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ISO 12944 Standard

Corrosion Protection of Steel Structures by Protective Paint Systems

ISO 12944

Corrosion Protection of Steel Structures by Protective Paint Systems

This standard is intended to assist the user in the best practice for protecting steel surfaces from corrosion. It helps in the proper selection of coatings for different environmental exposures, from the identification of exposures to surface preparation to the testing of coatings and specification writing. The standard also covers the environmental classifications; and, in a general nature, helps define the types of exposures that a coating system might be exposed to. These classifications are listed below.

C1 & C2
Rural areas, low pollution; or interior controlled environment

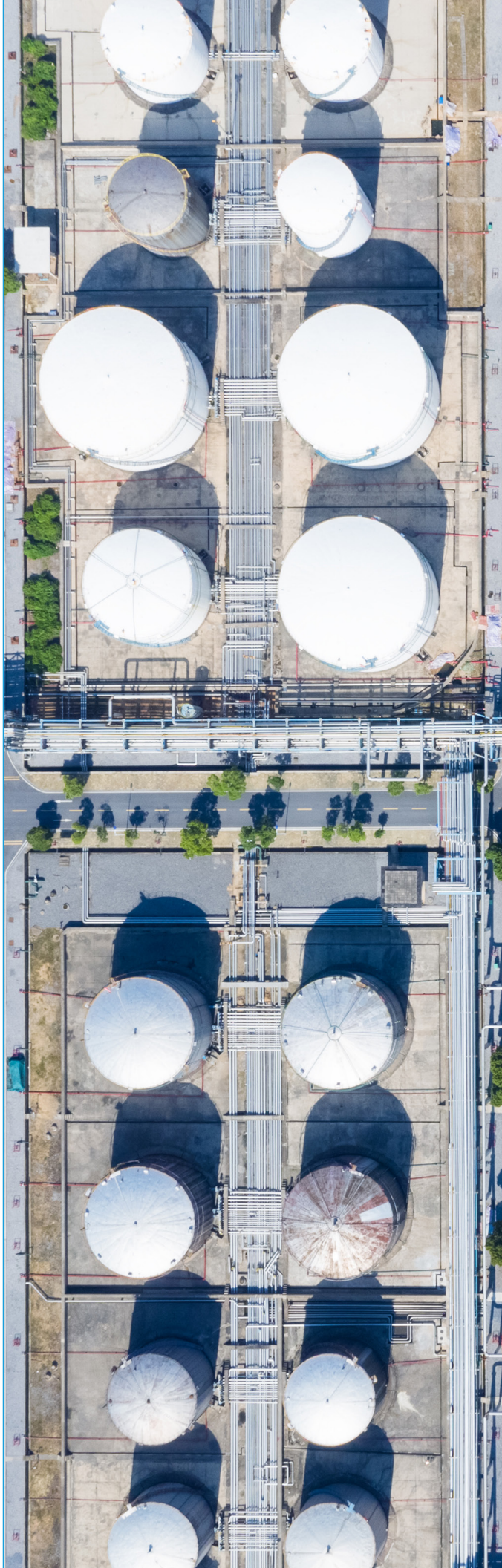
C3
Urban and industrial atmospheres, moderate sulfur dioxide pollution; coastal areas with low salinity

C4
Industrial areas and coastal areas with moderate salinity

C5
Industrial areas with high humidity and aggressive atmosphere and coastal areas with high salinity

CX
Offshore areas with high salinity and industrial areas with extreme humidity and aggressive atmosphere and sub-tropical and tropical atmospheres

Im1
Immersion in fresh water



Changes to corrosion categories:

The old C5-I and C5-M categories have been replaced with C5 High for harsh onshore categories. The CX category for offshore and marine have been added and its testing requirements are detailed under the ISO 12944-9 part. There is also the addition of a fourth immersion category, IM4, which covers immersed structures in the sea or brackish water protected by cathodic protection. The new ISO 12944 standard has incorporated the cyclic aging testing method traditionally used in the ISO 20340 testing protocol for the C4 Very High, C5 High, and C5 Very High categories, in addition to the traditional testing regimes used in the old ISO 12944 standard. The number of cycles varies depending on the corrosivity levels. The new standard incorporates minimum dry film thicknesses for individual coats and total system in effort to improve performance and longevity - for more information check Table B.2 in ISO 12944-5 (2018).

DEFINED BY: ISO 12944-2				DEFINED BY: ISO 12944-1
CATEGORY	CORROSIVITY CATEGORY	ENVIRONMENTAL DESCRIPTION (EXTERIOR)	ENVIRONMENTAL DESCRIPTION (INTERIOR)	DURABILITY RANGES
C1	Very low	N/A	Heated buildings with clean atmospheres e.g. offices, shops, schools, hotels	Low (<7 years)
				Medium (7-15 years)
				High (15-20 years)
				Very High (>25 years)
C2	Low	Atmospheres with low level of pollution: mostly rural areas	Unheated buildings where condensation can occur	Low (<7 years)
				Medium (7-15 years)
				High (15-20 years)
				Very High (>25 years)
C3	Medium	Urban and industrial atmospheres, moderate sulfur dioxide pollution; coastal areas with low salinity	Production rooms with high humidity and some air pollution, e.g. food-processing plants, laundries, breweries, dairies	Low (<7 years)
				Medium (7-15 years)
				High (15-20 years)
				Very High (>25 years)
C4	High	Industrial areas and coastal areas with moderate salinity	Chemical plants, swimming pools, coastal ship and boat yards	Low (<7 years)
				Medium (7-15 years)
				High (15-20 years)
				Very High (>25 years)
C5	Very high	Industrial areas with high humidity and aggressive atmosphere and coastal areas with high salinity	Buildings or areas with almost permanent condensations and with high pollution	Low (<7 years)
				Medium (7-15 years)
				High (15-20 years)
				Very High (>25 years)
CX	Extreme	Offshore areas with high salinity and industrial areas with extreme humidity and aggressive atmosphere and sub-tropical and tropical atmospheres	Industrial areas with extreme humidity and aggressive atmosphere	Very High (>25 years)

Understanding ISO 12944 exposure classifications

Specifiers rely on the ISO 12944 classifications shown on the prior page to select the most appropriate corrosion protection for the environmental characteristics of its location.

Products marketed to meet each classification's performance requirements must pass laboratory tests that simulate the expected environmental conditions. As the graphic below shows, the required tests vary based on how long a corrosion protection coating system is expected to perform, as well as how harsh or mild its service environment will be.

<table>
<tr><th></th><th>C3</th><th>C4</th><th>C5</th><th>CX</th></tr>
<tr><td>LOW
(<7 YEARS)</td><td colspan="2" rowspan="3">Non-cyclic testing
Durations as 1998 (E) revision
ISO 6270 / ISO 9227</td><td>Non-cyclic testing: linear durations TBC ISO 6270 / ISO 9227</td><td>N/A</td></tr>
<tr><td>MEDIUM
(7-15 YEARS)</td><td rowspan="2">N/A</td></tr>
<tr><td>HIGH
(15-25 YEARS)</td><td>Phased introduction of Cyclic aging testing: 10 cycles / 1680 hours</td></tr>
<tr><td>VERY HIGH
(25+ YEARS)</td><td>Non-cyclic testing durations as 1998 (E)</td><td>Phased introduction of Cyclic aging testing: 10 cycles / 1680 hours</td><td>Cyclic ageing testing: 16 cycles / 2688 hours</td><td>Cyclic aging testing: 25 cycles / 4200 hours</td></tr>
</table>

Testing methods key terms

Understanding some of the key terms in the table above can show why the performance testing methods noted in ISO 12944 are appropriate.

Non-cyclic testing is conducted under consistent conditions (such as temperature, moisture, or some other variable) for the duration of a test. Generally, non-cyclic testing is adequate to simulate performance of corrosion protection systems in low-corrosivity and short- to medium-life performance.

For one example, ISO 6270 is a non-cyclic test where test panels are suspended over warm water so that condensation forms over the coating. For another, ISO 9227 describes salt spray testing, where test panels are placed in a salt fog cabinet and exposed to salt spray.

Cyclic ageing refers to testing where important variables (such as moisture, temperature, or UV radiation) change within each cycle. These are more strenuous conditions, so cyclic ageing tests are conducted to verify performance of coating systems for more corrosive or longer-lived service.

For example, one cycle in the cyclic ageing test described above consists of three days of ISO 16474-3 UV Condensation testing, followed by three days of ISO 9227 Neutral Salt Spray testing, and finally one day of low-temperature exposure at -4°F (-20°C). As performance requirements increase, the number of cycles required to verify performance increase.

Innovative Technologies Clause (ISO 12944-5)

New innovative coating technologies might provide equivalent corrosion protection at lower NDFT and/or reduced MNOC.

Field experience may also prove higher performance vs. NDFT/MNOC guidelines.

A combination of field and lab testing should be used to prove the performance of new systems.

Shorter durations of testing in harsher environments can establish systems fit for purpose.

C3 Medium (durability years 7-15):

Urban and industrial atmospheres, moderate sulfur dioxide pollution; coastal areas with low salinity

GENERIC TYPE	COATING SYSTEM	TOTAL DFT (MM)
Aliphatic polyaspartic	Carboquick 200	**6 mils (150 microns)**
	Phosphatized cold-rolled steel	**6 mils (150 microns)**
Aliphatic polyaspartic	Carboquick 200	
Zinc-rich epoxy	Carbozinc 8701	**5 mils (150 microns)**
Aliphatic polyurethane	Carbothane 8832	
Acrylic aliphatic polyurethane	Carbothane 8845	**4 mils (100 microns)***
Acrylic aliphatic polyurethane	Carbothane 8815	**4 mils (100 microns)***

System tested with reduced Dry Film Thicknesses (DFTs) and/or reduced coats per Innovative Coating Technology Clause.

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C3 High (durability years 15-25):

Urban and industrial atmospheres, moderate sulfur dioxide pollution; coastal areas with low salinity

GENERIC TYPE	COATING SYSTEM	TOTAL DFT (MM)
Inorganic copolymer	Thermaline Heat Shield	**9 mils (225 microns)**
Inorganic copolymer	Thermaline Heat Shield	
Epoxy phenalkamine	Carbomastic 615	**8 mils (200 microns)**
Epoxy phenalkamine	Carbomastic 615	
Epoxy phenalkamine	Carboguard 635	**8 mils (200 microns)**
Epoxy phenalkamine	Carboguard 635	
Cycloaliphatic amine epoxy	Carboguard 890	**8 mils (200 microns)**
Aliphatic polyaspartic	Carboquick 200	**8 mils (200 microns)**
Inorganic zinc silicate	Carbozinc 11	**7 mils (175 microns)**
Epoxy polyamide	Carboguard 60	
Inorganic zinc silicate	Carbozinc 11	**7 mils (175 microns)**
Cycloaliphatic amine epoxy	Carboguard 890	
Epoxy phenalkamine	Carboguard 635	**7 mils (175 microns)***
Polyurethane finish	Carbothane 134 HG	
Reinforced zinc-rich primer	Carbozinc 808	**7 mils (175 microns)**
Cycloaliphatic amine epoxy	Carboguard 890	
Zinc-rich epoxy	Carbozinc 858	**7 mils (175 microns)**
Epoxy polyamide	Carboguard 60	
Zinc-rich epoxy	Carbozinc 858	**7 mils (175 microns)**
Cycloaliphatic amine epoxy	Carboguard 890	
Modified siloxane hybrid	Carboxane 2000	**6 mils (150 microns)***
Modified siloxane hybrid	Carboxane 2000 Satin	**6 mils (150 microns)***
Modified siloxane hybrid	Carboxane 2100 FC	**6 mils (150 microns)***
Epoxy polyamide	Carboguard 60	**4 mils (105 microns)***

System tested with reduced Dry Film Thicknesses (DFTs) and/or reduced coats per Innovative Coating Technology Clause.

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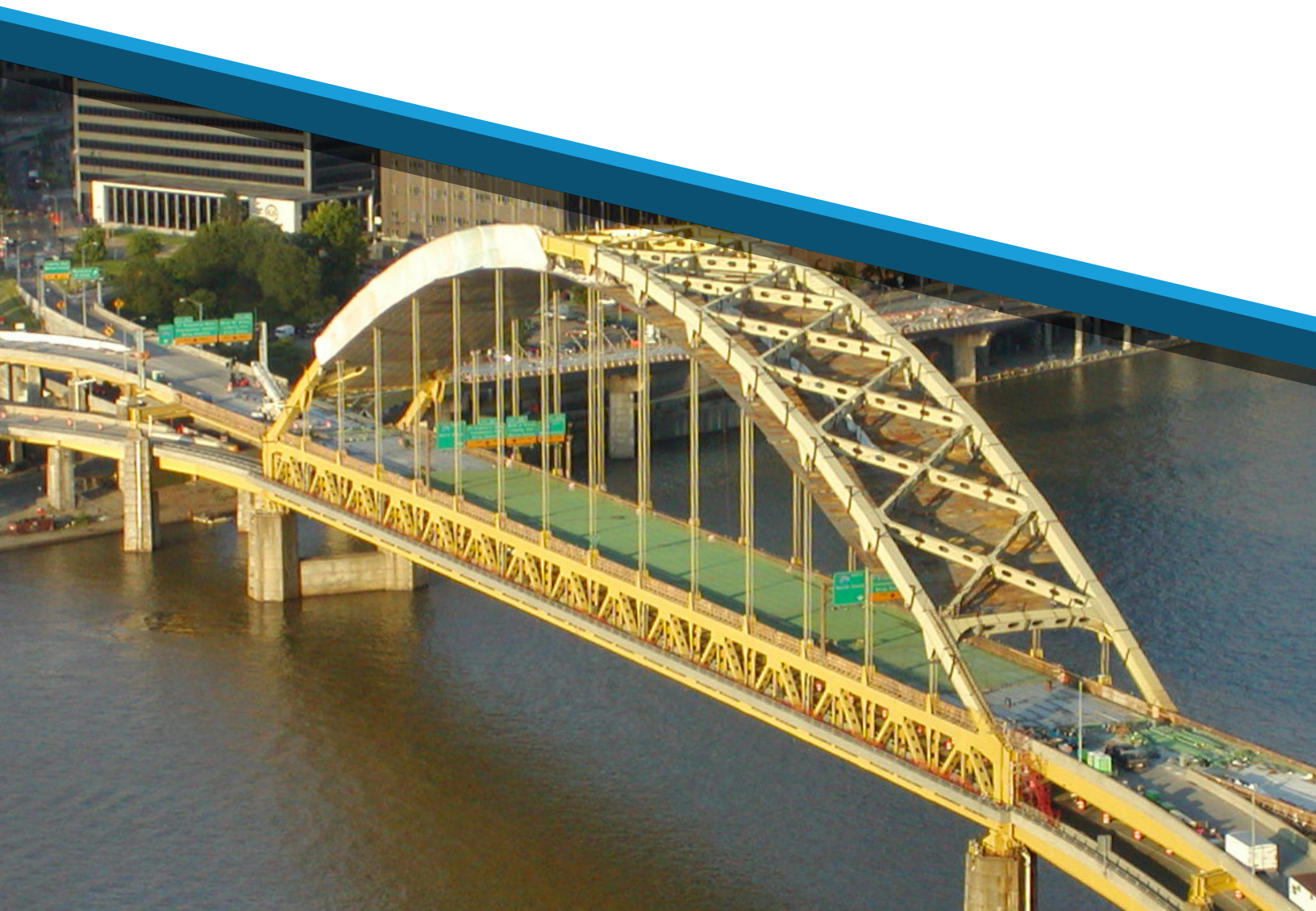
C4 Medium (durability years 7-15):

Industrial areas and coastal areas with moderate salinity

GENERIC TYPE	COATING SYSTEM	TOTAL DFT (MM)
Modified siloxane hybrid	Carboxane 2000	**6 mils (150 microns)***
Modified siloxane hybrid	Carboxane 2000 Satin	**6 mils (150 microns)***
Modified siloxane hybrid	Carboxane 2100 FC	**6 mils (150 microns)***

System tested with reduced Dry Film Thicknesses (DFTs) and/or reduced coats per Innovative Coating Technology Clause.

The durability range is not a "guarantee time." Durability is a technical consideration/planning parameter that was developed by the ISO 12944 Standards Committee that can help the owner set up a maintenance program.



C4 High (durability years 15-25):

Industrial areas and coastal areas with moderate salinity

GENERIC TYPE	COATING SYSTEM	TOTAL DFT (MM)
Zinc-rich epoxy	Carbozinc 859	**12 mils (300 microns)**
Cycloaliphatic amine epoxy	Carboguard 890	
Zinc-rich epoxy	Carbozinc 859 VOC	**11 mils (275 microns)**
Cycloaliphatic amine epoxy	Carboguard 890 LT	
Phenalkamine epoxy	Carboguard 690	**10 mils (250 microns)**
Aliphatic acrylic polyurethane	Carbothane 134 HG	
Aluminum-filled phenalkamine epoxy mastic	Carbomastic 615 AL	**10 mils (250 microns)**
Aliphatic acrylic polyurethane	Carbothane 134 HG	
Zinc-rich epoxy	Carbozinc 858	**9 mils (225 microns)**
Epoxy phenalkamine	Carboguard 635	
Aliphatic acrylic polyurethane	Carbothane 134 HG	
Epoxy polyamide	Carboguard 60	**8 mils (200 microns)**
Epoxy polyamide	Carboguard 60	
Zinc-rich epoxy	Carbozinc 858	**8 mils (200 microns)**
Epoxy polyamide	Carboguard 60	
Aliphatic acrylic polyurethane	Carbothane 134 HG	
Organic zinc-rich epoxy	Carbozinc 859	**8 mils (200 microns)**
Epoxy polyamide with corrosion inhibitor (zinc phosphate)	Carboguard 893 SG	
Reinforced zinc-rich primer	Carbozinc 808	**7 mils (175 microns)***
Cycloaliphatic amine epoxy	Carboguard 890	
Galvanizing	Hot Dip Galvanized (HDG)	**7 mils (175 microns)***
Epoxy phenalkamine	Carboguard 635	
Aliphatic acrylic polyurethane	Carbothane 134 HG	
Epoxy polyamide	Carboguard 60	**6 mils (150 microns)***
Aliphatic acrylic polyurethane	Carbothane 134 HG	
Epoxy amine	Carboguard 904	**6 mils (150 microns)***
Polyamide epoxy	Railplex EE-2020	**6 mils (150 microns)***

System tested with reduced Dry Film Thicknesses (DFTs) and/or reduced coats per Innovative Coating Technology Clause.

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C5 Low (durability years <7):

Industrial areas with high humidity and aggressive atmosphere and coastal areas with high salinity

GENERIC TYPE	COATING SYSTEM	TOTAL DFT (MM)
Flake-reinforced phenalkamine epoxy zinc	Carbozinc 608 HB	**13 mils (325 microns)**
Cycloaliphatic amine epoxy	Carboguard 890	
Flake-reinforced phenalkamine epoxy zinc	Carbozinc 608 HB	**10 mils (250 microns)**
Aliphatic acrylic polyurethane	Carbothane 134 HG	
Zinc-rich epoxy primer	Carbozinc 8701	**10 mils (250 microns)**
Cycloaliphatic amine epoxy	Carboguard 890 LT	
Aliphatic polyurethane	Carbothane 8812	

C5 Medium (durability years 7-15):

Industrial areas with high humidity and aggressive atmosphere and coastal areas with high salinity

GENERIC TYPE	COATING SYSTEM	TOTAL DFT (MM)
Epoxy polyamide	Carboguard 60	**17 mils (425 microns)**
Epoxy polyamide	Carboguard 60	
Inorganic zinc silicate	Carbozinc 11	**11 mils (275 microns)**
Epoxy polyamide	Carboguard 60	
Solvent-based organic zinc-rich epoxy	Carbozinc 858	**11 mils (275 microns)**
Epoxy polyamide	Carboguard 60	
Zinc-rich epoxy primer	Carbozinc 8701	**10 mils (250 microns)**
Cycloaliphatic amine epoxy	Carboguard 890 LT	
Aliphatic polyurethane	Carbothane 8812	
Inorganic copolymer	Thermaline Heat Shield	**9 mils (225 microns)**
Inorganic copolymer	Thermaline Heat Shield	
Zinc-rich epoxy	Carbozinc 8701	**9 mils (225 microns)**
Cross-linked epoxy	Carboguard 8922	
Acrylic aliphatic polyurethane	Carbothane 8815	
Zinc-rich polyurethane	Carbozinc 621 PW	**8 mils (200 microns)**
Modified siloxane hybrid	Carboxane 2000	
Zinc-rich polyurethane	Carbozinc 621 PW	**8 mils (200 microns)**
Modified siloxane hybrid	Carboxane 2100 FC	

System tested with reduced Dry Film Thicknesses (DFTs) and/or reduced coats per Innovative Coating Technology Clause.

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C5 High (durability years 15-25):

Industrial areas with high humidity and aggressive atmosphere and coastal areas with high salinity

GENERIC TYPE	COATING SYSTEM	TOTAL DFT (MM)
Phenalkamine Epoxy	Carbomastic 615	**20 mils (500 microns)**
Phenalkamine Epoxy	Carbomastic 615	
Zinc-Rich Epoxy	Carbozinc 859 VOC	**14 mils (350 microns)**
Cycloaliphatic Amine Epoxy	Carboguard 890 VOC	
Aliphatic Acrylic-Polyester Polyurethane	Carbothane 133 MC	
Aluminum-filled phenalkamine epoxy mastic	Carbomastic 615 AL	**12 mils (300 microns)**
Aliphatic acrylic polyurethane	Carbothane 134 HG	
Epoxy phenalkamine	Carboguard 690	**12 mils (300 microns)**
Aliphatic acrylic polyurethane	Carbothane 134 HG	
Inorganic zinc silicate	Carbozinc 11	**11 mils (275 microns)**
Epoxy polyamide	Carboguard 60	
Aliphatic acrylic polyurethane	Carbothane 134 HG	
Zinc-rich epoxy	Carbozinc 858	**11 mils (275 microns)**
Epoxy polyamide	Carboguard 60	
Aliphatic acrylic polyurethane	Carbothane 134 HG	
Zinc-rich epoxy	Carbozinc 858	**11 mils (275 microns)**
Epoxy phenalkamine	Carboguard 690	
Aliphatic acrylic polyurethane	Carbothane 134 HG	
Zinc-rich epoxy	Carbozinc 858	**11 mils (275 microns)**
Epoxy phenalkamine	Carboguard 635	
Aliphatic acrylic polyurethane	Carbothane 134 HG	
Zinc-rich epoxy	Carbozinc 859	**11 mils (275 microns)**
Aliphastic polyaspartic	Carboquick 201	
Zinc-rich epoxy	Carbozinc 858	**10 mils (250 microns)***
Epoxy phenalkamine	Carboguard 820	
Aliphatic acrylic polyurethane	Carbothane 138	

System tested with reduced Dry Film Thicknesses (DFTs) and/or reduced coats per Innovative Coating Technology Clause.

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C5 High (durability years 15-25):

Industrial areas with high humidity and aggressive atmosphere and coastal areas with high salinity

GENERIC TYPE	COATING SYSTEM	TOTAL DFT (MM)
Two-Component Zinc-Rich Epoxy Primer	Carbozinc 8701	**10 mils (250 microns)***
Cycloaliphatic Amine Epoxy	Carboguard 890 LT	
Two-Component Acrylic Aliphatic Polyurethane	Carbothane 8812	
	Galvanized	**9 mils (225 microns)***
Epoxy phenalkamine	Carboguard 690	
Aliphatic acrylic polyurethane	Carbothane 134 HG	
Inorganic zinc silicate	Carbozinc 11	**9 mils (225 microns)***
Epoxy phenalkamine	Carbothane 820	
Aliphatic acrylic polyurethane	Carbothane 134 HG	
Zinc-rich polyurethane	Carbozinc 621 PW	**8 mils (200 microns)***
Modified siloxane hybrid	Carboxane 2100 FC	
Zinc-rich polyurethane	Carbozinc 621 PW	**8 mils (200 microns)***
Modified siloxane hybrid	Carboxane 2000	
Zinc-rich epoxy	Carbozinc 8701	**8 mils (200 microns)***
Epoxy polyamide	Carboguard 60	
Aliphatic acrylic polyurethane	Carbothane 134 HG	
Inorganic Zinc Silicate	Carbozinc 11	**7 mils (175 microns)***
Inorganic Ethyl Silicate	Armorlast I	
Inorganic Zinc Silicate	Carbozinc 11	**3 mils (75 microns)***

System tested with reduced Dry Film Thicknesses (DFTs) and/or reduced coats per Innovative Coating Technology Clause.

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C5 Very High (durability years 25+):

Industrial areas with high humidity and aggressive atmosphere and coastal areas with high salinity

GENERIC TYPE	COATING SYSTEM	TOTAL DFT (MM)
Zinc-rich epoxy	Carbozinc 11 HS	**10 mils (250 microns)***
Epoxy phenalkamine	Carboguard 820	
Acrylic aliphatic urethane	Carbothane 138	
Zinc-rich epoxy	Carbozinc 11	**9.4 mils (240 microns)***
Epoxy phenalkamine	Carboguard 820	
Acrylic aliphatic urethane	Carbothane 138	
Inorganic zinc silicate	Carbozinc 11 HS	**8 mils (200 microns)***
Epoxy phenalkamine	Carboguard 820	
Acrylic aliphatic urethane	Carbothane 138	
Zinc-rich polyurethane	Carbozinc 621 PW	**8 mils (200 microns)***
Modified siloxane hybrid	Carboxane 2000	
Zinc-rich polyurethane	Carbozinc 621 PW	**8 mils (200 microns)***
Modified siloxane hybrid	Carboxane 2100 FC	

System tested with reduced Dry Film Thicknesses (DFTs) and/or reduced coats per Innovative Coating Technology Clause.

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CX Extreme (durability years 15-25):

Offshore areas with high salinity and industrial areas with extreme humidity and aggressive atmosphere and sub-tropical and tropical atmospheres

GENERIC TYPE	COATING SYSTEM	TOTAL DFT (MM)
Inorganic zinc silicate	Carbozinc 11 HS	**18 mils (450 microns)**
Epoxy polyamide	Carboguard 60	
Acrylic aliphatic urethane	Carbothane 134 HG	
Inorganic zinc silicate	Carbozinc 11 FC	**17 mils (425 microns)**
Epoxy phenalkamine	Carboguard 635	
Acrylic aliphatic urethane	Carbothane 134 HG	
Zinc-rich epoxy	Carbozinc 858	**14 mils (350 microns)**
Epoxy mastic	Carbomastic 15	
Epoxy polyamide	Carboguard 60	
Acrylic epoxy	Carbocrylic 1295 HS	
Inorganic zinc	Carbozinc 11	**13 mils (325 microns)**
Epoxy polyamide	Carboguard 60	
Acrylic aliphatic urethane	Carbothane 134 HG	
Zinc-rich epoxy	Carbozinc 859	**13 mils (325 microns)**
Epoxy polyamide	Carboguard 60	
Acrylic aliphatic urethane	Carbothane 134 HG	
Zinc-rich epoxy	Carbozinc 859	**12 mils (300 microns)***
Epoxy phenalkamine	Carboguard 820	
Acrylic aliphatic urethane	Carbothane 138	
Inorganic zinc silicate	Carbozinc 11	**10 mils (250 microns)***
Epoxy phenalkamine	Carboguard 820	
Acrylic aliphatic urethane	Carbothane 138	
Inorganic zinc silicate	Carbozinc 11 HS	**10 mils (250 microns)**
Epoxy phenalkamine	Carboguard 820	
Acrylic aliphatic urethane	Carbothane 138	

System tested with reduced Dry Film Thicknesses (DFTs) and/or reduced coats per Innovative Coating Technology Clause.

The durability range is not a "guarantee time." Durability is a technical consideration/planning parameter that was developed by the ISO 12944 Standards Committee that can help the owner set up a maintenance program.

Im1 Very High (durability years 25+):

Immersion in fresh water

GENERIC TYPE	COATING SYSTEM	TOTAL DFT (MM)
Cycloaliphatic amine epoxy	Carboguard 890 GF	**18 mils (450 microns)***

System tested with reduced Dry Film Thicknesses (DFTs) and/or reduced coats per Innovative Coating Technology Clause.

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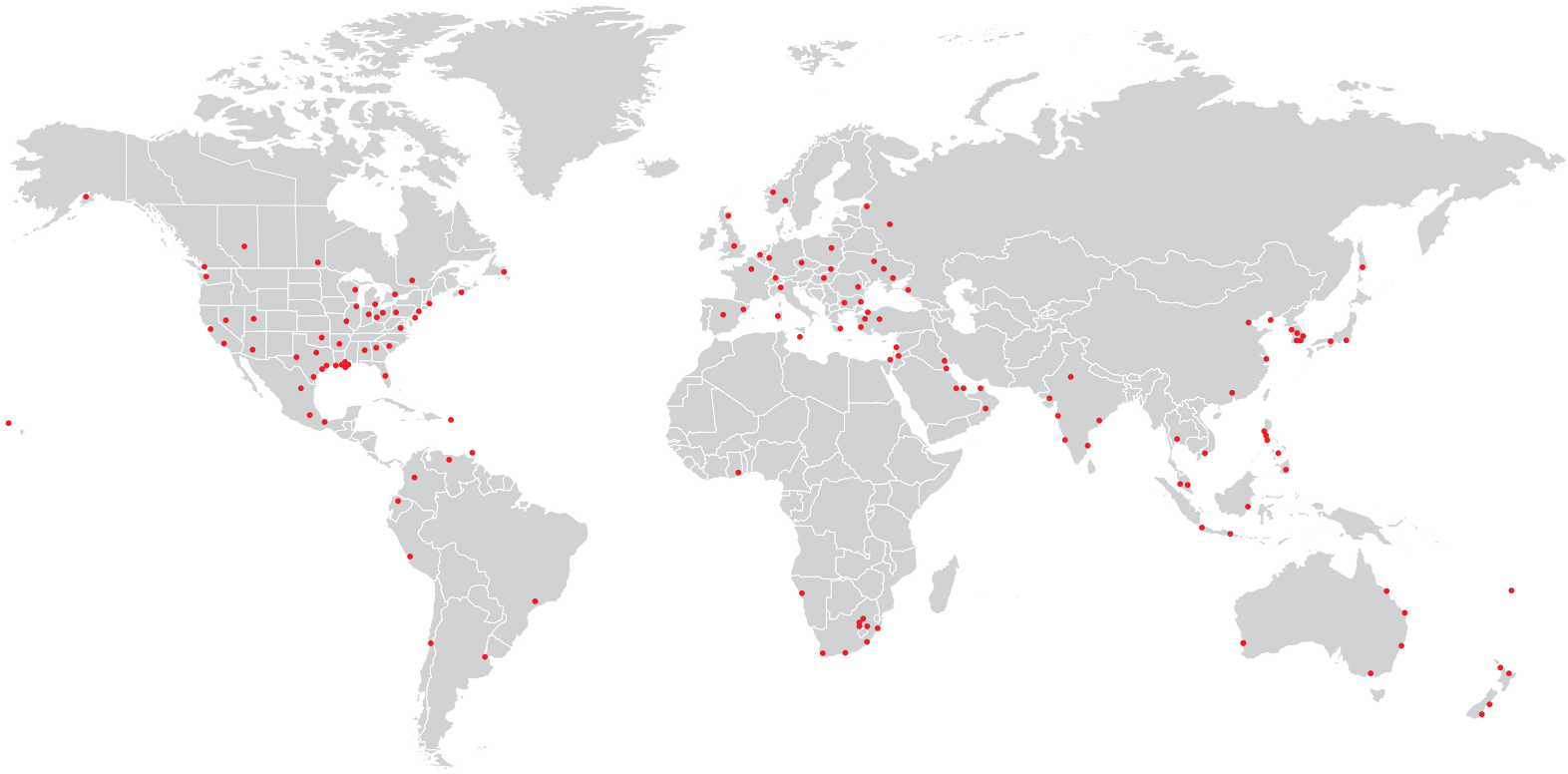

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