

# **CORROSION AND CORROSION PROTECTION**

**ENCYCLOPEDIA OF INTERNATIONAL  
STANDARDS**

by  
Gennady S. FOMIN

## CONTENTS

FOREWORD.....	11
Chapter 1. CORROSION AND ITS IMPACT ON NATIONAL ECONOMIES.....	13
1.1. Optimizing protection from corrosion by standard methods.....	16
1.2. The economic effectiveness of using standards in corrosion protection.....	17
Chapter 2. INTERNATIONAL AND REGIONAL STANDARDIZATION.....	19
2.1. International standardization.....	20
2.2. Regional standardization.....	34
North America.....	34
South America.....	38
Africa.....	38
Asia.....	38
Western Europe.....	38
Eastern Europe.....	41
Chapter 3. MANAGEMENT SYSTEMS.....	53
3.1. Quality management.....	54
3.2. Reliability management.....	55
3.3. Risk management.....	56
3.4. Environmental management.....	57
3.5. Energy management.....	60
3.6. Management of labor safety.....	61
3.7. Social responsibility.....	63
Chapter 4. REQUIREMENTS FOR STANDARDS, TESTING AND LABORATORY.....	65
4.1. Requirements to development of standards.....	66
4.2. Requirements to testing.....	67
4.3. Requirements to laboratories.....	69
Chapter 5. TERMS, CLASSIFICATION AND CODIFICATION.....	71
5.1. Terms and definitions.....	72
5.2. Classification of facilities for protection against corrosion and protective coatings.....	81
Classification of oils and greases.....	81
Classification of temporary protection and conditions of use.....	83
Classification of abrasives for surface preparation prior to coating.....	83
Classification of painting materials and coatings.....	85
Classification of electroplating coatings.....	86
Classification of thermal spray coatings.....	88
5.3. Codification of facilities for protection against corrosion.....	89
Chapter 6. CORROSIVITY OF THE ENVIRONMENT.....	91
6.1. Classification of climatic conditions.....	92
Outdoors temperature and humidity.....	94
Classification of climatic group.....	94

6.2. Classification of the corrosivity of the atmosphere.....	96
Categories of corrosivity of the atmosphere.....	96
Determination of corrosion rate of standard specimens.....	102
Guiding values for the corrosivity categories.....	105
Determination of temperature and humidity.....	106
Determination corrosive agents.....	106
6.3. Classification of corrosivity of indoor atmospheres.....	119
6.4. Classification of atmospheric corrosivity of industrial undertakings.....	122
6.5. Classification of atmospheric corrosivity in building.....	125
6.6. Classification of the corrosivity of waters and soils.....	127
6.7. Classification of the corrosivity of outer space.....	128
6.8. International programs for monitoring atmospheric pollution.....	130
Reporting requirements.....	131
Environmental monitoring system.....	133
Monitoring acid rain.....	134
6.9. The ISOCORRAG international atmospheric exposure program.....	135
6.10. The ICP Materials international co-operative programme on effects on materials.....	141
<b>Chapter 7. GENERAL REQUIREMENTS FOR METHODS OF CORROSION TESTING.....</b>	<b>147</b>
7.1. Testing programme.....	148
7.2. Specimens.....	151
7.3. Conducting the tests.....	153
7.4. Corrosion test site.....	155
7.5. Test chambers.....	162
7.6. Methods of removing corrosion products.....	165
7.7. Test reporting.....	168
<b>Chapter 8. METHODS OF EVALUATING CORROSION RESISTANCE AND PROTECTIVE PROPERTIES.....</b>	<b>171</b>
8.1. Evaluation of uniform corrosion.....	172
8.2. Evaluation of localized corrosion.....	174
Assessment of pitting corrosion.....	174
Method for metallographic examination of corrosion damage.....	176
8.3. Evaluation of protective metallic coatings.....	177
8.4. Evaluation of protective paint coatings.....	183
Assessment types of defect.....	183
Assessment of degree of rusting.....	184
Assessment of degree of cracking.....	185
Assessment of degree of flaking.....	185
Assessment of degree of destruction around a scribe.....	186
Assessment of filiform corrosion.....	187
Assessment protective properties in the marine environment.....	188
Assessment of resistance to cathodic disbonding in the marine environment.....	189
8.5. Corrosion data bases and expert systems.....	190
Requirements for treatment results of corrosion test.....	190

Requirements for the introduction of corrosion data.....	191
Data bases.....	191
Expert systems.....	193
<b>Chapter 9. CORROSION TESTING IN ATMOSPHERIC CONDITIONS.....</b>	<b>195</b>
9.1. General requirements for atmospheric corrosion testing.....	196
9.2. Testing of bimetallic corrosion.....	200
9.3. Testing in industrial atmospheres.....	203
9.4. Testing at high temperatures.....	204
9.5. Testing of thermal resistance.....	207
<b>Chapter 10. CORROSION TESTING IN NATURAL AQUEOUS MEDIA.....</b>	<b>209</b>
10.2. Testing in potable waters.....	214
10.3. Testing in recirculating cooling water systems.....	217
<b>Chapter 11. CORROSION TESTING IN SOILS.....</b>	<b>219</b>
<b>Chapter 12. CORROSION TESTING IN ARTIFICIAL ATMOSPHERE.....</b>	<b>225</b>
12.1. General requirements for testing in artificial atmosphere.....	226
12.2. Testing in moisture atmosphere.....	228
Testing without condensation of moisture.....	228
Testing with condensation of moisture.....	231
12.3. Testing in salt spray.....	233
12.4. Cyclic testing of metals.....	235
Modeling the impact of the atmosphere with salt contamination.....	236
Modeling the impact of acid rain.....	238
Modeling the impact of the industrial atmospheres.....	241
12.5. Cyclic testing of paint coatings.....	243
12.6. Testing in corrosive gas mixture.....	248
Testing in sulfur dioxide.....	248
Testing in hydrogen sulphide.....	250
Testing in gas mixture.....	250
12.7. Testing in corrosive liquids, sediment and melts.....	252
Salt droplet tests.....	252
Corrodote test.....	252
Testing in molten salt.....	253
<b>Chapter 13. CORROSION TESTING WITH IMMERSION IN AN ELECTROLYTE.....</b>	<b>255</b>
13.1. Test with alternating immersion.....	256
13.2. Test with permanent immersion.....	258
<b>Chapter 14. TEST METHODS FOR RESISTANCE TO LOCALIZED CORROSION.....</b>	<b>261</b>
14.1. Tests for intergranular corrosion.....	262
Tests of steel and alloys.....	262
Tests of nickel alloys.....	265
14.2. Stress corrosion cracking tests.....	267
General guidance on testing procedure.....	268

Testing of bent-beam specimens.....	273
Testing of U-bend specimens.....	275
Testing of C-ring specimens.....	277
Testing of pre-cracked specimens.....	277
Testing of specimens to evaluate weldments.....	281
Testing of stainless steel and nickel alloys.....	284
Testing of aluminum alloys.....	284
14.3. Tests for fatigue corrosion.....	286
14.4. Tests for pitting corrosion.....	289
14.5. Tests for exfoliation corrosion.....	290
14.6. Tests for selective corrosion.....	291
14.7. Tests for fretting corrosion.....	292
14.8. Tests for hydrogen embrittlement.....	293
Chapter 15. ELECTROCHEMICAL CORROSION TESTING.....	297
15.1. General requirements for electrochemical corrosion test methods.....	298
15.2. Intergranular corrosion tests.....	300
Testing of stainless steel and alloys.....	300
Testing of aluminum alloys.....	304
15.3. Pitting corrosion tests.....	306
Chapter 16. REQUIREMENTS FOR PROTECTIVE COATINGS.....	309
16.1. Requirements for surface preparation before deposition of coatings.....	310
16.2. Requirements for electrodeposited anodic coatings.....	313
16.3. Requirements for electrodeposited cathodic coatings of non-ferrous metals.....	317
16.4. Requirements for electrodeposited anodic coatings of precious metals.....	323
16.5. Requirements for conversion coatings.....	328
16.6. Requirements for diffusion coatings.....	331
16.7. Requirements for hot-dip coatings.....	334
16.8. Requirements for thermal spray coatings.....	335
16.9. Requirements for anodic oxide coatings.....	341
16.10. Requirements for vitreous enamel coatings.....	343
16.11. Requirements for protective paint coatings.....	344
16.12. Requirements for physical vapour-deposited coatings.....	348
Chapter 17. METHODS FOR INSPECTING OF COATINGS.....	351
17.1. Sample selection and evaluation appearance.....	352
17.2. General requirements for checking thickness.....	354
17.3. Checking coating thickness by non-destructive methods.....	359
17.4. Checking coating thickness by destructive methods.....	366
17.5. Testing for porosity.....	378
Testing of electrodeposited coatings.....	378
Testing of thermal spraying coatings.....	388
17.6. Tests for strength adhesion.....	388
17.7. Checking ductility, internal stresses and microhardness.....	396
17.8. Checking the chemical composition and presence residuals.....	403

17.9. Checking of functional properties.....	405
<b>Chapter 18. METHODS FOR INSPECTION ANODIC OXIDE COATINGS.....</b>	<b>407</b>
18.1. Inspecting of appearance, color and reflective power.....	408
18.2. Checking of sealing.....	411
18.3. Checking of continuity and insulating properties.....	412
18.4. Checking of mechanical properties.....	413
<b>Chapter 19. TEST METHODS FOR VITREOUS ENAMEL COATINGS.....</b>	<b>417</b>
19.1. Methods of specimen preparation.....	418
19.2. Physical methods of testing.....	419
Methods for detecting defects.....	419
Testing for scratch resistance.....	420
Testing for adhesive strength.....	422
Testing for thermal shock.....	423
Testing for self-cleaning.....	424
19.3. Chemical methods of testing.....	424
19.4. Testing for safety.....	431
<b>Chapter 20. TEMPORARY PROTECTION.....</b>	<b>433</b>
20.1. Determination of the protective properties of oils and lubricants.....	435
20.2. Requirements for temporary protective agents.....	436
20.3. Requirements for the selections of the protective agents.....	439
20.4. Methods of determining the effectiveness of a temporary protective.....	442
<b>Chapter 21. PROTECTION BY CORROSION INHIBITORS.....</b>	<b>445</b>
21.1. Testing for inhibitors for protection in atmospheric conditions.....	446
21.2. Testing of acid corrosion inhibitors.....	447
21.3. Testing of inhibitors for water-oil media.....	449
<b>Chapter 22. ELECTROCHEMICAL PROTECTION.....</b>	<b>451</b>
22.1. General principles of cathodic protection.....	453
22.2. Cathodic protection of steel in concrete.....	454
22.3. Cathodic protection for fixed steel offshore structures.....	455
22.4. Cathodic protection for steel offshore floating structures.....	457
22.5. Cathodic protection for ships.....	459
22.6. Cathodic protection for harbour installations.....	460
<b>Chapter 23. PROTECTION FROM MICROBE CORROSION AND BIODEGRADATION.....</b>	<b>463</b>
Checking of bio persistence.....	465
Protection of structures from fouling.....	465
<b>Chapter 24. PROTECTION FROM CORROSION AT DESIGN STAGE.....</b>	<b>467</b>
24.1. Guidelines for selection of protection methods against atmospheric corrosion.....	471
Requirements for the selection of contacts between metals and non-metals.....	471
Requirements for designing products for coating.....	473

Requirements for the selection of metals and alloys without coatings.....	477
Methods for surface finishing stainless steel.....	478
24.2. Methods for assessing the corrosion condition of an article or structure.....	478
<b>Chapter 25. NATIONALLY IMPORTANT EXAMPLES OF CORROSION BEHAVIOR.....</b>	<b>481</b>
25.1. Corrosion protection in the nuclear industry.....	482
Testing of zirconium alloys in water.....	483
Testing of steel and alloys for nuclear industry.....	484
25.2. Corrosion protection in buildings.....	484
25.3. Corrosion protection in medicine.....	491
Testing of dental materials.....	492
Testing of implants for surgery.....	493
25.4. Corrosion protection in the oil industry.....	494
Requirements for the selection of metals and alloys.....	497
Requirements for protective paint coatings.....	505
25.5. Corrosion protection of pipelines.....	514
Requirements for cathodic protection.....	514
Requirements for external protective coatings.....	519
Requirements for internal protective coatings.....	523
<b>ANNEXES.....</b>	<b>527</b>
<b>Annex 1. LIST OF INTERNATIONAL STANDARDS.....</b>	<b>531</b>
Standards of the International organization for standardization (ISO).....	531
Standards of the International Electrotechnical Commission (IEC).....	580
<b>Annex 2. LIST OF AMERICAN STANDARDS.....</b>	<b>587</b>
Standards of the ASTM International.....	587
Standards and guidelines of the NACE International.....	612
<b>Annex 3. LIST OF EUROPEAN STANDARDS.....</b>	<b>625</b>
Standards of the European committee for standardization (CEN).....	625
Publication of the European federation of corrosion series (EFC).....	644
Standards of the Council for mutual economic assistance (CMEA).....	648
<b>Annex 4. LIST OF RUSSIAN STANDARDS.....</b>	<b>657</b>
Standards of the United system of corrosion and ageing protection (USCAP).....	657
Other Russian national standards on corrosion and corrosion protection..	671
<b>Annex 5. CONCORDANCE OF STANDARDS.....</b>	<b>677</b>
<b>BIBLIOGRAPHY.....</b>	<b>689</b>
<b>CONTENTS.....</b>	<b>704</b>
<b>SUMMARY.....</b>	<b>710</b>