

# ISO 29400:2015-05 (E)

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

---

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

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

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