

REFERENCE SAFETY ANALYSIS REPORT

STANDARD PLANT FOR THE '90'S

RESAR-SP/90

PRIMARY SIDE SAFEGUARDS SYSTEM MODULE

WESTINGHOUSE NON-PROPRIETARY

prepared by
Westinghouse Nuclear Energy Systems
Pittsburgh, Pennsylvania

I.D. # _____

TABLE OF CONTENTS

<u>Section</u>	<u>Title</u>	<u>Page</u>	<u>Reference SAR Section Status</u>
1.0	INTRODUCTION AND GENERAL DESCRIPTION OF THE PLANT	1.1-1	NA
1.1	INTRODUCTION	1.1-1	I
1.2	GENERAL PLANT DESCRIPTION	1.2-1	NA
1.2.3	Plant Description	1.2-1	NA
1.2.3.1	Primary Side Safeguards System	1.2-1	II
1.2.3.1.1	System Functions	1.2-1	I
1.2.3.1.2	System Description	1.2-3	I
1.2.3.1.2.1	Safety Injection	1.2-6	I
1.2.3.1.2.2	Containment Spray	1.2-8	I
1.2.3.1.2.3	Normal Cooldown	1.2-9	I
1.2.3.1.2.4	Emergency Boration	1.2-10	I
1.2.3.1.2.5	System Testing	1.2-10	I
1.2.3.1.2.6	Feed and Bleed Emergency Core Cooling	1.2-11	I
1.3	COMPARISON TABLES	1.3-1	NA
1.3.1	Comparison With Similar Facility Designs	1.3-1	II
1.6	MATERIAL INCORPORATED BY REFERENCE	1.6-1	II
1.7	DRAWINGS AND OTHER DETAILED INFORMATION	1.7-1	NA
1.7.2	Piping and Instrumentation Diagrams	1.7-1	II
1.8	CONFORMANCE WITH THE STANDARD REVIEW PLAN	1.8-1	II
2.0	SITE CHARACTERISTICS	2.0-1	NA
3.0	DESIGN OF STRUCTURES, COMPONENTS, EQUIPMENT AND SYSTEMS	3.1-1	NA
3.1	CONFORMANCE WITH NRC GENERAL DESIGN CRITERIA	3.1-1	II
3.2	CLASSIFICATION OF STRUCTURES, COMPONENTS, AND SYSTEMS	3.2-1	II
3.2.1	Seismic Classification	3.2-2	II
3.2.2	System Quality Group Classification	3.2-2	II
3.2.3	Safety Classes	3.2-2	II
3.2.5	References	3.2-2	II

TABLE OF CONTENTS

<u>Section</u>	<u>Title</u>	<u>Page</u>	Reference SAR Section Status
4.0	REACTOR	4.0-1	NA
5.0	REACTOR COOLANT SYSTEM AND CONNECTED SYSTEMS	5.4-1	NA
5.4	COMPONENT AND SUBSYSTEM DESIGN	5.4-1	NA
5.4.7	Residual Heat Removal System	5.4-1	I
5.4.7.1	Design Basis	5.4-2	I
5.4.7.2	System Design	5.4-4	I
5.4.7.2.1	Schematic Piping and Instrumentation Diagrams	5.4-4	I
5.4.7.2.2	Equipment and Component Descriptions	5.4-7	I
5.4.7.2.3	Control	5.4-7	I
5.4.7.2.4	Applicable Codes and Classifications	5.4-7	I
5.4.7.2.5	System Reliability Considerations	5.4-7	I
5.4.7.2.6	Manual Actions	5.4-8	I
5.4.7.3	Performance Evaluation	5.4-14	I
5.4.7.5	Instrumentation	5.4-14	I
6.0	ENGINEERED SAFETY FEATURES	6.1-1	NA
6.1	ENGINEERED SAFETY FEATURE MATERIALS	6.1-1	NA
6.1.1	Metallic Materials	6.1-1	NA
6.1.1.1	Materials Selection and Fabrication	6.1-1	II
6.1.1.2	Composition, Compatibility, and Stability of Containment and Core Spray Coolants	6.1-3	II
6.1.2	Organic Materials	6.1-4	II
6.1.3	References	6.1-5	I
6.2	CONTAINMENT SYSTEMS	6.2-1	NA
6.2.2	Containment Heat Removal System	6.2-1	II
6.2.2.1	Design Basis	6.2-1	I
6.2.2.2	System Design	6.2-2	I
6.2.2.3	Design Evaluation	6.2-5	I
6.2.2.4	Tests and Inspections	6.2-5	I
6.2.2.5	Instrumentation Requirements	6.2-7	I

TABLE OF CONTENTS

<u>Section</u>	<u>Title</u>	<u>Page</u>	<u>Reference SAR Section Status</u>
6.3	EMERGENCY CORE COOLING SYSTEM	6.3-1	NA
6.3.1	Design Basis	6.3-1	I
6.3.2	System Design	6.3-3	I
6.3.2.1	Schematic Piping and Instrumentation Diagrams	6.3-3	I
6.3.2.2	Equipment and Component Descriptions	6.3-6	I
6.3.2.2.1	High Head Pumps	6.3-9	I
6.3.2.2.2	Low Head Pumps	6.3-10	I
6.3.2.2.3	Accumulators	6.3-11	I
6.3.2.2.4	Core Reflood Tanks	6.3-13	I
6.3.2.2.5	Emergency Water Storage Tank (EWST)	6.3-14	I
6.3.2.2.6	Residual Heat Removal (RHR) Heat Exchangers	6.3-14	I
6.3.2.2.7	Low Head Pump Miniflow Heat Exchangers	6.3-15	I
6.3.2.2.8	Valves	6.3-15	I
6.3.2.3	Applicable Codes and Classifications	6.3-19	I
6.3.2.4	Material Specifications and Compatability	6.3-19	I
6.3.2.5	System Reliability	6.3-19	I
6.3.2.5.1	Active Failure Criteria	6.3-20	I
6.3.2.5.2	Passive Failure Criteria	6.3-21	I
6.3.2.5.3	Detection and Termination of Leaks	6.3-21	I
6.3.2.5.4	Lag Times	6.3-23	I
6.3.2.5.5	Potential Boron Precipitation	6.3-23	I
6.3.2.6	Protection Provisions	6.3-23	I
6.3.2.7	Provisions for Performance Testing	6.3-24	I
6.3.2.8	Manual Actions	6.3-24	I
6.3.2.8.1	Recirculation Phase	6.3-25	I
6.3.2.8.2	Hot Leg Recirculation Phase	6.3-25	I

TABLE OF CONTENTS

<u>Section</u>	<u>Title</u>	<u>Page</u>	<u>Reference SAR Section Status</u>
6.3.3	Performance Evaluation	6.3-26	I
6.3.3.1	Inadvertent Opening of a Steam Generator Relief or Safety Valve	6.3-28	II
6.3.3.2	Small Break Loss of Coolant Accident	6.3-28	I
6.3.3.3	Large Break Loss of Coolant Accident	6.3-29	I
6.3.3.4	Major Secondary System Pipe Failure	6.3-31	II
6.3.3.5	Steam Generator Tube Failure	6.3-32	II
6.3.3.6	Feedwater System Pipe Break	6.3-33	II
6.3.3.7	Inadvertent Operation of the Emergency Core Cooling System During Power Operation	6.3-34	I
6.3.4	Tests and Inspections	6.3-35	I
6.3.4.1	ECCS Performance Tests	6.3-35	I
6.3.4.2	Reliability Tests and Inspections	6.3-36	I
6.3.5	Instrumentation Requirements	6.3-37	NA
6.3.5.1	Engineered Safeguards Actuation Signals	6.3-37	I
6.3.5.2	Instrumentation	6.3-39	I
6.3.5.2.1	Pressure	6.3-39	I
6.3.5.2.2	Flow	6.3-40	I
6.3.5.2.3	Temperature	6.3-41	I
6.3.5.2.4	Level	6.3-43	I
6.3.5.2.5	Critical Function Valve Alarm	6.3-44	I
6.3.5.2.6	Monitor Lights	6.3-44	I
6.5	FISSION PRODUCT REMOVAL AND CONTROL SYSTEMS	6.5-1	NA
6.5.2	Containment Spray System (Fission Product Removal)	6.5-1	I
6.5.2.1	Design Bases	6.5-1	I
6.5.2.2	System Design	6.5-2	I

TABLE OF CONTENTS (Cont)

<u>Section</u>	<u>Title</u>	<u>Page</u>	<u>Reference SAR Section Status</u>
6.5.2.3	Design Evaluation	6.5-3	I
6.5.2.3.1	Spray Removal Airborne Iodine	6.5-3	I
6.5.2.3.2	Deposition Removal of Airborne Iodine	6.5-4	I
6.5.2.4	Tests and Inspections	6.5-4	I
6.5.2.5	Instrumentation Requirements	6.5-5	I
6.5.2.6	Materials	6.5-5	I
6.5.2.7	References	6.5-6	I
7.0	INSTRUMENTATION AND CONTROLS	7.1-1	NA
7.1	INTRODUCTION	7.1-1	II
8.0	ELECTRIC POWER	8.0-1	NA
9.0	AUXILIARY SYSTEMS	9.0-1	NA
10.0	STEAM AND POWER CONVERSION SYSTEM	10.0-1	NA
11.0	RADIOACTIVE WASTE MANAGEMENT	11.0-1	NA
12.0	RADIATION PROTECTION	12.0-1	NA
13.0	CONDUCT OF OPERATIONS	13.0-1	NA
14.0	INITIAL TEST PROGRAM	14.0-1	NA

TABLE OF CONTENTS (Cont)

<u>Section</u>	<u>Title</u>	<u>Page</u>	<u>Reference SAR Section Status</u>
15.0	ACCIDENT ANALYSES	15.0-1	NA
15.5	INCREASE IN REACTOR COOLANT INVENTORY	15.5-1	II
15.5.1	Inadvertent Operation of the Emergency Core Cooling System During Power Operation	15.5-1	I
15.5.1.1	Identification of Causes and Accident Description	15.5-1	I
15.5.1.2	Conclusions	15.5-2	I
15.6	DECREASE IN REACTOR COOLANT INVENTORY	15.6-1A	II
15.6.2	Break in Instrument Line or Other Line From Reactor Coolant Pressure Boundary That Penetrate Containment	15.6-1A	I
15.6.2.1	Identification of Causes and Frequency Classification	15.6-1A	I
15.6.4	LOCA Resulting From a Spectrum of Postulated Breaks Within RCS Pressure Boundary	15.6-1B	I
15.6.4.1	Identification of Causes and Frequency Classification	15.6-1B	I
15.6.4.2	Sequence of Events and Systems Operations	15.6-2	I
15.6.4.3	Core and System Performance	15.6-5	I
15.6.4.3.1	Mathematical Model	15.6-5	I
15.6.4.3.2	Input Parameters and Initial Conditions	15.6-9	I
15.6.4.3.3	Results	15.6-10	I
15.6.4.4	Radiological Consequences	15.6-13	I
15.6.4.4.1	Fission Produce Release to the Containment	15.6-13	I
15.6.4.4.2	Fission Product Release Due to Containment Leakage	15.6-14	I

TABLE OF CONTENTS (Cont)

<u>Section</u>	<u>Title</u>	<u>Page</u>	<u>Reference SAR Section Status</u>
15.6.4.4.3	Fission Product Release Due to Containment Purge Operation	15.6-15	I
15.6.4.4.4	Radioactive Releases Resulting From Leakage From ISS Recirculation Lines	15.6-16	I
15.6.4.4.5	Identification of Uncertainties and Conservatisms in the Analysis	15.6-16	I
15.6.4.4.6	Conclusions	15.6-17	I
15.6.4.4.6.1	Filter Loadings	15.6-17	I
15.6.4.4.6.2	Doses to Receptor at the Exclusion Area Boundary and Low Population Zone Outer Boundary	15.6-18	I
15.6.4.4.6.3	Doses to Control Room Personnel	15.6-18	I
15.6.7	References	15.6-19	II
15A	ACCIDENT ANALYSIS RADIOLOGICAL CONSEQUENCES EVALUATION MODELS AND PARAMETERS	15A-1	NA
15A.1	GENERAL ACCIDENT PARAMETERS	15A-1	II
15A.2	OFFSITE RADIOLOGICAL CONSEQUENCES CALCULATIONAL MODELS	15A-1	II
15A.2.1	ACCIDENT RELEASE PATHWAYS	15A-2	II
15A.2.2	SINGLE-REGION RELEASE MODEL	15A-2	I
15A.2.3	TWO-REGION SPRAY MODEL IN CONTAINMENT (LOCA)	15A-4	I
15A.2.4	OFFSITE THYROID DOSE CALCULATIONAL MODEL	15A-5	I
15A.2.5	OFFSITE BETA-SKIN DOSE CALCULATIONAL MODEL	15A-6	I
15A.2.6	OFFSITE GAMMA-BODY DOSE CALCULATIONAL MODEL	15A-7	I

TABLE OF CONTENTS (Cont)

<u>Section</u>	<u>Title</u>	<u>Page</u>	<u>Reference SAR Section Status</u>
15A.3	CONTROL ROOM RADIOLOGICAL CONSEQUENCES CALCULATIONAL MODELS	15A-7	I
15A.3.1	INTEGRATED ACTIVITY IN CONTROL ROOM	15A-7	I
15A.3.2	INTEGRATED ACTIVITY CONCENTRATION IN CONTROL ROOM FROM SINGLE-REGION SYSTEM	15A-8	I
15A.3.3	CONTROL ROOM THYROID DOSE CALCULATIONAL MODEL	15A-9	I
15A.3.4	CONTROL ROOM BETA-SKIN DOSE CALCULATIONAL MODEL	15A-10	I
15A.3.5	CONTROL ROOM GAMMA-BODY DOSE CALCULATION	15A-11	I
15A.3.5.1	MODEL FOR RADIOLOGICAL CONSEQUENCES DUE TO RADIOACTIVE CLOUD EXTERNAL TO THE CONTROL ROOM	15A-11	I
15A.4	REFERENCES	15A-12	I
16.0	TECHNICAL SPECIFICATIONS	16.0-1	NA
17.0	QUALITY ASSURANCE	17.1-1	NA
17.1	QUALITY ASSURANCE DURING DESIGN AND CONSTRUCTION	17.1-1	II
17.1.1	References	17.1-1	II

TABLE OF CONTENTS (Cont)

KEY TO "REFERENCE SAR SECTION STATUS" COLUMN:

Category I

Those sections which are complete and for which no additional information is to be provided for the PDA application.

Category II

Those sections which are complete insofar as providing material relevant to this system module but for which additional information will be provided in support of subsequent modules.

Category III

Those sections for which information on interfacing systems will be provided at a later date.

NA

Those sections for which categorization is not applicable. Only the section titles are included for clarity.

TABLE OF CONTENTS (Cont)

LIST OF FIGURES

<u>Number</u>	<u>Title</u>
1.2.1-1	Integrated Safeguards System Normal Valve Alignment
1.2.1-2	Integrated Safeguards (Four Mechanical Subsystems)
1.2.1-3	Containment Plan
1.7-1	Flow Diagram Legend
6.2.2-1	Containment Spray Nozzle (1713A Nozzle)
6.2.2-2	Containment Spray Nozzle Capacity Curve
6.2.2-3	Mean Droplet Size Distribution
6.2.2-4	Nozzle Spray Pattern (Vertical)
6.2.2-5	Nozzle Spray Pattern (Horizontal)
6.2.2-6	Nozzle Spray Pattern (Downward)
6.3-1	ISS Piping and Instrumentation Diagram
6.3-2	ISS Process Flow Diagram
6.3-3	Conceptual Containment Plan
6.3-4	ISS High Head Pump Performance Curve
6.3-5	ISS Low Head Pump Performance Curve
15.6.4-1	Sequence of Events for Large Break Loss-Of-Coolant Analysis
15.6.4-2	Code Interface Description for Large Break Model
15.6.4-3	Code Interface Description for Small Break Model
15.6.4-4	Peak Clad Temperature, Elevation 6.5 Feet DECLG ($C_D = 1.0$)
15.6.4-5	Core Pressure DECLG ($C_D = 1.0$)
15.6.4-6	Reflood Transient Core and Downcomer Water Levels DECLG ($C_D = 1.0$)
15.6.4-7	Reflood Transient Core Inlet Velocity DECLG ($C_D = 1.0$)

TABLE OF CONTENTS (Cont)

LIST OF FIGURES

<u>Number</u>	<u>Title</u>
15.6.4-8	Core Power Transient DECLG ($C_D = 1.0$)
15.6.4-9	Containment Pressure DECLG ($C_D = 1.0$)
15.6.4.10	Core Flow (Top and Bottom) DECLG ($C_D = 1.0$)
15.6.4.11	Heat Transfer Coefficient Peak Clad Temperature Elevation DECLG ($C_D = 1.0$)
15.6.4-12	Fluid Temperature Elevation 6.5 Feet DECLG ($C_D = 1.0$)
15.6.4-13	Break Flow Rate DECLG ($C_D = 1.0$)
15.6.4-14	Break Energy Released to Containment DECLG ($C_D = 1.0$)
15.6.4-15	Fluid Quality Peak Clad Temperature Elevation, 6.5 Feet DECLG ($C_D = 1.0$)
15.6.4-16	Accumulation Flow (Blowdown) DECLG ($C_D = 1.0$)
15.6.4-17	Mass Velocity, Elevation 6.5 Feet DECLG ($C_D = 1.0$)
15.6.4-18	ECCS Flow During Reflood DECLG ($C_D = 1.0$)
15.6.4-19	Peak Clad Temperature, Elevation 6.5 Feet DECLG ($C_D = 0.6$)
15.6.4-20	Core Pressure DECLG ($C_D = 0.6$)
15.6.4-21	Reflood Transient - Core and Downcomer Water Levels DECLG ($C_D = 0.6$)
15.6.4-22	Reflood Transient Core Inlet Velocity DECLG ($C_D = 0.6$)
15.6.4-23	Core Power Transient DECLG ($C_D = 0.6$)
15.6.4-24	Containment Pressure DECLG ($C_D = 0.6$)
15.6.4-25	Peak Clad Temperature, Elevation 6.5 Feet DECLG ($C_D = 0.8$)
15.6.4-26	Core Pressure DECLG ($C_D = 0.8$)
15.6.4-27	Reflood Transient Core and Downcomer Water Levels DECLG ($C_D = 0.8$)

TABLE OF CONTENTS (Cont)

LIST OF FIGURES

<u>Number</u>	<u>Title</u>
15.6.4-28	Reflood Transient Core Inlet Velocity DECLG ($C_D = 0.8$)
15.6.4-29	Core Power Transient DECLG ($C_D = 0.8$)
15.6.4-30	Containment Pressure DECLG ($C_D = 0.8$)
15.6.4-31	RCS Depressurization Transient (3 Inch)
15.6.4-32	Core Mixture Height (3 Inch)
15.6.4-33	Core Power After Reactor Trip
15.6.4-34	RCS Depressurization Transient (4.313 Inch)
15.6.4-35	RCS Depressurization Transient (6 Inch)
15.6.4-36	Core Mixture Height (4.313 Inch)
15.6.4-37	Core Mixture Height (6 Inch)
15.6.4-38	Small Break Safety Injection Flow Rates
15.6.4-39	Small Break Power Distribution
15.A-1	Release Pathways

TABLE OF CONTENTS (Cont)

LIST OF TABLES

<u>Number</u>	<u>Title</u>	<u>Page</u>
1.3-1	DESIGN COMPARISON	1.3-2
1.6-1	MATERIAL INCORPORATED BY REFERENCE	1.6-2
1.7-1	PIPING AND INSTRUMENTATION DRAWINGS	1.7-2
1.8-1	STANDARD REVIEW PLAN DEVIATIONS	1.8-2
1.8-2	USNRC REGULATORY GUIDES	1.8-3
3.1-1	GDC APPLICABLE TO PSSS	3.1-2
3.2-1	CLASSIFICATION OF STRUCTURES, SYSTEMS, AND COMPONENTS FOR THE ISS	3.2-3
5.4.7-1	FAILURE MODES AND EFFECTS ANALYSIS - RHR NORMAL COOLDOWN	5.4-15
6.1-1	ENGINEERED SAFETY FEATURES MATERIALS	6.1-6
6.1-2	PROTECTIVE COATINGS ON WESTINGHOUSE SUPPLIED EQUIPMENT INSIDE CONTAINMENT	6.1-8
6.2.2-1	CONTAINMENT SPRAY SYSTEM COMPONENT PARAMETERS	6.2-8
6.2.2-2	FAILURE MODE AND EFFECTS ANALYSIS - ISS CONTAINMENT SPRAY FUNCTIONS	6.2-9
6.3-1	ISS INTERFACE PARAMETERS	6.3-46
6.3-2	ISS COMPONENT PARAMETERS	6.3-48
6.3-3	ISS RELIEF VALVE DATA	6.3-54
6.3-4	FMEA FOR THE ISS-ECC FUNCTION	6.3-55
6.5.2-1	TYPICAL INPUT PARAMETERS AND RESULTS OF SPRAY IODINE REMOVAL ANALYSIS	6.5-7
15.6.4-1	INPUT PARAMETERS USED IN THE ECCS ANALYSIS	15.6-21
15.6.4-2	LARGE BREAK - TIME SEQUENCE OF EVENTS	15.6-22
15.6.4-3	LARGE BREAK RESULTS	15.6-23
15.6.4-4(a)	3-INCH SMALL BREAK LOCA TIME SEQUENCE OF EVENTS	15.6-24
15.6.4-4(b)	4.313-INCH SMALL BREAK LOCA TIME SEQUENCE OF EVENTS	15.6-25
15.6.4-4(c)	6-INCH SMALL BREAK LOCA TIME SEQUENCE OF EVENTS	15.6-26
15.6.4-5	SMALL BREAK LOCA RESULTS	15.6-27
15.6.4-6	PARAMETERS USED IN EVALUATING THE RADIOLOGICAL CONSEQUENCIES OF A LOCA	15.6-28

TABLE OF CONTENTS (Cont)

LIST OF TABLES

<u>Number</u>	<u>Title</u>	<u>Page</u>
15.6.4-7	DESIGN COMPARISON TO THE REGULATORY POSITIONS OF REGULATORY GUIDE 1.4, ASSUMPTIONS USED FOR EVALUATING THE POTENTIAL RADIOLOGICAL CONSEQUENCES OF A LOCA FOR PWRs, REV. 2, JUNE 1974	15.6-31
15.6.4-8	DOSES RESULTING FROM A LOCA	15.6-38
15A-1	PARAMETERS USED IN ACCIDENT ANALYSIS	15A-13
15A-2	LIMITING SHORT-TERM ATMOSPHERIC DISPERSION FACTORS FOR ACCIDENT ANALYSIS	15A-15
15A-3	FUEL AND ROD GAP INVENTORIES - CORE (C1)	15A-16
15A-4	DOSE CONVERSION FACTORS USED IN ACCIDENT ANALYSIS	15A-17
15A-5	REACTOR COOLANT IODINE CONCENTRATIONS FOR $\mu\text{Ci}/\text{GRAM}$ AND 60 $\mu\text{Ci}/\text{GRAM}$ OF DOSE EQUIVALENT I-131	15A-18
15A-6	IODINE APPEARANCE RATES IN THE REACTOR COOLANT	15A-19
15A-7	REACTOR COOLANT NOBLE GAS SPECIFIC ACTIVITY BASED ON ONE PERCENT DEFECTIVE FUEL	15A-20