DEUTSCHE NORM

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Ersatz für
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Erdöl- und Erdgasindustrie – Auslegung und Betrieb von Unterwasser-Produktionssystemen – Teil 1: Allgemeine Anforderungen und Empfehlungen (ISO 13628-1:2005 + Amd 1:2010); Englische Fassung EN ISO 13628-1:2005 + A1:2010, nur auf CD-ROM

Petroleum and natural gas industries –
Design and operation of subsea production systems –
Part 1: General requirements and recommendations (ISO 13628-1:2005 + Amd 1:2010);
English version EN ISO 13628-1:2005 + A1:2010, only on CD-ROM

Industries du pétrole et du gaz naturel –
Conception et exploitation des systèmes de production immergés –
Partie 1: Exigences générales et recommandations (ISO 13628-1:2005 + Amd 1:2010);
Version anglaise EN ISO 13628-1:2005 + A1:2010, seulement en CD-ROM

Gesamtumfang 256 Seiten

Normenausschuss Erdöl- und Erdgasgewinnung (NÖG) im DIN

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Full document details: DIN EN ISO 13628-1:2010-12

Nationales Vorwort

Dieses Dokument (EN ISO 13628-1:2005 + A1:2010) wurde vom ISO/TC 67 „Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries“, Subkomitee SC 4, Working Group WG 6 „Subsea equipment“ in Zusammenarbeit mit dem Technischen Komitee CEN/TC 12 „Materialien, Ausrüstungen und Offshore-Bauwerke für die Erdöl-, petrochemische und Erdgasindustrie“ (Sekretariat: AFNOR, Frankreich) erarbeitet

Für Deutschland hat hieran der Arbeitskreis NA 109-00-01-04 AK „Bohr- und Fördereinrichtungen — Spiegelausschuss zu ISO/TC 67/SC 4“ im Normenausschuss Erdöl- und Erdgasgewinnung (NÖG) des DIN Deutsches Institut für Normung e. V. mitgearbeitet.

Dieses Dokument enthält die Änderung 1, angenommen von CEN am 2010-08.

Der Beginn und das Ende des hinzugefügten oder geänderten Textes wird im Text durch die Textmarkierungen A1 A1 angezeigt.

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

Dieses Dokument enthält neben den gesetzlichen Einheiten auch die Einheiten „°F“, „bbl“, „ft“, „in (inch)“, „NPS“ und „psi“, die im Deutschen Normenwerk nicht zugelassen sind. Es wird ausdrücklich darauf hingewiesen, dass die Anwendung dieser Einheiten im nationalen amtlichen und geschäftlichen Verkehr aufgrund des Gesetzes über Einheiten im Messwesen nicht zulässig ist.

Umrechnung:

Nicht-SI-Einheit	**SI-Einheit**	**Umrechnung**	
°F	°C	°C	= (5/9) (°F-32)
bbl	dm^3	1 bbl	= 158,987 dm^3
ft	m	1 ft	= 0,304 8 m
in (inch)	mm	1 inch	= 25,4 mm
NPS	DN	1 NPS	= DN 25
psi (psig)	kPa	1 psi	= 6,894 757 kPa

ISO 13628 *Petroleum and natural gas industries — Design and operation of subsea production systems* besteht aus den folgenden Teilen:

— *Part 1: General requirements and recommendations*

— *Part 2: Unbonded flexible pipe systems for subsea and marine applications*

— *Part 3: Through flowtime (TFL) systems*

— *Part 4: Subsea wellhead and tree equipment*

— *Part 5: Subsea umbilicals*

— *Part 6: Subsea production control systems*

— *Part 7: Completion/workover riser systems*

— *Part 8: Remotely Operated Vehicle (ROV) interfaces on subsea production systems*

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— *Part 9: Remotely Operated Tools (ROT) intervention systems*

— *Part 10: Specification for bonded flexible pipe*

— *Part 11: Flexible pipe systems for subsea and marine applications*

— *Part 15: Subsea structures and manifolds*

— *Part 16: Specification for flexible pipe ancillary equipment*

— *Part 17: Guidelines for flexible pipe ancillary equipment*

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

ISO 3506-1	siehe	DIN EN ISO 3506-1
ISO 3506-2	siehe	DIN EN ISO 3506-2
ISO 8501-1	siehe	DIN EN ISO 8501-1
ISO 8503 (all parts)	siehe	DIN EN ISO 8503 (alle Teile)
ISO 10423	siehe	DIN EN ISO 10423
ISO 12944 (all parts)	siehe	DIN EN ISO 12944 (alle Teile)
ISO 13535	siehe	DIN EN ISO 13535
ISO 13628-4	siehe	DIN EN ISO 13628-4
ISO 13628-5	siehe	DIN EN ISO 13628-5
ISO 13628-6	siehe	DIN EN ISO 13628-6
ISO 13628-7	siehe	DIN EN ISO 13628-7
ISO 13628-8	siehe	DIN EN ISO 13628-8
ISO 13628-9	siehe	DIN EN ISO 13628-9
ISO 15156 (all parts)	siehe	DIN EN ISO 15156 (alle Teile)
ISO 23936-1	siehe	DIN EN ISO 23936-1

Änderungen

Gegenüber DIN EN ISO 13628-1:2006-02 wurden folgende Änderungen vorgenommen:

a) Umsetzung der Änderung 1: EN ISO 13628-1:2005/A1:2010;

b) Aktualisierungen der normativen Verweisungen, als Umsetzung von EN ISO 13628-1:2005/A1:2010;

c) Aktualisierungen der Begriffsdefinitionen, als Umsetzung von EN ISO 13628-1:2005/A1:2010;

d) Überarbeitung des gesamten Abschnitts 6 „Materials and corrosion protection“, als Umsetzung von EN ISO 13628-1:2005/A1:2010;

e) Aktualisierung der Literaturhinweise, als Umsetzung von EN ISO 13628-1:2005/A1:2010.

Frühere Ausgaben

DIN EN ISO 13628-1: 1999-07, 2006-02

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Nationaler Anhang NA
(informativ)

Begriffe und Abkürzungen

Folgende Begriffe und Abkürzungen werden in der Norm verwendet. Die Referenznummer entspricht der Referenznummer im Dokument, die Abkürzungen sind identisch mit denen im Dokument.

3 Begriffe und Abkürzungen

Für die Anwendung dieses Dokuments gelten die folgenden Begriffe und Abkürzungen.

3.1 Begriffe

3.1.1
Abdeckung
Bauelement, das Teil einer druckbeaufschlagten Hülle ist und unbeabsichtigtes Abfließen von geförderten/injizierten Fluiden, insbesondere in die äußere Umgebung verhindern soll

3.1.2
Tiefwasser
Wasser mit einer Tiefe, die üblicherweise von 610 m (2 000 Fuß) bis 1 830 m (6 000 Fuß) reicht

ANMERKUNG Da sich die physikalischen Gegebenheiten einer beliebigen Situation als Funktion der Wassertiefe ändern, bedeutet die Verwendung des Begriffes „Tiefwasser“, dass es notwendig sein kann, alternative Konstruktionsweisen und/oder Technologien in Betracht zu ziehen.

3.1.3
erste Verbindung
zu Beginn des Installationsvorgangs der Förderleitung oder von Versorgungskabeln hergestellte Verbindung

3.1.4
Förderleitung
Produktions-/Injektionsleitung, Versorgungsleitung oder Rohrleitung, durch die ein Fluid fließt

ANMERKUNG In diesem Teil von ISO 13268 wird dieser Begriff verwendet, um Lösungen oder Umstände allgemeiner Art zu beschreiben, die mit einer Förderleitung verbunden sind.

3.1.5
freier Anschluss
unbewehrte Versorgungskabelüberbrückung mit einer Anschlussplatte an jedem Ende, (die Verbinder für die verschiedenen Leitungen enthält), die zum Verbinden der Unterwasser-Anlagen miteinander dient

ANMERKUNG 1 Freie Anschlüsse werden üblicherweise eingesetzt, um z. B. ein Unterwasser-Steuermodul an einem Unterwasser-Eruptionskreuz mit einer Unterwasser-Versorgungskabel-Verteileinheit zu verbinden.

ANMERKUNG 2 Da es sich um eine Leichtgewicht-Versorgungskabelüberbrückung handelt, kann sie von einem Ausbringungskorb auf dem Meeresboden aufgenommen und mithilfe eines frei beweglichen ROV in Stellung gebracht werden.

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3.1.6
Überbrückung
kurzes Segment eines biegsamen Rohres mit einer Verbinderhälfte an jedem Ende

ANMERKUNG Eine Überbrückung wird üblicherweise verwendet, um Förderleitungen und/oder Unterwasseranlagen miteinander zu verbinden, z. B. eine Unterwasser-Förderleitung mit einem auf einer Förderplattform montierten Hartrohr-Riser.

3.1.7
Prozessventil
alle im Förderstromweg nach den Seitenschiebern des Eruptionskreuzes angeordneten Ventile

3.1.8
Einzugskopf
Vorrichtung, die dazu dient, das Ende einer Förderleitung oder eines Versorgungskabels anzuschließen, so dass sie/es von einem Schiff abgeladen und über den Meeresboden und/oder durch ein I-Rohr oder J-Rohr gezogen werden kann

3.1.9
letzte Verbindung
zum Abschluss des Installationsvorgangs der Förderleitung oder des Versorgungskabels hergestellte Verbindung

3.1.10
Spool
kurzes Segment eines starren Rohres mit einer Verbinderhälfte an jedem Ende

ANMERKUNG Eine Spool wird gewöhnlich verwendet, um Förderleitungen und/oder Unterwasseranlagen miteinander zu verbinden, z. B. ein Unterwasser-Eruptionskreuz mit einem Unterwasser-Manifold.

3.1.11
extremes Tiefwasser
Wassertiefe von mehr als 1 830 m (6 000 Fuß)

ANMERKUNG 1 Da sich die physikalischen Gegebenheiten einer beliebigen Situation als Funktion der Wassertiefe ändern, bedeutet die Verwendung des Begriffes „extremes Tiefwasser“, dass es notwendig sein kann, alternative Konstruktionsweisen und/oder Technologien in Betracht zu ziehen.

ANMERKUNG 2 Zur Beschreibung der Druck-Temperaturstufen werden die in der zutreffenden Internationalen Norm zu dem jeweiligen Teilsystem oder in weiteren maßgeblichen Normen und Konstruktionsvorschriften angegebenen Definitionen angewendet.

3.1.12
Versorgungskabelüberbrückung
kurzes Segment eines Versorgungskabels mit einer Anschlussplatte an jedem Ende, (die Verbinder für die verschiedenen Leitungen enthält), das zum Verbinden der Unterwasser-Anlagen miteinander dient

ANMERKUNG Eine Versorgungskabelüberbrückung wird üblicherweise eingesetzt, um z. B. einen Unterwasser-Versorgungskabelanschluss an eine Unterwasser-Versorgungskabelverteileinheit anzuschließen.

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3.1.13
unlegierter Stahl
Kohlenstoffstahl
eine Legierung von Kohlenstoff und Eisen, die einen Massenanteil an Kohlenstoff von bis zu 2 % und einen Massenanteil an Mangan von bis zu 1,65 % sowie Restmengen weiterer Elemente enthält, nicht gerechnet jene, die absichtlich in spezifischen Mengen zur Desoxidation beigegeben werden (meist Silizium und/oder Aluminium)

ANMERKUNG In der Erdölindustrie verwendete Kohlenstoffstähle enthalten üblicherweise einen Massenanteil an Kohlenstoff von weniger als 0,8 %.

[ISO 15156-1:2009, 3.3]

3.1.14
korrosionsbeständige Legierungen
CRAs
Legierungen, die beständig gegen allgemeine und örtliche Korrosion in solchen Ölfeldumgebungen sein sollen, in denen unlegierte Stähle korrodieren

ANMERKUNG Diese Definition stimmt mit ISO 15156-1 überein und soll solche Werkstoffe wie z. B. nichtrostende Stähle mit einem Mindest-Massenanteil an Cr von 11,5 % sowie Nickel-, Kobalt- und Titanbasislegierungen umfassen. In anderen ISO-Dokumenten können andere Definitionen angegeben sein.

3.1.15
niedriglegierter Stahl
Stähle mit einem Gesamtlegierungsgehalt, der einem Massenanteil von weniger als 5 % entspricht, aber größer ist als für unlegierten Stahl festgelegt

BEISPIELE Beispiele für niedriglegierte Stähle sind AISI 4130, AISI 8630, ASTM A182 Güte F22 [12].

3.1.16
Lochfraßindex (Wirksumme)
PREN
Index, der entwickelt wurde, um die Lochfraßbeständigkeit von nichtrostendem Stahl wiederzugeben und vorauszuberechnen, was auf der Grundlage der Anteile der Elemente Cr, Mo, W und N in der chemischen Zusammensetzung der Legierung geschieht

ANMERKUNG Dieser Index beruht auf der bei korrosionsbeständigen Legierungen beobachteten Lochfraßbeständigkeit bei Vorhandensein von Chloriden und Sauerstoff, z. B. in Meerwasser und weist nicht direkt auf die Beständigkeit in den Umgebungen der Öl- und Gasförderung hin.

$$F_{\mathrm{PREW}} = w_{\mathrm{Cr}} + 3{,}3\left(w_{\mathrm{Mo}} + 0{,}5 w_{\mathrm{W}}\right) + 16 w_{\mathrm{N}}$$

Dabei ist

w_{Cr} der Massenanteil von Chrom in der Legierung, angegeben als prozentualer Anteil an der Gesamtzusammensetzung

w_{Mo} der Massenanteil von Molybdän in der Legierung, angegeben als prozentualer Anteil an der Gesamtzusammensetzung

w_{W} der Massenanteil von Wolfram in der Legierung, angegeben als prozentualer Anteil an der Gesamtzusammensetzung

w_{N} der Massenanteil von Stickstoff in der Legierung, angegeben als prozentualer Anteil an der Gesamtzusammensetzung

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3.1.17
saurer Einsatzbereich
Einsatz in einem H_2S-haltigen (sauren) Fluid

ANMERKUNG In diesem Teil von ISO 13628 bezieht sich der Begriff „saurer Einsatzbereich“ auf Bedingungen, unter denen der H_2S-Gehalt so hoch ist, dass die in ISO 15156 (alle Teile) festgelegten Einschränkungen gelten.

3.1.18
süßer Einsatzbereich
Einsatz in einem H_2S-freien (süßen) Fluid

3.1.19
Stahltyp 316
austenitische nichtrostende Stahllegierungen vom Typ UNS S316000/S31603

3.1.20
Stahltyp 6Mo
austenitische nichtrostende Stahllegierungen mit einem PREN $\geq$ 40 und bei denen der Massenanteil des Legierungselements Mo $\geq$ 6,0 % ist, sowie Nickellegierungen mit einem Mo-Massenanteil im Bereich von 6 % bis 8 %

BEISPIELE UNS S31254-, N08367- und N08926-Legierungen.

3.1.21
Duplex-Stahl vom Typ 22Cr
ferritische/austenitische nichtrostende Stahllegierungen, bei denen 30 $\leq$ PREN $\leq$ 40 ist und der Massenanteil an Mo $\leq$ 2,0 % beträgt

BEISPIELE UNS S31803- und S32205-Stahl.

3.1.22
Duplex-Stahl vom Typ 25Cr
ferritische/austenitische nichtrostende Stahllegierungen mit 40 $\leq$ PREN $\leq$ 45

BEISPIELE UNS S32750- und S32760-Stahl.

3.2 Abkürzungen

AAV Zugangsventil zum Ringraum

AC Wechselstrom

ADS Tauchsystem unter atmosphärischem Druck

AIV Ringraum-Abschaltventil

AMV Ringraum-Hauptschieber

API American Petroleum Institute (amerikanisches Erdölinstitut)

ASV Ringraum-Servicearmatur

AUV Autonomes Unterwasserfahrzeug (engl. autonomous underwater vehicle)

AWS American Welding Society (Amerikanische Gesellschaft für Schweißtechnik)

BOP Bloutout-Preventer

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Full document details: DIN EN ISO 13628-1:2010-12

CRA	korrosionsbeständige Legierung
C/WO	Komplettierung/Aufwältigung
DC	Gleichstrom
DFI	Konstruktion, Herstellung, Montage
DHPTT	Druck-Temperatur-Messwertgeber für Bohrlochanwendungen
DNV	Det Norske Veritas
EDP	Notfall-Trenn-Vorrichtung
ESD	Notabschaltung
ESP	elektrische Tauchpumpe
FAT	Werksabnahmeprüfung
FMEA	Fehlermöglichkeits- und Einflussanalyse
FPS	schwimmendes Fördersystem
FPU	schwimmende Fördereinheit
GOR	Gas-Öl-Verhältnis
GVF	Gasvolumenanteil
HAZOP	Gefährdungsanalyse der Betriebsprozesse
HB	Brinellhärte
HBW	Brinellhärte
HIC	wasserstoffinduzierte Rissbildung
HIPPS	Hochleistungs-Überdruckschutzsystem
HPU	Hydraulik-Einheit
HRC	Rockwellhärte nach Skala C
HV	Vickershärte
HXT	horizontales E-Kreuz
ID	Innendurchmesser
IPU	integriertes Rohrleitungs-Versorgungskabel
LMRP	unteres Riserpaket (für Bohrungen)
LPMV	unterer Produktionshauptschieber
LRFD	Bemessung mit Teilsicherheitsbeiwerten

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LRP	untere Riser-Abdichtung (für Aufwältigung)
LWI	System für einen leichten Eingriff in das Bohrloch
MEG	(Mono-)Ethylenglycol
MIC	Mikrobiologisch beeinflusste Korrosion
MIV	Methanol-Einspritzventil
MODU	verfahrbare Offshore-Bohreinheit
MPFM	Mehrphasen-Durchflussmesser
MPP	Mehrphasenpumpe
NACE	National Association of Corrosion Engineers
OTDR	optische Zeitbereichsreflektometrie
PCS	Produktionsleitsystem
PGB	stationäre Führung
PIV	Produktions-Abschaltventil
PLEM	Manifold am Rohrleitungsende
PLET	Rohrleitungsendanschluss
PLS	plastischer Grenzzustand
PMV	Produktions-Hauptschieber
PRE	Lochfraßbeständigkeitsäquivalent
PSD	Abschaltung der Produktion
PSV	Produktions-Servicearmatur
PWV	Produktions-Seitenschieber
QRA	quantitative Risikoanalyse
RAL	„Reichsausschuss für Lieferbedingungen“, von deutschen Farbenherstellern verwendetes Farbvorlagensystem
ROT	fernbetätigtes Werkzeug
ROV	ferngelenktes Fahrzeug
SAS	Sicherheits- und Automatisierungssystem
SCM	Unterwasser-Steuermodul
SCSSV	übertage gesteuertes Untertage-Sicherheitsventil

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SEM	Unterwasser-Elektronikmodul
SIL	Sicherheits-Integritätslevel
SITHP	Schließdruck am Steigrohrkopf
SSIV	Unterwasser-Abschaltventil
SSP	Unterwasser-Bearbeitung
SUDU	Unterwasser-Versorgungskabelverteileinheit
SUT	Unterwasser-Versorungskabelanschluss
SWC	stufenweise Rissbildung
SXT	obertägiges Eruptionskreuz
TFL	durch die Förderleitung (durchgeführte Verfahren)
TGB	zeitweilige Führung
TH	Steigrohrhänger
THRT	Steigrohrhänger-Einbauwerkzeug
TRT	E-Kreuz-Einbauwerkzeug
ULS	Grenzzustand der Tragfähigkeit
UNS	US-amerikanisches vereinheitlichtes Nummerierungssystem
UPMV	oberer Produktions-Hauptschieber
UPS	unterbrechungsfreie Stromversorgung
VXT	vertikales E-Kreuz
WAT	Wachskristallisationstemperatur
WHP	Bohrlochkopfdruck
WOCS	Aufwältigungs-Steuersystem
WOR	Aufwältigungs-Riser
XOV	Übergangsventil
XT	E-Kreuz

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Nationaler Anhang NB
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Literaturhinweise

DIN EN ISO 3506-1, *Mechanische Eigenschaften von Verbindungselementen aus nichtrostenden Stählen — Teil 1: Schrauben*

DIN EN ISO 3506-2, *Mechanische Eigenschaften von Verbindungselementen aus nichtrostenden Stählen — Teil 2: Muttern*

DIN EN ISO 8501-1, *Vorbereitung von Stahloberflächen vor dem Auftragen von Beschichtungsstoffen — Visuelle Beurteilung der Oberflächenreinheit — Teil 1: Rostgrade und Oberflächenvorbereitungsgrade von unbeschichteten Stahloberflächen und Stahloberflächen nach ganzflächigem Entfernen vorhandener Beschichtungen*

DIN EN ISO 8503-1, *Vorbereitung von Stahloberflächen vor dem Auftragen von Beschichtungsstoffen — Rauheitskenngrößen von gestrahlten Stahloberflächen — Teil 1: Anforderungen und Begriffe für ISO-Rauheitsvergleichsmuster zur Beurteilung gestrahlter Oberflächen*

DIN EN ISO 8503-2, *Vorbereitung von Stahloberflächen vor dem Auftragen von Beschichtungsstoffen — Rauheitskenngrößen von gestrahlten Stahloberflächen — Teil 2: Verfahren zur Prüfung der Rauheit von gestrahltem Stahl; Vergleichsmusterverfahren*

DIN EN ISO 8503-3, *Vorbereitung von Stahloberflächen vor dem Auftragen von Beschichtungsstoffen — Rauheitskenngrößen von gestrahlten Stahloberflächen — Teil 3: Verfahren zur Kalibrierung von ISO-Rauhheitsvergleichsmustern und zur Bestimmung der Rauheit; Mikroskopverfahren*

DIN EN ISO 8503-4, *Vorbereitung von Stahloberflächen vor dem Auftragen von Beschichtungsstoffen — Rauheitskenngrößen von gestrahlten Stahloberflächen — Teil 4: Verfahren zur Kalibrierung von ISO-Rauheitsvergleichsmustern und zur Bestimmung der Rauheit; Tastschnittverfahren*

DIN EN ISO 8503-5, *Vorbereitung von Stahloberflächen vor dem Auftragen von Beschichtungsstoffen — Rauheitskenngrößen von gestrahlten Stahloberflächen — Teil 5: Abdruckverfahren zum Bestimmen der Rauheit*

DIN EN ISO 10423, *Erdöl- und Erdgasindustrie — Bohr- und Förderausrüstung — Bohrlochkopf- und Eruptionskreuz-Ausrüstung*

DIN EN ISO 12944-1, *Beschichtungsstoffe — Korrosionsschutz von Stahlbauten durch Beschichtungssysteme — Teil 1: Allgemeine Einleitung*

DIN EN ISO 12944-2, *Beschichtungsstoffe — Korrosionsschutz von Stahlbauten durch Beschichtungssysteme — Teil 2: Einteilung der Umgebungsbedingungen*

DIN EN ISO 12944-3, *Beschichtungsstoffe — Korrosionsschutz von Stahlbauten durch Beschichtungssysteme — Teil 3: Grundregeln zur Gestaltung*

DIN EN ISO 12944-4, *Beschichtungsstoffe — Korrosionsschutz von Stahlbauten durch Beschichtungssysteme —Teil 4: Arten von Oberflächen und Oberflächenvorbereitung*

DIN EN ISO 12944-5, *Beschichtungsstoffe — Korrosionsschutz von Stahlbauten durch Beschichtungssysteme —Teil 5: Beschichtungssysteme*

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DIN EN ISO 12944-6, *Beschichtungsstoffe — Korrosionsschutz von Stahlbauten durch Beschichtungssysteme — Teil 6: Laborprüfungen zur Bewertung von Beschichtungssystemen*

DIN EN ISO 12944-7, *Beschichtungsstoffe — Korrosionsschutz von Stahlbauten durch Beschichtungssysteme — Teil 7: Ausführung und Überwachung der Beschichtungsarbeiten*

DIN EN ISO 12944-8, *Beschichtungsstoffe — Korrosionsschutz von Stahlbauten durch Beschichtungssysteme — Teil 8: Erarbeiten von Spezifikationen für Erstschutz und Instandsetzung*

DIN EN ISO 13535, *Erdöl- und Erdgasindustrie — Bohr- und Fördereinrichtungen — Hebegerät*

DIN EN ISO 13628-4, *Erdöl- und Erdgasindustrien — Konstruktion und Betrieb von Unterwasser-Produktionssystemen — Teil 4: Bohrlochkopf- und E-Kreuz-Ausrüstungen für den Unterwassereinsatz*

DIN EN ISO 13628-5, *Erdöl- und Erdgasindustrie — Auslegung und Betrieb von Unterwasser-Produktionssystemen — Teil 5: Unterwasser-Versorgungskabel*

DIN EN ISO 13628-6, *Erdöl- und Erdgasindustrie — Auslegung und Betrieb von Unterwasser-Produktionssystemen — Teil 6: Steuersysteme für die Unterwasser-Produktion*

DIN EN ISO 13628-7, *Erdöl- und Erdgasindustrie — Auslegung und Betrieb von Unterwasser-Produktionssystemen — Teil 7: Komplettierungs-/Aufwältigungs-Risersysteme*

DIN EN ISO 13628-8, *Erdöl- und Erdgasindustrie — Auslegung und Betrieb von Unterwasser-Produktionssystemen — Teil 8: Schnittstellen mit ferngelenkten Transporteinheiten (ROV) auf Unterwasser-Produktionssystemen*

DIN EN ISO 13628-9, *Erdöl- und Erdgasindustrie — Auslegung und Betrieb von Unterwasser-Produktionssystemen — Teil 9: ROT-Systeme*

DIN EN ISO 15156-1, *Erdöl- und Erdgasindustrie — Werkstoffe für den Einsatz in H_2S-haltiger Umgebung bei der Öl- und Gasgewinnung — Teil 1: Allgemeine Grundlagen für die Auswahl von gegen Rissbildung beständigen Werkstoffen*

DIN EN ISO 15156-2, *Erdöl- und Erdgasindustrie — Werkstoffe für den Einsatz in H_2S-haltiger Umgebung bei der Öl- und Gasgewinnung — Teil 2: Gegen Rissbildung beständige unlegierte und niedriglegierte Stähle und Gusseisen*

DIN EN ISO 15156-3, *Erdöl- und Erdgasindustrie — Werkstoffe für den Einsatz in H_2S-haltiger Umgebung bei der Öl- und Gasgewinnung — Teil 3: Hochlegierte Stähle (CRAs) und andere Legierungen*

DIN EN ISO 23936-1, *Erdöl-, petrochemische und Erdgasindustrie — Nichtmetallische Werkstoffe mit Medienkontakt bei der Öl- und Gasproduktion — Teil 1: Thermoplaste*

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Foreword

This document (EN ISO 13628-1:2005) has been prepared by Technical Committee ISO/TC 67 “Materials, equipment and offshore structures for petroleum 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 May 2006, and conflicting national standards shall be withdrawn at the latest by May 2006.

This document supersedes EN ISO 13628-1:1999.

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

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The text of ISO 13628-1:2005 has been approved by CEN as EN ISO 13628-1:2005 without any modifications.

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Foreword of A1

This document (EN ISO 13628-1:2005/A1:2010) 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 Amendment to the European Standard EN ISO 13628-1:2005 shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by February 2011, and conflicting national standards shall be withdrawn at the latest by February 2011.

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Introduction

This part of ISO 13628 has been prepared to provide general requirements, recommendations and overall guidance for the user to the various areas requiring consideration during development of a subsea production system for the petroleum and natural gas industries. The functional requirements defined in this part of ISO 13628 will allow alternatives in order to suit specific field requirements. The intention is to facilitate and complement the decision process rather than to replace individual engineering judgement and, where requirements are non-mandatory, to provide positive guidance for the selection of an optimum solution.

1 Scope

This part of ISO 13628 provides general requirements and overall recommendations for development of complete subsea production systems, from the design phase to decommissioning and abandonment. This part of ISO 13628 is intended as an umbrella document to govern other parts of ISO 13628 dealing with more detailed requirements for the subsystems which typically form part of a subsea production system. However, in some areas (e.g. system design, structures, manifolds, lifting devices, and colour and marking) more detailed requirements are included herein, as these subjects are not covered in a subsystem standard.

The complete subsea production system comprises several subsystems necessary to produce hydrocarbons from one or more subsea wells and transfer them to a given processing facility located offshore (fixed, floating or subsea) or onshore, or to inject water/gas through subsea wells. This part of ISO 13628 and its related subsystem standards apply as far as the interface limits described in Clause 4.

Specialized equipment, such as split trees and trees and manifolds in atmospheric chambers, are not specifically discussed because of their limited use. However, the information presented is applicable to those types of equipment.

If requirements as stated in this part of ISO 13628 are in conflict with, or are inconsistent with, requirements as stated in the relevant complementary parts of ISO 13628, then the specific requirements in the complementary parts take precedence.

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 3506-1, *Mechanical properties of corrosion-resistant stainless-steel fasteners — Part 1: Bolts, screws and studs*

ISO 3506-2, *Mechanical properties of corrosion-resistant stainless-steel fasteners — Part 2: Nuts*

〈A1〉 ISO 8501-1, *Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness — Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings. Informative supplement to part 1: Representative photographic examples of the change of appearance imparted to steel when blast-cleaned with different abrasives*

ISO 8503 (all parts), *Preparation of steel substrates before application of paints and related products — Surface roughness characteristics of blast-cleaned steel substrates*

ISO 9588, *Metallic and other inorganic coatings — Post-coating treatments of iron or steel to reduce the risk of hydrogen embrittlement* 〈A1〉

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ISO 10423, *Petroleum and natural gas industries — Drilling and production equipment — Wellhead and christmas tree equipment*

〈A1〉 ISO 12944 (all parts), *Paints and varnishes — Corrosion protection of steel structures by protective paint Systems* 〈A1〉

ISO 13535, *Petroleum and natural gas industries — Drilling and production equipment — Hoisting equipment*

ISO 13628-4, *Petroleum and natural gas industries — Design and operation of subsea production systems — Part 4: Subsea wellhead and tree equipment*

ISO 13628-5, *Petroleum and natural gas industries — Design and operation of subsea production systems — Part 5: Subsea umbilicals*

ISO 13628-6, *Petroleum and natural gas industries — Design and operation of subsea production systems — Part 6: Subsea production control systems*

ISO 13628-7: —[1)], *Petroleum and natural gas industries — Design and operation of subsea production systems — Part 7: Completion/workover riser systems*

ISO 13628-8, *Petroleum and natural gas industries — Design and operation of subsea production systems — Part 8: Remotely Operated Vehicle (ROV) interfaces on subsea production systems*

ISO 13628-9, *Petroleum and natural gas industries — Design and operation of subsea production systems — Part 9: Remotely Operated Tool (ROT) intervention systems*

〈A1〉 ISO 15156 (all parts)[2)] *Petroleum and natural gas industries — Materials for use in H_2S-containing environments in oil and gas production*

ISO 23936-1, *Petroleum, petrochemical and natural gas industries — Non-metallic materials in contact with media related to oil and gas production — Part 1: Thermoplastics* 〈A1〉

API RP 2A, *Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms — Working Stress Design* Twenty-First Edition

DNV2.7-1, *Offshore freight containers*

3 Terms, definitions and abbreviations

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

3.1 Terms and definitions

3.1.1
barrier
element forming part of a pressure-containing envelope which is designed to prevent unintentional flow of produced/injected fluids, particularly to the external environment

3.1.2
deep water
water depth generally ranging from 610 m (2 000 ft) to 1 830 m (6 000 ft)

NOTE Since the physical circumstances of any situtation will change as a function of water depth, use of the term “deep water” implies that it may be necessary to consider design and/or technology alternatives.

1) To be published.

2) 〈A1〉 ISO 15156 (all parts) was adopted by NACE as NACE MR0175/ISO 15156 [41] 〈A1〉

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3.1.3
first-end connection
connection made at the initiation point of the flowline or umbilical installation process

3.1.4
flowline
production/injection line, service line or pipeline through which fluid flows

NOTE In this part of ISO 13628, the term is used to describe solutions or circumstances of general nature related to a flowline.

3.1.5
flying lead
unarmoured umbilical jumper with a termination plate at either end (incorporating connectors for the various lines) used to connect subsea facilities together

NOTE 1 A flying lead is commonly used to connect e.g. a subsea control module on a subsea tree to a subsea umbilical distribution unit.

NOTE 2 This type of umbilical jumper is lightweight and hence can be picked up from a deployment basket on the seabed and manoeuvred into position using a free-flying ROV.

3.1.6
jumper
short segment of flexible pipe with a connector half at either end

NOTE A jumper is commonly used to connect flowlines and/or subsea facilities together, e.g. a subsea flowline to a hard pipe riser installed on a production platform.

3.1.7
process valve
any valve located downstream of the tree wing valves in the production flow path

3.1.8
pull-in head
device used for terminating the end of a flowline or umbilical so that it can be loaded/offloaded from a vessel and pulled along the seabed and/or through an I-tube or J-tube

3.1.9
second-end connection
connection made at the termination point of the flowline or umbilical installation process

3.1.10
spool
short segment of rigid pipe with a connector half at either end

NOTE A spool is commonly used to connect flowlines and/or subsea facilities together, e.g. a subsea tree to a subsea manifold.

3.1.11
ultra-deep water
water depth exceeding 1 830 m (6 000 ft)

NOTE 1 Since the physical circumstances of any situtation will change as a function of water depth, use of the term “ultra-deep water” implies that it may be necessary to consider design and/or technology alternatives.

NOTE 2 For description of pressure and temperature ratings, the definition given in the applicable subsystem International Standard and other relevant standards and design codes is used.

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3.1.12
umbilical jumper
short segment of umbilical with a termination plate at either end (incorporating connectors for the various lines) used to connect subsea facilities together

NOTE An umbilical jumper is commonly used to connect e.g. a subsea umbilical termination to a subsea umbilical distribution unit.

〈A1〉 3.1.13
carbon steel
alloy of carbon and iron containing up to 2 % mass fraction carbon, up to 1,65 % mass fraction manganese and residual quantities of other elements, except those intentionally added in specific quantities for deoxidation (usually silicon and/or aluminium)

NOTE Carbon steels used in the petroleum industry usually contain less than 0,8 % mass fraction carbon.

[ISO 15156-1:2009, 3.3]

3.1.14
corrosion-resistant alloys
CRAs
alloys that are intended to be resistant to general and localized corrosion in oilfield environments that are corrosive to carbon steels

NOTE This definition is in accordance with ISO 15156-1 and is intended to include materials such as stainless steels with minimum 11,5 % mass fraction Cr, and nickel, cobalt and titanium base alloys. Other ISO documents can have other definitions.

3.1.15
low-alloy steel
steels containing a total alloying element content of less than 5 % mass fraction, but more than that for carbon steel

EXAMPLES AISI 4130, AISI 8630, ASTM A182 Grade F22[12] are examples of low alloy steels.

3.1.16
pitting resistance equivalent number
PREN
number developed to reflect and predict the pitting resistance of a stainless steel, based on the proportions of Cr, Mo, W and N in the chemical composition of the alloy

NOTE This number is based on observed resistance to pitting of CRAs in the presence of chlorides and oxygen, e.g. seawater, and is not directly indicative of the resistance to produced oil and gas environments.

$$F_{\mathrm{PREW}} = w_{\mathrm{Cr}} + 3{,}3(w_{\mathrm{Mo}} + 0{,}5w_{\mathrm{W}}) + 16w_{\mathrm{N}}$$

where
w_{Cr} is the mass fraction of chromium in the alloy, expressed as a percentage of the total composition;
w_{Mo} is the mass fraction of molybdenum in the alloy, expressed as a percentage of the total composition;
w_{W} is the mass fraction of tungsten in the alloy, expressed as a percentage of the total composition;
w_{N} is the mass fraction of nitrogen in the alloy, expressed as a percentage of the total composition.

3.1.17
sour service
service in an H_2S-containing (sour) fluid

NOTE In this part of ISO 13628, “sour service” refers to conditions where the H_2S content is such that restrictions as specified by ISO 15156 (all parts) apply.

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3.1.18
sweet service
service in an H_2S-free (sweet) fluid

3.1.19
type 316
austenitic stainless steel alloys of type UNS S31600/S31603

3.1.20
type 6Mo
austenitic stainless steel alloys with PREN ≥ 40 and Mo alloying ≥ 6,0 % mass fraction, and nickel alloys with Mo content in the range 6 % mass fraction to 8 % mass fraction

EXAMPLES UNS S31254, N08367 and N08926 alloys.

3.1.21
type 22Cr duplex
ferritic/austenitic stainless steel alloys with 30 ≤ PREN ≤ 40 and Mo ≤ 2,0 % mass fraction

EXAMPLES UNS S31803 and S32205 steels.

3.1.22
type 25Cr duplex
ferritic/austenitic stainless steel alloys with 40 ≤ PREN ≤ 45

EXAMPLES UNS S32750 and S32760 steels. 〈A1

3.2 Abbreviated terms

AAV	annulus access valve
AC	alternating current
ADS	atmospheric diving system
AIV	annulus isolation valve
AMV	annulus master valve
API	American Petroleum Institute
ASV	annulus swab valve
AUV	autonomous underwater vehicle
AWS	American Welding Society
BOP	blow-out preventer
CRA	corrosion-resistant alloy
C/WO	completion/workover
DC	direct current
DFI	design, fabrication, installation
DHPTT	downhole pressure temperature transmitter
DNV	Det Norske Veritas
EDP	emergency disconnect package
ESD	emergency shutdown
ESP	electrical submersible pump
FAT	factory acceptance test

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FMEA	failure mode and effects analysis
FPS	floating production system
FPU	floating production unit
GOR	gas-oil ratio
GVF	gas volume fraction
HAZOP	hazards in operation analysis
⟨A1⟩ HB	Brinell hardness ⟨A1⟩
HBW	Brinell hardness
⟨A1⟩ HIC	hydrogen induced cracking ⟨A1⟩
HIPPS	high-integrity pressure protection system
⟨A1⟩ HRC	Rockwell hardness C scale ⟨A1⟩
HPU	hydraulic power unit
HV	Vickers hardness
HXT	horizontal tree
ID	internal diameter
IPU	integrated pipeline umbilical
LMRP	lower marine riser package (for drilling)
LPMV	lower production master valve
LRFD	load and resistance factored design
LRP	lower riser package (for workover)
LWI	light well intervention
MEG	monoethylene glycol
⟨A1⟩ MIC	microbiologically influenced corrosion ⟨A1⟩
MIV	methanol injection valve
MODU	mobile offshore drilling unit
MPFM	multiphase flowmeter
MPP	multiphase pump
NACE	National Association of Corrosion Engineers
OTDR	optical time domain reflectometry
PCS	production control system
PGB	permanent guide base
PIV	production isolation valve
PLEM	pipeline end manifold
PLET	pipeline end termination
PLS	plastic limit state
PMV	production master valve
PRE	pitting-resistance equivalent
PSD	production shut-down
PSW	production swab valve

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PWV	production wing valve
QRA	quantitative risk analysis
RAL	“Reichsausschuss für Lieferbedingungen”, a Colour system used by German paint manufacturers
ROT	remotely operated tool
ROV	remotely operated vehicle
SAS	safety and automation system
SCM	subsea control module
SCSSV	surface-controlled subsurface safety valve
SEM	subsea electronic module
SIL	safety integrity level
SITHP	shut-in tubing head pressure
SSIV	subsea isolation valve
SSP	subsea processing
SUDU	subsea umbilical distribution unit
SUT	subsea umbilical termination
A1 SWC	stepwise cracking A1
SXT	surface tree
TFL	through-flowline system
TGB	temporary guidebase
TH	tubing hanger
THRT	tubing hanger running tool
TRT	tree running tool
ULS	ultimate limit state
UNS	unified numbering system
UPMV	upper production master valve
UPS	uninterruptable power supply
VXT	vertical tree
WAT	wax appearance temperature
WHP	wellhead pressure
WOCS	workover control system
WOR	workover riser
XOV	cross-over valve
XT	tree

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4 Systems and interface descriptions

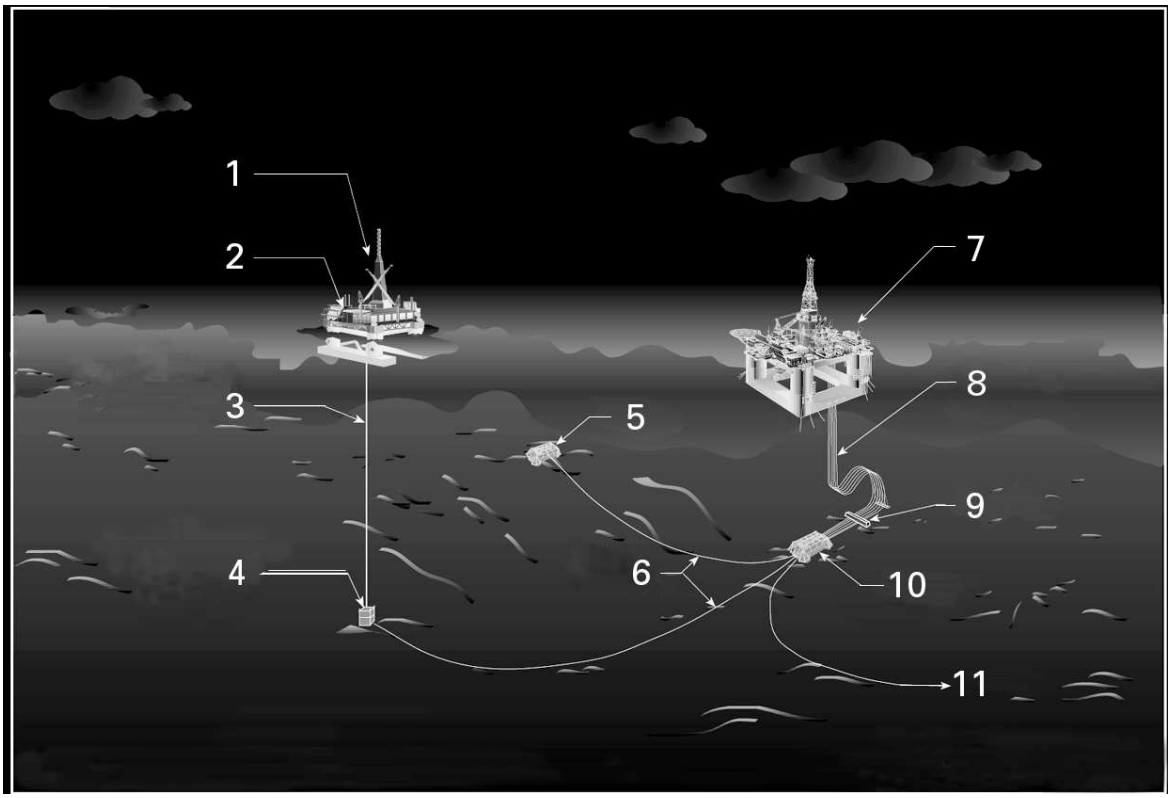
4.1 General

4.1.1 This clause describes subsea systems and main components in general and defines subsystem interfaces and corresponding specification break points.

4.1.2 Subsea production systems can range in complexity from a single satellite well with a flowline linked to a fixed platform or an onshore installation, to several wells on a template or clustered around a manifold producing via subsea processing/commingling facilities and transferring to a fixed or floating facility, or directly to an onshore installation.

4.1.3 The major components of a typical subsea production system are shown in Figure 1. The various elements are further described in detail in Annex A.

4.1.4 Detailed requirements are given in the following clauses and in subsystem standards of this part of ISO 13628. Some specific requirements are covered by this part of ISO 13628 only. They apply to overall system design, materials, structures, manifold piping, colour and marking, and lifting devices.



Key

1 running and retrieving tools
2 installation and workover controls
3 completion/workover riser and workover controls umbilical
4 satellite well
5 template
6 flowlines
7 production controls
8 production riser
9 riser base/SSIV
10 manifold
11 export flowline

Figure 1 — Typical development scenarios

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4.2 System description

4.2.1 Subsea production systems can be used to develop reservoirs, or parts of reservoirs, which require drilling of the wells from more than one location. Deep water conditions, or even ultradeep water conditions, can also inherently dictate development of a field by means of a subsea production system, since traditional surface facilities such as on a steel-piled jacket, might be either technically unfeasible or uneconomical due to the water depth.

4.2.2 Subsea equipment may also be used for the injection of water/gas into various formations for disposal and/or to provide pressure maintenance in the reservoir.

4.2.3 The subsystems comprising a subsea production or injection system may include the following:

— a structural foundation/template for positioning and support of various equipment;

— one or more wellhead systems with associated casing strings to provide a basic foundation structure and pressure containment system for the well(s);

— one or more subsea trees incorporating flow and pressure control valves;

— a well entry system, used for initial installation and abandonment, as well as various maintenance activities on the subsea wells which require overhead well entry;

— a PCS for remote monitoring and control of various subsea functions;

— an umbilical which may include electrical power and signal cables, as well as conduits for hydraulic control/service fluids and various chemicals to be injected subsea into the produced fluid streams;

— a manifold system for controlled commingling of various fluid streams;

— multiphase flowmeters, sand detection meters and/or leak detection devices;

— subsea processing equipment, including fluid separation devices and/or pumps/compressors;

— one or more flowlines to convey produced and/or injected fluids between the subsea installations and the host facility;

— HIPPS to protect flowlines not rated for the full shut-in wellhead pressure from being overpressured;

— one or more risers to convey produced and/or injected fluids to/from the various flowlines located on the seafloor to the host processing facilities;

— intervention and inspection, maintenance and repair equipment as defined for all of the above;

— subsea protection structures;

— protection mats;

— pig launcher/receiver;

— pressure- and temperature-monitoring devices;

— power distribution equipment;

— tie-in spools and jumper flowlines;

— flowline and jumper protection devices (mattresses, rock dumping, trenching, dog houses, etc.);

— SSIVs at base of risers.

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4.2.4 The subsea production system components are required to functionally and physically interface to each other, as well as to

— the downhole completion equipment, including the SCSSV and any downhole pressure/temperature gauges or chemical injection systems, and to any other interactive components such as remotely operable sliding sleeves and corresponding equipment,

— the host processing facilities, including slug suppression/control devices.

4.3 Subsystem interfaces

4.3.1 Several systems and system elements interface such that determination of e.g. correct design standard in many instances is difficult. In order to avoid inconsistent system design and subsequent contractual disputes, it is recommended to focus on and define these areas and associated standards at an early stage.

4.3.2 Typical system and “code-break” areas which should be addressed are

— tree to flowline/umbilical/manifold,

— tree/TH to well completion system,

— tree to WOR or marine riser,

— tree control system interfaces.

4.3.3 In addition, system-dependent “weak points” should be defined and agreed.

5 Design

5.1 General

5.1.1 When designing a subsea production system, a systems approach should be used which considers equipment and system testing, installation, commissioning, operation, inspection, maintenance, repair, design life and abandonment requirements.

5.1.2 Provision for possible future extensions and operational flexibility to cater for reservoir uncertainty should be planned at an early design stage.

5.1.3 The design of a subsea production system should take into account the above phases of the field development, the requirements to operate the field, and the design data and design loads relevant at the location of the subsea installation. The information should be provided in a design basis document. Typical datasheets included in Annex F may be used for this purpose.

5.1.4 The following subclauses give an overview of typical information required.

5.2 Design criteria

5.2.1 Environmental data

5.2.1.1 General

The following environmental data are typically required for the installation site of the subsea installation, and applicable along flowline routes in the field and along pipeline routes for export.

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5.2.1.2 Oceanographic data

Typically data are required for

— *water*: depth, visibility, salinity, temperature, lowest astronomical tide level, highest astronomical tide level, resistivity, oxygen content, pH, mass density, specific heat capacity, swell, surge,

— *currents*: velocity profile, direction, distribution and periodic occurrence through the water column,

— *seabed*: soil description, friction angles, soil shear-strength, depth profile and load-bearing capacity, pockmarks, presence of shallow gas, earthquake data, seabed topography, stability under cyclonic conditions, resistivity, density, marine growth, subsea obstacles, volcanoes, mudslides, scouring, topology, subsurface hydrates, thermal conductivity, friction factors, lithology.

5.2.1.3 Meteorological data

Typically data are required for

— *waves*: height, wavelength, frequency, direction, distribution and periodic occurrence;

— *weather*: air temperature, wind speeds, wind direction, distribution and periodic occurrence;

— *icebergs*: size, mass, frequency of occurrence, direction, velocity.

5.2.2 Reservoir and fluid data

The following data are typically required for various points over the life of the field:

— reservoir characteristics (basic sediment and water data including reservoir depth, reservoir structure type, reservoir life);

— reservoir inflow information;

— product characteristics such as shut-in pressure, flowing (max./min.) pressure, temperature, density, GOR, water cut, bubblepoint, chemical composition, corrosivity (H_2S and CO_2 mol %), sand, emulsions, wax content and WAT, asphaltenes and hydrates, flowrates, API gravity, chlorides/salinity/pH of produced water, viscosity, cloud points, pour point and scaling potential, formation-water content of minerals;

— injection characteristics (turbidity, oil in water or gas allowances, scaling probability, pressure, temperature, corrosivity, filtration requirements).

The datasheet F1 in Annex F provides guidance on information typically required.

5.2.3 Well completion data

The following information related to drilling operation, corresponding well completion and well intervention is required:

NOTE Depending on the scenario, some of the information asked for below is required at different stages.

— wellhead details, i.e. size, pressure rating and well interface data if existing wellhead;

— wellhead type, i.e. subsea, mudline, hybrid, etc.;

— drilling and casing programme;

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— subsea BOP and drilling riser system details, i.e. size, pressure rating, etc.;

— guidebase details;

— wellhead elevation and orientation;

— equipment installation system, i.e. guidelines or guidelineless ROV, ROT, ADS and diving systems;

— potential drilling loads on the wellhead system;

— completion/workover riser type, dual string, single string, concentric, subsea test tree, etc. and interfaces with stress-joint, EDP/TRT, LRP and THRT;

— completion tubing size and drift schedule with relevant plug nipple information;

— downhole control and monitoring requirements, i.e. valve, pump, sleeve, pressure, temperature and flow functions;

— well barrier requirements;

— tubing hanger system and design, i.e. mechanically or hydraulically set, size, configuration, etc.;

— completion/workover riser facilities, i.e. running of subsea tree, running of tubing hanger, wireline, coiled tubing, snubbing and operations, well stimulation, clean-up and testing, etc.

5.2.4 Process and operation data

The following process and operating data are typically required for various points over the life of the field:

— production systems requirements, i.e. flowrates, flow regimes, flow control requirements, pressures (flowing and shut-in) and temperatures at wellhead and at processing facility, insulation, circulation and heating requirements;

— injection systems (water and/or gas) requirements, i.e. flowrates, flow regimes, flow control and filtration requirements, pressures (flowing and shut-in) and temperatures at wellhead and at processing facility;

— chemical injection requirements, i.e. type and characteristics of fluids, rates, flow control requirements, pressures and temperatures at wellhead and at processing facility;

— well shut-in requirements, i.e. barrier requirements, ESD requirements, kill/service fluids, rates, pressures and temperatures at wellhead and at drilling rig or processing facility, hydrate control philosophy during start-up and shut-down, HIPPS;

— flowline cleaning requirements, i.e. pigging round-trip/bidirectional;

— well management requirements, i.e. flow control requirements, rate limitations, testing/logging requirements;

— inspection requirements, i.e. type of inspection to be performed, inspection frequency, access requirements, intelligent pigging requirements, barrier testing;

— intervention requirements, i.e. intervention methods; ROV, ROT, ADS and diving;

— well workover, i.e. frequency, type of workover operation and methods to be used;

— simultaneous drilling and production requirements;

— abandonment requirements, i.e. plug and abandonment.

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5.2.5 Host facilities data

The subsea system interfaces with the hosting facility, and relevant interface information for the facility is therefore required as follows:

— type of hosting facility, i.e. fixed platform, floating production facility or land terminal;

— production riser type and characteristics, i.e. rigid or flexible;

— service facilities available, i.e. electrical, hydraulic, air, water, chemicals, etc.;

— ESD and control interface;

— deck plan for equipment location;

— flowline and umbilical interfaces, including pigging and kill facilities;

— flowline and umbilical routing and approach corridors;

— existing and planned seabed installations, i.e. pipelines, flowlines and umbilicals;

— protection requirements for flowlines and equipment inside receiving-defined-facility safety zones, if applicable;

— distance between subsea facilities and host facility;

— motion characteristics for floating production vessels;

— number, specification and position of J-tubes and/or I-tubes;

— pressure/capacity ratings for topsides process equipment;

— existing export flowline capacities.

5.2.6 Safety and hazards

Safety includes all operational, technical and emergency preparations significant for the protection of people, environment, installations and vessels present.

To prepare for marine and mudline activities and to establish safety criteria for technical design solutions for production equipment, early information about the following is important:

— shallow gas pocket(s);

— fishing activity and design criteria for its protection;

— vessel activities;

— military activities;

— seabed scouring;

— iceberg activity;

— mudslide probabilities;

— subsea volcanic activity;

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— sand waves;

— flowline trajectories;

— seabed characteristics;

— environmental protection (wildlife, breeding seasons, etc.);

— emergency preparations;

— other infrastructure;

5.3 Field development

5.3.1 System definition

Due consideration should be given to the following aspects during system definition:

— water depth, hydrostatic pressure and temperature;

— field configuration, i.e. template, well cluster, satellite wells, manifolds, processing equipment, etc.;

— details of existing facilities and infrastructure, i.e. platforms, appraisal wells, pipelines, etc.;

— moored and/or dynamically positioned drilling-vessel type, i.e. semisub, monohull or jack-up;

— anchor patterns and/or footprint and rig heading;

— field development schedule, i.e. planned development wells, future wells, future production tie-in philosophy, spare capacity including hook-up philosophy;

— possibilities for “early” well testing, and early production;

— artificial lift requirements, i.e. ESP, hydraulic turbines or gas lift;

— well stimulation requirements, i.e. acidizing, fracturing, etc.;

— requirements for well killing (from production facility or from intervention vessel, kill-fluid characteristics, flowrates and pressure);

— requirements for gas or water injection (flowrates, cleanliness and pressures);

— requirement for chemical injection or periodic squeeze treatment for prevention of hydrate formation, waxing, scaling, corrosion, etc. (injection chemical type, flowrates and pressure);

— requirement for any flowline over-pressure protection system;

— well testing requirements;

— workover system type, i.e. conventional and/or subsea lubricator type;

— control and monitoring philosophy;

— intervention philosophy, i.e. diver or diverless;

— flowline cleaning requirements;

— well clean-up strategy;

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— design basis data accuracy range;

— moored or dynamically positioned installation and intervention vessels;

— reservoir characteristics;

— characteristics of produced and injected fluids;

— commissioning requirements.

In addition, a strategy on flow assurance for the development should be established. Various subjects on flow assurance to consider are discussed in Annex I.

5.3.2 Simultaneous operations

The potential for simultaneous operations during installation and/or intervention should be assessed. Simultaneous operations may be achieved typically in the following combinations:

— simultaneous rig intervention on a template/manifold-cluster well and hydrocarbon production from neighbouring wells;

— simultaneous production through flowline transport systems during rig activity in the affected area.

5.3.3 Environment

System design shall comply with applicable regulations and, in order to protect the marine environment, due consideration should be taken of the following:

— seabed congestion from subsea structures and pipelines;

— restrictions on fishing activities and marine traffic;

— discharge of hydraulic fluid;

— discharge of produced water;

— disposal of purge/pigging/test fluids;

— disposal of drilling fluids and cuttings.

5.4 Design loads

5.4.1 General

All applicable loads that can affect the subsea production system during all relevant phases, such as fabrication, storing, testing, transportation, installation, drilling/completion, operation and removal, should be defined and form the basis for the design.

Accidental loads are project-specific, and should be verified by a special risk analysis for the actual application. Accidental loads can include dropped objects, snag loads (fishing gear, anchors), abnormal environmental loads (earthquake), etc.

The datasheets in Annex F may be used to record applicable loads.

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5.4.2 Unpressurized primary structural components and lifting devices

Specific design requirements for unpressurized primary structural components, such as guidebases, and for pad eyes and other lifting devices, such as running tools, are given in Annex K.

5.5 System design

5.5.1 System engineering

Subsea system engineering is an interdisciplinary approach which covers the complete system, from the reservoir to the processing facilities on the host (inclusive), with consideration of the requirements of all phases of the development, including engineering, procurement, construction, testing, installation, commissioning, operation, workover/maintenance and abandonment.

The system engineering process consists of a management part and a technical part. An evaluation of the need for application of the various system engineering processes should be performed for each specific field development, based upon the characteristics of the development.

System engineering methodology is further described in Annex H.

5.5.2 Overall design

5.5.2.1 The subsea production system should be designed to optimize life-cycle benefit while meeting functional and safety requirements.

5.5.2.2 The system shall be designed such that any operation can be suspended, leaving the well(s) in a safe state if predefined operational limits are about to be exceeded.

5.5.2.3 The system should be designed for easy fault diagnosis without system retrieval.

5.5.2.4 A high system availability should be obtained through use of simple designs and reliable products (supplier's standard equipment preferably with a satisfactory field performance record). The system availability requirement should be established in the design basis information for the development.

5.5.2.5 Operational reliability should be documented for the subsea systems. For noncritical and temporary equipment, relaxed requirements may be accepted.

5.5.2.6 Connectors should have an inherent feature preventing unintentional release.

5.5.2.7 Means of obtaining/maintaining cleanliness in hydraulic systems to the standard required for fabrication, testing, installation, commissioning and operational periods should be included in the design.

5.5.2.8 Drag/wave-induced forces during launching/retrieval through the splash zone should be considered for design and arrangement of structural elements, including those which are not rigid members of the overall structure, e.g. hatches.

5.5.2.9 Heavy modules designed for guidelineless marine operation, such as subsea trees and BOPs, should be capable of sustaining all relevant loads and be equipped for guidance during landing of tools and modules. The load-absorbing structure should have sufficient strength to withstand loads determined by the operational parameters of the defined intervention strategy.

5.5.2.10 The subsea system should allow flushing of hydraulic circuits subsequent to connection of interfaces.

5.5.2.11 In order to improve overall availability, the possibility to replace components while other parts of the system are in operation should be evaluated during the subsea system design phase.

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5.5.2.12 The subsea system should include, where justified or where required by local regulations, protection of sensitive equipment from potential damage caused by fishing gear and dropped objects. The protection should be evaluated on a probability/consequence basis. For protection related to intervention, overall design requirements should be evaluated based on operating philosophy and procedures.

5.5.2.13 Subsea production equipment installed inside the applicable safety/restricted zone of a production unit should be protected against dropped objects. Such protection should be evaluated on the basis of probability of drop/hit during operations.

5.5.2.14 In areas with fishing activity, two design options exist:

— establishment of a restricted zone, i.e. an area in which no bottom-gear fishing is allowed. This requires trawl-resistant structures and/or continuous surveillance;

— if the establishment of a restricted zone is not allowed, overtrawlable structures may be required.

5.5.2.15 If overtrawlable subsea protective structures are required, the design should aim at prevention of any accidental damage to the subsea production equipment. Due consideration should be given to damage scenarios which could limit the possibility for later access, intervention or re-entry. The datasheet F5 for dropped-object protection and fishing gear loads in Annex F should be used.

5.5.2.16 The subsea production system should include means of determining the fully open and closed positions for equipment, such as valves and connectors, etc., that may cause damage or be damaged due to wrong/unknown position when performing an operation.

5.5.2.17 The subsea production system should have position indicators for all subsea-operated connections.

5.5.2.18 Equipment located near areas involving intervention by ROV/diver should be protected. The protection should be evaluated on a probability/consequence basis of both impact and snagging.

5.5.2.19 The subsea production system equipment should be designed to be

— equipped with lifting points, for which the primary loadbearing structures shall be certified in accordance with appropriate requirements (see Annex K),

— equipped with transportation skids as relevant,

— transported in a safe manner,

— equipped with facilities to enable attachment of sea-fastenings which should be certified.

5.5.3 Barriers

5.5.3.1 A barrier normally shall be testable.

5.5.3.2 As part of the overall subsea production system design, a comprehensive barrier philosophy should be developed. The barrier philosophy should provide clear and concise guidance on barrier requirements, with the objective of preventing unintentional release of produced/injected fluids which may harm personnel and/or the environment.

5.5.3.3 For new subsea projects, a complete barrier philosophy should be developed prior to the commencement of detailed design. This document should define what types and how many barriers are required for operation of the facilities, through all of the various phases of the field life, including the following:

— installation activities, including tie-in of subsequent wells to a live manifold;

— drilling and completion activities, including well testing and clean-up activities;

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— hook-up and commissioning activities;

— routine production operations, for both producing/injecting and shut-in modes as well as for service modes such as circulating of flowlines and pigging;

— well intervention activities, involving re-entry into a well and or retrieval of a tree;

— maintenance activities, such as replacement of a subsea choke;

— decommissioning activities.

Similarly, for new subsea projects the barrier philosophy should cover all of the pressure-containing elements of the system, from the reservoir(s) through to the first block valve(s) at the receiving/injecting facilities on the permanent host facility or the MODU/intervention vessel, as applicable.

5.5.3.4 In situations where a project/field specific barrier philosophy (as described above) does not exist (e.g. for pre-existing subsea production facilities), then it is advisable to develop an operating barrier philosophy or generic barrier philosophy to cover at the least the barrier requirements during “routine” operation of the system, i.e. production, shut-ins and barrier testing. A case-specific barrier philosophy can then be developed prior to any intervention, workover, etc., activity to address those elements not covered in the operating/generic barrier-philosophy document.

5.5.3.5 Given the wide variety of possible field characteristics and equipment configurations, as well as the varying requirements of existing local regulations combined with field operator preferences, it is not possible or desirable to provide specific guidelines in this part of ISO 13628 that could be used as a standard barrier philosophy. Not withstanding this constraint, it can be stated that

— the barrier philosophy for each subsea production system shall be consistent with all applicable local regulations,

— while some aspects of a generic barrier philosophy may be applicable to many subsea production systems, each specific situation should be evaluated on a case-by-case basis to at least confirm that the generic barrier philosophy is appropriate and applicable,

— development of both generic and case-specific barrier philosophies requires the use of experienced personnel and typically involves the use of one or more risk assessment techniques such as HAZOP, FMEA, QRA, task analysis and/or scenario based risk assessment,

— the barrier philosophy should be clearly communicated to all relevant personnel, including design engineers, equipment suppliers and field personnel,

— the guidance/requirements contained in the barrier philosophy should be clear and concise, i.e. not open to different interpretations and/or misinterpretation.

General guidance on considerations for development of a barrier philosophy (including test philosophy) is provided in Annex J.

5.6 Subsea wellhead

5.6.1 General

The wellhead system is the structural foundation for a subsea completion. Depending on the configuration of the production system, the environmental conditions and soil conditions, the loads applied to the wellhead system may vary significantly. Structural integrity should be verified for maximum load conditions considering all drilling and production operations. Specific design requirements for subsea wellheads are given in ISO 13628-4.

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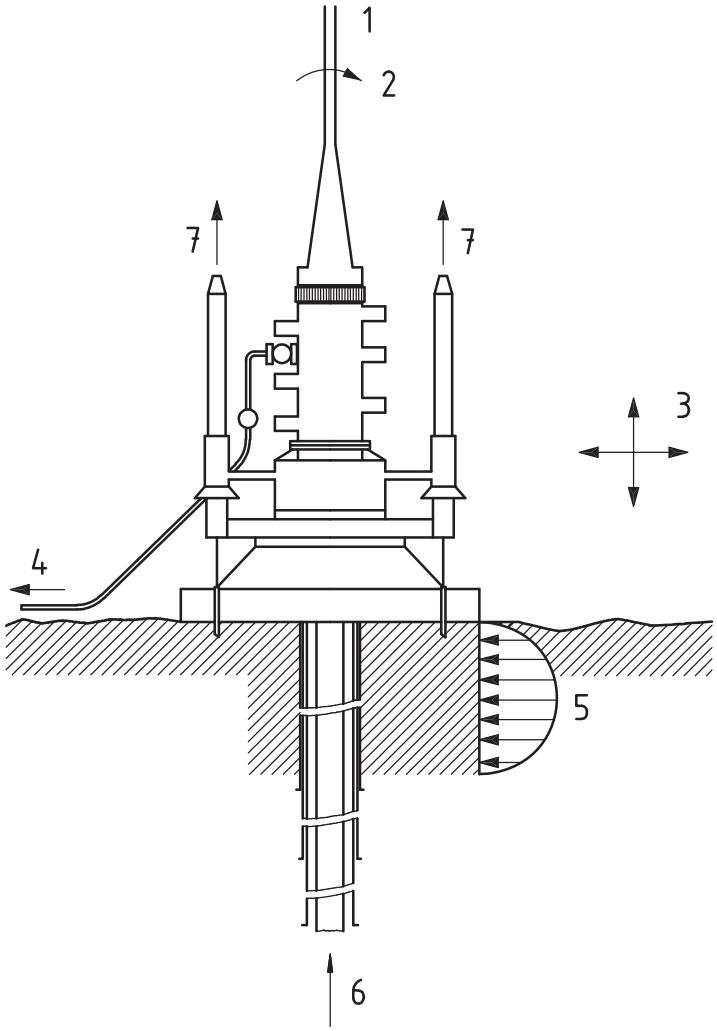
5.6.2 External loading

5.6.2.1 Loads on a subsea wellhead system may include component dead loads (mass, weight, gravity), riser loads, flowline pull-in and expansion loads, thermal growth, and direct environmental action. Typical loads are shown in Figure 2.



Key

1 riser tension
2 applied moments
3 environmental load (current, wave action, snag loads, etc.)
4 flowline connection
5 soil reaction
6 thermal growth
7 guidewire tension

Figure 2 — Loads on subsea wellhead system

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5.6.2.2 Riser loads are transferred to the wellhead system during drilling, well completion, workover and production. Depending on the type of subsea system, these loads can be either temporary (i.e. marine drilling riser and C/WO riser) or permanent (i.e. production risers or injection risers). These loads should be determined by performing riser analysis. Further guidance can be obtained from ISO 13628-7, API RP 16Q [18], API RP 2RD [17] and DNV OS-F-201 [30]. Fatigue analysis may also be required where variable loading conditions exist (i.e. vessel motion and wave-induced riser loads and riser loads due to vortex-induced vibrations).

Applicable loads and applicable load combinations (see Annex F) and operational criteria for the determination riser loads, identification of accidental riser loads, identification of any code-break inconsistencies and their implications should be established during system engineering (see Annex H).

NOTE Riser design codes account for normal, extreme and accidental loading conditions. The design codes used for subsea trees and wellhead systems are normally based on rated capacity for normal operating conditions and on the working stress format. Riser codes are based on either working stress design (WSD) format or load- and resistance-factored design (LRFD) format.

5.6.2.3 Flowline pull-in loads can induce significant shear and bending moments on the wellhead. Consideration should also be given to the effects of thermal growth or contraction in the well tubulars and attached flowlines and to additional loads due to the possible non-verticality of the wellhead.

5.6.2.4 For template wells, the interface between the well and the template manifold piping is particularly critical and shall be analysed for tolerances related to variation in temperature, pressure, position and elements of orientation of both well and manifold components. All permutations in parameter values should be considered, including thermal growth of the well and the well's different global index with respect to the manifold piping, and any expected subsidence of the template supporting structure. This interface is a typical critical design feature of a template design, and should be carefully analysed.

5.6.2.5 A subsea completion may be subject to direct environmental loads, for example current, wave action, earthquakes, ice, and soil movements. Dropped objects and snag loads from anchors or trawls can also be a concern for certain applications.

5.6.3 Well intervention

In order to accommodate well intervention, the subsea production system should be designed to

— facilitate orientation and guidance of intervention tooling, if applicable, i.e. ROV, ROT, WO riser,

— provide access points for intervention by vertical well, or alternatively by TFL,

— enable safe shut-down and disconnect of risers within a pre-defined time,

— facilitate establishment of two independent reservoir barriers in the event of any critical operational situation,

— retrieve critical components,

— allow well intervention with rig offset within specified limits.

5.6.4 Structural analysis

The soil data, external loads and reactions are used as input to a structural analysis of the subsea wellhead system to determine the appropriate wellhead stick-up height and structural casing requirements. This structural evaluation should verify that all components, as well as the foundation, will retain structural integrity during drilling, installation, operation and workover. ISO 19901-2 [13], ISO 19901-4 [14] and ISO 19901-5 [15] contain discussions of methods available for this type of soil-structure analysis.

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5.6.5 Wellhead rating

5.6.5.1 Subsea wellhead systems are designed to withstand a specific maximum working pressure. The design of the subsea wellhead housing is such that the BOP stack or tree is usually attached directly to the housing. Therefore, the housing shall be designed to withstand the maximum pressure specified for the life of the well. Maximum conditions are typically referred to as shut-in pressure and pressure during well kill, stimulation or injection operations, including maximum differential temperature anticipated.

5.6.5.2 In deep-water applications, the differential pressure across pressure-containing bodies is substantially reduced by the effect from the external hydrostatic pressure. In some applications this effect may be taken into consideration when determining *in situ* working pressure for such equipment. Note that pressure tests under atmospheric conditions should be modified accordingly.

5.6.5.3 Subsea wellhead systems commonly being manufactured are rated to working pressures of 35 MPa (5 000 psi), 70 MPa (10 000 psi) and 104 MPa (15 000 psi).

5.6.6 Service

Subsea wellhead systems shall be compatible with the type of service specified. Consideration should be given to the temperature of produced fluid and the presence of carbon dioxide, hydrogen sulfide or chlorides, which all can contribute to mass loss and corrosion or stress-corrosion/cracking failures. The risk of hydrogen embrittlement due to free hydrogen from cathodic protection systems shall also be evaluated.

5.6.7 Running tool requirements

In addition to specific requirements, each running tool design should meet the following basic guidelines:

— adequate flowby area around or through the tool;

— sufficient length of large-diameter elements to prevent hang-up in a BOP ram cavity;

— resistance to drilling mud and cuttings;

— shouldered connections for tools required to transmit torque;

— running protection for seals located on the largest diameter;

— ease of strip-down and redressing on the rig.

All running tools should be compatible with the running-string tensile load, cementing practices, and internal pressure rating for the casing string being run.

5.6.8 Completing exploratory wells

In some cases, wells originally drilled as exploratory evaluation wells are converted to subsea production or injection wells. The recommendations in this part of ISO 13628 should be applied to such wells, and potential problem areas identified. The wellhead system should be carefully inspected to ensure that damage has not occurred during the time since the well was suspended.

Areas that should be investigated prior to making a decision to complete exploratory wells are:

— height of the wellhead above mudline;

— setting of casing hangers at dedicated locations within the wellhead housing;

— condition and pressure integrity of casing hanger seal assemblies;

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— condition of the permanent guidebase;

— condition of the latching profile and seal area of the wellhead housing;

— condition of uppermost casing hanger internal seal area.

A detailed review of the well history should be made to determine possible problem areas.

5.7 Tubing hanger/tree system

5.7.1 System design considerations

The general considerations given in 5.6 for subsea wellhead systems are also applicable to the tubing hanger and tree systems. Specific design requirements are given in ISO 13628-4.

5.7.2 Tubing hanger system

Specific design considerations with regard to the tubing hanger system include the following:

— number, size and mass of tubing strings to be supported;

— type of threaded connection for the tubing;

— number and size of control ports, and pressure rating for downhole safety valve(s) and others as required;

— installation of tubing hanger in its appropriate receptacle;

— requirement for electrical and/or fibre optical connectors for downhole monitoring and/or control;

— manufacture and type of wireline or TFL plug profiles (if any) to be machined in the major bores;

— whether or not the tree design permits vertical access to the tubing hanger annulus port. This determines whether a wireline plug, stab-to-open check valve, hydraulically actuated sleeve or other means is used to secure the annulus when the tree or BOP is removed;

— orientation, if required, relative to a given datum for corresponding interface with the tree;

— type of riser, integral riser or individual tubing tieback strings used for installation and for wireline work;

— protection of control ports from debris/fluid contamination;

— type of XT;

— location of TH (in wellhead, in tubing spool or in XT).

5.7.3 Special considerations for design of subsea trees

5.7.3.1 Pressure rating

A complete operating envelope of the expected maximum and minimum pressures for the wellbore, annulus, service bore (if used) and hydraulic lines should be outlined.

Flowing pressure, shut-in pressure, injection and/or kill pressure of the well should be considered. In addition, the maximum service pressure for a TFL tree and the maximum control pressure for the SCSSV should be

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considered. The pressure information should be evaluated in conjunction with the external loads acting on the system for the particular operation taking place.

All components and connections should have a pressure rating consistent with the system rating. Wye spools should be rated to the same pressure as other tree components. Tree loops should be designed to the same pressure rating as the flowline if located downstream of the wing valve, or the tree components if located upstream. The tree running tool(s) should have a pressure rating equal to or greater than the lesser of the tree or the installation riser. Proof testing of the components, pressure testing across valves and plugs, and gas testing required for trees used in gas service should be performed.

ISO 13628-4 and the guidelines in Clause 7 should be followed for selection/identification of test criteria.

5.7.3.2 Service

Tree components should be evaluated with respect to fluid compatibility. A careful examination of potential fluid types and constituents should be performed (considering amounts, states, total and partial pressures, and temperature ranges), see Clause 6.

5.7.3.3 Pressure compensation

The installation water depth should be considered so that hydraulic and pressure-compensation devices can be adequately specified and designed. These devices are relevant for such items as the control system, running tools, valve actuators and pressure-containing equipment.

5.7.3.4 Rig type

Overall tree and running tool sizes and shapes should be compatible with vessel handling space and operating constraints. These should be evaluated early in the design. The use of a bottom-supported or floating vessel (anchored or dynamically positioned) can determine the tension and bending capabilities required of the tree.

5.7.3.5 External loads

There are two types of primary external load, other than environmental load, to which a subsea tree and its upper and lower connectors can be subjected. The first type is installation, which includes riser loads and flowline connection loads. The second type of external load occurs during workover and, depending on the type of tree, can be due to attachment of a C/WO riser system or marine drilling riser system. See 5.6.2.2 for applicable riser codes.

Structural analysis should be performed to verify that, in case the installation/workover vessel accidentally shifts its position (rig drift-off) and the installation tool does not disconnect immediately, the structural failure will occur in a point above the specified barrier element for the operation, leaving the well in a safe state. Motion compensator lock-up should also be addressed. The specified barrier elements shall remain leaktight after an accidental condition.

Snag loads imposed on the tree and/or the flowlines can also be a concern. If the loads are such that damage is unavoidable, then the failure point and the consequence for the tree functions after the damage should be considered.

When flow loops are connected to pressure-containing members such as valve bodies, the external loads, in addition to maximum pressure loads, should be considered to act on the valves.

5.7.3.6 Tree valve configuration

Arrangements of tree valves depend on the intended service. Valves and bore configuration should be studied to ensure safety and the necessary operational flexibility, including compatibility with downhole tools, plugs, wireline operations, and TFL equipment as specified in ISO 13628-3 [6]. In addition, the fluid paths should be

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designed to avoid fluid or solids collection and erosion. If the tree piping/loops are to be pigged, the design should be consistent with the type(s) of pig(s) to be used.

A composite valve block should be considered when installation and workover will be from a floating vessel. This design has greater external load-carrying capacity, fewer connections and more compactness. At least one master valve per bore shall be a fail-closed valve. A diver/ROV override should be considered for remotely operated valves.

5.7.3.7 Bore size

The production or injection bore should permit the installation/removal of plugs, wireline-retrievable valves and running of other downhole tools and equipment in the tubing string as required. Flow direction, fluid type, suspended particle type and size, and flowrates should also be considered.

In the case of TFL trees, the Wye spool should be designed to pass TFL tools in accordance with ISO 13628-3 [6].

The annulus bore may be either directly vertically accessible from the upper tree connection to the tubing hanger bore, or accessible only for pressure-monitoring/equalization and injection. If injection of a fluid (into the annulus) is required, then the path configuration should be designed to avoid potential erosion.

5.7.3.8 Flowline connection

The method and type of flowline connection influences the transmission and reaction of loads that may be imposed on the tree.

The flowline connector should be designed for at least the same pressure rating as the flowline, when mounted outboard of the wing valve. If used with a TFL tree, the bores of the flowline connection should be designed in accordance with ISO 13628-3 [6]. Flowline and umbilical connections are discussed in more detail in 5.11.

5.7.3.9 Subsea intervention

The type of installation, whether diver-assist or diverless, and how backup operations will be handled if the primary method fails, are important concerns. These topics are addressed in more detail in 8.6 (see also ISO 13628-8 and ISO 13628-9).

If an ROV is to be used, the capabilities and the type of ROV should be considered. Special ROV concerns include

— access,

— docking/reaction points,

— required mechanical or hydraulic power,

— load carrying capacity of the ROV,

— design of special service tools,

— type of ROV deployment system (tether management system; cage deployment system or surface-deployed).

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5.7.3.10 Tree control

There are a number of control systems and associated configurations available for trees; these are covered in detail in Annex A. The external loading, layout and space constraints for the interface with the tree should be considered in the design of both components.

All hydraulic/electrical functions needed for tree operation should be controlled from the remote-control station. A tree control module, if used, can be mounted at any location on the tree that provides access and protection. Hydraulic piping and electrical cables, if used, should be routed to minimize potential damage. The mass and location of the SCM module should be considered in order to attain a balanced tree configuration.

5.7.3.11 Piping, connections, ring grooves and gaskets

Piping runs should be designed to avoid fluid or solids collection points and erosion, and appropriate allowances made for expected corrosion/erosion.

5.7.3.12 Tree running tool

For guideline or guidelineless operations from a floating vessel, the tree running tool and/or workover BOP running tool should be provided with a high-angle release connector. Also, a quick-disconnection feature should be provided.

Angle capability and disconnect time should be established for each specific application. Factors to be considered for design of high-angle release connections are

— local regulations,

— water depth and weather conditions,

— vessel station-keeping capability, etc.

5.8 Completion/workover riser system

5.8.1 Specific design requirements for completion and workover risers, including workover control systems for operation in open sea and inside marine drilling risers shall be in accordance with ISO 13628-7.

5.8.2 The completion/workover riser design is analogous to downhole tubing design if it is to be used only inside a jackup conductor pipe.

A workover or completion riser to be used in open sea or inside a marine drilling riser shall be designed by riser analysis (including fatigue analysis) as specified in ISO 13628-7.

5.8.3 The completion/workover riser should be designed to suit the subsea tree with respect to drift diameters, bore spacing, etc. In addition, operating conditions, including environmental loads for the specific field development, should be reflected in the design of the riser system.

5.8.4 The maximum permissible service life under specified operating conditions should be defined, see ISO 13628-7.

5.9 Mudline casing suspension system

5.9.1 System design considerations

The general design requirements for completing a subsea mudline casing suspension well are essentially the same as for a subsea wellhead (see 5.6). Specific design requirements are given in ISO 13628-4.

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5.9.2 Specific design considerations

The following items outline specific design considerations for subsea completion on mudline casing suspension systems:

— the system should be compatible with jack-up or other bottom-supported rigs;

— casing loads should be suspended near the seabed to reduce loads on the rig and provide a disconnect/reconnect point;

— the tension capacity, pressure rating and drift requirements should be selected to meet the requirements of the particular wells. Care should be exercised when selecting reduced-bore hangers to ensure that they are compatible with the drilling programme;

— adequate annulus flowby areas should be incorporated in mudline components, both in the running and landed conditions. The combined total area and the quality of the flowpaths shall be evaluated;

— the casing annuli should be accessible at the surface wellhead during drilling operations, but may be isolated when a subsea tree is to be installed;

— applied external loads which affect the mudline drilling system should be considered, i.e. wave and current forces, riser/BOP weight, etc.;

— direction of rotation and required downhole torque of mudline components should be compatible with the rest of the drilling system for installation and retrieval;

— accessibility and adaptability should be incorporated for abandonment;

— maximum allowable misalignment and lateral offset between the running/tieback strings and hangers should be defined;

— upon temporary abandonment, individual casing risers should be removed to meet elevation requirements at the ocean floor;

— a protective cap (or caps) should be installed on the well, as required for the well programme;

— an annulus seal assembly should be installed between the production casing and intermediate casing strings at the tie-back/adaptation point. Seal selection for component interfaces should be given particular attention.

5.10 Production controls

5.10.1 The general factors given in 5.10.2 to 5.10.4 should be considered during production control system design (specific design requirements shall be in accordance with ISO 13628-6).

5.10.2 Control system availability can be maximized by

— selecting highly reliable assemblies and components,

— selecting components that have a high resistance to wear and corrosion,

— providing component and system redundancy,

— providing diver/ROV/ROT intervention capability,

— providing system bypasses,

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— providing spare units (modules) for replacement,

— establishing control-fluid properties and cleanliness standards.

5.10.3 Maintenance should be considered early in system design. Maintainability of surface and subsea equipment can be enhanced by

— designing equipment and system assemblies for easy accessibility for retrieval and maintenance,

— designing control system assemblies to be retrieved independently from subsea completion hardware.

5.10.4 Specific design requirements for the PCS and its components shall be in accordance with ISO 13628-6.

5.11 Flowlines and end connections

5.11.1 General

This subclause presents guidelines intended for the design, construction, testing and installation of subsea flowlines and end connectors used in a subsea production system. The guidelines cover the unique factors of subsea systems, i.e. high pressure, multiphase flow, multiple lines, subsea connections and TFL systems.

This document does not replace design specifications for pipelines and flowlines. Their detailed design should be in accordance with design codes specified by the end user and recognized by regional regulations for transportation of hydrocarbons to other destinations. Interfaces and spec-breaks between specification regimes need to be adequately considered during system design.

5.11.2 System description

The delineation of a flowline system as covered by this part of ISO 13628 (see Figure 1) begins with both halves of the connector used at the subsea facility and ends with one of the following:

a) both halves of a connector used at another subsea facility,

b) the flowline side of a surface connection or weld at the top of a platform riser, or

c) the point at which riser design begins (in case of a flexible or catenary production riser that does not have a riser base).

The various components and installation methods for flowlines are described in A.9.

5.11.3 Design considerations

5.11.3.1 Flowline design considerations

The following flowline basic design considerations should be addressed.

a) The installed configuration of the flowline should be considered. Flowline systems may be configured in a number of ways, e.g. individual lines, bundle, cased bundle, piggyback, pipe-in-pipe or integrated into the control umbilical.

b) The loads imposed on the flowline during installation can be larger than subsequent loads.

c) Selection of a method for a particular application depends on the number of lines to be laid together, pipeline diameter and submerged weight, water depths, burial requirements, flowline length, distance from a host facility, availability of suitable equipment, end connection method, and economics.

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d) Many operating factors, including the following, should be considered in flowline design:

- *flowline fluid*: the line may convey produced hydrocarbons, water, solids, injection chemicals, carbon dioxide, hydrogen sulfide, etc.;
- multiphase flow;
- fluid flow rate;
- *fluid properties*: pressure, temperature, viscosity, density, and corrosion potential are important;
- *TFL applications*: TFL flowlines should be designed for free passage of TFL tools. ISO 13628-3 [6] should be referenced regarding flowline diameters, minimum radius of curvature, and other requirements;
- *pigging*: as with TFL tools, the use of pigs can restrict the permissible valves, fittings, connections, pipe inside diameters, and pipe bend radii;
- location of pipeline ends;
- *location of nearby flowlines*: adjacent or crossing lines may interfere with one another during operations as well as installation;
- flow assurance issues;
- pigging requirements;
- produced fluids temperature;
- insulation requirements;
- coating weight requirements.

e) *Upheaval buckling*: this can be a key issue in conceptual development of a production scenario, and can have very significant influence on cost of flowline projects, type and cost of expansion loops between flowlines and template manifolds, cost of repair of flowlines and any crossings required in a congested area.

f) *Seafloor topography*: hills and valleys can induce slug fluid flow and liquid hold-up in the line or trapped gas pockets which in turn encourage hydrate plug formation; boulders, outcroppings and mudslides can induce excessive external pipe stresses; and unsupported span can cause vortex-induced vibration fatigue or sag-bend-induced stresses.

g) *Seafloor environment*: currents and hydrostatic pressure apply forces to the flowline. Seafloor sediments can support the line, while sea water temperature and oxygen content affect the line’s external corrosion rate. Seafloor sediment transfer (scouring) can either bury the flowline, move its physical location, or leave it unsupported, further affecting the line's external loading conditions and external corrosion rates. Seafloor topography and characteristics also determine where the flowline encounters “virtual anchor” points at which the line-soil interaction prevents any lateral or axial movement. Knowledge of where these points are helps in dealing with flowline expansion and contraction due to temperature changes, with the assistance of loops or bends in the line. Other uses of the seafloor, such as fishing and ship anchoring, can affect the safety of the flowline.

h) *Anticipated line life*: the corrosion protection requirements are a function of the design life of the flowline. The design of a flowline and its end connections should consider intervention requirements throughout the life of the flowline. Intervention is required for

- initial end connection procedures,

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— routine in-service inspections,

— maintenance,

— repairs.

i) *Route selection*: although the location of the flowline ends may be specified, a straight line between them might not be the best. The flowline should, if possible, avoid mudslide areas, seafloor canyons, rock outcroppings and established anchor patterns. The route should avoid restricting future field developments and operations. The approach to a connection point is important for correctly aligning the connectors and accommodating other equipment or structures. Flowline expansion and contraction may also be accommodated by adding predetermined curved sections in the route.

j) *Weather*: anticipated weather conditions during the installation phase of the project should be thoroughly evaluated. Seasonal directions and magnitude of waves/winds, combined with the average frequency of excessive sea states, should be considered to determine the optimum timing for the project.

The intervention method chosen (for example divers, manned submersibles, ROVs or ROTs) affects the design of various components, the overall installation technique, and the operational procedures for the flowline system. ROV and ROT interfaces and general design shall be in accordance with ISO 13628-8 and ISO 13628-9 respectively.

5.11.3.2 Design of rigid and flexible pipe

The following factors should be considered in the design of rigid and flexible pipe.

a) Selection of pipe diameter and wall thickness is determined by the following factors:

— applicable design codes, which shall be consulted along with other applicable documents to determine stress allowances, wall thickness allowances, allowable geometries conditions (bends, tees, etc.), pressure and combined load conditions in every section of the pipeline and its end connections;

— flow rates;

— maximum working pressure;

— external pressure;

— pressure drops;

— variations in pipeline elevation;

— fluid density and viscosity;

— line length;

— use of TFL or pigging tools;

— requirements for installation and intervention equipment;

— parallel lines for TFL/pigging, service, injection or redundancy;

— availability of suitable pipe;

— corrosion/erosion wall thickness allowance;

— laying method (S-lay, J-lay or reeling);

— laying vessel type and limitations;

— fluid characteristics;

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— material grade;

— corrosion allowance (for CS pipe);

— CRA cladding requirements;

— manufacturability;

— water depth;

— arrival fluid temperature.

b) *Materials of rigid pipe construction*: ISO 3183 should be referenced for various grades and standard sizes of rigid pipe. It is important to consider that allowable mill tolerance variations in wall thickness and ovality can limit the intended use of the pipe in certain applications where external loads, external pressure and cold temperatures can exceed the pipe's material strength at the extremes of the dimensioned tolerance bands. Tighter mill-run arrangements, specifying smaller minimum wall thickness or minimum ovality dimensions, can improve the pipe's structural performance, but shall be agreed by manufacturer and end user. High-strength pipe grades (above X-60) or CRA materials can require special welding or mechanical joining techniques to achieve mechanical strength and fatigue resistance at the joints or end connections equal to that of the base material. Corrosion/erosion wall thickness allowances may be taken into account in stress calculations where excessive installation loads and test pressures could exceed the limits of nominally dimensioned pipe. However, the corrosion/erosion wall thickness allowance cannot be taken into account when dealing with *in situ* environmental loads, expansion/contraction loads, maximum internal working pressure, external pressure or other *in situ* operating conditions.

c) *Materials of flexible pipe construction*: ISO 13628-2 [5], ISO 13628-10 [7] and ISO 13628-11 [8] should be used for the design and use of flexible pipe. It is important to understand that flexible pipe is a manufactured multilayered product with several cross-layered strength members. Allowable stresses, tension capacity, bend radii, etc., depend on the construction design and manufacture of the product and are outlined in the referenced specifications. Make sure that design and manufacturing parameters are planned and specified with individual and combined loading parameters in mind;

d) Pipe designs should consider the effects of overbend and sag-bend strains, pipe tension, hydrostatic pressure, and lay vessel motions in conjunction with the seafloor environment and topography. Special consideration should be given to the combined loading of these situations. For example, very high installation tensions could lead to various degrees of ovality (flattening) in the pipe, which in turn could lead to structural collapse due to high external pressure in deep water.

e) In-service factors should consider the effects of

— residual load left over from installation,

— environmental forces composed of gravity loads, hydrostatic loads, hydrodynamic loads and pipe-soil interaction. Figure 3 identifies these loads in more detail,

— trenching, burial or anchoring. These methods are used to improve on-bottom stability, mechanical protection or insulating properties. However, these effects of restraint can cause unwanted buckling conditions or corrosion environments,

— upheaval buckling, expansion and contraction due to effects of pressure and temperature.

f) A rigid pipe buckles when it is bent in too small a radius of curvature or when it is severely compressed. For subsea pipelines, a buckle occurs most often when the pipe is installed under external pressure with insufficient tension, such as in the sag-bend region, or when it is subjected to external structural compression, such as when thermal expansion occurs at a restrained location. Once a buckle initiates locally subsea, it will propagate at a lower external pressure than at its initiation. The buckle will continue to propagate until the pipe moment of inertia increases and/or the external pressure decreases sufficiently to arrest the buckle. Buckle arrestors are used to mitigate extensive buckle propagation. Buckle arresters are usually pup pieces or sleeves of thicker pipewall welded into the linepipe.

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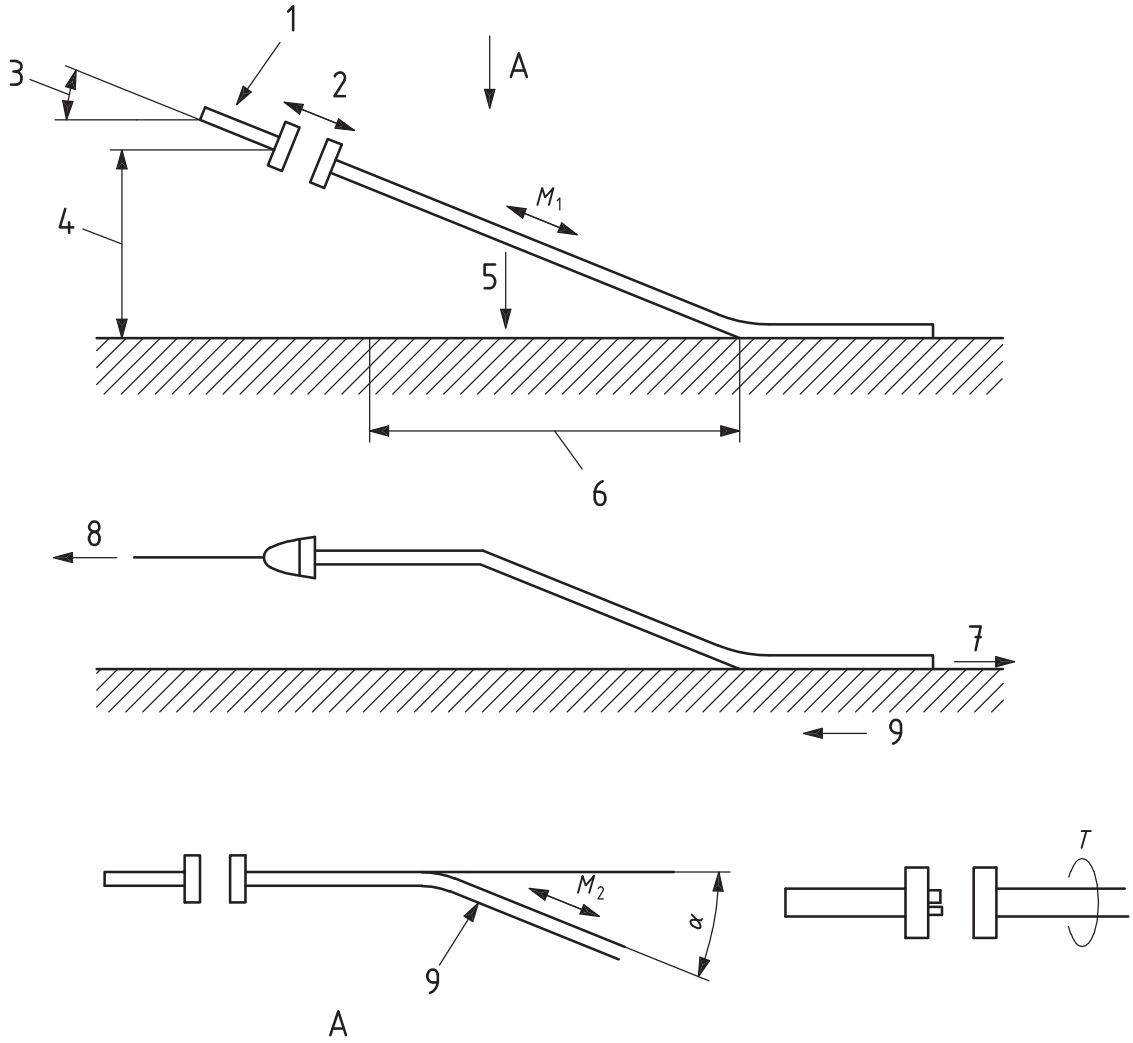
g) Increasing the pipewall thickness above the structural and pressure-containment requirements can add on-bottom stability weight or add a corrosion/erosion allowance.



Key

1 subsea connection point
2 additional axial movement for alignment
3 angle relative to bottom
4 height off bottom
5 pipe weight
6 unsupported span length
7 pipeline installation forces
8 pull-in forces
9 soil friction

M_1 vertical bending moment applied to pipe for end alignment
M_2 horizontal bending moment applied to pipe for end alignment
α angular movement of end for repositioning connector
T torque applied to bundled pipe for proper port orientation

Figure 3 — Factors that influence alignment loads and stresses

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5.11.3.3 Coating of pipelines

Pipelines may be coated externally in order to

a) provide improved on-bottom stability by increasing the pipe-soil forces against hydrodynamic forces in regions of heavy wave action or high seafloor currents, and by adding weighting material, such as concrete;

b) provide insulation to help maintain internal fluid temperature high enough to minimize the effects of increased viscosity, hydrate formation and paraffin formation;

c) provide mechanical protection from boat traffic and bottom-fishing activities, via pipe-in-pipe (carrier pipe) designs, concrete coatings, burial or trenching;

d) provide external corrosion protection. Examples of such coatings include coal tar, mastics and various organic/inorganic compounds or insulation coverings. However, external coatings can also reduce the amount of exposed surface area, which in turn can reduce the amount of cathodic protection. ISO 15589-2 [11] and DNV RPB 401 [31] should be referenced for pipeline cathodic protection design.

— Pipelines may be coated internally in order to reduce debris from manufacturing/construction activities,

— enhance corrosion protection,

— provide faster commissioning (drying) times,

— improve pig performance,

— improve hydraulic performance.

5.11.3.4 Design codes for rigid pipe

Several internationally accepted design codes are used for designing subsea pipelines. These include, but are not limited to

— ISO 13623 [4] for petroleum and natural gas pipeline transportation systems,

— ASME B31.4 [23] for liquid petroleum pipelines and ASME B31.8 [24] for gas and multiphase pipelines,

— API RP 1111 [21] for offshore hydrocarbon pipelines,

— DNV OS F-101 [29] for submarine pipeline systems.

These and other design codes for rigid pipe are based around four types of piping and pressure vessel theories: load, elastic, elastic-plastic, and plastic limit-states. Load limit-state design codes look at the individual hoop, radial and axial stresses and provide safe operating limits for each condition. These codes are the most widely used and are based on universally accepted pressure-vessel theory, with many of the required allowable safety factors built in. They are the most conservative of the pipeline design codes and work well in many environments. Elastic, elastic-plastic, and plastic limit-state design codes are derived from pipe burst and gross (excessive) plastic deformation formulations. Design algorithms based on these formulations provide the designer with a clear picture of load and stress interactions on ductile rigid pipe common in many offshore and subsea pipeline systems, where combined external structural and environmental loads are on the same level as internal pressure-containment loads. Pipe designs using plastic deformation theories can result in wall thicknesses which are 50 % to 80 % of the load limit designs for certain extreme conditions. Although appearing less robust, pipe designs derived from these codes provide designs with similar allowable safety factors.

It should be emphasized that this part of ISO 13628 does not recommend one design theory or code over another; all have their practical applications. Rather, the intent is to show that there are several methods

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available to address pipe design, given specific unique design requirements. Some design exercises may involve the use of multiple codes/theories to develop the best piping design.

5.11.3.5 Flexible pipe standards

International Standards used for flexible subsea flowlines are as follows:

— ISO 13628-2 [5] for the design, installation and operation of unbonded flexible pipe;

— ISO 13628-10 [7] for bonded flexible pipe;

— ISO 13628-11 [8] for unbonded flexible pipe for riser applications.

Although flexible pipe is a complex multi-layered composite, these International Standards provide a means to empirically identify many of the same structural constants and performance characteristics as used in rigid pipe calculations so that many rigid pipe installation and analysis programmes can be applied to flexible pipe constructions as well.

Specific design requirements for control system umbilicals and their components shall be in accordance with ISO 13628-5.

5.11.3.6 End connection design

After placing a pipeline on the seabed, it may be necessary to reposition the ends, modify them (e.g. by adding tie-in spools), or both, so that a connection can be made without further gross adjustment. The choice of a pipeline alignment and connection method and its subsequent design is influenced by several considerations, including the following:

a) *target area*: the location and accuracy with which the pipeline end is placed, and its effect on the lateral and angular alignments and related stresses;

b) *pipeline installation method*: the procedures and equipment of the chosen alignment method should be compatible with the procedures and equipment chosen to install the rest of the pipeline. Alignment equipment should also be designed for any residual pipeline reaction loads caused by the pipeline installation method and/or thermal expansion loads;

c) *pipeline end configuration*: the type and amount of alignment forces required of the chosen pipeline alignment method can be influenced by the pipe design being single, bundled or cased bundled, and by pipe size, mass, strength, stiffness and TFL requirements;

d) *local seabed conditions*: soil friction forces and load-bearing capacity, local obstructions and seabed topography can affect the alignment procedure;

e) *connection point*: alignment design is influenced by whether the connection point is another subsea facility or an offshore platform. An offshore platform can offer additional pipeline alignment methods, such as conventional riser installation or J-tube installation. Connection points can also require expansion loops, breakaway features or valves to complement the overall design. Spool pieces can be required to incorporate these added features;

f) *end connection method*: it is essential to the integrity of the end connection that the pipeline alignment method positions the end of the pipe within the appropriate axial, lateral and angular make-up tolerances of the pipeline connector. Rotational alignment should also be accommodated for bundled pipelines to guarantee proper port orientation. It is also important to understand when the end connections take place in the installation process. Some end connection techniques favor “first-end” connection, either as the start of the pipe lay operation, or the first end to be connected immediately after the pipe is laid. “Second-end” connections favor platform or riser connections, but are accommodated by almost all subsea end connection techniques;

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