

# ISO 24656:2022-05 (E)

## Cathodic protection of offshore wind structures

---

<b>Contents</b>		<b>Page</b>
Foreword .....		vi
Introduction .....		vii
1	Scope .....	1
2	Normative references .....	1
3	Terms and definitions .....	1
4	Symbols and abbreviations .....	5
4.1	Symbols .....	5
4.2	Abbreviations .....	7
5	Competence of personnel .....	8
6	Structural considerations .....	9
6.1	Structures to be protected .....	9
6.2	Materials .....	10
6.3	Corrosion protection strategy .....	10
7	Cathodic protection criteria .....	15
7.1	Temporary protection .....	15
7.2	Steel structures .....	16
7.3	Reinforced concrete structures .....	17
8	Cathodic protection design .....	17
8.1	Objectives .....	17
8.2	Design considerations .....	18
8.2.1	General .....	18
8.2.2	External cathodic protection .....	19
8.2.3	Internal cathodic protection .....	19
8.3	CP Design life .....	20
8.4	Surface area considerations .....	20
8.4.1	General .....	20
8.4.2	Structure subdivision .....	20
8.5	Environmental factors .....	21
8.5.1	General .....	21
8.5.2	Seawater flow velocity .....	21
8.5.3	Electrolyte resistivity .....	22
8.5.4	Seawater temperature .....	22
8.5.5	Calcareous deposits .....	22
8.6	Protection current demand .....	23
8.6.1	General .....	23
8.6.2	Calculation of current demand, external surfaces .....	23
8.6.3	Calculation of current demand, internal surfaces .....	26
8.7	Electrical continuity and continuity bonds .....	26
8.8	Current drains and interactions .....	27
8.9	Installation considerations during design .....	27
9	Galvanic anode systems .....	28
9.1	General .....	28

9.2	Anode current availability .....	28
9.3	Galvanic anode alloys .....	28
9.4	Anode selection .....	29
9.5	Anode requirements .....	30
9.6	Anode distribution .....	31
10	Impressed current systems .....	32
10.1	General .....	32
10.2	Design considerations .....	33
10.2.1	General .....	33
10.2.2	Resilience of impressed current CP system by design .....	33
10.2.3	Current requirement of impressed current CP system .....	34
10.2.4	Impressed current CP system components .....	34
10.2.5	DC power source .....	34
10.2.6	Impressed current anodes .....	36
10.2.7	Reference electrodes .....	37
10.2.8	Dielectric shields .....	37
10.3	Installation of impressed current CP systems .....	38
10.4	Hybrid systems and temporary power for impressed current systems .....	39
10.5	Continuity bonds .....	39
11	Cable systems .....	39
11.1	General .....	39
11.2	Cathodic protection DC cables .....	40
11.3	Inter-array and export AC cables .....	41
12	Commissioning and surveys .....	43
12.1	Objectives .....	43
12.2	Galvanic anode systems .....	43
12.2.1	General .....	43
12.2.2	Detailed external surveys .....	44
12.2.3	Detailed internal surveys .....	44
12.3	Permanent CP monitoring systems .....	45
12.4	Impressed current systems .....	45
13	CP surveying and monitoring .....	46
13.1	Objectives .....	46
13.2	General considerations .....	46
13.3	Reference electrodes .....	48
13.4	Frequency of survey and monitoring .....	48
14	Retrofitcathodicprotectionsystems .....	49
14.1	General considerations .....	49
14.2	Survey before retrofit .....	49
14.3	Retrofit for inadequate protection .....	50
14.4	Retrofit for structure life extension .....	50
14.5	All retrofits .....	51
14.6	Equipment considerations .....	52
15	Documentation .....	53
15.1	General .....	53
15.2	Design report .....	53
15.2.1	General .....	53
15.3	Material specification requirements .....	55
15.3.1	General .....	55
15.3.2	Galvanic anodes .....	55
15.3.3	Impressed current CP materials .....	56
15.4	Installation drawings and specifications .....	59
15.5	As-built installation and commissioning report requirements .....	59
15.6	Operation and maintenance requirements .....	60

<b>16</b>	<b>Safety and cathodic protection .....</b>	<b>60</b>
<b>16.1</b>	<b>Objectives .....</b>	<b>60</b>
<b>16.2</b>	<b>Physical obstructions .....</b>	<b>61</b>
<b>16.3</b>	<b>Protection against electric shock .....</b>	<b>61</b>
<b>16.4</b>	<b>Gas evolution .....</b>	<b>61</b>
<b>16.4.1</b>	<b>Hydrogen evolution .....</b>	<b>61</b>
<b>16.4.2</b>	<b>Chlorine evolution .....</b>	<b>62</b>
<b>Annex A (informative) Environmental checklist .....</b>		<b>63</b>
<b>Annex B (normative) Method of using metocean data to calculate marked-up seawater flow velocity .....</b>		<b>65</b>
<b>Annex C (informative) Guidance on cathodic protection current density requirement for cathodic protection of wind offshore structures .....</b>		<b>78</b>
<b>Annex D (informative) Coatings and coating breakdown for CP design .....</b>		<b>86</b>
<b>Annex E (normative) Anode resistance and life calculation .....</b>		<b>90</b>
<b>Annex F (normative) Calculation of voltage drop down connection cables .....</b>		<b>97</b>
<b>Annex G (normative) Typical electrochemical characteristics for commonly used impressed current anodes .....</b>		<b>99</b>
<b>Annex H (informative) Permanent monitoring system design process .....</b>		<b>101</b>
<b>Annex I (informative) Cathodic protection modelling .....</b>		<b>105</b>
<b>Bibliography .....</b>		<b>108</b>