

ISO 29400:2015-05 (E)

Ships and marine technology - Offshore wind energy - Port and marine operations

Contents		Page
Foreword		xii
Introduction		xiii
1	Scope	1
2	Normative references	1
3	Terms and definitions	2
4	Symbols and abbreviated terms	23
4.1	Symbols	23
4.2	Abbreviated terms	27
5	General considerations	27
5.1	Introduction	27
5.1.1	General	27
5.1.2	Safety requirements	29
5.2	Jurisdiction	29
5.2.1	Introduction	29
5.2.2	Life at sea	30
5.2.3	Environment	30
5.3	HSSE plan	30
5.4	Risk management	31
5.4.1	Introduction	31
5.4.2	Techniques to evaluate risks	31
5.5	Job safety analysis	31
5.6	Environmental impact study	32
5.7	Manning, qualifications, job and safety training	32
5.8	Incident reporting	33
5.9	Personnel tracking	33
5.10	Approval by national authorities	33
6	Organization, documentation and planning	33
6.1	Introduction	33
6.2	Organization and communication	34
6.2.1	Project organization	34
6.2.2	Operational organization	34
6.3	Quality assurance and administrative procedures	35
6.4	Technical procedures	35
6.5	Technical documentation	36
6.5.1	Document numbering system	36
6.5.2	Port and marine operations documents	36
6.5.3	Operational schedule/programme	37
6.5.4	Contingency philosophy	38
6.5.5	Contingency planning and emergency procedures	38
6.5.6	Emergency preparedness bridging document	39
6.5.7	As-built documentation	39
6.5.8	Standards for data transfer to CAD systems	40
6.6	Certification and documentation	43
6.6.1	General	43
6.6.2	Required or recommended documentation	43

6.7	Marine warranty survey	43
6.7.1	Role of the marine warranty surveyor	44
6.7.2	Certificate of approval	44
6.7.3	MWS scope of work	45
6.7.4	Certificate of approval	45
6.8	Systems and equipment	45
6.8.1	General	45
6.8.2	Marine vessels	45
6.8.3	Major equipment	47
7	Metocean and earthquake requirements	47
7.1	Introduction	47
7.2	Weather-restricted/weather-unrestricted operations	48
7.2.1	Weather-restricted operations	48
7.2.2	Weather-unrestricted operations	48
7.3	Metocean conditions	48
7.3.1	Wind	48
7.3.2	Wave, wave period and swell conditions	49
7.3.3	Current	49
7.3.4	Tidal factors	49
7.3.5	Other metocean factors	50
7.3.6	Temperature	50
7.3.7	Marine growth	50
7.4	Metocean criteria	50
7.4.1	Design criteria and operational limits	50
7.4.2	Return periods	51
7.4.3	Response-based analysis	52
7.4.4	Probability distributions of sea state parameters	53
7.5	Weather windows	53
7.5.1	Weather-restricted operations	53
7.5.2	Impact on design	54
7.6	Operational duration and weather window	54
7.6.1	Time schedule	54
7.6.2	Point of no return	54
7.7	Operational limits	55
7.8	Forecasted and monitored operational limits	55
7.9	Metocean forecast	55
7.9.1	General	55
7.9.2	Forecast parameters	56
7.9.3	On-site monitoring	56
7.10	Earthquake	56
7.11	Soil	56
8	Onshore transport and nearshore transport	56
8.1	Introduction	56
8.2	Structural integrity calculations	56
8.3	Personnel qualifications	57
8.4	Loading, unloading and lifting	57
8.5	Transport via roads	57
8.6	Transport via inshore waterways	57
8.7	Transport via nearshore waterways	57
8.8	Transport via railways	58
8.9	Transport frames and equipment	58
9	Intermediate storage areas	58
9.1	Introduction	58
9.2	Infrastructure requirements	59
9.2.1	Load bearing	59
9.2.2	Surface	59
9.3	Personnel qualifications	59
9.4	Loadout, unloading and lifting	59

9.5	Storage frames and equipment	59
9.6	Requirements of components for storage	60
9.7	Protection of components against environmental conditions	60
9.8	Structural integrity calculations	60
9.9	Safety and security	60
10	Pre-assembly	60
10.1	Introduction	60
10.2	Pre-assembly area requirements	61
10.3	Personnel qualifications	61
10.4	Loadout, lifting and internal transport	61
10.5	Pre-assembly activities	61
10.6	Operational limits/weather conditions	61
10.7	Pre-assembly equipment	61
10.8	Structural integrity calculations	61
10.9	Safety and security	61
11	Harbour activities	62
11.1	Introduction	62
11.2	Personnel qualifications	62
11.3	Accessibility of harbour areas	62
11.3.1	Water access	62
11.3.2	Inland access	62
11.4	Storage areas of quayside	62
11.5	Safety and security measures	63
11.6	Quayside requirements	63
11.7	Harbour subsea soil requirements for jacking activities	63
12	Weight control	64
12.1	Introduction	64
12.2	Weight control classes	64
12.3	Weight and CoG constraints	64
12.4	Weight control audits	64
12.5	Dimensional control	65
12.6	Serial items	65
12.7	Offshore wind farm components	65
12.8	Weight determinations	65
13	Stability	65
13.1	Introduction	65
13.2	General requirements	66
13.3	Stability calculations	66
13.4	Intact stability	67
13.4.1	Introduction	67
13.4.2	Intact stability criteria	68
13.5	Damage stability	69
13.5.1	Introduction	69
13.5.2	Damage stability criteria	70
13.6	Single-barge transports	71
13.7	Multi-barge transports	71
13.8	Classed vessels	72
13.9	Self-floating structures	72
13.9.1	General	72
13.9.2	Intact and damage stability	72
13.9.3	Upending and installation of self-floating and launched steel structures	73
13.10	Loadout operations	74
13.11	Watertight integrity and temporary closures	75
13.12	Inclining tests	75
14	Ballasting operations	75
14.1	Introduction	75
14.2	Ballast calculations for different stages	76

14.3	In ballast system	77
14.3.1	Operational aspects	77
14.3.2	Other operational considerations	78
14.4	Protection against damage and deterioration	78
14.4.1	General	78
14.4.2	Freezing	78
14.5	Prevention of progressive flooding in damage condition	78
14.6	Control and indicating systems	79
14.7	Pumps	80
14.7.1	Specification and layout	80
14.7.2	Pump performance curves and functional limitations	80
14.8	Valve arrangements	80
14.9	Vent systems	80
14.10	Air cushion system capacity	81
14.11	System testing	81
15	Loadout	81
15.1	Introduction	81
15.2	Categories of loadout	82
15.2.1	Design: structural analysis during all loadout phases	82
15.2.2	Loadout planning	82
15.2.3	Cargo weight details and COG information	83
15.2.4	Deck loading plan	83
15.3	Structure being loaded	83
15.4	Site and quay	84
15.5	Barge	84
15.6	Link beams, skidways and skidshoes	85
15.7	Moorings	85
15.7.1	Weather-restricted operation	85
15.7.2	Temporary mooring system	85
15.8	Grounded loadouts	86
15.9	Pumping and ballasting	86
15.9.1	Pump capacity	86
15.9.2	Recommended pump capacity	86
15.10	Loadouts by trailers, SPMTs or hydraulic skidshoes	88
15.10.1	Introduction	88
15.10.2	Structural capacity	88
15.10.3	Load equalization and stability	89
15.10.4	Vertical alignment	89
15.10.5	Skidshoes	89
15.11	Propulsion system design, redundancy and back-up	89
15.11.1	Propulsion system	89
15.11.2	Redundancy ad recommendations	90
15.12	Float-on onto submersible barges or vessels	91
15.13	Lifted loadouts	93
15.14	Transverse loadouts	93
15.15	Barge reinstatement and sea fastenings	93
15.16	Tugs	94
15.17	Management and organization	94
15.18	Loadout manual	94
15.19	Operating manual	95
16	Transportation	96
16.1	Introduction	96
16.2	General considerations	97
16.2.1	Manned tows	97
16.2.2	Unmanned tows	97
16.2.3	Navigation lights, signals and day shapes	97
16.2.4	Contingency	97
16.2.5	Motion responses	97
16.2.6	Structural verification of the transported object	98
16.2.7	Bunker ports	99

16.2.8	Weather forecast	99
16.2.9	Design: Structural analysis during all transport phases	99
16.2.10	Transport planning	99
16.2.11	Operational limits	99
16.3	Weather routeing and forecasting	100
16.4	Ports of shelter, shelter areas, holding areas	100
16.5	Inspections during the towage or voyage	100
16.6	Responsibility	101
16.7	Hazardous materials	101
16.8	Ballast water	101
16.9	Restricted depths, heights and manoeuvrability	101
16.10	Under-keel clearances	102
16.11	Air draught	103
16.12	Channel width and restricted manoeuvrability	103
16.13	Towline pull required, fleet composition and towing arrangement	103
16.13.1	Towline pull required	103
16.13.2	Towing fleet	104
16.13.3	Towing arrangement	104
16.13.4	Towline length	105
16.14	Tow out from dry dock	105
16.14.1	General	105
16.14.2	Under-keel clearance	105
16.14.3	Side clearances	105
16.14.4	Air cushion/air pressure	106
16.14.5	Capacity of winching and towing arrangements	106
16.14.6	Navigation systems	106
16.14.7	Survey requirements	106
16.15	Inshore tow	106
16.15.1	Tow route and towing clearances	106
16.15.2	Survey requirements	107
16.15.3	Navigation systems	107
16.16	Offshore tow	107
16.16.1	Holding areas and contingency plans for routing	107
16.16.2	Under-keel clearance	107
16.16.3	Special considerations	107
16.16.4	Navigation systems	108
16.16.5	Survey requirements	108
16.17	Transport onboard a vessel	108
16.17.1	Vessel selection	108
16.17.2	Stability	108
16.17.3	Under-keel clearance	108
16.17.4	Special considerations	108
16.17.5	Sea fastening	108
16.17.6	Navigation systems	110
16.18	Transport manual	110
16.18.1	Voyage planning	110
17	Temporary mooring and stationkeeping for marine operations	112
17.1	Introduction	112
17.2	Environmental criteria	112
17.3	Determination of mooring response	113
17.3.1	Analysis methods	113
17.3.2	General considerations on the mooring design	113
17.4	Sizing of mooring lines	114
17.4.1	General considerations	114
17.4.2	Line tension limits and design safety factors	114
17.4.3	Particular mooring conditions	114
17.5	Sizing of anchors	115
17.6	Sizing of attachments	115
17.7	Sizing of mooring line components	115
17.8	Clearances under extreme conditions	116
17.9	Tensioning of moorings	116

17.10	Other stationkeeping means	116
17.10.1	General	116
17.10.2	DP systems	117
17.10.3	Purpose-built mooring arrangements	117
17.10.4	Use of tugs	117
17.11	System for common reference stations	117
18	Offshore installation operations	118
18.1	Introduction	118
18.1.1	General	118
18.1.2	Design: Structural analysis during all installation phases	118
18.1.3	Installation planning	118
18.1.4	Cargo weight details and COG information	121
18.1.5	Operational limits	121
18.1.6	Design	122
18.2	Installation site	122
18.2.1	Sea floor survey	122
18.2.2	Soil survey	123
18.2.3	Soil preparation	123
18.2.4	Site-specific site plan	123
18.2.5	Unexploded Ordnance (UXO) Survey	123
18.3	Site actions on and motions of floating units	123
18.4	Systems and equipment	124
18.4.1	General	124
18.4.2	Vessels	124
18.4.3	Equipment (e.g. hammer, upending tools, grout spread, ROV, special lifting tools)	124
18.4.4	Position monitoring system	125
18.4.5	Ballast systems	125
18.4.6	Transport vessel interface with marine equipment	125
18.4.7	Floating structure interface with marine equipment	125
18.5	Launching	125
18.5.1	General	125
18.5.2	Operational aspects	125
18.5.3	Preparations at fabrication yard	126
18.5.4	Operational control parameters	126
18.6	Float-off	126
18.6.1	General	126
18.6.2	Operational aspects	126
18.6.3	Preparations at the fabrication yard	127
18.6.4	Operational control parameters	127
18.7	Positioning of vessels	127
18.8	Site reference system	128
18.9	Geotechnical site specific assessment	128
18.9.1	Required soil investigations	128
18.9.2	Penetration analysis, punch-through and horizontal-vertical-interaction	128
18.10	Site specific installation plan	130
18.11	Jack-up preloading procedure	131
18.12	Upending of foundation structure	131
18.12.1	General	131
18.12.2	Operational aspects	131
18.12.3	Preparations at the fabrication yard/offload location	132
18.12.4	Operational control parameters	132
18.13	Ballasting	132
18.14	Lifted installations	132
18.14.1	General	132
18.14.2	Installation of liftable jackets	133
18.14.3	Installation of templates for piles	133
18.14.4	Installation of piles	133
18.14.5	Installation of transition pieces	133
18.14.6	Installation of GBS	133
18.14.7	Installation of topsides	133
18.14.8	Transfer of items from a barge to the deck of a crane vessel/jack-up vessel	134

18.14.9	Installation of towers	134
18.14.10		
	Installation of WTG including nacelle, hub and blades	134
18.14.11		
	Operational aspects	134
18.14.12		
	Fabrication yard	135
18.14.13		
	Operational control parameters	135
18.15	Lowering by ballasting	135
18.15.1	General	135
18.15.2	Operational aspects	135
18.15.3	Operational control parameters	136
18.16	Precise positioning on the sea floor by active and passive means	136
18.16.1	General	136
18.16.2	Operational aspects	136
18.16.3	Operational control parameters	136
18.17	Skirt penetration	137
18.17.1	General	137
18.17.2	Gravity penetration	137
18.17.3	Suction penetration	137
18.17.4	Operational aspects	137
18.17.5	Operational control parameters	137
18.18	Piles installation	138
18.18.1	General	138
18.18.2	Operational aspects	138
18.18.3	Operational control parameters	139
18.19	Grouting	139
18.19.1	General	139
18.19.2	Grouting of pile -- Transition-piece structure	139
18.19.3	Underbase grouting of pile -- Jacket structures	140
18.19.4	Operational aspects	140
18.19.5	Preparations	140
18.19.6	Operational control parameters	141
18.20	Bolted connections of foundation	141
18.21	Welding of piles/foundation to topsides	141
18.22	Noise mitigation measures	141
18.23	Crew transfer from installation units	141
18.24	Offshore completion	142
18.24.1	General	142
18.24.2	ROV inspection	142
18.24.3	Removal of temporary equipment	142
18.24.4	Scour protection	142
18.25	Operating manual	143
19	Design of lifting equipment	144
19.1	Introduction	144
19.2	Rigging geometry	145
19.3	Actions and action effects	146
19.4	Weight contingency factors	147
19.5	Dynamic amplification factors (DAFs)	148
19.5.1	General	148
19.5.2	For lifts by a single crane on a vessel	148
19.5.3	For lifts by cranes on two or more vessels	149

19.5.4	Representative hook load	150
19.5.5	Representative lift weight per lift point	151
19.5.6	Representative forces on a lift point	152
19.6	Strengths of slings, grommets and shackles	156
19.6.1	General	156
19.6.2	Calculated strengths of the bodies of slings and grommets	157
19.6.3	Termination efficiency factor	159
19.6.4	Bending efficiency factor	160
19.6.5	Representative strengths of slings and grommets	161
19.6.6	Working load limits and design strengths of slings and grommets	162
19.6.7	Working load limit and design strength of shackles	164
19.7	Design verifications	165
19.7.1	Allowable hook load	165
19.7.2	Slings and grommets	165
19.7.3	Lift points and their attachment to the structure and supporting members	167
19.8	Lift point design	168
19.8.1	Introduction	168
19.8.2	Sling ovalization	169
19.8.3	Plate rolling direction and direction of loading	169
19.8.4	Pinholes	169
19.8.5	Cast padears and welded trunnions	169
19.8.6	Cheek plates	169
19.9	Clearances	170
19.9.1	Introduction	170
19.9.2	Clearances around lifted objects	170
19.9.3	Clearances around crane vessel	170
19.9.4	Clearances around mooring lines and anchors of crane vessels	171
19.9.5	Clearances around array cable zones	172
19.9.6	Clearances around spud-can positions of jack-up vessels	172
19.10	Bumpers and guides	172
19.10.1	Introduction	172
19.10.2	Object movements	172
19.10.3	Position of bumpers and guides	172
19.10.4	Bumper and guide loads	173
19.10.5	Design considerations	173
19.11	Heave compensated lifts	174
19.12	Lifts using DP	174
19.13	Practical considerations	174
19.13.1	Access	174
19.13.2	Design of sea fastening	174
19.13.3	Equipment	174
19.13.4	Slings	175
19.14	Certification requirements for lifting equipment	175
19.14.1	Standard lifting equipment	175
19.14.2	Custom-made lifting equipment	175
20	Laying, burial and pull-in of sub-sea cables	175
20.1	General	175
20.2	Planning and design	176
20.2.1	Cable dimensions and handling parameters	176
20.2.2	Seafloor survey -- Specifically cable route corridors between turbines and substation(s)	177
20.2.3	Metocean conditions and criteria	177
20.2.4	Vessel suitability	179
20.2.5	Cable storage and cable handling equipment	180
20.2.6	Navigation equipment -- Positioning and control of vessel/cable interface	180
20.3	Cable laying	181
20.3.1	Cable pull-in procedures	181
20.3.2	Cable lay	181
20.4	Cable protection	182
20.4.1	Cable burial	182
20.4.2	Non-burial cable protection	182
20.5	Post installation survey	184

20.6	Cable commissioning	184
20.7	Cable installation manual	184
21	Personnel transfer	184
22	Construction management	185
22.1	Introduction	185
22.2	Marine coordination	185
22.3	Harbour coordination	186
22.4	Guard vessel	186
22.5	Reporting	186
22.6	Personnel tracking	186
Annex A (informative) Additional information and guidance		187
Bibliography		201