of determining the glass transition temperature of a thermosetting resin

3.14

dry spot or un-impregnated/dry fibre

area of fibre not impregnated with resin, with bare, exposed fibre visible

3.15

engineered repair

repair which has been designed and applied under a specified, controlled process so that under the design conditions, there is a high degree of confidence that the repair will maintain its integrity over the design lifetime

3.16

exposed fibre

area of fibre not impregnated with resin that projects from the body of the repair

3.17

foreign matter

any substance other than the reinforcing fibre or other materials that form part of the repair system

3.18

finishing materials

final layer of material to help compact the repair laminate, typically a polymeric film or a fabric

Note 1 to entry: They should be fully removed after the repair has hardened and before the repair is inspected or painted.

3.19

glass transition temperature

temperature at which a resin undergoes a marked change in physical properties

3.20

hardener

component added to a thermosetting resin to effect cure

3.21

heat distortion temperature

HDT

temperature at which a standard test bar deflects by a specified amount under a given load

3.22

installer

person who is qualified to apply a composite repair system

3.23

filler material

material used to repair external surface imperfections prior to the application of the composite laminate

3.24

laminate

repair laminate

part of a repair system that is the composite

Note 1 to entry: Most composites considered in this International Standard are composed of discrete lamina or layers which are wrapped or stacked, one on top of the other. This stacked construction is the laminate.

3.25

layer

individual layer or wrap within the composite laminate

3.26

leak

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

Note 1 to entry: This does not refer to a fluid leaking through a hole or breach in the substrate.

3.27

occasional load

load that occurs rarely and during a short time

Note 1 to entry: Occasional loads typically occur less than 10 times in the life of the component and each load duration is less than 30 min.

3.28

owner

organization that owns or operates the substrate to be repaired

3.29

pin hole

pin-prick hole in the resin rich surface, not extending into the laminate

3.30

pipeline

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

Note 1 to entry: Components include bends, flanges, valves.

3.31

pipework

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

3.32

piping

piping system

assemblies of piping components used to convey fluids within a plant

Note 1 to entry: Components include pipe, fittings, flanges, gaskets, bolting, valves. A piping system is often above ground but sometimes buried.

3.33

pit

depression in the surface of the laminate

3.34

ply

single wrap or layer (lamina) of a repair laminate

3.35

post cure

additional elevated-temperature cure applied after resin has hardened to ensure the required glass transition temperature is achieved

3.36

qualification application procedure

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

3.37

qualification test temperature

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

3.38

reinforcement

fibre embedded in the resin system

Note 1 to entry: Possible fibre materials include aramid, carbon, glass, polyester, or similar materials. Reinforcement results in mechanical properties superior to those of the base resin.

3.39

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

3.40

repair system installer

company that installs the repair system

3.41

repair system supplier

company that designs and supplies the repair system

3.42

resin system

all of the components that make up the matrix portion of a composite

Note 1 to entry: Often this includes a resin, filler(s), pigment, mechanical property modifiers and catalyst or hardener.

3.43

risk

event encompassing what can happen (scenario), its likelihood (probability), and its level or degree of damage (consequences)

3.44

substrate

surface on which a repair is carried out

Note 1 to entry: The surface may belong to original pipework, pipework component, pipeline, tank, or vessel.

3.45

supervisor

experienced installer who is qualified by successfully completing the supervisor training course

3.46

Shore hardness

measure of surface hardness using a surface impresser or durometer

3.47

thermoset resin system

resin system that cannot be melted or remoulded following polymerization

3.48

wrinkle

wavy surface or distinct ridge in the laminate where the reinforcing fabric has creased during application

4 Symbols and abbreviated terms

4.1 Symbols

α_s	thermal expansion coefficient of substrate
α_c	thermal expansion coefficient of the repair laminate for either the axial or circumferential directions
c	crack length
D	original external diameter
D_b	original external branch, tee, nozzle 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
σ_{lt}	lower confidence limit of the long-term strain determined by performance testing

ε_t	thermal strain
$\varepsilon_{\text{short}}$	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
$f_{\text{th,overlay}}$	repair thickness increase factor for reduced available overlap length
$f_{\text{th,stress}}$	repair thickness increase factor for piping system or vessel component
f_{T1}	temperature de-rating factor for composite laminate 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 laminate, steel interface
γ_{soilg}	specific weight of soil
h	burial depth
I	second moment of area
l	total axial length of repair
$l_{\text{available}}$	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 wraps or layers or repair laminate
p	required design internal pressure
p_{after}	internal pressure after repair system is applied
p_e	external design pressure
p_{eq}	equivalent design pressure

$p_{\text{ext,soil}}$	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
p_1	fixed linear increase in test pressure
q	tensile stress
R_c	cyclic loading severity, defined as: $R_c = \frac{p_{\text{min}}}{p_{\text{max}}}$
s	allowable stress of the substrate material
s_a	measured yield stress of substrate or mill certification yield stress
T_d	required design temperature
T_g	glass transition temperature
T_m	maximum operating temperature of repair system
T_{amb}	ambient (qualification) test temperature
T_{test}	qualification test temperature
t	original wall thickness of substrate
t_{lifetime}	repair 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
τ	lap shear strength
ν	Poisson's ratio for the repair laminate
w	(axial) width of circumferential slot defect

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 sheets
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 composite repair systems in this International Standard cover situations involving the repair of damage commonly encountered in oil, gas, utility pipework systems and vessels. The procedures are also applicable to the repair of pipelines, caissons, and storage tanks with appropriate consideration.

Procedures in this International Standard 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.

This International Standard is not a defect assessment standard. Within this International Standard, no statements are made regarding whether a specific defect is acceptable or unacceptable for repair. The standard assumes that a defect assessment has already been performed to, for example ASME B31G or API RP 579. The starting point for this International Standard is that a decision has been taken to repair a given defect with a composite repair system and the output from the defect assessment, e.g. MAWP or minimum remaining wall thickness is used as input for the repair design. This International Standard is concerned with the subsequent activities of repair qualification, design, installation, and inspection.

Repair systems are applied to restore 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, i.e. the size of the defect at the end of the required design life of the repair should be taken as the size of the defect when designing the repair;
- crack like defects, where the defect is or is not through wall. It is a requirement that the length of the crack is known and will not increase during the lifetime of the repair. For through wall cracks, the crack should be modelled as a Type B defect, either a circumferential or axial slot (depending on the crack orientation). For non-through wall cracks, the crack should be modelled as Type A defect, [7.5.4](#);
- strengthening and/or stiffening 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 (metal pipes)	Applicability of repair system (GRP pipes)
General wall thinning	Y	Y
Local wall thinning	Y	Y
Pitting	Y	Y
Gouges/Dents	R	R
Blisters	Y	R
Laminations	Y	R
Circumferential cracks	Y	R
Longitudinal cracks	R	R
Through-wall penetration	Y	R
Y Implies generally appropriate. R Implies can be used, but requires extra consideration, i.e. will the composite repair reduce locally the stresses acting on the defect. For the case of gouges/dents or cracks, it will be required to assess whether application of the repair will stop future crack growth or whether a conservative assumption about the ultimate length of the crack is required. If either assessment is negative, then application of a composite repair is not appropriate.		

Services that are covered within the scope of this International Standard include those normally found in an oil and gas production or processing installation. These include the following:

- utility fluid, diesel, seawater, air;
- chemicals (liquids);
- production fluids, including liquid hydrocarbons, gaseous hydrocarbons, and gas condensates.

The upper temperature limit is defined in [7.5.3](#).

The lower temperature limit is dependent on the type of repair laminate being used. This limit is determined by the design requirements presented in [7.5.3](#).

The upper pressure limit is a function of defect type (internal, external, or through-wall), defect dimensions (depth and extent), pipe diameter, design temperature and repair design lifetime. Therefore, a unique number cannot be quoted but rather the limit is derived for a given set of conditions by calculations in accordance with this International Standard using the qualification test data.

The lower pressure limit, e.g. vacuum conditions, is determined by the design requirements presented in [7.5.9.7](#).

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

The pipework and vessel substrates considered within the standard include carbon steel, 6 moly steel, stainless steel, duplex steel, super duplex steel, GRP, Cunifer, aluminium, galvanised steel and titanium. Careful consideration is required before repair of GRP lines because the damage in the pipe may be more extensive than is visible on the surface and may affect a longer length of the pipe than is immediately obvious; advice of the GRP pipe manufacture and repair system supplier shall be sought before a repair is installed.

6 Summary of key issues

The key issues to be considered by the owner to ensure that a repair system complies with the requirements of this International Standard are specified in the relevant clauses of this International Standard.

The repair system is defined as the combination of the following elements and procedures:

- a) substrate, (component, e.g. pipe, pipeline tank, vessel outer surface);
- b) surface preparation;
- c) application of filler material;
- d) application of primer layer;
- e) application of repair laminate;
- f) curing procedure.

This International Standard does not provide guidance on when to use a repair system. It starts from the point that a decision to use a repair system has already been taken and gives guidance on how to use repair systems effectively covering testing, design, installer training, installation, and through to maintenance of a repair in service.

There are six key areas of the repair process that shall be considered.

Repair System Qualification

The owner shall confirm the repair system proposed has been tested in accordance with the requirements of this International Standard ([Clause 7](#)). This would typically require the supplier to submit test reports or to provide third-party verification that testing has been completed.

Qualification testing is specific to a particular pipe material and method of surface preparation for that material. The owner shall confirm that testing has been completed for the pipe material of interest and the method of surface preparation being considered.

Enquiry stage

All relevant data, e.g. design conditions, corrosion mechanisms, inspection data and surface preparation limitations shall be passed from the owner to the repair system supplier ([7.4](#)). Full details of design temperatures and pressures shall be provided. Upset conditions shall be considered, for example, if steaming of the line is expected then this must be noted.

Any limitations on working conditions shall be identified and supplied to the repair system installer/supplier through completion of the Design data sheet form ([Annex A](#)). Risk assessment and an overview of site conditions should be supplied by the owner.

The status of the pipework during repair application, e.g. live, no pressure but full, empty shall be defined and passed on from the owner to the repair system supplier. Details of the expected surface temperature and local humidity shall also be provided.

A photographic record of the defect prior to repair design/application should be kept by the owner.

Design of repair

The correct design procedure shall be followed as defined in [Figure 1](#).

When designed in accordance with this International Standard, repair systems can provide strengthening of lines to relatively high pressures for Type A defects but can only be used at lower pressures for Type B defects. The limits for Type B defects are strongly affected by the size of defect assumed.

The selection of the generic through-wall defect and size for design, i.e. the selection of the correct dimension, may not simply be the size of the actual defect but rather may be either the dimension of the unprepared surface area neighbouring the defect or if filler is used over the defect, the dimension of the defect is the surface area of filler ([7.5.7](#)).

Repairs to lines suffering internal corrosion or erosion must consider the defect size expected at the end of the repair service life. The repairs would generally be less resistant to erosion than a metal pipe and repair life would normally be restricted to the point that the defect goes through-wall.

The repair system supplier shall demonstrate how the repair system will satisfy the design requirements of this International Standard regarding temperature where the pipe has an elevated design temperature but generally operates at ambient or has an elevated design temperature but the repair is installed at ambient ([7.5.3](#)).

Installer Training

Correct installation will ultimately determine successful performance of a repair as defined in [Table 14](#).

Repair installers shall have been trained in the application of the specific repair system in use.

The owner shall confirm that repair installers have been trained in compliance with the requirements of this International Standard. The repair system supplier shall demonstrate competence of the installers via evidence of training and experience ([Annex I](#)).

Installation of repair

In terms of the performance of the repair system, the adhesion of the repair to the substrate is the key technical issue. The surface preparation procedure should be the same as that qualified by testing and assumed in the design. The pipe surface shall be dry and at a temperature above the dew point or otherwise in compliance with the conditions validated by repair qualification testing.

The actual defect size should be confirmed as being within the limits assumed in the design (e.g. physical dimension, unprepared surface area or surface area of filler).

QA measurements shall be recorded (as per the repair system supplier's method statement), as the repair is being applied ([Table 14](#)). The repair shall be fully cured before the pressure is brought back to normal operating conditions. The repair system supplier shall provide details on how to assess the cure status of the repair laminate ([Table 14](#)).

A photographic record of the repair application should be kept by the repair system supplier.

The completed QA measurements and photographs (if available) shall be submitted to and retained by the owner and the repair system supplier shortly after installation is completed.

The ends of the repairs, where they extend on to base metal, as a minimum should be painted over to prevent corrosion to the pipe at this location.

Inspection and maintenance of repair

If considered necessary, the repair should be inspected on a regular basis to ensure the integrity of the repair and that it is operating within the assumptions used in the design of repair (i.e. the defect size is less than assumed in design) ([Clause 9](#)). It may be appropriate to complete a baseline inspection immediately after application against which future inspections can be compared and changes identified.

At the end of the repair design lifetime, either the spool onto which the repair is situated should be removed, the repair removed, or the repair design lifetime re-validated ([9.5](#)).

7 Qualification and design

7.1 Repair feasibility assessment

The following factors shall be considered by the owner and repair system supplier when assessing the feasibility of designing and installing a repair system:

- 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 design lifetime (see [7.3](#));
- 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) and maintenance of the repair;
- repair system materials.

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

The information and data describing any hazards shall be included in the method statement ([8.2](#)) 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 ([7.2](#)), which determines the detail of the design method ([7.5](#)) 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 the assessment can be obtained from Reference [[36](#)].

7.2 Repair class

Each repair shall be allocated to a particular class as defined in [Table 2](#).