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PRESSURE RELIEF SUBSYSTEM  
DESIGN DESCRIPTION

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MASTER

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LIST OF ABBREVIATIONS AND ACRONYMS

ACI	American Concrete Institute
AFDUC	Allowance for Funds Used During Construction
AISC	American Institute for Steel Construction
ANI	American Nuclear Industries
ANS	American Nuclear Society
ANSI	American National Standards Institute
API	American Petroleum Institute
ACRI	Air Conditioning and Refrigeration Institute
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigeration and Air-Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWWA	American Water Works Association
BOP	Balance of Plant
BSBSG	Buildings, Structures and Building Services Group
CDS	Component Design Specification
CFR	Code of Federal Regulations
DOE	Department of Energy
EPA	Environmental Protection Agency
EG	Electrical Group
FHSS	Fuel Handling, Storage and Shipping System
HEI	Heat Exchange Institute
HEPA	High Efficiency Particulate Absorber
HI	Hydraulics Institute
HRG	Heat Rejection Group
HTGR	High Temperature Gas-Cooled Reactor
HTS	Heat Transport System
HVAC	Heat/Ventilation/Air-Conditioning
ICD	Interface Control Document
IEEE	Institute of Electrical and Electronics Engineers
IPCEA	Insulated Power Cable Engineers Association
ISA	Instrument Society of America

LIST OF ABBREVIATIONS AND ACRONYMS (continued)

ISI	In-Service Inspection
LEU	Low Enriched Uranium
MCIG	Miscellaneous Control and Instrumentation Group
MSG	Mechanical Service Group
MHTGR	Modular HTGR
NE	Nuclear Energy
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NI	Nuclear Island
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
NSRE	Nonsafety Related Electrical
NSSS	Nuclear Steam Supply System
OPDS	Overall Plant Design Specification
OSRM/S	Other Safety Related Mechanical/Structural
OSRE	Other Safety Related Electrical
PAG	Protective Action Guidelines
PCG	Power Conversion Group
PCDIS	Plant Control, Data and Instrumentation System
PPIS	Plant Protection & Instrument System
PRSS	Pressure Relief Subsystem
QA	Quality Assurance
OAL	Quality Assurance Level
RCCS	Reactor Cavity Cooling System
RS	Reactor System
RSG	Reactor Service Group
SCS	Shutdown Cooling System
SDD	System Design Description
SSC	Structure, System and Component
SSDD	Subsystem Design Description
TBD	To Be Determined
TPS	Turbine Plant Systems
UBC	Uniform Building Code

LIST OF ABBREVIATIONS AND ACRONYMS (continued)

UL	Underwriters Laboratories
UNC	Unclassified
VDSS	Vessels and Duct Subsystem
VS	Vessel System
VSSS	Vessel Support Subsystem
10CFR20	Title 10 Code of Federal Regulations, Part 20
10CFR50	Title 10 Code of Federal Regulations, Part 50

## DEFINITIONS

Activity: An identifiable set of human actions undertaken to accomplish a particular task within one of the more general industry activities of Design, Construction, Operation, Maintenance, and Decommissioning.

Beginning of Life (BOL) Performance: The nominal value of performance at the beginning of NSSS life based on unfouled and unplugged steam generators, and with best estimates of the performance parameters which are subject to uncertainties.

Cold Leg: Portion of a main loop between the steam generator outlet and the core inlet.

Constructibility: TBD

Cumulative Distribution: A cumulative distribution represents the percent of life spent at or below a given point within a distribution.

Depressurized Operation: The primary coolant inventory is reduced to slightly subatmospheric (approximately -0.5 psig) pressure, e.g., for depressurized shutdown or refueling.

Design Basis: Information which identifies the specific functions to be performed by a structure, system or component of the plant, and the specific values or ranges of values chosen for controlling parameters as reference bounds for design. The values may be:

- Constraints derived from generally accepted state-of-the-art practices for achieving function, or

DEFINITIONS (continued)

- Requirements derived from analysis (based on theory and/or experiments) of postulated conditions for which a structure, system, or component must meet its functions.

Design Criterion: A basis for judging the acceptability of a particular action, procedure, or design solution.

Design Value: The nominal value of a plant or system operating parameter plus an appropriate margin.

Energy Conversion Area: That portion of the plant not included within the Nuclear Island, e.g., that portion of the plant which contains the turbine-generator set and supporting auxiliaries.

Equilibrium Plant: An Nth of a kind, mature commercial plant.

Equivalent Availability: Equivalent availability is mathematically defined as:

$$A_e = \int_0^{T_p} \frac{P_a(t)}{T_p} dt$$

where:  $P_a(t)$  = available power expressed as a percentage of design power as a function of time (t)

t = time

$T_p$  = time period (operational lifetime)

DEFINITIONS (continued)

Fabricability: TBD

Failure: Occurrence which results in a loss of capability of a component to perform its functions.

Function: A statement of what is to be achieved.

Functional Analysis: A systems engineering technique or method used to derive functions and the relationships between functions and related requirements and to develop the bases and justification for design selections supporting an overall objective. Functional Analysis is one part of the Integrated Approach.

Functional Classification: The systematic ordering and documentation of functions, requirements, and success paths associated with accomplishing the ultimate plant goal.

Functional Requirement: A bounding quantification that is derived from a functional need versus being imposed by an institutional standard or need.

Functional Tree: A diagram which displays the interrelationships of functions. The HTGR functional tree also includes Integrated Approach goals and plant states.

Goal: An endpoint or accomplishment towards which an effort is directed. The Integrated Approach has identified the following four specific goals to achieve the ultimate goal of Safe, Economical Nuclear Power:

- o Maintain Plant Operation
- o Maintain Plant Protection
- o Maintain Control of Radionuclide Release
- o Maintain Emergency Preparedness

DEFINITIONS (continued)

Group: Systems which have different requirements but collectively have a common function.

Institution: A significant practice, relationship, or organization in a society. The general industry and government regulation institutional activities are design, construction, operation, maintenance, and decommissioning.

Institutional Requirement: A bounding quantification that is imposed by an institutional standard or need versus that derived from a functional need.

Integrated Approach: A systems engineering technique for establishing and defending a well-developed nuclear plant design.

Interface Requirement: A requirement imposed by a system, subsystem, or component on another system, subsystem, or component, which must be accomplished to facilitate satisfaction of a function(s) of the imposing system, subsystem or component.

Licensed Value: The limiting value of an operating parameter to be authorized under an operating license.

Local Variation: Deviation from the system average parameters at a given location within the system.

Margin for Design Evolution: A margin based on historical trends to absorb anticipated changes as the design evolves. (The inclusion of this margin in the design can prevent costly and time consuming redesign efforts in the later design and construction phases of a project).

DEFINITIONS (continued)

Maximum/Minimum Allowable Value: The maximum quantity/value of a parameter to which the plant/system/component can be subjected for a specific condition and not exceed operating limits permitted by the applicable codes and standards.

Middle of Life (MOL) Performance: Defined as conservative values of performance with 1% of steam generator tubes plugged and with component flow resistances at their design allowable (i.e., flow resistance design evolution margin completely consumed). Best estimates of the performance parameters which are subject to uncertainties are used in the analyses.

Nominal Value: The desired quantity/value of a parameter corresponding to a given plant condition.

Nuclear Island: That portion of the plant that has within its boundary the following:

1. The standard reactor modules and safety-related buildings, structures, systems, portions of systems, and components dedicated to assuring reactor shutdown, decay heat removal, fission product retention, and security of vital areas including new (unirradiated) fuel.
2. At the designer's discretion, nonsafety-related buildings, structures, systems, portions of systems, and components that support reactor operation or investment protection.

It is intended that a standard design certification be obtained from the NRC for this portion of the plant.

DEFINITIONS (continued)

Objective: A result to be achieved.

Operating Basis Earthquake (OBE): The earthquake which could reasonably be expected to affect the plant site during the operating life of the plant and for which the normal operating systems of the power plant are designed to remain functional.

Operating Life: The calendar time from receipt of the operating license to completion of plant power production.

Operational Accessibility: TBD

Plant: All buildings, structures, systems, and components that together accomplish the process of energy production and conversion and support the human activities of administration, operation, and maintenance.

Plant Life: The calendar time from construction permit issuance to completion of plant power production.

Parameter: A specific measurable and quantifiable aspect of a physical item.

Plant State: Implies the sum of the quantities involved at a particular time and place associated with a plant goal. The four plant states associated with the Integrated Approach are defined as follows:

State 1, Maintain Safe Energy Production: Plant operation delivering electricity to the grid with nominal feedwater flow in the range of 25% to 100% of rated.

DEFINITIONS (continued)

State 2, Maintain Safe Shutdown: Reactor shutdown (0% rated power); shutdown reactivity margin (-0.01 K) is met and maintained; decay heat removed and rejected.

State 3, Maintain Safe Refueling: Reactor shutdown (0% rated power); shutdown reactivity margin (-0.01 K) is met and maintained; decay heat removed and rejected. The primary coolant pressure is at or slightly subatmospheric and refueling equipment is in service or being installed or is being removed.

State 4, Maintain Safe Startup/Shutdown: Plant operation in an intermediate power range between shutdown and energy production prior to electricity production. The power range corresponds to conditions with nominal feedwater flow of 0% to 25% rated.

Pressurized Operation: The primary coolant inventory (mass of helium) is held constant, equal to its rated-power value.

Primary Coolant: The total helium inventory with its impurities contained within the primary coolant pressure boundary is called primary coolant. Some of the primary coolant continuously flows to the Helium Purification System for purification and to the Moisture Monitor and Analytical Instrumentation Systems. The helium ceases to be primary coolant as soon as it leaves the primary coolant pressure boundary.

Primary Coolant Pressure Boundary: The vessel system is the primary coolant pressure boundary and includes:

- 1) all steel vessels and the crossduct
- 2) all primary closures

DEFINITIONS (continued)

- 3) system piping that penetrates the vessel system, such as steam generator and auxiliary heat exchanger tubes, tubesheets, and piping
- 4) the Pressure Relief Subsystem, up to and including the pressure relief valves.

Principal Design Criteria: Criteria which establishes the necessary design, fabrication, construction, testing, and performance requirements for structures, systems, and components that provide reasonable assurance that the facility can be operated without undue risk to the health and safety of the public.

Rated Value: The nominal value of a parameter at 100% plant energy conditions.

Requirement: The bounding quantification (limits) of a function. [It must describe the boundary of the function, not an internal part.]

Safe Shutdown Earthquake (SSE): The earthquake for which those structures, systems and components are designed to ensure:

1. The integrity of the reactor coolant pressure boundary
2. The capability to shutdown the reactor and maintain it in a safe shutdown condition.
3. Offsite doses remain below 10CFR100 limits.

Safety-Related: Identifier on functions performed for compliance with dose limits of 10CFR100. Safety-related equipment perform the above functions.

Secondary Coolant: The treated condensate delivered from the hot well is called secondary coolant. The secondary coolant (or feedwater) is fed continuously to the steam generator after being heated through the feedwater heaters.

DEFINITIONS (continued)

Service Life: The length of time for which a system, a subsystem, or component shall be designed to perform and meet its requirements. Within this period of time, parts can be repaired or replaced so long as the system, subsystem, or component's availability and other performance requirements are met.

Standard Reactor Module: The portion of the Nuclear Island which is duplicated for each reactor.

Subfunction: One of a group of functions at the next lower level that supports the preceding function.

System: A collection of electrical, mechanical, and/or structural components and associated software and human actions treated as a unit for technical, administrative, or contractual purposes.

Unavailability: (Outage hours/yr) This includes both full outage hours and equivalent partial outage hours.

PREFACE

The objective of the HTGR plant project is to produce safe, economical power. Supporting this objective, four major goals and their associated plant states are identified as follows:

1. Maintain Safe Plant Operation
  - 1.1 Maintain Safe Energy Production
  - 1.2 Maintain Safe Plant Shutdown
  - 1.3 Maintain Safe Plant Refueling
  - 1.4 Maintain Safe Startup/Shutdown
  
2. Maintain Plant Protection (in the event that plant operation cannot be maintained in the normal operating envelope)
  - 2.1 Protect the capability to maintain safe energy production
  - 2.2 Protect the capability to maintain safe plant shutdown
  - 2.3 Protect the capability to maintain safe plant refueling
  - 2.4 Protect the capability to maintain safe plant startup/shutdown
  
3. Maintain Control of Radionuclide Release (in the low probability event of failure to maintain plant protection)
  - 3.1 Control radiation
  - 3.2 Control personnel access
  
4. Maintain Emergency Preparedness (in the extremely low probability of failure to maintain control of release of radionuclides)

The OPDS is the top-level technical document for the HTGR plant. The OPDS (based on owner requirements and regulatory requirements) establishes the overall performance, functional, institutional, operational, safety, maintenance, inspection and decommissioning requirements for design of the plant.

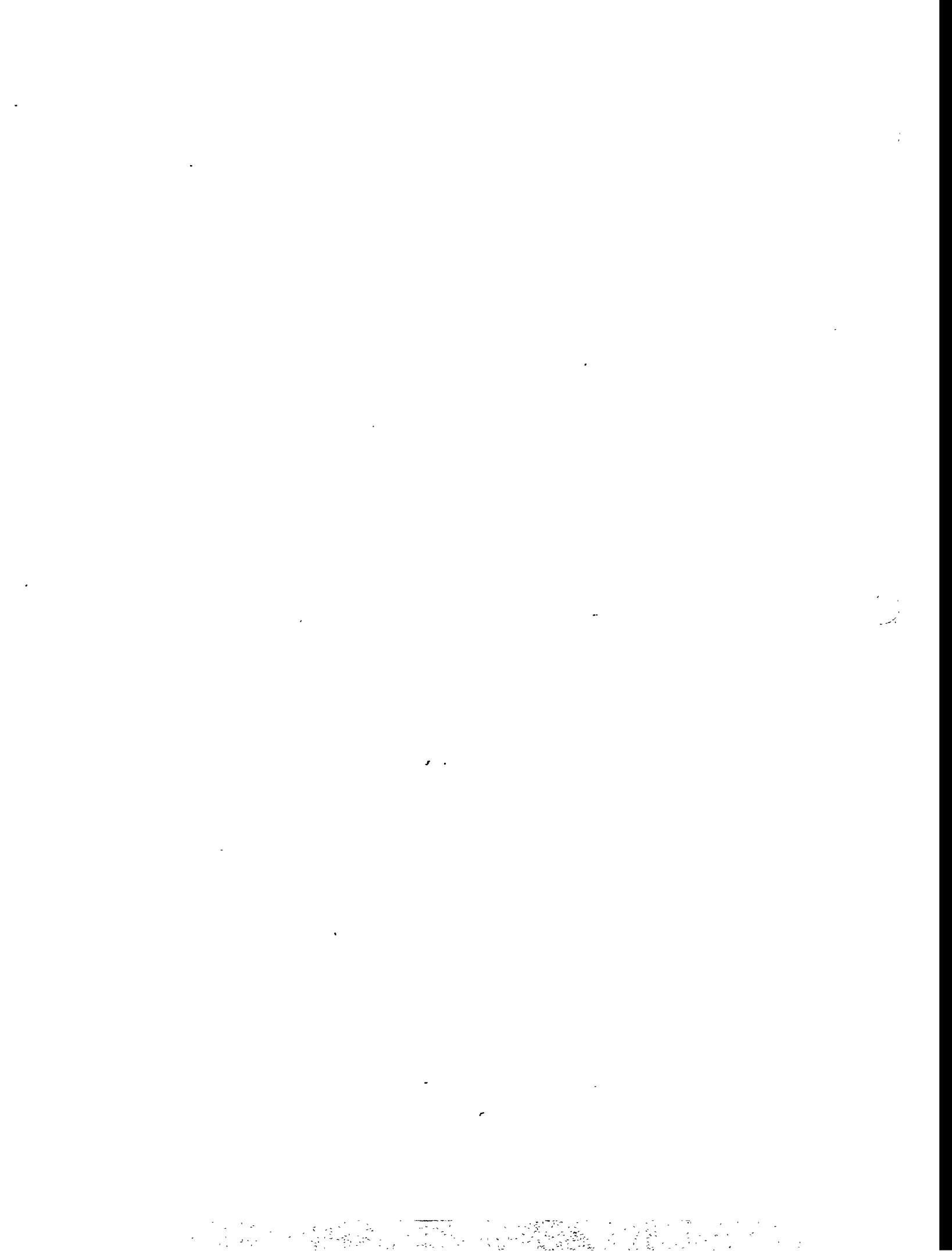
In response to the OPDS, SDDs and SSDDs are prepared which describe and control the individual system and subsystem designs. Traceability from plant-level requirements to equipment-level requirements is maintained throughout this hierarchy of design documents.

SUMMARY

The primary function of the Pressure Relief Subsystem, a subsystem of the Vessel System, is to provide overpressure protection to the Vessel System. When the overpressure setpoint is reached, pressure is reduced by permitting the flow of primary coolant out of the Vessel System. This subsystem also provides the flow path by which purified helium is returned to the vessel system, either as circulating purge/flow from the Helium Purification Subsystem or make-up helium from the Helium Storage and Transfer Subsystem.

The design of the Pressure Relief Subsystem requires two identical pressure relief trains interlocked so that at least one is available at all times. Both trains are connected to the steam generator vessel upper head at the main circulator discharge where the primary coolant pressure is nominally the highest. Each train contains a pilot-actuated spring-loaded safety relief valve in series with a burst disk, both of which must be activated to achieve pressure relief. To provide relief valve isolation for maintenance or reseating of the relief valve, a block valve is placed between the steam generator vessel and the relief valve in each PRSS train. The block valves are electronically interlocked to assure that both block valves cannot be in the closed position at the same time. The piping from the Helium Purification Subsystem and the Helium Storage and Transfer Subsystem connect to the piping between the block valve and the relief valve.

The design life of the Pressure Relief Subsystem is 40 years with a goal for unscheduled downtime of (TBD) hours per year. Maintenance includes relief valve testing during scheduled maintenance periods, as well as instrumentation testing and calibration.



## SECTION 1

## SUBSYSTEM FUNCTIONS AND DESIGN REQUIREMENTS

1.1. SUBSYSTEM FUNCTIONS

The Pressure Relief Subsystem (PRSS), a subsystem of the Vessel System (VS), provides overpressure protection to maintain vessel integrity by limiting the maximum primary coolant pressure for all states of the Integrated Approach, Goal 1, Maintain Safe Energy Production; Goal 2, Maintain Plant Protection; and Goal 3, Maintain Control of Radionuclide Release. Auxiliary functions of this subsystem are to limit the quantity of pressure relief flow leaving the VS, to accommodate the return of purified helium to the VS via a purge flow, and to provide a flow path for filling the VS subsequent to refueling or for adding make-up helium during normal operations.

## 1.2 SUBSYSTEM DESIGN REQUIREMENTS

1.2.1 Subsystem Configuration and Essential Features Requirements

The Pressure Relief Subsystem shall provide two independent relief trains, each sized to permit 100% relieving capacity of 11.3 kg/s (25 lbm/s) of the vessel system. (115.0102.001)

Pressure relief trains shall be connected to the steam generator vessel at the circulator outlet region. (115.0102.002)

The pressure relief trains shall be located in the top head of the steam generator vessel as far apart as practicable to provide physical separation. (115.0102.003)

The PRSS shall be capable of transporting helium from the Helium Purification Subsystem and the Helium Storage and Transfer Subsystem to the steam generator vessel. (115.0102.004)

The block valves shall be placed upstream in series with the relief valves to permit isolation of a relief valve for maintenance and/or testing and for limiting system blowdown should a relief valve fail to reseal. (115.0102.005)

A rupture disk shall be provided downstream of the relief valve to protect against sporadic discharges of radioactive helium to the atmosphere.

(115.0102.006)

The return purge helium from the Helium Purification Subsystem shall connect to the Heat Transport System through the Pressure Relief Subsystem.

(115.0102.007)

The helium to fill the Vessel System from the Helium Storage and Transfer Subsystem shall connect through the Pressure Relief Subsystem piping.

(115.0102.008)

The Pressure Relief Subsystem shall connect to the Gaseous Radioactive Waste Subsystem to handle relief valve leakage.

(115.0102.009)

The Pressure Relief Subsystem shall discharge to the Reactor Building.

(115.0102.010)

The Pressure Relief Subsystem shall be designed to meet the principal design criteria provided in Appendix C of the OPDS.

(115.0102.011)

Equipment arrangement and features shall facilitate the subsystem's ISI requirements, installation, removal, and reinstallations.

(115.0102.012)

The Pressure Relief Subsystem arrangement shall allow installation, removal, ISI, and on-line and in-situ maintenance of the main circulator and the steam generator.

(115.0102.013)

## 1.2.2 Operational Requirements

The Pressure Relief Subsystem shall be designed for an operating life of 40 years from the start of operation. (115.0102.014)

PRSS contributions to leakage of the primary coolant shall be minimized such that the total leakage from the vessel system does not exceed 10% per year. (115.0102.015)

The Pressure Relief Subsystem shall be insulated to limit heat losses from the primary coolant to less than (TBD MW) (TBD Btu/h) at rated power. (115.0102.016)

The Pressure Relief Subsystem shall be designed to perform through transients from the design duty cycle events listed in Table 1-1. (115.0102.017)

The Pressure Relief Subsystem shall protect against spurious valve discharge. (115.0102.018)

## 1.2.3 Structural Requirements

### 1.2.3.1 Mechanical

The Pressure Relief Subsystem shall be designed to support a Vessel System design pressure of 7.177 MPa absolute (1041 psia). (115.0102.019)

The Pressure Relief Subsystem shall be designed to withstand the cyclic loads resulting from the transients caused by the duty cycle events listed on Table 1-1, and mechanical loads (including reactionary loads resulting from bursting of the rupture disk) anticipated over the life of the plant. (115.0102.020)

### 1.2.3.2 Seismic

Equipment and components classified as Seismic Category I shall be designed to remain functional during a Safe Shutdown Earthquake (SSE). (115.0102.021)

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TABLE 1-1  
DESIGN DUTY CYCLE EVENTS

(Reference 1.2)

Event	Design No. of Occurrences (per Reactor Module)	Level of Service Limits
1. Startup from Refueling Conditions	143	A
2. Startup with Full Helium Inventory	312	A
3. Shutdown to Refueling Conditions	101	A
4. Shutdown with Full Helium Inventory	105	A
5. Rapid Load Increase (5% per min.) (25%-100%)	1000	A
6. Normal Load Increase (0.5% per min.) (25%-100%)	20800	A
7. Rapid Load Decrease (5% per min.) (100%-25%)	1000	A
8. Normal Load Decrease (0.5% per min.) (100%-25%)	17500	A
9. Step Load Increase (+15%)	1000	A
10. Step Load Decrease (-15%)	1000	A
11. Depressurized Decay Heat Removal, HTS to SCS Transition	80	A
12. Depressurized Decay Heat Removal, SCS to HTS Transition	122	A
13. Pressurized Decay Heat Removal, HTS to SCS Transition	61	A
14. Pressurized Decay Heat Removal, SCS to HTS Transition	86	A
15. Circulator Trip	30	B
16a. Reactor Trip from 100%	180(a)	B
16b. Reactor Trip from 25%		
17. Turbine Trip or Load Rejection	120	B
18. Sudden Reduction of FW Flow	30	B
19. Steam Generator Tube Leak (Small)	9	B
20. Control Rod Insertion	5	B

(Reference 1.2)

TABLE 1-1 (Continued)

Event	Design No. of Occurrences (per Reactor Module)	Level of Service Limits
21. Main Loop Overcooling	10	B
22. Operating Basis Earthquake (OBE)	1	B
23. Slow Primary System Depressurization	8	B
24a. Rod Withdrawal (normal rod speed) (P/F Trip)	1	C
24b. Rod Withdrawal (slow) (SGIT Trip)	1	C
25. Failure of Circulator Speed Control	1	C
26. Circulator Trip with He Shutoff Valve Failure	1	C
27. Steam Generator Tube Rupture	1	C
28. SCS Heat Exchanger Tube Leak	1	C
29. Total Loss of FW Flow	4	C
30a. Total Loss of SCS Cooling Water (HTS operating)	4	C
30b. Total Loss of SCS Cooling Water (SCS operating)	1	C
31. HTS Trip and Failure of SCS to Start (SRDC No. 1)	1	C
32. Loss of HTS Without Control Rod Insertion or SCS Operation (ATWS) (SRDC No. 2)	1	D(b)
33. Control Rod Withdrawal Followed by P/F Trip and RCCS Cooling (SRDC No. 3, 4)	1	D(b)
34. Large Earthquake Followed by RCCS Cooling [Safe Shutdown Earthquake (SSE)] (SRDC No. 5)	1	D(b)
35. Steam Generator Tube Rupture Without Isolation (SRDC No. 6A)	1	D(b)
36. Steam Generator Tube Rupture Without Isolation, Followed by RCCS Cooling (SRDC No. 6B)	1	D(b)
37. Steam Generator Tube Leaks Without Isolation, Followed by RCCS Cooling (SRDC No. 7)	1	D(b)

TABLE 1-1 (Continued)

(Reference 1.2)

Event	Design No. of Occurrences (per Reactor Module)	Level of Service Limits
38. Small Steam Generator Tube Leak Without Isolation, Followed by RCCS Cooling (SRDC No. 8)	1	D(b)
39. Small Steam Generator Tube Leak With Unterminated Dump Followed by RCCS Cooling (SRDC No. 9)	1	D(b)
40. Rapid Depressurization Followed by RCCS Cooling (SRDC No. 10)	1	D
41. Slow Primary System Depressurization With Loss of Forced Circulation (SRDC No. 11)	1	D(b)
42. Main Steam Pipe Rupture	1	D

(a) For components where reactor trip from 100% load is worse the breakdown should be 131 trips from 100% and 49 trips from 25%. For components where reactor trip from 25% load is worse, the breakdown should be 63 trips from 100% and 117 trips from 25%.

(b) In general, Level D Service Limits are assigned to SRDCs for specified safety functions of safety related SSCs. However, Level D limits are intended primarily for guidance. The plant level requirement is that 10CFR100 dose requirements not be exceeded. Event No. 31 (SRDC No. 1) and 40 (SRDC No. 10) are exceptions to this. Their minimum Service Limit Levels are C and D, respectively.

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Seismic loads shall be based on response spectra given in Figures 1-1 through 1-6. (115.0102.022)

1.2.3.3 Material

Materials shall be selected to minimize the production of radioactive materials due to activation and the generation of product of corrosion. (115.0102.023)

1.2.4 Environmental Requirements

Portions of the Pressure Relief Subsystem exposed to the reactor confinement building shall be designed for conditions shown in Table 1-2. (115.0102.024)

The Pressure Relief Subsystem components which are exposed to the primary coolant shall be designed for chemical impurities in accordance with Table 1-3. (115.0102.025)

1.2.5 Instrumentation and Control Requirements

An electrical interlock shall prevent the simultaneous closure of both pressure relief trains to ensure that at least one relief line is always available to protect the primary coolant pressure boundary. (115.0102.026)

Signals from pressure relief block valves shall be provided to indicate when either valve is not in full open position. This signal acts as an input to the vessel pressure relief block valve closure interlock. Two redundant and electrically separated limit switches from each pressure relief valve shall be provided. (115.0102.027)

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Figure 1-1 Design Acceleration Spectra for the OBE with Maximum  
Acceleration of 0.15 g (Ground); X Direction

(LATER)

Figure 1-2 Design Acceleration Spectra for OBE with Maximum Acceleration of 0.15 g (Ground); Y Direction

(LATER)

Figure 1-3 Design Acceleration Spectra for OBE with Maximum Acceleration of 0.15 g (Ground); Z Direction

(LATER)

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Figure 1-4 Design Acceleration Spectra for OBE with Maximum  
Acceleration of 0.30 g (Ground); X Direction

(LATER)

908476/c

Figure 1-5 Design Acceleration Spectra for OBE with Maximum  
Acceleration of 0.30 g (Ground); Y Direction

(LATER)

Figure 1-6 Design Acceleration Spectra for OBE with Maximum Acceleration of 0.30 g (Ground); Z Direction

(LATER)

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TABLE 1-2

REACTOR CONFINEMENT BUILDING ENVIRONMENTAL CONDITIONS

[TRD]

**PRIMARY COOLANT ENVIRONMENT CHEMICAL IMPURITIES \***

Chemical Impurities	Design Conditions At Rated Power	Maximum Allowable Value	
		Below 538°C (1000°F)	Above 538°C (1000°F)
Oxygen	Traces	[TBD]	Traces
Water	0.5 ppav (a)	[TBD]	600 ppav days/yr (c)
Carbon monoxide + carbon dioxide	3 ppav	1% vol (b)	2100 ppav days/yr (d)
Hydrogen	3 ppav	1% vol	100 ppav
Methane	0.1 ppav	1% vol	10 ppav
Nitrogen	2 ppav	N/A	100 ppav
Hydrogen sulfide	[TBD]	N/A	10 <sup>-11</sup> ata

(a) ppav signifies parts per million in volume.  
 (b) This limit applies only to carbon monoxide.  
 (c) 600 ppav days/yr are equivalent to 2 ppav of H<sub>2</sub>O continuously for 300 days.  
 (d) 2100 ppav days/yr are equivalent to 7 ppav of CO + CO<sub>2</sub> continuously for 300 days.

\* Values subject to change.

The capability shall be provided of accepting a signal from the vessel pressure relief block valve closure interlock to the block valve motor current relay/contractor to prevent the closure of one block valve if the other block valve is not fully open. Redundant relay contacts for each pressure relief valve control circuit shall be provided. (115.0102.028)

Signals shall be provided from each vessel pressure relief valve to the PPIS if the relief is not fully closed. Two redundant signals per valve shall be provided. (115.0102.029)

Provisions shall be made for monitoring the Pressure Relief Subsystem status and performance as a basis for maintenance diagnostics and decision making. (115.0102.030)

1.2.6 Surveillance and In-Service Inspection Requirements

Where possible, the design of the PRSS shall be such that on-line in-service inspection requirements are minimized. (115.0102.031)

For those inspection activities that require the unit or major component be removed from service, design features shall be included to accomplish the inspection as one of those activities to be completed during the allotted plant planned downtime. (115.0102.032)

Access shall be provided to the PRSS pressure boundary to facilitate in-service inspections required by Section XI of the ASME Code. (115.0102.033)

1.2.7 Availability Assurance Requirements

The Pressure Relief Subsystem shall be designed to meet its overall reliability and unscheduled unavailability allocations given in Appendix F of the OPDS. (115.0102.034)

The Pressure Relief Subsystem shall be designed to meet its planned outage allocation given in Appendix F of the OPDS. (115.0102.035)

Design modifications and improvements to achieve the above availability requirements shall be considered for incorporation into the design, if a one percentage increase in the total capital investment produces, at a minimum, a seven tenths percentage improvement in the equivalent availability factor. (115.0102.036)

### 1.2.8 Maintenance Requirements

Where possible, the design of the Pressure Relief Subsystem shall be such that on-line maintenance requirements are minimized. (115.0102.037)

Remote maintenance techniques shall be considered in the design where improved availability may result from time savings. (115.0102.038)

The Pressure Relief Subsystem and its components shall be designed to facilitate hands-on maintenance. (115.0102.039)

The use of standard "off-the-shelf" components and materials shall be used, where possible, to reduce costs associated with required spare parts. Components shall be classified to reduce the number of different types, sizes, and temperature and pressure ratings. (115.0102.040)

Components within the PRSS shall be capable of being tested and if necessary, calibrated during regularly scheduled maintenance operations. (115.0102.041)

A spare parts listing and recommended spare parts inventory shall be developed consistent with the Preventative Maintenance Plan, anticipated unscheduled maintenance, and plant availability requirements. (115.0102.042)

The design of mechanical and electrical systems, components and parts shall provided for reasonable and necessary interchangeability. (115.0102.043)

#### 1.2.9 Safety Requirements

The Pressure Relief Subsystem penetrations, closures, and piping shall be designed to limit the maximum free flow area where failures are postulated to be within the Design Basis Depressurization Accident (DBDA) value of (TBD) m<sup>2</sup> (TBD in. <sup>2</sup>). (115.0102.044)

The Pressure Relief Subsystem shall be Safety Class 1, Seismic Category I, and Quality Assurance Level I. (115.0102.045)

#### 1.2.10 Codes and Standards Requirements

##### 1.2.10.1 Regulatory Requirements

The design of the Pressure Relief Subsystem shall comply with requirements of the Regulatory Guides listed on Table 1-4. (115.0102.046)

##### 1.2.10.2 Industry Codes and Standards

The PRSS design shall meet the industry codes and standards for design and Construction of the PRSS and its components as listed in Table 1-5. (115.0102.047)

##### 1.2.11 Quality Assurance Requirements

All items designated safety-related, seismic category I, and/or electrical class 1E shall come under a quality assurance program which fully complies with the requirements of Title 10 Code of Federal Regulations Part 50 (10CFR50), Appendix B. The basic requirements and supplements of ANSI/ASME

Table 1-4

REGULATORY REQUIREMENTS

- 1) REG. GUIDE 1.60, Design Response Spectra for Seismic Design of Nuclear Power Plants
- 2) REG. GUIDE 1.61, Damping Values for Seismic Design of Nuclear Power Plants
- 3) REG. GUIDE 1.92, Combining Modal Responses and Spatial Components in Seismic Response Analysis
- 4) REG. GUIDE 1.99, Effects of Residual Elements on Predicted Radiation Damage to Reactor Vessel Materials
- 5) REG. GUIDE 1.29, Seismic Design Classification
- 6) REG. GUIDE 1.89, Rev. 01, Environmental Qualification of Certain Electrical Equipment Important to Safety for Nuclear Power Plants

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TABLE 1-5

INDUSTRIAL CODES AND STANDARDS APPLICABLE TO THE  
PRESSURE RELIEF SUBSYSTEM

- A. ASME Boiler and Pressure Vessel Code, American Society of Mechanical Engineers
- 1) Section II, Material Specifications
  - 2) Section III, Nuclear Power Plant Components
  - 3) Section IX, Welding and Brazing Qualifications
  - 4) Section XI, Rules for Inservice Inspection of Nuclear Power Plant Components
- B. ANSI Standards, American National Standards Institute
- 1) ANSI/ASME-NQA-1, Quality Assurance Program Requirements for Nuclear Power Plants.
  - 2) ANSI/ASME B31.1, Power Piping for Nuclear Facilities.
  - 3) ANSI/ASME NQA-2, Quality Assurance Program Requirements for Nuclear Power Plants.
  - 4) ANSI-Y14.5M, Dimensioning and Tolerancing.
  - 5) ANSI B36.10-1979, Welded and Seamless Wrought Steel Pipe.
  - 6) ANSI B16.5-1981, Steel Pipe Flanges and Flanged Fittings.
  - 7) ANSI B18.2.1-1981, Square and Hex Bolts and Screws, Including Askew Head Bolts, Hex Cap Screws and Lag Screws.
  - 8) ANSI B1.1-1982, Unified Inch Screw Threads (UN and UNR Thread Form).
- C. ANS Standards, American Nuclear Society
- 1) ANS-18-20, Nuclear Plant Reliability Data Collection and Reporting System.
  - 2) ANS-58-4, Criteria for Technical Specifications for Nuclear Power Stations.
- D. IEEE Standards, Institute of Electrical and Electronic Engineers
- (TBD)

- E. ISA Standards, Instrument Society of America  
(TBD)
- F. NEMA Standards, National Electrical Manufacturers Association  
(TBD)
- G. ASTM Standards, American Society for Testing and Materials  
(TBD)

NQA-1 and the four additional supplements from NE F2-10 regarding engineering holds, engineering drawing lists, design reviews, and management assessment shall be implemented on activities that affect the quality of such items. These items are designated as quality assurance level (QAL) I.

(115.0102.048)

Items designated nonsafety-related, seismic category Non CAT I, or electrical class Non 1E are QAL II or QAL III. QAL II items shall come under a quality assurance program which complies with selected basic requirements and supplements of NQA-1 and four additional supplements identified above. QAL III items shall come under a quality assurance program which complies with selected basic requirements of NQA-1 and the our additional supplements identified above.

(115.0102.049)

#### 1.2.12 Construction Requirements

The Pressure Relief Subsystem design shall incorporate features to facilitate manufacture and installation.

(115.0102.050)

A construction plan and schedule shall be developed by the end of preliminary design. The use of models should be considered to facilitate assessments of constructability, particularly in congested areas.

(115.0102.051)

The design of the Pressure Relief Subsystem shall be based upon parallel construction of the complete plant; however, features shall be included that facilitate construction and startup in increments of two standard reactor modules and one turbine.

(115.0102.052)

Shop, factory, or field fabricated, assembled and erected components and subsystems shall be utilized as appropriate to reduce erection costs and to enhance quality control.

(115.0102.053)

Materials, processes and parts for civil, structural, mechanical, electrical, and instrumentation systems and their components shall be incorporated as required to meet all transportation, handling, storage, construction and operational functions.

(115.0102.054)

Appropriate specifications and design categories shall be identified to meet safety and economic goals identified for the plant design. Maximum use shall be made for commercial practice typified by fossil-fired facilities.

(115.0102.055)

1.2.13 Decommissioning Requirements

Until more specific criteria and/or rules are developed, NUREG-0586, "Draft Generic Environmental Statement on Decommissioning of Nuclear Facilities," January, 1981 shall be used as guidance.

(115.0102.056)

An analysis shall be performed of the cost of decontaminating and dismantling the subsystem.

(115.0102.057)

## SECTION 2

### SUBSYSTEM DESIGN DESCRIPTION

#### 2.1 SUMMARY DESCRIPTION

The Pressure Relief Subsystem (PRSS) prevents the Vessel and Duct Subsystem (VDSS) from exceeding its design pressure, hence providing overpressure protection for the primary coolant pressure boundary. The design of the Pressure Relief Subsystem employs two identical pressure relief trains interlocked so that at least one is available at all times. Both trains are connected to the steam generator vessel upper head at the main circulator discharge where the primary coolant pressure is nominally the highest. Each train contains a pilot-actuated spring-loaded safety relief valve in series with a rupture disk, both of which must be activated in order to achieve pressure relief. To provide relief valve isolation for maintenance and/or testing, a block valve is placed between the steam generator vessel and the relief valve. The piping from the Helium Purification Subsystem (HPS) and the Helium Storage and Transfer Subsystem (HSTS) connect to the piping between the block valve and the relief valve. Piping to the Gas Waste System connects to the piping between the block valve and rupture disk.

#### 2.2 SUBSYSTEM CONFIGURATION

##### 2.2.1 Configuration and Essential Features

The PRSS consists of two identical relief trains, each capable of 100% relieving capacity.

Each of the relief train piping assemblies consists of a block valve, a relief valve and a rupture disk in series and associated piping, control valves and

instrumentation. The Pressure Relief Subsystem, which is connected to the VDSS through a 0.10 m (4 in) penetration, is shown schematically Figure 2-1. These assemblies originate at the top head of the SGV. The penetrations for each train in the top head of the SGV are widely separated, located 180° apart.

The PRSS interfaces with the Helium Purification Subsystem and the Helium Storage and Transfer Subsystem through a pipeline located between the block valve and the relief valve. The interfacing boundary is defined by a check valve (see Fig. 2-1) which prevents back-flow to these subsystems from the PRSS as the pressure approaches the relief valve set pressure. An interface occurs with Gaseous Radioactive Waste Subsystem at a piping junction between the relief valve and rupture disk.

VDSS pressure relief flow can only be released to Reactor Building if the relief valve and the rupture disk have both been opened in a single relief valve train as a result of excessive primary coolant pressure.

#### 2.2.1.1 Block Valve

The block valve is a remote motor-driven, operator-actuated 0.10 m (4 in) valve capable of isolating a pressure relief train from the VDSS:

- a. In the event of excessive relief valve leakage,
- b. To permit in-place testing of a relief valve,
- c. To permit maintenance of relief train components during plant shutdown, and

In addition, if a relief valve should fail to reseal, primary coolant depressurization can be limited by closing the block valve. The block valves of both trains are fully open at all times during normal plant operation or operations at excess VDSS pressures.

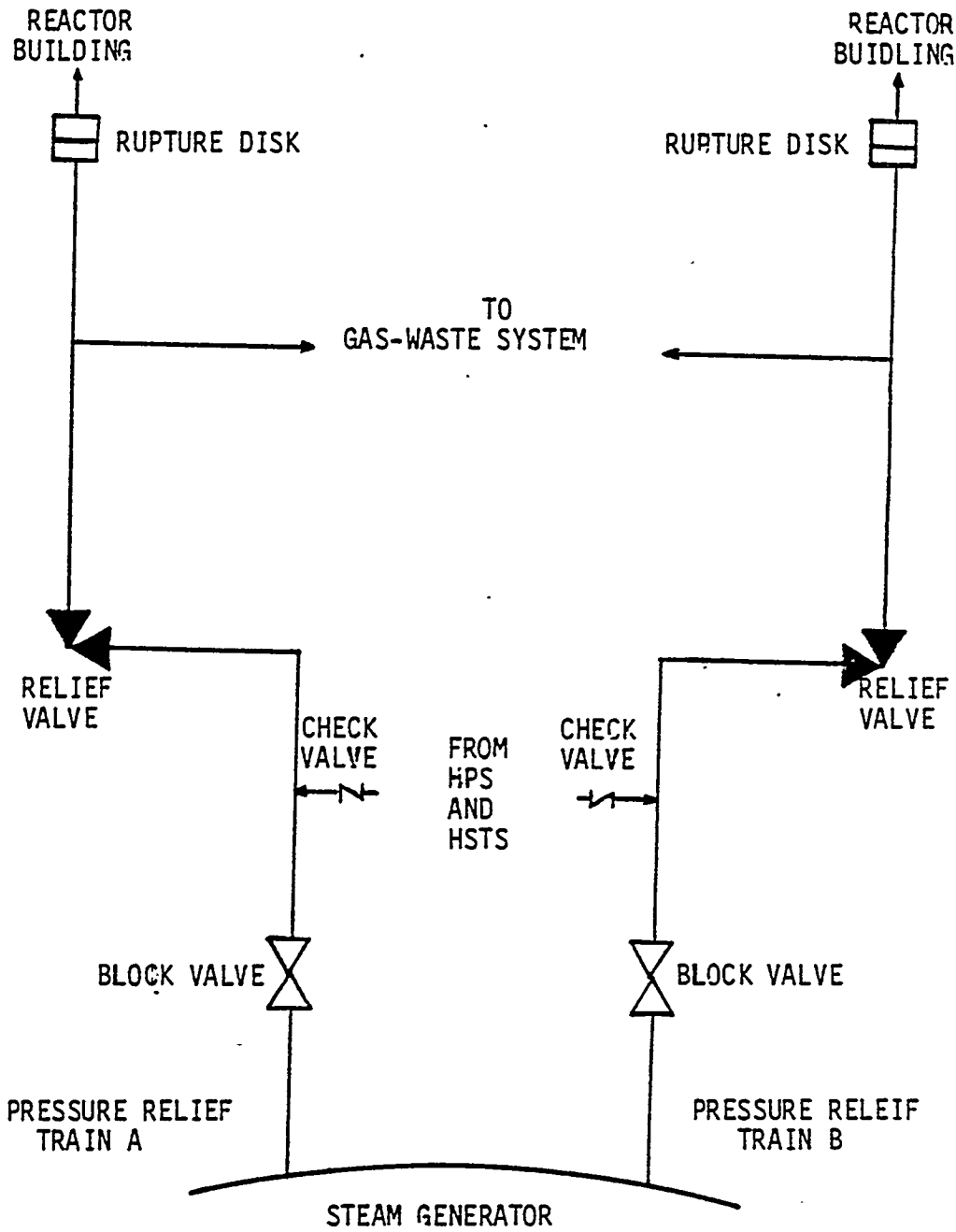


FIGURE 2-1  
PRESSURE RELIEF SUBSYSTEM - SCHEMATIC

As indicated in Figure 2-1, the block valve is the first component in each of the piping assemblies of the PRSS. Purified helium purge flow from the Helium Purification Subsystem enters the VDSS through the PRSS pipe between the block valve and the relief valve. Purified helium from the Helium Storage and Transfer Subsystem (HSTS), used for increasing the primary coolant pressure (i.e., from refueling or other operating conditions) is also introduced at this point. During maintenance of the PRSS the pure helium from the HSTS can be used to purge the subsystem.

2.2.1.2 Pressure Relief Valve

During normal plant operation this valve is closed; it is automatically opened for pressure relief of the VDSS when its preset pressure is reached and remains open until its reduced reseating pressure is attained.

The spring-loaded, pilot-actuated safety relief valve, is automatically opened by the primary helium pressure. The pilot valve section and the main valve section are directly coupled to provide a utilized, self-actuated relief/safety valve. The pilot valve section is the pressure sensing and control element, and the main valve is a hydraulically activated follower valve which provides the pressure relief function. Self-actuation of the pilot valve at the valve set pressure vents the piston chamber over the main valve stem and results in a system blowdown at full rated flow with essentially no pressure accumulation. The valve can be manually operated by a remote, helium-actuated pilot valve; e.g., for valve testing and calibration. Procedures are established to assure the valve cannot be opened manually during operation of the plant; e.g., by removal of the pilot valve pressure source in the Reactor Building or by using a key lock switch if the pilot valve is operated remotely from the control room.

2.2.1.3 Rupture Disk

During normal plant operation there is negligible pressure on the sealed disk. When activated by primary coolant overpressures, the disk ruptures (after opening of the relief valve) and primary coolant gases are discharged directly into the upper portion of the Reactor Building.

An expansion bellows is included on the downstream side of the rupture disk to accommodate movement in the piping assembly due to thermal expansion or vibrational disturbances.

### 2.3 SUBSYSTEM PERFORMANCE CHARACTERISTICS

#### 2.3.1 Subsystem Operating Modes

The PRSS is operable at all times. It is primarily a passive system during normal plant operation, but will automatically become active during abnormal operation if the VS pressure increases above the safety relief valve setpoint. The design insures that the primary pressure does not exceed 110% of the Vessel System design pressure during active operation. The valve reseats when the primary pressure reduces to 85% of the setpoint. A redundant (second) relief train provides increased reliability to ensure that the Vessel System will not be subjected to pressures exceeding the maximum vessel pressure.

#### 2.3.2 Subsystem Steady-State Performance

The PRSS is passive during plant steady state performance. However, it is continuously providing overpressure protection to the Vessel System. The PRSS remains passive until the Vessel System pressure exceeds the relief valve set pressure of 7.17 MPa (1041 psi) ±1% absolute.

#### 2.3.3 Subsystem Response to Plant Transients

A review of the available pressure transients associated with the duty cycle events indicates that the PRSS will be active only during two of the duty cycle events which involve steam generator tube rupture without isolation, events 36 and 37. These events are the same as licensing basis events which are described in Section 6.8.

#### 2.3.4 Subsystem Failure Modes and Effects

Subsystem failures arise from subsystem component failure and/or operator error. The PRSS is designed such that chance for operator error is nil. The

only component within the PRSS that can be activated from the control room during plant operation is the block valves. However, an electrical interlock system between the block valve in each pressure relief train prevents both block valves from being closed at the same time. Normally both block valves are open, and would only be closed during subsystem maintenance, calibration, or to limit pressure blowdown to reseal a stuck open relief valve. Since the PRSS is basically a passive system during normal plant operation and the valve interlock eliminates the chance for operator error, subsystem failure modes and effects will be limited to component failures within the subsystem.

Table 2-1 provides a listing of possible hardware failures, the effects of these failures on radionuclide control, of this or other systems, and the measures necessary to restore the function of the PRSS. Note that in each failure mode, there is not immediate risk to safety. However, each failure requires an actual reactor shutdown so that repairs can be made to the pertinent hardware.

#### 2.4 SUBSYSTEM ARRANGEMENT

(TBD)

#### 2.5 INSTRUMENTATION AND CONTROL

Instrumentation and control features of the pressure relief subsystem components, shown in P&I (TBD), are described below.

Block Valve. During normal plant operation, the block valves of both trains are fully open at all times. Control and Instrumentation (C&I) system interlocks and control room alarms are provided to assure that at least one valve is fully open at all times. Each valve has a position indicator and a position limit switch which actuates an alarm when a valve is closed. A hand switch permits the motor-driven valve to be actuated remotely. Control logic is such that the valve fails-as-is (FAI) with loss of power.

Table 2-1  
 FAILURE MODES AND EFFECTS FOR THE PRESSURE RELIEF SUBSYSTEM

FAILURE MODE	EFFECT	RECOVERY PROCEDURE
Relief Valve Failure to reseal	Additional loss of primary coolant beyond that released during overpressurization event.	Close block valve in train to isolate stuck open relief valve. The other train will then be utilized for pressure relief. The reactor will be shutdown and repairs made.
Inability to close open relief train	Depressurization of vessel system occurs	The reactor is shutdown and applicable component repairs are performed.
Relief valve failure to open	None	Redundant relief train sized for 100% capacity will provide pressure relief. Reactor will be shutdown and repairs made.
Rupture in piping connected to relief train (i.e., interfacing subsystem)	None	Check valve will automatically close to prevent depressurization. Block valves provide redundant means of preventing depressurization. Reactor will be shutdown and repairs made.
Excessive relief valve leakage	Primary coolant vented to Gaseous Radioactive Waste Subsystem	If excessive leakage in an amount (TBD) occurs, the reactor is shutdown and the relief valve is repaired.

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Pressure Relief Valve. The pressure relief (or safety) valve is actuated at 7.17 MPa (1041 psi)  $\pm 1\%$  absolute by the direct pressure of the primary coolant acting against a pilot valve spring. It can be remotely operated with (e.g., bottled) helium acting on the pilot valve (for testing or calibration), but procedures are established to assure the valve cannot be opened manually during operation of the plant. Signals from the pressure relief valve will be provided in the control room to indicate when the valve is open. These signals can be provided by a position limit switch located on the valve, or a flow meter or pressure indicator located downstream of the valve.

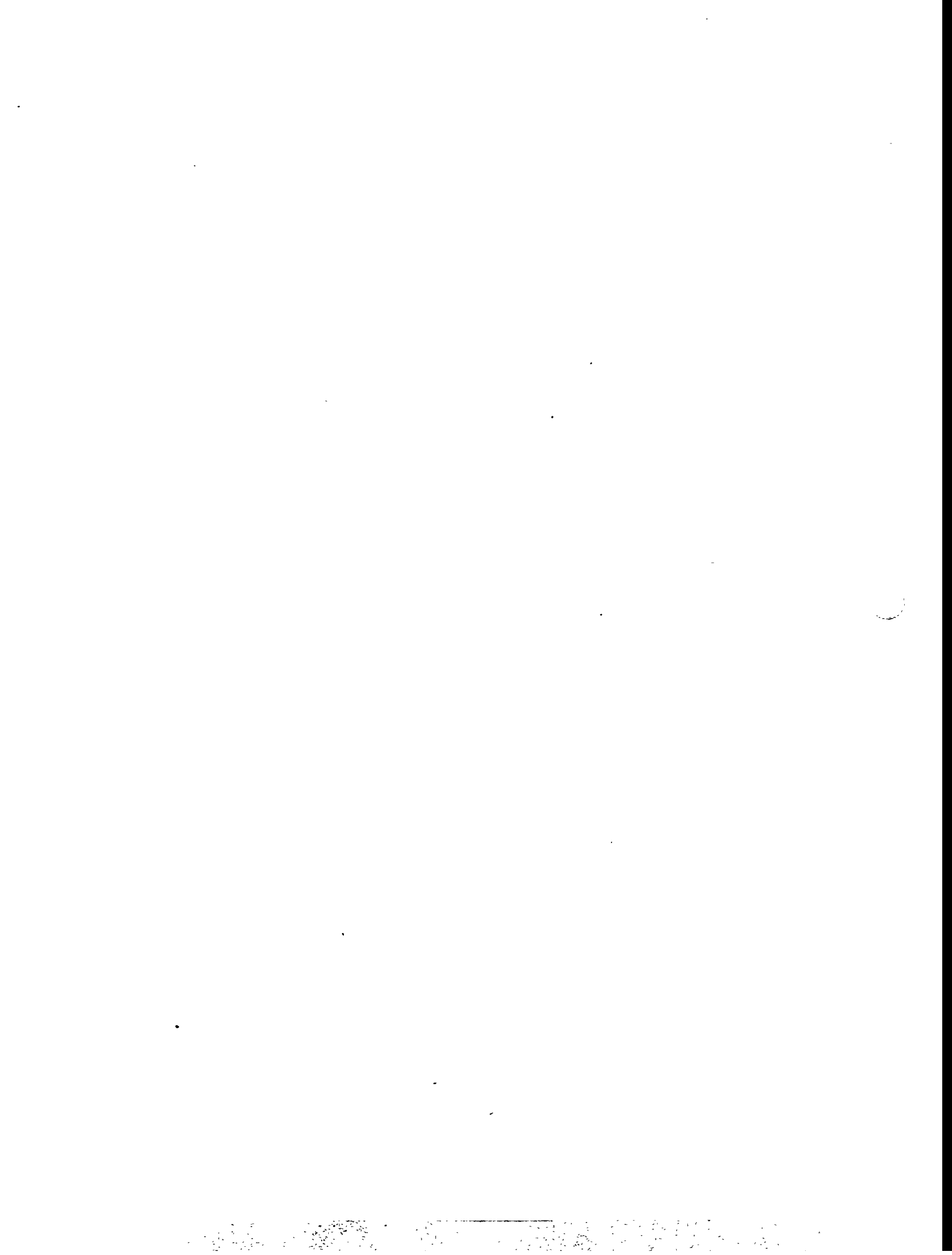
Rupture Disk. The rupture disk is opened at a pressure of 7.17 MPa (1041 psi)  $\pm 1\%$  absolute, the same as that for activation of the relief valve. There are no specific instruments or controls associated with the rupture disk.

Check Valve. In the pipeline between the block valve and the relief valve a pipe connection provides normal purge/makeup helium flow. A check valve will be located in this line to maintain PRSS pressure (and VS helium inventory) upon a break in a low pressure line within one of the interfacing subsystems.

SECTION 3

COMPONENT FUNCTIONS AND DESIGN REQUIREMENTS

(TBD)



SECTION 4

SUBSYSTEM AND COMPONENT INTERFACES

4.1 SUBSYSTEM INTERFACE REQUIREMENTS

Interface requirements imposed on other systems by the PRSS are as listed on Table 4-1.

4.2 COMPONENT BOUNDARY DEFINITION (TBD)

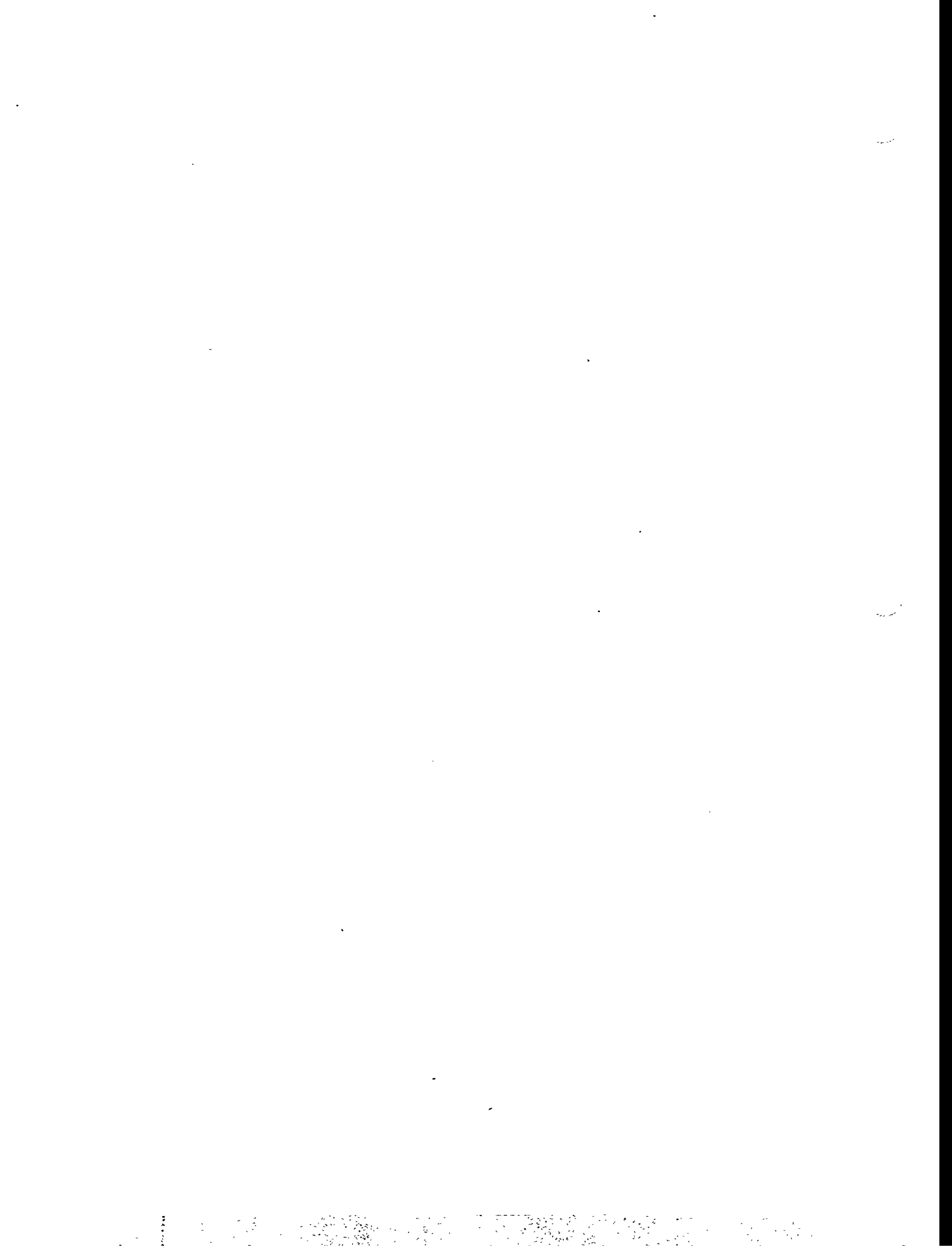
Table 4-1

INTERFACE REQUIREMENTS IMPOSED ON OTHER SYSTEMS BY THE PRESSURE RELIEF SUBSYSTEM

Interfacing Systems (with Subsystem Identification)	Nature of Interface	Interfacing Component	Interface Requirements
<u>Reactor Service (2000)</u> <u>(Gaseous Radioactive Waste)</u> (2064)	Provide capability of receiving gas waste continuously from vessel pressure relief subsystem	Pressure Relief Subsystem Piping	The RSG shall provide for (TBD) cu. ft. of potentially radioactive helium per year from venting of relief valve leakage from the relief-valve-rupture-disk interspace.
<u>Heat Transport System (2100)</u>	Limit blowdown capacity to PRSS	Pressure Relief Subsystem Piping	The HTS shall limit moisture ingress to nor more than 12.5 lb/sec.
<u>Plant Protection and Instrumentation (3200)</u>	Monitor position of Pressure Relief Valve and Block Valve	(TBD)	Provide necessary instrumentation to monitor valve position.
(Safety Protection) (3203)	Prevent simultaneous closure of both pressure relief trains.	Pressure Relief Block Valves	The PPIS shall provide block valve interlocks to assure one of the two block valves is always open.
<u>Buildings, Structures &amp; Building Service (7000)</u>	House the PRSS	Exterior of PRSS	Size shall be adequate and space shall be provided to contain the PRSS.
(Reactor Building) (7001)	Accommodate radioactive helium and steam due to pressure relief from the VS	Pressure Relief Subsystem Piping	Shall accommodate radioactive helium at a rate of (TBD) lb/sec.

Table 4-1 (continued)

Interfacing Systems (with Subsystem Identification)	Nature of Interface	Interfacing Component	Interface Requirements
(Reactor Building) (7001)	Accommodate access for ISI and maintenance	Exterior of Vessel System	Provide (TBD) passageways, platforms, scaffoldings, equipment, etc. for access to PRSS equipment.
<u>Electrical (9200)</u>	Provide Non-Class 1E 125 VDC power to block valves and Non-Class 1E 120 V ac power to instrumentation	Block valve and electrical interlock	(TBD)



SECTION 5

SUBSYSTEM CONSTRUCTION

(TBD)



SECTION 6

SYSTEM OPERATION

6.1 SUBSYSTEM LIMITATIONS, SET POINTS, AND PRECAUTIONS

6.1.1 Subsystem Limitations and Set Points

The PRSS is primarily a passive system during normal operation, but may become active during abnormal operation if the VS pressure increases above the safety relief valve setpoint. The principal design parameters are pressure and flow rate. The principal operating limits and set points for the PRSS are given in Table 6-1.

6.2 PREOPERATIONAL CHECKOUT

(TBD)

6.3 STARTING UP/SHUTTING DOWN

During planned startup/shutdown, the PRSS remains passive, providing continuous overpressure protection to the Vessel System.

6.4 NORMAL OPERATION

The PRSS is operable at all times. It is passive during normal operations and active only during a vessel overpressurization.

The operating conditions in the PRSS, up to and including the relief valve, are the same as those in the Vessel System. Purified helium from the HPS returns to the Vessel System at the upstream end of the PRSS at approximately (TBD lb/h). Any leakage through the relief valve(s) is directed to the Gaseous Radioactive Waste Subsystem.

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Table 6-1

OPERATING LIMITS AND SET POINTS  
FOR THE PRESSURE RELIEF SUBSYSTEM

Parameter	Operating Limit	System Set Point	Remarks
Relief valve pressure	(TBD) psia	1041 psia <u>+1%</u>	
Rupture disk pressure	(TBD) psia	1041 psia <u>+1%</u>	

## 6.5 REFUELING

The PRSS remains passive during plant refueling.

## 6.6 SHUTDOWN

The PRSS continues to operate passively during reactor shutdown in the same manner as during normal operations. Mass flow to the Vessel System, by way of the PRSS, is reduced but the volumetric flow is essentially constant. It is during this period that maintenance, testing and calibration can be performed.

## 6.7 ABNORMAL OPERATION

Vessel System overpressure protection is one of the primary PRSS features and its principal (abnormal) function is not activated until there is more than one coincidental plant failure. A redundant (second) relief train provides increased reliability to ensure that the Vessel System will not be subjected to pressures exceeding the Maximum Vessel Pressure (MVP).

If a relief valve does not reseal and terminate release of effluents from the Vessel System, the pressure relief train can be closed by remote, manual action of its block valve by the operator.

## 6.8 CASUALTY EVENTS AND RECOVERY PROCEDURES

### 6.8.1 Casualty Events

A preliminary list of casualty events which are enveloped by the Duty Cycle events of Table 1-1 and which could affect the proper performance of the Pressure Relief Subsystem is presented in the next two subsections.

#### 6.8.1.1 DBE Performance

Design Basis Events (DBEs) encompass those families of events whose mean frequencies are between 0.025 and 0.0001 per plant year. Eleven DBEs are

. 11.3 = 8 t/c

identified and described in Chapter 15 of the PSID. A review of these eleven DBEs indicates the PRSS will not be active during any of these events but will remain passive while providing continuous overpressure protection to the VS.

#### 6.8.1.2 SRDC Performance

Safety-related design conditions (SRDCs) are limiting accident conditions, derived from DBEs, in which only safety-related systems, subsystems, and components participate to control the accidental release of radioactivity. A review of the pressure transients comprising the eleven SRDC events has indicated that two of these, SRDC # 6 and SRDC # 7, result in VS pressures which exceed the PRSS relief valve set pressure.

SRDC-6 Large Unterminated Moisture Ingress. A steam generator offset tube rupture which results in a quasi-steady 12.5 lbm/sec moisture ingress to the primary coolant. The reactor vessel temperature rises to a peak value near 630°F at about 120 hours into the event, and reduces only a few degree by 300 hours. The primary coolant pressure rises to the pressure relief valve lift point due to the moisture ingress and the products of the graphite-water reaction. The pressure cycles between the pressure relief valve lift and reseal points for the entire course of this event.

SRDC-7 Small Unterminated Moisture Ingress. This event is essentially the same as SRDC-6.

#### 6.8.2 Design Features to Mitigate Effects of Casualty Events

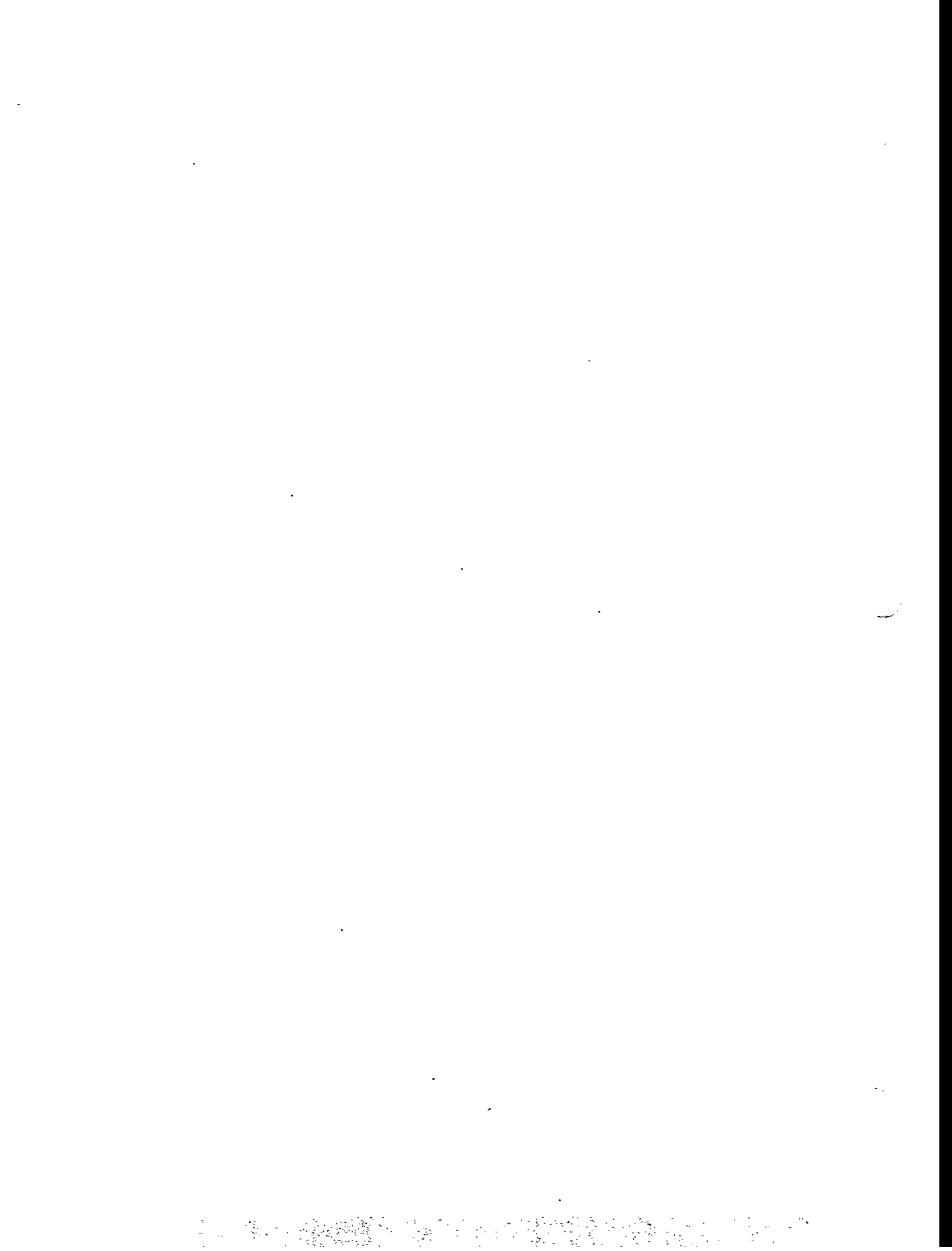
Under the pressure transient associated with SRDC #6 and #7, the PRSS becomes active 286 seconds after the start of the event, and limits primary coolant pressure to a maximum of 1041 psia. The PRSS becomes active with the relief valve reaching its set pressure and opening. This allows the high pressure helium to enter the piping upstream of the rupture disk, bursting the rupture disk, and venting the helium to the reactor building. During this high pressure transient, the check valve in the line from the Helium Purification Subsystem and the Helium Storage and Transfer Subsystem closes, confining the high pressure helium to the 4" pipe of the PRSS. The PRSS continues

#7 6/C

depressurizing the VS until the pressure at the relief valve drops to 885 psia, at which time the relief valve closes. The relief valve will then continue to cycle open and close as required during SRDC #6 and #7 to limit the pressure to a maximum of 1041 psia.

6.8:3 Recovery Procedures

(TBD)

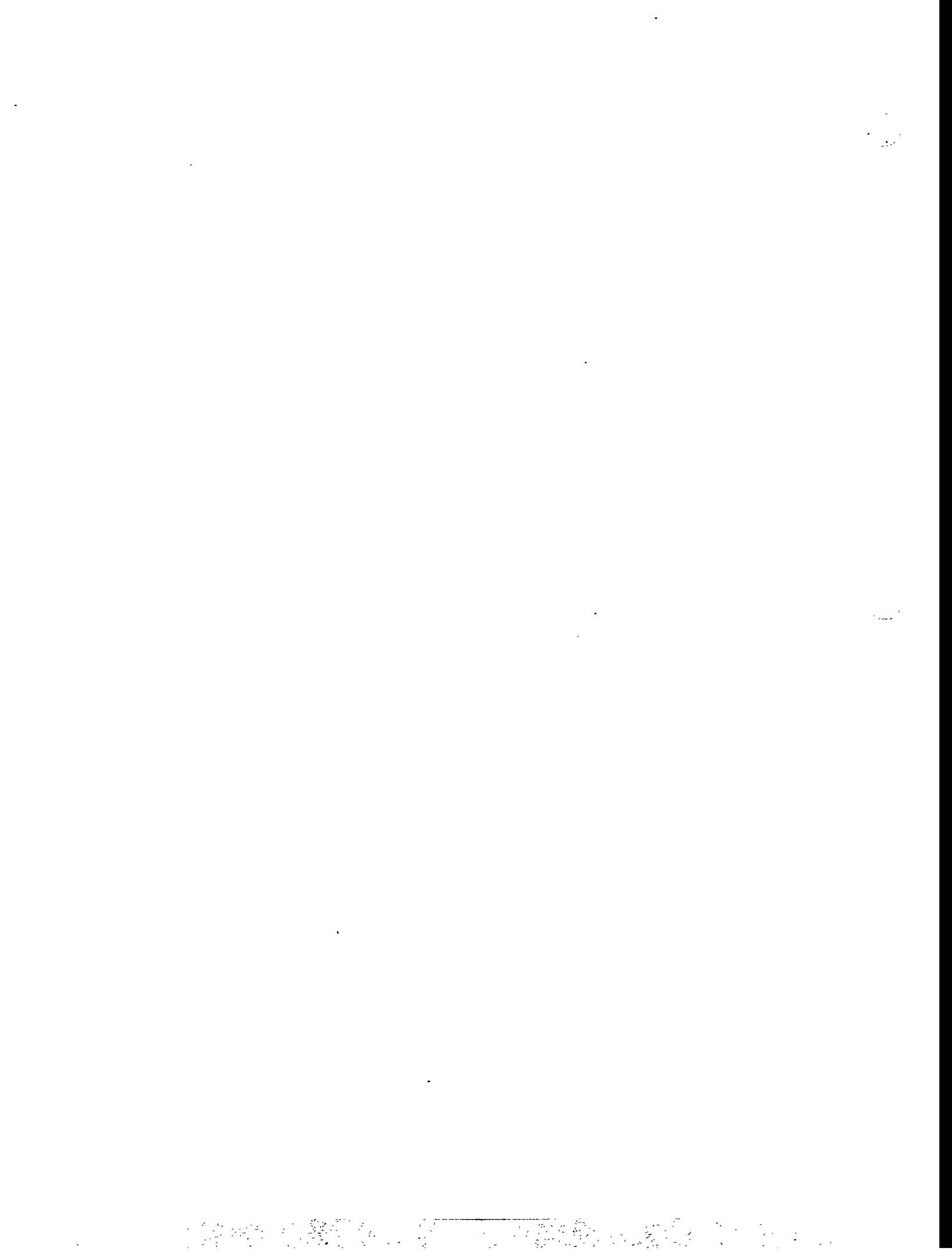


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SECTION 7

SYSTEM MAINTENANCE

(TBD)

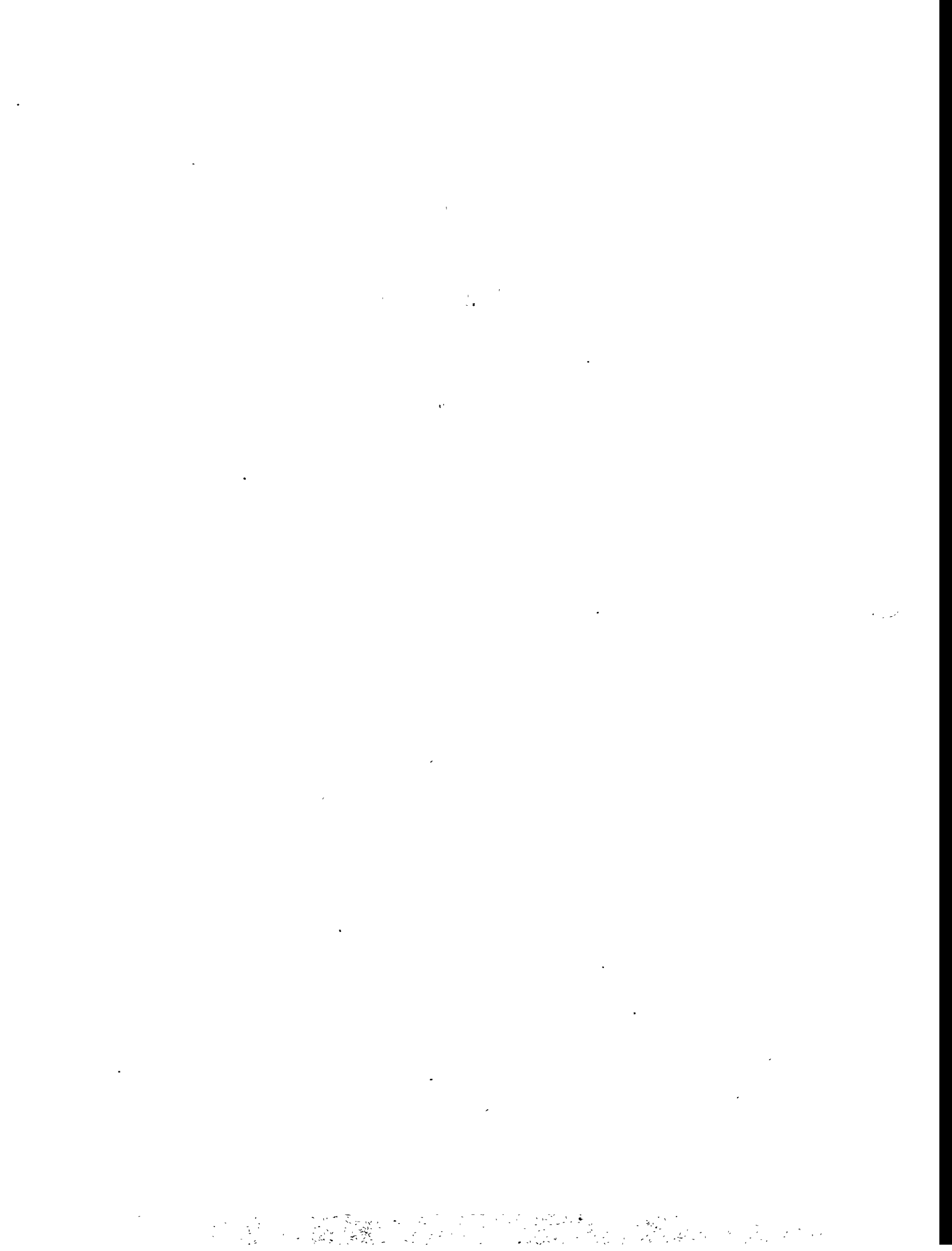


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SECTION 8

SYSTEM DECOMMISSIONING

(TBD)



## SECTION 9

REFERENCES

- 1.1 "Vessel System Design Description (SDD)," C-E-86-ADD-499, Document HFD-31100, March 1986, Rev. 1.
- 1.2 ASME Boiler and Pressure Vessel Code, Section III, Division 1, Article NB-7000.
- 1.3 "Overall Plant Design Specification (OPDS)," MHTGR, Document 908397/1, February 1986, Rev. 01.
- 1.4 GA Internal Correspondence, Strausberg to Swanson, "Top head Pipe Connections to the HPS & PRS - ILSV & SBSSV Modular Reactor," November 14, 1984.
- 1.5 ASME B&PV Code, Section XI, Division 2, In-Service Inspection.
- 1.6 ASME Boiler and Pressure Vessel Code, Section III, Division 1, Article NCA-2000.



APPENDIX A

TRACEABILITY OF REQUIREMENTS

TABLE A-1

TECHNICAL REQUIREMENTS TRACEABILITY SUMMARY

Traceability Number	Summary Requirements Description	Description/Reference Ref.	Source Description/Reference Section
115.0102.001	The Pressure Relief Subsystem shall provide two independent relief trains, each sized to permit 100% relieving capacity of 11.3 kg/s (25 lbm/s) of the vessel system.	1	3.2.3
115.0102.002	Pressure relief trains shall be connected to the steam generator vessel at the circulator outlet region.	1	3.2.3
115.0102.003	The pressure relief trains shall be located in the top head of the steam generator vessel as far apart as practicable to provide physical separation.		
115.0102.004	The PRSS shall be capable of transporting helium from the Helium Purification Subsystem and the Helium Storage and Transfer Subsystem to the steam generator vessel.	1	3.2.3

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TABLE A-1 (continued)

Traceability Number	Summary Requirements Description	Ref.	Description/Reference Section
115.0102.005	The block valves shall be placed upstream in series with the relief valves to permit isolation of a relief valve for maintenance and/or testing and for limiting system blowdown should a relief valve fail to reseal.	1	3.2.3
115.0102.006	A rupture disk shall be provided downstream of the relief valve to protect against sporadic discharges of radioactive helium to the atmosphere.	1	3.2.3
115.0102.007	The return purge helium from the Helium Purification Subsystem shall connect to the Heat Transport System through the Pressure Relief Subsystem.	1	3.2.3
115.0102.008	The helium to fill the Vessel System from the Helium Storage and Transfer Subsystem shall connect through the Pressure Relief Subsystem piping.	1	3.2.3
115.0102.009	The Pressure Relief Subsystem shall connect to the Gaseous Radioactive Waste Subsystem to handle relief valve leakage.	1	3.2.3
115.0102.010	The Pressure Relief Subsystem shall discharge to the Reactor Building.	1	3.2.3

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TABLE A-1 (continued)

Traceability Number	Summary Requirements Description	1	Description/Reference Section	Source
115.0102.011	The Pressure Relief Subsystem shall be designed to meet the principal design criteria provided in Appendix C of the OPDS.	1	3.2.3	3.2.3
115.0102.012	Equipment arrangement and features shall facilitate the subsystem's ISI requirements, installation, removal, and reinstallations.	1	3.2.3	3.2.3
115.0102.013	The Pressure Relief Subsystem arrangement shall allow installation, removal, ISI, and on-line and in-situ maintenance of the main circulator and the steam generator.	1	3.2.3	3.2.3
115.0102.014	The Pressure Relief Subsystem shall be designed for an operating life of 40 years from the start of operation.	1	3.2.3	3.2.3
115.0102.015	PRSS contributions to leakage of the primary coolant shall be minimized such that the total leakage from the vessel system does not exceed 10% per year.	1	3.2.3	3.2.3

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TABLE A-1 (continued)

Traceability Number	Summary Requirements Description	Ref.	Source Description/Reference Section
115.0102.016	The Pressure Relief Subsystem shall be insulated to limit heat losses from the primary coolant to less than (TBD MW) (TBD Btu/h) at rated power.	1	3.2.3
115.0102.017	The Pressure Relief Subsystem shall be designed to perform through transients from the design duty cycle events listed in Table 1-1.	1	3.2.3
115.0102.018	The Pressure Relief Subsystem shall protect against spurious valve discharge.	1	3.2.3
115.0102.019	The Pressure Relief Subsystem shall be designed to support a Vessel System design pressure of 7.177 MPa absolute (1041 psia).	1	3.2.3
115.0102.020	The Pressure Relief Subsystem shall be designed to withstand the cyclic loads resulting from the transients caused by the duty cycle events listed on Table 1-1, and mechanical loads (including reactionary loads resulting from bursting of the rupture disk) anticipated over the life of the plant.	1	3.2.3

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TABLE A-1 (continued)

Traceability Number	Summary Requirements Description	1	Description/Reference Section	Source
115.0102.021	Equipment and components classified as Seismic Category I shall be designed to remain functional during a Safe Shutdown Earthquake (SSE).	1	3.2.3	3.2.3
115.0102.022	Seismic loads shall be based on response spectra given in Figures 1-1 through 1-6.	1	3.2.3	3.2.3
115.0102.023	Materials shall be selected to minimize the production of radioactive materials due to activation and the generation of product of corrosion.	1	3.2.3	3.2.3
115.0102.024	Portions of the Pressure Relief Subsystem exposed to the reactor confinement building shall be designed for conditions shown in Table 1-2.	1	3.2.3	3.2.3
115.0102.025	The Pressure Relief Subsystem components which are exposed to the primary coolant shall be designed for chemical impurities in accordance with Table 1-3.	1	3.2.3	3.2.3
115.0102.026	An electrical interlock shall prevent the simultaneous closure of both pressure relief trains to ensure that at least one relief line is always available to protect the primary coolant pressure boundary.	1	3.2.3	3.2.3

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TABLE A-1 (continued)

Traceability Number	Summary Requirements Description	Source Description/Reference Section
115.0102.027	<p>Signals from pressure relief block valves shall be provided to indicate when either valve is not in full open position. This signal acts as an input to the vessel pressure relief block valve closure interlock. Two redundant and electrically separated limit switches from each pressure relief valve shall be provided.</p>	1 3.2.3
115.0102.028	<p>The capability shall be provided of accepting a signal from the vessel pressure relief block valve closure interlock to the block valve motor current relay/contractor to prevent the closure of one block valve if the other block valve is not fully open. Redundant relay contacts for each pressure relief valve control circuit shall be provided.</p>	1 3.2.3
115.0102.029	<p>Signals shall be provided from each vessel pressure relief valve to the PPIS if the relief is not fully closed. Two redundant signals per valve shall be provided.</p>	1 3.2.3
115.0102.030	<p>Provisions shall be made for monitoring the Pressure Relief Subsystem status and performance as a basis for maintenance diagnostics and decision making.</p>	1 3.2.3

115.0102.030

TABLE A-1 (continued)

Traceability Number	Summary Requirements Description	Ref.	Source Description/Reference Section
115.0102.031	Where possible, the design of the PRSS shall be such that on-line in-service inspection requirements are minimized.	1	3.2.3
115.0102.032	For those inspection activities that require the unit or major component be removed from service, design features shall be included to accomplish the inspection as one of those activities to be completed during the allotted plant planned downtime.	1	3.2.3
115.0102.033	Access shall be provided to the PRSS pressure boundary to facilitate in-service inspections required by Section XI of the ASME Code.	1	3.2.3
115.0102.034	The Pressure Relief Subsystem shall be designed to meet its overall reliability and unscheduled unavailability allocations given in Appendix F of the OPDS.	1	3.2.3
115.0102.035	The Pressure Relief Subsystem shall be designed to meet its planned outage allocation given in Appendix F of the OPDS.	1	3.2.3

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TABLE A-1 (continued)

Traceability Number	Summary Requirements Description	Source Description/Reference Ref.	Section
115.0102.036	Design modifications and improvements to achieve the above availability requirements shall be considered for incorporation into the design, if a one percentage increase in the total capital investment produces, at a minimum, a seven tenths percentage improvement in the equivalent availability factor.	1	3.2.3
115.0102.037	Where possible, the design of the Pressure Relief Subsystem shall be such that on-line maintenance requirements are minimized.	1	3.2.3
115.0102.038	Remote maintenance techniques shall be considered in the design where improved availability may result from time savings.	1	3.2.3
115.0102.039	The Pressure Relief Subsystem and its components shall be designed to facilitate hands-on maintenance.	1	3.2.3
115.0102.040	The use of standard "off-the-shelf" components and materials shall be used, where possible, to reduce costs associated with required spare parts. Components shall be classified to reduce the number of different types, sizes, and temperature and pressure ratings.	1	3.2.3

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TABLE A-1 (continued)

Traceability Number	Summary Requirements Description	Ref.	Source Description/Reference Section
115.0102.041	Components within the PRSS shall be capable of being tested and if necessary, calibrated during regularly scheduled maintenance operations.	1	3.2.3
115.0102.042	A spare parts listing and recommended spare parts inventory shall be developed consistent with the Preventative Maintenance Plan, anticipated unscheduled maintenance, and plant availability requirements.	1	3.2.3
115.0102.043	The design of mechanical and electrical systems, components and parts shall provided for reasonable and necessary interchangeability.	1	3.2.3
115.0102.044	The Pressure Relief Subsystem penetrations, closures, and piping shall be designed to limit the maximum free flow area where failures are postulated to be within the Design Basis Depressurization Accident (DBDA) value of (TBD) m <sup>2</sup> (TBD in. <sup>2</sup> ).	1	3.2.3
115.0102.045	The Pressure Relief Subsystem shall be Safety Class 1, Seismic Category I, and Quality Assurance Level I.	1	3.2.3

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TABLE A-1 (continued)

Traceability Number	Summary Requirements Description	Description/Reference Ref.	Source Section
115.0102.046	The design of the Pressure Relief Subsystem shall comply with requirements of the Regulatory Guides listed on Table 1-4.	1	3.2.3
115.0102.047	The PRSS design shall meet the industry codes and standards for design and Construction of the PRSS and its components as listed in Table 1-5.	1	3.2.3
115.0102.048	All items designated safety-related, seismic category I, and/or electrical class 1E shall come under a quality assurance program which fully complies with the requirements of Title 10 Code of Federal Regulations Part 50 (10CFR50), Appendix B. The basic requirements and supplements of ANSI/ASME 1-18NQA-1 and the four additional supplements from NE F2-10 regarding engineering holds, engineering drawing lists, design reviews, and management assessment shall be implemented on activities that affect the quality of such items. These items are designated as quality assurance level (QAL) I.	1	3.2.3

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TABLE A-1 (continued)

Traceability Number	Summary Requirements Description	Description/Reference Ref.	Source Section
115.0102.049	<p>Items designated nonsafety-related, seismic category 1 Non CAT I, or electrical class Non 1E are QAL II or QAL III. QAL II items shall come under a quality assurance program which complies with selected basic requirements and supplements of NQA-1 and four additional supplements identified above. QAL III items shall come under a quality assurance program which complies with selected basic requirements of NQA-1 and the our additional supplements identified above.</p>	1	3.2.3
115.0102.050	<p>The Pressure Relief Subsystem design shall incorporate features to facilitate manufacture and installation.</p>	1	3.2.3
115.0102.051	<p>A construction plan and schedule shall be developed by the end of preliminary design. The use of models should be considered to facilitate assessments of constructability, particularly in congested areas.</p>	1	3.2.3
115.0102.052	<p>The design of the Pressure Relief Subsystem shall be based upon parallel construction of the complete plant; however, features shall be included that facilitate construction and startup in increments of two standard reactor modules and one turbine.</p>	1	3.2.3

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TABLE A-1 (continued)

Traceability Number	Summary Requirements Description	1	Description/Reference Section	Source'
115.0102.053	Shop, factory, or field fabricated, assembled and erected components and subsystems shall be utilized as appropriate to reduce erection costs and to enhance quality control.	1	3.2.3	
115.0102.054	Materials, processes and parts for civil, structural, mechanical, electrical, and instrumentation systems and their components shall be incorporated as required to meet all transportation, handling, storage, construction and operational functions.	1	3.2.3	
115.0102.055	Appropriate specifications and design categories shall be identified to meet safety and economic goals identified for the plant design. Maximum use shall be made for commercial practice typified by fossil-fired facilities.	1	3.2.3	
115.0102.056	Until more specific criteria and/or rules are developed, NUREG-0586, "Draft Generic Environmental Statement on Decommissioning of Nuclear Facilities," January, 1981 shall be used as guidance.	1	3.2.3	
115.0102.057	An analysis shall be performed of the cost of decommissioning and dismantling the subsystem.	1	3.2.3	

References

1. "Vessel System Design Description," C-E-86-ADD-499, Document HFD-31100, March 1986, Rev. 1.

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APPENDIX B

DRAWINGS

(TBD)

APPENDIX C

TRANSIENTS

(TBD)

APPENDIX D

PARAMETERS LIST

Table D-1

Pressure Relief Subsystem Parameters List

Design Temperature	288°C (550°F)
Set Pressure	7.18 MPa (1041 psia) ±1%
Design Life	40 years
Line Size	10.2 cm (4.0 in) I.D.

## Pressure Relief Valve (Spring-Loaded Pilot-Actuated)

Size	10.2 cm (4.0 in) I.D.
Set Pressure	7.18 MPa (1041 psia) ±1%
Reseating Pressure	6.10 MPa (885 psia)
Design Pressure	8.27 MPa (1200 psia)
Design Temperature	288°C (550°F)
Dimensions (Approximate)	77.5 cm X 67 cm X 44.5 cm (30.5" X 26.4" X 17.5")

## Block Valve (Motor Operated Gate Valve)

Size	10.2 cm (4.0 in) I.D.
Design Pressure	8.27 MPa (1200 psia)
Design Temperature	288°C (550°F)
Dimensions (Approximate)	122 cm X 91.5 cm X 46 cm (48" X 36" X 18")

## Rupture Disk

Size	10.2 cm (4.0 in) I.D.
Set Pressure	7.18 MPa (1041 psia) ±5%
Design Temperature	288°C (550°F)
Dimensions (Approximate)	20 cm (8.0 in) O.D.

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APPENDIX E

PROPRIETARY CLAIMS

(TBD)