
CHAPTER 3—DESIGN OF STRUCTURES, COMPONENTS, EQUIPMENT AND SYSTEMS

TABLE OF CONTENTS

3.0	DESIGN OF STRUCTURES, COMPONENTS, EQUIPMENT AND SYSTEMS	3.1-1
3.1	Compliance with Nuclear Regulatory Commission General Design Criteria.....	3.1-1
3.1.1	Overall Requirements.....	3.1-1
3.1.1.1	Criterion 1 – Quality Standards and Records.....	3.1-1
3.1.1.2	Criterion 2 – Design Bases for Protection Against Natural Phenomena	3.1-2
3.1.1.3	Criterion 3 – Fire Protection	3.1-2
3.1.1.4	Criterion 4 – Environmental and Missile Design Bases	3.1-3
3.1.1.5	Criterion 5 – Sharing of Structures, Systems, and Components	3.1-4
3.1.2	Protection by Multiple Fission Product Barriers.....	3.1-4
3.1.2.1	Criterion 10 – Reactor Design	3.1-4
3.1.2.2	Criterion 11 – Reactor Inherent Protection.....	3.1-5
3.1.2.3	Criterion 12 – Suppression of Reactor Power Oscillations.....	3.1-5
3.1.2.4	Criterion 13 – Instrumentation and Control	3.1-6
3.1.2.5	Criterion 14 – Reactor Coolant Pressure Boundary	3.1-7
3.1.2.6	Criterion 15 – Reactor Coolant System Design.....	3.1-7
3.1.2.7	Criterion 16 – Containment Design	3.1-8
3.1.2.8	Criterion 17 – Electrical Power Systems	3.1-8
3.1.2.9	Criterion 18 – Inspection and Testing of Electric Power Systems.....	3.1-10
3.1.2.10	Criterion 19 – Control Room.....	3.1-11
3.1.3	Protection and Reactivity Control Systems	3.1-12
3.1.3.1	Criterion 20 – Protection System Functions	3.1-12

3.1.3.2	Criterion 21 – Protection System Reliability and Testability	3.1-12
3.1.3.3	Criterion 22 – Protection System Independence.....	3.1-13
3.1.3.4	Criterion 23 – Protection System Failure Modes.....	3.1-14
3.1.3.5	Criterion 24 – Separation of Protection and Control Systems	3.1-15
3.1.3.6	Criterion 25 – Protection System Requirements for Reactivity Control Malfunctions.....	3.1-16
3.1.3.7	Criterion 26 – Reactivity Control System Redundancy and Capability	3.1-16
3.1.3.8	Criterion 27 – Combined Reactivity Control Systems Capability.....	3.1-17
3.1.3.9	Criterion 28 – Reactivity Limits.....	3.1-17
3.1.3.10	Criterion 29 – Protection Against Anticipated Operational Occurrences	3.1-18
3.1.4	Fluid Systems	3.1-18
3.1.4.1	Criterion 30 – Quality of Reactor Coolant Pressure Boundary.....	3.1-18
3.1.4.2	Criterion 31 – Fracture Prevention of Reactor Coolant Pressure Boundary	3.1-19
3.1.4.3	Criterion 32 – Inspection of Reactor Coolant Pressure Boundary.....	3.1-20
3.1.4.4	Criterion 33 – Reactor Coolant Makeup	3.1-20
3.1.4.5	Criterion 34 – Residual Heat Removal	3.1-21
3.1.4.6	Criterion 35 – Emergency Core Cooling.....	3.1-22
3.1.4.7	Criterion 36 – Inspection of Emergency Core Cooling System	3.1-23
3.1.4.8	Criterion 37 – Testing of Emergency Core Cooling System	3.1-24
3.1.4.9	Criterion 38 – Containment Heat Removal System	3.1-24
3.1.4.10	Criterion 39 – Inspection of Containment Heat Removal System.....	3.1-25
3.1.4.11	Criterion 40 – Testing of Containment Heat Removal System	3.1-25
3.1.4.12	Criterion 41 – Containment Atmosphere Cleanup	3.1-26

3.1.4.13	Criterion 42 – Inspection of Containment Atmosphere Cleanup System.....	3.1-26
3.1.4.14	Criterion 43 – Testing of Containment Atmosphere Cleanup Systems.....	3.1-27
3.1.4.15	Criterion 44 – Cooling Water	3.1-27
3.1.4.16	Criterion 45 – Inspection of Cooling Water System	3.1-28
3.1.4.17	Criterion 46 – Testing of Cooling Water System	3.1-28
3.1.5	Reactor Containment.....	3.1-29
3.1.5.1	Criterion 50 – Containment Design Basis	3.1-29
3.1.5.2	Criterion 51 – Fracture Prevention of Containment Pressure Boundary	3.1-29
3.1.5.3	Criterion 52 – Capability for Containment Leakage Rate Testing	3.1-30
3.1.5.4	Criterion 53 – Provisions for Containment Testing and Inspection	3.1-30
3.1.5.5	Criterion 54 – Piping Systems Penetrating Containment.....	3.1-31
3.1.5.6	Criterion 55 – Reactor Coolant Pressure Boundary Penetrating Containment	3.1-31
3.1.5.7	Criterion 56 – Primary Containment Isolation.....	3.1-32
3.1.5.8	Criterion 57 – Closed System Isolation Valves	3.1-33
3.1.6	Fuel and Reactivity Control	3.1-33
3.1.6.1	Criterion 60 – Control of Releases of Radioactive Materials to the Environment.....	3.1-33
3.1.6.2	Criterion 61 – Fuel Storage and Handling and Radioactivity Control	3.1-34
3.1.6.3	Criterion 62 – Prevention of Criticality in Fuel Storage and Handling.....	3.1-35
3.1.6.4	Criterion 63 – Monitoring Fuel and Waste Storage.....	3.1-35
3.1.6.5	Criterion 64 – Monitoring Radioactivity Releases	3.1-36
3.1.7	References	3.1-36
3.2	Classification of Structures, Systems, and Components.....	3.2-1
3.2.1	Seismic Classification.....	3.2-2

3.2.1.1	Seismic Category I	3.2-3
3.2.1.2	Seismic Category II	3.2-4
3.2.1.3	Radwaste Seismic.....	3.2-4
3.2.1.4	Conventional Seismic.....	3.2-4
3.2.1.5	Non-Seismic	3.2-5
3.2.2	System Quality Group Classification	3.2-6
3.2.2.1	Quality Group A.....	3.2-7
3.2.2.2	Quality Group B.....	3.2-7
3.2.2.3	Quality Group C.....	3.2-8
3.2.2.4	Quality Group D.....	3.2-8
3.2.2.5	Quality Group E.....	3.2-9
3.2.3	References	3.2-198
3.3	Wind and Tornado Loadings	3.3-1
3.3.1	Wind Loadings.....	3.3-1
3.3.1.1	Design Wind Velocity	3.3-1
3.3.1.2	Determination of Applied Wind Forces.....	3.3-1
3.3.2	Tornado Loadings.....	3.3-2
3.3.2.1	Applicable Tornado Design Parameters.....	3.3-3
3.3.2.2	Determination of Tornado Forces on Structures	3.3-3
3.3.2.3	Interaction of Non-Seismic Category I Structures with Seismic Category I Structures	3.3-4
3.3.3	References	3.3-5
3.4	Water Level (Flood) Design.....	3.4-1
3.4.1	Internal Flood Protection	3.4-1
3.4.2	External Flood Protection	3.4-3
3.4.3	Analysis of Flooding Events	3.4-4
3.4.3.1	Internal Flooding Events.....	3.4-4
3.4.3.2	External Flooding Events	3.4-6
3.4.3.3	Reactor Building Flooding Analysis.....	3.4-6
3.4.3.4	Safeguard Buildings Flooding Analysis	3.4-9
3.4.3.5	Fuel Building Flooding Analysis	3.4-13
3.4.3.6	Nuclear Auxiliary Building Flooding Analysis	3.4-15
3.4.3.7	Radioactive Waste Building Flooding Analysis	3.4-15

3.4.3.8	Emergency Power Generating Buildings Flooding Analysis	3.4-15
3.4.3.9	Essential Service Water Pump Buildings and Essential Service Water Cooling Tower Structures Flooding Analysis.....	3.4-16
3.4.3.10	Ultimate Heat Sink Makeup Water Intake Structure Flooding Analysis.....	3.4-16
3.4.3.11	Permanent Dewatering System.....	3.4-16
3.4.4	Analysis Procedures.....	3.4-16
3.4.5	References	3.4-17
3.5	Missile Protection	3.5-1
3.5.1	Missile Selection and Description.....	3.5-2
3.5.1.1	Internally Generated Missiles Outside Containment.....	3.5-3
3.5.1.2	Internally Generated Missiles Inside Containment.....	3.5-6
3.5.1.3	Turbine Missiles	3.5-9
3.5.1.4	Missiles Generated by Tornadoes and Extreme Winds	3.5-10
3.5.1.5	Site Proximity Missiles (Except Aircraft).....	3.5-10
3.5.1.6	Aircraft Hazards.....	3.5-11
3.5.2	Structures, Systems, and Components to be Protected from Externally Generated Missiles.....	3.5-11
3.5.3	Barrier Design Procedures	3.5-12
3.5.3.1	Local Damage Prediction	3.5-13
3.5.3.2	Overall Damage Prediction	3.5-16
3.5.3.3	Ductility Requirements for Missile Barriers.....	3.5-17
3.5.4	References	3.5-18
3.6	Protection Against Dynamic Effects Associated with Postulated Rupture of Piping.....	3.6-1
3.6.1	Plant Design for Protection Against Postulated Piping Failures in Fluid Systems Outside of Containment.....	3.6-1
3.6.1.1	Design Basis	3.6-3
3.6.1.2	Protection Considerations	3.6-7
3.6.1.3	Failure Mode and Effects Analysis	3.6-10
3.6.1.4	References	3.6-11

3.6.2	Determination of Rupture Locations and Dynamic Effects Associated with the Postulated Rupture of Piping.....	3.6-21
3.6.2.1	Criteria Used to Define Break and Crack Location and Configuration	3.6-21
3.6.2.2	Guard Pipe Assembly Design Criteria.....	3.6-30
3.6.2.3	Analytical Methods to Define Forcing Functions and Response Models	3.6-31
3.6.2.4	Dynamic Analysis Methods to Verify Integrity and Operability	3.6-36
3.6.2.5	Implementation of Criteria Dealing with Special Features	3.6-40
3.6.2.6	References	3.6-42
3.6.3	Leak-Before-Break Evaluation Procedures	3.6-44
3.6.3.1	Application of Leak-Before-Break to the U.S. EPR.....	3.6-44
3.6.3.2	Methods and Criteria	3.6-44
3.6.3.3	Potential Piping Failure Mechanisms	3.6-45
3.6.3.4	Inputs for Leak-Before-Break Analysis.....	3.6-52
3.6.3.5	General Methodology	3.6-56
3.6.3.6	Results	3.6-71
3.6.3.7	Leak Detection	3.6-76
3.6.3.8	References	3.6-76
3.7	Seismic Design.....	3.7-1
3.7.1	Seismic Design Parameters	3.7-3
3.7.1.1	Design Ground Motion	3.7-3
3.7.1.2	Percentage of Critical Damping Values.....	3.7-9
3.7.1.3	Supporting Media for Seismic Category I Structures	3.7-11
3.7.1.4	References	3.7-12
3.7.2	Seismic System Analysis.....	3.7-61
3.7.2.1	Seismic Analysis Methods.....	3.7-63
3.7.2.2	Natural Frequencies and Response Loads	3.7-67
3.7.2.3	Procedures Used for Analytical Modeling	3.7-67
3.7.2.4	Soil-Structure Interaction.....	3.7-80
3.7.2.5	Development of Floor Response Spectra	3.7-87

3.7.2.6	Three Components of Earthquake Motion	3.7-92
3.7.2.7	Combination of Modal Responses	3.7-92
3.7.2.8	Interaction of Non-Seismic Category I Structures with Seismic Category I Structures	3.7-92
3.7.2.9	Effects of Parameter Variations on Floor Response Spectra	3.7-96
3.7.2.10	Use of Constant Vertical Static Factors	3.7-97
3.7.2.11	Method Used to Account for Torsional Effects	3.7-97
3.7.2.12	Comparison of Responses	3.7-98
3.7.2.13	Methods for Seismic Analysis of Category I Dams	3.7-98
3.7.2.14	Determination of Dynamic Stability of Seismic Category I Structures	3.7-98
3.7.2.15	Analysis Procedure for Damping	3.7-98
3.7.2.16	References	3.7-98
3.7.3	Seismic Subsystem Analysis	3.7-280
3.7.3.1	Seismic Analysis Methods	3.7-280
3.7.3.2	Determination of Number of Earthquake Cycles	3.7-284
3.7.3.3	Procedures Used for Analytical Modeling	3.7-285
3.7.3.4	Basis for Selection of Frequencies	3.7-287
3.7.3.5	Analysis Procedure for Damping	3.7-288
3.7.3.6	Three Components of Earthquake Motion	3.7-290
3.7.3.7	Combination of Modal Responses	3.7-291
3.7.3.8	Interaction of Non-Seismic Category I Subsystems	3.7-295
3.7.3.9	Multiply-Supported Equipment and Components with Distinct Inputs	3.7-297
3.7.3.10	Use of Equivalent Vertical Static Factors	3.7-298
3.7.3.11	Torsional Effects of Eccentric Masses	3.7-299
3.7.3.12	Buried Seismic Category I Piping and Conduits	3.7-299
3.7.3.13	Methods for Seismic Analysis of Category I Concrete Dams	3.7-300

3.7.3.14	Methods for Seismic Analysis of Aboveground Tanks	3.7-300
3.7.3.15	References	3.7-300
3.7.4	Seismic Instrumentation	3.7-302
3.7.4.1	Comparison with NRC Regulatory Guide 1.12.....	3.7-302
3.7.4.2	Location and Description of Instrumentation	3.7-302
3.7.4.3	Control Room Operator Notification	3.7-305
3.7.4.4	Comparison with Regulatory Guide 1.166.....	3.7-305
3.7.4.5	Instrument Surveillance.....	3.7-307
3.7.4.6	Program Implementation.....	3.7-308
3.7.4.7	References	3.7-308
3.8	Design of Category I Structures	3.8-1
3.8.1	Concrete Containment.....	3.8-1
3.8.1.1	Description of the Containment.....	3.8-2
3.8.1.2	Applicable Codes, Standards, and Specifications	3.8-6
3.8.1.3	Loads and Load Combinations.....	3.8-8
3.8.1.4	Design and Analysis Procedures	3.8-16
3.8.1.5	Structural Acceptance Criteria.....	3.8-24
3.8.1.6	Materials, Quality Control, and Special Construction Techniques.....	3.8-25
3.8.1.7	Testing and Inservice Inspection Requirements	3.8-30
3.8.2	Steel Containment.....	3.8-32
3.8.2.1	Description of the Containment.....	3.8-32
3.8.2.2	Applicable Codes, Standards, and Specifications	3.8-36
3.8.2.3	Loads and Load Combinations.....	3.8-37
3.8.2.4	Design and Analysis Procedures	3.8-43
3.8.2.5	Structural Acceptance Criteria.....	3.8-45
3.8.2.6	Materials, Quality Control, and Special Construction Techniques.....	3.8-46
3.8.2.7	Testing and Inservice Inspection Requirements	3.8-47
3.8.3	Concrete and Steel Internal Structures of Concrete Containment	3.8-47
3.8.3.1	Description of the Internal Structures	3.8-47

3.8.3.2	Applicable Codes, Standards, and Specifications	3.8-55
3.8.3.3	Loads and Load Combinations.....	3.8-58
3.8.3.4	Design and Analysis Procedures	3.8-64
3.8.3.5	Structural Acceptance Criteria.....	3.8-74
3.8.3.6	Materials, Quality Control, and Special Construction Techniques.....	3.8-74
3.8.3.7	Testing and Inservice Inspection Requirements	3.8-79
3.8.4	Other Seismic Category I Structures	3.8-79
3.8.4.1	Description of the Structures	3.8-79
3.8.4.2	Applicable Codes, Standards, and Specifications	3.8-87
3.8.4.3	Loads and Load Combinations.....	3.8-90
3.8.4.4	Design and Analysis Procedures	3.8-98
3.8.4.5	Structural Acceptance Criteria.....	3.8-113
3.8.4.6	Materials, Quality Control, and Special Construction Techniques.....	3.8-114
3.8.4.7	Testing and Inservice Inspection Requirements	3.8-115
3.8.5	Foundations.....	3.8-116
3.8.5.1	Description of the Foundations.....	3.8-116
3.8.5.2	Applicable Codes, Standards, and Specifications	3.8-118
3.8.5.3	Loads and Load Combinations.....	3.8-119
3.8.5.4	Design and Analysis Procedures	3.8-120
3.8.5.5	Structural Acceptance Criteria.....	3.8-127
3.8.5.6	Materials, Quality Control, and Special Construction Techniques.....	3.8-130
3.8.5.7	Testing and Inservice Inspection Requirements	3.8-131
3.8.6	References	3.8-131
3.9	Mechanical Systems and Components	3.9-1
3.9.1	Special Topics for Mechanical Components	3.9-1
3.9.1.1	Design Transients	3.9-2
3.9.1.2	Computer Programs Used in Analyses	3.9-17

3.9.1.3	Experimental Stress Analysis.....	3.9-19
3.9.1.4	Considerations for the Evaluation of the Faulted Condition	3.9-19
3.9.1.5	References	3.9-19
3.9.2	Dynamic Testing and Analysis of Systems, Components, and Equipment.....	3.9-22
3.9.2.1	Piping Vibration, Thermal Expansion, and Dynamic Effects	3.9-24
3.9.2.2	Seismic Analysis and Qualification of Seismic Category I Mechanical Equipment	3.9-27
3.9.2.3	Dynamic Response Analysis of Reactor Internals Under Operational Flow Transients and Steady-State Conditions.....	3.9-29
3.9.2.4	Preoperational Flow-Induced Vibration Testing of Reactor Internals	3.9-31
3.9.2.5	Dynamic System Analysis of the Reactor Internals Under Faulted Conditions.....	3.9-34
3.9.2.6	Correlations of Reactor Internals Vibration Tests with the Analytical Results.....	3.9-35
3.9.2.7	References	3.9-35
3.9.3	ASME Code Class 1, 2, and 3 Components, Component Supports, and Core Support Structures.....	3.9-37
3.9.3.1	Loading Combinations, System Operating Transients, and Stress Limits.....	3.9-38
3.9.3.2	Design and Installation of Pressure-Relief Devices.....	3.9-43
3.9.3.3	Pump and Valve Operability Assurance.....	3.9-44
3.9.3.4	Component Supports	3.9-45
3.9.3.5	References	3.9-47
3.9.4	Control Rod Drive System	3.9-61
3.9.4.1	Descriptive Information of CRDS	3.9-62
3.9.4.2	Applicable CRDS Design Specifications	3.9-65
3.9.4.3	Design Loads, Stress Limits, and Allowable Deformations	3.9-65
3.9.4.4	CRDS Operability Assurance Program	3.9-66
3.9.4.5	References	3.9-68
3.9.5	Reactor Pressure Vessel Internals	3.9-71

3.9.5.1	Design Arrangements.....	3.9-72
3.9.5.2	Loading Conditions.....	3.9-78
3.9.5.3	Design Bases	3.9-78
3.9.5.4	BWR Reactor Pressure Vessel Internal Including Steam Dryer.....	3.9-80
3.9.5.5	References	3.9-80
3.9.6	Functional Design, Qualification, and Inservice Testing Programs for Pumps, Valves, and Dynamic Restraints.....	3.9-90
3.9.6.1	Functional Design and Qualification of Pumps, Valves, and Dynamic Restraints	3.9-94
3.9.6.2	Inservice Testing Program for Pumps	3.9-96
3.9.6.3	Inservice Testing Program for Valves	3.9-98
3.9.6.4	Inservice Testing Program for Dynamic Restraints	3.9-108
3.9.6.5	Relief Requests and Alternative Authorizations to the OM Code	3.9-111
3.9.6.6	References	3.9-111
3.10	Seismic and Dynamic Qualification of Mechanical and Electrical Equipment.....	3.10-1
3.10.1	Seismic Qualification Criteria.....	3.10-4
3.10.1.1	Qualification Standards	3.10-4
3.10.1.2	Performance Requirements for Seismic Qualification.....	3.10-6
3.10.1.3	Acceptance Criteria	3.10-6
3.10.1.4	Input Motion.....	3.10-6
3.10.2	Methods and Procedures for Qualifying Mechanical, Electrical and I&C Equipment.....	3.10-6
3.10.2.1	Seismic Qualification of Electrical Equipment and Instrumentation.....	3.10-9
3.10.2.2	Seismic Qualification of Active Mechanical Equipment	3.10-9
3.10.2.3	Seismic Qualification of Non-Active Mechanical Equipment	3.10-10
3.10.3	Methods and Procedures for Qualifying Supports of Mechanical and Electrical Equipment and Instrumentation.....	3.10-11
3.10.4	Test and Analysis Results and Experience Database.....	3.10-12

3.10.5	References	3.10-13
3.11	Environmental Qualification of Mechanical and Electrical Equipment	3.11-1
3.11.1	Equipment Identification and Environmental Conditions	3.11-2
3.11.1.1	Equipment Identification	3.11-2
3.11.1.2	Definition of Environmental Conditions	3.11-6
3.11.1.3	Equipment Operability Times	3.11-8
3.11.2	Qualification Tests and Analysis.....	3.11-8
3.11.2.1	Environmental Qualification of Electrical Equipment	3.11-8
3.11.2.2	Environmental Qualification of Mechanical Equipment	3.11-10
3.11.2.3	Justification for Using Latest IEEE Standards Not Endorsed by a RG	3.11-16
3.11.3	Qualification Test Results.....	3.11-20
3.11.4	Loss of Ventilation	3.11-21
3.11.5	Estimated Chemical and Radiation Environment	3.11-21
3.11.5.1	Chemical Environments	3.11-21
3.11.5.2	Radiation Environments	3.11-21
3.11.6	Qualification of Mechanical Equipment	3.11-22
3.11.7	References	3.11-22
3.12	ASME Code Class 1, 2, and 3 Piping Systems, Piping Components, and their Associated Supports	3.12-1
3.12.1	Introduction.....	3.12-1
3.12.2	Codes and Standards.....	3.12-1
3.12.3	Piping Analysis Methods	3.12-1
3.12.3.1	Experimental Stress Analysis Methods	3.12-1
3.12.3.2	Modal Response Spectrum Method	3.12-1
3.12.3.3	Response Spectra Method (or Independent Support Motion Method).....	3.12-1
3.12.3.4	Time History Method	3.12-1
3.12.3.5	Inelastic Analysis Method.....	3.12-1
3.12.3.6	Small Bore Piping Method.....	3.12-1
3.12.3.7	Non-Seismic/Seismic Interaction (II/I)	3.12-2
3.12.3.8	Seismic Category I Buried Piping.....	3.12-2

3.12.4 Piping Modeling Techniques	3.12-2
3.12.4.1 Computer Codes	3.12-2
3.12.4.2 Dynamic Piping Model.....	3.12-2
3.12.4.3 Piping Benchmark Program	3.12-2
3.12.4.4 Decoupling Criteria.....	3.12-2
3.12.5 Piping Stress Analyses Criteria	3.12-3
3.12.5.1 Seismic Input Envelope versus Site-Specific Spectra	3.12-3
3.12.5.2 Design Transients	3.12-3
3.12.5.3 Loadings and Load Combinations.....	3.12-3
3.12.5.4 Damping Values	3.12-3
3.12.5.5 Combination of Modal Responses	3.12-3
3.12.5.6 High-Frequency Modes.....	3.12-3
3.12.5.7 Fatigue Evaluation for ASME Code Class 1 Piping	3.12-3
3.12.5.8 Fatigue Evaluation of ASME Code Class 2 and 3 Piping	3.12-4
3.12.5.9 Thermal Oscillations in Piping Connected to the Reactor Coolant System	3.12-4
3.12.5.10 Thermal Stratification	3.12-6
3.12.5.11 Safety Relief Valve Design, Installation, and Testing.....	3.12-8
3.12.5.12 Functional Capability	3.12-8
3.12.5.13 Combination of Inertial and Seismic Anchor Motion Effects.....	3.12-8
3.12.5.14 Operating Basis Earthquake as a Design Load	3.12-8
3.12.5.15 Welded Attachments	3.12-8
3.12.5.16 Modal Damping for Composite Structures	3.12-9
3.12.5.17 Minimum Temperature for Thermal Analyses	3.12-9
3.12.5.18 Intersystem Loss-of-Coolant Accident.....	3.12-9
3.12.5.19 Effects of Environment on Fatigue Design.....	3.12-9
3.12.6 Piping Support Design Criteria	3.12-9
3.12.6.1 Applicable Codes	3.12-9
3.12.6.2 Jurisdictional Boundaries	3.12-9

	3.12.6.3	Loads and Load Combinations.....	3.12-9
	3.12.6.4	Pipe Support Baseplate and Anchor Bolt Design	3.12-9
	3.12.6.5	Use of Energy Absorbers and Limit Stops	3.12-9
	3.12.6.6	Use of Snubbers.....	3.12-10
	3.12.6.7	Pipe Support Stiffnesses	3.12-10
	3.12.6.8	Seismic Self-Weight Excitation.....	3.12-10
	3.12.6.9	Design of Supplementary Steel.....	3.12-10
	3.12.6.10	Consideration of Friction Forces	3.12-10
	3.12.6.11	Pipe Support Gaps and Clearances.....	3.12-10
	3.12.6.12	Instrumentation Line Support Criteria.....	3.12-10
	3.12.6.13	Pipe Deflection Limits.....	3.12-10
	3.12.7	References	3.12-10
3.13		Threaded Fasteners (ASME Code Class 1, 2, and 3).....	3.13-1
	3.13.1	Design Considerations	3.13-2
	3.13.1.1	Materials Selection	3.13-2
	3.13.1.2	Special Materials Fabrication Processes and Special Controls	3.13-2
	3.13.1.3	Fracture Toughness Requirements for Threaded Fasteners Made from Ferritic Materials.....	3.13-3
	3.13.1.4	Pre-Service Inspection Requirements.....	3.13-3
	3.13.1.5	Certified Material Test Reports.....	3.13-3
	3.13.2	Inservice Inspection Requirements	3.13-4
	3.13.3	References	3.13-4
3A		Criteria for Distribution System Analysis and Support.....	3A-1
	3A.1	Piping and Supports	3A-1
	3A.2	Heating, Ventilation, and Air Conditioning Ducts and Supports	3A-1
	3A.2.1	Codes and Standards.....	3A-1
	3A.2.2	HVAC Ductwork	3A-2
	3A.2.3	HVAC Duct Supports and Restraints	3A-3
	3A.2.4	Design and Analysis.....	3A-4
	3A.2.5	Other Criteria.....	3A-6
	3A.3	Cable Tray, Conduit, and Supports	3A-7

	3A.3.1	Codes and Standards.....	3A-7
	3A.3.2	Loads.....	3A-7
	3A.3.3	Load Combinations	3A-8
	3A.3.4	Allowable Stress Criteria	3A-8
	3A.3.5	Damping.....	3A-8
	3A.3.6	Seismic Analysis	3A-8
	3A.4	References	3A-10
3B		Dimensional Arrangement Drawings.....	3B-1
3C		Reactor Coolant System Structural Analysis Methods.....	3C-1
	3C.1	Hydraulic Model Development.....	3C-1
	3C.1.1	Reactor Coolant System Four Loop Hydraulic Model.....	3C-1
	3C.1.2	Steam Generator Secondary Side Hydraulic Model.....	3C-5
	3C.1.3	Reactor Pressure Vessel Isolated Hydraulic Model.....	3C-6
	3C.1.4	Asymmetric Cavity Pressure Hydraulic Model	3C-7
	3C.2	Structural Model Development	3C-7
	3C.2.1	Reactor Coolant System Four Loop Structural Model.....	3C-7
	3C.2.2	Reactor Pressure Vessel Isolated Structural Model.....	3C-12
	3C.3	Hydraulic Loading Analyses	3C-13
	3C.3.1	Thrust Loading	3C-14
	3C.3.2	Jet Impingement Loading	3C-14
	3C.3.3	System Internal Pressure Waves	3C-15
	3C.3.4	Asymmetric Cavity Pressure Wave Loading	3C-17
	3C.4	Structural Loading Analysis	3C-18
	3C.4.1	Static Loading.....	3C-19
	3C.4.2	Dynamic Loading.....	3C-20
	3C.4.3	Load Combinations	3C-27
	3C.5	Amplified Response Spectra Generation	3C-27
	3C.6	Description of Computer Programs	3C-27
	3C.7	References	3C-29

3D	Methodology for Qualifying Safety-Related Electrical and Mechanical Equipment.....	3D-1
3D.1	Purpose	3D-1
3D.2	Scope	3D-1
3D.3	Introduction.....	3D-1
3D.4	Qualification Criteria	3D-2
3D.4.1	Qualification Guides	3D-2
3D.4.2	Definitions.....	3D-2
3D.4.3	Mild versus Harsh Environments.....	3D-4
3D.4.4	Test Sequence	3D-4
3D.4.5	Aging	3D-5
3D.4.6	Operability Time	3D-9
3D.4.7	Performance Criterion	3D-9
3D.4.8	Margin	3D-10
3D.4.9	Treatment of Failures	3D-10
3D.4.10	Traceability	3D-10
3D.5	Design Specifications	3D-10
3D.5.1	Normal Operating Conditions.....	3D-10
3D.5.2	Abnormal Operating Conditions	3D-11
3D.5.3	Seismic.....	3D-11
3D.5.4	Containment Test Environment.....	3D-11
3D.5.5	Design Basis Event Conditions	3D-11
3D.6	Qualification Methods.....	3D-12
3D.6.1	Type Test	3D-13
3D.6.2	Analysis.....	3D-14
3D.7	Equipment Qualification Maintenance Requirements.....	3D-16
3D.7.1	Operating Experience.....	3D-17
3D.7.2	On-Going Qualification	3D-18
3D.7.3	Combinations of Methods.....	3D-18
3D.8	Documentation	3D-19
3D.8.1	Equipment Qualification Data Package.....	3D-19
3D.8.2	Equipment Qualification Test Reports.....	3D-19
3D.8.3	Qualification Maintenance Requirements.....	3D-19

3D.9	References	3D-19
3D Attach A	Sample Equipment Qualification Data Package (EQDP)	3D-40
3D Attach B	Aging Evaluation Program	3D-83
B.1	Introduction.....	3D-83
B.2	Objectives.....	3D-83
B.3	Basic Approach	3D-83
B.4	Safety-Related Electrical Equipment Located in a Harsh Location	3D-83
B.5	Safety-Related Electrical Equipment Located in a Mild Location	3D-85
3D Attach C	Effects of Gamma Radiation Doses Below 10^4 Rads on the Mechanical Properties of Materials	3D-87
C.1	Introduction.....	3D-87
C.2	Scope	3D-87
C.3	Discussion	3D-87
C.4	Results	3D-88
C.5	References	3D-88
3D Attach D	Accelerated Thermal Aging Parameters.....	3D-89
D.1	Introduction.....	3D-89
D.2	Arrhenius Equation.....	3D-89
D.3	Activation Energy	3D-89
D.4	Thermal Aging (Normal/Abnormal Operating Conditions)	3D-91
D.5	References	3D-92
3D Attach E	Seismic Qualification Techniques.....	3D-94
E.1	Purpose	3D-94
E.2	Definitions.....	3D-94
E.3	Seismic Qualification Methods	3D-95
E.4	Requirements	3D-97
E.5	Qualification by Test.....	3D-98
E.6	Qualification by Analysis	3D-103
E.7	Qualification by Similarity	3D-107
E.8	Deleted.....	3D-107

	E.9	Performance Criteria	3D-107
	E.10	References	3D-108
	3D Attach F	Sample Seismic Qualification Data Package (SQDP)	3D-109
3E		Design Details and Critical Sections for Safety-Related Category I Structures	3E-1
	3E.1	Nuclear Island Structures	3E-1
	3E.1.1	Reactor Containment Building—Wall to Foundation Connection	3E-6
	3E.1.2	Reactor Containment Building—Equipment Hatch Area	3E-8
	3E.1.3	Reactor Containment Building—Typical Cylinder Wall and Buttress	3E-9
	3E.1.4	Reactor Building Internal Structures—Steam Generator and Reactor Coolant Pump Support and Typical Cavity Wall	3E-12
	3E.1.5	Reactor Building Internal Structures—Pressurizer Support and Typical Cavity Wall	3E-15
	3E.1.6	Reactor Building Internal Structures—Operating Floor Area.....	3E-17
	3E.1.7	Reactor Shield Building – Connection of FB and SB 2 and 3 Roofs to RSB Wall.....	3E-19
	3E.1.8	Safeguard Buildings—Walls Below Grade.....	3E-21
	3E.1.9	Foundation of Nuclear Island Buildings and Base Slab of the RB Internal Structures.....	3E-23
	3E.2	Emergency Power Generating Buildings.....	3E-171
	3E.2.1	Basemat Foundation	3E-174
	3E.2.2	Typical Wall at Column Line 11.....	3E-175
	3E.2.3	Reinforced Concrete Slab and Composite Beams at Elevation 51 ft – 6 in.....	3E-176
	3E.3	Essential Service Water Buildings.....	3E-198
	3E.3.1	Basemat Foundation at Elevation -16 ft – 0 in (Top of Concrete).....	3E-200
	3E.3.2	Shear Wall at Column Line 4.....	3E-201
	3E.3.3	Fan Deck Slab at Elevation 63 ft – 0 in	3E-203

Next File