

ASME PCC-2–2022
(Revision of ASME PCC-2–2018)

Repair of Pressure Equipment and Piping

AN AMERICAN NATIONAL STANDARD



ASME PCC-2-2022
(Revision of ASME PCC-2-2018)

Repair of Pressure Equipment and Piping

AN AMERICAN NATIONAL STANDARD



**The American Society of
Mechanical Engineers**

Two Park Avenue • New York, NY • 10016 USA

Date of Issuance: September 2, 2022

The next edition of this Standard is scheduled for publication in 2026.

ASME issues written replies to inquiries concerning interpretations of technical aspects of this Standard. Interpretations are published on the Committee web page and under <http://go.asme.org/InterpsDatabase>. Periodically certain actions of the ASME PCC Committee may be published as Cases. Cases are published on the ASME website under the PCC Committee Page at <http://go.asme.org/PCCcommittee> as they are issued.

Errata to codes and standards may be posted on the ASME website under the Committee Pages to provide corrections to incorrectly published items, or to correct typographical or grammatical errors in codes and standards. Such errata shall be used on the date posted.

The PCC Committee Page can be found at <http://go.asme.org/PCCcommittee>. There is an option available to automatically receive an e-mail notification when errata are posted to a particular code or standard. This option can be found on the appropriate Committee Page after selecting "Errata" in the "Publication Information" section.

ASME is the registered trademark of The American Society of Mechanical Engineers.

This code or standard was developed under procedures accredited as meeting the criteria for American National Standards. The standards committee that approved the code or standard was balanced to ensure that individuals from competent and concerned interests had an opportunity to participate. The proposed code or standard was made available for public review and comment, which provided an opportunity for additional public input from industry, academia, regulatory agencies, and the public-at-large.

ASME does not "approve," "rate," or "endorse" any item, construction, proprietary device, or activity. ASME does not take any position with respect to the validity of any patent rights asserted in connection with any items mentioned in this document, and does not undertake to insure anyone utilizing a standard against liability for infringement of any applicable letters patent, nor does ASME assume any such liability. Users of a code or standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, is entirely their own responsibility.

Participation by federal agency representatives or persons affiliated with industry is not to be interpreted as government or industry endorsement of this code or standard.

ASME accepts responsibility for only those interpretations of this document issued in accordance with the established ASME procedures and policies, which precludes the issuance of interpretations by individuals.

No part of this document may be reproduced in any form,
in an electronic retrieval system or otherwise,
without the prior written permission of the publisher.

The American Society of Mechanical Engineers
Two Park Avenue, New York, NY 10016-5990

Copyright © 2022 by
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
All rights reserved
Printed in U.S.A.

CONTENTS

Foreword		xvi
Committee Roster		xvii
Correspondence With the PCC Committee		xix
Summary of Changes		xxi
Part 1	Scope, Organization, and Intent	1
Article 101	Introduction	1
101-1	Scope	1
101-2	Organization	1
101-3	Intent	1
Part 2	Welded Repairs	4
Article 201	Butt-Welded Insert Plates in Pressure Components	4
201-1	Description	4
201-2	Limitations	4
201-3	Design	5
201-4	Fabrication	7
201-5	Examination of Welds	9
201-6	Pressure Testing	9
Article 202	External Weld Buildup to Repair Internal Thinning	11
202-1	Description	11
202-2	Limitations	11
202-3	Design	11
202-4	Fabrication	14
202-5	Examination	15
202-6	Testing	16
202-7	References	16
Article 203	Seal-Welded Threaded Connections and Seal Weld Repairs	17
203-1	Description	17
203-2	Limitations	17
203-3	Design	18
203-4	Fabrication	18
203-5	Examination	18
203-6	Testing	18
203-7	References	19
Article 204	Welded Leak Box Repair	20
204-1	Description	20
204-2	Limitations	20
204-3	Design	21
204-4	Fabrication	22

204-5	Examination	23
204-6	Testing	23
Article 205	Weld Ring Gaskets (Welded Lip Seals)	24
205-1	Description	24
205-2	Limitations	24
205-3	Design	24
205-4	Fabrication	26
205-5	NDE Examinations	28
205-6	Testing	28
205-7	References	28
Article 206	Full Encirclement Steel Reinforcing Sleeves for Piping	30
206-1	Description	30
206-2	Cautions and Limitations	30
206-3	Design	31
206-4	Fabrication	33
206-6	Testing	35
206-7	References	36
Article 207	Fillet Welded Patches With Reinforcing Plug Welds	37
207-1	Description	37
207-2	Limitations	37
207-3	Design	37
207-4	Fabrication	41
207-5	Examination	42
207-6	Testing	42
207-7	References	42
Article 208	Alternatives to Traditional Welding Preheat	43
208-1	Description	43
208-2	Limitations	43
208-3	Design	43
208-4	Fabrication	45
208-5	Examination	46
208-6	Testing	47
208-7	References	47
Article 209	Alternatives to Postweld Heat Treatment	49
209-1	Description	49
209-2	Limitations	49
209-3	Design	50
209-4	Fabrication	50
209-5	Examination	50
209-6	Testing	51
209-7	References	51
Article 210	In-Service Welding Onto Carbon Steel Pressure Components or Pipelines	52
210-1	Description	52
210-2	Limitations	53

210-3	Design	53
210-4	Fabrication	54
210-5	Examination	58
210-6	Testing	58
210-7	References	58
Mandatory Appendix 210-I	In-Service Welding Procedure/Welder Performance Qualification Setup	62
Article 211	Weld Buildup, Weld Overlay, and Clad Restoration	64
211-1	Description	64
211-2	Limitations	64
211-3	Design	64
211-4	Fabrication	65
211-5	Examination	67
211-6	Testing	67
211-7	References	68
Article 212	Fillet Welded Patches	70
212-1	Description	70
212-2	Limitations	70
212-3	Design	70
212-4	Fabrication	73
212-5	Examination	74
212-6	Testing	74
212-7	References	74
Article 213	Threaded or Welded Plug Repairs	76
213-1	Description	76
213-2	Limitations	76
213-3	Design	76
213-4	Fabrication	76
213-5	Examination	77
213-6	Testing	77
213-7	References	77
Article 214	Field Heat Treating of Vessels	79
214-1	Description	79
214-2	Limitations	79
214-3	Design	79
214-4	Fabrication	82
214-5	Examination	83
214-6	Testing	83
214-7	References	84
Mandatory Appendix 214-I	Developing a Heat Treatment Procedure	85
Mandatory Appendix 214-II	Typical Hot Box Design	86
Article 215	Repair Welding Considerations for Cr-Mo Steel Pressure Vessels .	88
215-1	Description	88
215-2	Limitations	88
215-3	Design	88

215-4	Fabrication	89
215-5	Examination	89
215-6	Pressure Testing	90
215-7	References	90
Article 216	Welded Hot Taps in Pressure Equipment or Pipelines	99
216-1	Description	99
216-2	Limitations	100
216-3	Design	101
216-4	Fabrication	105
216-5	Examination	106
216-6	Pressure Testing	107
216-7	References	108
Nonmandatory Appendix 216-A	Glossary of Acronyms	110
Article 217	Seal Welding of Leaking Water Systems	111
217-1	Description	111
217-2	Limitations	111
217-3	Design	111
217-4	Fabrication	111
217-5	Examination of the Seal Weld	112
217-6	Pressure Testing	112
217-7	References	112
Part 3	Mechanical Repairs	113
Article 301	Replacement of Pressure Components	113
301-1	Description	113
301-2	Limitations	113
301-3	Design	113
301-4	Fabrication	113
301-5	Examination	114
301-6	Testing	114
301-7	References	114
Article 302	Freeze Plugs	115
302-1	Description	115
302-2	Limitations	115
302-3	Design	116
302-4	Fabrication	117
302-5	Examination	119
302-6	Testing	120
Article 303	Damaged Threads in Tapped Holes	121
303-1	Description	121
303-2	Limitations	121
303-3	Design	122
303-4	Fabrication	122
303-5	Examination	123
303-6	Testing	123
303-7	References	123

Mandatory Appendix 303-I	Recommended Detail for Stud Threads Modification to Prevent Damage to Threads in Tapped Holes	125
Mandatory Appendix 303-II	An Illustrative Example Showing an Engineering Analysis Associated With Enlarging a Tapped Hole	129
303-II-1	Example 1	129
303-II-2	Example 2	132
Article 304	Flaw Excavation and Weld Repair	133
304-1	Description	133
304-2	Limitations	133
304-3	Design	134
304-4	Fabrication	135
304-5	Examination	136
304-6	Testing	136
304-7	References	136
Mandatory Appendix 304-I	Metal Removal Process	137
304-I-1	Flapping	137
304-I-2	Grinding	137
304-I-3	Honing	137
304-I-4	Lapping	137
304-I-5	Machining	137
304-I-6	Thermal Gouging	138
304-I-7	Boat Sample Cutting	138
Article 305	Flange Repair and Conversion	140
305-1	Description	140
305-2	Limitations	140
305-3	Design	140
305-4	Fabrication	141
305-5	Examination	142
305-6	Testing	142
305-7	References	142
Article 306	Mechanical Clamp Repair	143
306-1	Description	143
306-2	Limitations	143
306-3	Design	144
306-4	Fabrication	146
306-5	Examination	146
306-6	Testing	146
306-7	References	146
Article 307	Pipe Straightening or Alignment Bending	147
307-1	Description	147
307-2	Limitations	147
307-3	Design	147
307-4	Fabrication	148
307-5	Examination	148
307-6	Testing	149
307-7	Reference	149

Article 308	Damaged Anchors in Concrete (Postinstalled Mechanical Anchors)	150
308-1	Description	150
308-2	Limitations	151
308-3	Design	151
308-4	Fabrication	152
308-5	Examination	156
308-6	Testing	157
308-7	References	157
Mandatory Appendix 308-I	Anchors Installation Using Chemical Means (Adhesive)	158
308-I-1	Adhesive Anchors	158
Article 309	Valves With Pressure Seal-Type Bonnets	159
Article 310	Hot Bolting	160
Article 311	Hot and Half Bolting Removal Procedures	161
311-1	Description	161
311-2	Limitations	161
311-3	Design	162
311-4	Fabrication	163
311-5	Examination	164
311-6	Testing	164
311-7	References	164
Article 312	Inspection and Repair of Shell and Tube Heat Exchangers	165
312-1	Description	165
312-2	Limitations	165
312-3	Design	165
312-4	Fabrication	167
312-5	Examination	171
312-6	Testing	172
312-7	References	172
Mandatory Appendix 312-I	Methods for Determining Minimum Number of Tubes to Inspect	174
312-I-1	Introduction	174
Mandatory Appendix 312-II	Examination of Pressure Containment Components	177
312-II-1	Examination	177
312-II-2	Inspection	177
312-II-3	Suitability	177
Article 313	Crimping of Metallic Pipe	178
313-1	Description	178
313-2	Limitations	178
313-3	Design	178
313-4	Fabrication	179
313-5	Examination	182
313-6	Testing	182
313-7	References	182
Part 4	Nonmetallic and Bonded Repairs	183
Article 401	Nonmetallic Composite Repair Systems: High-Risk Applications	183
401-1	Description	183

401-2	Limitations	184
401-3	Design	184
401-4	Fabrication (Installation)	193
401-5	Examination	195
401-6	System Pressure Testing	196
401-7	References	196
Mandatory Appendix 401-I	Design Data Sheet	201
Mandatory Appendix 401-II	Qualification Data for the Repair System	204
Mandatory Appendix 401-III	Short-Term Pipe Spool Survival Test	205
Mandatory Appendix 401-IV	Measurement of γ for Leaking Defect Calculation	206
Mandatory Appendix 401-V	Measurement of Performance Test Data	207
Mandatory Appendix 401-VI	Measurement of Impact Performance	208
Mandatory Appendix 401-VII	Installer Qualification	209
401-VII-1	Introduction	209
401-VII-2	Training	209
401-VII-3	Training Records	209
401-VII-4	Requalification	210
Mandatory Appendix 401-VIII	Installation	211
401-VIII-1	Introduction	211
401-VIII-2	Surface Preparation	211
401-VIII-3	Laminate Lay-Up	211
401-VIII-4	Cure	211
401-VIII-5	Documentation	211
Nonmandatory Appendix 401-A	Glossary of Terms and Acronyms	213
401-A-1	Glossary of Terms	213
401-A-2	Glossary of Acronyms	214
Nonmandatory Appendix 401-B	Recommended Retesting for a Modified Qualified Repair System	215
Article 402	Nonmetallic Composite Repair Systems: Low-Risk Applications	216
402-1	Description	216
402-2	Limitations	217
402-3	Design	217
402-4	Fabrication (Installation)	219
402-5	Examination	220
402-6	System Pressure Testing	220
402-7	References	222
Mandatory Appendix 402-I	Repair Data Sheet	224
Mandatory Appendix 402-II	Qualification Data for Repair System	226
Mandatory Appendix 402-III	Validation for Repair of Leaking Component	227
Mandatory Appendix 402-IV	Installer Qualification	228
402-IV-1	Introduction	228
402-IV-2	Training	228
402-IV-3	Training Records	228
402-IV-4	Qualification Period	228
Mandatory Appendix 402-V	Installation	229
402-V-1	Introduction	229

402-V-2	Surface Preparation	229
402-V-3	Laminate Lay-Up	229
402-V-4	Cure	229
402-V-5	Documentation	229
Nonmandatory Appendix 402-A	Glossary of Terms and Acronyms	231
402-A-1	Glossary of Terms	231
402-A-2	Glossary of Acronyms	232
Article 403	Nonmetallic Internal Lining for Pipe: Sprayed Form for Buried Pipe	233
403-1	Description	233
403-2	Cautions and Limitations	233
403-3	Design	234
403-4	Fabrication (Installation)	236
403-5	Examination	237
403-6	Testing	238
403-7	References	238
Mandatory Appendix 403-I	Design Considerations for Buried Pipe	241
403-I-1	Wall Thickness of Cipp	241
403-I-2	Design Equations	241
403-I-3	Applied Loads Design	242
Mandatory Appendix 403-II	Inspection/Examination and Corrective Action Requirements for CIPP	243
403-II-1	General	243
403-II-2	Polymer Mixture	243
403-II-3	Polymer Thickness Sampling	243
403-II-4	Polymer Hardness	243
403-II-5	Polymer Coverage	243
403-II-6	Surface Defect Corrective Actions	243
403-II-7	Corrective Action for Areas of Insufficient Curing	244
Mandatory Appendix 403-III	Glossary of Terms and Acronyms	245
403-III-1	Glossary of Terms	245
403-III-2	Glossary of Acronyms	245
Article 404	Nonmetallic Internal Lining for Pipe: High-Risk Buried Pipe	246
Article 405	Qualification of Nonmetallic Composite Repair Systems	247
405-1	Description	247
405-2	Limitations	247
405-3	Design	247
405-4	Fabrication (Installation)	251
405-5	Examination	251
405-6	System Pressure Testing	251
405-7	References	251
Mandatory Appendix 405-I	Qualification Data Sheet	253
405-I-1	Repair System Details	253
405-I-2	Test Data	253
Mandatory Appendix 405-II	Basic Qualification Testing	255
405-II-1	Introduction	255

405-II-2	Data for Repair Laminate	255
405-II-3	Data for Repair/substrate Interface	255
Mandatory Appendix 405-III	Short-Term Pipe Spool Survival Test	257
405-III-1	Introduction	257
405-III-2	Method	257
405-III-3	Report	258
Mandatory Appendix 405-IV	Measurement of γ for Leaking Defect Calculation	259
405-IV-4	Report	260
Mandatory Appendix 405-V	Measurement of Performance Test Data	261
405-V-1	Introduction	261
405-V-2	Methods	261
405-V-3	Report	262
Mandatory Appendix 405-VI	Measurement of Impact Performance	263
405-VI-1	Introduction	263
405-VI-2	Methods	263
405-VI-3	Report	263
Mandatory Appendix 405-VII	Validation for Repair Technique of Leaking Component	264
405-VII-1	Introduction	264
405-VII-2	Method	264
405-VII-3	Report	264
Nonmandatory Appendix 405-A	Glossary of Terms and Acronyms	265
405-A-1	Glossary of Terms	265
405-A-2	Glossary of Acronyms	266
Nonmandatory Appendix 405-B	Retesting Requirements for a Modified Qualified Repair System	267
405-B-1	General	267
405-B-2	Modified Repair System	267
405-B-3	Engineering Judgment	267
Part 5	Examination and Testing	270
Article 501	Pressure and Tightness Testing of Piping and Equipment	270
501-1	Description	270
501-2	Limitations	270
501-3	Design	270
501-4	Fabrication	271
501-5	Examination	271
501-6	Testing	273
501-7	References	278
Mandatory Appendix 501-I	Pressure/Leak Testing	279
Mandatory Appendix 501-II	Stored Energy Calculations for Pneumatic Pressure Test	281
501-II-1	General	281
Mandatory Appendix 501-III	Safe Distance Calculations for Pneumatic Pressure Test	282
501-III-1	Blast Wave Distance	282
501-III-2	Fragment Throw Distance	282
Mandatory Appendix 501-IV	Risk Evaluation Considerations for Pneumatic Pressure Test	284
501-IV-1	Introduction	284
501-IV-2	Pneumatic Test Risk Considerations	284

501-IV-3	Piping System Volume Considerations	284
Article 502	Nondestructive Examination in Lieu of Pressure Testing for Repairs and Alterations	286
502-1	Description	286
502-2	Limitations	287
502-3	Design	287
502-4	Fabrication (Repair or Alteration)	287
502-5	Examination — Nondestructive Examination (NDE)	287
502-6	Testing	288
502-7	References	288
Mandatory Appendix 502-1	Comparison of Selected NDE Methods	289
Article 503	Test Devices for Localized Pressure or Tightness Testing of Welded Repairs	292
503-1	Description	292
503-2	Limitations	292
503-3	Design	293
503-4	Fabrication	295
503-5	Examination	297
503-6	Testing	297
503-7	References	298
 Figures		
201-3.5-1	Flush Insert in Pipe or Tube	6
201-3.8-1	Flush Insert Plate (With or Without Nozzle/Manway) With Its Butt Weld Intersecting Existing Butt Weld in Shells or Heads	6
201-3.8-2	Intersecting “Doghouse” Type Insert Plate Butt Weld (With or Without Nozzle/Manway) With Shell Butt Weld in Vessel Shells and Heads	7
202-3-1	Weld Buildup Profile	12
204-1-1	Example of a Welded Leak Box Repair of a Tee	20
205-1-1	Membrane Weld Ring Gaskets	24
205-1-2	Weld Ring Gaskets	24
205-1-3	Hollow-Lip Weld Ring Gaskets	25
205-4.3-1	Centering Pin Arrangement	26
205-4.3-2	Clamped Lip Seal	27
205-4.3-3	Assembled Lip Seal	27
206-1.1.1-1	Type A Sleeve	31
206-1.1.2-1	Type B Sleeve	32
206-2.7-1	Welded Split Sleeve for Use Over a Girth Weld	33
206-3.5-1	Type B Sleeve Fillet Weld Size for Sleeve Thickness Less Than or Equal to 1.4 Times the Carrier Pipe Thickness	34
206-3.5-2	Type B Sleeve Fillet Weld Size for Sleeve Thickness Greater Than 1.4 Times the Carrier Pipe Thickness	34
207-1-1	Typical Shell Repair Near Discontinuity	38
208-3.1-1	Typical Residual Stresses in a Weld	44
208-3.1-2	Effect of Weld Area on Transverse Shrinkage	44
208-4.2-1	Typical Back Stepping Weld Sequence	46

208-4.2-2	Difference Between Oscillated Stringer Beads (Left) and Wide Weave Beads (Right)	46
208-4.4-1	Effect of Weld Bead Cross Section on Cracking	47
210-4.2.1.2-1	Heat-Affected Zone Hardness Indent Locations	56
210-4.2.1.4-1	Mandrel Location Relative to the Weld Toe When Doing Face Bend Test for a Typical In-Service Fillet Weld	57
210-4.2.1.4-2	Examples of In-Service Welding Procedure Qualification Face Bend Test Samples	57
210-4.2.2-1	Test Sample Locations for In-Service Fillet Welding Procedure Qualification Assuming Equal Spacing Around the Circumference to Obtain All the Required Test Specimens	59
210-4.2.2-2	Test Sample Locations for In-Service Attachment Welding Procedure Qualification Assuming Equal Spacing Around the Circumference to Obtain All the Required Test Specimens	60
210-4.2.2-3	Test Sample Locations for In-Service Weld Metal Buildup Welding Procedure Qualification	61
210-I-1	Procedure and Welder Qualification Test Assembly for an In-Service Fillet Weld	62
210-I-2	Procedure and Welder Qualification Test Assembly for an In-Service Attachment Weld	63
211-4.4.1-1	Weld Seam With Back Cladding	66
212-1-1	Typical Shell Repair Near Discontinuity	71
213-3.1-1	Typical Plug Arrangement	78
214-II-1	Typical Hot Box Design	87
215-3.1-1	Standard Steps in Repair Welding	93
215-3.3-1	Examples of Damage Common to Cr–Mo Pressure Vessels	95
215-3.4-1	Flowchart for the Selection of Repair Welding Methods	96
216-1.2-1	Typical Hot Tapping Setup	100
302-3.6.3-1	Nitrogen Freeze Plug Assembly	118
303-3.3.3-1	Example of Tapered Stud	123
303-I-1	Inch Thread Series (U.S. Customary Units)	126
303-I-2	Inch Thread Series (SI Units)	127
303-I-3	Metric Thread Series (SI Units)	128
304-3.1-1	Excavation and Weld Repair of Surface Flaw	134
304-3.1-2	Excavation and Weld Repair of Embedded Flaw	134
304-3.1-3	Grinding of Weld Flaw	135
304-I-7-1	Boat Sample	139
305-4.5.2-1	Flange Dimensions	142
306-1-1	Example of a Mechanical Clamp	143
306-1-2	Square Mechanical Clamp Over Drain Branch, With Sealant Injection Nozzle	144
308-1.3-1	Anchors	151
308-1.5-1	Anchor and Concrete Failure	151
308-1.7-1	Column Base Anchors in Concrete	152
308-4.1-1	Weld Repair of Existing Rod	153
308-4.3.1-1	Wedge Anchor	155
308-4.3.2-1	Sleeve Anchor	155

308-4.5.1.1-1	Relocation of One or Two Anchors Within an Arc ($r = \frac{1}{2}d$)	155
308-4.5.1.1-2	Relocation of One or Two Anchors Within an Arc ($r = d$)	156
308-4.6.1-1	Relocation of One or Two Anchors Within a Design Plate Assembly . . .	156
308-4.6.2-1	Relocation of More Than Two Anchors Within a Design Plate Assembly	156
308-4.6.3-1	Using an Enlarged Plate	157
312-4.2-1	Typical Friction Fit Tapered Tube Plug	168
312-4.2-2	Typical Mechanical Fit Tube Plugs	169
312-4.2-3	Typical Installation of Mechanical Fit Tube Plugs	169
312-4.2-4	Sample Chart: Number of Tube Failures by Month	170
313-4.1-1	Crimp Block on Pipe	180
313-4.1-2	Crimp With Injection Arrangement	181
313-4.1-3	Crimp Clamp in Position (Right) and Sealant Injection Box (Left)	181
401-5.1-1	Schematic of a Repair System and Location of Defects	196
403-1.1-1	Structural Liner in Raw Water System	234
405-II-2-1	Test Specimen Geometry	256
405-III-2-1	Defect Dimensions	257
501-3.3-1	Test Type Selection	272
501-IV-3-1	A Schematic Diagram of a Pipeline Burst, Showing the Flow of Gas Within the Pipes	285
503-1.1.2-1	Hydrotest Device Types for Piping or Nozzles	293
503-1.1.3-1	Hydrotest Device Types for Nozzles or Branch Connections	294
503-4-1	Hydrotest Device Seal Location	296
503-4.1-1	Type I Hydrotest Device With Lanyard	297
503-4.1-2	Type I Hydrotest Device Without Lanyard	297
503-4.1-3	Type I Typical Installations	298
503-4.2-1	Location of Split Ring Flange	299
503-4.4-1	Type IV Device	299
 Tables		
208-3.3-1	Comparison of Specification and Actual Weld Metal Properties	45
209-4.1-1	Summary of Postweld Heat Treatment Requirements and Potential Alternatives	50
210-4.2.1-1	Type and Number of Test Specimens Required for an In-Service Welding Procedure Qualification	55
215-1.2-1	Cr–Mo Steels Applicable to This Article	92
215-3.2-1	Typical In-Service Degradation	94
215-3.2-2	Typical Considerations for Weld Repair of In-Service Degradation	94
215-3.5-1	Repair Methods Applicable to Cr–Mo Vessels	96
215-4.1-1	Repair Approach Sequence	97
215-4.4-1	Typical Preheat and Interpass Temperatures	97
215-4.5-1	De-Embrittlement Heat Treatment	98
308-4.3-1	Minimum Edge Distance for Punched, Reamed, or Drilled Holes	154
308-4.3-2	Expansion Anchor — Illustrative Example of Typical Minimum Limits for Reference	154
312-I-1.3-1	Inspection Effectiveness Table	175
401-3.2-1	Repair System Required Material and Performance Properties	186

401-3.4.2-1	Service Temperature Limits for Repair Systems	189
401-3.4.4-1	Allowable (Long-Term) Strains for Repair Laminates (No Allowance for Temperature Effects)	190
401-3.4.5-1	Service Factors for Repair Laminates	191
401-4.6-1	Hold Points During Installation	195
401-5.2-1	Defect Type and Allowable Limits for the Composite Wrap	197
402-3.2-1	Repair System Required Material and Performance Properties	218
402-4.4-1	Hold Points During Installation	220
402-5.2-1	Defect Type and Allowable Limits for the Composite Repair	221
405-3.3-1	Repair System Required Material and Performance Properties	249
405-IV-3-1	Student's t_v Value for Double-Sided 0.025 Level of Significance	260
405-B-1-1	Recommended Testing for Requalification of a Modified Qualified Repair System	268
501-III-1-1	Alternative Values for R_{scaled}	282
501-III-2-1	Minimum Distances for Fragment Throw Considerations	283
502-I-1	Comparison of Selected NDE Methods	290
503-3-1	Device Type Selection Guidance	295
 Forms		
	Component Repair Data Sheet	202
	Repair Data Sheet	225
	Test Data	254
	Test Record	280