LIMERICK GENERATING STATION UNITS 1 & 2

DESIGN ASSESSMENT REPORT

REVISION 4 PAGE CHANGES

The attached pages, tables, and figures are considered part of a controlled copy of the Limerick Generating Station DAR. This material should be incorporated into the DAR by following the instructions below.

After the revised pages are inserted, place the page that follows these instructions in the front of Volume 1.

REMOVE	INSERT
VOLUME 1	
Table 1.3-2 (pgs 1 thru 10)	Table 1.3-2 (pgs 1 thru 11)
Table 1.4-1 (pg 1)	Table 1.4-1 (pg 1)
Page 480.69-1	Page 480.69-1
Page 480.71-1	Page 480.71-1
----	Page 640.29-1
VOLUME 2	
Page G-i	Page G-i
Page H-i	Page H-i
Page I-i	Pages I-i thru Figure I.2-6

THIS DAR SET HAS BEEN UPDATED TO INCLUDE REVISIONS THROUGH 4 DATED 06/83.

COMPARI

Load or Phenomenon

I. LOCA Related Hydrodynamic Loads

A. Submerged Boundary Loads During Vent Clearing

B. Poolswell Loads

1. Poolswell Analytical Model

a. Air-Bubble Pressure

b. Poolswell Elevation

c. Poolswell Velocity

TABLE 1.3-2

SON OF LGS LICENSING BASIS WITH NRC ACCEPTANCE CRITERIA

NRC Acceptance Criteria	Criteria Source	LGS Position
24 psi overpressure added to local hydrostatic pressure below vent exit (walls and basemat) - linear attenuation to pool surface.	NUREG-0487 Supplement 1	Acceptable
Calculated by the pool-swell analytical model (PSAM) used in calculation of submerged boundary loads.	NUREG-0487	Acceptable
Use PSAM with polytropic exponent of 1.2 to a maximum swell height which is the greater of 1.5 x vent submergence or the elevation corresponding to the drywell floor uplift ΔP=2.5 psid.	NUREG-0487 Supplement 1	Acceptable
Velocity history vs. pool elevation predicted by the PSAM used to compute impact loading on small structures and drag on gratings between initial pool surface and maximum pool elevation and steady-state drag between vent exit and maximum pool elevation. Analytical velocity variation is used up to maximum velocity.	NUREG-0487	Acceptable

Load or Phenomenon

d. Poolswell Acceleration

e. Wetwell Air Compression

f. Drywell Pressure

2. Loads on Submerged Boundaries

3. Impact Loads

a. Small Structures

NRC Acceptance Criteria	Criteria Source	LGS Position
Maximum velocity applies thereafter up to maximum poolswell. PSAM predicted velocities multiplied by a factor of 1.1.		
Acceleration predicted by the PSAM. Pool acceleration is used in the calculation of acceleration loads on submerged components during poolswell.	NUREG-0487	Acceptable
Wetwell air compression is calculated by PSAM consistent with maximum poolswell elevation in B.1.b.	NUREG-0487 Supplement 1	Acceptable
Methods of NEDM-10320 and NEDO-20533 Appendix B. Used in PSAM to calculate poolswell loads.	NUREG-0487	Acceptable
Maximum bubble pressure predicted by the PSAM added uniformly to local hydrostatic pressure below vent exit (walls and basemat) - linear attenuation to pool surface. Applied to walls up to maximum poolswell elevation.	NUREG-0487	Acceptable
1.35 x Pressure-Velocity correlation for pipes and I-beams based on PSTF impulse data and flat pool assumption. Variable pulse duration.	NUREG-0487	Acceptable

T

Load or Phenomenon

b. Large Structures

c. Grating

4. Wetwell Air Compression

a. Wall Loads

b. Diaphragm Upward Loads

5. Asymmetric LOCA Pool

C. Steam Condensation and Chugging Loads

1. Downcomer Lateral Loads

a. Single-Vent Loads (24 in.)

ABLE 1.3-2 (Continued)

NRC Acceptance Criteria	Criteria Source	LGS Position
None - Plant unique load where applicable.	NUREG-0487	Not Applicable No large structures
Poolswell drag vs. grating area correlation and pool velocity vs. elevation. Pool velocity from the PSAM. Poolswell drag multiplied by dynamic load factor.	NUREG-0487	Acceptable
Direct application of the PSAM calculated pressure due to wetwell compression.	NUREG-0487	Acceptable
5.5 psid for diaphragm loadings only.	NUREG-0808	Acceptable. Calculated diaphragm uplift ΔP = 10.6 psid (Figs. 4.2-3, 4.2-4). Design diaphragm uplift ΔP = 20 psid.
Use 20 percent of maximum bubble pressure statically applied to 1/2 of the submerged boundary.	NUREG-0487 Supplement 1	Acceptable
Dynamic load to end of vent. Half sine wave with a duration of 3 to 5 ms and corresponding maximum amplitudes of 5 to 10 Klbf.	NUREG-0808	Acceptable

Load or Phenomenon

b. Multiple-Vent Loads (24 in.)

c. Single/Multiple vent loads (28 in.)

2. Submerged Boundary Loads

a. High/Medium Steam Flux Condensation Oscillation Load

c. Low Steam Flux Chugging Load

- Symmetric Load

- Asymmetric Load Case

NRC Acceptance Criteria	Criteria Source	LGS Position
Prescribed variation of load per vent vs. number of vents. Determined from single vent dynamic load specification and multivent reduction factor.	NUREG-0808	Acceptable
Multiply basic vent loads by factor f=1.34	NUREG-0808	Not Applicable
Bounding CO pressure histories observed in 4TCO tests. Inphase application.	NUREG-0808	Acceptable
Conservative set of 10 sources derived from 4TCO tests. Applied to plants using the IWEGS/MARS acoustic model. Source desynchronization of 50 ms or alternate load using 7 sources derived from the 4TCO key chugs without averaging.	NUREG-0808	Acceptable
All vents use source of equal strength for each of the sources.		
Source strengths $S\pm = S\ (1\pm\alpha)$ applied to all vents on + and - side of containment. Sources based on the symmetric sources. Asymmetric parameter α based on rms moment method of interpreting experimental 4TCO single-vent and JAERI multivent data.		

Load or Phenomenon

II. SRV Related Hydrodynamic Loads

A. Pool Temperatures Limits

NRC Acceptance Criteria	Criteria Source	LGS Position
For plants using a discharge device with the exact hole pattern as described in the SSES DAR Section 4.1, the following limits shall apply:	NUREG-0783	
1. For all plant transients involving SRV operations during which steam flux exceeds 94 lb_m/ft^2-sec, the local pool temperature shall not exceed 200°F.	NUREG-0783	Acceptable
2. For all plant transients involving SRV operations during which steam flux is less than 42 lb_m/ft^2-sec, the local pool temperature shall be at least 20°F subcooled. This is equivalent to a temperature of 210°F with quencher submergence of 14 feet.	NUREG-0783	Acceptable
3. For all plant transients involving SRV operations during which steam flux is between 42 and 94 lb_m/ft^2-sec, the local pool temperature can be determined by linear	NUREG-0783	Acceptable

Load or Phenomenon

B. Evaluation of Air Clearing Load Definition Procedures

NRC Acceptance Criteria	Criteria Source	LGS Position
interpolation between the temperatures defined in items 1 and 2 above.		
The T-quencher load specification described in Section 4.1 of the SSES DAR may be applied for evaluation of SRV containment boundary pressure loads with the following restrictions:	NUREG-0802	Acceptable
1. All valves load case The DLV and DLWL combinations must lie below the limit line of Fig. A.1 defined in the criteria where: a. DLV shall be equal to the arithmetic average of all discharge line volumes (m^3) b. DLWL shall be equal to the quencher submergence at high water level (m)	NUREG-0802	Acceptable
2. ADS Load Case The DLV and DLWL combinations must lie below the limit line of Fig. A.2 defined in the criteria where: a. DLV shall be equal to the arithmetic average of all ADS discharge line volumes (m^3)	NUREG-0802	Acceptable

Load or Phenomenon

C. T-Quencher
Tie Down Loads

NRC Acceptance Criteria	Criteria Source	LGS Position
b. DLWL shall be equal to the differences between the plant downcomer exit elevation and the quencher center line elevation (m)		
3. Frequency Range For the single valve and asymmetric load cases, the timewise compression of the design pressure signatures shall be increased to provide an overall dominant frequency range that extends up to 11 Hz.	NUREG-0802	Acceptable (DAR Section 4.1.4.1)
4. Vertical Pressure Distribution The maximum pressure amplitudes shall be applied uniformly to the containment and pedestal walls up to an elevation 2.5 feet above the quencher centerline followed by linear attenuation to zero at pool surface.	NUREG-0802	Acceptable
The T-quencher load specification described in SSES DAR Section 4.1.2 may be applied for evaluation of quencher and quencher support.	NUREG-0802	Acceptable

Load or Phenomenon

D. SRV Boundary Loads

III. LOCA/SRV Submerged Structure Loads

A. LOCA Downcomer Jet Load

B. SRV T-Quencher Jet

C. LOCA Air Bubble Drag Loads

NRC Acceptance Criteria	Criteria Source	LGS Position
The acceptance criteria specified in NUREG-0802, Appendix A (A.1.1 through A.1.7), are recommended for plants following the "alternate" load methodology (i.e., T-Quencher load specification described in SSES DAR Section 4.1)	NUREG-0802	Acceptable. DAR Section 4.1.1.1 demonstrates the acceptability of using the SSES SRV load specification for LGS.
Alternate methodology presented in Zimmer DAR may be applied.	NUREG-0487 Supplement 1	Acceptable
SRV T-quencher jet loads may be neglected beyond a 5 ft cylindrical zone of influence. Cylinder should be extended 10 hole diameters on the arm with holes in the end cap.	NUREG-0487	Acceptable
Calculate based on methods described in NEDE-21471 subject to the following constraints and modifications:	NUREG-0487	Applying plant-unique methodology defined in LGS DAR Section 4.2.1.5
1. To account for bubble asymmetry, accelerations and velocities shall be increased 10%.	NUREG-0487	Acceptable
2. For standard drag in accelerating flow fields, use draft coefficients presented in Zimmer FSAR Attachment 1.k with following modifications:	NUREG-0487 Supplement 1	Acceptable

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Load or Phenomenon

NRC Acceptance Criteria	Criteria Source	LGS Position
a. Use $C_H = C_m - 1$ in the F_A formula		
b. For noncylindrical structures, use lift coefficient for appropriate shape or $C_L = 1.6$		
c. The standard drag coefficient for poolswell and SRV oscillating bubbles should be based on data for structures with sharp edges.		
3. For equivalent uniform flow velocity and acceleration calculations, structures are segmented into small sections such that $1.0 \leq L/D \leq 1.5$. The loads are then applied to the geometric center of each segment. This approach, as presented in Zimmer FSAR Attachment 1.k, may be applied.	NUREG-0487 Supplement 1	Acceptable
4. A detailed methodology on the approach for considering interference effects as presented in Zimmer FSAR Attachment 1.k may be applied.	NUREG-0487 Supplement 1	Acceptable

Load or Phenomenon

D. SRV Air Bubble
Drag Load

E. Steam Condensation
Drag Loads

IV. Secondary Loads

1. Sonic Wave Load

2. Compressive Wave
Load

3. Fallback Load on
Submerged Boundary

4. Thrust Loads

5. Friction Drag
Loads on Vents

6. Vent Clearing
Loads

7. Post Swell
Wave Load

TABLE 1.3-2 (Continued)

NRC Acceptance Criteria	Criteria Source	LGS Position
5. Formula 2-23 of NEDE-21730 shall be modified by replacing M_H by $\rho_{FB} V_A$ where V_A is obtained from Tables 2-1 & 2-2.	NUREG-0487	Acceptable
No criteria specified for T-quencher		Applying plant-unique methodology defined in LGS DAR Section 4.1.4
No criteria specified		Applying plant-unique methodology defined in LGS DAR Section 4.2
Negligible Load	NUREG-0487	Acceptable
Negligible Load	NUREG-0487	Acceptable
Negligible Load	NUREG-0487	Acceptable
Momentum balance	NUREG-0487	Acceptable
Standard friction drag calculations	NUREG-0487	Acceptable
Negligible Load	NUREG-0487	Acceptable
Methodology for establishing loads resulting from post swell waves to be evaluated on a plant unique basis.	NUREG-0487	Load is negligible when compared to design basis loads (Section 4.2.3.6)

Load or Phenomenon

8. Seismic Slosh Load

V. Confirmatory In-plant Tests of SRV Discharge

A. SRV Load Specification

B. Pool Temperature Specification (Thermal Mixing)

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NRC Acceptance Criteria	Criteria Source	LGS Position
Methodology for establishing loads resulting from seismic slosh to be evaluated on a plant unique basis.	NUREG-0487	Load is negligible when compared to design basis loads (Section 4.2.3.7)
In the event that an applicant cannot demonstrate, to the staff's satisfaction, equivalence in any of the areas cited in acceptance criteria A.1.1 through A.1.7 of NUREG-0802, Appendix A, in-plant confirmatory testing may be employed to demonstrate the applicability of the acceptance criteria for individual plants. Such testing, if proposed, should conform to the guidelines set down in NUREG-0763.	NUREG-0802, Appendix A	Acceptable. No in-plant test is required. DAR Section 4.1.1.1 demonstrates the acceptability of using the SSES SRV load specification for LGS.
The acceptability of the safety relief valve in-plant confirmatory test program shall be based on conformance with the guidelines specified in Sections 6, 7, and 8 of NUREG-0763. If the applicant/licensee elects not to perform the SRV in-plant tests, the acceptability of this exception shall be determined in conformance with the guidelines specified in Section 4 of NJREG-0763.	NUREG-0763	Acceptable. The LGS pool thermal mixing analysis will be confirmed by in-plant testing and analysis.

TABLE 1.4-1

CONTAINMENT DESIGN PARAMETERS

	Drywell	Suppression Chamber
DRYWELL AND SUPPRESSION CHAMBER		
Internal design pressure, psig	55	55
External to internal design differential pressure, psid	5	5
Drywell deck design differential pressure, psid	30 downward	20 upward
Design temperature, °F	340	220
Drywell net free volume including downcomers, ft^3	248,950	
Suppression chamber free volume, ft^3		
Low level		161,350
High level		149,425
Suppression pool water volume, ft^3		
Low level		115,903
High level		127,756
Suppression pool net surface area, outside pedestal, ft^2		4974
Supression pool depth, ft		
Low level		22'
Normal level		23'
High level		24'-3"
VENT SYSTEM		
Number of downcomers	87	
Nominal downcomer diameter, ft	2	
Total vent area, ft^2	256.5	

QUESTION 480.69

Provide the pool temperature analysis for the transient involving the actuation of one or more SRV's. For additional guidance, your attention is directed to NUREG-0873, "Pool Temperature Transients for BWR."

RESPONSE

The requested information is provided in Appendix I.2. The guidance provided in NUREG-0783 has been followed in our analysis of pool temperature response to SRV discharge.

QUESTION 480.71

Concerns regarding the capability of the vacuum breaker to perform its function during the pool swell and chugging phases of LOCA have been raised. Provide the design changes, if any, that have been implemented to resolve this concern.

RESPONSE

The four downcomers on which the wetwell/drywell vacuum breakers are mounted are being capped, thereby eliminating the adverse effects of the chugging phenomenon on the vacuum breakers.

The vacuum breaker has been redesigned so that it will successfully perform its given task during and after poolswell. The adequacy of the redesign has been demonstrated by analysis and test.

The redesign and requalification program that considers the effects of the poolswell and chugging events was initiated and funded by three utilities: Philadelphia Electric Co., Pennsylvania Power and Light, and Long Island Lighting Co. The DAR will be updated after the design changes are implemented on Limerick.

QUESTION 640.29

Provide a test description for any Confirmatory Inplant Tests of Safety-Relief Valve Discharges to be performed in compliance with NUREG-0763.

RESPONSE

NUREG-0763 provides guidelines to determine if in-plant tests are required on the basis of plant-unique parameters in order to confirm generically established specifications for SRV loads and maximum suppression pool temperature.

Limerick Specification for SRV Loads

Confirmatory in-plant tests of SRV discharges to verify the adequacy of the Limerick SRV hydrodynamic load specification are not required. Limerick uses the generic Mark II T-Quencher load specification developed by Kraftwerk Union (KWU) for Susquehanna (SSES) due to similarities in key operating parameters between SSES and LGS (DAR Table 4.1-1 and Section 4.1.1.1). To verify this load specification and to further verify the quencher's steam condensing characteristics, full-scale single cell tests were conducted at the KWU laboratories in Karlstein, West Germany. The generic load specification used for Limerick is described in DAR Section 4.1, while the Mark II T-Quencher verification test is described in DAR Chapter 8.

The acceptability of the Limerick SRV load specification conforms with NUREG-0763 and NUREG-0802 acceptance criteria. General NRC acceptance criteria are provided in Section 4 of NUREG-0763, while specific acceptance criteria for plants using the SSES SRV load specification are provided in Appendix A of NUREG-0802. These specific criteria have been addressed in DAR Section 4.1.1.1 and demonstrate the acceptability of using the SSES SRV hydrodynamic load specification for Limerick.

Limerick Specification for Suppression Pool Temperature

The Limerick suppression pool thermal mixing capability will be assessed through in-plant testing and analysis in conformance with NUREG-0763.

DAR Table 1.3-2, Parts II.D and V, have been added to clarify our position on NUREG-0763 guidelines for in-plant tests of SRV discharges and NUREG-0802 SRV load acceptance criteria.

APPENDIX G

NSSS DESIGN ASSESSMENT

DELETED

APPENDIX H

BOP EQUIPMENT DESIGN ASSESSMENT

DELETED

APPENDIX I

SUPPRESSION POOL DESIGN ASSESSMENT

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APPENDIX I

FIGURES

I.1.1 SUPPRESSION POOL TEMPERATURE MONITORING SYSTEM DESIGN CRITERIA

The suppression pool temperature monitoring system (SPTMS) monitors the suppression pool temperature during normal plant operations and after transients or accidents. Operator monitoring of pool temperature is required to ensure that the suppression pool is operated within the allowable temperature limits set forth in the Limerick technical specifications. Operation of the pool within these technical specifications will provide assurance that the suppression pool temperature will be maintained within the limits specified in NUREG-0783. Section I.1.1.4 describes the Limerick technical specification temperature alarm setpoints for pool operation.

The SPTMS is designed in conformance with the acceptance criteria specified in NUREG-0487 (Ref. I.2-2) and NUREG-0783 (Ref. I.2-4).

I.1.1.1 SENSOR LOCATIONS

The suppression pool temperature is redundantly monitored by two divisionalized systems. Eight dual element RTDs are provided for each system and are evenly distributed around the pool to provide a reasonable measure of the bulk water temperature. The eight monitoring locations and individual RTD identifications are shown in Figure I.1-1.

The sensor are located at a depth of two feet below the minimum pool water level. This depth ensures a conservative measurement of bulk temperature because the hottest water will rise to the pool surface. This depth also provides adequate sensor submergence to preclude the possibility of sensor uncovery during an accident or transient.

I.1.1.2 SAFETY EVALUATION

The indication of suppression pool temperature in the control room is required to ensure that the plant is always operating within the technical specification limits. Manual operator action is required to maintain the plant within the specifications. Suppression pool temperature is also required for post accident monitoring. These functions are safety related.

The system design conforms to all applicable criteria for physical separation, redundancy and divisionalization. Physical and electrical separation is provided for the safety related instrumentation. The safety related instrumentation is powered from divisionalized Class 1E power sources.

The suppression pool temperature sensors are qualified to seismic Category I and Class 1E criteria and are energized from onsite emergency power supplies.

The hardcopy timeplot of suppression pool temperature is for operating history only and is not safety related.

I.1.1.3 EQUIPMENT DESIGN

The signals from the redundant sensors are processed by two independent divisionalized microprocessors located on a main control room cabinet. The microprocessors convert the RTD signals into degrees Fahrenheit and compute the average of the eight temperatures. The average value is displayed by digital indicators provided on the microprocessors and on remote indicators located at the main control board. Keyboards located on the microprocessor and on the remote indicator allow the operator to display any individual temperature input.

The SPTMS trouble alarm located in the main control room is generated if the calculated average temperature exceeds any of the four distinct high temperature setpoints that are permanently stored in the microprocessors. (Section I.1.1.4 provides details on the temperature alarm setpoints.) Also, appropriate high temperature status lights are initiated on the associated microprocessor and remote indicator. Electrically isolated outputs interface with the SPTMS trouble alarm located in the main control room.

The SPTMS trouble alarm is also initiated if one of the RTDs fails or if non-1E power to the cabinet cooling fans is lost. Keyboards allow the operator to remove a failed RTD from the calculated average.

Both elements of each dual element RTD are wired out through containment penetrations. One element of each RTD is connected

to a microprocessor loop. This design provides the capability to easily connect the backup RTD elements in case of a failure.

A digital printer located on the microprocessor periodically prints the average temperature, the individual temperature, and the current date and time. Trending information may also be printed at the operator's request. Alarm conditions are printed along with the temperature.

Electrically isolated digital and analog signals are provided to interface with other plant information systems including a signal to the emergency response facility data system (ERFDS) computer. The microprocessor has a self checking diagnostic system that provides an error alarm if a failure is detected in any part of the system.

I.1.1.4 ALARM SETPOINTS

The SPTMS provides alarm at four pool temperature setpoints (95, 105, 110, and 120°F) to provide assurance that the suppression pool will be maintained within the temperature limits defined in NUREG-0783. Appendix I.2 describes these pool temperature limits and provides Limerick's analysis for suppression pool temperature response to SRV discharge. This analysis demonstrates the adequacy of these alarm setpoints with regard to alerting the operator to maintain the pool temperature below the NUREG-0783 limit. The alarm setpoints are based on Ref. I.1-1 and are defined as follows:

a. 95°F: maximim allowable pool temperature for continuous power operation without suppression pool cooling

b. 105°F: maximim allowable pool temperature during testing at power which adds heat to the pool.

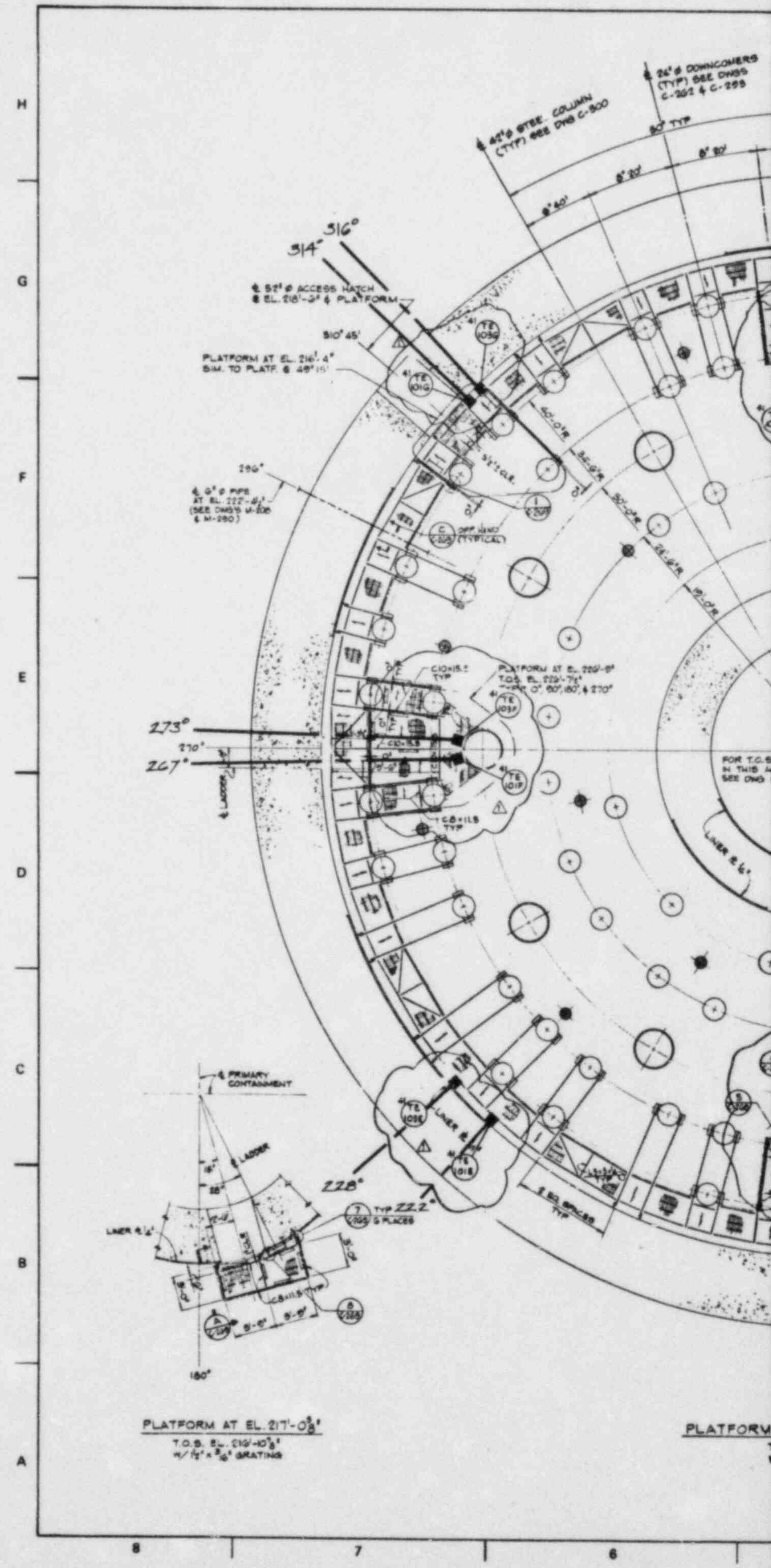
c. 110°F: manual reactor scram setpoint

d. 120°F: manual reactor depressurization setpoint.

I.1.2 (LATER)

I.1.3 REFERENCES

I.1-1 General Electric Service Information Letter (SIL) No. 106, October 25, 1974.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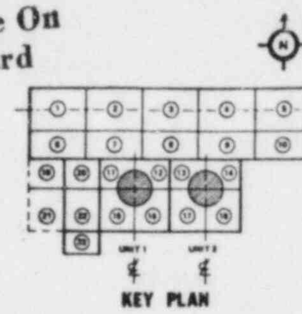
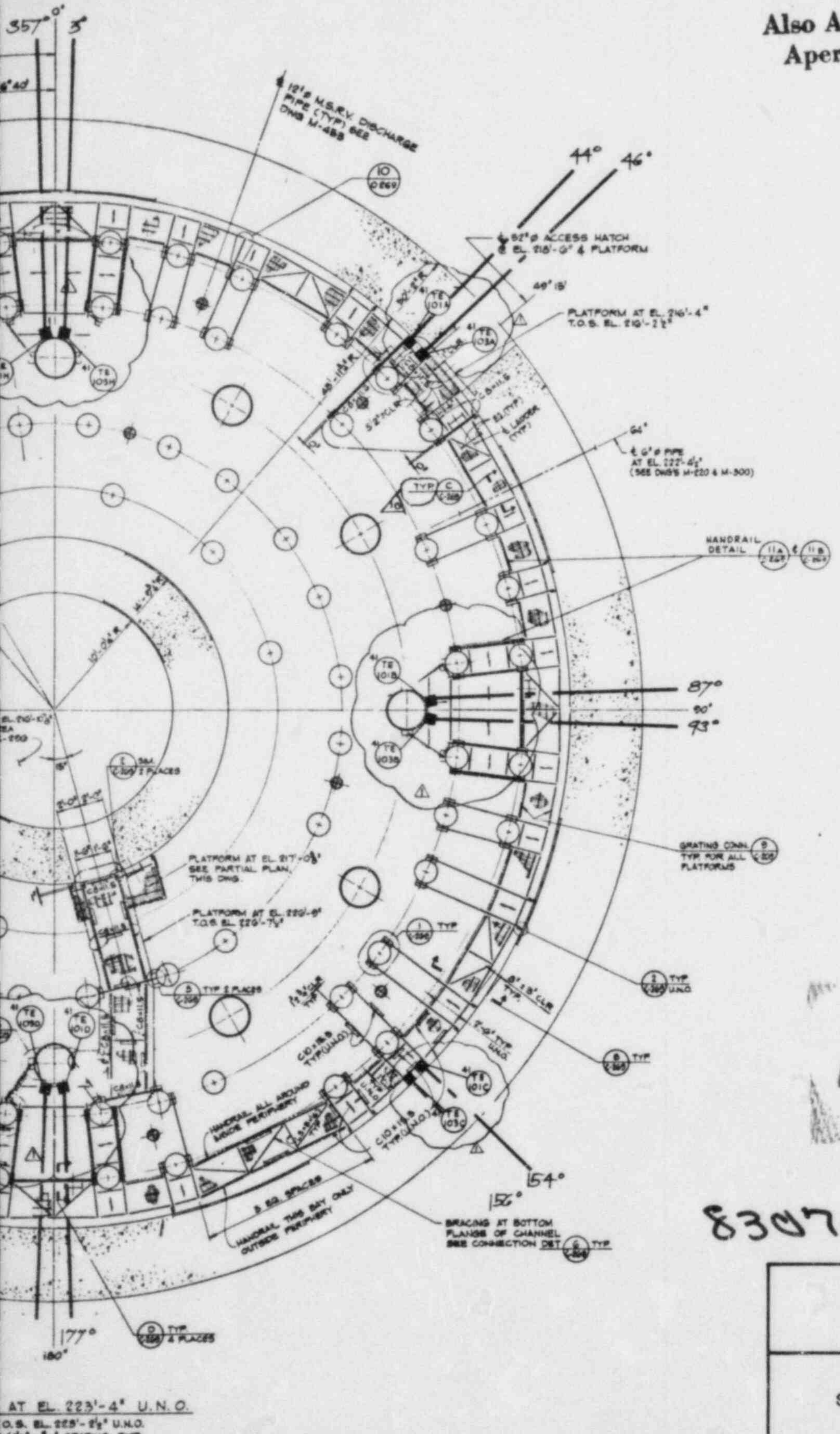
℄ 52"⌀ ACCESS HATCH
℄ 42"⌀ STEEL COLUMN (TYP) SEE DWG C-300
℄ 24"⌀ DOWNCOMERS (TYP) SEE DWGS C-292 & C-293
30° TYP
PLATFORM AT EL. 216'-4"
PRIMARY CONTAINMENT
LADDER
PLATFORM AT EL. 217'-0 3/8"
T.O.S. EL. 216'-10 3/8"
PLATFORM

Also Available On Aperture Card





NOTES:

1. FOR LEGEND AND GENERAL NOTES SEE DWG M-325
2. DISTANCE BETWEEN TWO REDUNDANT SENSORS (E.G. TE-41-101A & TE-41-103A) SHOULD BE AT LEAST 12" OR MORE.
3. APPROX. ELEV OF SUPPRESSION POOL TEMP CONN CENTER LINE IS 220'-5". FOR EXACT ELEV SEE INSTALLATION DETAIL [illegible]

PRC APERTURE CARD

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LIMERICK GENERATING STATION
UNITS 1 AND 2
DESIGN ASSESSMENT REPORT

SUPRESSION POOL TEMPERATURE
MONITORING SYSTEM
SENSOR LOCATIONS

FIGURE I.1-1 Rev. 4, 06/83

5 4 3 2 1

I.2 SUPPRESSION POOL TEMPERATURE RESPONSE TO SRV DISCHARGE

I.2.1 INTRODUCTION

In late 1974, the NRC alerted the BWR Owners to the potential for severe vibratory loads on the containment structure due to safety/relief valve (SRV) discharge at elevated suppression pool temperature (Ref. I.2-1). This phenomenon, or condensation instability, was associated with certain SRV discharge device configurations and occurred above given threshold values of pool temperature and steam mass flux. While the condensation instability phenomenon described above has never been exhibited for quencher devices, even in large scale tests where local temperatures approached saturation, the NRC (Ref. I.2-2) has taken the position that a local pool temperature limit of 200°F "will provide additional conservatism and will ensure that unstable steam condensation will not occur with a quencher device" and that "applicants will have to provide plant unique analyses for pool temperature responses to transients involving SRV operations to demonstrate that the plants will operate within the limit of 200°F."

The Mark II Owners Group subsequently prepared a generic report, the "White Paper" (Ref. I.2-3), which was used by the utilities, including Philadelphia Electric Co., as a guideline for plant-unique analyses. In conjunction with the development of this report, the Mark II Owners Group proposed alternative suppression pool temperature limits. These alternative acceptance criteria were subsequently accepted by the NRC for plants using the generic Mark II T-Quencher design. The alternative pool temperature limits are defined in NUREG-0783 (Ref. I.2-4) as follows:

a. For all plant transients involving SRV operations during which the steam flux through the quencher perforations exceeds 94 lbm/ft^2-sec, the suppression pool local temperature shall not exceed 200°F.

b. For all plant transients involving SRV operations during which steam flux through the quencher perforations is less than 42 lbm/ft^2-sec, the suppression pool local temperature shall be at least 20°F subcooled. This is equivalent to a local temperature of 210°F with quencher submergence of 14 feet.

c. For plant transients involving SRV operations during which the steam flux through the quencher perforations exceeds 42 lbm/ft²-sec but is less than 94 lbm/ft²-sec, the suppression pool local temperature can be established by linearly interpolating the local temperatures established under items a and b above.

The following presentation of the suppression pool temperature analysis for Limerick conforms with NUREG-0783 in terms of the pool temperature limit acceptance criteria, assumptions, and pool heatup events required for analysis.

I.2.2 EVENTS FOR THE ANALYSIS OF POOL TEMPERATURE TRANSIENTS

The following events have been analyzed on the basis of mass and energy balance on the suppression pool during SRV blowdown. The results of the pool temperature transients demonstrate the history of the pool bulk temperature for all the events analyzed. Assumptions for the events are discussed in Section I.2.3. The associated peak pool temperatures calculated for each event are summarized in Table I.2-2.

I.2.2.1 Event 1: Stuck-Open SRV (SORV) at Power Operation

SORV at power cases are analyzed to demonstrate that the spurious opening of an SRV during normal power operation will not result in high pool temperatures.

Two cases of SORV at power are considered separately:

Case 1.a: Single failure of one RHR heat exchanger

Case 1.b: Initiation of the main steam isolation valve (MSIV) closure signal at the time of scram and subsequent unavailability of main condenser.

I.2.2 2 Event 2: SRV Discharge Following Isolation/Scram

Isolation/scram cases are analyzed to demonstrate that the loss of the main condenser by the sudden closure of the MSIVs and subsequent scram, SRV openings at set pressure, and manual depressurization will not result in high pool temperature.

Two single failures are considered separately:

Case 2.a: Single failure of one RHR heat exchanger

Case 2.b: Failure of an SRV to reclose (SORV)
(Note: Case 2.b is not required by NUREG-0783 but is presented to maintain consistency with the "White Paper" cases.)

I.2.2.3 Event 3: SRV Discharge Following a Small Break Accident

SBA cases are analyzed to demonstrate that SRV discharge required to depressurize the reactor coolant system following a small break will not result in high pool temperatures. As a result of continued flow through the break, peak pool temperature is not reached until after SRV discharge has terminated.

Two cases of SBA are considered separately:

Case 3.a: Single failure of one RHR heat exchanger

Case 3.b: Loss of shutdown cooling
(Note: Case 3.b is not required by NUREG-0783 but is presented to maintain consistency with the "White Paper" cases.)

I.2.3 ASSUMPTIONS USED IN THE ANALYSIS

I.2.3.1 General Assumptions

The following general assumptions and initial conditions have been used for all transients. Table I.2-1 summarizes the values for important system characteristics and input parameters listed below.

a. Power level, decay heat standard, RHR heat exchanger capability (considering design fouling factors), and suppression pool initial temperature (maximum technical specification temperature for continuous power operation without pool cooling) are consistent with those used for the analysis of containment pressure and temperature

response to a loss-of-coolant accident specified in the FSAR.

b. The service water temperature is characterized as a transient starting at 88°F (technical specification limit for average spray pond temperature).

c. The initial water level of the suppression pool is at the minimum level in the technical specification.

d. MSIV closure is complete 3.5 seconds after the isolation signal (t=0) for transients where isolation occurs.

e. The water volume within the reactor vessel pedestal is not included in the calculation of pool temperature response.

f. To maximize heat addition to the pool, feedwater at the temperature in excess of instantaneous pool temperature is assumed to maintain RPV level rather than condensate storage tank inventory via RCIC and HPCI. Feedwater injection is terminated when additional feedwater will ultimately result in cooling the pool. (Note: This requirement is more conservative than the NUREG-0783 assumption that "feedwater pumps supply feedwater to the reactor until the feedpumps trip on an automatic signal.") HPCI (from the suppression pool) and CRD (from the condensate storage tank) systems provide vessel makeup after all the hot feedwater is expended. CRD flow was used for all cases except small break accidents with one RHR.

g. Offsite power is not available for isolation/scram and SBA events or where MSIV closure is assumed, except SBA Case 3.b. Offsite power is available for Case 3.b; however, Case 3.b is conservative due to the conservatism associated with feedwater addition (see assumption "if" above) and the unavailability of the main condenser. Also, Case 3.b is not the controlling event for calculation of peak pool temperature (Table I.2-2).

h. High pressure coolant injection (HPCI) system is terminated at or before a pool temperature of 170°F.

i. A single electrical division failure may result in the unavailability of RHR shutdown cooling and one loop of RHR pool cooling. The assessment of this single failure assumption on suppression pool temperature response to SRV discharge is provided in Section I.2.3.2.3.1.

j. The calculation of mass and energy release to the suppression pool due to SRV discharge follows the methodology described in Reference I.2-5.

k. There are no heat losses to the containment atmosphere and structures.

l. The RHR operates in the suppression pool cooling mode 10 minutes after the high pool temperature alarm (95°F).

m. All transients involving one RHR heat exchanger operation assume a minimum controlled depressurization rate and employ a rapid transfer (16 minutes, without flush) from pool cooling to shutdown cooling using the available RHR heat exchanger when the reactor pressure reaches the permissive value (89.7 psia). Shutdown cooling is not used in the analyses for those transients having both RHR trains available.

n. In accordance with the Limerick technical specifications, manual depressurization at a rate of 100°F/hour begins at a pool temperature of 120°F unless the depressurization rate for the event itself (e.g., SORV, SBA) exceeds the required rate at that time. Manual depressurization is terminated upon initiation of shutdown cooling.

o. SRV flow rate = 122.5 percent of ASME rated.

I.2.3.2 <u>Assumptions for Specific Events</u>

This section describes the specific assumptions used for the events described in Section I.2.2. Operator actions are also described for justification of the assumptions.

I.2.3.2.1 Event 1: SORV at Power

This initating event postulates that an SRV is inadvertently actuated while the plant is operating at power. Following actuation, the SRV fails to reseat and remains open throughout the transient. As a result of this malfunction, steam from the primary system is discharged through the SRV and released to the suppression pool.

Two independent systems will generate alarms and displays in the control room so as to give the operator immediate and unambiguous indications of an SORV. First, the safety relief valve position indication (SRVPI) system (FSAR Section 7.6.1.5.1) provides positive indication and alarm of SRV position through the use of acoustic sensors (two per valve) which detect noise generated by steam flow through an open SRV. Secondly, the safety grade suppression pool temperature monitoring system (SPTMS) will indicate a rise in the suppression pool temperature and alert the operator to initiate corrective action. A control room alarm is generated when the average pool temperature increases to 95, 105, 110, and 120°F. Further details of the SPTMS are provided in Appendix I.1.

In accordance with the Emergency Procedure Guidelines (EPGs), the operator will manually scram the reactor by turning the mode switch to "shutdown" if the SRV cannot be reclosed immediately. The EPGs will specify the number of attempts that the operator will be allowed to reclose a stuck open SRV.

For analysis purposes, it is conservatively assumed that manual scram does not occur until the technical specification limit on pool temperature for power operation is reached (110°F).

Case 1.a: Single Failure - One RHR Heat Exchanger Unavailable

- Manual scram at pool temperature = 110°F.
- Offsite power is available.
- One RHR system is placed in pool cooling mode 10 minutes after the SORV.

- The MSIVs remain open because the mode switch has been taken out of the "run" position.

- Following scram, the reactor steam generation will decrease so that the turbine control valves will mechanistically close as the RPV pressure drops, thus isolating the turbine from the reactor. The turbine bypass valves are also mechanistically closed. The steam jet air ejectors will continue to maintain vacuum in the main condenser.

- The operator manually depressurizes the reactor by reestablishing the main condenser as a heat sink through the main turbine bypass system. It is assumed that the operator will manually open the turbine bypass valve 20 minutes after scram.

- The main condenser is available using full bypass capacity until the reactor vessel pressure permissive for RHR shutdown cooling is reached (89.7 psia).

- RHR out of pool cooling when pressure permissive for RHR shutdown cooling is reached; 16 minute delay for RHR transfer to shutdown cooling.

Case 1.b: Single Failure - Spurious Main Steam Line Isolation at Scram

- Manual scram at pool temperature = 110°F

- Non-mechanistic main steam line isolation occurs at scram (t = 0)

- Loss of offsite power.

- Two RHR systems are placed in the pool cooling mode 10 minutes after the SORV.

- When the pool temperature = 120°F, the operator begins manual depressurization to maintain 100°F/hour cooldown rate by opening additional SRVs as needed.

- RHR shutdown cooling is not initiated.

I.2.3.2.2 Event 2: SRV Discharge Following Isolation/Scram

Case 2.a: Single Failure - One RHR Heat Exchanger Unavailable

- Non-mechanistic main steam line isolation and automatic scram at t=0

- Loss of offsite power.

- One RHR system placed in pool cooling mode 10 minutes after the event.

- When the pool temperature = 120°F, the operator begins manual depressurization at a rate of 100°F/hour by opening SRVs as needed.

- RHR out of pool cooling when pressure permissive for RHR shutdown cooling is reached; 16 minute delay for RHR transfer to shutdown cooling.

Case 2.b: Single Failure - SORV

- Non-mechanistic main steam line isolation and automatic scram at t=0.

- SORV occurs at t=0

- Loss of offsite power.

- Two RHR systems are placed in the pool cooling mode 10 minutes after the event.

- When the pool temperature = 120°F, the operator begins manual depressurization to maintain 100°F/hour cooldown rate by opening additional SRVs as needed.

- RHR shutdown cooling is not initiated.

I.2.3.2.3 Event 3: SRV Discharge Following SBA

Case 3.a: Single Failure - One RHR Heat Exchanger Unavailable

- Automatic scram on high drywell pressure at t=0.
- Non-mechanistic main steam line isolation at t=0
- Loss of offsite power.
- One RHR system is placed in the pool cooling mode 10 minutes after event.
- When the pool temperature = 120°F, the operator begins manual depressurization at a rate of 100°F/hour by opening SRVs as needed.
- Automatic RHR switchover to the low pressure coolant injection (LPCI) system mode on LPCI initiation signal. (LPCI signal occurs at (a) low reactor level or (b) high drywell pressure combined with low reactor pressure.) The operator manually converts back to the pool cooling mode in 10 minutes.
- RHR out of pool cooling when pressure permissive for RHR shutdown cooling is reached; 16 minute delay for RHR transfer to shutdown cooling.

Case 3.b: Single Failure - Shutdown Cooling Unavailable

- Automatic scram on high drywell pressure at t=0.
- Non-mechanistic main steam line isolation at t=0.
- Offsite power is available.

- Two RHR systems are placed in the pool cooling mode 10 minutes after event.

- When the pool temperature = 120°F, the operator begins manual depressurization at a rate of 100°F/hour by opening SRVs as needed.

- Automatic RHR switchover to the low pressure coolant injection (LPCI) system mode on LPCI initiation signal. The operator manually converts back to the pool cooling mode in 10 minutes.

- RHR shutdown cooling is not initiated. The operator will ultimately reach cold shutdown by establishing the alternate shutdown cooling path as outlined in FSAR section 15.2.9.

I.2.3.2.3.1 SRV Discharge Following SBA: Single Electrical Division Failure

In response to NUREG-0783, sections 5.7.1(8) and 5.7.2.3(2), Limerick has evaluated the effect of a most limiting single failure on the suppression pool peak temperature. It was concluded that a worst case single failure of an electrical division power source may result in the unavailability of RHR shutdown cooling and one loop of RHR pool cooling. However, the peak pool temperature resulting from this single failure will be bounded by the peak temperature calculated from limiting SBA Case 3.a when taking credit for manual operator action to regain the lost loop of pool cooling.

Approximately 2-1/2 hours are available to the operator for manual realignment of affected valves to obtain additional pool cooling capability from the second RHR heat exchanger. This available time is conservatively derived from the pressure-temperature-time history for comparable Case 3.a (Figure I.2-5). Limiting Case 3.a is similar to the single electrical division failure case because only one loop of RHR pool cooling is available during the depressurization phase of the event.

The time is based on the conservative assumption that loss of offsite power (and subsequent operator awareness of loss of both RHR shutdown cooling and one loop of pool cooling) occurs at a pool temperature of 120°F (technical specification limit for manual depressurization). From Figure I.2-5 (Case 3.a), the pool

temperature reaches 120°F at approximately 1000 seconds. The time available for manual operator action after t=1000 seconds without the pool exceeding the peak calculated temperature is limited to the same point in time in Case 3.a where shutdown cooling was initiated (89.7 psia), i.e., approximately 10,000 seconds. Therefore, the total time available based on limiting Case 3.a is approximately 9,000 seconds or 2-1/2 hours.

A study of required manual operator actions has concluded that a second RHR heat exchanger could be available in the pool cooling mode in less than 2-1/2 hours (the time when Case 3.a peak pool temperature is reached). The pool temperature will decrease following the initiation of the second RHR loop in the pool cooling mode because the heat removal rate of both RHR exchangers will exceed the heat addition rate to the pool at this time in the event.

Because the RHR shutdown cooling mode is not initiated, the operator will ultimately reach cold shutdown by establishing the alternate shutdown cooling path as outlined in FSAR Section 15.2.9. The heat addition rate to the pool resulting from this alternate path of shutdown cooling will be controlled to preclude the possibility of additional pool heatup.

If manual operator actions are required in case of a worst case single electrical division failure, the plant operator could actually reduce the blowdown rate to extend the time before the peak pool temperature is reached. This scenario allows additional time for operator actions and would result in a peak pool temperature which is lower than Case 3.a.

I.2.4 ANALYSIS RESULTS AND CONCLUSIONS

Table I.2-2 lists the peak bulk suppression pool temperatures that were calculated using the General Electric computer code HEX for the scenarios described in Sections I.2.2 and I.2.3. Figures I.2-1 through I.2-6 provide plots of the suppression pool temperature and the respective reactor pressure versus time.

As stated earlier, the pool temperatures summarized in Table I.2-2 represent "bulk" temperatures, i.e., they were calculated assuming a homogeneously mixed suppression pool. In reality, pool mixing will not be perfect and differences will exist between the "local" temperature of the water in the immediate vicinity of the quencher and the calculated "bulk" temperature. However, because of the special design features of quenchers and their predominantly radial orientation in the

suppression pool to optimize pool thermal mixing (Figure 1.4-3), the local-to-bulk ΔT is expected to be small and not exceed the value that was previously derived for ramshead discharge devices in Mark I plants (10°F, Ref. I.2-2). This number will be verified using in-plant tests and analysis (Appendix I.1).

The suppression pool temperature limits defined in NUREG-0783 and listed in Section I.2.1 are specified in terms of "local" pool temperature and quencher mass flux criteria. Because Figures I.2-1 through I.2-6 specify the Limerick time histories in terms of "bulk" pool temperature and reactor pressure, it is necessary to convert the NUREG-0783 local pool temperature limit criteria to bulk pool temperature and reactor pressure criteria. Applying a local-to-bulk ΔT of 10°F as described above and calculating the Limerick reactor pressures corresponding to steam fluxes of 42 and 94 lbm/ft^2 sec, respectively, a bulk suppression pool temperature limit curve is developed. These curves are shown on Figures I.2-1 through I.2-6 and demonstrate that the Limerick suppression pool temperatures due to SRV discharge comply with the temperature limits defined in NUREG-0783.

I.2.5 REFERENCES

I.2-1 RO Bulletin 74-14, "BWR Relief Valve Discharge to Suppression Pool," November 15, 1974.

I.2-2 NUREG-0487, "Mark II Containment Lead Plant Program - Load Evaluation and Acceptance Criteria," October 1978.

I.2-3 Mark II Owners Group, "Assumptions for Use in Analyzing Mark II BWR Suppression Pool Temperature Response to Plant Transients Involving Safety/Relief Valve Discharge," March 24, 1980.

I.2-4 NUREG-0783, "Suppression Pool Temperature Limits for BWR Containments," November 1981.

I.2-5 Letter report, R. H. Bucholz to Karl Kniel dated March 12, 1981, "Mark II Containment Program Method for Calculating Mass and Energy Release for Suppression Pool Temperature Response to Safety Relief Valve Discharges."

TABLE I.2-1 (Page 1 of 2)

SYSTEM CHARACTERISTICS AND INPUT PARAMETERS

REACTOR	
Initial core power (105% Rated)	3.26×10^6 Btu/sec
Initial RPV liquid mass	608,142 lbm
Initial RPV steam mass	24,669 lbm
RPV and internals mass	2.772×10^6 lbm
Initial vessel pressure	1025 psia
Initial steam flow (105% Rated)	4129 lbm/sec
REACTOR MAKEUP	
Initial CRD flow	8.89 lbm/sec
CRD flow after scram (P_{RPV} = 0 psig)	23.6 lbm/sec
CRD enthalpy (from condensate storage tank)	108 Btu/lbm
Feedwater flow rate	as required to maintain RPV level
Feedwater mass/enthalpy	
Mass (lbm)	Enthalpy (Btu/lbm)
165,385	402
256,919	342
370,885	235
359,442	156
235,746	126
HPCI "on" volume (RPV level 2)	12,675 ft^3
HPCI "off" volume (RPV level 8)	15,281 ft^3
VALVES	
Main steam line isolation valve (MSIV) closure time	3.5 sec
SRV flow rate (122.5% ASME)	390 lbm/sec at 1500 psia
SRV setpoints	See DAR Table 1.4-1

TABLE I.2-1 (Cont'd) (Page 2 of 2)

RHR SYSTEM

RHR heat exchanger effectiveness, K (shutdown cooling)	288.9 Btu/sec °F
RHR heat exchanger effectiveness, K (pool cooling)	288.9 Btu/sec °F
RHR flow rate in pool cooling	1390 lbm/sec
RHR flow rate in shutdown cooling	1390 lbm/sec
RHR pump horsepower	1250 hp/pump
RHR service water temperature	88°F at time = 0 sec 91.2°F at time = 18,000 sec 92.5°F at time = 36,000 sec
RHR service water flow rate	9000 gpm
Maximum reactor pressure for switch-over from RHR pool cooling to shutdown cooling	89.7 psia

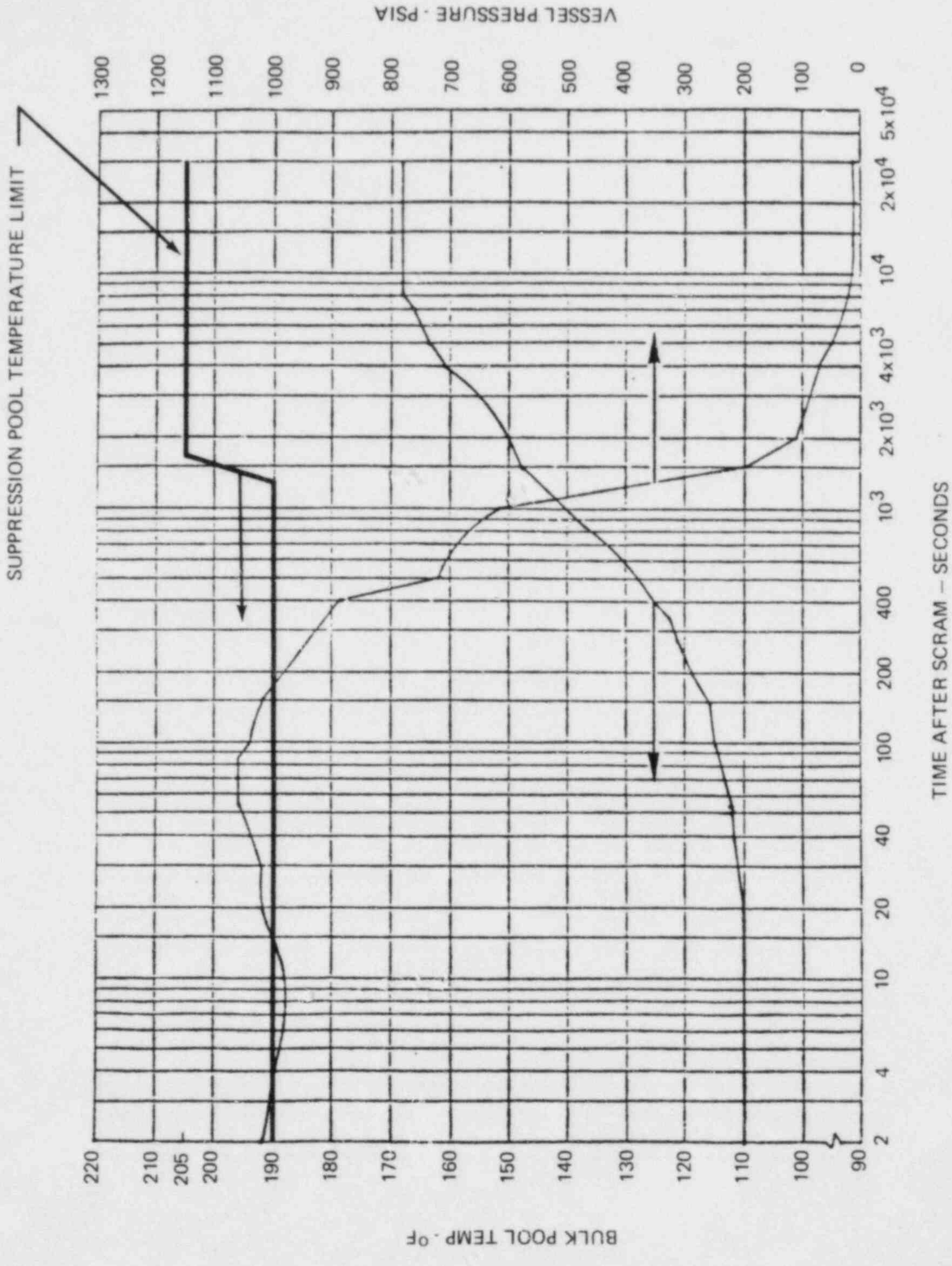
WETWELL/SUPPRESSION POOL

Wetwell airspace pressure	15.45 psia
Initial suppression pool water mass (at low water level, without water mass inside pedestal)	7.194×10^6 lbm
Initial suppression pool temperature	95°F
Suppression pool temperature technical specification limits for:	
a) Continuous operation without suppression pool cooling	95°F
b) Continuous testing at power	105°F
c) Power operation (Scram tech. spec. temperature)	110°F
d) Hot standby (Depressurization tech. spec. temperature)	120°F
Quencher submergence (at low water level)	18.5 feet

TABLE I.2-2

PEAK SUPPRESSION POOL TEMPERATURES

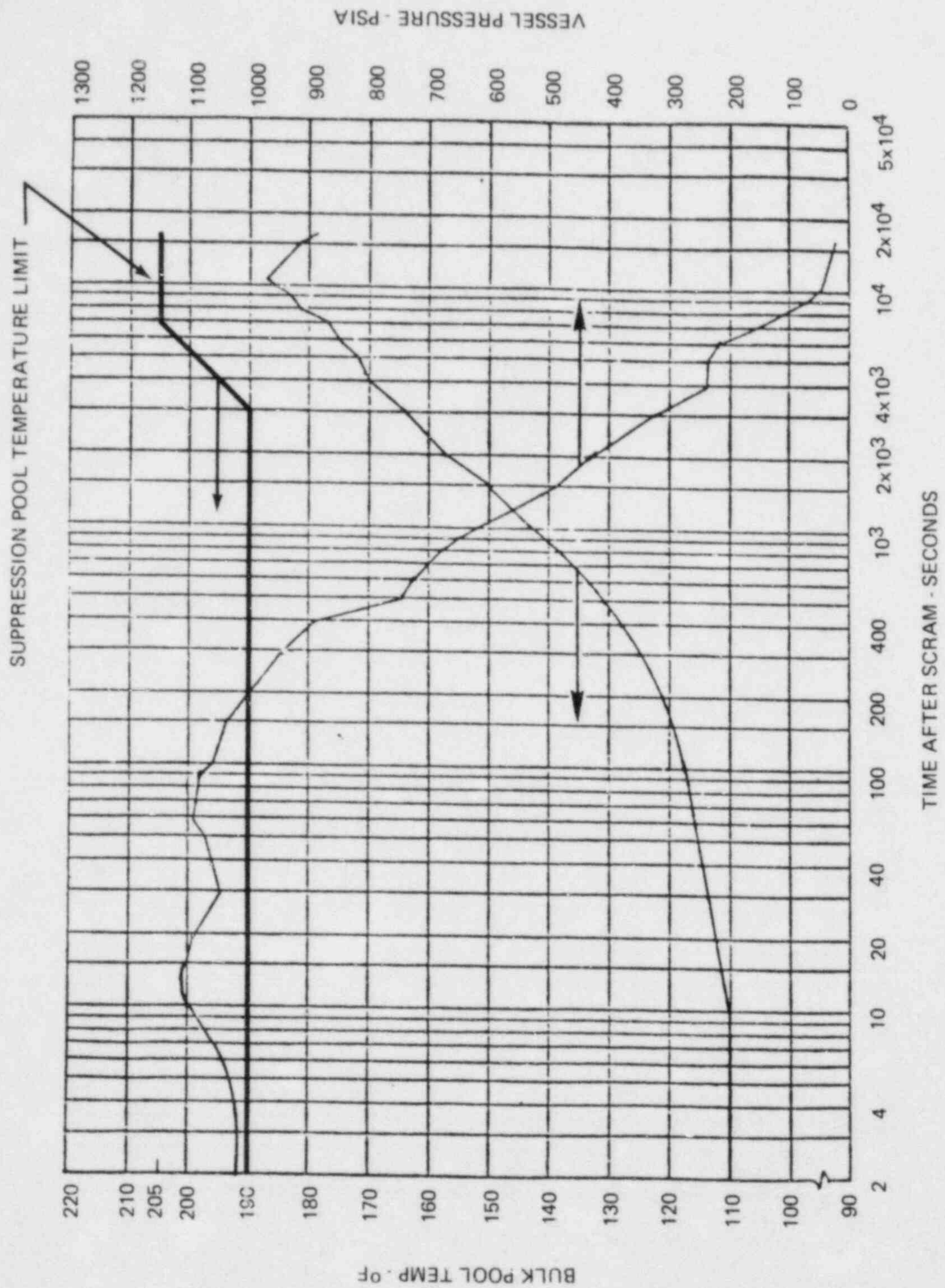
EVENT	TEMPERATURE
1. SORV at Power	
Case 1.a	169°F
Case 1.b	187°F
2. Isolation/Scram	
Case 2.a	201°F
Case 2.b	183°F
3. SBA	
Case 3.a	202°F
Case 3.b	182°F



LIMERICK GENERATING STATION
UNITS 1 AND 2
DESIGN ASSESSMENT REPORT

SUPPRESSION POOL
TEMPERATURE TRANSIENT
CASE 1.a

FIGURE I.2-1 | **REV. 4, 06/83**



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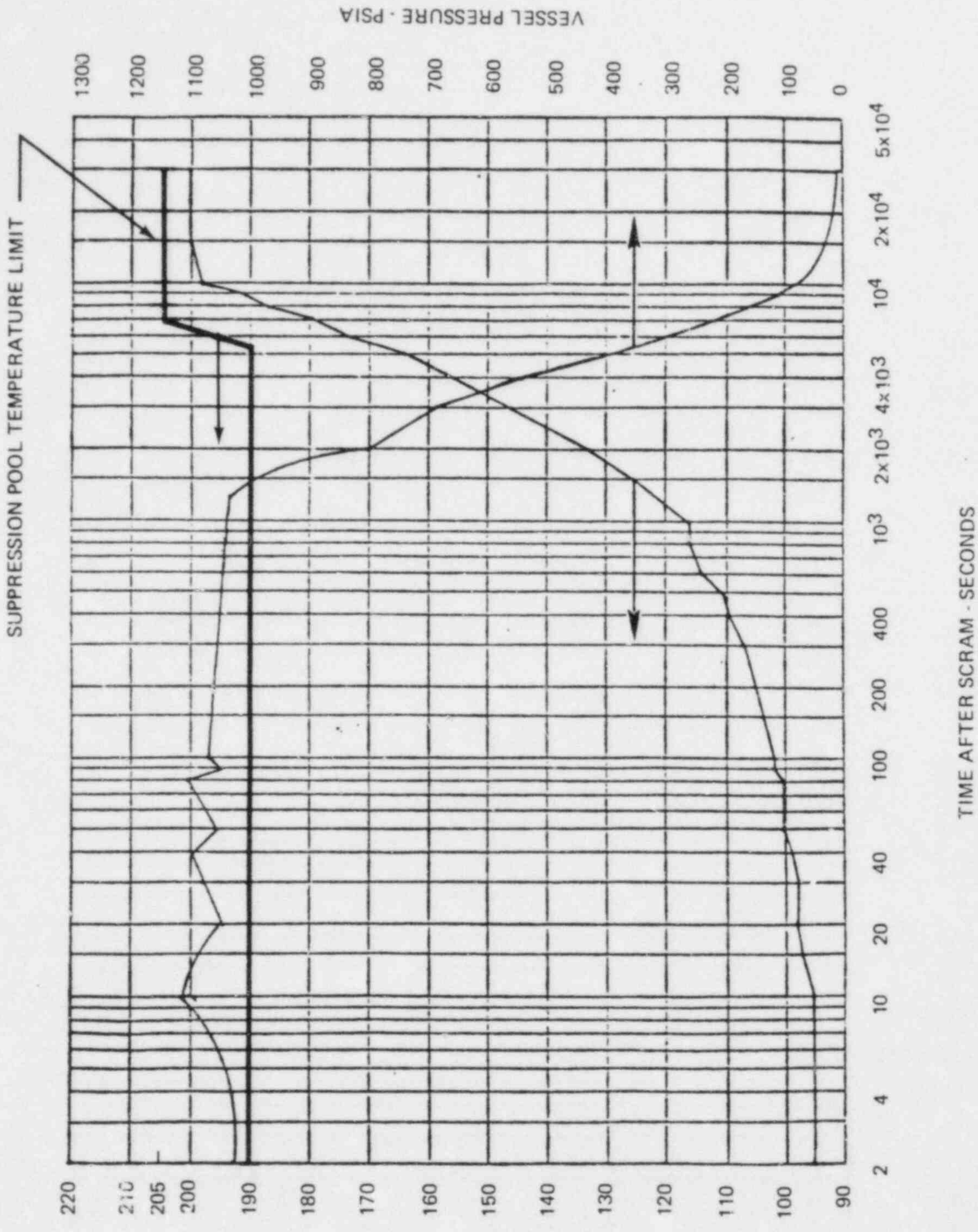
SUPPRESSION POOL
TEMPERATURE TRANSIENT
CASE 1.b

FIGURE I.2-2 **REV. 4, 06/83**



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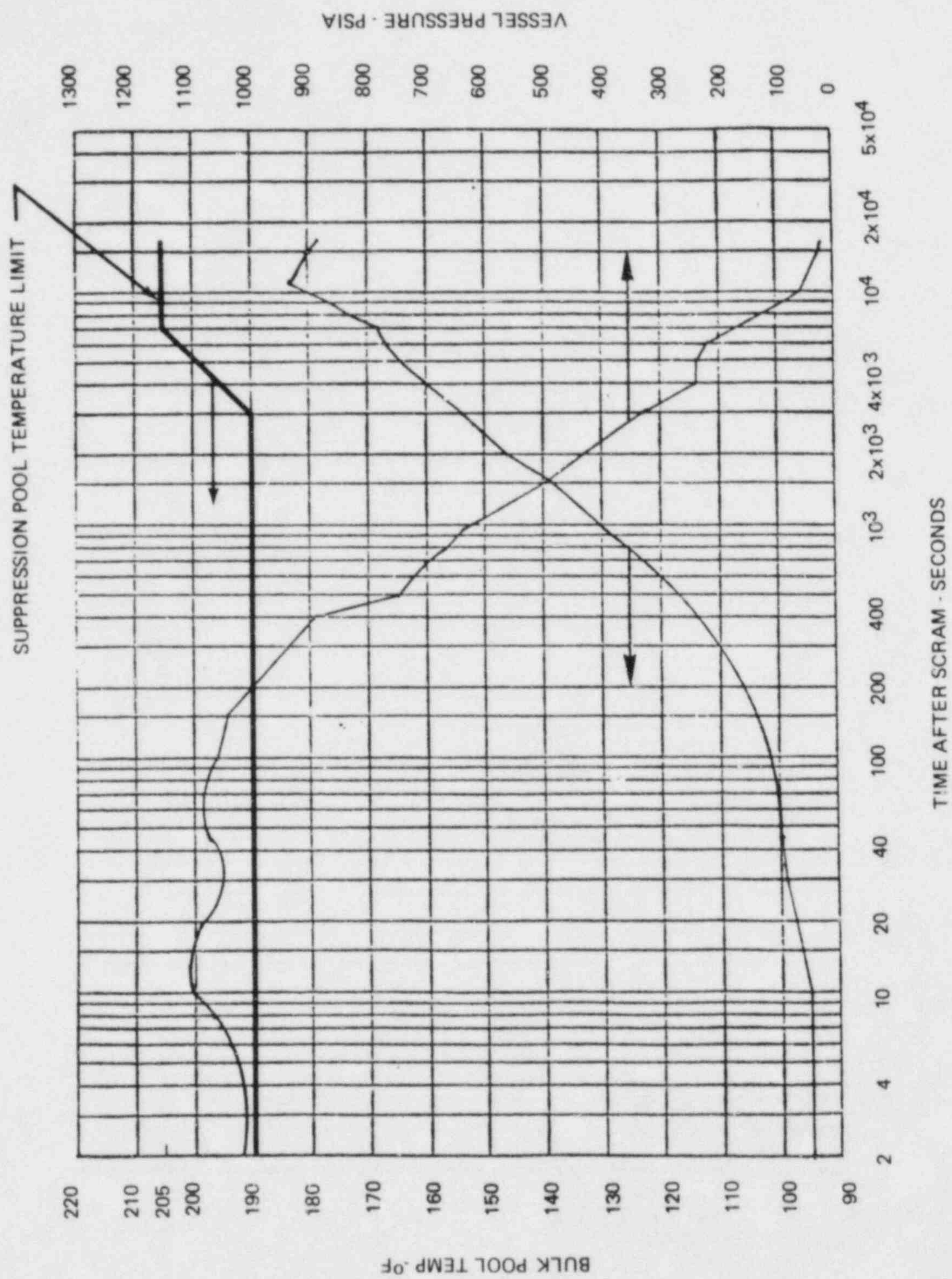
UNITS 1 AND 2

DESIGN ASSESSMENT REPORT

SUPPRESSION POOL
TEMPERATURE TRANSIENT
CASE 2.a

FIGURE I.2-3 REV. 4, 06/83



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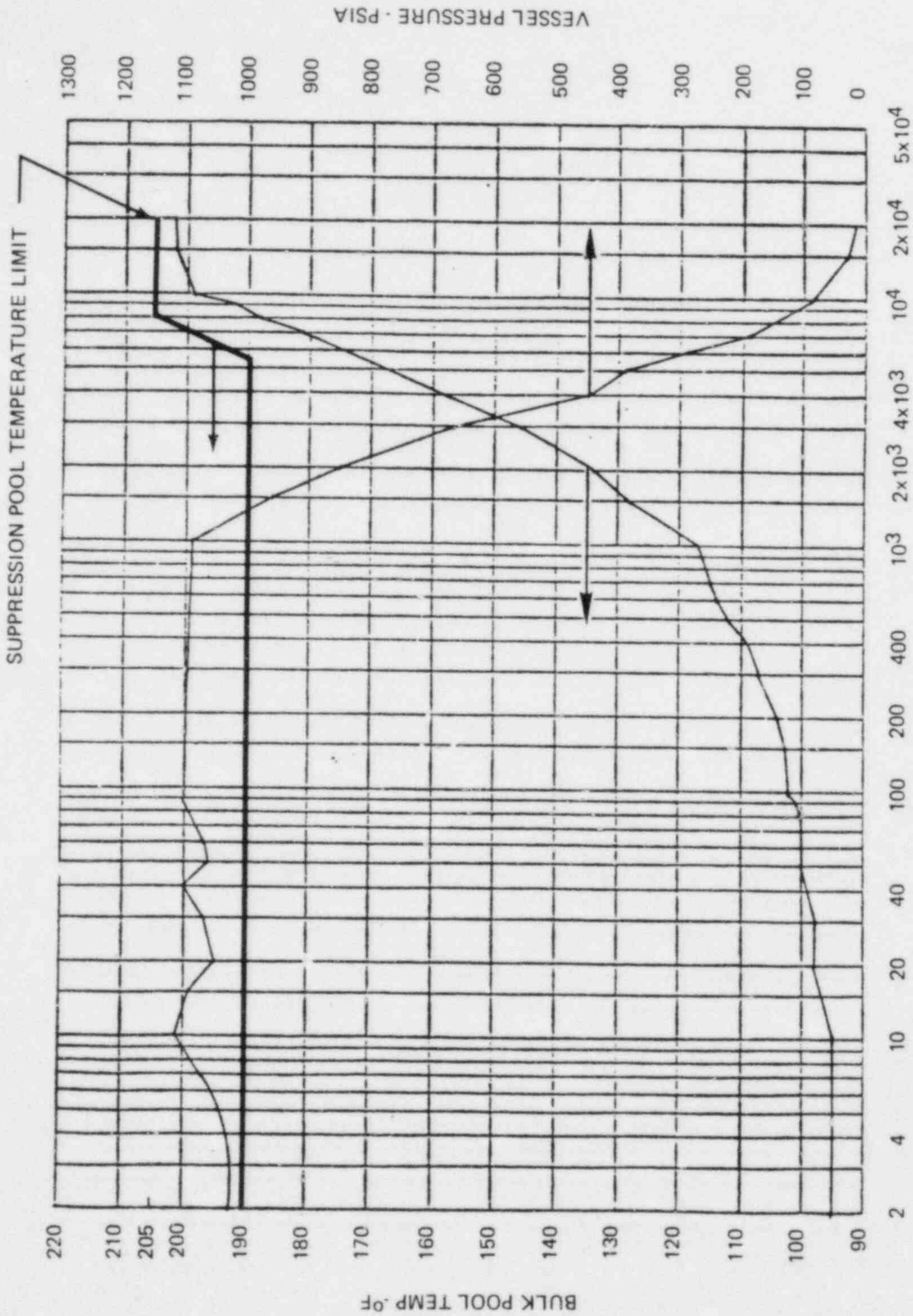
UNITS 1 AND 2
DESIGN ASSESSMENT REPORT

SUPPRESSION POOL
TEMPERATURE TRANSIENT
Case 2.b

FIGURE I.2-4 REV. 4, 06/83



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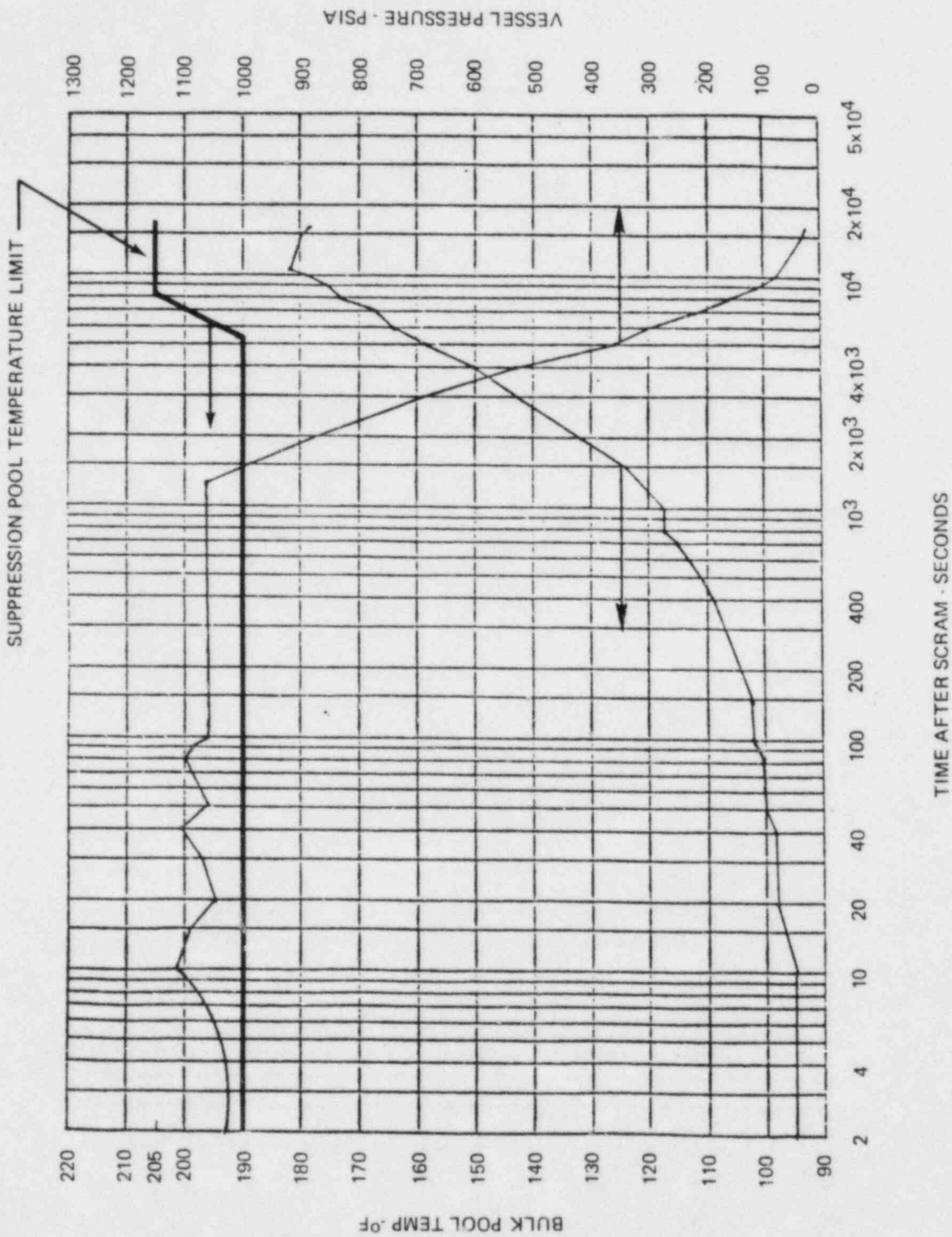
SUPPRESSION POOL
TEMPERATURE TRANSIENT
CASE 3.a

FIGURE I.2-5 **REV. 4, 06/83**



LIMERICK GENERATING STATION
UNITS 1 AND 2
DESIGN ASSESSMENT REPORT

SUPPRESSION POOL
TEMPERATURE TRANSIENT
CASE 3.b

FIGURE I.2-6 **REV. 4, 06/83**