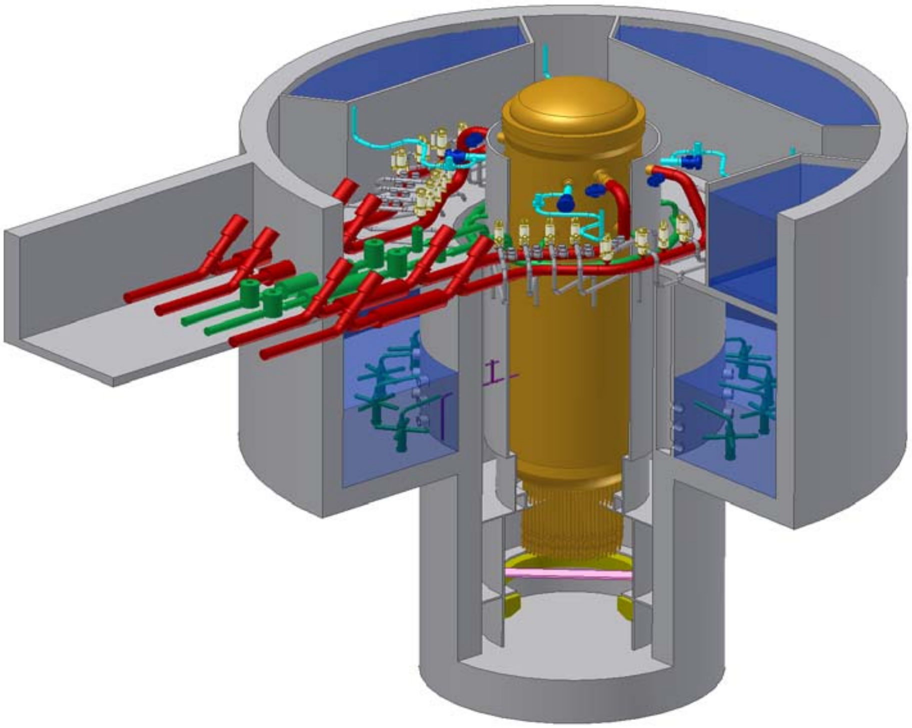
GE Nuclear Energy

26A6642BN
Revision 2
October 2006



ESBWR Design Control Document

Tier 2
Chapter 14
Initial Test Program

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Global Abbreviations And Acronyms List

Term	**Definition**
10 CFR	Title 10, Code of Federal Regulations
A/D	Analog-to-Digital
AASHTO	American Association of Highway and Transportation Officials
AB	Auxiliary Boiler
ABS	Auxiliary Boiler System
ABWR	Advanced Boiling Water Reactor
ac / AC	Alternating Current
AC	Air Conditioning
ACF	Automatic Control Function
ACI	American Concrete Institute
ACS	Atmospheric Control System
AD	Administration Building
ADS	Automatic Depressurization System
AEC	Atomic Energy Commission
AFIP	Automated Fixed In-Core Probe
AGMA	American Gear Manufacturer's Association
AHS	Auxiliary Heat Sink
AHU	Air Heating Unit
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
AL	Analytical Limit
ALARA	As Low As Reasonably Achievable
ALWR	Advanced Light Water Reactor
ANS	American Nuclear Society
ANSI	American National Standards Institute
AOO	Anticipated Operational Occurrence
AOV	Air Operated Valve
API	American Petroleum Institute
APLHGR	Average Planar Linear Head Generation Rate
APRM	Average Power Range Monitor
APR	Automatic Power Regulator
APRS	Automatic Power Regulator System
ARI	Alternate Rod Insertion
ARMS	Area Radiation Monitoring System
ASA	American Standards Association
ASD	Adjustable Speed Drive
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
AST	Alternate Source Term

Term	**Definition**
ASTM	American Society of Testing Methods
AT	Unit Auxiliary Transformer
ATLM	Automated Thermal Limit Monitor
ATWS	Anticipated Transients Without Scram
AV	Allowable Value
AWS	American Welding Society
AWWA	American Water Works Association
B&PV	Boiler and Pressure Vessel
BAF	Bottom of Active Fuel
BHP	Brake Horse Power
BOP	Balance of Plant
BPU	Bypass Unit
BPWS	Banked Position Withdrawal Sequence
BRE	Battery Room Exhaust
BRL	Background Radiation Level
BTP	NRC Branch Technical Position
BTU	British Thermal Unit
BWR	Boiling Water Reactor
BWROG	Boiling Water Reactor Owners Group
CAV	Cumulative absolute velocity
C&FS	Condensate and Feedwater System
C&I	Control and Instrumentation
C/C	Cooling and Cleanup
CB	Control Building
CBGAHVS	Control Building General Area
CBHVAC	Control Building HVAC
CBHVS	Control Building Heating, Ventilation and Air Conditioning System
CCI	Core-Concrete Interaction
CDF	Core Damage Frequency
CFR	Code of Federal Regulations
CIRC	Circulating Water System
CIS	Containment Inerting System
CIV	Combined Intermediate Valve
CLAVS	Clean Area Ventilation Subsystem of Reactor Building HVAC
CM	Cold Machine Shop
CMS	Containment Monitoring System
CMU	Control Room Multiplexing Unit
COL	Combined Operating License
COLR	Core Operating Limits Report
CONAVS	Controlled Area Ventilation Subsystem of Reactor Building HVAC

Term	**Definition**
CPR	Critical Power Ratio
CPS	Condensate Purification System
CPU	Central Processing Unit
CR	Control Rod
CRD	Control Rod Drive
CRDA	Control Rod Drop Accident
CRDH	Control Rod Drive Housing
CRDHS	Control Rod Drive Hydraulic System
CRGT	Control Rod Guide Tube
CRHA	Control Room Habitability Area
CRHAHVS	Control Room Habitability Area HVAC Sub-system
CRT	Cathode Ray Tube
CS&TS	Condensate Storage and Transfer System
CSDM	Cold Shutdown Margin
CS / CST	Condensate Storage Tank
CT	Main Cooling Tower
CTVCF	Constant Voltage Constant Frequency
CUF	Cumulative usage factor
CWS	Chilled Water System
D-RAP	Design Reliability Assurance Program
DAC	Design Acceptance Criteria
DAW	Dry Active Waste
DBA	Design Basis Accident
dc / DC	Direct Current
DCD	Design Control Document
DCS	Drywell Cooling System
DCIS	Distributed Control and Information System
DEPSS	Drywell Equipment and Pipe Support Structure
DF	Decontamination Factor
D/F	Diaphragm Floor
DG	Diesel-Generator
DHR	Decay Heat Removal
DM&C	Digital Measurement and Control
DOF	Degree of freedom
DOI	Dedicated Operators Interface
DOT	Department of Transportation
dPT	Differential Pressure Transmitter
DPS	Diverse Protection System
DPV	Depressurization Valve
DR&T	Design Review and Testing

Term	Definition
DS	Independent Spent Fuel Storage Installation
DTM	Digital Trip Module
DW	Drywell
EB	Electrical Building
EBAS	Emergency Breathing Air System
EBHV	Electrical Building HVAC
ECCS	Emergency Core Cooling System
E-DCIS	Essential DCIS (Distributed Control and Information System)
EDO	Environmental Qualification Document
EFDS	Equipment and Floor Drainage System
EFPY	Effective full power years
EFU	Emergency Filter Unit
EHC	Electrohydraulic Control (Pressure Regulator)
ENS	Emergency Notification System
EOC	Emergency Operations Center
EOC	End of Cycle
EOF	Emergency Operations Facility
EOP	Emergency Operating Procedures
EPDS	Electric Power Distribution System
EPG	Emergency Procedure Guidelines
EPRI	Electric Power Research Institute
EQ	Environmental Qualification
ERICP	Emergency Rod Insertion Control Panel
ERIP	Emergency Rod Insertion Panel
ESF	Engineered Safety Feature
ETS	Emergency Trip System
FAC	Flow-Accelerated Corrosion
FAPCS	Fuel and Auxiliary Pools Cooling System
FATT	Fracture Appearance Transition Temperature
FB	Fuel Building
FBHV	Fuel Building HVAC
FCI	Fuel-Coolant Interaction
FCM	File Control Module
FCS	Flammability Control System
FCU	Fan Cooling Unit
FDDI	Fiber Distributed Data Interface
FFT	Fast Fourier Transform
FFWTR	Final Feedwater Temperature Reduction
FHA	Fire Hazards Analysis
FIV	Flow-Induced Vibration

Term	**Definition**
FMCRD	Fine Motion Control Rod Drive
FMEA	Failure Modes and Effects Analysis
FPS	Fire Protection System
FO	Diesel Fuel Oil Storage Tank
FOAKE	First-of-a-Kind Engineering
FPE	Fire Pump Enclosure
FTDC	Fault-Tolerant Digital Controller
FTS	Fuel Transfer System
FW	Feedwater
FWCS	Feedwater Control System
FWS	Fire Water Storage Tank
GCS	Generator Cooling System
GDC	General Design Criteria
GDCS	Gravity-Driven Cooling System
GE	General Electric Company
GE-NE	GE Nuclear Energy
GEN	Main Generator System
GETAB	General Electric Thermal Analysis Basis
GL	Generic Letter
GM	Geiger-Mueller Counter
GM-B	Beta-Sensitive GM Detector
GSIC	Gamma-Sensitive Ion Chamber
GSOS	Generator Sealing Oil System
GWSR	Ganged Withdrawal Sequence Restriction
HAZ	Heat-Affected Zone
HCU	Hydraulic Control Unit
HCW	High Conductivity Waste
HDVS	Heater Drain and Vent System
HEI	Heat Exchange Institute
HELB	High Energy Line Break
HEP	Human error probability
HEPA	High Efficiency Particulate Air/Absolute
HFE	Human Factors Engineering
HFF	Hollow Fiber Filter
HGCS	Hydrogen Gas Cooling System
HIC	High Integrity Container
HID	High Intensity Discharge
HIS	Hydraulic Institute Standards
HM	Hot Machine Shop & Storage
HP	High Pressure

Term	**Definition**
HPNSS	High Pressure Nitrogen Supply System
HPT	High-pressure turbine
HRA	Human Reliability Assessment
HSI	Human-System Interface
HSSS	Hardware/Software System Specification
HVAC	Heating, Ventilation and Air Conditioning
HVS	High Velocity Separator
HWC	Hydrogen Water Chemistry
HWCS	Hydrogen Water Chemistry System
HWS	Hot Water System
HX	Heat Exchanger
I&C	Instrumentation and Control
I/O	Input/Output
IAS	Instrument Air System
IASCC	Irradiation Assisted Stress Corrosion Cracking
IBC	International Building Code
IC	Ion Chamber
IC	Isolation Condenser
ICD	Interface Control Diagram
ICS	Isolation Condenser System
IE	Inspection and Enforcement
IEB	Inspection and Enforcement Bulletin
IED	Instrument and Electrical Diagram
IEEE	Institute of Electrical and Electronic Engineers
IFTS	Inclined Fuel Transfer System
IGSCC	Intergranular Stress Corrosion Cracking
IIS	Iron Injection System
ILRT	Integrated Leak Rate Test
IOP	Integrated Operating Procedure
IMC	Induction Motor Controller
IMCC	Induction Motor Controller Cabinet
IRM	Intermediate Range Monitor
ISA	Instrument Society of America
ISI	In-Service Inspection
ISLT	In-Service Leak Test
ISM	Independent Support Motion
ISMA	Independent Support Motion Response Spectrum Analysis
ISO	International Standards Organization
ITA	Inspections, Tests or Analyses
ITAAC	Inspections, Tests, Analyses and Acceptance Criteria

Term	Definition
ITA	Initial Test Program
LAPP	Loss of Alternate Preferred Power
LCO	Limiting Conditions for Operation
LCW	Low Conductivity Waste
LD	Logic Diagram
LDA	Lay down Area
LD&IS	Leak Detection and Isolation System
LERF	Large early release frequency
LFCV	Low Flow Control Valve
LHGR	Linear Heat Generation Rate
LLRT	Local Leak Rate Test
LMU	Local Multiplexer Unit
LO	Dirty/Clean Lube Oil Storage Tank
LOCA	Loss-of-Coolant-Accident
LOFW	Loss-of-feedwater
LOOP	Loss of Offsite Power
LOPP	Loss of Preferred Power
LP	Low Pressure
LPCI	Low Pressure Coolant Injection
LPCRD	Locking Piston Control Rod Drive
LPMS	Loose Parts Monitoring System
LPRM	Local Power Range Monitor
LPSP	Low Power Setpoint
LWMS	Liquid Waste Management System
MAAP	Modular Accident Analysis Program
MAPLHGR	Maximum Average Planar Linear Head Generation Rate
MAPRAT	Maximum Average Planar Ratio
MBB	Motor Built-In Brake
MCC	Motor Control Center
MCES	Main Condenser Evacuation System
MCPR	Minimum Critical Power Ratio
MCR	Main Control Room
MCRP	Main Control Room Panel
MELB	Moderate Energy Line Break
MLHGR	Maximum Linear Heat Generation Rate
MMI	Man-Machine Interface
MMIS	Man-Machine Interface Systems
MOV	Motor-Operated Valve
MPC	Maximum Permissible Concentration
MPL	Master Parts List

Term	Definition
MS	Main Steam
MSIV	Main Steam Isolation Valve
MSL	Main Steamline
MSLB	Main Steamline Break
MSLBA	Main Steamline Break Accident
MSR	Moisture Separator Reheater
MSV	Mean Square Voltage
MT	Main Transformer
MTTR	Mean Time To Repair
MWS	Makeup Water System
NBR	Nuclear Boiler Rated
NBS	Nuclear Boiler System
NCIG	Nuclear Construction Issues Group
NDE	Nondestructive Examination
NE-DCIS	Non-Essential Distributed Control and Information System
NDRC	National Defense Research Committee
NDT	Nil Ductility Temperature
NFPA	National Fire Protection Association
NIST	National Institute of Standard Technology
NICWS	Nuclear Island Chilled Water Subsystem
NMS	Neutron Monitoring System
NOV	Nitrogen Operated Valve
NPHS	Normal Power Heat Sink
NPSH	Net Positive Suction Head
NRC	Nuclear Regulatory Commission
NRHX	Non-Regenerative Heat Exchanger
NS	Non-seismic
NSSS	Nuclear Steam Supply System
NT	Nitrogen Storage Tank
NTSP	Nominal Trip Setpoint
O&M	Operation and Maintenance
O-RAP	Operational Reliability Assurance Program
OBCV	Overboard Control Valve
OBE	Operating Basis Earthquake
OGS	Offgas System
OHLHS	Overhead Heavy Load Handling System
OIS	Oxygen Injection System
OLMCPR	Operating Limit Minimum Critical Power Ratio
OLU	Output Logic Unit
OOS	Out-of-service

Term	Definition
ORNL	Oak Ridge National Laboratory
OSC	Operational Support Center
OSHA	Occupational Safety and Health Administration
OSI	Open Systems Interconnect
P&ID	Piping and Instrumentation Diagram
PA/PL	Page/Party-Line
PABX	Private Automatic Branch (Telephone) Exchange
PAM	Post Accident Monitoring
PAR	Passive Autocatalytic Recombiner
PAS	Plant Automation System
PASS	Post Accident Sampling Subsystem of Containment Monitoring System
PCC	Passive Containment Cooling
PCCS	Passive Containment Cooling System
PCT	Peak cladding temperature
PCV	Primary Containment Vessel
PFD	Process Flow Diagram
PGA	Peak Ground Acceleration
PGCS	Power Generation and Control Subsystem of Plant Automation System
PH	Pump House
PL	Parking Lot
PM	Preventive Maintenance
PMCS	Performance Monitoring and Control Subsystem of NE-DCIS
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
PQCL	Product Quality Check List
PRA	Probabilistic Risk Assessment
PRMS	Process Radiation Monitoring System
PRNM	Power Range Neutron Monitoring
PS	Plant Stack
PSD	Power Spectra Density
PSS	Process Sampling System
PSWS	Plant Service Water System
PT	Pressure Transmitter
PWR	Pressurized Water Reactor
QA	Quality Assurance
RACS	Rod Action Control Subsystem
RAM	Reliability, Availability and Maintainability
RAPI	Rod Action and Position Information
RAT	Reserve Auxiliary Transformer
RB	Reactor Building

Term	Definition
RBC	Rod Brake Controller
RBCC	Rod Brake Controller Cabinet
RBCWS	Reactor Building Chilled Water Subsystem
RBHV	Reactor Building HVAC
RBS	Rod Block Setpoint
RBV	Reactor Building Vibration
RC&IS	Rod Control and Information System
RCC	Remote Communication Cabinet
RCCV	Reinforced Concrete Containment Vessel
RCCWS	Reactor Component Cooling Water System
RCPB	Reactor Coolant Pressure Boundary
RCS	Reactor Coolant System
RDA	Rod Drop Accident
RDC	Resolver-to-Digital Converter
REPAVS	Refueling and Pool Area Ventilation Subsystem of Fuel Building HVAC
RFP	Reactor Feed Pump
RG	Regulatory Guide
RHR	Residual heat removal (function)
RHX	Regenerative Heat Exchanger
RMS	Root Mean Square
RMS	Radiation Monitoring Subsystem
RMU	Remote Multiplexer Unit
RO	Reverse Osmosis
ROM	Read-only Memory
RPS	Reactor Protection System
RPV	Reactor Pressure Vessel
RRPS	Reference Rod Pull Sequence
RSM	Rod Server Module
RSPC	Rod Server Processing Channel
RSS	Remote Shutdown System
RSSM	Reed Switch Sensor Module
RSW	Reactor Shield Wall
RTIF	Reactor Trip and Isolation Function(s)
RT_{NDT}	Reference Temperature of Nil-Ductility Transition
RTP	Reactor Thermal Power
RW	Radwaste Building
RWBCR	Radwaste Building Control Room
RWBGA	Radwaste Building General Area
RWBHVAC	Radwaste Building HVAC
RWCU/SDC	Reactor Water Cleanup/Shutdown Cooling

Term	**Definition**
RWE	Rod Withdrawal Error
RWM	Rod Worth Minimizer
SA	Severe Accident
SAR	Safety Analysis Report
SB	Service Building
S/C	Digital Gamma-Sensitive GM Detector
SC	Suppression Chamber
S/D	Scintillation Detector
S/DRSRO	Single/Dual Rod Sequence Restriction Override
S/N	Signal-to-Noise
S/P	Suppression Pool
SAS	Service Air System
SB&PC	Steam Bypass and Pressure Control System
SBO	Station Blackout
SBWR	Simplified Boiling Water Reactor
SCEW	System Component Evaluation Work
SCG	Startup Coordinating Group
SCRRI	Selected Control Rod Run-in
SDC	Shutdown Cooling
SDM	Shutdown Margin
SDS	System Design Specification
SEOA	Sealed Emergency Operating Area
SER	Safety Evaluation Report
SF	Service Water Building
SFP	Spent fuel pool
SIL	Service Information Letter
SIT	Structural Integrity Test
SIU	Signal Interface Unit
SJAE	Steam Jet Air Ejector
SLC	Standby Liquid Control
SLCS	Standby Liquid Control System
SLMCPR	Safety Limit Minimum Critical Power Ratio
SMU	SSLC Multiplexing Unit
SOV	Solenoid Operated Valve
SP	Setpoint
SPC	Suppression Pool Cooling
SPDS	Safety Parameter Display System
SPTMS	Suppression Pool Temperature Monitoring Subsystem of Containment Monitoring System
SR	Surveillance Requirement
SRM	Source Range Monitor

Term	Definition
SRNM	Startup Range Neutron Monitor
SRO	Senior Reactor Operator
SRP	Standard Review Plan
SRS	Software Requirements Specification
SRSRO	Single Rod Sequence Restriction Override
SRSS	Sum of the squares
SRV	Safety Relief Valve
SRVDL	Safety relief valve discharge line
SSAR	Standard Safety Analysis Report
SSC(s)	Structure, System and Component(s)
SSE	Safe Shutdown Earthquake
SSLC	Safety System Logic and Control
SSPC	Steel Structures Painting Council
ST	Spare Transformer
STP	Sewage Treatment Plant
STRAP	Scram Time Recording and Analysis Panel
STRP	Scram Time Recording Panel
SV	Safety Valve
SWH	Static water head
SWMS	Solid Waste Management System
SY	Switch Yard
TAF	Top of Active Fuel
TASS	Turbine Auxiliary Steam System
TB	Turbine Building
TBCE	Turbine Building Compartment Exhaust
TEAS	Turbine Building Air Supply
TBE	Turbine Building Exhaust
TBLOE	Turbine Building Lube Oil Area Exhaust
TBS	Turbine Bypass System
TBHV	Turbine Building HVAC
TBV	Turbine Bypass Valve
TC	Training Center
TCCWS	Turbine Component Cooling Water System
TCS	Turbine Control System
TCV	Turbine Control Valve
TDH	Total Developed Head
TEMA	Tubular Exchanger Manufacturers' Association
TFSP	Turbine first stage pressure
TG	Turbine Generator
TGSS	Turbine Gland Seal System

Term	Definition
THA	Time-history accelerograph
TLOS	Turbine Lubricating Oil System
TLU	Trip Logic Unit
TMI	Three Mile Island
TMSS	Turbine Main Steam System
TRM	Technical Requirements Manual
TS	Technical Specification(s)
TSC	Technical Support Center
TSI	Turbine Supervisory Instrument
TSV	Turbine Stop Valve
UBC	Uniform Building Code
UHS	Ultimate heat sink
UL	Underwriter's Laboratories Inc.
UPS	Uninterruptible Power Supply
USE	Upper Shelf Energy
USM	Uniform Support Motion
USMA	Uniform support motion response spectrum analysis
USNRC	United States Nuclear Regulatory Commission
USS	United States Standard
UV	Ultraviolet
V&V	Verification and Validation
Vac / VAC	Volts Alternating Current
Vdc / VDC	Volts Direct Current
VDU	Video Display Unit
VW	Vent Wall
VWO	Valves Wide Open
WD	Wash Down Bays
WH	Warehouse
WS	Water Storage
WT	Water Treatment
WW	Wetwell
XMFR	Transformer
ZPA	Zero period acceleration

14. INITIAL TEST PROGRAM

14.1 INITIAL TEST PROGRAM FOR PRELIMINARY SAFETY ANALYSIS REPORTS

The standard review plan for this section has been deleted.

14.2 INITIAL PLANT TEST PROGRAM FOR FINAL SAFETY ANALYSIS REPORTS

14.2.1 Summary of Test Program and Objectives

The initial test program consists of a series of tests categorized as construction, preoperational, or initial startup tests. The construction acceptance tests determine correct installation and functional operability of equipment. Preoperational tests are those tests normally conducted prior to fuel loading to demonstrate the capability of plant systems to meet performance requirements. Initial startup tests begin with fuel loading and demonstrate the capability of the integrated plant to meet performance requirements.

The objectives of the initial test program are to:

- Ensure that the construction is complete and acceptable;
- Demonstrate the capability of structures, systems, and components to meet performance requirements;
- Effect fuel loading in a safe manner;
- Demonstrate, where practical, that the plant is capable of withstanding anticipated transients and postulated accidents;
- Evaluate and demonstrate, to the extent possible, plant operating procedures to provide assurance that the operating group is knowledgeable about the plant and procedures and fully prepared to operate the facility in a safe manner; and
- Bring the plant to rated capacity and sustained power operation.

14.2.1.1 Construction Test Objectives

Construction tests are performed to demonstrate that components and systems are correctly installed and operational. These tests include, but are not limited to, flushing and cleaning, hydrostatic testing, initial calibration of instrumentation, checks of electrical wiring and equipment, valve testing, and initial energization and operation of equipment and systems. Completion of this phase assures systems are ready for preoperational testing. Abstracts of these tests are not provided as part of this chapter.

14.2.1.2 Preoperational Test Objectives

Preoperational tests are conducted prior to fuel loading in order to verify that plant systems are capable of operating in a safe and efficient manner compatible with the system design bases. The general objectives of the preoperational test phase are as follows:

- Ensure design specification and test acceptance criteria are met;
- Provide documentation of the performance and safety of equipment and systems;
- Provide baseline test and operating data on equipment and systems for future reference;
- Run-in new equipment for a sufficient period so that any design, manufacturing, or installation defects can be detected and corrected;
- Ensure plant systems operate together on an integrated basis to the extent possible;

- Give maximum opportunity to the permanent plant operating staff to obtain practical experience in the operation and maintenance of equipment and systems;
- Establish and evaluate normal, abnormal, and emergency operating procedures to the extent possible;
- Establish and evaluate surveillance testing procedures; and
- Demonstrate that systems and safety equipment are operational and that it is possible to proceed to fuel loading and to the startup phase.

14.2.1.3 Startup Test Objectives

After the preoperational test phase has been completed, the startup phase begins with fuel loading and extends to commercial operation. This phase may be generally subdivided into the following four parts:

(1) Fuel loading and shutdown power level tests

(2) Testing during nuclear heatup to rated temperature and pressure (approximately 5% power);

(3) Power testing at low power, mid-power and high power; and

(4) Warranty demonstration.

The tests conducted during the startup phase consist of major and minor plant transients, steady-state tests, and process control system tests. These tests are directed towards demonstrating correct performance of the nuclear boiler and the various plant systems while at power.

The general objectives of the startup phase are to:

- Achieve an orderly and safe initial core loading;
- Accomplish testing and measurements necessary to assure the approach to initial criticality and subsequent power ascension is safe and orderly;
- Conduct low-power physics tests sufficient to ensure test acceptance criteria have been met;
- Conduct initial heatup and an orderly safe power ascension program, with requisite physics and systems testing, to ensure that integrated plant operation at power meets test acceptance criteria; and
- Conduct a successful warranty demonstration.

14.2.1.4 Organization and Staffing

Normal Plant Staff

Normal plant staff responsibilities, authorities, and qualifications are given in Chapter 13. During the construction cycle and the various testing phases, the plant owner/operator, GE Nuclear Energy (GE-NE), and others supply additional staff.

Startup Group

The startup group is an ad hoc organization created for the purpose of ensuring that the initial test program of preoperational and startup tests is conducted in an efficient, safe, and timely manner. The startup group is responsible for the planning, executing and documenting of the startup and testing related activities that occur between the completion of the construction phase and commencement of commercial operation of the plant. At approval to load fuel, the plant operations organization assumes complete responsibility for the plant. The licensed RO/SRO's have legal responsibility. The start-up organization will report to the operations department for testing support. At completion of the startup program, the startup group is dissolved and the normal plant operating staff assumes complete responsibility for the plant. Ideally, the startup group includes individuals assigned temporarily from the various departments and disciplines within the normal plant and utility organization. This assures maximum transfer and retention of experience and knowledge gained during the startup program for the subsequent commercial operation of the plant. The normal plant staff is included in as many aspects of the test programs as is practicable considering their normal duties in the operation and maintenance of the plant.

General Electric Company

GE-NE is the designer and supplier of the ESBWR power plant. During the construction and testing phases of the plant, GE-NE personnel are onsite to direct the work of the constructor and to offer consultation and technical direction. The GE-NE resident site manager is responsible for these activities , and is the official site spokesman for GE-NE. He coordinates with the combined operating license (COL) licensee’s normal and augmented plant staff for the performance of his duties, which include:

- Reviewing and approving test procedures, changes to test procedures, and test results for equipment and systems within the plant;
- Providing technical direction to the station staff;
- Managing the activities of the GE-NE site personnel in providing technical direction to shift personnel in the testing and operation of the plant;
- Providing liaison between the site and the GE-NE home office to provide rapid and effective solutions for problems which cannot be solved onsite; and
- Participating as a member of the Startup Coordinating Group (SCG). [Note: The official designation of this group may differ for the plant owner/operator referencing the ESBWR design, and SCG is used throughout this discussion for illustrative purposes only.]

Others

Other concerned parties (outside the plant staff organization) such as the constructor, the turbine-generator supplier, and vendors of other systems and equipment, are involved in the testing program to various degrees. Such involvement may be in a direct role in the startup group as discussed above or in an indirect capacity offering consultation or technical direction concerning the testing, operation, or resolution of problems or concerns with equipment and systems for which they are responsible or are uniquely familiar with.

Interrelationships and Interfaces

Effective coordination between the various site organizations involved in the test program is achieved through the SCG, which is composed of representatives of the plant owner/operator, GE-NE, and others. The duties of the SCG are to review and approve project testing schedules and to effect timely changes to construction or testing in order to facilitate execution of the preoperational and initial startup test programs.

14.2.2 Test Procedures

In general, testing during the initial test program is conducted using detailed, step-by-step written procedures to control the conduct of each test. These specifically include safety precautions and limits as needed for the test to supplement those in the normal operating procedure. Such test procedures:

- specify testing prerequisites,
- describe desired initial conditions,
- include appropriate methods to direct and control test performance (including the sequencing of testing),
- specify acceptance criteria by which the test is to be evaluated, and
- provide for or specify the format by which data or observations are to be recorded.

The procedures are developed and reviewed by personnel with appropriate technical backgrounds and experience. This includes the participation of principal design organizations (including GE-NE) to establish test performance requirements and acceptance criteria. Specifically, GE-NE provides the COL licensee with scoping documents (i.e., plant preoperational and startup test specifications) containing testing objectives and acceptance criteria applicable to the plant design. Such documents shall also include, as appropriate, delineation of specific plant operational conditions at which tests are to be conducted, testing methodologies to be utilized, specific data to be collected, and acceptable data reduction techniques. Available information on operating and testing experiences of operating power reactors is factored into test procedures as appropriate. Test procedures are reviewed by the SCG and receive final approval by designated plant management personnel. Approved test procedures for satisfying the commitments of this chapter are made available approximately 60 days prior to their intended use for preoperational tests and 60 days prior to scheduled fuel loading for power ascension tests.

Conduct of Test Program

The startup group conducts the initial test program in accordance with the startup administrative manual. This manual contains the administrative procedures and requirements that govern the activities of the startup group and their interface with other organizations. The startup administrative manual receives the same level of review and approval, as do other plant administrative procedures. It defines the specific format and content of preoperational and startup test procedures, as well as the review and approval process for both initial procedures and subsequent revisions or changes. The startup administrative manual also specifies the process for review and approval of test results and for resolution of failures to meet acceptance criteria and of other operational problems or design deficiencies noted. It describes the various phases of the initial test program and establishes the requirements for progressing from one phase to the next, as well as those for moving beyond selected holdpoints or milestones within a given phase. It also describes the controls in place that assure the as-tested status of each system is known and that track modifications, including retest requirements, deemed necessary for systems undergoing or already having completed specified testing. Additionally, the startup administrative manual delineates the qualifications and responsibilities of the different positions within the startup group. The startup administrative manual is intended to supplement normal plant administrative procedures by addressing those concerns that are unique to the startup program or that are best approached in a different manner. To avoid confusion, the startup program attempts to be consistent with normal plant procedure where practical. The plant staff typically performs their duties according to normal plant procedures. However, in areas of potential conflict with the goals of the startup program, the startup administrative manual or the individual test procedures address the required interface.

Review, Evaluation, and Approval of Test Results

Individual test results are evaluated and reviewed by members of the startup group. Test exceptions or acceptance criteria violations are communicated to the affected and responsible organizations who help resolve the issues by suggesting corrective actions, design modifications, and retests. GE-NE and others outside the plant staff organization, as appropriate, have the opportunity to review the results for conformance to predications and expectations. Test results, including final resolutions, are then reviewed and approved by designated startup group supervisory personnel. Final approval is obtained from the SCG and the appropriate level of plant management as defined in the startup administrative manual. The SCG and the designated level of plant management also have responsibility for final review and approval of overall test phase results and of that for selected milestones or hold-points within the test phases.

Test Records

Initial test program results are compiled and maintained according to the startup manual, plant administrative procedures, and applicable regulatory requirements. Test records that demonstrate the adequacy of safety-related components, systems and structures shall be retained for the life of the plant. Retention periods for other test records are based on consideration of their usefulness in documenting initial plant performance characteristics.

14.2.3 Test Program's Conformance with Regulatory Guides

The development of the initial test program uses NRC Regulatory Guides listed below (see compliance section 1.8):

- Regulatory Guide 1.68 — “Initial Test Programs for Water-Cooled Nuclear Power Plants;”
- Regulatory Guide 1.68.1 — “Preoperational and Initial Startup Testing of Feedwater and Condensate Systems for Boiling Water Reactor Power Plants;”
- Regulatory Guide 1.68.2 — “Initial Startup Test Program to Demonstrate Remote Shutdown Capability for Water-Cooled Nuclear Power Plants;”

- Regulatory Guide 1.68.3 — "Preoperational Testing of Instrument and Control Air Systems;"
- Regulatory Guide 1.20 — "Comprehensive Vibration Assessment Program for Reactor Internals During Preoperation and Initial Startup Testing;"
- Regulatory Guide 1.41 — "Preoperational Testing of Redundant Onsite Electric Power Systems to Verify Proper Load Group Assignments;"
- Regulatory Guide 1.56 — "Maintenance of Water Purity in Boiling Water Reactors;"
- Regulatory Guide 1.95 — "Protection of Nuclear Power Plant Control Room Operators Against an Accidental Chlorine Release," in accordance with SRP Section 14.2;
- Regulatory Guide 1.108 — "Periodic Testing of Diesel Generator Units Used as Onsite Electric Power Systems at Nuclear Power Plants" in accordance with SRP Section 14.2;
- The application portion (shutdown cooling) of RG 1.139, "Guidance for Residual Heat Removal," in accordance with SRP Section 14.2;
- Regulatory Guide 1.140 — "Design, Testing and Maintenance Criteria for Normal Ventilation Exhaust System Air Filtration and Adsorption Units of Light Water Cooled Nuclear Power Plants."

14.2.4 Utilization of Reactor Operating and Testing Experience in the Development of Test Program

Because every reactor/plant in a GE-NE BWR product line is an evolutionary development of the previous plant in the product line (and each product line is an evolutionary development from the previous product line), it is evident that the ESBWR plants have the benefits of experience acquired with the successful and safe startup of more than 30 previous BWR and ABWR plants. The operational experience and knowledge gained from these plants and other reactor types have been factored into the design and test specifications of ESBWR systems and equipments that are demonstrated during the preoperational and startup test programs. Additionally, reactor operating and testing experience of similar nuclear power plants obtained from NRC Licensee Event Reports, Institute of Nuclear Operations (INPO) correspondence, and through other industry sources are utilized to the extent practicable in developing and carrying out the initial test program.

14.2.5 Use of Plant Operating and Emergency Procedures

To the extent practicable throughout the preoperational and initial startup test program, test procedures utilize operating, surveillance, emergency, and abnormal procedures where applicable in the performance of tests. The use of these procedures is intended to do the following:

- Prove the specific procedure or illustrate changes which may be required;
- Provide training of plant personnel in the use of these procedures; and
- Increase the level of knowledge of plant personnel on the systems being tested.

A testing procedure may use a combination of references to operating, emergency, or abnormal procedure or repeat a series of steps from the procedure in order to accomplish the above goals while efficiently performing the specified testing.

14.2.6 Initial Fuel Loading and Initial Criticality

Fuel loading and initial criticality are conducted in a controlled manner in accordance with specific written procedures as part of the startup test phase (Subsection 14.2.8.2). However, unforeseen circumstances may arise that would prevent the completion of the preoperational testing (including the review and approval of the test results), but that would not necessarily justify the delay of fuel loading. Under such circumstances, the COL licensee may decide to request permission from the NRC to proceed with fuel loading. If portions of any preoperational tests are intended to be conducted, or their results approved, after commencement of fuel loading, then the following shall be documented in such a request:

- List each test;
- State which portions of each test are delayed until after fuel loading;
- Provide technical justification for delaying these portions; and
- State when each test would be completed and the results approved.

Pre-Fuel Load Checks

Once the plant has been declared ready to load fuel, a number of specific checks shall be made prior to proceeding, including a final review of the preoperational test results and the status of any design changes, work packages, and/or retests that were initiated as a result of exceptions noted during this phase. Also, the Technical Specifications surveillance program requirements (Chapter 16) shall be instituted at this time to ensure the operability of systems required for fuel loading. Just prior to the initiation of fuel loading, proper vessel water level and chemistry shall be verified and the calibration and response of nuclear instruments shall be checked.

Initial Fuel Loading

Fuel loading requires the movement of the full core complement of assemblies from the fuel pool to the core, with each assembly being identified by serial number before being placed in the correct coordinate position. The fuel loading procedure ensures safe loading increments by specifying the predetermined intervals to check the shutdown margin and subcriticality. In-vessel neutron monitors provide continuous indication of the core flux level as each assembly is added. A complete check is made of the fully loaded core to ascertain that the assemblies are properly installed, correctly oriented, and occupying their designated positions.

Pre-Criticality Testing

Prior to initial criticality, the shutdown margin shall be verified for the fully loaded core. The control rods shall be function and scram tested with the fuel in place. Additionally, a final verification that the required Technical Specification surveillances have been performed shall be made.

Initial Criticality

During initial criticality, the full core shutdown margin shall be verified as specified in Subsection 14.2.8.2.4. Initial criticality shall be achieved in an orderly, controlled fashion following specific detailed procedures in a prescribed rod withdrawal sequence that has been approved by the plant management. Core neutron flux shall be continuously monitored during the approach to critical and the rod pattern at critical is compared to prediction to allow early detection and evaluation of potential anomalies.

14.2.7 Test Program Schedule and Sequence

The schedule, relative to the initial fuel load date, for conducting each major phase of the initial test program is provided by the COL licensee. This includes the timetable for generation, review, and approval of procedures, as well as the actual testing and analysis of results. As a minimum, at least nine months should be allowed for conducting the preoperational phase prior to the fuel loading date, and at least three months should be allowed for conducting the startup and power ascension testing that commences with fuel loading. To allow for NRC review, test procedure preparation are scheduled such that approved procedures are available approximately 60 days prior to their intended use or 60 days prior to fuel load for power ascension test procedures. Although there is considerable flexibility available in the sequencing of testing within a given phase, there is also a basic order that results in the most efficient schedule.

The design of the ESBWR utilizes a Distributed Control & Information System (DCIS) for instrumentation and control systems. Thus, the DCIS must be functional before many pre-op tests can begin. The DCIS Pre-Op Test (see Subsection 14.2.8.1.7) can begin early and would control scheduling for other tests until they are completed. During the preoperational phase, testing should be performed as system turnover from construction allows. However, the interdependence of systems should also be considered so that common support systems, such as electrical power distribution, DCIS, service and instrument air, and the various makeup water and cooling water systems, are tested as early as possible.

Sequencing of testing during the startup phase depends primarily on specified power conditions and intersystem prerequisites. To the extent practicable, the schedule should establish that, prior to exceeding 25% power, the test requirements are met for those plant structures, systems, and components that are relied on to prevent, limit, or mitigate the consequences of postulated accidents.

Power ascension testing is conducted in essentially three phases:

(1) Initial fuel loading and open vessel testing;

(2) Testing during nuclear heatup to rated temperature and pressure (less than 5% power); and

(3) Power operation testing from 5% to 100% rated power.

The power operation testing plateaus shall consist of low power testing at less than 25% power, mid-power testing up to about 75% power, and high power testing up to rated power. Thus, there are a total of five different testing plateaus designated, Table 14.2-1 indicates in which testing plateaus the various power ascension tests are performed. Although the order of testing within a given plateau is somewhat flexible, the normal recommended sequence of tests would be:

(1) Core performance analysis;

(2) Steady-state tests;

(3) Control system tuning;

(4) System transient tests; and

(5) Major plant transients (including trips).

For a given testing plateau, testing at lower power levels should generally be performed prior to that at higher power levels.

The detailed testing schedule is generated by GE and the COL licensee and is made available to the NRC prior to actual implementation. The schedule may be updated and continually optimized to reflect actual progress and subsequent revised projections.

14.2.8 Individual Test Descriptions

14.2.8.1 Preoperational Test Procedures

The following general descriptions relate the objectives of each preoperational test. During the final construction phase, it may be necessary to modify the preoperational test methods as operating and preoperational test procedures are developed. Consequently, methods in the following descriptions are general, not specific.

Specific testing to be performed and the applicable acceptance criteria for each preoperational test is documented in test procedures to be made available to the NRC approximately 60 days prior to their intended use. Preoperational tests are in accordance with the system specifications and associated equipment specifications for equipment in those systems provided as part of scoping documents to be supplied by GE-NE and others as described in Subsection 14.2.2. The tests demonstrate that the installed equipment and systems perform within the limits of these specifications. To insure the tests are conducted in accordance with established methods and appropriate acceptance criteria, the plant and system preoperational test specifications will also be made available to the NRC.

The preoperational tests anticipated for the ESBWR are described in the following paragraphs. Testing of systems outside the scope of the standard ESBWR design, but which may have related design (and therefore testing) requirements, are discussed in Subsection 14.2.9, along with other information related to the initial test program. Tests and systems that are not applicable to the ESBWR standard design are:

- Electrical switchyard and equipment;
- The site security plan;
- Personnel monitors and radiation survey instruments; and
- The automatic dispatcher control system.

14.2.8.1.1 Nuclear Boiler System Preoperational Test

Purpose

To verify that the valves, actuators, instrumentation, trip logic, alarms, annunciators, and indications associated with the Nuclear Boiler System (NBS) function as specified.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. The reactor pressure vessel (RPV) and main steam lines (MSL) can accept water during the test. The nitrogen gas and instrument air are available to support operation of MS valves. Electrical power is available to support main steam (MS) valves, instrumentation, and system operation. To the extent necessary, the interfacing systems are available to support the specific system testing and the appropriate system configurations.

General Test Methods and Acceptance Criteria

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Verification that the sensing devices respond to actual process variables and provide alarms and trips at specified values;
- Proper operation of system instrumentation and any associated logic, including that of the automatic depressurization system (ADS);
- Proper operation of MSIVs and main steamline drain valves, including verification of closure time in the isolation mode;
- Verification of SRV and MSIV accumulator capacity;
- Proper operation of SRV air piston actuators and discharge line vacuum breakers;
- Verification of the acceptable leak tightness and overall integrity of the reactor coolant pressure boundary via the leakage rate and/or hydrostatic testing as described in Section 5.2.
- Proper operation of Depressurization Valves (DPV) and SRV

Other checks shall be performed, as appropriate, to demonstrate that design requirements, such as those for sizing or installation, are met via as-built calculations, visual inspections, review of qualification documentation or other methods. For instance, SRV setpoints and capacities shall be verified from certification or bench tests consistent with applicable requirements.

14.2.8.1.2 Feedwater Control System Preoperational Test

Purpose

This test is to verify proper operation of the Feedwater Control System (FWCS) and meet design requirements..

Prerequisites

The construction tests have been successfully completed, and the Condensate and Feedwater System preoperational test (Subsection 14.2.8.1.44) has been completed. The RWCU/SDC System and Feedwater System low flow control valve are available to support FWCS testing at low power. The SCG has reviewed the test procedures and approved the initiation of testing. FWCS components shall have an initial calibration in accordance with vendor instructions. Required interfacing systems shall be available, as needed, to support the specified testing and the appropriate system configurations.

General Test Methods and Acceptance Criteria

Testing of the FWCS during the preoperational phase may be limited by the absence of an acceptable feedwater recirculation flow path. Comprehensive flow testing is conducted during the startup phase.

Performance shall be observed and recorded during a series of individual component and overall system response tests to demonstrate the following:

- Proper operation of instrumentation and controls in the required combinations of logic and instrument channel trips, including verification of setpoints;
- Proper functioning of instrumentation and alarms used to monitor system operation and status;
- Proper operation of system valves, including timing and stroke, in response to control demands (including RWCU/SDC dump valve response to the low flow controller);
- Proper operation of interlocks and equipment protective devices within the FWCS;
- Verification of loss of feedwater heating signal to initiate Selected Control Rod Run-In (SCRRI);
- Verification of feedwater level control level setdown logic on reactor low water level (Level 3) signal;
- Verification of feedwater runback on reactor high level (Level 8) signal;
- Verification of feedwater runback on Anticipated Transient Without Scram (ATWS) trip signal; and
- Proper communication and interface with other control systems and related equipment.

14.2.8.1.3 Standby Liquid Control System Preoperational Test

Purpose

To verify that the operation of the Standby Liquid Control (SLC) system, including accumulator, tanks, control, logic, and instrumentation, is as specified.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. The reactor vessel shall be available for injecting demineralized water. Required interfacing systems shall be available, as needed, to support the specified testing and the appropriate system configurations.

General Test Methods and Acceptance Criteria

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in the required combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability;
- Proper operation of system valves, including timing, under expected operating conditions;
- Proper operation of the nitrogen pressurization system;
- Proper system flow paths and discharge (with demineralized water substituted for the neutron absorber mixture);
- Proper operation of interlocks and equipment protective devices in valve controls; and
- Proper operation of the squib type injection valves.

Note: Proper volume and concentration of the neutron absorber solution (refer to Subsection 9.3.5) will be surveilled prior to entry in the Technical Specification mode in which the SLC system is required to be operable.

14.2.8.1.4 Control Rod Drive System Preoperational Test

Purpose

To verify that the Control Rod Drive (CRD) System, including the CRD hydraulic and fine motion control rod subsystems, functions as designed.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. The control blades and temporary guides in the RPV shall be installed and the FMCRDs are ready to be stroked and scrammed. Reactor component cooling water, instrument air, and other required interfacing systems shall be available, as needed, to support the specified testing and the corresponding system configurations.

Additionally, the Rod Control and Information System (RC&IS) shall be functional when needed, with the applicable portion of its specified preoperational testing complete.

General Test Methods and Acceptance Criteria

The CRD pumps take suction from the condensate system (preferred source) or the condensate storage tank (backup). This test must include testing both sources and the transfer between sources. Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper functioning of instrumentation and alarms used to monitor system operation and status, including control room video panels designed to display CRD positions, etc.;
- Proper communication with, and response to demands from, the RC&IS and the Reactor Protection System, including that associated with Alternate Rod Insertion (ARI), alternate rod run-in (post-scram), and select control rod run-in functions;
- Proper functioning of system valves, including purge water pressure control valves, under expected operating conditions;
- Proper operation of CRD pumps and motors in all design operating modes;
- Proper operation of CRD makeup to reactor pressure vessel on reactor low level signal;
- Acceptable pump NPSH under the most limiting design flow conditions;
- Proper pump motor start sequence and margin to actuation of protective devices;
- Proper system flow paths and flow rates, including sufficient pump capacity and discharge head;
- Proper operation of interlocks and equipment protective devices in pump, motor, and valve controls;
- Verification of charging water low pressure input to reactor protection system;
- Acceptability of pump/motor vibration levels and system piping movements during both transient and steady-state operation;
- Proper operation of fine motion motors and drives and associated control units, including verification of acceptable normal insert and withdraw timing; and
- Proper operation of hydraulic control units and associated valves, including CRD scram timing demonstrations against atmospheric pressure.

14.2.8.1.5 Rod Control and Information System Preoperational Test

Purpose

To verify that the RC&IS functions as designed.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. All electrical connections for rod position indication and RC&IS have been completed. All RC&IS cabinet power is available and system power supplies calibrated.

General Test Methods and Acceptance Criteria

Performance shall be observed and recorded during a series of tests to demonstrate the following:

- Proper operation of rod blocks and associated alarms and annunciators in all combinations of logic and instrument channel trip, including all positions of the reactor mode switch;

- Proper system response to control rod run-in logic, including that associated with Alternate Rod Insertion (ARI), Selected Control Rod Run-In (SCRRI) and normal post-SCRAM follow;
- Proper functioning of instrumentation used to monitor fine motion control rod drive (FMCRD) subsystem status such as rod position indication instrumentation and that used to monitor rod/drive separation status;
- Proper operation of RC&IS software including verification of gang and group assignments and Automatic Thermal Limit Monitors (ATLM), Rod Worth Minimizer (RWM) and automatic rod selection and movement functions; and
- Proper communication with plant automation system.

14.2.8.1.6 Safety System Logic and Control Preoperational Test

Purpose

This test is to verify proper operation of the Safety System Logic and Control (SSLC).

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedures and approved the initiation of testing. The required AC and DC electrical power sources shall be operational and the appropriate interfacing systems shall be available as required to support the specified testing.

General Test Methods and Acceptance Criteria

The testing consists of the following:

- Verify the self-test portion of the SSLC, including the proper reporting of all detected failures.
- Verify the non-interaction of the SSLC self-test system to confirm that the self-test system does not cause a false indication.
- Verify the correct activation of the inputs to the SSLC such as pushbutton switches, control operating switches, key-operated switches and analog inputs.
- Verify the local indication devices on the SSLC properly indicate the correct status.
- Verify the proper interface with diverse protection system.

14.2.8.1.7 DCIS System Preoperational Test

Purpose

To verify proper functioning of the plant Distributed Control and Information System (DCIS), including both essential and nonessential subsystems.

Prerequisites

Construction tests have been successfully completed and the SCG has reviewed the test procedures and approved the initiation of testing. The required AC and DC electrical power sources shall be operational and the appropriate interfacing systems shall be available as required to support the specified testing. Interfacing systems shall be tested and operational. Fiber optic cables have been connected.

General Test Methods and Acceptance Criteria

The testing consists of the following:

- Verify the ability to communicate to each nonessential and each essential system. Confirm proper addressing of the nonessential and essential multiplexing networks. Confirm that multiple devices do not answer to or transmit the same address;
- Verify the ability to transmit and receive data from interfacing systems within specified response times and data rate requirements;
- Verify the ability to receive error messages from interfacing systems;
- Verify the synchronization of time signals;
- Verify the multiplexing system failure recovery capabilities;
- Verify the ability of the communications software to identify and locate a problem on the network; and
- Proper Performance Monitoring and Control subsystem function and interfaces to Technical Support Center.

14.2.8.1.8 Leak Detection and Isolation System Preoperational Test

Purpose

This test is to verify proper response and operation of the Leak Detection and Isolation System (LD&IS) logic.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedures and approved the initiation of testing. The required AC and DC electrical power sources shall be operational and the appropriate interfacing systems shall be available as required to support the specified testing.

General Test Methods and Acceptance Criteria

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and controls in all combinations of logic and instrument channel trip;
- Proper functioning of indications, annunciators, and alarms used to monitor system operation and status;
- Proper operation of leakoff and drainage measurement functions such as those associated with the reactor vessel head flange and drywell cooler condensate;
- Proper interface with related systems in regard to the input and output of leak detection indications and isolation initiation commands; and

- Proper operation of bypass switches and related logic.

14.2.8.1.9 Reactor Protection System Preoperational Test

Purpose

To verify proper operation of the Reactor Protection System (RPS), including complete channel logic and response time.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedures and approved the initiation of testing. The Control Rod Drive System, Instrument Air System, and the required AC and DC electrical power sources are operational. The other required interfacing systems shall be available, as needed, to support the specified testing.

General Test Methods and Acceptance Criteria

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and controls in all combinations of logic and instrument channel trip, including those associated with all positions of the reactor mode switch;
- Proper functioning of instrumentation and alarms used to monitor sensor and channel operation and availability;
- Proper calibration of primary sensors;
- Proper operation of bypass switches, including related logic;
- Proper operation of permissive and prohibit interlocks;
- Proper function of the interface to diverse displays and controls;
- Proper system operation while powered from primary and alternate sources, including transfers, and in degraded modes for which the system is expected to remain operational; and
- Acceptability of instrument channel response times, as measured from each applicable process variable (except for neutron sensors and suppression pool temperature sensors) to the deenergization of the scram pilot valve solenoids.

14.2.8.1.10 Neutron Monitoring System Preoperational Test

Purpose

To verify the proper operation of the Neutron Monitoring System (NMS), including the startup range neutron monitor, power range neutron monitor, and automated fixed incore probe subsystems and related hardware and software.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. All Startup Range Neutron Monitor (SRNM) subsystem components and Power Range Neutron Monitor (PRNM) subsystem components have been calibrated per vendor instructions. Additionally, required interfacing systems shall be available, as needed, to support the specified testing.

General Test Methods and Acceptance Criteria

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in all combinations of logic and instrument channel trip, including rod block and scram signals;
- Proper functioning of instrumentation, displays, alarms, and annunciators used to monitor system operation and status;
- Proper operation of detectors and associated cabling, preamplifiers, and power supplies;
- Proper operation of interlocks and equipment protective devices;
- Proper operation of permissive, prohibit, and bypass functions;
- Proper system operation while powered from primary and alternate sources, including transfers, and in degraded modes for which the system is expected to remain operational;
- Proper operation of system and subsystem self-test diagnostic and calibration functions; and
- The ability to communicate and interface between appropriate plant systems and NMS subsystems.

14.2.8.1.11 Plant Automation System Preoperational Test

Purpose

This test is to verify the proper operation of the Plant Automation System (PAS) including the Power Generation Control Subsystem (PGCS) and their related functions.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. The PGCS, RC&IS, Turbine Control System, and other required system interfaces shall be available to support the specific system testing. The required input and output devices and various system interfaces shall be connected and available, as needed, for supporting the specified testing configurations.

General Test Methods and Acceptance Criteria

Proper performance of system hardware and software is verified by a series of individual and integral tests that include the following demonstrations:

- Proper connection and calibration of all input signals;
- Proper operation of data logging and transient data recording features, including verification of data rate requirements;
- Verification of computer printouts;

- Verification of operability of control room video display units which are driven by the PAS;
- Proper communication and interface with other plant equipment, computers and control systems; verify that output signals (analog and digital) are correct; and
- Proper operation of operator guidance and prompting functions, including alarms and status messages, in all operating modes for plant startup, shutdown and power maneuvering iterations.

Much of the testing performed during the preoperational phase is done utilizing simulated conditions and inputs via system hardware and software. Final system performance during actual plant conditions is evaluated during the startup phase.

14.2.8.1.12 Remote Shutdown System Preoperational Test

Purpose

Verify the feasibility and operability of intended remote shutdown functions from the remote shutdown panel and other local and remote locations outside the main control room, which are utilized during a safe shutdown from outside the main control room.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Additionally, control power shall be supplied to the remote shutdown panel and the required system and component interfaces shall be available, as needed, to support the specified testing.

General Test Methods and Acceptance Criteria

The Remote Shutdown System (RSS) consists of the control and instrumentation available at the dedicated remote shutdown panel(s) and other local and remote locations intended to be used during a safe shutdown from outside the control room.

Much of the specified testing can be accomplished in conjunction with, or as part of, the individual system and component preoperational testing. However, the successful results of such testing shall be documented as part of this test, as applicable. Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper functioning of the control and instrumentation associated with the RSS;
- Proper operation of pumps and valves, including establishment of system flow paths using RSS control;
- Proper functioning of RSS transfer switches, including verification of proper override of main control room functions and proper indication in the MCR that these functions have been overridden;
- Proper operation of prohibit and permissive interlocks and bypass functions after transfer of control;

- Proper system operation while powered from primary and alternate electrical sources; and
- The ability to establish and maintain communication among personnel performing the remote shutdown operation.

14.2.8.1.13 Reactor Water Cleanup/Shutdown Cooling System Preoperational Test

The RWCU/SDC system provides both the reactor water cleanup function and the shutdown cooling function.

Purpose

To verify that the operation of the reactor water cleanup and shutdown cooling subsystem, including pumps, valves, heat exchangers and demineralizer equipment, is as specified.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Resin material for filter demineralizers shall be available. Reactor component cooling water, instrument air, CRD purge supply, and other required interfacing systems shall be available, as needed, to support the specified testing and the appropriate system configurations.

General Test Methods and Acceptance Criteria

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and controls in all combinations of logic and instrument channel trip, including those associated with the Leak Detection and Isolation System;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability;
- Proper operation of system valves, including timing, under expected operating conditions;
- Proper operation of pumps and motors in all design operating modes;
- Acceptable pump NPSH under the most limiting design flow conditions; this is repeated during startup tests with the reactor hot;
- Proper system flow paths and flow rates, including pump capacity and discharge head;
- Proper pump motor start sequence and margin to actuation of protective devices;
- Proper operation of interlocks and equipment protective devices in pump and valve controls;
- Proper switch over of the RWCU and SDC mode of operation;
- Acceptability of pump/motor vibration levels at all pump speeds and system piping movements during both transient and steady-state operation;

- Proper operation of the RWCU demineralizers and associated support facilities; and
- Proper operation of heatup function.

14.2.8.1.14 Fuel and Auxiliary Pools Cooling System Preoperational Test

Purpose

To verify that the operation of the Fuel and Auxiliary Pools Cooling System (FAPCS), including the pumps, heat exchangers, controls, valves, and instrumentation, is as specified.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. The required interfacing systems shall be available, as needed, to support the specified testing and the appropriate system configurations.

General Test Methods and Acceptance Criteria

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in all combinations of logic and instrument channel trip, including isolation and bypass of the non-safety-related fuel pool cleanup filter/demineralizers;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability, including those associated with pool water level;
- Proper operation of system valves, including timing, under expected operating conditions;
- Verification that drywell spray nozzles, headers and piping are free of debris;
- Proper operation of pumps and motors in all design operating modes;
- Acceptable pump NPSH under the most limiting design flow conditions; verify NPSH acceptability when cooling IC pool after testing ICs during startup testing;
- Proper system flow paths and flow rates, including pump capacity and discharge head;
- Proper water levels are maintained in GDCS pools when the system is operating in the GDCS cooling and cleanup mode;
- Proper pump motor start sequence and margin to actuation of protective devices;
- Proper operation of interlocks and equipment protective devices in pump, motor, and valve controls;
- Proper operation of permissive, prohibit, and bypass functions;
- Acceptability of pump/motor vibration levels and system piping movements during both transient and steady-state operation;
- Proper functioning of pool anti-siphon devices and acceptable leakage from pool drains, sectionalizing devices, and gaskets or bellows;

- Proper operation of filter/demineralizer units and their associated support facilities; and
- Smooth transfer from one pool to another and acceptable transfer time.

14.2.8.1.15 Process Sampling System Preoperational Test

Purpose

To verify the proper operation and the accuracy of equipment and techniques to be used for on-line and periodic sampling and analysis of overall plant water systems as well as that of individual plant process streams.

Prerequisites

Construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Adequate laboratory facilities and appropriate analytical procedures shall be in place. The systems are available to provide required flow to associated sample panel. Instrument air, and closed cooling water are available to support testing.

General Test Methods and Acceptance Criteria

Performance shall be observed and recorded during a series of tests to demonstrate the following:

- Proper calibration of on-line sampling and monitoring equipment, indication and alarm/functions;
- Proper operation of the sample coolers;
- Capability of obtaining grab samples of designated process streams at the desired locations;
- Proper functioning of personnel protective devices at local sampling stations; and
- Adequacy and accuracy of sample analysis methods.

14.2.8.1.16 Process Radiation Monitoring System Preoperational Test

Purpose

To verify the ability of the Process Radiation Monitoring System (PRMS) to indicate and alarm normal and abnormal radiation levels, and to initiate, if appropriate, isolation functions upon detection of high radiation levels in any of the process streams that are monitored.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. The various process radiation monitoring subsystems, including the sensors, the digital radiation monitors and associated sampling racks have been calibrated according to instructions. The required interfacing systems shall be available, as needed, to support the specified testing.

General Test Methods and Acceptance Criteria

The PRMS consists of a number of subsystems that monitor various liquid and gaseous process streams, building and area ventilation exhausts, and plant and process effluents. The offgas system and the main steamlines are also monitored.

Performance shall be observed and recorded during a series of individual component and integrated subsystem tests to demonstrate the following:

- Proper calibration of detector assemblies and associated equipment using a standard radiation source or portable calibration unit;
- Proper functioning of radiation monitors and alarms;
- Proper system trips in response to high radiation and downscale/inoperative conditions;
- Proper operation of the isolation functions; and
- Proper operation of the sampling functions.

14.2.8.1.17 Area Radiation Monitoring System Preoperational Test

Purpose

To verify the ability of the Area Radiation Monitoring (ARM) System to indicate and alarm normal and abnormal general area radiation levels throughout the plant.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Sensors and digital radiation monitors have been calibrated according to vendor instructions.

General Test Methods and Acceptance Criteria

Performance shall be observed and recorded during a series of channel tests to demonstrate the following:

- Proper calibration of detector assemblies and associated equipment using a standard radiation source or portable calibration unit;
- Proper functioning of sensors, monitors, displays, and alarms; and
- Proper system trips in response to high radiation and downscale/inoperative conditions.

14.2.8.1.18 Containment Monitoring System Preoperational Test

Purpose

To verify the ability of the Containment Monitoring System to monitor oxygen, hydrogen, and gross gamma radiation levels in the wetwell and drywell airspace regions of the primary containment and to verify the proper operation of the other functions of the system including drywell-wetwell differential pressure monitoring, suppression pool water level and temperature monitoring, drywell (post LOCA) pool level monitoring and post-accident sampling.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Initial system installation and setup has been accomplished per instructions. The required interfacing systems shall be available, as needed, to support the specified testing and the appropriate system configurations.

General Test Methods and Acceptance Criteria

The Containment Monitoring System consists of radiation, oxygen and hydrogen, suppression pool water level and temperature, drywell-wetwell differential pressure monitoring and post accident sampling subsystems. Performance of each of these subsystems shall be observed and recorded during a series of individual subsystem tests to demonstrate the following:

- Proper calibration of detector assemblies and associated equipment using the standard source or portable calibration unit and gas calibration sources;
- Proper functioning of indications, sampling racks, displays, and alarms including those monitoring system availability;
- Proper system trips in response to high setpoint and downscale/inoperative conditions;
- Proper initiation and operation of detection and sampling functions, including pump start and valve sequencing, if appropriate, in response to a LOCA signal;
- Proper operation of calibration gas supply systems and self-calibration functions;
- Proper operation of the suppression pool temperature to provide signals to initiate scram on high temperature;
- Proper operation of the suppression pool temperature to initiate the shutdown cooling on high temperature; and
- Proper operation of post accident sampling valves.

14.2.8.1.19 Instrument Air and Service Air Systems Preoperational Tests

Purpose

To verify the ability of the Instrument Air System and Service Air Systems (IAS and SAS) to provide the design quantities of clean dry compressed air to user systems and components.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Electrical power, the supplied system and components loads, and component closed cooling water system to provide cooling to the compressor units are available, as needed, to support the specified testing.

General Test Methods and Acceptance Criteria

The IAS and the SAS are specified as separate systems. However, the preoperational test requirements are essentially the same because they are so closely related.

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in all combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability;
- Proper operation of compressors and motors in all design operating modes;
- Ability of compressor(s) to maintain receiver at specified pressure(s) and to recharge within specified time under design loading conditions;
- Proper system flow paths and acceptable flow rates to individual loads at specified air temperatures and pressures under design loading conditions, including a determination that the total air demand at steady-state conditions, including leakage for the system, is in accordance with design;
- Proper operation of interlocks and equipment protective devices in compressor and valve controls;
- Acceptability of compressor/motor vibration levels and system piping movements during both transient and steady-state operation;
- Ability of the air to meet end user cleanliness requirements with respect to oil, water, and particulate matter content;
- Continued operability of supplied loads in response to credible failures that result in an increase in the supply system pressure; and
- Ability of the SAS to act as backup to the IAS.
- Separate from the intergrated system Instrument and Service Air Preoperational tests, individual components will be tested for proper "failure" (open, close, or as is) to both instantaneous (pipe break) and slow (plugging or freezing) simulated air losses;

14.2.8.1.20 High Pressure Nitrogen Supply System Preoperational Test

Purpose

To verify the ability of the High Pressure Nitrogen Supply System (HPNSS) to furnish compressed nitrogen to user systems at design quantity and quality.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. User system loads and other required system interfaces shall be available, as needed, to support the specified system testing.

General Test Methods and Acceptance Criteria

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in all combinations of logic and instrument channel trip;

- Proper functioning of instrumentation and alarms used to monitor system operation and availability;
- Proper operation of system valves, including timing, under expected operating conditions;
- Proper system flow paths and acceptable flow rates to individual loads at specified temperatures and pressures under design loading conditions;
- The ability of the nitrogen gas to meet end use cleanliness requirements with respect to oil, water, and particulate matter content;
- Proper "failure" (open, close, or as is) of supplied components to both instantaneous (pipe break) and slow (plugging or freezing) simulated nitrogen gas supply losses; and
- Proper switch over nitrogen supply to bottled nitrogen on low pressure.

14.2.8.1.21 Reactor Component Cooling Water System Preoperational Test

Purpose

To verify proper operation of the Reactor Component Cooling Water System (RCCWS) including its ability to supply design quantities of cooling water, at the specified temperatures, to assigned loads, as appropriate, during normal, abnormal, and accident conditions.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Electrical power, plant service water, instrument air, and other required supporting systems shall be available, as needed, for the specified testing configurations. The cooled components shall be operational and operating to the extent possible during heat exchanger performance evaluation.

General Test Methods and Acceptance Criteria

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in all combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability;
- Proper operation of system valves, including timing, under expected operating conditions;
- Proper operation of pumps and motors in all design operating modes;
- Acceptable pump NPSH under the most limiting design flow conditions;
- Proper system and component flow paths, flow rates, and pressure drops, including pump capacity and discharge head;
- Proper operation of interlocks and equipment protective devices in pump and valve controls;

- Acceptability of pump/motor vibration levels and system piping movements during both transient and steady-state operation;
- Proper operation of system surge tanks and chemical addition tanks and their associated functions; and
- Acceptable performance of heat exchangers, to the extent practical.

Because of insufficient heat loads during the preoperational phase, the final system flow balancing and heat exchanger performance evaluation is performed during the startup phase.

14.2.8.1.22 Makeup Water System Preoperational Test

Purpose

To verify the ability of the Makeup Water System (MWS) to supply the designated plant systems with design quantity and quality for each system.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Final interconnection with the supplied systems is complete and those systems are ready to accept transfer of design quantities of makeup water.

General Test Methods and Acceptance Criteria

System performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in all combinations of logic;
- Proper functioning of instrumentation and alarms used to monitor system operation and status;
- Proper operation of pumps, motors, and valves under expected operating conditions;
- Proper functioning of interlocks and equipment protective devices in pump, motor, and valve controls;
- The adequacy of system flow paths and flow rates, including pump and tank capacities;
- Proper functioning of water treatment facilities and equipment;
- Proper functioning of freeze protection methods and devices, if applicable; and
- Acceptability of pumps and motor vibration levels and system piping movements during both transient and steady state operations.

14.2.8.1.23 Hot Water System Preoperational Test

Purpose

Verify the ability of the Hot Water System (HWS) to provide hot water to the appropriate HVAC systems in order to maintain the specified design temperatures within the various building rooms and areas.

Prerequisites

The construction tests have been completed and the SCG has reviewed the test procedure and approved the initiation of testing. Electrical power, the appropriate heating source(s), and the various HVAC systems heating coils shall be available, as needed, to support the specified testing.

General Test Methods and Acceptance Criteria

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in all combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation;
- Proper operation of system valves under expected operating conditions;
- Proper operation of pumps and motors in all design operating modes;
- Proper system flow paths and flow rates, including pump capacity and discharge head; and
- Proper operation of interlocks and equipment protective devices in pump, motor and valve controls.

14.2.8.1.24 Chilled Water System Preoperational Test

The Chilled Water System serves the HVAC for Reactor Building, Control Building, Turbine Building, Fuel Building, Radwaste Building, Electrical Building and Drywell Coolers.

Purpose

To verify the ability of the chilled water system to supply the design quantities of chilled water at the specified temperatures to the various cooling coils of the HVAC systems serving rooms and areas require conditioned air.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Electrical power, reactor building and turbine building closed cooling water systems, the applicable HVAC system cooling coils, and other required system interfaces shall be available, as needed, to support the specified system testing.

General Test Methods and Acceptance Criteria

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in all combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability;

- Proper operation of system valves, including isolation functions, under expected operating conditions;
- Proper operation of pumps and motors in all design operating modes;
- Proper system flow paths and flow rates to all supplied loads, including pump capacity and discharge head;
- Chiller heat removal capacity with inlet and outlet temperatures and flow data;
- Proper operation of interlocks and equipment protective devices in pump and valve controls;
- Acceptability of pump/motor vibration levels and system piping movements during both transient and steady-state operation; and
- Proper functioning of system surge tank and chemical addition features.

14.2.8.1.25 Heating, Ventilation, and Air Conditioning Systems Preoperational Test

There are several Heating, Ventilation and Air Conditioning (HVAC) Systems in the plant, including those serving the following:

- Control Building
- Fuel Building
- Turbine Building
- Reactor Building
- Electrical Building
- Radwaste Building

These systems and the dedicated systems for drywell and main control room will be tested, the preoperational tests will probably be conducted in multiple separate tests.

Purpose

To verify the ability of the various HVAC systems to establish and maintain the specified environment, with regards to temperature, pressure, and airborne particulate level, in the applicable rooms, areas, and buildings throughout the plant, supporting equipment and systems.

Prerequisites

The construction tests, including initial flow balancing, have been successfully completed and the SCG has reviewed the test procedure(s) and approved the initiation of testing. Additionally, the normal and backup electrical power sources, the applicable heating, cooling, and chilled water systems, and any other required system interfaces shall be available, as needed, to support the specified testing.

General Test Methods and Acceptance Criteria

Because the various HVAC systems are similar in design of equipment and function, they are subject to the same basic testing requirements.

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in all combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability;
- Proper operation of system valves and dampers, including isolation functions, under expected operating conditions;
- Proper operation of fans and motors in all design operating modes;
- Proper system flow paths and flow rates, including individual component and total system capacities and overall system flow balancing;
- Proper operation of interlocks and equipment protective devices;
- Proper system operation while powered from primary and alternate sources, including transfers, and in degraded modes for which the system is expected to remain operational;
- The ability to maintain the specified positive or negative pressure(s) in the designated rooms and areas and to direct local and total air flow, including any potential leakage, relative to the anticipated contamination levels;
- The ability of exhaust, supply, and recirculation filter units to maintain the specified dust and contamination free environment(s);
- The ability of the control room habitability function to detect the presence of airborne radioactive material, smoke and/or toxic gas and to remove or prevent in-leakage of such;
- Proper operation of HEPA filters and charcoal adsorber sections, if applicable, including relative to the in-place testing requirements of Regulatory Guide 1.140 regarding visual inspections and airflow distribution, DOP penetration and bypass leakage testing;
- The ability of the heating and cooling coils to maintain the specified thermal environment(s) while considering the heat loads present during the preoperational test phase; and
- The ability of HVAC systems to provide sufficient purge, exhaust, and recirculation flows in support of drywell inerting and deinerting operations.

It is not possible to fully evaluate the cooling and heating coil performance of the HVAC during the preoperational phase because of limited heat source. The final system evaluation will be performed in the startup test.

14.2.8.1.26 Containment Inerting System Preoperational Test

Purpose

To verify the ability of the Containment Inerting System (CIS) to establish and maintain the specified inert atmosphere in the primary containment during all expected plant conditions.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. The primary containment is intact, the drywell coolers and RB HVAC systems are operational, and the steam evaporator and electric heater in the nitrogen supply are available, as needed, to support the specified testing.

General Test Methods and Acceptance Criteria

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in all combinations of logic;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability;
- Proper operation of system valves, including timing, under expected operating conditions;
- Proper nitrogen/air flow paths and flow rates both into and out of the primary containment;
- Proper operation of interlocks and equipment protective devices; and
- Ability to inert and de-inert containment atmosphere conditions within the designated interval.

14.2.8.1.27 Containment Isolation Valve Leakage Rate Tests

Purpose

The objective of this test is to verify that the leakage rate through each containment isolation valve meets the limit specified in the Containment Leakage Rate Testing Program.

Prerequisites

Required test instrumentation, e.g., pressure and temperature sensors, flowmeters and stopwatch, is installed, calibrated and functionally tested. Each containment isolation valve to be tested is operable. Each valve is closed by normal operation and without any preliminary exercising or adjustments (e.g., no manual tightening of valve after closure by valve actuator). Pneumatic (air or nitrogen) supply to the air operated valves is available. Test connections for pressurizing or venting (or both) the test volume of each valve to be tested are available. Test boxes used for this test are calibrated.

General Test Methods and Acceptance Criteria

The containment isolation valves that require leakage rate testing and acceptance criteria are discussed in Section 6.2. Containment isolation valve leakage rate testing is included in the applicable system preoperational test.

14.2.8.1.28 Containment Penetration Leakage Rate Tests

Purpose

The objective of this test is to verify that the leakage rate through each containment penetration meets the limit specified in the Containment Leakage Rate Testing Program.

Prerequisites

Permanently installed system consisting of a pressurized gas source (air or nitrogen), manifold, and valves may be provided and used as pressurizing equipment. Calibrations of the required test instruments within the scope of this test, e.g., temperature and pressure sensors, flowmeters, are current. Test boxes used for this test are calibrated.

General Test Methods and Acceptance Criteria

Those containment penetrations receiving Containment Penetration Leakage Rate Test (Type B Test) are indicated in Table 6.2-47. Containment penetrations will be leak rate tested by performing the surveillance testing as required in the Containment Leakage Rate Testing Program. Containment penetrations leak rate test and acceptance criteria are performed as described in Section 6.2.

14.2.8.1.29 Containment Airlock Leakage Rate Tests

Purpose

The objective of this test is to verify that the leakage rate through each airlock meets the criteria specified in the Technical Specifications.

Prerequisites

Permanently installed system consisting of a pressurized gas source (air or nitrogen), manifold, and valves may be provided and used as pressurizing equipment. Installation and calibration of required test instrumentation, e.g., temperature and pressure sensors, flowmeters, are complete. Test boxes used for this test are calibrated.

General Test Methods and Acceptance Criteria

Descriptions of and criteria for testing the primary containment air lock leakage rate are given in Section 6.2. Containment air locks leak rate and acceptance criteria are performed as required in the Containment Leakage Rate Testing Program.

14.2.8.1.30 Containment Integrated Leakage Rate Test

Purpose

The objectives of this test are: (a) to demonstrate that the integrated leakage rate of the primary containment at the design basis accident pressure is within the design limits, and (b) to obtain base line data for use during subsequent leak rate tests as described in Section 6.2.

Prerequisites

Construction is completed to the extent necessary to perform this test. Reactor vessel, GDCS Pools, IC/PCCS Pools, reactor cavity, dryer/separator pool, spent fuel pool and suppression pool are filled with water to the normal operating level. Pressurizing and test equipment is checked out and ready for the test. Individual leak rate tests, Type B and C of 10 CFR 50, Appendix J, have been completed. A general inspection of the accessible interior and exterior surfaces of the primary containment structures and components is performed and corrective actions are taken if evidence of structural deterioration exists. Containment isolation valves are functionally tested and aligned in accordance with Containment Leakage Rate Testing Program.

General Test Methods and Acceptance Criteria

Description of the preoperational containment integrated leakage rate tests and acceptance criteria are provided in Section 6.2.

During the Type A test, the drywell to suppression pool gas space differential pressure test will be performed as required by the Technical Specifications.

14.2.8.1.31 Containment Structural Integrity Test

Purpose

The objective of this test is to verify that the design and construction of the primary containment is capable of withstanding specified internal pressure loads as described in Section 3.8.

Prerequisites

The containment construction is complete to the extent necessary to perform this test. Construction turnover of the system is completed. Reactor vessel, GDCS Pools, IC/PCCS Pools, reactor cavity, dryer/separator pool, spent fuel pool and suppression pool are filled with water to the normal operation level. The instruments and controls within the scope of this test are calibrated. The structural integrity measurement and pressurizing equipment is available for use to support the test. Equipments incapable of withstanding the test pressure are removed from containment or otherwise protected.

General Test Methods and Acceptance Criteria

The internal pressure in the containment will be increased from atmospheric pressure to the test pressure in equally spaced pressure increments. The drywell and containment are depressurized in the same increments. During the test, the radial and vertical displacements of the drywell and containment structure are measured, and crack patterns and crack widths of the containment exterior surface at prescribed locations are observed. Pertinent system performance data are recorded and compared with the predicted response. During the analysis, verify that system performance test data satisfy the requirements as specified in Section 3.8.

14.2.8.1.32 Pressure Suppression Containment Bypass Leakage Tests

Purpose

The objectives of this test are:

- To verify that the suppression pool bypass leakage rate is within limits for high pressure and low pressure tests, and
- To obtain the baseline data for use during subsequent leak rate tests.

Prerequisites

After attaining test pressure, the Suppression pool gas space pressure is stabilized for one hour prior to collecting data. Suppression pool gas space closures are in place and the containment ventilation system is operable to support this test. Pressurizing and test equipment is checked out and ready for the test. The wetwell is filled with water to normal operating level.

General Test Methods and Acceptance Criteria

The suppression pool bypass leakage test will be performed at both high and low test pressure conditions to detect potential leakage in the drywell to the suppression pool gas space as described in the following:

With the drywell being pressurized at the specified test pressures, adjust the suppression pool gas space pressure to establish the prescribed test differential pressure. Allow pressure to stabilize for one hour prior to collecting data used to determine the leak rate. Verify that the measured drywell to suppression pool gas space bypass leakage rate is within design limit as specified in Section 6.2.

14.2.8.1.33 Containment Isolation Valve Functional and Closure Timing Tests

Purpose

To verify proper function of the containment isolation valves, including the required closure timing are met.

Prerequisites

Permanently installed equipment and instrumentation shall have been functionally tested and calibrated.

General Test Methods and Acceptance Criteria

The Containment Isolation System is discussed in Section 6.2 with characteristics of and requirements for individual valves listed in Tables 6.2-16 through 6.2-42. Preoperational functional and closure timing tests of valves performing containment isolation functions will be done as part of the testing of the systems to which such valves belong (see Table 6.2-50 for system affiliation of individual valves). Overall containment isolation initiation logic is a function of the leak detection and isolation system testing that is described in Subsection 14.2.8.1.

14.2.8.1.34 Wetwell-to-Drywell Vacuum Breaker System Preoperational Test

Purpose

This test is to verify proper functioning of the wetwell-to-drywell vacuum breakers. The leakage rate test of the vacuum breakers are performed in conjunction with suppression pool bypass described in Subsection 14.2.8.1.

Prerequisites

The visual inspections of the mechanical components on the vacuum breakers have been completed and the SCG has reviewed the test procedure and approved the initiation of testing.

General Test Methods and Acceptance Criteria

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of vacuum breaker valves, including verification of opening and closing;
- Proper functioning of valve positive closure, including verification of adequate valve leak tightness;
- Proper functioning of vacuum breaker open; and
- Proper operation of instrumentation and alarms used to monitor valve position indication.

14.2.8.1.35 DC Power Supply System Preoperational Test

Purpose

To verify the ability of DC power supply systems to supply reliable, uninterruptible power for instrumentation, logic, control, lighting and other normal and emergency loads that must remain operational during and after a loss of AC power.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedures and approved the initiation of testing. Permanently installed and test instrumentation are properly calibrated and operational. The power supply and battery charger are available. Additionally, a test load is available for the performance of battery capacity test. Adequate ventilation to battery rooms is available and operational. All interfacing systems and equipment required to support system operation shall be available, as needed, for the specified testing configurations.

General Test Methods and Acceptance Criteria

The DC power supply systems consist of safety-related and nonsafety-related equipment, including batteries, battery chargers, inverters, static transfer switches, and associated instrumentation and alarms, that is used to supply both normal and emergency loads. Performance shall be observed and recorded during a series of individual component and integrated systems tests to demonstrate the following:

- Capability of each battery bank to supply its design load for the specified time without the voltage dropping below minimum battery or cell limits;
- Capability of each battery charger to fully recharge its associated battery (or bank), from the discharged state, within the specified time while simultaneously supplying the specified loads;
- Verification that actual loading of each DC bus is consistent with battery sizing assumptions;
- Verification that each DC bus meets the specified level of redundancy and electrical independence for its particular application;
- Proper functioning of transfer devices, breakers, cables and inverters (including load capability);
- Verify that safety-related batteries are capable to support essential loads for a period of 24 or 72 hours;

- Proper calibration and trip settings of protective devices, including relaying, and proper operation of permissive and prohibit interlocks;
- Voltage spikes between rails and rails to ground in the loaded system are within design parameters assumed for connected electronics;
- Proper operation of instrumentation and alarms associated with undervoltage, overvoltage, and ground conditions; and
- Proper operation of emergency DC lighting, including capacity of self-contained batteries.

14.2.8.1.36 AC Power Distribution System Preoperational Test

Purpose

To verify the ability of the AC power distribution system to provide a means for supplying AC power to plant auxiliary equipment, from both offsite and onsite sources, via independent distribution subsystems for each redundant load group.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. All the necessary permanently installed and test instrumentation shall have been calibrated and operational. Adequate ventilation to both switchgear and battery rooms are available and operational. All interfacing systems and equipment required to support system operation shall be available, as needed, for the specified testing configurations.

General Test Methods and Acceptance Criteria

The AC power distribution system is comprised of the equipment required for transformation, conversion, and regulation of voltage to the buses, the switchgear and motor control centers required for the individual loads served, and the coordinated system protective relaying. Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of initiating, transfer, and trip devices;
- Proper operation of relaying and logic;
- Proper operation of equipment protective devices, including permissive and prohibit interlocks;
- Proper operation of instrumentation and alarms used to monitor system and equipment status;
- Proper operation and load carrying capability of breakers, motor controllers, switchgear, transformers, and cables;
- The capability to transfer between onsite and offsite power sources as per design;
- The ability of emergency and vital loads to start in the proper sequence and to operate properly under simulated accident conditions; and

- The adequacy of the plant emergency lighting system.

14.2.8.1.37 Standby Diesel Generator & AC Power System Preoperational Test

Purpose

To demonstrate the capability of the standby diesel generators to provide electrical power to plant nonsafety-related loads when the normal offsite power sources are unavailable.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. The diesel generator auxiliary systems (e.g., diesel fuel oil transfer, diesel-generator starting air supply, jacket cooling water, and lube oil) are operable to support continuous diesel operation. Appropriate electrical power sources, cooling water supply, diesel generator room HVAC and equipment required to support system operation shall be available, as needed, for the specified testing configuration. Additionally, sufficient diesel fuel shall be available onsite to perform the scheduled tests.

General Test Methods and Acceptance Criteria

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper automatic startup and operation of the diesel generators upon simulated loss of preferred power (LOPP) and attainment of the required frequency and voltage within the specified time limits;
- Proper operation of the diesel generators during load shedding, load sequencing, and load rejection, including a test of the loss of the largest single load and of the complete loss of load, verifying that voltage and frequency are maintained within design limits and that overspeed limits are not exceeded;
- That a LOPP signal initiates termination of parallel operations (test or manual transfer) and that the diesel generator continues to run and assume load as required;
- That the engine speed governor and the generator voltage regulator automatically return to an isochronous (constant speed) mode of operation upon initiation of a LOPP signal;
- Full-load carrying capability of the diesel generators for a period of not less than 24 hours, of which 22 hours are at a load equivalent to the continuous rating of the diesel generator and 2 hours are at the manufacturer’s 2-hour load rating, including verification that the diesel cooling systems function within design limits, and that the HVAC System maintains the DG room within design limits;
- The ability to synchronize the diesel generators with offsite power while connected to the standby load, transfer the load from the diesel generators to the offsite power, isolate the diesel generators, and restore them to standby status;
- The rate of fuel consumption and the operation of the fuel oil transfer pumps, while operating at the design-basis load, meets the requirements for 7-day storage inventory for each diesel generator;
- The proper function of the diesel generator protective devices;

- That all permissive and prohibit interlocks, controls, and alarms (both local and remote) operate in accordance with design specifications;
- Proper operation of auxiliary systems such as those used for starting, cooling, heating, ventilating, lubricating, and fueling the diesel generators;
- Proper operation of the isolation breakers in the Class 1E motor control centers which act as isolation devices between the non-Class 1E power sources and the Class 1E loads; for Class 1E battery chargers only; and
- Capability of the system to allow a portable generator to supply power to the 1E AC Motor Control Centers.

14.2.8.1.38 Plant Communications System Preoperational Test

Purpose

To verify the proper operation and adequacy of plant communications systems and methods that are used during normal and abnormal operations, including those needed to carry out the plant emergency plan.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Initial system and component settings (gains, volumes, etc.) shall be adjusted based on expectations of the acoustic environment and background noise levels for each location and for all modes of operation.

General Test Methods and Acceptance Criteria

The communications systems to be tested include the plant paging system, telephone systems, portable radio systems, and the plant emergency alarms. Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper functioning of transmitters and receivers without excessive interference levels;
- Proper operation of controls, switches, and interfaces, including silencing and muting features;
- Proper isolation and independence of various channels and systems;
- Proper operation of systems under multiple user and fully loaded conditions as per design;
- Proper operation of plant emergency alarms;
- Audibility of speakers and receivers under anticipated background noise levels;
- The ability to establish the required communications with outside agencies; and
- Proper functioning of dedicated use systems and of those systems expected to function under abnormal conditions such as loss of electrical power or shutdown from outside the control room scenarios.

14.2.8.1.39 Fire Protection System Preoperational Test

Purpose

This test is to verify the ability of the Fire Protection System to detect and alarm the presence of combustion, smoke or fire within the plant and to initiate the appropriate suppression systems or devices. The test purpose is also to provide the required volume of water to fill the IC/PCCS and Spent Fuel Pool up to seven days.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. The required electrical power and makeup water sources, diesel fuel oil system for the diesel driven fire pump, and other appropriate interfaces and support systems, are available as needed for the specified testing.

General Test Methods and Acceptance Criteria

The Fire Protection System is but one part of the overall fire protection program. This program is an integrated effort involving components, procedures, and personnel utilized in carrying out all activities of fire protection, in accordance with Criterion 3 of 10 CFR 50 Appendix A. It includes systems and components, facility design, fire prevention, detection, annunciation, confinement, suppression, administrative controls, fire brigade organization, training, quality assurance, inspection, testing, and maintenance. Fire Protection System in accordance with the criteria in codes and standards listed in Table 9.5-1 testing demonstrates the equipment and facilities designed for the detection, annunciation, and suppression of fires operate properly and meet all functional requirements described in subsection 9.5.1.1. This testing shall include the following demonstrations:

- Proper operation of instrumentation and equipment in all combinations of logic and control;
- Proper operation of system valves, pumps, motors and pump-driving diesel under expected operating conditions;
- Proper system and component flow paths, flow rates and capacities;
- Verification of proper installation of all fire protection equipment, including sprinkler heads, spray nozzles, fire detectors, annunciators, hose stations, and portable fire extinguishers;
- Proper operation of water-based suppression systems such as sprinkler, deluge, and hose stations and other suppression systems such as foams and dry chemicals;
- Proper operation of freeze protection methods and devices, if applicable;
- Proper functioning of all fire detection devices;
- Proper operation of both local and remote alarms, including those interfacing with outside agencies;
- Proper operation of primary and secondary electrical power sources;
- Verification of proper installation and integrity of all fire barriers, including penetration seals, fire doors and fire dampers;

- Proper installation and operation of HVAC systems used for smoke control and exhaust.

14.2.8.1.40 Radioactive Liquid Drainage and Transfer Systems Preoperational Tests

Purpose

This test is to verify the proper operation of the various equipment and pathways of the radioactive liquid drainage and transfer system.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. An adequate supply of demineralized water, the necessary electrical power, and other required interfacing systems shall be available, as needed, to support the specified testing.

General Test Methods and Acceptance Criteria

The performance of the radioactive liquid drain system is observed and recorded during the individual component and system test that characterizes the various modes of system operation. Also included are dedicated systems for the handling of liquids that require special collection and disposal considerations such as detergents.

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of automatic isolation function of radwaste system containment isolation valves;
- Proper functioning of instrumentation and alarms used to monitor system operation and status;
- Acceptable system and component flow paths and flow rates, including pump capacities and sump or tank volumes;
- Proper operation of filter and demineralizer regeneration cycles of the liquid radwaste system and the associated support facilities; and
- Proper functioning of drains and sumps, including those dedicated for handling of specific agents such as detergents.

14.2.8.1.41 Fuel-Handling and Reactor Servicing Equipment Preoperational Test

Purpose

This test is to verify proper operation of the fuel-handling and reactor component servicing equipment. This includes cranes, hoists, grapples, trolleys, platforms, hand tools, viewing aids, and other equipment used to lift, transport, or otherwise manipulate fuel, control rods, neutron instrumentation, and other in-vessel and undervessel components. Also included is equipment needed to lift and relocate structures and components necessary to provide access to fuel, vessel internals, and reactor components during the refueling and servicing operations.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. The required electrical power sources and sufficient lighting shall be available undervessel, and on the refueling floor. The refueling floor (including the fuel storage pool and reactor cavity), and drywell and undervessel areas shall be capable of supporting load and travel testing of the various cranes, bridges, and hoists. Other interfacing systems shall be available as required to support the specified testing.

General Test Methods and Acceptance Criteria

Fuel-handling and reactor component servicing equipment testing described herein includes that of the reactor building crane, the refueling machine, fuel-handling platform and the fuel transfer system, the auxiliary platform, and the associated hoists and grapples, as well as other lifting and rigging devices. Also included are specialized hand tools and viewing aids. Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation for each crane, bridge, trolley, or platform through its full travel and up to its maximum speed, including verification of braking action and overspeed or overtravel protection devices;
- Proper operation of the various cables, grapples, and hoists, including brakes, limit switches, load cells, and other equipment protective devices;
- Proper functioning of all control, instrumentation, logic, interlocks and alarms;
- Proper operation of reactor servicing equipment, including reactor vessel servicing tools, main steam line plugs, shroud head stud wrench, RPV head tensioning and de-tensioning, dryer and separator strongback, and reactor head strongback;
- Proper functioning of fuel handling servicing equipment such as fuel preparation machine, new fuel inspection stand, channel handling tools, refueling platform and inclined fuel transfer system;
- Proper operation of under-vessel servicing equipment, including FMCRD servicing tools and handling equipment, in-core flange seal test plugs;
- Proper operation of various servicing aids such as underwater lights and viewing tubes, viewing aids;
- Proficiency in fuel movement operations using dummy fuel (prior to actual fuel loading); and
- Dynamic and static load testing of all cranes, hoists, and associated lifting and rigging equipment, including static load testing at 125% of rated load and full operational testing at 100% of rated load.

14.2.8.1.42 Expansion, Vibration and Dynamic Effects Preoperational Test

Purpose

To verify that critical components and piping runs are properly installed and supported such that expected steady-state and transient vibration and movement due to thermal expansion does not result in excessive stress or fatigue to safety-related plant systems and equipment.

Prerequisites

Hydro testing and flushing of the piping systems have been completed. The SCG has reviewed the test procedure and approved the initiation of testing. Inspect and determined that piping and components and their associated supports and restraints are installed per design. Additionally, verify that support devices such as snubbers and spring cans are in their expected cold, static positions, and observe that temporary restraining devices such as hanger locking pins are removed.

General Test Methods and Acceptance Criteria

Vibration and thermal expansion testing is conducted on plant systems and components of the following classifications:

- ASME Code Class 1,2 and 3 systems;
- High energy piping systems inside Seismic Category I structures;
- High energy portions of systems whose failure could reduce the functioning of any Seismic Category I plant features to an unacceptable level; and
- Seismic Category I portions of moderate energy piping systems located outside containment.

Thermal expansion testing during the preoperational phase is limited to those systems that are expected to be heated up significantly above their normal ambient temperatures. The testing is in conformance with ANSI/ASME-OM7 as discussed in Subsection 3.9.2.1.2, and consists of a combination of visual inspections and local and remote displacement measurements. Visual inspections are performed to identify actual or potential constraints to free thermal growth. Displacement measurements are made utilizing specially installed instruments and also using the position of supports such as snubbers. Results of the thermal expansion testing are acceptable when all systems move as predicted and there are no observed restraints to free thermal growth or when additional analysis shows that any unexpected results would not produce unacceptable stress values.

Vibration testing is performed on system components and piping during preoperational function and flow testing. This testing is in accordance with ANSI/ASME-OM3 as discussed in Subsection 3.9.2.1.1, and includes visual observation and local and remote monitoring in critical steady-state operating modes and during transients such as pump starts and stops, valve stroking, and significant process flow changes. Results are acceptable when visual observations show no signs of excessive vibration and when measured vibration amplitudes are within acceptable levels to assure no failures from fatigue over the life of the plant as calculated based on expected steady-state and transient operation.

14.2.8.1.43 Reactor Vessel Flow-Induced Vibration Preoperational Test

The ESBWR is a natural circulation reactor in which core flow can only be achieved with core power; thus, a preoperational test to measure the flow-induced vibration of reactor internals is not possible (refer to the discussion of the initial startup testing and measurement of flow induced vibration in Subsection 14.2.8.2.11).

The pre-operational testing is to verify the test instruments have been installed and calibrated. The internals, test instrumentation, and instrumentation lead wires are installed in the reactor vessel head and it is water leak tight. The proper operation and calibration of the test instrumentation and recording equipment is verified during the leak testing of the reactor pressure vessel.

14.2.8.1.44 Condensate and Feedwater Systems Preoperational Test

Purpose

To verify proper operation of the various components that comprise the Condensate and Feedwater System and their capability to deliver the required flow from the condenser hotwell to the Nuclear Boiler System.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure(s) and approved the initiation of testing. The required interfacing systems shall be available, as needed, to support the specified testing. For flow testing there shall be an adequate suction source available and an appropriate flow path established. The main condenser shall be intact and the hotwell water level is in the normal range.

General Test Methods and Acceptance Criteria

Preoperational testing of the Condensate and Feedwater System includes the piping, components, and instrumentation between the condenser and the nuclear boiler, but not the condensate filters or demineralizers nor the feedwater heaters, which are tested separately per the specific discussions provided for those features.

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in all combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability;
- Proper operation of system valves, including timing, under expected operating conditions;
- Proper operation of pumps and motors in all design operating modes;
- Acceptable pump NPSH under the most limiting design flow conditions;
- Proper system flow paths and flow rates, including pump capacity and discharge head;
- Proper pump motor start sequence and margin to actuation of protective devices;

- Proper operation of interlocks and equipment protective devices in pump, motor, and valve controls;
- Acceptability of pump/motor vibration levels and system piping movements during both transient and steady-state operation; and
- Proper operation of controllers for pump drivers and flow control valves, including those in minimum flow recirculation lines.

14.2.8.1.45 Condensate Cleanup System Preoperational Test

Purpose

To verify proper operation of the condensate filters and demineralizers, and the associated support facilities.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. The condensate system shall be operational with an established flow path capable of supporting condensate filter and demineralizer flow. Adequate supplies of ion exchange resin should be available, and the Radwaste System shall be capable of processing the expected quantities of water and spent resins. Other required interfacing systems shall also be available, as needed, to support the specified testing.

General Test Methods and Acceptance Criteria

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in all combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and status;
- Proper operation of system valves, including timing, under expected operating conditions;
- Proper individual vessel and overall system flow rates and pressure drops, including bypass capabilities (for both filter and demineralizer units);
- Proper operation of interlocks and equipment protective devices;
- The ability to perform on-line exchange of standby and spent filter units and demineralizer vessels;
- Proper operation of filter/demineralizer support facilities such as those used for regeneration of resins or for handling of wastes; and
- Regeneration times and spent resin discharge volumes.

14.2.8.1.46 Reactor Water Chemistry Control Systems Preoperational Test

Purpose

This test is to verify proper operation of the Oxygen Injection System .

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure(s) and approved the initiation of testing. The required interfacing systems shall be available, as needed, to support the specified testing.

General Test Methods and Acceptance Criteria

Preoperational testing concentrates on verifying proper operation of the equipment skids and the various individual components. Actual oxygen injection demonstrations and/or simulations shall be limited to only those cases where it is deemed practicable or appropriate with regards to the aforementioned precautions.

Performance shall be observed and recorded during a series of individual component and integrated system tests (to the extent possible) to demonstrate the following:

- Proper operation of instrumentation and equipment in all combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability;
- Proper operation of system valves, including timing and sequencing, under expected operating conditions;
- Proper system flow paths, flow rates and pressures; and
- Proper operation of system interlocks and equipment protective devices.

14.2.8.1.47 Condenser Evacuation System Preoperational Test

Purpose

To verify the ability of the mechanical vacuum pumps and steam jet air ejectors to establish and maintain vacuum in the main condenser as designed. The test of the steam jet air ejectors is performed in conjunction with offgas system described in Subsection 14.2.8.1.48.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Additionally, instrument air, electrical power, cooling water, turbine gland sealing steam, and other required system interfaces shall be available, as needed, to support the specified testing.

General Test Methods and Acceptance Criteria

Performance shall be observed and recorded during a series of individual component and integrated system tests. The test demonstrate the mechanical vacuum pump operates as designed through the following testing:

- Proper operation of instrumentation and equipment in all combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability;
- Proper operation of the mechanical vacuum pumps, including the ability to establish the required vacuum within the design time frame;
- Proper operation of all remote-operated valves, including position indications; and
- Proper operation of the mechanical vacuum pump trip function and its discharge valve closure on simulated main steam line radiation signal.

14.2.8.1.48 Offgas System Preoperational Test

Purpose

To verify proper operation of the Offgas System, including steam jet air ejectors, valves, recombiner, condensers, coolers, filters, and hydrogen analyzers.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Additionally, instrument air, electrical power, cooling water, turbine gland sealing steam, auxiliary boiler system and other required system interfaces shall be available, as needed, to support the specified testing.

General Test Methods and Acceptance Criteria

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in all combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability;
- Proper operation of the steam jet air ejectors, including their ability to maintain the specified vacuum in the main condenser (while accounting for the source of the driving steam used);
- Proper operation of system valves, including isolation features, under expected operating conditions;
- Proper operation of components in all design operating modes;
- Proper system and component flow paths and flow rates;

- Proper operation of interlocks and equipment protective devices;
- Proper operation of permissive, prohibit, and bypass functions; and
- Proper operation of the isolation valve closure of the offgas system on the simulated low steam flow signal.

14.2.8.1.49 Condensate Storage and Transfer System Preoperational Test

Purpose

To verify the ability of the Condensate Storage and Transfer System to provide an adequate reserve of condensate quality water for makeup to the condenser, CRD, RWCU/SDC system, Fuel Pool system and for other uses as designed.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Required interfacing systems shall be available, as needed, to support the specified testing.

General Test Methods and Acceptance Criteria

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in all combinations of logic;
- Proper functioning of permissive and prohibit interlocks;
- Proper operation of the condensate storage and transfer pumps;
- Proper functioning of instrumentation and alarms used to monitor system operation and status, including CST volume and/or level;
- Proper operation of main condenser water level control;
- Proper operation of the freeze protection and flood protection, if applicable; and
- Ability of the system to provide desired flow rates and volumes to the applicable systems and/or components.

14.2.8.1.50 Circulating Water System Preoperational Test

Purpose

To verify the proper operation of the Circulating Water System and its ability to circulate cooling water through the tubes of the main condenser in sufficient quantities to condense the steam exhausted from the main turbine under all expected operating conditions.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. The main condenser, the cooling water source, pump bearing lubricating and shaft sealing water, vacuum priming for the water boxes, electrical power source and other required interfacing systems shall be available, as needed, to support the specified testing.

General Test Methods and Acceptance Criteria

Because of insufficient heat loads during the preoperational test phase, condenser and cooling water source performance evaluation are performed during the startup phase with the turbine-generator on line.

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in all combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability;
- Proper operation of system valves, including timing, under expected operating conditions;
- Proper operation of pumps and motors in all design operating modes;
- Proper system flow paths and flow rates, including pump capacity and discharge head;
- Proper pump motor start sequence and margin to actuation of protective devices;
- Proper operation of interlocks and equipment protective devices in pump and valve controls;
- Proper operation of permissive, prohibit, and bypass functions;
- Proper operation of freeze protection methods and devices, if applicable; and
- Acceptability of pump/motor vibration levels and system piping movements during both transient and steady state operation.

14.2.8.1.51 Plant Service Water System Preoperational Test

Purpose

To verify proper operation of the Plant Service Water System (PSWS) and its ability to supply design quantities of cooling water to the Reactor Component Cooling Water System (RCCWS) and Turbine Component Cooling Water System (TCCWS) heat exchangers.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Electrical power, the RCCWS and TCCWS (including heat exchangers), instrument air, cooling towers, and other required interfacing systems shall be available, as needed, to support the specified testing.

General Test Methods and Acceptance Criteria

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in all combinations of logic and instrument channel trip;

- Proper functioning of instrumentation and alarms used to monitor system operation and availability;
- Proper operation of system valves, including timing, under expected operating conditions;
- Proper operation of pumps and motors in all design operating modes;
- Acceptable pump NPSH under the most limiting design flow conditions;
- Proper operation of motorized self cleaning strainers;
- Proper system flow paths and flow rates, including pump capacity and discharge head;
- Proper pump motor start sequence and margin to actuation of protective devices;
- Proper operation of interlocks and equipment protective devices in pump, motor and valve controls;
- Proper operation of freeze protection methods and devices, if applicable; and
- Acceptability of pump/motor vibration levels and system piping movements during both transient and steady state operation.

The heat exchangers, which serve as interface with the RCCWS and TCCWS, are considered part of those systems and are tested as such. However, due to insufficient heat loads during the preoperational test phase, the heat exchanger performance verification is deferred until the startup phase.

14.2.8.1.52 Turbine Component Cooling Water System Preoperational Test

Purpose

To verify proper operation of the Turbine Component Cooling Water System (TCCWS) and its ability to supply design quantities of cooling water, at the specified temperatures, to designated plant loads.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Electric power, Plant Service Water (PSWS), instrument air, and other required supporting systems shall be available, as needed, for the specified testing configurations. The cooled components shall be operating to the extent possible during heat exchanger performance evaluation.

General Test Methods and Acceptance Criteria

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in all combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability;

- Proper operation of system valves, including timing, under expected operating conditions;
- Proper operation of pumps and motors in all design operating modes;
- Acceptable pump NPSH under the most limiting design flow conditions;
- Proper system and component flow paths, flow rates, and pressure drops, including pump capacity and discharge head;
- Proper pump motor start sequence and margin to actuation of protective devices;
- Proper operation of interlocks and equipment protective devices in pump and valve controls;
- Acceptability of pump/motor vibration levels and system piping movements during both transient and steady-state operation;
- Proper operation of system surge tanks and chemical addition tanks and their associated functions; and
- Acceptable performance of TCCWS heat exchangers, to the extent practical.

Because of insufficient heat loads during the preoperational phase, the final system flow balancing and heat exchanger performance evaluation is performed during the startup phase.

14.2.8.1.53 Main Turbine Control System Preoperational Test

Purpose

To verify the proper operation of the Main Turbine Control System that operates the turbine stop valves, control valves, combined intermediate valves (CIVs) and bypass valves through their associated actuators and hydraulic control to the extent that it can be done without steam.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Electrical power supply to motors, control circuits, and instrumentation are available, the steam bypass and pressure control system shall be operational and other required interfacing systems are available, as needed, to support the specific testing. The Turbine Instruction Manual (TIM) is available to identify the necessary supporting systems and to define the test steps.

General Test Methods and Acceptance Criteria

This test and those other turbine tests detailed in Subsection 14.2.8.1.57 are probably performed as a set. The TIM shall be used to prepare a detailed procedure for testing the hydraulic system in manual and automatic modes, all turbine trip paths, stop and control valves, combined intermediate valves, extraction nonreturn valves, local instrumentation and control room instrumentation.

This test demonstrates main turbine control system functions properly through the following testing:

- Proper operation of the hydraulic control subsystem, including hydraulic fluid pumps and accumulators, and power supplies;
- Proper operation of the main stop and control valves, CIVs in response to simulated signals related to turbine speed, load, and pressure;
- Proper operation of the main stop and control valves, CIVs upon loss of the control system electrical power or hydraulic system pressure;
- Capability of manual operation of the turbine valves, including position indications and stroke rate adjustments;
- Proper interface with steam bypass and pressure control system; and
- Verification that various component alarms used to monitor system operation.

14.2.8.1.54 Main Turbine Bypass System Preoperational Test

Purpose

To verify the proper operation of the Main Turbine Bypass System (MTBS) to the extent that it can be done without steam.

Prerequisite

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. The Turbine Instruction Manual (TIM) is available to identify the necessary supporting systems and to define the test steps.

General Test Methods and Acceptance Criteria

Performance shall be observed and recorded during a series of component and system tests. This test shall demonstrate that the turbine bypass system operates properly through the following testing:

- Proper functioning of instrumentation and system controls in all combinations of logic and instrument channel trip;
- Capability of manual bypass operation, including stroke rate adjustments and position indications;
- Proper operation of the bypass valve closure in response to loss of condenser vacuum, control system electrical signal or hydraulic power;
- Proper bypass valve response following a simulated turbine and generator trip initiation signal, including the fast opening timing to avoid the reactor trip; and
- Proper interface with the steam bypass and pressure control system.

14.2.8.1.55 Steam Bypass and Pressure Control (SB&PC) System Preoperational Test

Purpose

To verify the proper operation of the SB&PC System, including turbine valves and turbine bypass valve control and the plant automation system.

Prerequisite

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. The preoperational tests of the turbine valves and bypass valves have been completed to extend necessary to support integrated system testing. All SB&PC system components have been calibrated. The TIM is available to identify the necessary supporting systems and to define the test steps.

General Test Methods and Acceptance Criteria

Performance shall be observed and recorded during a series of individual component and overall system response tests to demonstrate the following:

- Preliminary adjustments of controllers for prescribed open-loop frequency response or step response;
- Proper operation of redundant controller upon simulated operating controller failure;
- Proper calibration of redundant pressure sensors to within the prescribed limits as specified in the system design specification;
- Proper operation of permissive, prohibit, and bypass functions; and
- Proper communication and interface with other control systems and related equipment.

14.2.8.1.56 Heater, Drain and Vent System Preoperational Test

Purpose

To verify proper operation of the feedwater heaters and their associated drains and vents, including heater level control capabilities.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Appropriate power sources that supply power to the control circuits and instrumentation are available to support testing. Required interfacing systems shall be available, as needed, to support the specified testing.

General Test Method and Acceptance Criteria

The Feedwater Heater and Drain System includes the feedwater heaters, internal and external drain coolers, normal and emergency dump valves, shell and tube side isolation valves, shell side vents and safety/relief valves, and associated instrumentation, control and logic.

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in all combinations of logic and instrument channel trip;

- Proper functioning of instrumentation and alarms used to monitor system operation and status;
- Proper operation of system valves and actuators under expected operating conditions;
- Proper operation of interlocks and equipment protective devices; and
- Proper operation of heater level controls, including response of the associated drain/dump valves.

14.2.8.1.57 Extraction Steam System Preoperational Test

Purpose

To verify proper operation of the components which comprise the extraction steam system.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Appropriate power sources that supply power to the control circuits and instrumentation are available to support testing. Required interfacing systems shall be available, as needed, to support the specified testing.

General Test Methods and Acceptance Criteria

Comprehensive testing of the extraction steam system requires the turbine generator to be on-line with a substantial amount of steam flow available. The preoperational testing of the extraction steam system without main turbine generator on-line is limited.

Performance shall be observed and recorded during a series of component and system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in all combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and status;
- Proper operation of system valves under expected operating conditions, including response of air-assisted nonreturn check valves to a turbine trip signal; and
- Proper operation of interlocks and equipment protective devices.

14.2.8.1.58 Moisture Separator Reheater System Preoperational Test

Purpose

To verify proper operation of the turbine Moisture Separator Reheater (MSR) and the associated drain pathways, steam extraction lines, and isolation and non-return check valves.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Appropriate power sources that supply power to the control circuits and instrumentation are available to support testing. Required interfacing systems shall be available, as needed, to support the specified testing.

General Test Methods and Acceptance Criteria

Comprehensive testing of the extraction steam system require the turbine generator to be on-line with a substantial amount of steam flow available. The preoperational testing of the moisture separator system without main turbine generator on-line is limited.

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in all combinations of logic and instrument channel trip including turbine trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and status;
- Proper operation of system valves and actuators (including isolation and nonreturn check valves) under expected operating conditions;
- Proper operation of interlocks and equipment protective devices; and
- Proper operation of moisture separator drain pathways.

14.2.8.1.59 Main Turbine and Auxiliaries Preoperational Test

Purpose

To verify that the operation of the main turbine and its auxiliary systems, including the gland sealing system, lube oil system, turning gear, supervisory instrumentation, and turbine protection system (including overspeed protection), is as specified. Testing of the turbine valves and associated control systems is included.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Appropriate power sources that supply power to the control circuits and instrumentation are available to support testing. Required interfacing systems shall be available, as needed, to support the specified testing and the corresponding system configurations.

General Test Methods and Acceptance Criteria

Performance shall be observed and recorded during a series of individual component, subsystem and integrated system tests (to the extent possible) to demonstrate the following, with regard to both the turbine and its auxiliaries:

- Proper operation of instrumentation and equipment in all combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability, including the turbine supervisory instrumentation;
- Proper operation of system pumps and valves in all design operating modes;
- Proper system flow paths, flow rates, temperatures and pressures (particularly with regard to the lube oil and gland sealing steam systems);

- Proper operation of valve auxiliaries such as hydraulic fluid systems, including pumps and accumulators, and power supplies;
- Verification that automatic starting of motor driven lube oil pumps, the alarm functions of lube oil level and the pressure drop of lube oil filters;
- Proper operation of interlocks and equipment protective devices in various turbine, pump, and valve controls; and
- Proper operation of the turbine turning gear including proper turning gear engagement and disengagement functions.

14.2.8.1.60 Main Generator and Auxiliary Systems Preoperational Test

Purpose

Verify that the operation of the main generator and its auxiliary systems, including the generator hydrogen system and its associated seal oil and cooling systems, those subsystems and/or components that provide cooling to the generator exciter, stator, circuit breakers and isophase bus duct, and the generator protection system, is as specified.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure(s) and approved the initiation of testing. Appropriate power sources that supply power to the control circuits and instrumentation are available to support testing. The generator instruction manual shall be reviewed in detail in order that precautions relative to generator operation are followed. Required interfacing systems shall be available, as needed, to support the specified testing and the corresponding system configurations.

General Test Methods and Acceptance Criteria

Performance shall be observed and recorded during a series of individual component, subsystem and integrated system tests (to the extent possible) to demonstrate the following, with regard to both the generator and its auxiliaries:

- Proper operation of instrumentation and equipment in all combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability;
- Proper operation of system pumps, valves, fans, and piping or ducting in all design operating modes;
- Proper system flow paths, flow rates and pressures (particularly with regard to the generator hydrogen system and its associated seal oil and cooling systems);
- Proper operation of the generator purge system;
- Proper operation of interlocks and equipment protective devices in the various generator and auxiliary system controls; and
- Proper operation of the field excitation.

14.2.8.1.61 Seismic Monitoring System Preoperational Test

Purpose

To verify that the Seismic Monitoring System operates as designed in response to a seismic event.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. The required electrical power shall be available and system-recording devices should have sufficient storage medium available. Instrument calibration and instrument loop checks have been completed.

General Test Methods and Acceptance Criteria

Performance shall be observed and recorded during a series of tests, as recommended by the manufacturer, to demonstrate the following:

- Proper calibration and response of seismic instrumentation, including verification of alarm and initiation setpoints;
- Proper operation of internal calibration or test features; and
- Proper operation of recording and playback devices.

14.2.8.1.62 Liquid and Solid Radwaste Systems Preoperational Tests

Purpose

To verify the proper operation of the various equipment and processes which make up the liquid and solid radwaste systems.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure(s) and approved the initiation of testing. There shall be access to appropriate laboratory facilities and an acceptable effluent discharge path shall be established. Additionally, an adequate supply of demineralized water, the electrical power, and other required interfacing systems shall be available, as needed, to support the specified testing.

General Test Methods and Acceptance Criteria

The testing described below includes that of equipment and processes for the handling, treating, storing, and preparation for the disposal or discharge of liquid and solid radwaste.

The liquid and solid radwaste systems performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate to the extent possible for the following:

- Proper operation of equipment controls and logic, including prohibit and permissive interlocks;
- Proper operation of equipment protective features and automatic isolation functions, including those for ventilation systems and liquid effluent pathways;

- Proper functioning of instrumentation and alarms used to monitor system operation and status;
- Acceptable system and component flow paths and flow rates, including pump capacities and tank volumes;
- Proper operation of system pumps, valves, and motors under expected operating conditions;
- Proper operation of phase separators;
- Proper operation of concentrating and packaging functions, including verification of the absence of free liquids in packaged waste;
- Proper operation of filter and demineralizer units and their associated support facilities; and
- Proper functioning of drains and sumps, including those dedicated for handling of specific agents such as detergents.

14.2.8.1.63 Isolation Condenser System Preoperational Test

Purpose

To verify that the operation of the Isolation Condenser (IC) system loops, including valves, logic and instrumentation is as specified.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. High-pressure nitrogen must be available to operate the spring-loaded condensate return valves, and nitrogen operated pneumatic rotary motor isolation valves. Electrical power is also required to operate valves and controls.

General Test Methods and Acceptance Criteria

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in all combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability;
- Proper operation of system valves, including timing;
- Verification that the steam flow paths from the IC/PCCS pools to the atmosphere are unobstructed;
- Verification that IC steam and condensate-return piping flow passages are unobstructed;
- Verification that IC system valves are in their operational readiness positions as required by design, and the IC pool is filled to normal level;
- Proper operation of IC/PCCS pool level control;

- Verification that the IC Pool subcompartment valves are locked open; and
- Proper isolation of IC containment isolation valves upon receipt of simulated isolation signals.

14.2.8.1.64 Passive Containment Cooling System Preoperational Test

Purpose

To verify the operation of Passive Containment Cooling Systems (PCCS) is as specified.

Prerequisites

The construction tests have been successfully completed and the integrated containment leak rate test has been completed successfully. Makeup Water System is available to support the proper level control of IC/PCCS pool. The SCG has reviewed the test procedure and approved this visual inspection.

General Test Methods and Acceptance Criteria Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Verification that PCCS steam supply, drain and vent piping is unobstructed;
- Verification that PCCS condenser air flow versus differential pressure is within acceptable test limits;
- Verification that PCCS pool subcompartment valves are locked open;
- Proper operation of IC/PCCS pool level control; and
- Verification of the system interface with Fuel and Auxiliary Pools Cooling System for IC/PCCS pool cooling.

14.2.8.1.65 Gravity-Driven Cooling System Preoperational Test

Purpose

To verify that the operation of the four divisions of the Gravity-Driven Cooling System (GDCS), including valves, logic and instrumentation, is as specified.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. The reactor vessel shall be ready to accept GDCS flow. The required electrical power shall be available for squib type valve power supply. Instrument calibration and instrument loop checks have been completed.

General Test Method and Acceptance Criteria

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in all combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability;

- Proper operation of system valves, including timing;
- Verification that the flow passages from GDCS and Suppression Pool to reactor vessel are unobstructed;
- Verification that the flow passages to upper drywell are unobstructed; and
- Adequacy to provide required design flow rate.

14.2.8.1.66 Loose Parts Monitoring System Preoperational Test

Purpose

This test is to verify proper functioning of loose parts monitoring equipment.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Reactor internals except the steam dryer and moisture separator shall be in place with all system sensors connected.

General Test Methods and Acceptance Criteria

Performance shall be observed and recorded during a series of system and component tests to demonstrate the following:

- Proper calibration of loose part monitor instruments;
- Proper operation of the data acquisition equipment and alarm setpoint; and
- Adequacy of alert level setpoints based on preliminary data.

14.2.8.2 General Discussion of Startup Tests

Those tests proposed and expected to comprise the startup test phase are discussed in this subsection. For each test, a general description is provided for test purpose, test prerequisites, test description and test acceptance criteria, where applicable.

Because additions, deletions, and changes to these discussions are expected to occur as the test program is developed and implemented, the descriptions remain general in scope. In describing a test, however, an attempt is made to identify those operating and safety-oriented characteristics of the plant, which are to be explored and evaluated.

The ESBWR, because it is a natural circulation reactor, has unique characteristic during startups and especially during the initial startup. The control rod drive (CRD) cooling flow provides a steady supply of cold water into the bottom of the RPV and core heat warms the upper part of the RPV (i.e., there is a designed-in tendency for temperature stratification until natural circulation is established). This can be overcome with the RWCU/SDC system (See Subsection 14.2.8.2.17).

Where applicable, the relevant acceptance criteria for the test are discussed. Some of the criteria relate to the value of process variables assigned in the design or analysis of the plant, component systems, and associated equipment. Other criteria may be associated with expectations relating to the performance of systems. The startup administrative manual shall describe the various categories of acceptance criteria and shall designate how differentiation between them is accomplished in the test procedures. Specific actions for dealing with criteria failures and other testing exceptions or anomalies are also described in the startup administrative manual.

The specifics of the startup tests relating to test methodology, plant prerequisites, initial conditions, acceptance criteria, analysis techniques, and the like, is incorporated into the detailed test procedures to be utilized, based on the scoping documents to be supplied by the appropriate design and engineering organizations in the form of plant, system and component performance and testing specifications. The power ascension test phase procedures are made available to the NRC 60 days prior to the scheduled date for fuel loading. Furthermore, to insure that the tests are conducted in accordance with established methods and appropriate acceptance criteria, the associated plant testing specification(s) is made available to the NRC.

14.2.8.2.1 Chemical and Radiochemical Measurements

Purpose

To secure information on the chemistry and radiochemistry of the reactor coolant while verifying that the sampling equipment, procedures and analytic techniques are adequate to supply the data required to demonstrate that the chemistry of all parts of the entire reactor system meet specifications and process requirements.

Prerequisites

The preoperational tests have been completed and plant management has reviewed the test procedures and approved the initiation of testing. For each scheduled testing iteration, the plant shall be in the appropriate operational configuration with prerequisite testing completed. Instrumentation has been checked or calibrated as appropriate.

Description

Specific objectives of the test program include evaluation of fuel performance, evaluations of demineralizer operations by direct and indirect methods, measurements of filter performance, confirmation of condenser integrity, and evaluation and calibration of certain process instrumentation (including that used to monitor reactor water conductivity). Data for these purposes is secured from a variety of sources such as plant operating records, regular routine coolant analysis, radiochemical measurements of specific nuclides, and special chemical tests.

Prior to fuel loading, a complete set of chemical and radiochemical samples is taken to ensure that all sample stations are functioning properly, if not demonstrated during the preoperational testing, and to determine initial concentrations. Subsequent to fuel loading, during reactor heatup, and at each major power level change, samples are taken and measurements made to determine the chemical and radiochemical quality of reactor water and incoming feedwater, amount of radiolytic gas in the steam, gaseous activities leaving the air ejectors, decay times in the offgas lines, and performance of filters and demineralizers.

Calibrations are made of monitors in effluent release paths, waste handling systems, and process lines. Proper functioning of such monitors is verified, as appropriate, including via comparison with independent laboratory or other analyses. In particular, the proper operation of failed fuel detection functions of the main steamline and offgas pretreatment process radiation monitors is verified. In this regard, sufficient data is taken to assure proper setting of, or to make needed adjustments to, the alarm and trip settings of the applicable instrumentation.

Criteria

Chemical factors defined in the Fuel Warranty Operating Limits must be maintained within the limits specified.

The activity of gaseous and liquid effluents must conform to license limitations.

Water quality must be known at all times and shall remain within the guidelines of the water quality specifications and the requirements of the Fuel Warranty document.

14.2.8.2.2 Radiation Measurements

Purpose

To determine the background radiation levels in the plant environs prior to operation for base data on activity buildup and to monitor radiation at selected power levels to assure the protection of personnel during plant operation.

Prerequisites

The preoperational tests have been completed and plant management has reviewed the test procedures and approved the initiation of testing. For each scheduled testing iteration, the plant shall be in the appropriate operational configuration with the specified prerequisite testing complete. Instrumentation has been checked or calibrated as appropriate.

Description

A survey of natural background radiation throughout the plant site is made prior to fuel loading, and repeated periodically during startup testing, subsequent to fuel loading, during reactor heatup, and at several power levels up to and including rated power, gamma dose rate measurements and, where appropriate, neutron dose rate measurements are made at specific locations throughout the plant. All potentially high radiation areas are surveyed, including:

- Containment penetrations;
- All accessible areas where intermittent activities have the potential to produce transient high radiation conditions before, during, and after such operations; and
- A complete survey of all accessible floor areas within the plant prior to fuel loading, at intermediate powers, and at full power.

Criteria

The radiation doses of plant origin and the occupancy times of personnel in radiation zones shall be controlled consistent with the guidelines outlined in 10 CFR 20, “Standards for Protection Against Radiation.”

14.2.8.2.3 Fuel Loading

Purpose

This test is to load fuel safely and efficiently to the full core size.

Prerequisites

The plant has received the proper authorization from the NRC to proceed with fuel loading and plant management has reviewed the applicable procedures and the overall plant readiness, and approved the initiation of loading.

Additionally, the following requirements are met prior to commencing fuel loading to assure that this operation is performed in a safe manner:

- The status of all systems required for fuel loading is specified and the systems are in the required status;
- Fuel and control rod inspections are complete. Control rods are fully inserted and functionally tested;
- For the initial core, neutron sources are installed;
- The required number of SRNM channels are operable and calibrated with high flux scram and rod block trips being set conservatively low in the non-coincident mode;
- Nuclear instruments are source checked with a neutron source prior to loading;
- Reactor vessel status is specified relative to internal component placement and this placement established to make the vessel ready to receive fuel;
- Final functional testing of the Reactor Protection System to demonstrate proper trip points and logic, as well as the operability of scram valves, and manual scram functions are completed;
- Reactor vessel water level is established above the minimum level prescribed; and
- Other required systems shall be operable as defined by the plant Technical Specifications and as demonstrated by the applicable surveillance tests.

Description

Fuel loading commences and proceeds according to written procedures in a predetermined sequence that assure a safe and efficient loading, with each fuel assembly by serial number in its specified location. The neutron count rates shall be monitored as the core loading progresses to ensure continuous subcriticality, and shutdown margin demonstrations are performed at specified loading intervals.

Criteria

The partially loaded core, at the applicable intervals, must be subcritical by at least the specified amount, in terms of reactivity, with the analytically determined highest worth rod pair fully withdrawn (a rod pair is defined as having a shared accumulator).

14.2.8.2.4 Full Core Shutdown Margin Demonstration

Purpose

To demonstrate that the reactor is subcritical throughout the first fuel cycle with the highest worth control rod pair (two CRDs with a shared accumulator) fully withdrawn and all other control rods fully inserted.

Prerequisites

The plant management has reviewed the test procedure and approved the initiation of the testing. The following prerequisites are satisfied prior to performing the full core shutdown margin tests:

- The predicted rod position for the criticality has been determined;
- The Standby Liquid Control System is operable;
- Nuclear instrumentation is operable with the minimum neutron count rate and signal-to-noise ratio as specified by the Technical Specifications; and
- High-flux scram trips are set conservatively low on SRNMs.

Description

This test is performed in the fully loaded core in the xenon free condition. This test is performed by withdrawing the control rods from the all-rods-in configuration in the specified withdrawal sequence until criticality is reached. The difference between the measured K_{eff} and the calculated K_{eff} for the in-sequence critical is applied to the calculated value to obtain the true shutdown margin.

Criteria

The shutdown margin of the fully loaded, cold (20°C/68°F), xenon-free core occurring at the most reactive time during the cycle must be at least that amount required by Technical Specifications, with the analytically strongest rod pair (or the reactivity equivalent) fully withdrawn. If the core reactivity is calculated to increase during the fuel cycle, compliance with the above criterion is shown by demonstrating that the shutdown margin is the specified amount plus an exposure-dependent increment which adjusts for the difference in core reactivity between the most reactive exposure and the time at which the shutdown margin is demonstrated. Additionally, criticality shall occur within the specified tolerance of the predicted critical.

14.2.8.2.5 Control Rod Drive System Performance

Purpose

To demonstrate that the control rods operate properly over the full range of primary coolant temperatures and pressures from ambient to operating conditions, in both the scram and fine motion control modes, in conjunction with the Rod Control and Information System (RC&IS).

Prerequisites

The preoperational tests have been completed and plant management has reviewed the test procedures and approved the initiation of testing. For each scheduled testing iteration, the plant shall be in the appropriate operational configuration with the specified prerequisite testing complete. The applicable instrumentation shall be checked or calibrated as appropriate. In addition, a special test fixture containing a small pump and associated hydraulic control shall be available for performing driveline friction testing.

Description

The control rod drive (CRD) testing performed during the heatup and power ascension phases of the startup test program is designed as an extension of the testing performed during the preoperational phase. The continuous-insert friction test is performed after completion of fuel loading for each drive with the reactor at cold, atmospheric pressure condition. The underside of each Fine Motion Control Rod Drive (FMCRD) hollow piston will be pressurized using a portable friction test cart connected to the hydraulic control unit. The pressure acting on the bottom surface of the FMCRD hollow piston is measured by the friction test device as the control rod drive moves towards insertion. The variation in water pressure under the hollow piston is then compared against the acceptable limit for indication of abnormal driveline resistance that would adversely affect drive operation.

After it is verified that all CRDs operate properly when installed, tests are performed periodically during heatup to assure that there is no significant binding caused by thermal expansion of the core components and no significant effect on performance due to increased pressure, power or flow. Additionally, software functions such as those associated with the RC&IS are tested to the extent that they could not be checked during preoperational testing.

Coupling tests will be performed by withdrawing each drive from full-out to overtravel-out position (i.e., uncoupling check position) using Coupling Check Test Mode. The coupling test is performed to:

- Demonstrate actuation of the separation switches
- Confirm synchro position indication as the drive is withdrawn to the overtravel-out position, and
- Confirm the integrity of the coupling between the control blade and the hollow piston.

Gang rod operation in response to commands from the RC&IS and the Plant Automation System during automatic rod movement will be demonstrated during reactor heatup and at reactor rated temperature and pressure conditions. This test will also verify that a rod withdrawal block is activated as a result of rod gang misalignment during normal gang rod movement.

The scram performance tests will be demonstrated at atmospheric and rated reactor pressure conditions by using Scram Test Switches on the test panel. The accumulator charging line valve in the associated hydraulic control unit (HCU) shall be closed so that the CRDs do not ride the CRD pump head during the paired (two-CRD per HCU) and unpaired (one-CRD per HCU) CRD scram performance test. Four CRDs will be selected based on slow normal accumulator pressure scram times as determined from preoperational or atmospheric scram performance testing, or unusual operating characteristics. During reactor heatup with reactor pressure at 4.14 and 5.51±0.34 MpaG (800±50 psig), scram performance tests of these four selected CRDs with the CRD accumulators normally charged will be conducted for continuous monitoring purposes.

Additionally, the full core scram tests will be performed in conjunction with the various planned scram tests. The scram insertion time of each fully withdrawn rod will be measured during each scram test. The scram follow function will be confirmed to actuate automatically and go to completion. The intermediate position reed switches will be verified to actuate momentarily at the end of scram. The separation switches will be verified to actuate at the start of scram and return to their normal state at the completion of the scram follow function.

Criteria

Each CRD shall have a measured scram time that is less than or equal to the Technical Specifications requirements and consistent with safety analysis assumptions during both individual rod pair and full core scrams, as applicable. Each CRD shall have a measured insert/withdrawal speed consistent with specified design requirements, including those associated with group or gang movement. The CRDs shall meet friction test requirements. For each control rod, the scram-follow function shall actuate automatically to insert the scrammed control rod(s) to the full-in position within the time limit specified as per design. The separation switches for each control rod shall operate normally from scram occurrence to scram-follow completion during both paired/unpaired rod and full core scram performance tests.

14.2.8.2.6 Neutron Monitoring System Performance

Purpose

To verify response, calibration and operation of Startup Range Neutron Monitors (SRNMs), Local Power Range Monitors (LPRMs), Average Power Range Monitors (APRMs), and other hardware and software of the Neutron Monitoring System during fuel loading, control rod withdrawal, heatup and power ascension.

Prerequisites

The applicable preoperational phase testing is complete and the plant management has reviewed the test procedure(s) and approved the initiation of testing. For each scheduled test iteration the plant shall be in the appropriate operational configuration with all specified prerequisite testing complete. The applicable instrumentation shall be checked or calibrated, as appropriate.

Description

Testing of the Neutron Monitoring System commences prior to fuel loading and continues at intervals up to and including rated power. The SRNMs and operational sources are tested during fuel loading and during rod withdrawal on the approach to criticality and heatup to rated temperature and pressure and low power operation. The LPRMs and APRMs are tested as soon as sufficient flux levels exist and at specified intervals during the ascension to rated power. Testing includes response checks, calibrations and verification of system software calculations using actual core flux levels and other plant inputs.

Criteria

The SRNMs, in conjunction with the installed neutron sources, shall have count rates that meet Technical Specifications and design requirements, as applicable. The respective range functions of the SRNMs and APRMs shall provide for overlapping neutron flux indication as required by plant Technical Specifications and the applicable design specifications. The APRMs shall be calibrated against core thermal power by means of a heat balance. The accuracy of this calibration shall be consistent with the Technical Specifications. The LPRMs shall be calibrated consistent with design calibration and accuracy requirements. Additionally, all system hardware and software shall function properly in response to actual core flux levels.

14.2.8.2.7 Core Performance

Purpose

To demonstrate that the various core and reactor performance characteristics such as power and flow, core power distributions, and those parameters used to demonstrate compliance with core thermal limits and plant license conditions are in accordance with design limits and expectations.

Prerequisites

The applicable preoperational tests have been completed and plant management has reviewed the test procedure(s) and approved the initiation of testing. For each scheduled testing iteration, the plant shall be in the appropriate operational configuration with all specified prerequisite testing complete. Applicable instrumentation shall have been checked and calibrated, as appropriate.

Description

This test collects data sufficient to demonstrate that reactor and core performance characteristics remain within design limits and expectations for the operational conditions the plant is normally expected to encounter. Beginning with rod withdrawal and continuing through initial criticality, plant heatup, and the ascension to rated power, pertinent data is collected at various rod patterns and powers sufficient to determine the axial and radial core power distributions, compliance with core thermal limits, and the level of consistency with predicted core reactivity and core flow versus core power. Core flow is calculated from a heat and mass-flow balance on the downcomer. Core power is calculated from a heat and mass-flow balance on the nuclear boiler.

Criteria

Technical Specification and license condition requirements involving core thermal limits, maximum power level, and any observed reactivity anomalies or core instabilities shall be met.

14.2.8.2.8 Nuclear Boiler Process Monitoring

Purpose

To verify proper operation of various nuclear boiler process instrumentation and to collect pertinent data from such instrumentation at various plant operating conditions in order to validate design assumptions and identify any operational limitations that may exist.

Prerequisites

The applicable preoperational testing has been completed and plant management has reviewed the test procedure(s) and approved the initiation of testing. For each scheduled testing iteration, the plant shall be in the appropriate operational configuration with all specified prerequisite testing complete. Additionally, system and test instrumentation shall have been installed and calibrated.

Description

After all in-vessel work has been completed and the RPV head has been secured, a hydrostatic pressure test is required before nuclear heatup. The RPV must be heated to a minimum temperature before it can be hydrotested; refer to the pressure-temperature curve for the RPV. The Feedwater System in conjunction with the RWCU/SDC System shall be used to meet this temperature requirement and demonstrate their capability.

During plant heatup and power ascension, pertinent parameters such as reactor coolant temperature, vessel bottom head temperature, vessel dome pressure, vessel water level, and water-level reference column temperature distribution are monitored at selected intervals and plant conditions. This data is used to verify proper instrument response to changing plant conditions and to document the relationships among these parameters and with other important parameters such as reactor power, feedwater flow and steam flow. The data are also used to validate design assumptions such as those used in the calibration of vessel level indication and to identify potential operational condition limitations such as excessive coolant temperature stratification in the vessel bottom head region.

Criteria

The various nuclear boiler process instrumentations shall operate as designed in response to changes in plant conditions. The observed process characteristics shall be conservative relative to applicable safety analysis assumptions and shall be consistent with design expectations.

14.2.8.2.9 System Expansion

Purpose

The purpose of the thermal expansion test is to confirm that the pipe suspension system is working as designed, and the piping is free of obstructions during power changes. The measured and observed pipe expansion is in accordance with design, the piping returns to its approximate cold condition after cooldown.

Prerequisites

The preoperational tests have been completed and plant management has reviewed the test procedures and approved the initiation of testing. For each scheduled testing iteration, the plant shall be in the appropriate operational configuration with the specified prerequisite testing complete. The applicable instrumentation shall be checked or calibrated as is appropriate.

Description

The thermal expansion tests consist of measuring displacements and temperatures of piping during various operating modes. The power levels used to heat and hold the system at a constant temperature shall be as low as practicable. The Plant Automation System can be used to control the rate of heatup and hold the temperature constant. Thermal movement and temperature measurements shall be recorded for at least the following test points (following a suitable hold period to assure steady-state temperatures):

- During reactor pressure vessel heatup at least one intermediate temperature (between 121°C/250°F and 177°C/350°F) prior to reaching normal operating temperature, including an inspection of the piping and its suspension for obstructions or inoperable supports;
- Following reactor pressure vessel heatup to normal operating temperature;
- Following heatup of other piping systems to normal operating temperature (those systems whose heatup cycles differ from the reactor pressure vessel); and
- Subsequent heatup/cooldown cycles, as specified, at the applicable operating and shutdown temperatures, to measure possible shakedown effects.

Thermal expansion shall be conducted on plant systems of the following systems:

- Main Steam Piping: Steam lines between the RPV nozzles and the outboard main steam isolation valves (MSIVs), and steam lines downstream of the outboard MSIVs shall be tested;
- Relief Valve Discharge Piping: The piping attached to the main steam lines and bounded by the SRV discharge flange and the quencher in the wetwell shall be within the scope of the test;
- Feedwater Piping: The feedwater discharge piping downstream of the butt welds, located nominally one meter of piping outside of the reactor building boundary up to the RPV feedwater nozzles, shall be within the scope of this test;
- Isolation Condenser Piping: The steam supply and condensate return piping shall be within the scope of this test;
- RWCU/SDC Piping: The RWCU pumps suction and discharge piping is within the scope of the test;
- RPV Head Vent Piping: RPV Head Vent piping shall be tested; and
- Piping Inside Drywell: Major piping systems inside the drywell including the GDCS and SLC discharge piping are within the scope of the test and subject to inspection.

The system expansion test consists of measuring displacements and temperatures of piping systems using installed instruments or local measurements during various system and plant operating modes. A visual examination for evidence of obstruction or interference will be performed on the above mentioned system piping inside containment at appropriate hold points during reactor heatup to rated temperature and pressure conditions and after three heatup and cooldown cycles. In addition, visual observation will also be made by a system walkdown at accessible locations to determine acceptability of the system outside containment under the conditions existing during each specified system testing.

Thermal movement and temperature measurements shall be recorded inside the drywell and wetwell on the following piping: main steam, selected SRV discharge lines, IC steam piping, feedwater lines, and RWCU/SDC, at least at the following points during the power ascension phase of startup testing:

- Ambient temperature (for baseline data);
- 1.05 MPaG (150psig) reactor pressure;
- 4.14 MPaG (600 psig) reactor pressure;
- Approximately 7.07 MpaG (1025 psaig); and
- 20-25%, 50%, 75% and 100% of rated thermal power.

Thermal movements will also be recorded at appropriate temperature increments up to the required test temperature for the feedwater, RWCU/SDC system piping when each system is placed in service during normal plant operation.

For applicable BOP system piping, cold baseline data will be initially recorded. During initial reactor heatup, measurement data will be obtained at specified temperature plateaus. Stop the heatup if any excessive movement is encountered. On completion of cooldown to ambient temperature, measurement data will again be collected.

Additionally, a special test will be performed to monitor the conditions and effects of temperature stratification that may exist on the feedwater discharge piping inside and outside of containment. This special test will be conducted during heatup, hot standby, post scram, during IC operation, and during reactor shutdown. During the performance of this test, thermal displacements, strains, and temperature measurements will be taken on at least one of the main feedwater headers inside and outside the containment, at selected feedwater riser piping, and at selected feedwater RPV nozzles to measure thermal cycling.

Criteria

The thermal expansion acceptance criteria are based upon the actual movements being within a prescribed tolerance of the movements predicted by analysis. Measured movements are not expected to precisely correspond with those mathematically predicted. Therefore, a tolerance is specified for differences between measured and predicted movement. The tolerances are based on consideration of measurement accuracy, suspension free play, and piping temperature distributions. If the measured movement does not vary from the predictions by more than the specified tolerance, the piping is expanding in a manner consistent with predictions and is therefore acceptable. Tolerances shall be the same for all operating test conditions. The locations to be monitored and the predicted displacements for the monitored locations in each plant are provided by the applicable testing specification.

14.2.8.2.10 System Vibration

Purpose

To verify that the vibration of critical plant system components and piping is within acceptable limits during normal steady-state power operation and during expected anticipated operational occurrences (AOOs).

Prerequisites

The applicable preoperational phase testing is complete and plant management has reviewed the test procedure(s) and approved the initiation of testing. Applicable systems have been walked through and verified complete to the extent required to conduct this test. Temporary hangers have been removed and replaced with permanently installed hangers for the systems involved, prior to starting the test on the particular system. For each scheduled test iteration the plant shall be in the appropriate operational configuration with all specified prerequisite testing complete. The required remote monitoring instrumentation shall be calibrated and operational.

Description

Vibration testing during the power ascension phase is limited to those systems that could not be adequately tested during the preoperational phase. Systems within the scope of this testing are therefore the same as mentioned in Subsection 14.2.8.1.42. However, the systems that remain to be tested are primarily of those exposed to and affected by steam flow and high rates of core flow. Because of the potentially high levels of radiation present during power operation, the testing is performed using remote monitoring instrumentation. Displacement, acceleration, and strain data is collected at various critical steady-state operating conditions and during significant anticipated operational occurrences (AOOs) such as turbine or generator trip, main steamline isolation, and SRV actuation.

Criteria

Criteria are calculated for those points monitored for vibration for both steady state and AOO cases. Two levels of criteria are generated, one level for predicted vibration and one level based on acceptable values of displacement and acceleration and the associated stress to assure that there are no failures from fatigue over the life of the plant. Failure to remain within the predicted levels of vibration shall be investigated but do not necessarily preclude the continuation of further testing. However, failure to meet the criteria based on stress limits requires prompt investigation and resolution while the plant or affected system is placed in a safe condition.

14.2.8.2.11 Reactor Internals Vibration (Initial Startup Flow-Induced Vibration Testing)

Purpose

To collect information needed to verify the adequacy of the design, manufacture, and assembly of reactor vessel internals with respect to the potential affects of flow-induced vibration. Instrumentation of major components and the flow tests and remote inspections provide assurance that excessive vibration amplitudes, if they exist, are detected at the earliest possible time. The data collected also helps establish the margin to safety associated with steady state and AOO conditions and helps confirm the pretest analytical vibration calculations. This testing fulfills the initial startup test requirements of Regulatory Guide 1.20 for a vibration measurement and inspection program for prototype reactor internals.

Prerequisites

The applicable preoperational phase testing is complete and plant management has reviewed the test procedure(s) and approved the initiation of testing. The initial vibration analysis computations and specifications of acceptance criteria shall be complete. These results shall be utilized to define final inspection and measurement programs. All reactor vessel components and structures shall be installed and secured as designed in expectation of being subjected to rated volumetric core flow. This includes the steam separator and dryer assembly and reactor vessel head. The assembly and disassembly of vessel internals shall be choreographed such that structures and components requiring remote inspections are accessible at the proper times. The required sensors shall be installed and calibrated prior to the flow testing. All other systems, components and structures shall be available, as required, to support the reactor internals vibration assessment program. For each scheduled testing iteration, the plant shall be in the appropriate operational configuration with all specified testing complete.

Description

The reactor internals vibration testing subsequent to fuel loading is performed during the power ascension phase and includes intermediate and high power and flow conditions during steady-state operation. AOOs that are expected to result in limiting or significant levels of reactor internals vibration are also included.

The reactor internals vibration assessment program consists of two parts: a vibration analysis program, and an inspection and measurement program. The vibration analysis portion is performed on the final design, prior to the initial startup test, and the results are used to develop the measurement and inspection portions of the program. The initial startup test therefore consists of an instrumented flow test and pre- and post-test inspections as described in the following paragraphs:

Pre-flow Vessel Inspection — The pre-flow inspection is performed primarily to establish and document the status of vessel internal structures and components. Some of the inspection requirements may be met by normal visual fabrication inspections. The majority of the inspection requirements are met by visual and remote observations of the installed reactor internals in a flushed and drained vessel. The following types of structures and components shall be included in the vessel internals inspection program:

- Major load bearing elements, including lateral, vertical and torsional supports;
- Locking and bolting components whose failure could adversely affect structural integrity;
- Known or potential contact surfaces;
- Critical locations as identified by the vibration analysis program; and
- Interior surfaces for evidence of loose parts or foreign material.

Flow Testing — The initial startup flow test are performed at low, mid and high core powers leading to rated volumetric core flow with the vessel internals completely assembled, including the fuel bundles, the control blades and the steam dryer assembly. The internals vibration is measured during individual component or system startup testing where operation may result in significant vibrational excitation of reactor internals, such as Isolation Condenser testing. The duration of the startup testing at the various flow configurations shall ensure that each critical component vibration is within design limitations.

Post-Flow Vessel Inspection — The post-flow inspection shall be performed after the resultant vibration from the startup flow testing described above. This is done at the first refueling outage unless there are compelling reasons--based on the data obtained during testing--to investigate earlier. The structures and components inspected shall be the same as specified for the pre-flow inspection. Remote observations are performed after the vessel has been depressurized and the head removed. The schedule for this step is determined by analysis of the measured data obtained during flow testing.

Criteria

The acceptance criteria are generated as part of the analytical portion of the program in terms of maximum vibrational response levels of overall structures and components and translated to specific sensor locations.

Reactor vessel internals vibration is considered acceptable when results of the measurement program correlate and compare favorably with those of the analysis program, and when the results of inspections show no signs of defects, loose parts, extraneous material, or excessive wear due to flow testing, and are consistent with the results obtained from the analysis and measurement programs.

14.2.8.2.12 Feedwater Control

Purpose

To demonstrate that the stability and response characteristics of the Feedwater Control System are in accordance with design requirements for applicable system configurations and operational conditions.

Prerequisites

The preoperational tests are complete and plant management has reviewed the test procedure and approved the initiation of testing. For each scheduled testing iteration, the plant shall be in the appropriate operational configuration with all specified prerequisite testing complete. This includes preliminary adjustments and optimization of control system components, as appropriate.

Description

Startup phase testing of the Feedwater Control System is intended to demonstrate that the overall response and stability of the system meets design requirements subsequent to controller optimization. Testing begins during plant heatup for any special configurations designed for very low feedwater or condensate flow rates and continues up through the normal full power lineup. Testing shall include all modes of control and encompass all expected plant power levels and operational conditions. Testing is accomplished by manual manipulation of controllers and/or by direct input of demand changes at various levels of control. System response shall also be evaluated under AOO conditions such as an unexpected loss of a feedwater pump or a rapid reduction in core power level and after plant trips such as turbine trip or main steamline isolation. Proper setup of control system components or features designed to handle the nonlinearities or dissimilarities in system response at various conditions shall also be demonstrated. The above testing also serves to demonstrate overall core stability to subcooling changes.

Criteria

Above all else, the Feedwater Control System performance shall be stable such that any type of divergent response is avoided. The response shall be sufficiently fast but with any oscillatory modes of response well damped, usually with decay ratios less than 0.25.

14.2.8.2.13 Pressure Control

Purpose

To demonstrate that the stability and response characteristics of the pressure regulation system are in accordance with the design requirements for all modes of control under expected operating conditions.

Prerequisites

The preoperational tests have been completed and plant management has reviewed the test procedure and approved the initiation of testing. For each scheduled testing iteration, the plant shall be in the appropriate operational configuration with all specified prerequisite testing complete. Additionally, applicable instrumentation shall have been checked or calibrated as appropriate. This includes preliminary adjustment and optimization of control system components, as appropriate.

Description

Startup phase testing of the Pressure Control System is intended to demonstrate that the overall response and stability of the system meets design requirements, subsequent to control system optimization. Performance shall be evaluated across the spectrum of anticipated steam flows for both the pressure regulation and load-following modes of control, as applicable. Testing shall demonstrate acceptable response with either the turbine control valves or bypass control valves in control and for the transition between the two. Testing is accomplished by manual manipulation of controllers and/or direct input of demand changes at various levels of control. It shall also be demonstrated that other affected parameters remain within acceptable limits during such pressure regulator-induced maneuvers. Overall system response is evaluated during other plant AOOs as well. Additionally, proper setup of components or features designed to deal with the nonlinearities or dissimilarities in system response that may exist under various conditions shall be demonstrated.

Criteria

System performance shall be stable such that any type of divergent response is avoided. The response shall be sufficiently fast but with any oscillatory modes of response well damped, usually with decay ratios less than 0.25.

14.2.8.2.14 Plant Automation and Control

Purpose

To verify proper plant performance in automatic modes of control such as during automatic plant startup or automatic load following under the direction of the Plant Automation System (PAS). To verify the ability of the Plant Automation System (PAS) to collect, process, and display plant data, execute plant performance calculations, support main control room display functions, and interface with various plant control systems during actual plant operating conditions.

Prerequisites

The applicable preoperational tests have been completed and plant management has reviewed the testing procedure and approved the initiation of testing. Affected systems and equipment, including lower level control systems such as RC&IS, feedwater control and turbine control, as well as monitoring and predicting functions of the Plant Automation System and/or automation computer, shall have been adequately tested under actual operating conditions.

Description

A comprehensive series of tests is performed in order to demonstrate proper functioning of the various plant automation and control features. This testing shall include or bound all expected plant operating conditions under all permissible modes of control and shall also verify, to the extent possible, avoidance of prohibited or undesirable conditions or control modes. Auto load following capabilities are demonstrated under control of the PAS for control rod movements, including anticipated transition regions. Such testing includes demonstration(s) that the dynamic response of the plant (including BOP signals) to design load swings for the facility, including limiting step and ramp changes as appropriate, is in accordance with design. The ability of the PAS to properly orchestrate automated plant startup, shutdown and power maneuvering is shown. Also to be tested are system components or interfaces that perform monitoring, prediction, processing, validation, alarm, protection or control functions.

Criteria

The PAS and other features and functions of plant automation and control shall perform in accordance with the applicable design and testing specifications. Automatic maneuvering characteristics of plant and systems shall meet the appropriate response and stability requirements. Safety and protection features shall perform consistent with safety analysis assumptions and predictions.

14.2.8.2.15 Feedwater System Performance

Purpose

This test is to verify that the overall feedwater system performance characteristics are in accordance with the design requirements.

Prerequisites

The preoperational testing is complete and plant management has reviewed the test procedure and approved the initiation of testing. For each scheduled testing iteration, the plant shall be in the appropriate operational configuration with all specified prerequisite testing complete. Applicable instrumentation has been checked or calibrated, as appropriate.

Description

Pertinent parameters are monitored throughout the feedwater system, and condensate system if appropriate, across the spectrum of system flow and plant operating conditions in order to demonstrate that system operation is in accordance with design. Parameters to be monitored may include temperatures, pressures, flow rates, pressure drops, pump speeds and developed heads, and general equipment status. Of special interest is data that serves to verify design assumptions used in plant AOO performance and safety analysis calculations (e.g., maximum feedwater runout capabilities and feedwater temperature versus power level relationships). Steady-state and AOO testing are conducted, as necessary, to assure that adequate margins exist between system variables and setpoints of instruments monitoring these variables to prevent spurious actuations or loss of system pumps and motor-operated valves.

Criteria

When applicable, measured parameters shall compare conservatively with safety analysis design assumptions. Additionally, test data shall demonstrate that system steady state and AOO performance meets design requirements.

14.2.8.2.16 Main Steam System Performance

Purpose

To verify that main steam system related performance characteristics are in accordance with design requirements.

Prerequisites

The preoperational tests are complete and plant management has reviewed the test procedure and approved the initiation of testing. For each scheduled testing iteration, the plant shall be in the appropriate operational configuration with prerequisite testing complete. Applicable instrumentation shall be checked or calibrated, as appropriate.

Description

Pertinent system parameters, such as temperatures, pressures, and flows, are monitored at various steam flow rates in order to demonstrate that system operation is in accordance with design. The steam flow measuring devices that provide input to feedwater control and/or leak detection logic shall be crosschecked to verify the accuracy of design calibration assumptions. If appropriate, the pressure drop developed across critical components shall be compared with design values. The quality of the steam leaving the reactor shall also be determined to be within design requirements.

Criteria

When applicable, measured parameters shall compare conservatively with safety analysis design assumptions. Additionally, test data shall demonstrate that system steady state and AOO performance meets design requirements.

14.2.8.2.17 Reactor Water Cleanup/Shutdown Cooling System Performance

Purpose

To verify that RWCU/SDC System performance, in all modes of operation, is in accordance with design requirements at rated reactor temperature and pressure conditions.

Prerequisites

The preoperational testing is complete and plant management has reviewed the test procedure and approved the initiation of testing. For each scheduled testing iteration, the plant shall be in the appropriate operational configuration with the specified prerequisite testing complete. Instrumentation has been checked or calibrated as appropriate.

Description

To prevent thermal stratification in the RPV during RPV heatup for reactor startup and hot standby conditions, both trains of the RWCU/SDC System shall be aligned to take suction from only the bottom drain lines to preclude vessel thermal stratification.. The normal shutdown cooling suction line shall be shut during this mode of operation.

Startup phase testing of the RWCU/SDC System is an extension of the preoperational tests for rated temperature and pressure conditions. System parameters are monitored in the various modes of operation at critical temperature, pressure and flow conditions. Acceptable NPSH for the pumps must be demonstrated.

The performance of system heat exchangers and demineralizer units are evaluated at hot operating conditions. The ability of the system to reject excess vessel inventory during plant heatup is verified. Other system features shall be demonstrated as appropriate.

Criteria

The RWCU/SDC System shall maintain the temperature difference between the reactor steam dome and the bottom head drain to less than 80.6°C (145°F) during reactor startup and hot standby conditions. System performance shall meet other specified design requirements in required operating modes.

14.2.8.2.18 Plant Service Water System Performance

Purpose

To verify performance of the Plant Service Water System, including the Reactor Component Cooling Water System (RCCWS), and the Turbine Component Cooling Water System (TCCWS) under expected reactor power operation load conditions.

Prerequisites

The preoperational tests are complete and plant management has reviewed the test procedure and approved the initiation of testing. For each scheduled testing iteration, the plant shall be in the appropriate operational configuration with the specified prerequisite testing complete. All applicable instrumentation shall be checked or calibrated as is appropriate

Description

Power ascension phase testing of plant cooling water systems is necessary only to the extent that fully loaded conditions could not be approached during the preoperational phase. Pertinent parameters shall be monitored in order to provide a verification of proper system flow balancing and heat exchanger performance under near design or special conditions, as appropriate. This includes extrapolation of results obtained under normal or test conditions as needed to demonstrate required performance at limiting or accident conditions.

Criteria

System performance shall be consistent with design requirements.

14.2.8.2.19 HVAC System Performance

Purpose

To verify ability various HVAC systems to maintain area temperatures and humidity within the specified limits during reactor power operation.

Prerequisites

The preoperational tests are complete and plant management has reviewed the test procedure(s) and approved the initiation of testing. For each scheduled testing iteration, the plant shall be in the appropriate operational configuration with the specified prerequisite testing complete. All applicable instrumentation shall be checked or calibrated as is appropriate.

Description

Power ascension phase testing of plant HVAC systems is necessary only to the extent that fully loaded conditions could not be approached during the preoperational phase. Pertinent parameters shall be monitored in order to provide a final verification of proper system flow balancing and cooler performance under near design or special situation conditions, as appropriate. For some sites it may be necessary to perform this test at the most limiting time of the year.

Criteria

System performance shall be consistent with design requirements. For systems that are taken credit for in the plant safety analysis, performance shall meet the minimum requirements assumed in such analysis.

14.2.8.2.20 Turbine Valve Performance

Purpose

To demonstrate proper functioning of the main turbine control, stop, and bypass valves during reactor power operation.

Prerequisites

The preoperational tests are complete and plant management has reviewed the test procedure(s) and approved the initiation of testing. For each scheduled testing iteration, the plant shall be in the appropriate operational configuration with the specified prerequisite testing complete. All applicable instrumentation shall be checked or calibrated as is appropriate.

Description

Early in the startup test phase with the reactor at a moderate power level and with the turbine generator on-line, the operability of the control, stop, and bypass valves are demonstrated. This testing is similar to the individual valve testing required by the Technical Specification surveillances. In addition to valve operability, the overall plant response is observed. Because turbine valve testing is required routinely during power operation, the maximum power level at which such tests can safely be performed is determined by observing plant response during such tests at successively higher power levels.

Criteria

Turbine valves shall operate properly and in accordance with applicable Technical Specification requirements. Valve performance and plant response shall be consistent with design requirements. During high power testing, adequate scram avoidance margins shall be maintained.

14.2.8.2.21 MSIV Performance

Purpose

To demonstrate proper operation of and to verify closure times for Main Steamline Isolation Valves (MSIVs), including branch steamline isolation valves, during power operation.

Prerequisites

The preoperational tests are complete and plant management has reviewed the test procedure(s) and approved the initiation of testing. For each scheduled testing iteration, the plant shall be in the appropriate operational configuration with the specified prerequisite testing complete. All applicable instrumentation shall be checked or calibrated as is appropriate.

Description

At rated temperature and pressure (hot standby), and then again at an intermediate power level, each MSIV is individually stroked in the fast closure mode. Valve operability and closure time are verified and overall plant response observed. Closure times are evaluated consistent with Technical Specification and safety analysis requirements. If appropriate, the maximum power level at which such tests can safely be performed is determined by observing plant response during such tests at successively higher power levels. In addition, at rated temperature and pressure, proper functioning and stroke timing of branch steamline isolation valves (e.g., on the common drain line) are demonstrated.

Criteria

MSIV closure times shall be within the limits required by plant Technical Specifications and those assumed in the plant safety analysis. Overall valve performance shall be in accordance with design requirements. During higher power level tests, adequate scram avoidance margins shall be maintained.

14.2.8.2.22 SRV Performance

Purpose

To demonstrate that each ADS safety/relief valve (SRV) can be manually opened and closed properly during reactor power operation.

Prerequisites

The preoperational tests are complete and plant management has reviewed the test procedure(s) and approved the initiation of testing. For each scheduled testing iteration, the plant shall be in the appropriate operational configuration with the specified prerequisite testing complete. All applicable instrumentation shall be checked or calibrated as is appropriate.

Description

A functional test of each SRV shall be performed during plant heatup and at the 50% power plateau by manually opening/closing each valve. Opening and closing of each valve, as well as evidence of steam flow, are verified by response of SRV discharge tailpipe temperature sensors and by observed changes in turbine bypass valve positions or generator load. Tailpipe temperature indication is also used to confirm valve closure and no significant leakage. Downstream indications of SRV operation could be changes in such parameters as turbine valve positions or generator output. Such changes are also evaluated for anomalies that may indicate a restriction or blockage in a particular SRV tailpipe by making valve-to-valve comparisons.

Criteria

There shall be a positive indication of steam discharge during each manual valve opening. SRV open/close indications, and tailpipe temperature sensor, shall function as designed. For manual openings, the apparent steam flow through each SRV shall not vary significantly from the average for all valves. Each SRV shall be properly reseated after testing.

14.2.8.2.23 Loss of Feedwater Heating

Purpose

To demonstrate proper integrated plant response to a loss of feedwater heating event and verify the adequacy of the modeling and associated assumptions used for this AOO in the plant licensing analysis.

Prerequisites

The preoperational tests are complete and plant management has reviewed the test procedure and approved the initiation of testing. The plant shall be in the appropriate operational configuration with the specified prerequisite testing complete. All applicable instrumentation shall be checked or calibrated as is appropriate.

Description

The credible single failure or operator error that has been identified as resulting in the largest feedwater temperature reduction is initiated at a significantly high power level, while considering the event analyzed and the predicted results. The ESBWR design provides automatic SCRRI (Selected Control Rods Run-In) when a loss of feedwater heating is greater than or equal to 18.8°C (30°F). This feature is checked and verified in this test. Core performance and overall plant response are observed in order to demonstrate proper integrated response and to compare actual results with those predicted. This comparison takes into account the differences between actual initial conditions and observed results and the assumptions used for the analytical predictions.

Criteria

Resultant MCPR (Minimum Critical Power Ratio) shall remain greater than the MCPR safety limit, and measured results shall compare conservatively with design assumptions and predictions. The overall plant response shall be according to design and test specifications. Proper SCRRI operation shall be verified.

14.2.8.2.24 Feedwater Pump Trip

Purpose

To demonstrate the ability of the plant to respond and continue power operation following the loss of an operating feedwater pump from near rated power conditions.

Prerequisites

The preoperational tests are complete and plant management has reviewed the test procedure and approved the initiation of testing. The plant shall be in the appropriate operational configuration with the specified prerequisite testing complete. Applicable instrumentation shall be checked or calibrated, as appropriate.

Description From an initial reactor power level near rated, one of the normally operating feedwater pumps is tripped to demonstrate that the overall plant response is such that a reactor scram is avoided. Specifically, it shall be verified that the Feedwater Control System is sufficiently responsive, in conjunction with specified mitigating features, to prevent a reactor scram due to the reactor water level change. Separate tests may be required to demonstrate auto start of a standby pump.

Criteria

From normal operating conditions, the reactor shall avoid low water level scram with adequate margin to the low water level trip setpoint.

14.2.8.2.25 Shutdown From Outside the Main Control Room

Purpose

To demonstrate that the reactor can be shut down from normal power operation to the point where a controlled cooldown has been established, via decay heat rejection to the environment, with vessel pressure and water level under control, all using means entirely outside the main control room.

Prerequisites

The preoperational tests are complete and plant management has reviewed the test procedure and approved the initiation of testing. The plant shall be in the appropriate operational configuration with the specified prerequisite testing complete. The applicable instrumentation shall be checked or calibrated, as appropriate. An adequate number of qualified personnel shall be on site to perform the specified testing as well as their normal plant operational duties.

Description

This test shall be performed from a low initial power level but from one that is sufficiently high that a majority of plant systems are in their normal configurations for power operation. This test is as much a test of normal and emergency plant procedures and the ability of plant personnel to carry them out, as it is a test of plant systems and equipment. Therefore, the test shall be performed using the minimum shift crew that would be available during an actual event. Additional qualified personnel is available in the control room to monitor the progress of the test and to re-establish control of the plant should an unsafe condition develop. The personnel also perform predefined nonsafety-related activities to protect plant equipment, where such activities would not be required during an actual emergency situation. The test is initiated by simulating a control room evacuation and then tripping and isolating the reactor by means outside of the main control room. Achievement and maintenance of the hot standby condition and subsequent reactor cool down is then demonstrated through control of vessel pressure and water level from the remote shutdown panel. The cold shutdown capability does not necessarily have to be demonstrated immediately following the shutdown and hot standby demonstration as long as the total integrated capability is adequately demonstrated. Also, additional personnel, over and above the minimum shift crew, may be utilized for the cold shutdown portion of the test consistent with plant procedure and management's ability to assemble extra help at the plant site in emergency situations.

Criteria

The remote shutdown test shall, as a minimum, demonstrate the capability of plant personnel, equipment, and procedures to initiate a reactor trip, to achieve and maintain hot standby conditions for at least 30 minutes, and to initiate decay heat removal such that coolant temperature is reduced by at least 28°C (44.9°F) at a rate within Technical Specification limit, all from outside the main control room. Additionally, system and plant performance shall be consistent with design and testing specification requirements.

14.2.8.2.26 Loss of Turbine Generator and Offsite Power

Purpose

To verify proper electrical equipment response and reactor system transient performance during and subsequent to a turbine generator trip with coincident loss of all offsite power sources.

Prerequisites

The preoperational tests are complete and plant management has reviewed the test procedure and approved the initiation of testing. The plant shall be in the appropriate operational configuration with all specified prerequisite testing complete. Applicable instrumentation shall be checked or calibrated, as appropriate. A sufficient number of qualified personnel shall be available to handle the needs of this test, as well as those associated with normal plant operation.

Description

This test shall be performed at a relatively low power level early in the power ascension phase, but with the generator on-line at greater than 10% load. The test is initiated in a way such that the turbine generator is tripped and the plant is completely disconnected from all offsite power sources. The plant shall then be maintained isolated from offsite power for a minimum of 30 minutes. During this time, appropriate parameters are monitored in order to verify the proper response of plant systems and equipment, including the proper switching of electrical equipment and the proper starting and sequencing of onsite power sources and their respective loads.

Criteria

Reactor protection system actions shall prevent violation of fuel thermal limits. Diesel generator and plant systems shall function properly without manual assistance to maintain reactor level above the initiation level of ADS and GDCS. Other systems and equipment shall perform consistent with applicable design and testing specifications.

14.2.8.2.27 Turbine Trip and Generator Load Rejection

Purpose

To verify that the dynamic response of the reactor and applicable systems and equipment is in accordance with design for protective trips of the turbine and generator during power operation.

Prerequisites

The preoperational tests are complete and plant management has reviewed the test procedure and approved the initiation of testing. The plant shall be in the appropriate operational configuration with all specified prerequisite testing complete. Applicable instrumentation shall be checked or calibrated, as appropriate, including steamline expansion/vibration sensors.

Description

In the ESBWR design, there is no direct scram because of turbine trip or generator load rejection. From an initial power level near rated, the main generator is tripped in order to verify the proper reactor and integrated plant response. The method for initiating the trip should be chosen so that the turbine is subjected to maximum overspeed potential. Reactor parameters such as vessel dome pressure and simulated fuel surface heat flux are monitored and compared with predictions so that the adequacy and conservatism of the analytical models and assumptions used to license the plant can be verified. Proper response of systems and equipment such as the turbine stop, control, and bypass valves, steamline vibration, the reactor protection system, and the feedwater system are also demonstrated. The ability of the feedwater system to control vessel level after a reactor trip shall also be verified. Overspeed of the main turbine shall also be evaluated because the generator is unloaded prior to complete shutoff of steam to the turbine.

For a turbine trip, the generator remains loaded and there is no overspeed. However, the dynamic response of the reactor may be different if the steam shutoff rate is different. If there is expected to be a significant difference, it may be necessary to perform a separate demonstration and evaluation (similar to that discussed above), but initiated by a direct trip of the main turbine.

A turbine or generator trip should also be performed at a lower power level. Reactor dynamic response is not as important for this AOO except for the ability to remain operating as designed. More important is the demonstration of proper integrated plant and system performance.

Criteria

The reactor shall not scram during turbine or generator trips. For high power turbine or generator trips, reactor dynamic response shall be consistent with predictions based on expected system characteristics and shall be conservative relative to analysis results based on design assumptions. Feedwater control shall prevent flooding of the steamline following generator or turbine trip. After generator load rejection, the generator shall continue to supply the station house load. The positive change in reactor dome pressure and fuel surface heat flux shall not exceed limits assumed in the transient analysis. Other plant systems and equipment shall perform in accordance with the appropriate design and testing specifications.

14.2.8.2.28 Reactor Full Isolation

Purpose

To verify that the dynamic response of the reactor and applicable systems and equipment is in accordance with design for a simultaneous full closure of all MSIVs from near rated reactor power.

Prerequisites

The preoperational tests are complete and plant management has reviewed the test procedure and approved the initiation of testing. The plant shall be in the appropriate operational configuration with all specified prerequisite testing complete. All applicable instrumentation shall be checked or calibrated, as appropriate.

Description

A simultaneous full closure of all MSIVs is initiated from near rated power in order to verify proper reactor and integrated plant response. Reactor dynamic response, as determined by such parameters as vessel dome pressure and simulated fuel surface heat flux, is compared with analytical predictions in order to verify the adequacy and conservatism of the models and assumptions used in the plant safety and licensing analysis. Proper response of systems and equipment such as the MSIVs, ICs, the Reactor Protection System, and the Feedwater System is also demonstrated.

Criteria

The reactor must scram to limit the severity of the neutron flux and simulated fuel surface heat flux transients.

Feedwater system settings must prevent flooding of the main steam lines following the full reactor isolation transient event.

The recorded MSIV full closure times must meet the limits specified in the Technical Specifications.

The positive change in vessel dome pressure and simulated fuel surface heat flux shall not exceed the limits assumed in transient analysis.

Initiation of Isolation Condenser and system performance shall be within specification.

14.2.8.2.29 Offgas System

Purpose

To verify proper operation of the various components of the Offgas System over the expected operating range of the system.

Prerequisites

The preoperational tests have been completed and plant management has reviewed the test procedure and approved the initiation of testing. For each scheduled testing iteration, the plant shall be in the appropriate operational configuration with the specified prerequisite testing complete. Applicable instrumentation shall be checked or calibrated as is appropriate.

Description

Proper operation of the Offgas System is demonstrated by monitoring pertinent parameters such as temperature, pressure, flow rate, humidity, hydrogen content, and effluent radioactivity. Data shall be collected at selected operating points such that each critical component of the system is evaluated over its particular expected operating range. Performance shall be demonstrated for specific components such as catalytic recombiners, and activated carbon adsorbers, as well as the various heaters, coolers, dryers and filters. Also to be evaluated are the piping, valving, instrumentation and control that comprise the overall system.

Criteria

Hydrogen concentration and radioactivity effluents shall not exceed Technical Specification limits. Steam supply to the non-condensing stage of steam jet air ejector must be maintained above the required flow. All applicable system and component parameters shall be consistent with design and testing specification requirements.

14.2.8.2.30 Loose Parts Monitoring System

Purpose

To verify proper functioning of the loose parts monitoring (LPM) System as the nuclear boiler is heated and core flow increases to its operating value.

Prerequisite

The preoperational testing has been completed and plant management has reviewed the test procedure and approved the initiation of testing. Verify that the LPM has been adjusted and calibrated.

Description

At each testing plateau, perform the following:

- Check channel.
- Listen to audio portion of signals from all recommended sensors for the purpose of detecting the presence of loose parts.
- Change the alert alarm level if necessary.

Refer to Reg. Guide 1.133 Positions 3 and 4 and begin data acquisition and reporting to NRC as required. Verify that the automatic mode is activated when the alert level is exceeded.

Criteria

Initial baseline data for the LPM has been satisfactorily established for each specified power and flow conditions during steady state operation.

14.2.8.2.31 Concrete Penetration Temperature Surveys

Purpose

To demonstrate the acceptability of concrete wall temperatures in the vicinity of selected high temperature penetrations under normal plant operational conditions.

Prerequisites

The plant management has reviewed the test procedure and approved the initiation of testing. The plant shall be in the appropriate operational configuration for the scheduled testing. Applicable instrumentation shall be installed and checked or calibrated as is appropriate.

Description

Concrete temperature data is collected, around selected high temperature penetrations, at various power levels and system configurations in order to verify acceptable performance under expected plant operational conditions. Penetrations and measurement locations selected for monitoring, as well as the test conditions at which data is to be collected, shall be sufficiently comprehensive so as to include the expected limiting thermal loading conditions on critical concrete walls and structures within the plant.

Criteria

The temperature(s) of the concrete at the monitored locations shall be consistent with design predictions and shall not exceed design basis requirements or assumptions critical to associated design basis analyses.

14.2.8.2.32 Liquid Radwaste System Performance

Purpose

To demonstrate acceptable performance of liquid radioactive waste processing, storage and release systems under normal plant operational conditions.

Prerequisites

The preoperational tests are complete and plant management has reviewed the test procedure and approved the initiation of testing. The plant shall be in the appropriate operational configuration for the scheduled testing. The necessary instrumentation shall be checked or calibrated. Appropriate precautions shall be taken relative to activities conducted in the vicinity of radioactive material or potential radiation areas.

Description

Radwaste System operation is monitored, and appropriate data collected, during the power ascension test phase to demonstrate that system operation is in accordance with design requirements. Operation of liquid Radwaste Systems is discussed in detail in Sections 11.2. Performance shall be demonstrated periodically throughout the startup test program to evaluate acceptable operation of piping, valving, and instrumentation and control that comprise the overall system.

Criteria

The liquid radwaste system shall be capable of collecting, process, and controlling the liquid radwaste as designed. Handling and release of radioactive wastes shall be in conformance with all applicable regulations.

14.2.8.2.33 Steam and Power Conversion System Performance

Purpose

To demonstrate acceptable performance of the power conversion systems under expected operational conditions, particularly those equipments that could not be fully tested during the preoperational phase due to inadequate steam flow conditions.

Prerequisites

The preoperational tests are complete and plant management has reviewed the test procedure and approved the initiation of testing. The plant shall be in the appropriate operational configuration for the scheduled testing. The necessary instrumentation shall be checked or calibrated.

Description

Operation of the main turbine-generator power conversion system with related auxiliaries is monitored, and appropriate data collected, during the power ascension test phase to demonstrate that system operation is in accordance with design requirements. Systems to be monitored include the main turbine and generator and their auxiliaries, the feedwater heaters and moisture separator, the main condenser and condenser evacuation system, and the main circulating water system. At each major power level change, data is taken to determine reactor power, core flow and generator output. Operation and testing of power conversion systems is discussed in detail in Chapter 10. The main turbine generator and related auxiliaries are discussed in Section 10.2 and other power conversion equipment and systems are discussed in Section 10.4. Testing specific to turbine valves is described in Subsection 14.2.8.2.20 and plant AOO testing involving the main turbine generator is also described in Subsection 14.2.8.2.27.

Criteria

Performance characteristics of the various systems monitored shall be in accordance with the appropriate design and testing specifications, and as discussed in Sections 10.2 and 10.4.

14.2.8.2.34 Isolation Condenser Performance

Purpose

To demonstrate acceptable performance of the four isolation condensers when supplied with reactor steam at rated pressure. Heat balances on the reactor to determine the IC capacity.

Prerequisites

The preoperational tests are complete and plant management has reviewed the test procedure and approved the initiation of testing. The plant shall be in the appropriate operational configuration for the scheduled testing. The necessary instrumentation shall be checked or calibrated. Any required expansion/vibration instrumentation for the IC piping must be in place.

Description

With the plant operating at steady state mid-power, perform a heat balance on the reactor, and recording the main generator electrical output, APRMs and turbine control valve position. Initiate operation of one IC by opening the condensate drain valves and record the generator output, APRMs, and turbine control valve position. Perform a heat balance on the reactor with IC in operation. Determine the IC capacity by the difference in heat input before and after IC operation. Operate the FAPCS to cool the IC/PCCS pools during the test.

Criteria

Performance characteristics of the ICs shall be in accordance with the design and test specifications.

14.2.9 COL Information

The preceding discussion of preoperational and startup tests was limited to those systems and components within, or directly related to, the ESBWR. Other testing, with respect to site-specific aspects of the plant, is necessary. Testing of such systems and components should be adequate to demonstrate conformance to such requirements as defined throughout the specific chapters of the SSAR. Below are systems that may require such testing:

- Electrical switchyard and equipment;
- The site security plan;

- Personnel monitors and radiation survey instruments; and
- The automatic dispatcher control system (if applicable).

The COL holder will make available 60 days prior to use, the startup administration manual described in Subsection 14.2.2, which describes, among other things, what specific permissions are required for the approval of test results and the permission to proceed to the next testing plateau.

Regulatory Guide 1.68 specifies criteria (see Regulatory Position C.1) for determining what structures, systems, components and design features are required to be tested during the power ascension test phase in accordance with the requirements therein. Testing of such structures, systems, components and design features is then subject to license conditions requiring NRC prior approval for major test changes. The COL applicant shall also provide a list of those tests to be performed as part of the power ascension test phase that are proposed to be exempt from operating license conditions requiring NRC prior approval for major test changes, and the basis for the exemption.

14.2.9.1 Test Procedures/Test Program/Startup Administrative Manual

The COL holder will make a startup administrative manual available to the NRC 60 days prior to use that:

(1) The responsibilities of the organization that will carry out the test program, methods and plans for providing the necessary manpower, and a description of the staff responsibilities, authorities and personnel qualifications for conducting the initial test program.
(2) Delineates the development, review and approval of test procedures per Appendix C of RG 1.68. The site approved test procedures will be made available approximately 60 days before their intended use.
(3) Delineates utilization of reactor operating and testing experience in the development of the test procedures.
(4) Requires the development of plant operating and emergency procedures prior to fuel loading, and their application during the test program, consistent with section C.7 of RG 1.68.
(5) Defines requirements for the test program schedule consistent with section C.5 of RG 1.68 and the test sequence, consistent with sections 1 through 5 in Appendix A of . RG 1.68.
(6) Defines requirements for the test methodology, prerequisites, initial conditions, acceptance criteria, and analysis techniques consistent with RG 1.68.

14.2.10 References

See Subsection 14.2.3 for a list of applicable Regulatory Guides.

Table 14.2-1

Power Ascension Test Matrix

Power Ascension Test	Testing Plateau *					Notes
	OV	HU	LP	MP	HP	
Chemical and Radiochemical Measurements						
Sampling System Functioning	X	X	X	X	X	Includes verification of water quality
Process Rad Monitoring Functioning	X	X	X	X	X	
Liquid and Gaseous Effluent ActivitiesSteady-state Performance Measurements	X	X	X	X	X	Includes verification of water quality
Condensate Polisher Performance		X	X	X	X	
RWCU F/D Performance (No Cleanup Test)				X	X	
Radiation Measurements						
Steady-state Measurements	X	X	X	X	X	Back ground survey before fuel loading and initial criticality
Shielding Adequacy Assessment		X	X	X	X	
Fuel Loading						
-Partial Core S/D Margin	X					
-Full Core Verification	X					
Full Core Shutdown Margin Demonstration	X					
Control Rod Control System Performance						
CRD Functional Testing	X	X				Step, notch and continuous drive mode
Gang Motion Verification		X				
Friction Testing	X	X				After fuel has been loaded in the cell

Table 14.2-1

Power Ascension Test Matrix

Power Ascension Test	Testing Plateau *					Notes
	OV	HU	LP	MP	HP	
Rod Pair Scram Testing	X	X				Open vessel and rated pressure
Full Core Scram			Y	Y	Y	With planned scrams
SCRRI Functioning					Y	During generator load rejection and loss of feedwater heating tests
Alternate Rod Run-in Functioning			Y	Y	Y	Post scram verification following planned trips
Neutron Monitoring System Performance						
-SRNM Calibration/Response	X	X				
-LPRM Calibration/Response		X	X	X	X	Calibrate to local power density using AFIP
-APRM Calibration/Response		X	X	X	X	Calibrate to total core power by heat balance
Core Performance		X	X	X	X	
Nuclear Boiler Process Monitoring						
-Reactor Coolant Temperature Measurement		X		X	X	At MP & HP during steady-state
-Reactor Water Level Measurement	X	X	X	X	X	
System Expansion						
-Support Inspection/Interference Check		X	Y	Y	Y	Only as needed upon return to cold setting conditions after planned shutdowns subsequent to HU
Displacement Measurements		X	X	X	X	

Table 14.2-1

Power Ascension Test Matrix

Power Ascension Test	Testing Plateau *					Notes
	OV	HU	LP	MP	HP	
System Vibration						
-Steady-state Measurements		X	X	X	X	
-AOO (Transient) Response			X	X	X	
- **Reactor Internals Vibration**		X	X	X	X	
Feedwater Control						
Control System Adjustment/Confirmation		X	X	X	X	
Pressure Control						
Control System Adjustment/Confirmation		X	X	X	X	
Plant Automation and Control						
NSS/BOP Monitoring Program		X	X	X	X	
-Plant Startup/ Shutdown		X	X	X	X	
-Load Following					X	
Feedwater System Performance						
Steady-state Performance		X	X	X	X	
- Maximum Runout Flow Determination					X	
Main Steam System Performance						
Steady-state Performance		X	X	X	X	
Reactor Water Cleanup/Shutdown Cooling System Performance						

Table 14.2-1

Power Ascension Test Matrix

Power Ascension Test	Testing Plateau *					Notes
	OV	HU	LP	MP	HP	
Steady-state Performance		X			X	
Inventory Rejection Mode		X				
Plant Service Water System Performance						
Steady-state Power Operations		X	X	X	X	
Off-Normal Operations		Y	Y		Y	
HVAC System Performance						
Steady-state Power Operations		X	X	X	X	
Off-Normal Operations		Y	Y	Y	Y	In individual spaces as conditions allow (i.e. . as pertinent equipment is operated)
Turbine Valve Performance		X	X	X	X	Only bBypass valves need be tested at HU
MSIV Performance						
Individual MSIV Closure/ Timing		X	X	X		Fast closure not required at High Power
Branch Line Closure/ Timing		X	X			
SRV Performance						
Individual Valve Functioning		X		X		
Loss of Feedwater Heating					X	At 80-90% CTP
Feedwater Pump Trip					X	
Shutdown from Outside the Control Room			X			At >10% Generator Load
Loss of Turbine Generator and Offsite Power			X			At 10-20% rated power

Table 14.2-1

Power Ascension Test Matrix

Power Ascension Test	Testing Plateau *					Notes
	OV	HU	LP	MP	HP	
Turbine Trip and Generator Load Rejection						
- Load Rejection within Bypass Capacity			X			
- Turbine Trip				X		
- Full Power Load Rejection					X	
Reactor Full Isolation					X	
Offgas System Performance		X	X	X	X	
Loose Part Monitor Performance		X	X	X	X	
Power Conversion Equipment Performance		X	X	X	X	
Liquid RadWaste Systems Performance		X	X		X	
Concrete Penetration Temperatures		X			X	
Isolation Condenser Performance				X		

* OV = Open Vessel; HU = Nuclear Heatup; LP = Low Power; MP = Mid Power; HP = High Power

X = Testing required in plateau; alternative test conditions or exceptions identified in detailed testing specification.

Y = Testing not specifically required in indicated plateau, but to be done in conjunction with other testing, or at specific testing conditions, generally within indicated plateau; see Notes column for explanation.

14.3 SELECTION OF TIER 1 CRITERIA AND PROCESSES

This section provides the selection criteria and processes used to develop the Tier 1 information. The Tier 1 information provides the principal design bases and design characteristics that are certified by the 10 CFR Part 52 rulemaking process and included in the formal ESBWR design certification rule.

This top-level design information in Tier 1 is extracted directly from the more detailed ESBWR design information presented in Tier 2. Limiting the Tier 1 contents to top-level information reflects the tiered approach to design certification endorsed by the Commission (Staff Requirements Memorandum February 15, 1991 regarding SECY-90-377; 10 CFR Part 52 Statement of Considerations 54 Fed. Reg. 15372, 154377, (1989). See also SECY-90-241, 90-377 and SECY-91-178.) The objective of this section is to define the bases and methods that were used to develop Tier 1. This section contains no new technical information regarding the ESBWR design.

Tier 1 consists of the following:

- An introduction section that defines terms used in Tier 1 as well as listing general provisions, which are applicable to Tier 1 entries. The intent of these entries is to avoid ambiguities and misinterpretations by providing front-end guidance to users of Tier 1.
- Design descriptions for:
  - Systems that are fully within the scope of the ESBWR design certification, and
  - The in-scope portion of those systems that are only partially within the scope of the ESBWR design certification.

  The intent of the Tier 1 design descriptions is to delineate the principal design bases and principal design characteristics that are referenced in the design certification rule. The design descriptions are accompanied by the inspections, tests, analyses and acceptance criteria (ITAAC) required by 10 CFR 52 to be part of the design certification application. The ITAAC define verification activities that are to be performed for a facility with the objective of confirming that the plant is built and operates in accordance with the design certification. Successful completion of these certified design ITAAC, together with the combined operating license (COL) applicant's ITAACs for the site-specific portions of the plant, are the basis for the NRC finding under 10 CFR Part 52.103(g).
- Tier 1 design descriptions and their associated ITAAC for design and construction activities that are applicable to more than one system. Design related processes have been included in Tier 1 for:
  - Aspects of the ESBWR design likely to undergo rapid, beneficial technological developments in the lifetime of the design certification. Certifying the design processes associated with these areas of the design rather than specific design details permits future license applicants referencing the ESBWR design certification to take advantage of the best technology available at the time of COL application and facility construction. Example: design of programmable, microprocessor-based instrumentation and control systems.

   – Aspects of the design that depend upon characteristics of as procured, as-installed systems, structures and components. These characteristics are not available at the time of certification, and therefore, cannot be used to develop and certify design details. Example: design of piping systems that depend upon detailed routing and equipment information.

- Interface requirements as defined within 10 CFR Part 52.47. Interface requirements are those that must be met by the site-specific portions of the complete nuclear power plant that are not within the scope of the certified design. These requirements define characteristics of the site-specific features that must be provided in order for the certified design to comply with certification commitments. Interface requirements are defined for: (a) systems entirely outside the scope of the design certification, and (b) the out-of-scope portions of those systems that are only partially within the scope of the design certification. The COL applicant provides ITAAC for the site-specific design features that implement the interface requirements; therefore, Tier 1 does not include ITAAC for interface requirements.
- Site parameters used as the basis for ESBWR design presented in Tier 2. These parameters represent a bounding envelope of site conditions for any license application referencing the ESBWR design certification. No ITAAC is necessary for the site parameters entries, because compliance with site parameters are verified as part of issuance of a license for a plant that references the ESBWR design certification.
- Appendices listing acronyms and legends used in the body of Tier 1. (This material is self-explanatory and is not discussed any further in this section.)

The following is a description of the criteria and methods by which specific technical entries for Tier 1 were selected. The structure of the description is based on the Tier 1 report structure. The criteria and methods that are discussed in the following sections are guidelines only. For some matters, the contents of Tier 1 may not directly correspond to these guidelines, because special considerations related to the matters may have warranted a different approach. For such matters, a case-by-case determination was made regarding how or whether the matters should be addressed in Tier 1. These determinations were based upon the principles inherent in Part 52 and its underlying purposes.

14.3.1 Tier 1, Section 1 - Introduction

This section includes two subsections:

1.1 Tier 1 Information Level Of Detail

1.2 Definitions and General Provisions

Level of Detail and Scope - Tier 1, Section 1.1 provides the basis of the level of detail for the technical descriptions in Tier 1, and the general scope of the ESBWR presented for certification.

Selection Criteria — Tier 1, Section 1.2 first defines terms that are used throughout Tier 1 and could (potentially) be subject to various interpretations. Selection of entries was based on a judgment that a particular word/phrase merits definition - with particular emphasis on terms associated with implementation of the ITAAC. Second, Tier 1, Section 1.2 contains a mixture of provisions that were selected on the basis that the provision was necessary to either

- Define technical requirements applicable to multiple systems in Tier 1, or to
- Provide clarification and guidance for future users of Tier 1.

Selection Methodology — Entries in the Definition section were largely made on the basis of a self-evident need for a term to be defined. These terms were accumulated during the preparation and review of Tier 1. Entries in the General Provisions section also were arrived at as part of Tier 1 development and review process. Each entry has a unique background, but the overall intent is to clearly state the broad guidelines and interpretations that guided Tier 1 preparation for the ESBWR and should be understood by Tier 1 users.

Example Entries — Typical terms defined in Tier 1, Subsection 1.2.1 are "as-built," "Division," "important to safety," "Type Test." Issues requiring Tier 1, Subsection 1.2.2 treatment include guidance on interpretation of figures provided in the body of Tier 1 and defining the scope of what is included if a system configuration check is specified in an ITAAC entry.

14.3.2 Tier 1, Section 2 - Design Descriptions and ITAACs

This section has the design description and ITAAC material for the individual ESBWR systems, and has an entry for every system that is either fully or partially within the scope of the ESBWR design certification. Consequently, there is a Tier 1, Section 2 entry for every ESBWR system identified in Tier 2, Section 1.2. The intent of this comprehensive listing of ESBWR systems is to better define at the Tier 1 level the full scope of the certified design. (As discussed below, the Tier 1 entry for many systems with no safety significance (i.e., are not important to safety) is limited to the system name only and does not include any design description or ITAAC material.) Because preparation of system design descriptions and the associated ITAAC are sequential, separate processes, they are discussed separately in the next two subsections.

14.3.2.1 Design Descriptions

The Tier 1 design descriptions for each ESBWR system address the top-level design features and performance standards that pertain to the safety of the plant and include descriptive text and supporting figures. The intent of Tier 1 design descriptions is to define the ESBWR design characteristics which are referenced in the design certification rule as a result of the certification provisions of 10 CFR Part 52.

Selection Criteria — The following criteria were considered in determining which information warranted inclusion in the certified design descriptions.

(1) The information in the Tier 1 design descriptions is to be selected from the technical information presented in Tier 2 and should not contain information that is not in Tier 2. This reflects the approach that Tier 1 contains top-level design information and is based on the Commission directive in the Statement of Considerations for Part 52 that there "be less detail in a certification than in an application for certification." In this context, the certification is Tier 1 and the application for certification includes Tier 2.

(2) The Tier 1 design descriptions should only contain information from Tier 2 that is most significant to safety. Tier 2 contains a wide spectrum of information on various aspects of the ESBWR design, and not all of this information warrants inclusion in the Tier 1 design descriptions. This selection criterion reflects the Commission directive in the Statement of Considerations for Part 52 that the certified design should "encompass roughly the same

design features that Section 50.59 prohibits changing without prior NRC approval." However, for clarity and better understanding, additional information if often provided. In determining what Tier 2 information is most significant to safety, several factors were considered, including the following:

a. Whether the feature or function in question is necessary to satisfy the NRC's regulations in Parts 20, 50, 52, 73 and 100.

b. Whether the feature or function in question pertains to a structure, system or component (SSC) important to safety (as defined in Tier 1 Subsection 1.2.1).

c. Whether the feature or function in question is specified in the NRC's Standard Review Plan as being necessary to perform a safety-significant function.

d. Whether the feature or function in question represents an important assumption or insight from the probabilistic risk assessment.

e. Whether the feature or function in question is important in preventing or mitigating severe accidents.

f. Whether the feature or function in question has had a significant effect on the safety or operation of the nuclear power plant.

g. Whether the feature or function in question is typically the subject of a provision in the Technical Specifications.

The absence or existence of any of one of these factors was not conclusive in determining which information is significant to safety. Instead, these factors, together with the other factors listed in this section, were taken into account in making this determination.

(1) In general, only the import to safety features and functions of SSCs are discussed in the Tier 1 design descriptions. Some nonsafety-related SSCs are discussed in the Tier 1 design descriptions only to the extent that they perform safety significant functions or have features to prevent a significant adverse effect upon the safety-related functions of other SSCs. This criterion follows from the principle that only features and functions that are safety-significant warrant treatment in Tier 1. Nonsafety features and functions of safety-related SSCs are not generally discussed in the Tier 1 design descriptions.

(2) In general, the Tier 1 design descriptions for SSCs are limited to a discussion of design features and functions. The design bases of SSCs, and explanations of their importance to safety, are provided in Tier 2 and are not included in the Tier 1 design descriptions. The purpose of the Tier 1 design descriptions is to define the certified design. Justification that the design meets regulatory requirements is presented in Tier 2. For example, the design descriptions for the emergency core cooling systems (ECCS) state the flow capacity of the systems; the descriptions do not provide information that demonstrates these flow capacities are sufficient to maintain post-accident fuel cladding temperatures within 10 CFR 50.46 acceptance criteria.

(3) The Tier 1 design descriptions focus on the physical characteristics of the facility. The Tier 1 design descriptions do not contain programmatic requirements related to operating conditions or to operations, maintenance, or other programs because these matters are

controlled by other means such as the Technical Specifications. For example, the design descriptions do not describe operator actions needed to control systems.

(4) The design descriptions in Tier 1, Section 2 discuss the configuration and performance characteristics that the SSCs should have after construction is completed. In general, the Tier 1 design descriptions do not discuss the processes that are used for designing and constructing a plant that references the ESBWR design certification. This is acceptable because the safety-function of a SSC is dependent upon its final as-built condition and not the processes used to achieve that condition. There are some exceptions to this criterion. These are:

a. The welding, dynamic qualification (including seismic and other design bases dynamic loads), environmental qualification and valve testing requirements addressed in Tier 1, Section 2; and

b. The various design and qualification processes defined in Tier 1, Section 3. In addition, the programmatic aspects of the design and construction processes (training, qualification of welders, etc.) are part of the licensee's programs and are subject to commitments made at the time of COL issuance. Consequently, these issues are not addressed in Tier 1.

(5) In general, the Tier 1 design descriptions address fixed design features expected to be in place for the lifetime of the facility. This is acceptable because portable equipment and replaceable items are controlled through operational related programs. Because Tier 1 pertains to the design, it is not appropriate for it to include a discussion of these items. One exception to this general approach pertains to nuclear fuel, fuel channels, and control rods. These components are discussed in the Tier 1 design descriptions due to their importance to safety and the desire to control their overall design throughout the lifetime of a plant that references the certified ESBWR design.

(6) The Tier 1 design descriptions do not (usually) discuss component types (e.g., valve and instrument types), component internals, or component manufacturers. This approach is based on the premise that the safety function of a particular design element can be performed by a variety of component types and internals from different manufacturers. Consequently, a Tier 1 entry that defines particular component type/manufacturer would have no safety-related benefit and would unnecessarily restrict the procurement options of future applicants and licensees. Tier 1 does contain exceptions to this general criterion, and these exceptions occur when the type of component is of safety significance. For example, Tier 1 specifies that the ESBWR safety/relief valves shall be of the direct-acting type with pneumatic operators. This precludes the use of reverse acting valves controlled by pilot valves.

(7) The Tier 1 design descriptions do not contain any proprietary information, because of the need to comply with requirements associated with publication of rules.

(8) In order to allow the applicant or licensee of a plant that references the ESBWR design certification to take advantage of improvements in technology, the Tier 1 design descriptions in general do not prescribe design features that are the subject of rapidly evolving technology. Examples are: design of the main control room and instrumentation and control systems. This issue is discussed further in Subsection 14.3.3.

(9) Tier 1 design descriptions are intended to be self-contained and do not make direct reference to Tier 2, industrial standards, regulatory requirements or other documents. (There are some exceptions involving the ASME Code and the Code of Federal Regulations.) If these sources contain technical information of sufficient safety-significance to warrant Tier 1 treatment, the information has been extracted from the source and included directly in the appropriate system design description. This approach is appropriate because it is unambiguous and it avoids potential questions regarding how much of a referenced document is encompassed in, and becomes part of the Tier 1.

(10) Selection of the technical terminology to be used in Tier 1 was guided by the principle that the terminology should be as consistent as possible with that used in Tier 2 and the body of regulatory requirements and industrial standards applicable to the nuclear industry. This approach is intended to minimize problems in interpreting the intent of Tier 1 commitments.

Selection Methodology — Using the criteria listed above, Tier 1 description material was developed for each system by reviewing Tier 2 material relating to that system. Tier 1 utilizes a system-by-system report structure that is different than the structure of Tier 2. Consequently, developing the Tier 1 design description entry for any one system was based on review of the multiple Tier 2 chapters having technical information related to that system.

Because the safety significance of the ESBWR systems varies, application of the criteria listed above results in a graded treatment of the systems. This leads to considerable variations in the scope of the design description entries. Table 14.3-1 lists the types of ESBWR systems, and is a summary of the overall consequences of this graded treatment.

For safety-related systems, application of the above criteria resulted in design description entries that include the following information, as applicable:

- The system’s name and scope;
- The system’s purpose;
- The system’s safety-related modes of operation;
- The system’s classification (i.e., safety-related, seismic category, and ASME Code Class);
- The system’s location;
- The basic configuration of the system’s safety-significant components (usually shown by means of a figure);
- The type of electrical power provided for the system;
- The electrical independence and physical separation of divisions within the system;
- The system’s important instruments, controls, and alarms to the extent located in the Main Control Room or Remote Shutdown System;
- Identification of which of the important Class 1E electrical equipment within the system is qualified for a harsh environment;
- Motor-operated valves within the system that have an active safety-related function; and

- Any other features of functions that are significant to safety.

The Tier 1 design descriptions for nonsafety-related systems also include the information listed above but only to the extent that the information is relevant to the system and is significant to safety. Because much of this information is not relevant to safety-related systems, the Tier 1 design descriptions for nonsafety-related systems are generally substantially less extensive than the descriptions for safety-related systems. As discussed above, there are many systems for which no design description entries (and therefore no ITAAC) are included in Tier 1 and the entry is limited to the system title.

14.3.2.2 Inspections, Tests, Analyses and Acceptance Criteria (ITAAC)

As needed, a table of ITAAC entries is provided for each system that has design description entries. The intent of these ITAAC is to define activities that are undertaken to verify the as-built system conforms to the design features and characteristics defined in the design description for that system. ITAAC are provided in tables with the following three-column format.

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria

Each design commitment in the left-hand column of the ITAAC tables has an associated inspections, tests or analyses (ITA) requirement specified in the middle column, and the acceptance criteria for the ITA are defined in the right-hand column.

Selection Criteria: — The following were considered when determining which information warranted inclusion in the Tier 1 ITAAC entries:

(1) The scope and content of the ITAAC correspond to the scope and content of the Tier 1 design descriptions. There are no ITAAC for aspects of the design not addressed in the design description. This is appropriate because the objective of the ITAAC design certification entries is to verify that the as-built facility has the design features and performance characteristics defined in the Tier 1 design descriptions.

With only a few special-case exceptions (nuclear fuel, fuel channels and control rods), each ESBWR system with any design description text has an ITAAC table. This reflects the assessment that (in general) any design feature meriting a Tier 1 description also merits an ITAAC entry to verify that the feature has been included in the as-built facility.

(2) One inspection, test, or analysis may verify one or more provisions in the Tier 1 design description. In particular, an ITAAC that calls for a system functional test or an inspection of basic configuration may verify a number of provisions in Tier 1 design description. Therefore, there is not necessarily a one-to-one correspondence between the ITAAC and the Tier 1 design descriptions.

(3) The inspections, tests, and analyses are to be completed (and the acceptance criteria satisfied) prior to fuel loading. Therefore, the ITAAC do not include any inspections, tests, or analyses that are dependent upon conditions that only exist after fuel load.

(4) Because the Tier 1 design descriptions are limited to fixed design features expected to be in place for the lifetime of the facility, the ITAAC also are limited to a verification of fixtures in the plant. For example, there are no ITAAC for nuclear fuel, fuel channels and control rods, because a licensee frequently changes them. (In the specific case of nuclear fuel, fuel

channels and control rods, ITAAC also are not possible for these components, because they are not installed in the plant until after authorization is given for fuel load.)

(5) In general, the ITAAC verify the as-built configuration and performance characteristics of SSCs as identified in the Tier 1 design descriptions. With limited exceptions, (e.g., welding), the ITAAC do not address typical construction processes for the reasons discussed in item (6) of Subsection 14.3.2.1. As necessary, ITAAC coverage of the exceptions is by:

   a. The general provisions of Tier 1, Section 1.2.2, Items (1) through (4) that are invoked by configuration verification entries in individual system ITAAC tables; and

   b. The ITAAC entries in Tier 1, Section 3

Selection Methodology — Using the criteria listed above, ITAAC table entries were developed for each system. This was achieved by evaluating the design features and performance characteristics defined in the Tier 1 design descriptions and preparing an ITAAC table entry for each design description entry that satisfied the above selection criteria. As a result of this process there is a close correlation (although not necessarily one-for-one for the reasons noted in item (2) above) between the left-hand column of the ITAAC table and the corresponding design description entry.

Having established the design features for which ITAAC are appropriate, the ITAAC table was completed by selecting the method to be used for verification (either a test, an inspection or an analysis) and the acceptance criteria against which the as-built feature/performance are measured. The emphasis when selecting an ITAAC verification method was to utilize in-site testing of the as-built facility wherever possible. However, the selection of these items was dependent upon the plant feature to be verified but was guided by the ITA approach presented in Table 14.3-2.

The proposed verification activity is identified in the middle column of the ITAAC table. Where appropriate, Tier 2 provides details regarding implementation of the verification activity. Selection of acceptance criteria is dependent upon the specific design characteristic being verified by the ITAAC table entry: in most cases the appropriate acceptance criteria is self-evident and is based upon the Tier 1 design descriptions. For many of the ESBWR ITAAC, the acceptance criterion is a statement that the as-built facility has the design feature or performance characteristic identified in the design description. A central guiding principle for acceptance criteria preparation is the recognition that the criteria should be objective and unambiguous. The use of objective and unambiguous terms for the acceptance criteria minimizes opportunities for multiple, subjective (and potentially conflicting) interpretations as to whether an acceptance criterion has, or has not, been met. In some cases, the ITAAC acceptance criteria contain numerical parameters from Tier 2 that are not specifically identified in the Tier 1 design description or the Design Commitment column of the ITAAC table. This is acceptable because the design description defines the important design feature/performance that merits Tier 1 treatment whereas the acceptance criterion defines a measurement standard for determining if the as-built facility is in compliance with the Tier 1 design description commitment. Where appropriate, Tier 2 has identified detailed criteria applicable to the same design feature or function that is the subject of more general acceptance criteria in the ITAAC table.

For numerical acceptance criteria, ranges and/or tolerances are included. This is necessary and acceptable because:

- Specification of a single-value acceptance criterion is impractical because minute/trivial deviations would represent noncompliance;
- Tolerances recognize that legitimate site variations can occur in complex construction projects; and
- Minor variations in plant parameters within the tolerance bounds have no effect on plant safety.

14.3.3 Tier 1, Section 3 - Non-System Based Material

Entries in this section of Tier 1 have the same structure as the system material discussed in Subsection 14.3.2; i.e., design description text and figures and a table of ITAAC entries. The objective of this Tier 1 material is to address selected design and construction activities, which are applicable to more than one system and cannot conveniently be covered in the system-by-system information presented in Tier 1, Section 2. The following summarizes the scope and bases for the Tier 1, Section 3 entries. For each, the design description text defines the applicability of the entry.

14.3.3.1 Piping Design

The piping design section of Tier 1 defines the processes by which ESBWR piping is designed and evaluated. The material applies to piping systems that are classified as nuclear safety related. In general, these piping systems are designated as Seismic Category I and are further classified as ASME Code Class 1, 2 or 3. The section also addresses the consequential effects of pipe rupture such as jet impingement, potential missile generation, pressure/temperature effects etc.

Certification of plant safety-related piping systems via design processes rather than via certification of specific design features is necessitated and justified by the following:

- Piping design is based on detailed piping arrangement information as well as the geometry and dynamic characteristics of the as-procured equipment that forms part of the piping system. This detailed plant-specific information is unavailable at the time of design certification and cannot therefore be used to develop detailed design information. This precludes certification of specific piping designs.
- An extensive definition of design methodologies is contained in Tier 2, Chapter 3. These methodologies are not considered to be part of Tier 1 but are one of several methods for executing the design process steps defined in the piping design. In addition, sample design calculations have been performed with these methods to provide confidence that they are complete and yield acceptable design information.
- Piping design for nuclear plants is a well-understood process based on straightforward engineering principles. This, together with Tier 2 methodology definition and sample calculations, provides confidence that future design work by individual applicants/licensees results in acceptable designs that properly implement the applicable requirements.

The technical material in the piping design Tier 1 entry was selected using the criteria and methodology as discussed above for Tier 1, Section 2 system entries.

14.3.3.2 Software Development

Development of specific software is dependent upon the detailed, as-procured characteristics of the hardware to be used - especially the microprocessors to be used for the programmable digital control features. Consequently, software development cannot be completed at the time of design certification without selecting the specific implementation hardware. In addition to the technology issue discussed below, this would be incompatible with the principle that certification should not define vendor-specific (i.e., as-procured) design characteristics for components.

All aspects of digital, microprocessor based control technology are expected to undergo significant changes as the technology continues to evolve. These future changes are expected to be beneficial and involve both the software and the hardware. Certification of specific software details at this time would preclude future COL applicants from taking advantage of these technology advances.

Development of software for programming of real-time microprocessor based controllers is a well understood process which is being continual upgraded by application of such techniques as automated development of requirements and automated verification activities. These trends, coupled with ongoing industry efforts to establish standards for software development, provide confidence that future execution of this Tier 1 entry results in I&C equipment fully in compliance with ESBWR requirements and all Tier 2 commitments.

The software development process is discussed in detail in Appendix 7C. This material is not considered part of Tier 1; however, it provides one of several acceptable methods for implementing the ITAAC in the Tier 1.

14.3.3.3 Human Factors Engineering

The human factors engineering (HFE) entry defines the processes by which the details of the human-system interface (HSI) is developed, designed and evaluated. The processes defined in this entry require the use of analyses based on human factors principles and apply to the main control room (MCR), including areas which provide the displays, controls and alarms required for normal, abnormal and emergency plant conditions. They also apply to the Remote Shutdown System (RSS). For MCR and RSS detailed HSI design implementation, the certification of processes (rather than specific design features) is necessitated and justified by the following:

- The technology of equipment associated with HSI implementation is rapidly evolving (and improving) and certification of implementation processes permits future licensees to take advantage of beneficial technological advances available at the time of application. An example is the rapid advances that have taken (and are taking) place in flat panel display technology.
- Detailed implementation of the HSI is dependent upon the details of the as procured, as-installed equipment. For example, different manufacturers use different techniques to monitor equipment performance. Because this equipment is not available at the time of design certification, it is not possible to develop HSI implementation details. This can be only be accomplished by a licensee when specific equipment characteristics are known.

- The fundamental design work for the ESBWR HSI has been completed and is described in Tier 2. This includes commitments to a set of standard design features as well as a minimum inventory of fixed alarms, displays and controls necessary for the operators to implement the emergency operating procedures and to carry out those human actions shown to be important by the plant PRA. This design information, coupled with the comprehensive commitments to HSI implementation processes based on currently accepted HFE practices, provides confidence that the execution of these processes result in acceptable MCR and RSS detail designs that implement the applicable requirements.

Selection of specific technical material for the HFE design descriptions and ITAAC entries in the Tier 1 utilized the same selection criteria and methodology as described above for Tier 1, Section 2 system entries.

14.3.3.4 Radiation Protection

The radiation protection chapter (Chapter 12) defines the design confirming that radiation protection features maintain exposures for both plant personnel and the general public below allowable limits. The material applies to the radiological shielding and ventilation design of buildings within the scope of the ESBWR certified design. Confirmation that the building shield wall and floor thickness are in accordance with the radiation shielding calculations are included in the building inspection ITAAC in Tier 1.

14.3.3.5 Initial Test Program

The Initial Test Program (ITP) defines testing activities that are conducted following completion of construction and construction-related inspections and tests. The ITP extends through to the start of commercial operation of the facility. This program is discussed within Section 14.2 and centers heavily on testing of the safety-related systems.

A summary of the ITP has been included in Tier 1, Section 3.5. This summary includes an overview of the ITP structure together with commitments related to test documentation and administration controls. This information has been included in Tier 1 because of the importance of the ITP in defining comprehensive pre- and post-fuel load testing for the as-built facility to demonstrate compliance with the design certification. Key pre-fuel load ITP testing for individual systems is defined in the system ITAAC in Tier 1, Sections 2 and 3.

No ITAAC entries have been included in Tier 1 for the ITP. This is acceptable because:

- Many of the ITP activities involve testing with the reactor at various power levels and thus cannot be completed prior to fuel load (Part 52 requires ITAAC to be completed prior to fuel load).
- Testing activities specified as part of the ITAAC in Tier 1, Sections 2 and 3 must be performed prior to fuel load. Because these ITAAC testing activities address the design features and characteristics of key safety significance, additional ITAAC for the ITP as defined in Tier 1, Section 3.5 are not necessary to assure that the as-built plant conforms with the ESBWR certified design.

14.3.4 Tier 1, Section 4 - Interface Material

This section of Tier 1 provides interface requirements for those system of a complete power-generating facility that are either totally or partially not within the scope of the ESBWR design as defined in the certification application (Tier 2). Generally structures, systems and components that are part of, or within, the Reactor Building, Fuel Storage Building, Service Building, Control Building, Turbine Building and Radwaste Building are in the ESBWR scope. Those portions of the plant outside of these buildings are not generally in the DCD scope. This scope split occurs because design of the plant features located outside the main buildings is dependent upon site-specific characteristics that are unknown at the time of certification (e.g., the source of normal plant cooling water, the characteristics of the electrical grid to which the plant is connected, etc.). The basis for this interface requirements entry in Tier 1 is the discussion in 10 CFR Part 52.47. An applicant for a license that references the ESBWR design certification must provide site-specific systems with design features/characteristics that comply with the interface requirements. For systems that are partially within the scope of the ESBWR, interface requirements are listed in either Tier 1, Section 4 or in a separate sub-part of the Tier 1, Section 2 entry that addresses the in-scope portion of the system. In all cases, the Tier 1 entries for these systems are limited to defining interface requirements. Conceptual designs for the out-of-scope interfacing systems are presented in Tier 2 but are not addressed in Tier 1. This is appropriate because the applicant provides site-specific designs that meet the interface requirement; these site-specific designs may not correspond to the conceptual designs described in Tier 2. Tier 1 does not define any ITAAC associated with the interface requirements. This is acceptable because the individual COL applicants who reference the ESBWR design certification provide ITAAC for the plant SSCs outside the scope of the ESBWR design certification on a site-specific, design-specific basis. (Part of the review process at the time of the license application is to assess compliance of the site-specific designs with the interface requirements.)

Design certification applications should contain justification that the requirements are verifiable through inspection, testing or analysis and that the method to be used for verification be included as part of the ITAAC. The introductory text of Tier 1, Section 4 addresses these issues by stating the interface requirements are similar in nature to the design commitments in Tier 1, Section 2 for which ITAAC have been developed. This represents justification that a COL applicant is able to develop ITAAC to verify compliance with the design features or characteristics that implement the interface requirements. The methods to be used for these verifications are specified in the COL ITAAC and are similar to the methods in the Tier 1, Section 2 ITAAC for comparable/similar design characteristics.

Selection Criteria — The selection criteria listed in Tier 2, Subsection 14.3.2.1 were used to guide selection of interface requirements defined in Tier 1, Section 4 (or in the Section 2.0 entries referenced from Tier 1, Section 4). The intent is that the interface requirements in Tier 1 define key, safety-significant design attributes and performance characteristics of the site-specific, out-of-scope portion of the plant which must be provided in order for the certified portions of the ESBWR to comply with the design commitments in Tier 1. It is an objective of this section that it address interfaces between in-scope and out-of-scope portions of the plant that are unique to the ESBWR design; it is not intended that it be a comprehensive listing of all design requirements applicable to the out-of-scope portions of the plant. The latter is provided for NRC review when the COL applicant submits a site-specific safety analysis report that includes a discussion of the site-specific design features.

Selection Methodology — The interface requirements included in the Tier 1 were selected from the interface requirements listed in Tier 2 for fully or partially out-of-scope systems. For example: Tier 2, Subsection 8.2.3 defines interface requirements for the Offsite Power Systems. These sections and similar interface requirement sections for other systems were reviewed, and Tier 1, Section 4 entries selected using the criteria discussed above.

14.3.5 Tier 1, Section 5 - Site Parameters

This section of Tier 1 defines the site parameters that were used as a basis for the design defined in the ESBWR certification application. These entries respond to the 10 CFR 52.47 requirement that the design certification documentation include site parameter information. The plant must be designed and built using the parameters in Tier 1, Section 5. Furthermore, it is intended that applicants referencing the ESBWR design certification demonstrate that these parameters for the selected site are within the certification envelope.

Site-specific external threats that relate to the acceptability of the design (and not to the acceptability of the site) are not considered site parameters and are addressed as interface requirements in the appropriate system entry in Tier 1, Section 4. For example, the Technical Support Center (TSC) HVAC System requires that toxic gas monitors be located in the outside air intake if the site is adjacent to toxic gas sources with the potential for releases of significance to plant operating personnel in the TSC.

Section 5 of Tier 1 does not include any ITAAC, and is limited to defining the ESBWR site parameters. This is an appropriate approach because a license applicant prior to issuance of the license must demonstrate compliance of the site with these parameters.

Selection Criteria — Tier 2, Section 2 provides the envelope of site design parameters used for the ESBWR design. The corresponding Tier 1, Section 5 is based on using information from Tier 2 Section 2. Tier 1, Section 5 is limited to tabular entries, and no supporting text material is required.

14.3.6 Tier 1 Generation Summary

A central element of the design certification processes deriving from 10 CFR Part 52 centers on selection and documentation of the technical information to be included in the rule as the ESBWR certified design. The certified design description is a subset of the comprehensive set of design information presented in Tier 2. It includes:

- The key, important safety-significant aspects of the overall design described in the certification application (Tier 2);
- The ITAAC that are used to verify the as-built facility conforms with the ESBWR certified design;
- Interface requirements; and
- Site parameters.

The information presented in Tier 1 is prepared using the selection criteria and methodology described herein, and is intended to satisfy the above Part 52 requirements for Rule content. In particular, the ITAAC entries in Tier 1, Sections 2 and 3 confirm that key design performance characteristics and design features are in place, and that the as-built facility operates in accordance with the design certification.

14.3.7 Change Process For Tier 1 System Design Descriptions and ITAAC

Most Tier 1 and ITAAC related changes are in the response to NRC RAIs. The following guidance is based on draft SRPs 14.3 through 14.3.11 and Draft Guide (DG)-1145, with respect to the ESBWR design. This guidance is to be followed for determining the content of RAI requested system design description (DD) and/or ITAAC updates, changes and additions in Section 2 of Tier 1, and may be used by the COL applicant for determining site-specific ITAAC.

In general, each (RAI) requested Tier 1 change is addressed in the RAI response. If a requested Tier 1 change is determined to be not appropriate, then the RAI response shall justify the no change conclusion and describe where or how (e.g., Tier 1 location, COL application, COL holder to provide) the technical concern/information is or will be addressed/provided. If a requested Tier 1 change is needed, then the RAI response should include the Tier 1 DD and/or ITAAC changes and Tier 1 shall be updated.

To ensure the appropriate level of detail for Tier 1 RAI related changes, the following Tier 1 content determination process (outlined in Figure 14.3-1) for systems uses a graded approach with sets of Tier 1 DD and ITAAC selection criteria.

14.3.7.1 Generic Guidance

The DCD Tier 2 safety analyses are based largely on system-level safety functions (assumed and analyzed) being performed and the key parameters of each safety-related function (e.g., water injection in “x” seconds with a flow rate of “y” gallons per minute), rather than addressing all aspects of each individual component in a system. Therefore, component-level details that are already covered by a verifiable design characteristic, feature or function (DCFF) of a safety-related function or a system-level detail should be described in Tier 2, if appropriate, and need not be included in the Tier 1 design descriptions (DDs). The ITAAC, however, should be written with objective criteria that can, to the extent practical, be verified through inspection or testing, and should include values that verify that a structure, system or component (SSC) performs as assumed in the safety analyses (as applicable) or as required by NRC regulation.

Tier 1 should address the equipment performance values modeled in the Tier 2 safety analyses and other performance values directly related to ensuring nuclear safety and/or ensuring compliance with NRC regulations.

To ensure the safety of the as-built plant, the ITAAC should confirm the DCFFs assumed and/or modeled in the Tier 2 safety analyses.

10 CFR 52.97(b)(1) states “*The Commission shall identify within the combined license the inspections, tests, and analyses, including those applicable to emergency planning, that the licensee shall perform, and the acceptance criteria that, if met, are necessary and sufficient to provide reasonable assurance that the facility has been constructed and will be operated in conformity with the license, the provisions of the Atomic Energy Act, and the Commission's rules and regulations.*” Therefore, Tier 1 should include the DDs and ITAACs needed to ensure that the design related regulations (e.g., the 10 CFR 50, App. A, *General Design Criteria*) will be verified.

It is understood that not all safety-related SSCs are safety/risk-significant, and that all nonsafety-related are not safety/risk-significant. For a passive plant like the ESBWR, the safety-significant nonsafety-related SSCs are determined by applying the Regulatory Treatment on Nonsafety Systems (RTNSS) criteria. Plus, there are nonsafety-related functions modeled/assumed in the plant safety analyses with respect to mitigating the effects of anticipated operational occurrences (AOOs) and special events (e.g., station blackout and ATWS). To ensure conservatism, all safety-related SSCs should be assumed to be safety-significant. Therefore, for completeness, it is assumed that all SSCs that perform safety-related, AOO mitigation, special event mitigation and RTNSS mitigation functions have some degree of safety significance. By exclusion, all other SSC functions are not safety-significant, and are not required to be addressed in Tier 1, except to address any design aspects directly required to ensure compliance with a regulation.

14.3.7.2 Guidance From Draft SRPs 14.3 – 14.3.11 and DG-1145

Much of the information within draft SRPs 14.3 - 14.3.11 and DG-1145 addresses active or evolutionary plants, and thus, may not be directly applicable to a passive plant like the ESBWR. However, those portions that apply to both evolutionary and passive plants can be applied to the ESBWR.

Draft SRP 14.3, Section I, "AREAS OF REVIEW," second paragraph states "*The overall review approach consists of ensuring that the top-level design information in the DCD Tier 2 is appropriately included in Tier 1. The type of information and the level of detail in Tier 1 is based on a graded approach that is commensurate with the safety significance of the SSCs for the design. The top-level information selected should contain the principal performance characteristics and safety functions of the SSCs. This information must be appropriately verified by ITAAC.*" Plus, Draft SRP 14.3, Appendix A, Section IV, first paragraph states "*While the Tier 1 information must address the complete scope of the design to be certified, the amount of design information is proportional to the safety-significance of the structures and systems of the design.*" Therefore, a graded approach, based on safety functions, should be used determining the amount of detail in the Tier 1 DD and ITAAC. Therefore, (a) the content of the Tier 1 design information should come from the top-level safety significant information in Tier 2, (b) the level of detail in Tier 1 should be based on a graded approach with respect to safety, and (c) the ITAAC should be based on the content of the Tier 1 design information (but must include values, if appropriate).

Draft SRP 14.3, Section III, "General Review Procedures," Item 5 states "*Ensure that the standard ITAAC entries in Appendix D that are related to your review area are appropriately included*."

Draft SRP 14.3, Section III, "General Review Procedures," Item 10 states "*Ensure that the ITAAC are consistent with the technical specifications, including their bases and limiting conditions for operation.*" The safety functions and essential values used in the Tier 2 safety analyses may be reflected in the Technical Specifications (TS) limiting conditions for operation (LCOs).

Draft SRP 14.3, Appendix A, Section IV, Item B.1 states

> "*The design descriptions (DD) address the most safety-significant aspects of each of the systems of the design, and were derived from the detailed design information contained in*

Tier 2. The level of detail in Tier 1 governed by a graded approach to the SSCs of the design, based on the safety significance of the functions they perform."

"For example, safety-related SSCs should be described in Tier 1 with a relatively greater amount of information. Other SSCs should also be included based on their importance to safety, such as containment isolation aspects of non-safety systems. Some non-safety aspects of SSCs need not be discussed in Tier 1. This graded approach recognizes that although many aspects of the design are important to safety, the level of design detail in Tier 1 and verification of the key design features and performance characteristics should be commensurate with the significance of the safety functions to be performed."

"Numeric performance values and key parameters in safety analyses should be specified in the design descriptions based on their safety significance; however, numbers for all parameters need not be specified unless there is a specific reason to include them (e.g., important to be maintained for the life of the facility)."

"Two important factors should be balanced in reaching a decision to incorporate information into the DD: (1) the safety significance of the design feature or commitment to the staff's safety decision, and (2) an evaluation of whether it is likely or not that the design feature or commitment will need to be changed in the future. If the staff concludes that it is likely that the details of a particular design feature or commitment will need to change then it is appropriate to limit the amount of detail in the DD. For example, if current technology is changing and the staff concludes it is inappropriate to specify a particular technology by rulemaking, then the level of detail in the DD should be limited to functional requirements and/or broad commitments. Additional detail as to how the functional requirements and/or broad commitments will be met must be specified in Tier 2 in sufficient detail for the staff to reach its safety decision."

Based on the above, the following provides examples of factors to be considered when determining whether to include a particular design element or feature in an ITAAC.

- If a RAI requests a new ITAAC line item, which is consistent with a standard ITAAC entree from draft SRP 14.3, Appendix D **and** is applicable to the ESBWR's passive design, then the requested ITAAC topic should be included in the Tier 1 system DD and ITAAC.
- The safety functions and essential values used in the Tier 2 safety analyses may be reflected in the TS LCOs. Therefore, in those cases, to ensure ITAAC and LCO consistency, the ITAAC (as applicable) should be consistent with the LCOs containing the essential safety analysis values.

  Note: TS trip allowable values are conservatively based (due to the application of setpoint methodology) on the analytical limits used in Tier 2, and thus, are not equal to those values.
- A graded approach, based on safety functions and NRC regulations, is used determining the amount of detail in the Tier 1 DD and ITAAC.
- Only those design aspects that can be verified prior to fuel load should be included in the ITAAC.

- A global commitment to a code (ASME or IEEE) may not be readily verifiable, while specific code requirements can be readily verifiable, and thus, they should be included in the ITAAC. The ITAAC should be written so that the verification of completion will be readily discernable.
- In some cases, for designs/technologies that are subject to change, the DD should contain higher level functional commitments, and need not include the lower level details that are described within Tier 2. However, if the safety analysis or a SSC functional description relies on a value for performing the safety analyses or for compliance with NRC regulatory requirements, the ITAAC should include those values/details.
- The ITAAC for a system should be based on the safety significant information in the DD or on information that demonstrate how an NRC regulation is met, whether safety significant or not.
- If information beyond the top level Tier 1 information is needed to verify an ITAAC, then that information should be within Tier 2. Therefore, if additional information to understand or verify an ITAAC is needed and is not currently within Tier 2, then this information should be added to Tier 2 and in the ITAAC, as appropriate.
- When fixed (safety-significant) design information is not available during the design certification phase, then the Design Acceptance Criteria (DAC) for the COL applicant/holder to meet should be provided in Tier 1 and Tier 2.
- SSCs with no safety significance generally should have no DD or ITAAC entry. However, the system should be listed, and Tier 1 state that there is no ITAAC entry. This ensures that ITAAC were considered and determined to be not required. Exceptions to this approach are SSCs that are relied upon to comply with NRC regulatory requirements, which, in many cases, are deterministic and not necessarily based on safety and risk significance.
- If a RAI requests design certification scope ITAAC information, which is verifiable prior to fuel load **<u>and</u>** is suggested by DG-1145, Section C.II.2, Subsections 14.3.1 – 14.3-12 and/or Attachment A, then the Tier 1 DD and ITAAC should be updated (with referencing to Tier 2 for additional/specific details) as requested by the RAI.

14.3.7.3 Criteria and Application Process

Each system addressed in Tier 2 shall be addressed in Tier 1 to the appropriate level of detail. The following graded three-level approach (outlined in Figure 14.3-1) is used to determine the general level of detail in each Tier 1 system description.

(1) General Tier 1 Content Determination:

a. Systems with system-level or component-level safety-related, RTNSS, Infrequent Event and/or Special Event (e.g., ATWS, Station Blackout and Safe Shutdown Fire in Tier 2, Chapter 15) mitigation functions or have a DCFF required for meeting a regulation shall have Tier 1 inputs that include DD and ITAAC.

b. For nonsafety-related systems with design functions or features that:

(i) Prevent or mitigate AOOs analyzed in Tier 2,

(ii) Perform fuel protection or cooling (inside or outside the reactor vessel) functions, and/or

(iii) Are included in the plant to actively/automatically control offsite doses below 10 CFR 20 limits,

Tier 1 shall include DDs, but ITAAC are not required. However, if ITAAC would facilitate the NRC verification of the system by providing the pertinent items to be verified, then it is recommended that an ITAAC table be included.

c. The Tier 1 content of those systems that do not qualify under Items (1)a or (1)b generally need not include DDs or ITAAC. (These systems generally will be included in Tier 1 only by subject [i.e., title], and include a “no entry” statement.)

(2) DD Content Determination:

For each Item (1)a system, the following DCFFs shall be included in the Tier 1 DDs. (The level of detail of each DCFF should be such that it is not expected to change, and DCD Tier 2 should referenced for the additional details needed to verify the ITAAC.)

a. Purpose and functions

b. Classifications (i.e., safety-related, seismic category, and ASME Code Classes);

c. Safety-related functions (i.e., modes of operation) and requirements;

d. Application of 10 CFR 50, Appendix A single failure criterion (e.g., separate trains, loops and divisions) to provide each safety-related function;

e. Features or functions used to mitigate the special events evaluated in the Tier 2 safety analyses;

f. Safety-related electrical trip signals and initiations modeled in the Tier 2 safety analyses;

g. The configuration of a safety-related system’s safety-significant components (usually provided by means of a figure or table), generally showing which equipment must be qualified for a harsh environment (i.e., within the primary containment);

h. Use of safety-related (Class 1E) electrical power;

i. Class 1E electric power independence, capacity, capability, electrical protection and controls;

j. The safety-related instruments and manual controls located in the Main Control Room;

k. Safety-related logic, interlocks, bypasses and system inputs;

l. Safety-related electrical channel integrity and channel independence;

m. Safety to non-safety interfaces and isolation devices (if any);

n. Regulatory Guide 1.97 Category I instruments;

o. In a separate Tier 1 subsection, Remote Shutdown System instruments and controls for performing safety-related functions;

p. Equipment initiations and system performance parameters used in the Tier 2 accident analyses (e.g., key containments design parameters, validated by the plant safety analyses);

q. Non-system level safety-related functions in nonsafety-related systems (e.g., containment isolation);

r. Features or functions described in the Tier 2 RTNSS evaluation;

s. Any additional safety-significant details from draft SRP 14.3, Appendix D (Attachment 1) or DG-1145, Section C.II.2, Subsections 14.3.1 – 14.3-12 and/or Attachment A (Attachment 2); and

t. Non-safety significant DCFFs, needed to verify the design related NRC regulations.

For the each Item (1)b system, the following DCFFs shall be included in the Tier 1 DDs. (The level of detail of each DCFF in the DDs should be such that it is not expected to change.)

u. Those that are specifically provided to prevent or mitigate Anticipated Operational Occurrences analyzed in Tier 2, Chapter 15;

v. Those that are specifically provided to perform nonsafety-related fuel protection or cooling (inside or outside the reactor vessel) functions;

w. Those that actively/automatically control offsite doses below 10 CFR 20 limits; and

x. Non-safety significant DCFFs, needed to verify the design related NRC regulations or to comply with NRC regulations.

(3) ITAAC Table Line Item Topics Determination:

Starting with the DCFFs determined in Item (2)a, and reviewing them against the functions and features assumed in the Tier 2 safety analyses, use the following criteria to determine the ITAAC table line item topics for each system. (The level of detail of each ITAAC line item should be such that it is not expected to change, and DCD Tier 2 should be referenced for the additional details needed to verify the ITAAC.)

a. The as-built configuration and performance characteristic of the DCFF, which can be confirmed prior to fuel load;

b. The DCFF is assumed or modeled in a Tier 2 safety analysis; and

c. The DCFF is not already covered by the confirmation of a higher level ITACC table line item (e.g., system or function vs. component). (Do not combine DCFFs if it would be easier to confirm them separately, via separate line items, particularly if there are objective criteria for each of these items.)

Starting with the DCFFs determined in Item (2)b, determine which DCFFs (if included in the ITAAC table) would facilitate the NRC verification of the system, and provide the pertinent DCFFs in the ITAAC table.

Table 14.3-1

Types of Systems and Summary of Their Graded Treatment

System Type	Scope of Design Description
Safety-related systems that contribute to plant performance during design basis events (e.g., emergency core cooling systems).	Major safety-related features and performance characteristics.
Nonsafety-related systems involved in special events (e.g., station blackout).	Brief discussion of design features and performance characteristics affecting the safety of the plant's response to the event(s).
Nonsafety-related systems potentially affecting safety (e.g. potential missiles from the main turbine).	Brief discussion of design features which prevent or mitigate the potential safety concern.
Nonsafety-related systems, which affect overall plant design (e.g., Drywell Cooling System).	Case-by-case evaluation. A brief discussion of the system if warranted by overall standardization goals.
Nonsafety-related systems with no relationship to safety or any influence on overall plant design (e.g., House Boiler System).	No discussion except identification of the system title.
System for which the Tier 1 entry has been included in another system (e.g., the Unit Auxiliary Transformer is addressed in the electrical power distribution system).	No additional discussion except identification of the system title.

Table 14.3-2

Test, Inspection or Analysis Approach & Application Process

ITA Approach	Application
Inspection	To be used when verification can be accomplished by visual observations, physical examinations, review of records based on visual observations or physical examinations that compare the as-built structure, system or component condition to one or more Tier 1 design description commitments.
Test	To be used when verification can be accomplished by the actuation or operation, or establishment of specified conditions, to evaluate the performance or integrity of the as-built structures, system or components. The type of tests identified in the ITAAC tables are not limited to in-situ testing of the completed facility but also include (as appropriate) other activities such as factory testing, special test facility programs, and laboratory testing.
Analysis	To be used when verification can be accomplished by calculation, mathematical computation or engineering or technical evaluations of the as-built structures, systems or components. (In this case, engineering or technical evaluations could include, but are not limited to, comparisons with operating experience or design of similar structures, systems or components.)