Volume 1

CONTENTS

Dedication to the First Edition
Robert E. Nickell and William E. Cooper ................. iii

Acknowledgements (to the First Edition) .............. v

Acknowledgements (to the Second Edition) .......... v

Acknowledgements (to the Third Edition) .......... vi

Acknowledgements (to the Fourth Edition) ....... vii

Contributor Biographies ......................... ix

Preface to the First Edition
K. R. Rao and Robert E. Nickell ................. xxxix

Preface to the Second Edition
K. R. Rao ..................................................... xl

Preface to the Third Edition
K. R. Rao ..................................................... xli

Preface to the Fourth Edition
K. R. Rao ..................................................... xlii

Introduction ............................................... xlv

Organization and Operation of the ASME
Boiler and Pressure Vessel Committee ............. lix

PART 1: POWER BOILERS—SECTIONS I & VII
OF B&PV CODE

CHAPTER 1 Introduction to Power Boilers
John R. MacKay ............................................. 1-1

1.1 Introduction ........................................... 1-1
1.2 History and Philosophy of Section I ......... 1-1
1.3 The Organization of Section I ................. 1-3
1.4 Scope of Section I: Pressure Limits and
Exclusions ................................................. 1-7
1.5 Distinction Between Boiler Proper Piping
and Boiler External Piping ......................... 1-12

1.6 How and Where Section I is Enforced and
Effective Dates .......................................... 1-12
1.7 Fundamentals of Section I Construction .... 1-15
1.8 References ............................................. 1-32
1.9 Design Exercises ..................................... 1-32

CHAPTER 2 Section VII—Recommended
Guidelines for the Care of Power Boilers
James T. Pillow, Edmund W. K. Chang and
Geoffrey M. Halley ........................................... 2-1

2.1 Introduction - Chapter 2 ......................... 2-1
2.2 Introduction - Section VII ................. 2-1
2.3 Fundamentals—Subsection C1 ............... 2-3
2.4 Boiler Operation—Subsection C2 ......... 2-7
2.5 Boiler Auxiliaries—Subsection C3 ....... 2-13
2.6 Appurtenances—Subsection C4 ........ 2-15
2.7 Instrumentation, Controls, and Interlocks—
Subsection C5 ............................................. 2-21
2.8 Inspection—Subsection C6 ................. 2-22
2.9 Repairs, Alterations, and Maintenance—
Subsection C7 ............................................. 2-24
2.10 Control of Internal Chemical Conditions—
Subsection C8 ............................................. 2-25
2.11 Preventing Boiler Failures—Subsection C9 .. 2-28
2.12 Final Notes ............................................. 2-29
2.13 References ............................................. 2-29

PART 2: SECTION II OF B&PV CODE

CHAPTER 3 PART 2, Section II—Materials and
Specifications
Elmar Upitis, Richard A. Moen, Marvin L. Carpenter,
John F. Grubb, Richard C. Sutherlin, Jeffrey Henry,
C. W. Rowley and Anne Chaudouet ...................... 3-1

3.1 History of Materials in the ASME Boiler and
Pressure Vessel Code .................................. 3-1
3.2 Basis for Acceptance of Materials for Code
Construction—Section II, Part A: Ferrous
Material Specifications ................................ 3-7
3.3 Basis for Acceptance of Materials for Code
Construction—Section II, Part B: Nonferrous
Material Specifications ................................ 3-13
3.4 Section II, Part C: Specification for Welding
Rods, Electrodes, and Filler Metals ............. 3-52
3.5 Basis for Acceptance of Materials for Code
Construction—Section II, Part D: Properties 3-77
3.6 Non-metallic Material Used in Structural
Applications 3-94
3.7 Basis for Acceptance of Material for Code
Construction—Section II, International
Material Specifications 3-98

PART 3: SECTION III—RULES FOR CONSTRUCTION
OF NUCLEAR POWER PLANT COMPONENTS

SECTION III DIVISION 1

CHAPTER 4 A Commentary for Understanding and
Applying the Principles of the ASME Boiler and
Pressure Vessel Code
Roger F. Reedy ............................................. 4-1

4.1 Introduction 4-1
4.2 Design Factors Used in the ASME Code 4-3
4.3 Design Specifications and Design Reports 4-5
4.4 Section III Versus Section VIII 4-5
4.5 Design Life and Commutative-Usage Factors 4-6
4.6 Service-Level Loadings 4-6
4.7 Seismic Evaluations 4-6
4.8 Engineers, Design, and Computers 4-7
4.9 Containment Vessels 4-7
4.10 Tolerances, Significant Figures, and Nominal
Dimensions 4-8
4.11 Corrosion and Erosion 4-9
4.12 Forming Operations 4-9
4.13 Post-Weld Heat Treatment 4-9
4.14 Nondestructive Examination 4-10
4.15 Hydrostatic Test 4-10
4.16 Quality Assurance 4-10
4.17 Design Loadings and Stresses Compared to
Actual Conditions 4-11
4.18 Post-Construction Postulated Loadings and
Stresses 4-12
4.19 Maintenance of Design Margins 4-13
4.20 Thermal Relief Devices 4-13
4.21 Code Cases 4-13
4.22 ASME Interpretations 4-13
4.23 Code Simplification 4-13
4.24 Future Considerations for Cyclic Service 4-14
4.25 New ASME Code—2007 Edition of Section VIII,
Division 2 4-15
4.26 Summary 4-16
4.27 References 4-16

CHAPTER 5 Subsection NCA—General
Requirements for Division 1 and Division 2
Richard W. Swayne ............................................. 5-1

5.1 Introduction 5-1
5.2 Article NCA-1000 Scope of Section III 5-1
5.3 Article NCA-2000 Classification of Components
and Supports 5-4
5.4 Article NCA-3000 Responsibilities and Duties 5-6
5.5 Article NCA-4000 Quality Assurance 5-21

5.6 Article NCA-5000 Authorized Inspection 5-26
5.7 Article NCA-8000 Certificates, Nameplates,
Code Symbol Stamping, and Data Reports 5-28
5.8 Article NCA-9000 Glossary 5-33

CHAPTER 6 Subsection NB—Class 1 Components
David P. Jones and Chakrapani Basavaraju ............. 6-1

6.1 Introduction 6-1
6.2 Design 6-3
6.3 Analysis 6-6
6.4 Primary Stress Limits 6-11
6.5 Primary-Plus-Secondary Stress Limits 6-20
6.6 Fatigue 6-24
6.7 Special Procedures 6-31
6.8 Elastic-Plastic FEA 6-43
6.9 References 6-43
6.10 Summary of Changes 6-44

CHAPTER 7 Section III: Subsections NC and
ND—Class 2 and 3 Components
Chakrapani Basavaraju and Marcus N. Bressler ......... 7-1

7.0 Introduction to Chapter 7.0 7-1
7.1 Articles NC-1000 and ND-1000 7-2
7.2 Articles NC-2000 and ND-2000, Material 7-4
7.3 Articles NC-3000 and ND-3000 (Design) 7-10
7.4 Articles NC-4000 and ND-4000 (Fabrication
and Installation) 7-31
7.5 Articles NC-5000 and ND-5000 (Examination) 7-32
7.6 Articles NC-6000 and ND-6000 (Testing) 7-35
7.7 Articles NC-7000 and ND-7000 (Overpressure
Protection) 7-40
7.8 Articles NC-8000 and ND-8000 (Nameplate,
Stamping, and Reports) 7-40
7.9 Summary of Changes 7-41
7.10 Summary of Changes 7-43
7.11 References 7-45

CHAPTER 8 Subsection NB, NC, ND-3600 Piping
Jack R. Cole and Donald F. Landers ..................... 8-1

8.1 Background 8-1
8.2 Nuclear Class 1, NB-3600 8-2
8.3 Nuclear Class 2 and 3 NC/ND-3600 8-16
8.4 Design Process 8-22
8.5 Design Specification Discussion 8-25
8.6 References 8-26

CHAPTER 9 Subsection NE—Class MC
Components
Roger F. Reedy ............................................. 9-1

9.1 Introduction 9-1
9.2 Scope of Subsection NE 9-1
9.3 Boundaries of Jurisdiction of Subsection NE 9-1
9.4 General Material Requirements 9-5
9.5 Certified Material Test Reports 9-6
9.6 Material Toughness Requirements 9-7
9.7 General Design Requirements 9-9
9.8 Qualifications of Professional Engineers 9-9

CHAPTER 8 Subsection NB, NC, ND-3600 Piping
Jack R. Cole and Donald F. Landers ..................... 8-1

8.1 Background 8-1
8.2 Nuclear Class 1, NB-3600 8-2
8.3 Nuclear Class 2 and 3 NC/ND-3600 8-16
8.4 Design Process 8-22
8.5 Design Specification Discussion 8-25
8.6 References 8-26

CHAPTER 9 Subsection NE—Class MC
Components
Roger F. Reddy ............................................. 9-1

9.1 Introduction 9-1
9.2 Scope of Subsection NE 9-1
9.3 Boundaries of Jurisdiction of Subsection NE 9-1
9.4 General Material Requirements 9-5
9.5 Certified Material Test Reports 9-6
9.6 Material Toughness Requirements 9-7
9.7 General Design Requirements 9-9
9.8 Qualifications of Professional Engineers 9-9
9.9 Owner's Design Specifications 9-10
9.10 Certified Design Report 9-10
9.11 Design by Analysis 9-10
9.12 Appendix F 9-12
9.13 Fatigue Analysis 9-12
9.14 Buckling 9-13
9.15 Reinforcement of Cone-to-Cylinder Junction 9-15
9.16 Plastic Analysis 9-15
9.17 Design by Formula 9-15
9.18 Openings 9-15
9.19 Bolted Flange Connections 9-16
9.20 Welded Connections 9-17
9.21 General Fabrication Requirements 9-17
9.22 Tolerances 9-18
9.23 Requirements for Weld Joints 9-18
9.24 Welding Qualifications 9-19
9.25 Rules for Marking, Examining, and Repairing Welds 9-19
9.26 Heat Treatment 9-19
9.27 Examination 9-20
9.28 Qualifications and Certification of NDE Personnel 9-22
9.29 Testing 9-22
9.30 Overpressure Protection 9-23
9.31 Nameplates, Stamping, and Reports 9-23
9.32 Recommendations 9-24
9.33 References 9-24
9.34 Summary of Changes 9-24

CHAPTER 10 Subsection NF—Supports
Uma S. Bandyopadhyay .......................... 10-1

10.1 Executive Summary 10-1
10.2 NF-1000 Introduction 10-1
10.3 NF-2000 Materials 10-6
10.4 NF-3000 Design 10-14
10.5 NF-4000 Fabrication and Installation 10-29
10.6 NF-5000 Examination 10-30
10.7 NF-8000 Nameplates, Stamping, and Reports 10-32
10.8 NF Appendices 10-32
10.9 Code Cases and Interpretations 10-33
10.10 Summary of Changes 10-36
10.11 ASME B31.1 and B31.3 Supports 10-36
10.12 References 10-37

CHAPTER 11 Subsection NG—Core Support Structures
Richard O. Vollmer .................................. 11-1

11.1 Introduction 11-1
11.2 Definition of Core Support Structures (NG-1120) 11-2
11.3 Jurisdictional Boundaries (NG-1130) 11-2
11.4 Unique Conditions of Service 11-4
11.5 Materials of Construction (NG-2000) 11-4
11.6 Special Materials 11-6
11.7 Design (NG-3000) 11-7
11.8 Fabrication and Installation (NG-4000) 11-17
11.9 Examination (NG-5000) 11-17
11.10 Testing 11-20
11.11 Overpressure Protection 11-20
11.12 Nameplates/Stamping Effects (NG-8000) 11-20
11.13 Environmental Effects (NG-3120) 11-20
11.14 Special Bolting Requirements (NG-3230) 11-21
11.15 Code Cases (NCA-1140) 11-21
11.16 Interpretations for Subsection NG 11-22
11.17 Elevated Temperature Applications 11-22
11.18 Additional Considerations 11-22
11.19 Beyond the State-of-the-Art 11-24
11.20 References 11-26
11.21 Abbreviations and Nomenclature 11-27
11.22 Summary of Changes 11-27

CHAPTER 12 Subsection NH—Class 1 Components in Elevated Temperature Service
Robert I. Jetter .................................. 12-1

12.0 Introduction and Scope 12-1
12.1 Article NH-1000, Introduction 12-1
12.2 Article NH-2000, Materials 12-2
12.3 Article NH-3000, Design 12-2
12.4 Article NH-4000, Fabrication and Installation 12-31
12.5 Article NH-5000, Examination 12-31
12.6 Article NH-6000, Testing 12-31
12.7 Article NH-7000, Overpressure Protection 12-32
12.8 Other Component Classes, Components, and Materials 12-32
12.9 Current and Emerging Issues for Nuclear Components in Elevated Temperature Service 12-34
12.10 Future ASME Code Considerations for Nuclear Components in Elevated Temperature Service 12-35
12.11 References 12-35

CHAPTER 13 Nuclear Pumps
Robert E. Cornman, Jr. .......................... 13-1

13.1 Introduction 13-1
13.2 General Section III Requirements 13-1
13.3 Specific Pump Requirements 13-3
13.4 General Requirements for Class 1 Pumps 13-4
13.5 NC-3400 Class 2 Pumps 13-4
13.6 ND-3400 Class 3 Pumps 13-7
13.7 General Requirements for Class 2 and 3 Pumps 13-8
13.8 Changes in the 2010 Editions 13-8
13.9 References 13-8
13.10 Additional Documents of Interest 13-9

CHAPTER 14 Nuclear Valves
Guy A. Jolly .......................... 14-1

14.1 Introduction 14-1
14.2 General Section III Requirements 14-2
14.3 Specific Valve Requirements 14-3
14.4 NC-3500 and ND-3500, Class 2 and Class 3 Valves 14-9
14.5 Changes in the 2010 Edition 14-11
14.6 Other Valve Standards 14-11
14.7 References 14-11
14.8 Additional Documents of Interest 14-11
SECTION III DIVISION 2

CHAPTER 15  Code for Concrete Containments
Joseph F. Artuso, Arthur C. Eberhardt, Clayton T. Smith, Michael F. Hessheimer and Ola Jovall

15.1 Introduction 15-1
15.2 Future Containment Development 15-6
15.3 Background Development of Concrete Containment Construction Code Requirements 15-8
15.4 Reinforced-Concrete Containment Behavior 15-11
15.5 Concrete Reactor Containment Design Analysis and Related Testing 15-12
15.6 Code Design Loads 15-13
15.7 Allowable Behavior Criteria 15-13
15.8 Analytical Models and Design Procedures 15-14
15.9 Special Design Features 15-14
15.10 Current Organization of the Code 15-14
15.11 Article CC-4000: Fabrication and Construction 15-18
15.12 Article CC-5000: Construction Testing and Examination 15-19
15.13 Article CC-6000: Structural Integrity Test of Concrete Containments 15-19
15.14 Article CC-7000: Overpressure Protection 15-19
15.15 Article CC-8000: Nameplates, Stamping, and Reports 15-19
15.16 Practical Nuclear Power Plant Containment Designed to Resist Large Commercial Aircraft Crash and Postulated Reactor Core Melt 15-19
15.17 Items Which Should Be Considered in Future Revisions of the Code 15-24
15.18 Summary 15-24
15.19 References 15-25

SECTION III DIVISION 3

CHAPTER 16  Containments for Transportation and Storage of Spent Nuclear Fuel and High-Level Radioactive Material and Waste
D. Keith Morton and D. Wayne Lewis

16.1 Introduction 16-1
16.2 Historical Development 16-1
16.3 Scope of Subgroup NUPACK 16-2
16.4 Code Development 16-2
16.5 General Provisions 16-2
16.6 Specified Loading Categories 16-3
16.7 Allowable Stress 16-3
16.8 Materials, Fabrication, Installation, Examination, and Testing 16-5
16.9 Code Text Organization 16-5
16.10 Current Activities in Division 3 16-9
16.11 Suggested Enhancements for the Future 16-10
16.12 References 16-10
16.13 Summary of Changes 16-11

CHAPTER 17  Division 5—High Temperature Reactors
D. Keith Morton and Robert I. Jetter

17.1 Introduction 17-1
17.2 Scope 17-1
17.3 Background 17-1
17.4 Organization of Division 5 17-2
17.5 Future Expectations 17-9
17.6 Summary 17-11
17.7 References, Including Annotated Bibliographical Notations 17-11

PART 4: HEATING BOILERS—SECTION IV & VI OF B&PV CODE

CHAPTER 18  ASME Section IV: Rules for the Construction of Heating Boilers
Edwin A. Nordstrom

18.1 Introduction 18-1
18.2 Part HG: General Requirements for All Materials of Construction 18-4
18.3 Part HF: Requirements for Boilers Constructed of Wrought Materials 18-28
18.4 Part HF, Subpart HW: Requirements for Boilers Fabricated by Welding 18-29
18.5 Part HF, Subpart HB: Requirements for Boilers Fabricated by Brazing 18-37
18.6 Part HC: Requirements for Boilers Constructed of Cast Iron 18-39
18.7 Rules of Part HA: Hot Water Heating Boilers Constructed Primarily of Cast Aluminum 18-44
18.8 Part HLW: Requirements for Potable-Water Heaters 18-46
18.9 Considerations Likely to Be in Future Code Editions 18-57
18.10 What Should the ASME Code Committees and Regulators Consider, Recognizing the Intent of the ASME B&PV Code? 18-58
18.11 References 18-58

CHAPTER 19  ASME Section VI: Recommended Rules for the Care and Operation of Heating Boilers
Edwin A. Nordstrom

19.1 Introduction 19-1
19.2 General 19-2
19.3 Types of Boilers 19-7
19.4 Accessories 19-10
19.5 Installation 19-14
19.6 Fuels 19-18
19.7 Fuel-Burning Equipment and Fuel-Burning Controls 19-20
19.8 Boiler-Room Facilities 19-22
19.9 Operation, Maintenance, and Repair of Steam Boilers 19-23
19.10 Operation, Maintenance, and Repair of Hot-Water-Supply and Hot-Water-Heating Boilers 19-31
19.11 Water Treatment 19-36
19.12 General Comment 19-39
19.13 Considerations Likely to Be in Future Code Editions 19-39
PART 5: SECTION V OF B&PV CODE

CHAPTER 20 Nondestructive Examination (NDE)

Jon E. Batey .......................... 20-1

20.1 Introduction .......................... 20-1
20.2 Organization of Section V .......................... 20-1
20.3 Relation to Other ASME Code Book Sections .......................... 20-2
20.4 Article 1: General Requirements .......................... 20-2
20.5 Article 2: Radiographic Examination .......................... 20-4
20.6 Article 4: Ultrasonic Examination Methods for Welds .......................... 20-9
20.7 Ultrasonic Examination Methods for Materials .......................... 20-14
20.8 Article 6: Liquid-Penetrant Examination .......................... 20-14
20.9 Article 7: Magnetic-Particle Examination .......................... 20-16

20.10 Article 8: Eddy-Current Examination .......................... 20-17
20.11 Article 9: Visual Examination .......................... 20-18
20.12 Article 10: Leak Testing .......................... 20-18
20.13 Acoustic Emission Examination .......................... 20-19
20.15 Article 12: Acoustic Emission Examination of Metallic Vessels during Pressure Testing .......................... 20-20
20.16 Article 13: Continuous AE Monitoring .......................... 20-21
20.17 Article 14: Examination System Qualification .......................... 20-21
20.18 Article 15: Alternating Current Field Measurement .......................... 20-21
20.19 Article 16: Magnetic Flux Leakage .......................... 20-22
20.20 Article 17: Remote Field Testing .......................... 20-22
20.21 Technical Changes to Section V Since the 2nd Edition .......................... 20-22
20.22 Future Changes Anticipated for Section V .......................... 20-23
20.23 References .......................... 20-23
CONTENTS

Dedication to the First Edition
Robert E. Nickell and William E. Cooper . . . . . . . . . . . iii

Acknowledgements (to the First Edition) . . . . . . . . . . . v

Acknowledgements (to the Second Edition) . . . . . . . . . v

Acknowledgements (to the Third Edition) . . . . . . . . . vi

Acknowledgements (to the Fourth Edition) . . . . . . . . vii

Contributor Biographies . . . . . . . . . . . . . . . . . . . . . . . ix

Preface (to the First Edition)
K. R. Rao and Robert E. Nickell . . . . . . . . . . . . . . . . . xxxvii

Preface (to the Second Edition)
K. R. Rao . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . xxxviii

Preface (to the Third Edition)
K. R. Rao . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . xxxix

Preface (to the Fourth Edition)
K. R. Rao . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . xli

Introduction . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . xliii

Organization and Operation of the ASME
Boiler and Pressure Vessel Committee . . . . . . . . . . . . . . . . iv

PART 6: SECTION VIII – RULES FOR CONSTRUCTION
OF PRESSURE VESSELS

CHAPTER 21 Section VIII–Division 1: Rules for
Construction of Pressure Vessels
Urey R. Miller and Thomas P. Pastor . . . . . . . . . . . . . . . . 21-1

21.1 Introduction 21-1
21.2 Section VIII, Division 1, Foreword 21-1
21.3 Section VIII, Division 1, Introduction 21-2
21.4 Subsection A: General Requirements for
All Methods of Construction and All Materials 21-7
21.5 Subsection B–Requirements Pertaining to
Methods of Fabrication of Pressure Vessels 21-28
21.6 Subsection C: Requirements Pertaining to
Classes of Materials 21-45
21.7 Mandatory Appendices 21-66
21.8 NonMandatory Appendices 21-93
21.9 References 21-110

CHAPTER 22 Section VIII–Division 2:
Alternative Rules
David A. Osage, Clay D. Rodery, Thomas P. Pastor
Robert G. Brown, Philip A. Henry, and
James C. Sowinski. . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22-1

22.1 Introduction 22-1
22.2 Organization of VIII–2 22-2
22.3 Part 1 – General Requirements 22-2
22.4 Part 2 – Responsibilities and Duties 22-4
22.5 Part 3 – Materials Requirements 22-8
22.6 Part 4 – Design-By-Rule 22-13
22.7 Part 5 – Design-By-Analysis 22-31
22.8 Part 6 – Fabrication Requirements 22-40
22.9 Part 7 – Inspection and Examination
Requirements 22-46
22.10 Part 8 – Pressure Testing Requirements 22-55
22.11 Part 9 – Pressure Vessel Overpressure
Protection 22-56
22.12 References 22-58

CHAPTER 23 Section VIII–Division 3: Alternative
Rules for Construction of High-Pressure Vessels
J. Roberts Sims Jr. . . . . . . . . . . . . . . . . . . . . . . . . . . . . 23-1

23.1 Introduction 23-1
23.2 Foreword and Policy Statements 23-1
23.3 Part KG – General Requirements 23-1
23.4 Part KM – Material Requirements 23-4
23.5 Part KD – Design Requirements 23-6
23.6 PartKF–Fabrication Requirements 23-20
23.7 Part KR – Pressure-Relief Devices 23-22
23.8 Part KE – Examination Requirements 23-23
23.9 Part KT – Testing Requirements 23-23
23.10 Part KS – Marking, Stamping,
Reports, and Records 23-23
23.11 Mandatory and Nonmandatory Appendices 23-23
23.12 Recommendations for Further Development
of Division 3 23-24
CHAPTER 24 Safety of Personnel Using Quick-Actuating Closures on Pressure Vessels and Associated Litigation Issues

Roger F. Reedy .................................................. 24-1

24.1 Introduction ............................................. 24-1
24.2 Background ............................................. 24-1
24.3 History of the Rules Governing Quick-Actuating Closures ........................................... 24-2
24.4 The Future .............................................. 24-9
24.5 Conclusion .............................................. 24-9
24.6 References ............................................. 24-10

PART 7: SECTION IX OF B&PV CODE – WELDING AND BRAZING QUALIFICATIONS

CHAPTER 25 Welding and Brazing Qualifications

Joel G. Feldstein .............................................. 25-1

25.1 Introduction ............................................. 25-1
25.2 History of Section IX .................................. 25-1
25.3 Organization of Section IX ......................... 25-1
25.4 Welding Processes .................................... 25-1
25.5 Classification of Materials ......................... 25-6
25.6 Qualification of Welding Procedures .......... 25-7
25.7 Qualification of Welders and Welding Operators ........................................... 25-16
25.8 Impact Tested Weld Procedures .................. 25-21
25.9 Testing and Examination Requirements .... 25-25
25.10 Corrosion-Resistant and Hardfacing Overlay ........................................... 25-31
25.11 Brazing .................................................. 25-36
25.12 Future Actions for Section IX’s Consideration ........................................... 25-37

CHAPTER 26 Fiber-Reinforced Pressure Vessels and ASME RTP-1 – Reinforced Thermoset Plastic Corrosion-Resistance Equipment

Peter Conlisk and Bernard F. Shelley .................. 26-1

26.1 Introduction ............................................. 26-1
26.2 FRP Technology ....................................... 26-1
26.3 Fabrication Methods .................................. 26-6
26.4 Stress Analysis of FRP Vessels .................... 26-10
26.5 Scopes of Section X and RTP-1 .................... 26-14
26.6 Design Qualifications of Section X and RTP-1 Vessels ........................................... 26-16
26.7 Section X: Example Design Specification ........................................... 26-20
26.8 Section X: Example Design Calculations .... 26-22
26.9 RTP-1: Example 1 Design Specification ........ 26-28
26.10 RTP-1: Design Example 2 ......................... 26-36
26.11 Quality Assurance of Section X and RTP-1 Vessels ........................................... 26-42
26.12 References ............................................. 26-45

PART 8: SECTION X OF B&PV CODE

CHAPTER 27 Overview of Section XI Stipulations

Owen Hedden .................................................. 27-1

27.1 Introduction ............................................. 27-1
27.2 Development of Scope and Content of Section XI ........................................... 27-3
27.3 Future Issues ........................................... 27-21
27.4 Applicability of Code Editions and Addenda, and the Use and Content of Code Cases and Interpretations ........................................... 27-21
27.5 Efforts that did not Reach Publications .... 27-22
27.6 Acknowledgments ...................................... 27-22
27.7 References ............................................. 27-23
27.8 Bibliography ............................................ 27-23
27.9 Appendix A: Code Cases ......................... 27-24
27.10 Appendix B: Interpretations ...................... 27-27

CHAPTER 28 Repair/Replacement Activities for Nuclear Power Plant Items

Richard E. Gimple and Richard W. Swayne .......... 28-1

28.1 Introduction ............................................. 28-1
28.2 Background of Repair/Replacement Activity Requirements ........................................... 28-3
28.3 Scope and Applicability of Repair/Replacement Activity Requirements .... 28-5
28.4 Alternative Requirements ......................... 28-10
28.5 Responsibilities ....................................... 28-15
28.6 Repair/Replacement Program and Plan .... 28-19
28.7 Additional General Requirements .......... 28-22
28.8 Requirements for Items Used in a Repair/Replacement Activity ........................................... 28-26
28.9 Design Associated with Repair/Replacement Activities ........................................... 28-32
28.10 Welding, Brazing, Metal Removal, Fabrication and Installation ........................................... 28-36
28.11 Examination and Testing Requirements .... 28-45
28.12 Alternatives to Construction Code Welding ........................................... 28-53
28.13 Plugging and Sleeving of Heat Exchanger Tubing ........................................... 28-55
28.14 Code Cases ............................................. 28-56
28.15 Future Considerations ......................... 28-57
28.16 References ............................................. 28-59

CHAPTER 29 Section XI: Rules for Inservice Inspection and Tests of Nuclear Power Plant Components

Richard W. Swayne ............................................ 29-1

29.1 Introduction ............................................. 29-1
29.2 Preface .................................................. 29-1
29.3 Organization ............................................ 29-1
29.4 Article IWA-1000: Scope and Responsibility ........................................... 29-2
29.5 Article IWA-2000: Examination and Inspection Personnel ........................................... 29-4
29.6 IWA-2000: Qualifications of Nondestructive Examination Personnel ........................................... 29-5
29.7 Mandatory Appendix VII: Qualification of Nondestructive Examination Personnel for UT ........................................... 29-7
29.8 IWA 2000: Inspection Program .................. 29-7
29.9 IWA 2420: Inspection Plans and Schedules ........................................... 29-8
29.10 IWA 2430: Inspection Intervals .......... 29-8
29.11 IWA 2440: Application of Code Cases .......... 29-9
29.12 IWA 2500: Extent of Examination ........ 29-10
29.13 IWA 2600: Weld Reference System .......... 29-10

PART 9: SECTION XI OF B&PV CODE – RULES FOR INSERVICE INSPECTION OF NUCLEAR POWER PLANT COMPONENTS

CHAPTER 27 Overview of Section XI Stipulations

Owen Hedden .................................................. 27-1
29.14 Subsections IWB/IWC/IWD/IWE/IWF/IWL: Requirements for Class 1, 2, 3, MC, and CC Components and Supports 29-10
29.15 Exemptions from the Examination Requirements 29-10
29.16 Class 1, 2, and 3 Components and their Supports Exempt from Examination 29-11
29.17 Class MC Components and Liners of Class Components Exempt from Examination 29-11
29.18 Portions of Reinforced Concrete Containment Vessels and their Posttensioning Systems Exempt from Examination 29-12
29.19 IWF-1300: Component Support Examination Boundaries 29-12
29.20 IWB/IWC/IWD/IWE/IWF-2000: Examination and Inspection 29-12
29.21 Combining Preservice Examinations with Construction Code Shop and Field Examinations 29-12
29.23 IWE-2000: Visual Examination, Personnel Qualification and the responsible Engineer 29-13
29.24 IWB/IWC/IWD/IWE/IWF/IWL-2400: Inspection Schedule 29-13
29.25 IWL-2400: Inspection Schedule 29-14
29.26 IWB/IWC/IWD/IWE/IWF-2420: Successive Inspections 29-14
29.27 IWB/IWC/IWD/IWE/IWF-2430: Additional Examinations 29-14
29.28 IWB/IWC/IWD/IWE/IWF-2500: Examination and Pressure Test Requirements 29-15
29.29 Unique Aspects of Containment Vessel Examination 29-17
29.30 IWL-2500: Examination Requirements 29-17
29.31 Unique Aspects of the Component Support Examination 29-18
29.32 IWA-5000: System Pressure Tests 29-18
29.33 IWA-5110: Periodic System Pressure Tests 29-19
29.34 IWA-5120: System Pressure Tests for Replacement Activities 29-19
29.35 IWA-5200: System Test Requirements 29-19
29.36 IWA/IWB/IWC/IWD-5220: Test Pressurization Boundaries 29-20
29.37 IWA-5240: Visual Examination 29-20
29.38 IWA-5250: Corrosive Action 29-21
29.39 IWA-5260: Instruments for System Hydrostatic Tests 29-22
29.40 IWA-5300: Test Records 29-22
29.41 IWA-6000: Records and Reports 29-22
29.42 IWA-6300: Retention 29-22
29.43 Risk-Informed Inservice Inspection 29-22
29.44 High-Temperature Gas-Cooled Reactors 29-23

CHAPTER 30 Section XI Flaw Acceptance Criteria and Evaluation Using Code Procedures
Russell C. Cipolla .......................... 30-1
30.1 Introduction 30-1
30.2 Evaluation of Examination Results (IWA-3000) 30-2
30.3 Acceptance of Flaws (IWB-3500) 30-8
30.4 Evaluation of Flaws in Components (IWB-3600) 30-13
30.5 Evaluation of Flaws in Reactor Head Penetrations Components (IWB-3660) 30-20
30.6 Evaluation of Flaws in Piping (IWB-3640) 30-23
30.7 Evaluation of Pipe Wall Thinning 30-30
30.8 Temporary Acceptance of Flaws 30-35
30.9 Evaluation of Plant Operating Events (IWB-3700) 30-42
30.10 Evaluation of Class 2, 3, MC, and NF Components 30-55
30.11 Recent and Future Developments in Flaw Evaluation 30-56
30.12 References 30-58

CHAPTER 31 IWE and IWL
Jim E. Staffiera ............................... 31-1
31.1 Introduction 31-1
31.2 Regulatory Requirements for Containments 31-5
31.3 ASME Code Requirements for Containments 31-6
31.4 General Requirements 31-8
31.5 Requirements for Metal (Class MC) Containments 31-8
31.6 Requirements for Concrete (Class CC) Containments 31-8
31.7 Later Code Editions and Addenda 31-8
31.8 Code Cases and Interpretations 31-8
31.9 Advance Nuclear Power Plant Designs 31-9
31.10 References 31-9

CHAPTER 32 Fatigue Crack Growth, Fatigue and Stress Corrosion Crack Growth: Section XI Evaluation
Warren H. Bamford ........................... 32-1
32.1 Fatigue Crack Growth Analyses 32-1
32.2 Stress Corrosion Crack Growth 32-13
32.3 Operating Plant Fatigue Assessment: Section XI, Appendix L 32-27
32.4 References 32-30

CHAPTER 33 Applications of Elastic-Plastic Fracture Mechanics in Section XI, ASME Code Evaluations
Hardayal S. Mehta ............................. 33-1
33.1 Introduction 33-1
33.2 Early Progress in the Development of EPFM 33-1
33.3 Engineering Approach to EPFM and Piping Applications 33-2
33.4 Application to RPV Evaluation 33-9
33.5 References 33-21

PART 10: SECTION XII OF B&PV CODE

CHAPTER 34 Description of Rules of Section XII Transport Tank Code
Mahendra D. Rana and Stanley Staniszewski ............. 34-1
34.1 Introduction 34-1
34.2 Rules on General Requirements, Pressure, Relief Devices, Stamping, Marking Certification, Reports and Records 34-2
34.3 Rules for Materials and Design 34-3
34.4 Rules on Fabrication and Inspection 34-8
34.5 Additional Rules in Modal Appendix I on Categories 406, 407, 412, 331 and 338 Cargo Tanks 34-11
34.6 New Appendix on Rules on Cold Stretched Vessels 34-14
34.7 Conclusions 34-15
34.8 Acknowledgment 34-15
34.9 References 34-15

PART 11: ASME B31 CODES

CHAPTER 35 ASME Piping Code: B31.1, Power Piping
Jimmy E. Meyer and Joe Frey ................................. 35-1
35.1 Introduction 35-1
35.2 Scope and Definitions 35-2
35.3 Design 35-2
35.4 Materials 35-10
35.5 Dimensional Requirements 35-10
35.6 Fabrication, Assembly and Erection 35-10
35.7 Inspection, Examination, and Testing 35-18
35.8 Operations and Maintenance 35-19
35.9 Appendices in the Code 35-19
35.10 References 35-22

Jimmy E. Meyer ................................. 36-1
36.1 Coverage 36-1
36.2 References 36-26

CHAPTER 37 Transportation Pipelines, Including ASME B31.4, B31.8, B31.8S, B31.11, B31G, and B31Q Codes
Michael J. Rosenfeld ................................. 37-1
37.1 Introduction 37-1
37.2 ASME B31.4 “Transportation Systems for Liquid Hydrocarbons and other Liquids” 37-3
37.3 ASME B31.8 “Gas Transmission and Distribution Piping Systems” 37-3
37.4 ASME B31.8S “Managing System Integrity of Gas Pipelines”, Supplement to B31.8 37-16
37.5 ASME B31.11 “Slurry Transportation Piping Systems” 37-33
37.6 ASME B31G “Manual for Determining the Remaining Strength of Corroded Pipelines” 37-37
37.7 ASME B31Q “Pipeline Personnel Qualification” 37-41
37.8 Acknowledgements 37-43
37.9 References 37-43

CHAPTER 38 Hydrogen Piping and Pipe Lines
Louis E. Hayden ................................. 38-1
38.1 Background and General Information 38-1
38.2 Organization of B31.12 38-3
38.3 Part GR-General Requirements 38-3
38.4 Part GR; Materials 38-4
38.5 GR-3 Welding, Brazing, Heat Treating, Forming, and Testing 38-4
38.6 GR-4 Inspection, Examination and Testing 38-4
38.7 GR-5 Operation and Maintenance 38-4
38.8 GR-6 Quality System Program for Hydrogen Piping and Pipeline Systems 38-9
38.9 Part IP-2 Design Conditions and Criteria 38-9
38.10 IP-3 Pressure Design of Piping Components 38-10
38.11 IP-7 Specific Piping Systems 38-13
38.12 IP-8.1 Dimensional Requirements 38-14
38.13 IP-8.2 Ratings of Components 38-14
38.14 IP10 Inspection, Examination, and Testing 38-14
38.15 PL Pipelines 38-14
38.16 Chapter PL-2 Pipeline Systems Components and Fabrication Details 38-17
38.17 Mandatory Appendix III Safeguarding 38-27
38.18 References 38-28