

# ISO 19902:2007-12 (E)

Petroleum and natural gas industries — Fixed steel offshore structures

---

<b>Contents</b>		<b>Page</b>
Foreword.....		xi
Introduction .....		xiii
1 Scope .....		1
2 Normative references .....		1
3 Terms and definitions.....		2
4 Symbols .....		9
5 Abbreviated terms .....		13
6 Overall considerations .....		15
6.1 Types of fixed steel offshore structure .....		15
6.2 Planning.....		17
6.3 Service and operational considerations.....		17
6.4 Safety considerations.....		18
6.5 Environmental considerations .....		19
6.6 Exposure levels.....		20
6.7 Assessment of existing structures .....		22
6.8 Structure reuse .....		22
7 General design requirements .....		23
7.1 General.....		23
7.2 Incorporating limit states .....		23
7.3 Determining design situations .....		23
7.4 Structural modelling and analysis .....		24
7.5 Design for pre-service and removal situations .....		24
7.6 Design for the in-place situation .....		24
7.7 Determination of resistances .....		24
7.8 Strength and stability checks .....		25
7.9 Robustness .....		26
7.10 Reserve strength.....		26
7.11 Indirect actions .....		26
7.12 Structural reliability analysis .....		27
8 Actions for pre-service and removal situations .....		27
8.1 General.....		27
8.2 General requirements.....		28
8.3 Actions associated with lifting .....		30
8.4 Actions associated with fabrication .....		33
8.5 Actions associated with loadout.....		33
8.6 Actions associated with transportation .....		34
8.7 Actions associated with installation.....		35
8.8 Actions associated with removal .....		36
9 Actions for in-place situations .....		36
9.1 General.....		36
9.2 Permanent actions ( $G$ ) and variable actions ( $Q$ ).....		36
9.3 Extreme environmental action due to wind, waves and current .....		38
9.4 Extreme quasi-static action due to wind, waves and current ( $E_e$ ).....		39
9.5 Extreme quasi-static action caused by waves only ( $E_{we}$ ) or by waves and currents ( $E_{wce}$ ) .....		41
9.6 Actions caused by current.....		46
9.7 Actions caused by wind .....		47

9.8	Equivalent quasi-static action representing dynamic response caused by extreme wave conditions .....	48
9.9	Factored actions .....	50
9.10	Design situations .....	51
9.11	Local hydrodynamic actions.....	53
10	Accidental situations .....	54
10.1	General .....	54
10.2	Vessel collisions .....	58
10.3	Dropped objects.....	59
10.4	Fires and explosions .....	59
10.5	Abnormal environmental actions .....	59
11	Seismic design considerations .....	60
11.1	General .....	60
11.2	Seismic design procedure .....	60
11.3	Seismic reserve capacity factor .....	61
11.4	Recommendations for ductile design .....	61
11.5	ELE requirements .....	63
11.6	ALE requirements .....	64
11.7	Topsides appurtenances and equipment.....	66
12	Structural modelling and analysis .....	67
12.1	Purpose of analysis .....	67
12.2	Analysis principles .....	68
12.3	Modelling.....	68
12.4	Analysis requirements.....	75
12.5	Types of analysis .....	81
12.6	Non-linear analysis .....	83
13	Strength of tubular members.....	86
13.1	General .....	86
13.2	Tubular members subjected to tension, compression, bending, shear or hydrostatic pressure .....	87
13.3	Tubular members subjected to combined forces without hydrostatic pressure.....	94
13.4	Tubular members subjected to combined forces with hydrostatic pressure.....	96
13.5	Effective lengths and moment reduction factors .....	99
13.6	Conical transitions.....	101
13.7	Dented tubular members.....	111
13.8	Corroded tubular members.....	118
13.9	Grouted tubular members .....	118
14	Strength of tubular joints .....	123
14.1	General .....	123
14.2	Design considerations.....	124
14.3	Simple circular tubular joints.....	132
14.4	Overlapping circular tubular joints .....	138
14.5	Grouted circular tubular joints .....	139
14.6	Ring stiffened circular tubular joints .....	139
14.7	Other circular joint types.....	139
14.8	Damaged joints .....	139
14.9	Noncircular joints.....	140
14.10	Cast joints .....	140
15	Strength and fatigue resistance of other structural components.....	140
15.1	Grouted connections .....	140
15.2	Mechanical connections.....	147
15.3	Clamps for strengthening and repair .....	151
16	Fatigue.....	155
16.1	General .....	155
16.2	General requirements .....	156
16.3	Description of the long-term wave environment .....	159

16.4	Performing the global stress analyses .....	161
16.5	Characterization of the stress range data governing fatigue.....	164
16.6	The long-term local stress range history .....	165
16.7	Determining the long-term stress range distribution by spectral analysis .....	167
16.8	Determining the long-term stress range distribution by deterministic analysis .....	171
16.9	Determining the long-term stress range distribution by approximate methods.....	171
16.10	Geometrical stress ranges.....	172
16.11	Fatigue resistance of the material.....	174
16.12	Fatigue assessment.....	176
16.13	Other causes of fatigue damage than wave action .....	177
16.14	Further design considerations .....	178
16.15	Fracture mechanics methods.....	180
16.16	Fatigue performance improvement of existing components .....	181
17	Foundation design.....	182
17.1	General.....	182
17.2	Pile foundations .....	183
17.3	General requirements for pile design .....	184
17.4	Pile capacity for axial compression.....	185
17.5	Pile capacity for axial tension .....	190
17.6	Axial pile performance .....	190
17.7	Soil reaction for piles under axial compression.....	191
17.8	Soil reaction for piles under lateral actions .....	194
17.9	Pile group behaviour .....	198
17.10	Pile wall thickness .....	199
17.11	Length of pile sections.....	201
17.12	Shallow foundations.....	202
18	Corrosion control.....	203
18.1	General.....	203
18.2	Corrosion zones and environmental parameters affecting corrosivity .....	203
18.3	Forms of corrosion, associated corrosion rates and corrosion damage .....	204
18.4	Design of corrosion control.....	204
18.5	Fabrication and installation of corrosion control.....	209
18.6	In-service inspection, monitoring and maintenance of corrosion control .....	210
19	Materials .....	211
19.1	General.....	211
19.2	Design philosophy.....	212
19.3	Strength groups .....	214
19.4	Toughness classes.....	214
19.5	Applicable steels.....	215
19.6	Cement grout for pile-to-sleeve connections and grouted repairs. ....	216
20	Welding, fabrication and weld inspection .....	217
20.1	General.....	217
20.2	Welding .....	218
20.3	Inspection .....	224
20.4	Fabrication.....	225
21	Quality control, quality assurance and documentation.....	228
21.1	General.....	228
21.2	Quality management system .....	228
21.3	Quality control plan .....	229
21.4	Inspection of installation aids and appurtenances .....	230
21.5	Inspection of loadout, sea-fastening and transportation .....	231
21.6	Installation inspection .....	231
21.7	Documentation.....	232
21.8	Drawings and specifications .....	234
22	Loadout, transportation and installation.....	234
22.1	General.....	234
22.2	Loadout and transportation.....	235

22.3	Transfer of the structure from the transport barge into the water.....	237
22.4	Placement on the sea floor and assembly of the structure .....	238
22.5	Pile installation .....	240
22.6	Installation of conductors .....	245
22.7	Topsides installation .....	246
22.8	Grounding of installation welding equipment.....	247
23	In-service inspection and structural integrity management.....	247
23.1	General .....	247
23.2	Data collection and update .....	249
23.3	Evaluation .....	249
23.4	Inspection strategy .....	251
23.5	Inspection programme .....	253
23.6	Inspection requirements .....	253
23.7	Default periodic inspection requirements .....	256
23.8	Personnel qualifications.....	258
24	Assessment of existing structures .....	259
24.1	General .....	259
24.2	Assessment process .....	259
24.3	Data collection.....	262
24.4	Structural assessment initiators .....	263
24.5	Acceptance criteria .....	264
24.6	Structure condition assessment .....	265
24.7	Actions assessment .....	265
24.8	Screening assessment .....	266
24.9	Resistance assessment.....	266
24.10	Prevention and mitigation .....	269
25	Structure reuse.....	269
25.1	General .....	269
25.2	Fatigue considerations for reused structures .....	269
25.3	Steel in reused structures .....	269
25.4	Inspection of structures to be reused.....	270
25.5	Removal and reinstallation .....	271
25.6	In-service inspection and structural integrity management.....	271
Annex A	(informative) Additional information and guidance.....	272
A.1	Scope .....	272
A.2	Normative references .....	272
A.3	Terms and definitions.....	272
A.4	Symbols .....	272
A.5	Abbreviated terms .....	272
A.6	Overall considerations .....	272
A.6.1	Types of fixed steel offshore structure .....	272
A.6.2	Planning .....	272
A.6.3	Service and operational considerations.....	272
A.6.4	Safety considerations.....	274
A.6.5	Environmental considerations .....	274
A.6.6	Exposure levels.....	274
A.6.7	Assessment of existing structures .....	276
A.6.8	Structure reuse .....	276
A.7	General design requirements .....	276
A.7.1	General.....	276
A.7.2	Incorporating limit states .....	276
A.7.3	Determining design situations .....	276
A.7.4	Structural modelling and analysis .....	276
A.7.5	Design for pre-service and removal situations .....	276
A.7.6	Design for the in-place situation .....	277
A.7.7	Determination of resistances .....	277
A.7.8	Strength and stability checks .....	282
A.7.9	Robustness .....	282

A.7.10	Reserve strength .....	283
A.7.11	Indirect actions .....	284
A.7.12	Structural reliability analysis.....	284
A.8	Actions for pre-service and removal situations .....	284
A.8.1	General .....	284
A.8.2	General requirements .....	285
A.8.3	Actions associated with lifting.....	285
A.8.4	Actions associated with fabrication .....	287
A.8.5	Actions associated with loadout .....	287
A.8.6	Actions associated with transportation .....	287
A.8.7	Actions associated with installation .....	288
A.8.8	Actions associated with removal.....	288
A.9	Actions for in-place situations .....	289
A.9.1	General .....	289
A.9.2	Permanent actions ( $G$ ) and variable actions ( $Q$ ).....	289
A.9.3	Extreme environmental action due to wind, waves and current .....	290
A.9.4	Extreme quasi-static action due to wind, waves and current ( $E_e$ ).....	290
A.9.5	Extreme quasi-static action caused by waves only ( $E_{we}$ ) or by waves and currents ( $E_{wce}$ ).....	291
A.9.6	Actions caused by current .....	305
A.9.7	Actions caused by wind.....	305
A.9.8	Equivalent quasi-static action representing dynamic response caused by extreme wave conditions.....	305
A.9.9	Factored actions .....	310
A.9.10	Design situations.....	313
A.9.11	Local hydrodynamic actions .....	314
A.10	Accidental situations .....	316
A.10.1	General .....	316
A.10.2	Vessel collisions.....	316
A.10.3	Dropped objects .....	317
A.10.4	Fires and explosions.....	317
A.10.5	Abnormal environmental actions .....	317
A.11	Seismic design considerations.....	318
A.11.1	General .....	318
A.11.2	Seismic design procedure.....	318
A.11.3	Seismic reserve capacity factor.....	318
A.11.4	Recommendations for ductile design .....	318
A.11.5	ELE requirements .....	318
A.11.6	ALE requirements.....	318
A.11.7	Topsides appurtenances and equipment .....	319
A.12	Structural modelling and analysis .....	319
A.12.1	Purpose of analysis.....	319
A.12.2	Analysis principles .....	319
A.12.3	Modelling .....	320
A.12.4	Analysis requirements .....	325
A.12.5	Types of analysis.....	327
A.12.6	Non-linear analysis.....	330
A.13	Strength of tubular members .....	332
A.13.1	General .....	332
A.13.2	Tubular members subjected to tension, compression, bending, shear or hydrostatic pressure .....	333
A.13.3	Tubular members subjected to combined forces without hydrostatic pressure .....	342
A.13.4	Tubular members subjected to combined forces with hydrostatic pressure .....	344
A.13.5	Effective lengths and moment reduction factors.....	349
A.13.6	Conical transitions .....	354
A.13.7	Dented tubular members .....	356
A.13.8	Corroded tubular members .....	361
A.13.9	Grouted tubular members .....	361
A.14	Strength of tubular joints.....	365
A.14.1	General .....	365
A.14.2	Design considerations .....	365

A.14.3	Simple circular tubular joints .....	370
A.14.4	Overlapping circular tubular joints .....	374
A.14.5	Grouted circular tubular joints .....	374
A.14.6	Ring stiffened circular tubular joints .....	375
A.14.7	Other circular joint types .....	376
A.14.8	Damaged joints .....	376
A.14.9	Non-circular joints .....	376
A.14.10	Cast joints .....	376
A.15	Strength and fatigue resistance of other structural components .....	376
A.15.1	Grouted connections .....	376
A.15.2	Mechanical connections .....	379
A.15.3	Clamps for strengthening and repair .....	396
A.16	Fatigue .....	410
A.16.1	General .....	410
A.16.2	General requirements .....	414
A.16.3	Description of the long-term wave environment .....	414
A.16.4	Performing the global stress analyses .....	420
A.16.5	Characterization of the stress range data governing fatigue .....	422
A.16.6	The long-term local stress range history .....	423
A.16.7	Determining the long-term stress range distribution by spectral analysis .....	423
A.16.8	Determining the long-term stress range distribution by deterministic analysis .....	430
A.16.9	Determining the long-term stress range distribution by approximate methods .....	432
A.16.10	Geometrical stress ranges .....	436
A.16.11	Fatigue resistance of the material .....	462
A.16.12	Fatigue assessment .....	464
A.16.13	Other causes of fatigue damage than wave action .....	466
A.16.14	Further design considerations .....	467
A.16.15	Fracture mechanics methods .....	468
A.16.16	Fatigue performance improvement of existing components .....	470
A.17	Foundation design .....	472
A.17.1	General .....	472
A.17.2	Pile foundations .....	472
A.17.3	General requirements for pile design .....	473
A.17.4	Pile capacity for axial compression .....	473
A.17.5	Pile capacity for axial tension .....	487
A.17.6	Axial pile performance .....	487
A.17.7	Soil reaction for piles under axial compression .....	490
A.17.8	Soil reaction for piles under lateral actions .....	491
A.17.9	Pile group behaviour .....	493
A.17.10	Pile wall thickness .....	493
A.17.11	Length of pile sections .....	494
A.17.12	Shallow foundations .....	494
A.18	Corrosion control .....	494
A.19	Materials .....	494
A.19.1	General .....	494
A.19.2	Design philosophy .....	495
A.19.3	Strength groups .....	497
A.19.4	Toughness classes .....	499
A.19.5	Applicable steels .....	499
A.19.6	Cement grout for pile-to-sleeve connections and grouted repairs .....	499
A.20	Welding, fabrication and weld inspection .....	500
A.20.1	General .....	500
A.20.2	Welding .....	500
A.20.3	Inspection .....	506
A.20.4	Fabrication .....	506
A.21	Quality assurance, quality control and documentation .....	507
A.21.1	General .....	507
A.21.2	Quality management system .....	507
A.21.3	Quality control plan .....	507
A.21.4	Inspection of installation aids and appurtenances .....	508

A.21.5	Inspection of loadout, sea-fastening and transportation .....	509
A.21.6	Installation inspection.....	509
A.21.7	Documentation .....	509
A.21.8	Drawings and specifications .....	510
A.22	Loadout, transportation and installation .....	513
A.22.1	General .....	513
A.22.2	Loadout and transportation.....	513
A.22.3	Transfer of the structure from the transport barge into the water .....	513
A.22.4	Placement on the sea floor and assembly of the structure .....	513
A.22.5	Pile installation .....	513
A.22.6	Installation of conductors.....	515
A.22.7	Topsides installation.....	515
A.22.8	Grounding of installation welding equipment.....	515
A.23	In-service inspection and structural integrity management .....	515
A.23.1	General .....	515
A.23.2	Data collection and update.....	518
A.23.3	Evaluation.....	519
A.23.4	Inspection strategy.....	525
A.23.5	Inspection programme .....	530
A.23.6	Inspection requirements .....	530
A.23.7	Default periodic inspection requirements .....	532
A.23.8	Personnel qualifications .....	533
A.24	Assessment of existing structures.....	534
A.24.1	General .....	534
A.24.2	Assessment process.....	534
A.24.3	Data collection .....	534
A.24.4	Structure assessment initiators .....	535
A.24.5	Acceptance criteria .....	535
A.24.6	Structure condition assessment.....	536
A.24.7	Actions assessment.....	538
A.24.8	Screening assessment.....	542
A.24.9	Resistance assessment .....	542
A.24.10	Prevention and mitigation .....	545
A.25	Structure reuse .....	545
A.25.1	General .....	545
A.25.2	Fatigue considerations for reused structures.....	545
A.25.3	Steel in reused structures .....	545
A.25.4	Inspection of structures to be reused .....	545
A.25.5	Removal and reinstallation.....	547
A.25.6	In-service inspection and structural integrity management .....	547
<b>Annex B</b>	<b>(informative) CTOD testing procedures .....</b>	<b>548</b>
B.1	Testing procedure requirements.....	548
B.2	Test-assembly welding.....	548
B.3	Number and location of CTOD specimens.....	548
B.4	Specimen preparation .....	549
B.5	Pre-compression.....	549
B.6	Sectioning.....	549
<b>Annex C</b>	<b>(informative) Material category approach .....</b>	<b>553</b>
C.1	Selection of material category (MC).....	553
C.2	Selection of toughness class .....	553
C.3	Specific steel selection .....	553
<b>Annex D</b>	<b>(informative) Design class approach .....</b>	<b>558</b>
D.1	General.....	558
D.2	Specific steel selection .....	559
D.3	Welding and non-destructive inspection categories .....	565

<b>Annex E (informative) Welding and weld inspection requirements — Material category approach</b> .....	<b>568</b>
<b>E.1 General</b> .....	<b>568</b>
<b>E.2 Weld toughness</b> .....	<b>568</b>
<b>E.2.1 Weld metal toughness</b> .....	<b>568</b>
<b>E.2.2 HAZ toughness</b> .....	<b>568</b>
<b>E.3 Inspection</b> .....	<b>570</b>
<b>Annex F (informative) Welding and weld inspection requirements — Design class approach</b> .....	<b>573</b>
<b>F.1 General</b> .....	<b>573</b>
<b>F.2 Toughness of weld and heat affected zone (HAZ)</b> .....	<b>573</b>
<b>F.2.1 General</b> .....	<b>573</b>
<b>F.2.2 CTOD testing</b> .....	<b>573</b>
<b>F.2.3 PWHT alternative to CTOD testing</b> .....	<b>573</b>
<b>F.3 Extent of NDT for structural welds</b> .....	<b>573</b>
<b>Annex G (normative) Fabrication tolerances</b> .....	<b>576</b>
<b>G.1 Measurements</b> .....	<b>576</b>
<b>G.2 Launch rails</b> .....	<b>576</b>
<b>G.3 Global horizontal tolerances</b> .....	<b>576</b>
<b>G.4 Global vertical tolerances</b> .....	<b>578</b>
<b>G.5 Roundness of tubular members</b> .....	<b>579</b>
<b>G.6 Circumference of tubular members</b> .....	<b>579</b>
<b>G.7 Straightness and circumferential weld locations of tubular members</b> .....	<b>579</b>
<b>G.8 Joint mismatch for tubular members</b> .....	<b>582</b>
<b>G.9 Leg alignment and straightness tolerances</b> .....	<b>584</b>
<b>G.10 Tubular joint tolerances</b> .....	<b>585</b>
<b>G.11 Cruciform joints</b> .....	<b>587</b>
<b>G.12 Stiffener tolerances</b> .....	<b>588</b>
<b>G.12.1 Stiffener location</b> .....	<b>588</b>
<b>G.12.2 Stiffener cross-section</b> .....	<b>588</b>
<b>G.13 Conductor, pile guide, pile sleeve and appurtenance support tolerances</b> .....	<b>590</b>
<b>Annex H (informative) Regional information</b> .....	<b>592</b>
<b>H.1 General</b> .....	<b>592</b>
<b>H.2 North West Europe</b> .....	<b>592</b>
<b>H.2.1 Description of region</b> .....	<b>592</b>
<b>H.2.2 Regulatory framework in NW Europe</b> .....	<b>592</b>
<b>H.2.3 Technical information for NW Europe</b> .....	<b>593</b>
<b>H.3 Canada</b> .....	<b>593</b>
<b>H.3.1 Description of region</b> .....	<b>593</b>
<b>H.3.2 Regulatory framework in Canada</b> .....	<b>593</b>
<b>H.3.3 Technical information for Canada</b> .....	<b>594</b>
<b>H.3.4 Additional information and guidance for Canada</b> .....	<b>595</b>
<b>Bibliography</b> .....	<b>597</b>