LIMERICK GENERATING STATION UNITS 1 & 2

DESIGN ASSESSMENT REPORT

REVISION 6 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 have been inserted, place the page that follows these instructions in the front of Volume 1.

REMOVE	INSERT
VOLUME 1	
Table 1.3-2 (pgs 1,2,3,7,11)	Table 1.3-2 (pgs 1,2,3,7,11)
Table 1.4-1 (pgs 1 thru 3)	Table 1.4-1 (pgs 1 thru 4)
Page 4-iii	Page 4-iii
Pages 4.2-15 & -16	Pages 4.2-15 & -16
Tables 4.2-2 thru -4	Tables 4.2-2 thru -4
Figures 4.2-17 thru -23	Figures 4.2-17 thru -23
Table 5.7-1 (pgs 1 & 2)	Table 5.7-1 (pgs 1 & 2)
Page 480.71-1	Page 480.71-1
VOLUME 2	
----	Appendix J

THIS DAR SET HAS BEEN UPDATED TO INCLUDE REVISIONS THROUGH 6
DATED 11/83.

COMPARISON

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

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-0808	Acceptable. Used NUREG-0487, Supplement 1
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-0808	Acceptable. Used NUREG-0487. PSAM calculates velocity without 1.1 multiplier. However, poolswell velocity multiplied by 1.1 when used in force code.

Also Available On Aperture Card

8312020335-01

Load or Phenomenon

d. Poolswell Acceleration

e. Wetwell Air Compression

f. Drywell Pressure

2. Loads on Submerged Boundaries

3. Impact Loads

a. Small Structures

RC Acceptance Criteria	Criteria Source	LGS Position
aximum velocity applies hereafter up to maximum oolswell. PSAM predic- ed velocities multiplied y a factor of 1.1.		
cceleration predicted y the PSAM. Pool cceleration is used in he calculation of cceleration loads on ubmerged components uring poolswell.	NUREG-0487	Acceptable
etwell air compression s calculated by PSAM onsistent with maximum oolswell elevation alculated in B.1.b bove.	NUREG-0487 Supplement 1	Acceptable. Maximum poolswell elevation calculated in accordance with NUREG-0487, Supplement 1.
ethods of NEDM-10320 nd NEDO-20533 Appendix . Used in PSAM to cal- ulate poolswell loads.	NUREG-0487	Acceptable
aximum bubble pressure redicted by the PSAM dded uniformly to local ydrostatic pressure elow vent exit (walls nd basemat) - linear ttenuation to pool surface. pplied to walls up to max- mum poolswell elevation.	NUREG-0487	Acceptable
.35 x Pressure-Velocity orrelation for pipes nd I-beams based on STF impulse data and lat pool assumption. ariable pulse duration.	NUREG-0808	Acceptable

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Aperture Card

PRC
APERTURE
CARD

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.)

Acceptance Criteria	Criteria Source	LGS Position
ne - Plant unique load re applicable.	NUREG-0487	Not Applicable No large structures
olswell drag vs. grating area rrelation and pool velocity elevation. Pool velocity m the PSAM. Poolswell g multiplied by dynamic d factor.	NUREG-0808	Acceptable
ect application of PSAM calculated ssure due to wetwell pression.	NUREG-0487	Acceptable
psid for diaphragm dings only.	NUREG-0808	Acceptable. Calculated diaphragm uplift ΔP = 10.6 psid (Figs. 4.2-3, 4.2-4). Design diaphragm uplift ΔP = 20 psid.
20 percent of max- m bubble pressure tically applied to of the submerged ndary.	NUREG-0808	Acceptable
amic load to end of t. Half sine wave h a duration of 3 to s and corresponding imum amplitudes of to 10 Klbf.	NUREG-0808	Acceptable

Also Available On Aperture Card

PRC APERTURE CARD

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, as interpreted in Sections 2.2.3 and 2.3.3 of NUREG-0802, may be applied for evaluation of quencher and quencher support.	NUREG-0802	Acceptable

TA

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)

RC Acceptance Criteria	Criteria Source	LGS Position
ethodology for establish-ing loads resulting from eismic slosh to be valuated on a plant unique asis.	NUREG-0487	Load is negligible when compared to design basis loads (Section 4.2.3.7)
n the event that an applicant annot demonstrate, to the staff's atisfaction, equivalence in any f the areas cited in acceptance riteria A.1.1 through A.1.7 of UREG-0802, Appendix A, in-plant onfirmatory testing may be employed o demonstrate the applicability f the acceptance criteria for ndividual plants. Such testing, f proposed, should conform to the uidelines 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, justification should be provided following the guidelines specified in Section 4 of NUREG-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, at suppression pool low water level, including downcomers, ft³	243,580(3)	
Suppression chamber free volume including pedestal interior, ft³		
Low water level		159,540(3)
High water level		147,670(3)
Suppression pool water volume including pedestal interior, ft³		
Low water level		122,120(3)
High water level		134,600(3)
Suppression pool net surface area, ft²		
Outside pedestal		4974
Inside pedestal		293
Supression pool depth, ft		
Low level		22'
Normal level		23'
High level		24'-3"

TABLE 1.4-1 (Cont'd) (Page 2 of 4)

	Drywell	Suppression Chamber
VENT SYSTEM		
Number of downcomers		87(4)
Nominal downcomer diameter, ft		2
Downcomer area (each), ft^2		2.95
Downcomer submergence, ft		
Low water level		10'
Normal water level		11'
High water level		12'-3"
Downcomer loss coefficient (including exit loss)		2.18(3)
SAFETY RELIEF VALVES		
Number		14

Spring Set Pressures, Mass Flow Rates:

Valve	Set Pressure (psig)	Mass Flow (lbm/hr) at 103% of Spring Set Pressure
A	1150	917,000
B	1150	917,000
C	1150	917,000
D	1140	909,000
E*	1140	909,000
F	1150	917,000
G	1150	917,000
H*	1130	901,500
J	1130	901,500

TABLE 1.4-1 (Cont'd)

Valve	Set Pressure (psig)	Mass Flow (lbm/hr) at 103% of Spring Set Pressure
K*	1140	909,000
L	1130	901,500
M*	1140	909,000
N	1130	901,500
S*	1140	909,000

*ADS Valves

SAFETY RELIEF VALVE DISCHARGE LINES

Nominal Diameter 12"

Length, Number of Bends, and Air Volume for each SRV Pipe:

Valve	Bends	Length[1] (ft)	Volume[2] (ft^3)
A	9	142.2	94.3
B	7	115.1	74.2
C	7	115.3	75.4
D	9	142.2	94.8
E	9	133.6	89.1
F	11	134.0	88.3
G	11	134.6	88.5
H	11	138.1	91.2
J	7	116.1	76.0
K	12	131.6	86.2
L	10	131.6	86.5
M	13	134.9	88.2

TABLE 1.4-1 (Cont'd) (Page 4 of 4)

Valve	Bends	Length[1] (ft)	Volume[2] (ft^3)
N	10	142.2	93.8
S	12	140.0	93.2

(1) Line lengths are measured from the valve to the quencher inlet.
(2) Air volume is calculated up to pool normal water level.
(3) These values vary slightly from those actually used in the analysis. The difference in analysis results is negligible.
(4) Four of 87 downcomers are capped (Appendix J).

CHAPTER 4

TABLES

the structural loading conditions in the containment because they are the basis for other containment hydrodynamic phenomena. The response must be determined for a range of parameters such as break size, reactor pressure, and containment initial conditions.

4.2.4.1 Design Basis Accident (DBA) Transients

The DBA LOCA for LGS is conservatively estimated to be a 3.538 ft^2 break of the recirculation line. This transient results in the maximum drywell pressure and therefore governs the LOCA hydrodynamic loads. The LGS-unique assumptions and input for the analysis are given in FSAR Section 6.2.1. Drywell and wetwell pressure and temperature reponses are shown in Figures 4.2-11 and 4.2-12. This description of the transient does not include the effect of reactor subcooling.

4.2.4.2 Intermediate Break Accident (IBA) Transients

The worst-case intermediate break for LGS is a 0.1 ft^2 break of a liquid line. The drywell and wetwell pressure and temperature responses are shown in Figures 4.2-13 and 4.2-14. This description of the transient does not include the effect of reactor subcooling.

4.2.4.3 Small Break Accident (SBA) Transients

Plant-unique SBA data for LGS is not available. The wetwell and drywell pressure and temperature transients for a typical Mark II containment are used to estimate the LGS containment response to these accidents. These curves are shown in Figure 4.2-15 (extracted from Reference 4.2-6).

4.2.5 LOCA LOADING HISTORIES FOR LGS CONTAINMENT COMPONENTS

The various components directly affected by LOCA loads are shown schematically in Figure 4.2-16. These components may in turn load other components as they respond to the LOCA loads. For example, lateral loads on the downcomer vents produce minor reaction loads in the drywell floor from which the downcomers are supported. The reaction load in the drywell floor is an indirect load resulting from the LOCA and is defined by the appropriate structural model of the downcomer/drywell floor system. Only the direct loading situations are described in detail here.
Table 4.2-11 is a LOCA load chart for LGS. This chart shows

TABLE 4.2-2

SHORT-TERM DRYWELL PRESSURE DURING POOLSWELL

Time (sec)	Pressure (psia)
0.0000[1]	36.11
0.0600	36.29
0.1000	36.82
0.1200	37.08
0.1600	37.57
0.2000	38.04
0.2400	38.49
0.2800	38.91
0.3200	39.30
0.3600	39.67
0.4000	40.01
0.5000	40.75
0.6000	40.75
0.7000	41.39
0.8000	42.07
0.9000	42.30
1.0000	43.56
1.1000	44.603
1.2000	45.36
1.3000	46.08
1.4000	46.75

[1] Represents the beginning of the poolswell phase, which starts 0.7107 seconds after the break.

TABLE 4.2-3

LGS PLANT UNIQUE POOLSWELL CODE INPUT DATA

Downcomer area (each)	2.95 ft^2
Suppression pool free surface area (outside pedestal)	4973.89 ft^2
Maximum downcomer submergence	12.25 ft
Downcomer loss coefficient (without exit loss)	1.11
Number of downcomers	87
Initial wetwell pressure	15.45 psia
Wetwell free air volume	149,425 ft^3
Vent clearing time	0.7107 sec
Slug velocity in downcomer at vent clearing	3.096 ft/sec
Initial drywell temperature	135°F
Initial drywell relative humidity	0.20
Downcomer friction coefficient, f	0.0115 (nominal)
Bubble initialization parameter (nominal)	50

TABLE 4.2-4

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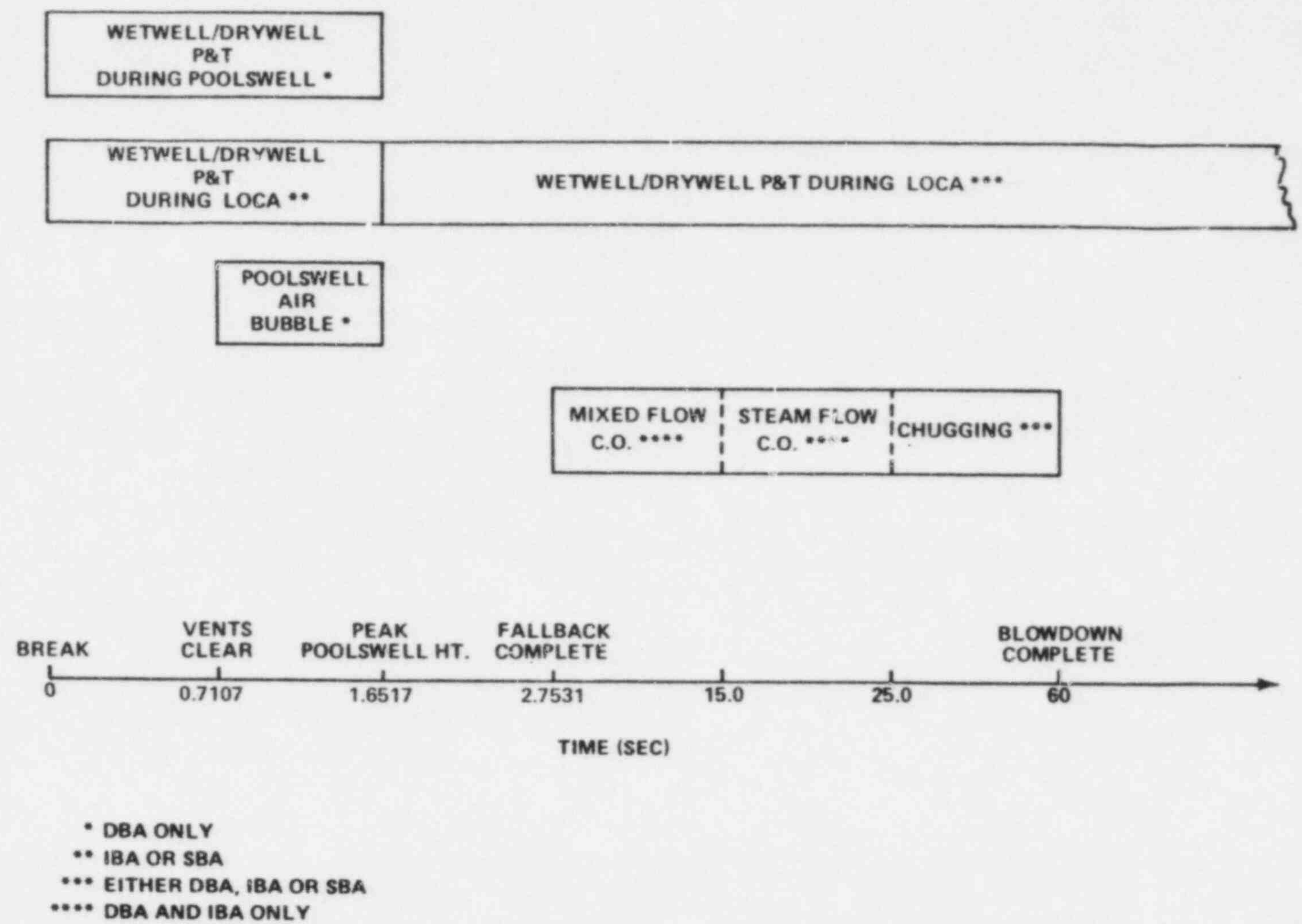

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LOCA LOADING HISTORY
FOR THE CONTAINMENT WALL
AND PEDESTAL

FIGURE 4.2-17

REV. 6, 11/83

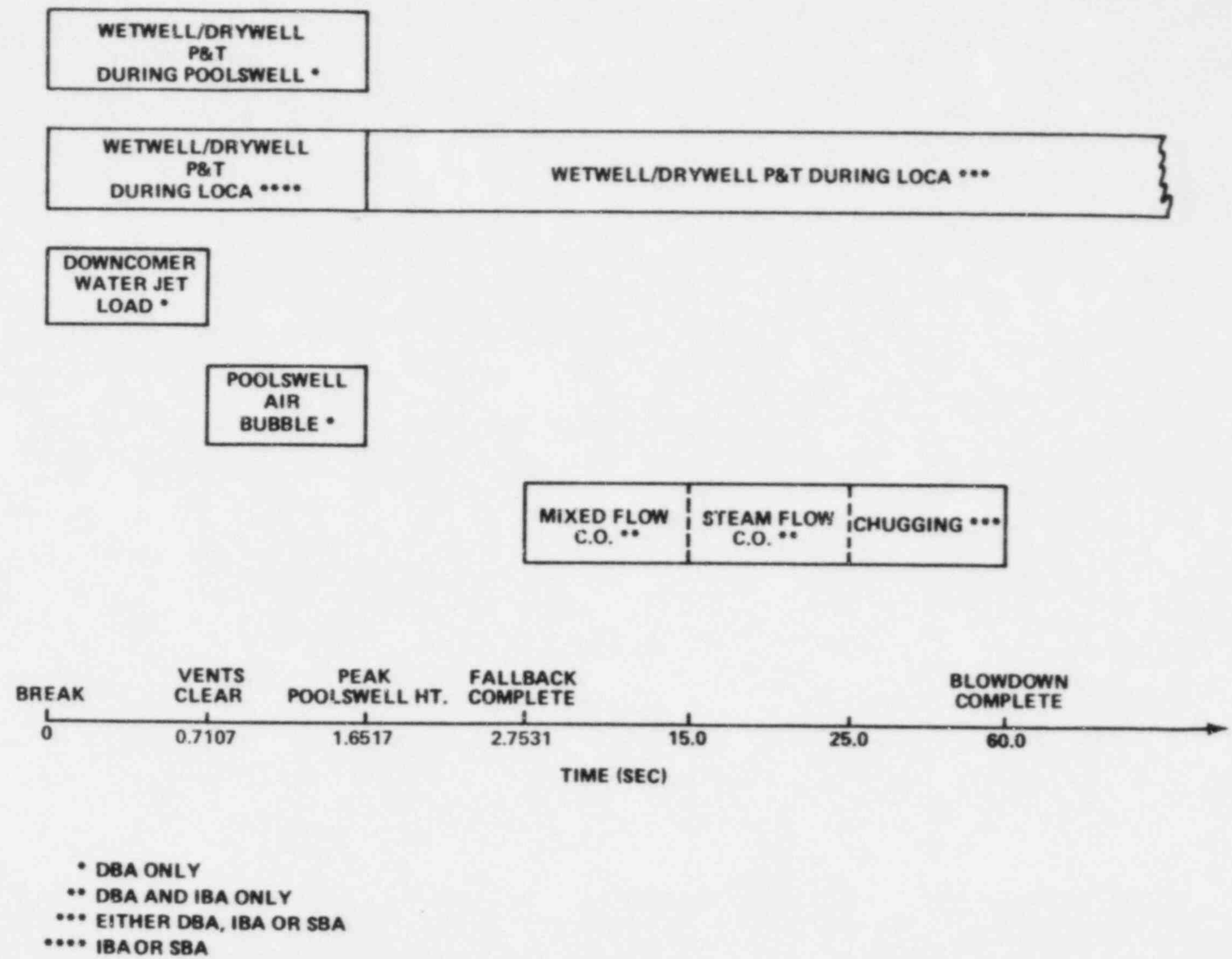

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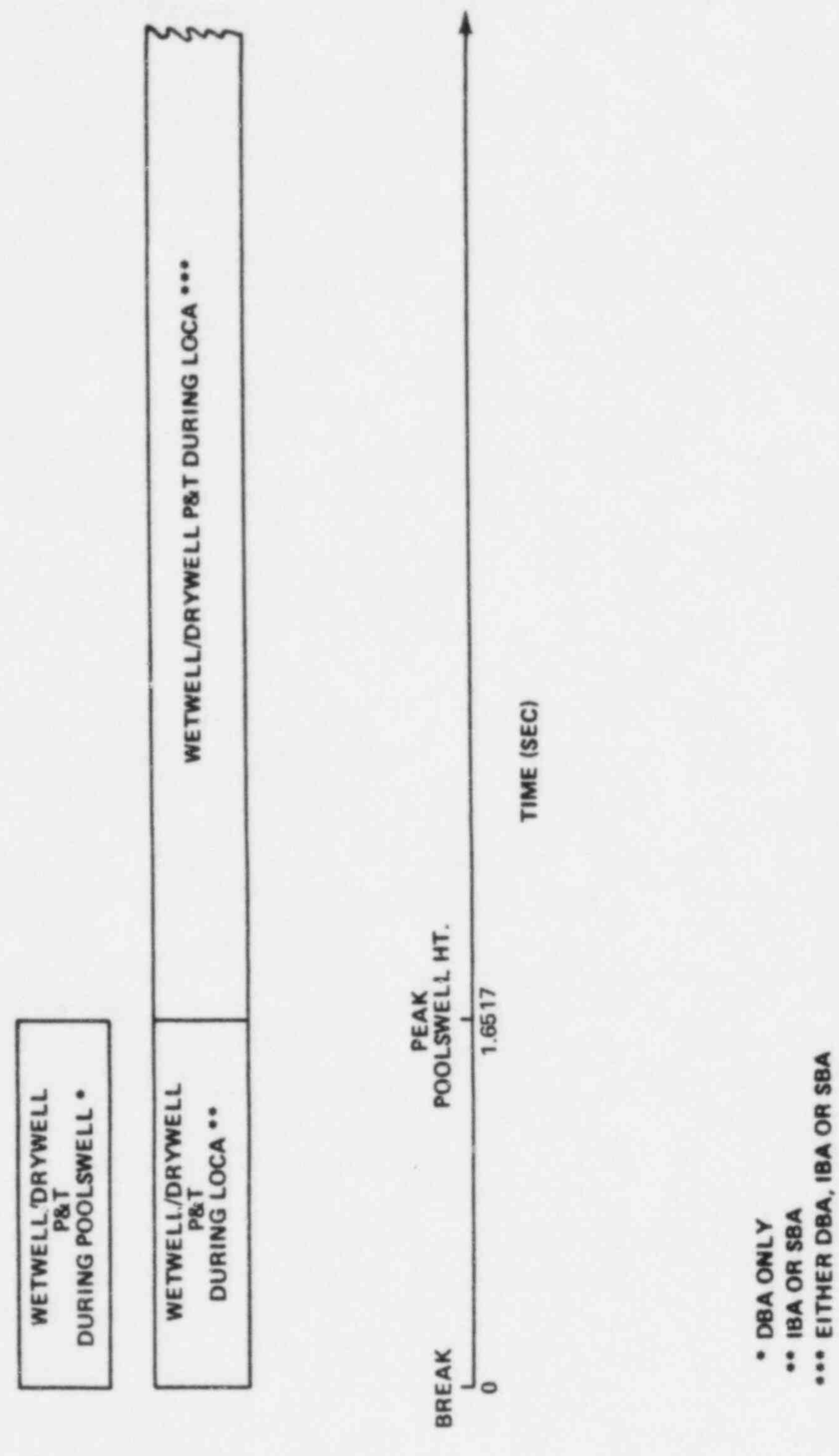
FIGURE 4.2-18

LOCA LOADING HISTORY
FOR THE BASEMAT
AND LINER PLATE

REV. 6, 11/83



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LOCA LOADING HISTORY
FOR THE DRYWELL AND
DRYWELL FLOOR

FIGURE 4.2-19 REV. 6, 11/83

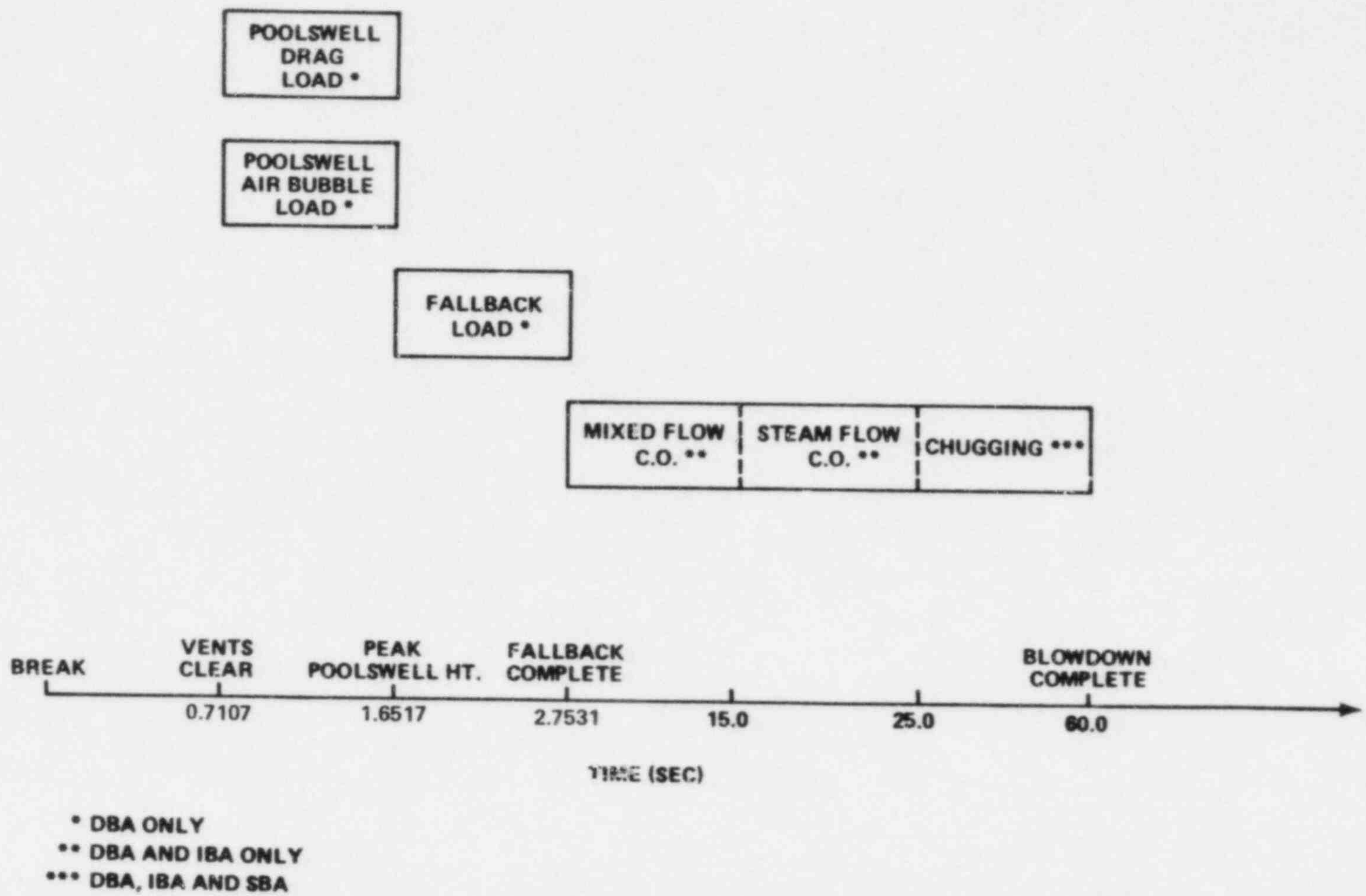

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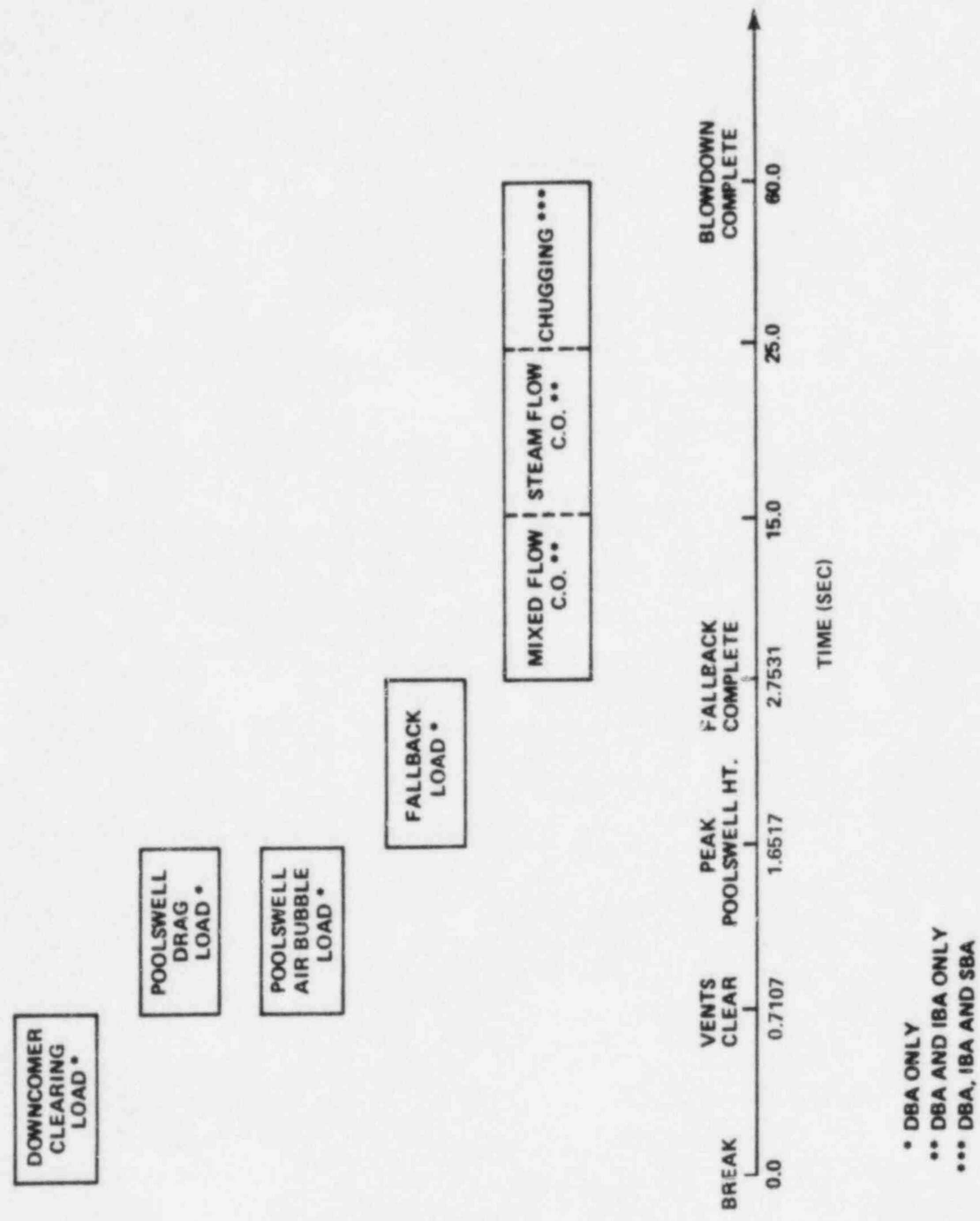
FIGURE 4.2-20

LOCA LOADING HISTORY FOR THE COLUMNS

REV. 6, 11/83



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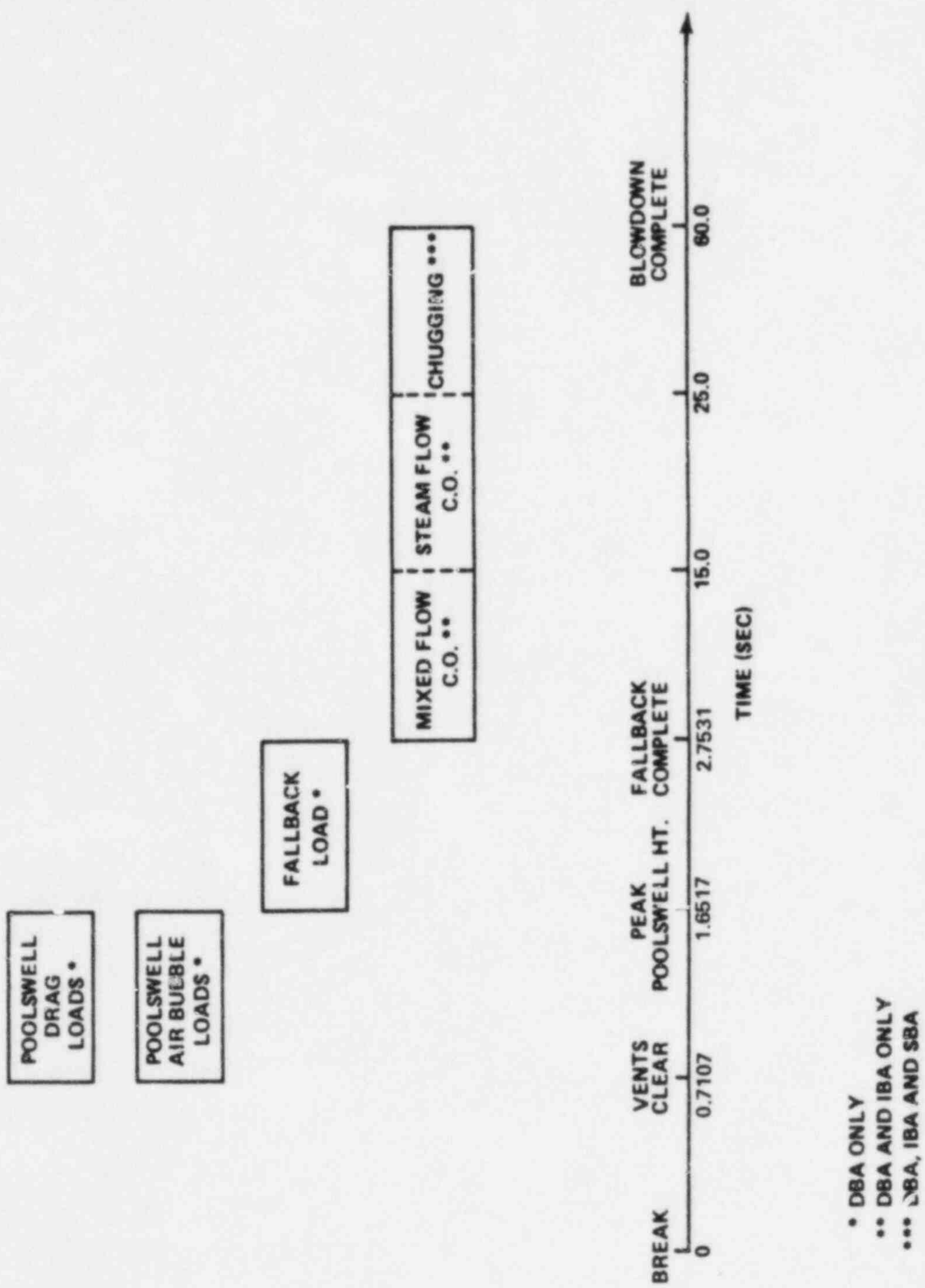
LOCA LOADING HISTORY
FOR THE DOWNCOMERS

FIGURE 4.2-21 REV. 6, 11/83



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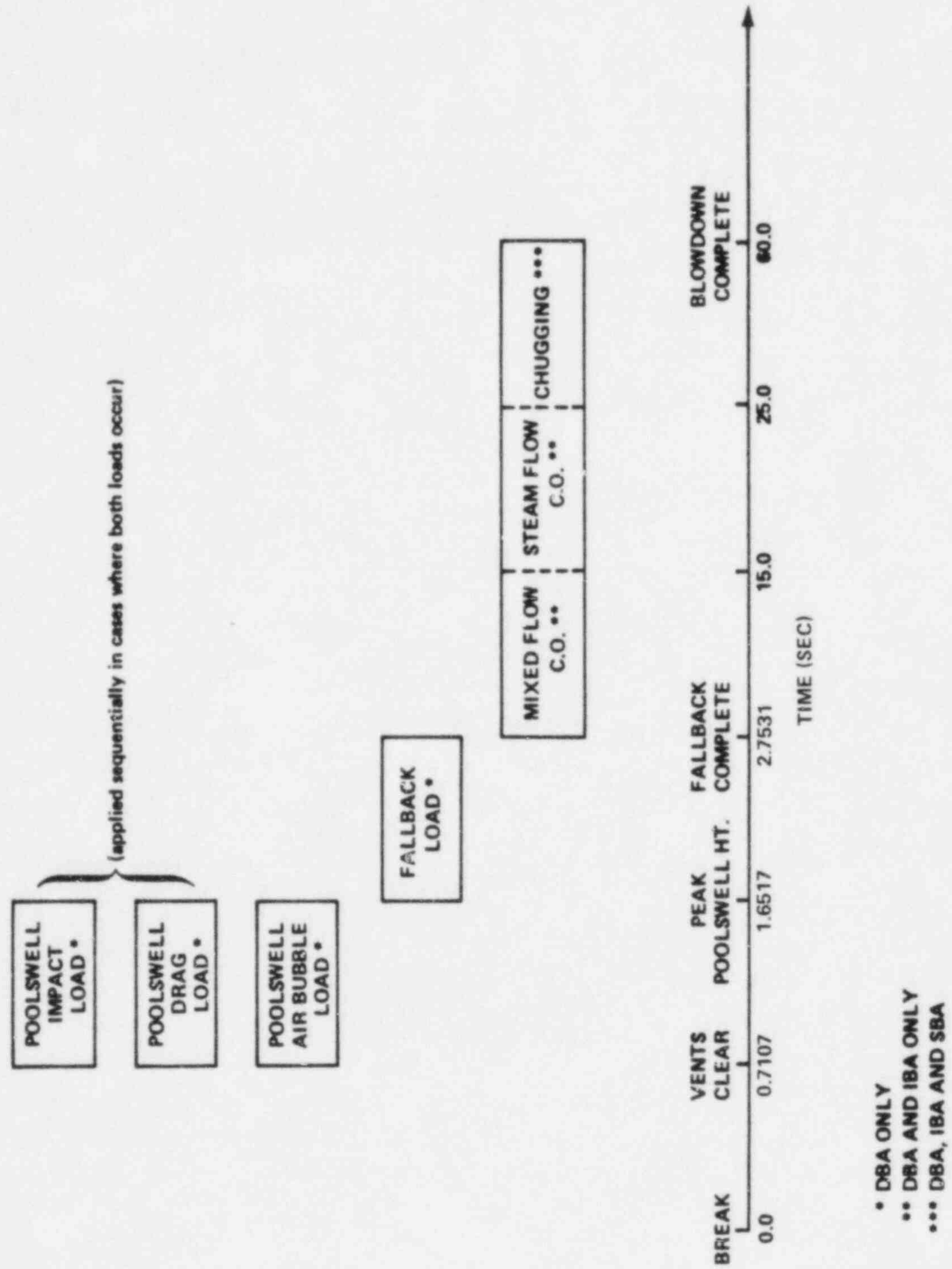
LOCA LOADING HISTORY FOR THE DOWNCOMER BRACING SYSTEM

FIGURE 4.2-22

REV. 6, 11/83



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LOCA LOADING HISTORY
FOR THE WETWELL PIPING

FIGURE 4.2-23

REV. 6, 11/83

TABLE 5.7-1 (Page 1 of 2)

LOAD COMBINATIONS AND ACCEPTANCE CRITERIA FOR
ASME CLASS 1, 2 AND 3 NSSS PIPING, EQUIPMENT, AND SUPPORTS

LOAD COMBINATION	DESIGN BASIS	EVALUATION[3] BASIS	SERVICE LEVEL
N + $SRV_{(ALL)}$	Upset	Upset	(B)
N + OBE	Upset	Upset	(B)
N + OBE + $SRV_{(ALL)}$	Emergency	Upset	(B)
N + SSE + $SRV_{(ALL)}$	Faulted	Faulted	(D)[1]
N + SBA + SRV	Emergency	Emergency	(C)[1]
N + SBA + $SRV_{(ADS)}$	Emergency	Emergency	(C)[1]
N + SBA/IBA + OBE + $SRV_{(ADS)}$	Faulted	Faulted	(D)[1]
N + SBA/IBA + SSE + $SRV_{(ADS)}$	Faulted	Faulted	(D)[1]
N + LOCA[2] + SSE	Faulted	Faulted	(D)[1]

LOAD DEFINITION LEGEND

N - Normal loads (e.g., weight, pressure, temperature, etc)

OBE - Operating basis earthquake loads

SSE - Safe shutdown earthquake loads

SRV - Safety/relief valve discharge induced loads from two adjacent valves (one valve actuated when adjacent valve is cycling)

TABLE 5.7-1 (cont'd) (Page 2 of 2)

SRV_{ALL}	-	Loads induced by actuation of all 14 safety/relief valves that activate within milliseconds of each other (e.g., turbine trip operational transient)
SRV_{ADS}	-	Loads induced by the actuation of all 5 safety/relief valves associated with automatic depressurization system that actuate within milliseconds of each other during the postulated small or intermediate size pipe rupture.
LOCA	-	Loss-of-coolant accident associated with the postulated pipe rupture of large pipes (e.g., main steam, feedwater, recirculation piping)
$LOCA_1$	-	Poolswell drag/fallback loads on piping and components located between the main vent discharge outlet and the suppression pool water upper surface
$LOCA_2$	-	Poolswell impact loads on piping and components located above the suppression pool water upper surface
$LOCA_3$	-	Oscillating pressure induced loads on submerged piping and components during condensation oscillations
$LOCA_4$	-	Building motion induced loads from chugging
$LOCA_5$	-	Building motion induced loads from main vent air clearing
$LOCA_6$	-	Vertical and horizontal loads on main vent piping
$LOCA_7$	-	Annulus pressurization loads
SBA	-	Abnormal transients associated with a small break accident
IBA	-	Abnormal transients associated with an intermediate break accident.

---

(1) All ASME Class 1, 2 and 3 piping that are required to function for safe shutdown under the postulated events are designed to meet the requirements described in NEDO-21985 (Sept. 1978).

(2) The most limiting case of load combinations among $LOCA_1$ through $LOCA_7$.

(3) Evaluation basis in accordance with NRC requirements.

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-to-drywell vacuum breakers are mounted have been 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.

DAR Appendix J has been added to provide details of the wetwell-to-drywell vacuum breaker and downcomer capping adequacy assessments.

APPENDIX J

WETWELL-TO-DRYWELL VACUUM BREAKER AND DOWNCOMER CAPPING ADEQUACY ASSESSMENT

TABLE OF CONTENTS

APPENDIX J

FIGURES

APPENDIX J

J.1 INTRODUCTION

In April 1981, the ACRS expressed concern regarding the potential pool bypass from a stuck-open wetwell-to-drywell vacuum breaker. This concern stems from the fact that following the onset of a LOCA about 20 seconds into the transient, the chugging phenomenon takes place. This rapid steam condensation will cause repeated and strong dynamic under and overpressure conditions in the downcomer. As a result of this pressure variation, the vacuum breaker attached to the downcomer may open.

Because chugging is a repetitive phenomenon, the vacuum breaker may be called on to function in a cyclic manner during these intermittent steam condensation events. These potential opening and closing impact loads could exceed the original design basis of the vacuum breakers. Failure of a vacuum breaker to close during this time could result in steam bypass of the suppression pool and subsequent pressurization of the wetwell air space, thus jeopardizing the integrity of the containment.

In July 1981, the NRC staff was informed that the Mark II owners who have vacuum breakers attached to the downcomer were conducting a joint qualification test program to demonstrate the operability of the vacuum breaker under this intermittent steam condensation loading. The Mark II owners also identified the potential adverse effect of poolswell on the performance of vacuum breakers. Because the wetwell air space will pressurize during the poolswell event, the resulting differential pressure will cause the vacuum breaker to cycle open and then cycle closed when the pool falls back to the normal water level. The potential opening and closing impact load could exceed the original design basis of the vacuum breakers.

J.2 DESIGN ASSESSMENT

J.2.1 VACUUM BREAKER CYCLING DURING POOLSWELL

To qualify the Limerick vacuum breakers to withstand the dynamic effects of poolswell, design modifications to the vacuum breakers have been implemented based on results from the Anderson Greenwood Company (AGCo) vacuum breaker test program. The modifications and test program results have been transmitted to the NRC (References J.2-1 and J.2-2).

J.2.2 VACUUM BREAKER CYCLING DURING CHUGGING

To qualify the Limerick vacuum breakers to withstand the dynamic effects of chugging, the four downcomers on which the wetwell-to-drywell vacuum breakers are mounted have been capped. Capping the downcomers will eliminate the dynamic under and overpressures caused by the sudden steam condensation at the downcomer exit and eliminate the vacuum breaker cyclic actuation due to chugging phenomena. The locations of these capped downcomers are shown in Figure J.2-1.

J.2.2.1 Downcomer Capping Design Assessment

J.2.2.1.1 Downcomer Modifications

Figure J.2-2 shows a configuration of a modified downcomer with vacuum breaker (typical of four). The modifications include installation of a cap, a 3-inch drain line, and a 1-inch weir at the drywell entrance of the downcomer.

The capping design incorporates a 3-inch Schedule 160 drain line. Water motion in the 3-inch drain line has been modeled. As a result of this work, the drain has been extended 9 ft 7-3/4 inches above the downcomer exit plane. This extended length will prevent water from fountaining into the downcomer during the rapid drywell depressurization caused by the gross chugging at the downcomer exits. In addition, to prevent water from exiting the drain line during the chugging/CO phase of a LOCA, the drain line is extended 4 feet below the downcomer exit plane. Therefore, potential chugging/CO dynamic loading phenomena at the drain exit are precluded.

The addition of a 1-inch weir at the drywell entrance of each capped downcomer is designed to limit the maximum ECCS flow into these downcomers during the recirculation mode after a LOCA. The 3-inch drain line is capable of passing this limited flow of ECCS water while preventing the downcomers from being filled to the vacuum breaker elevation.

J.2.2.1.2 Containment Evaluation

Capping 4 out of 87 downcomers requires an evaluation to determine its effect on the containment design basis LOCA loading conditions and safety margins. To resolve this concern,

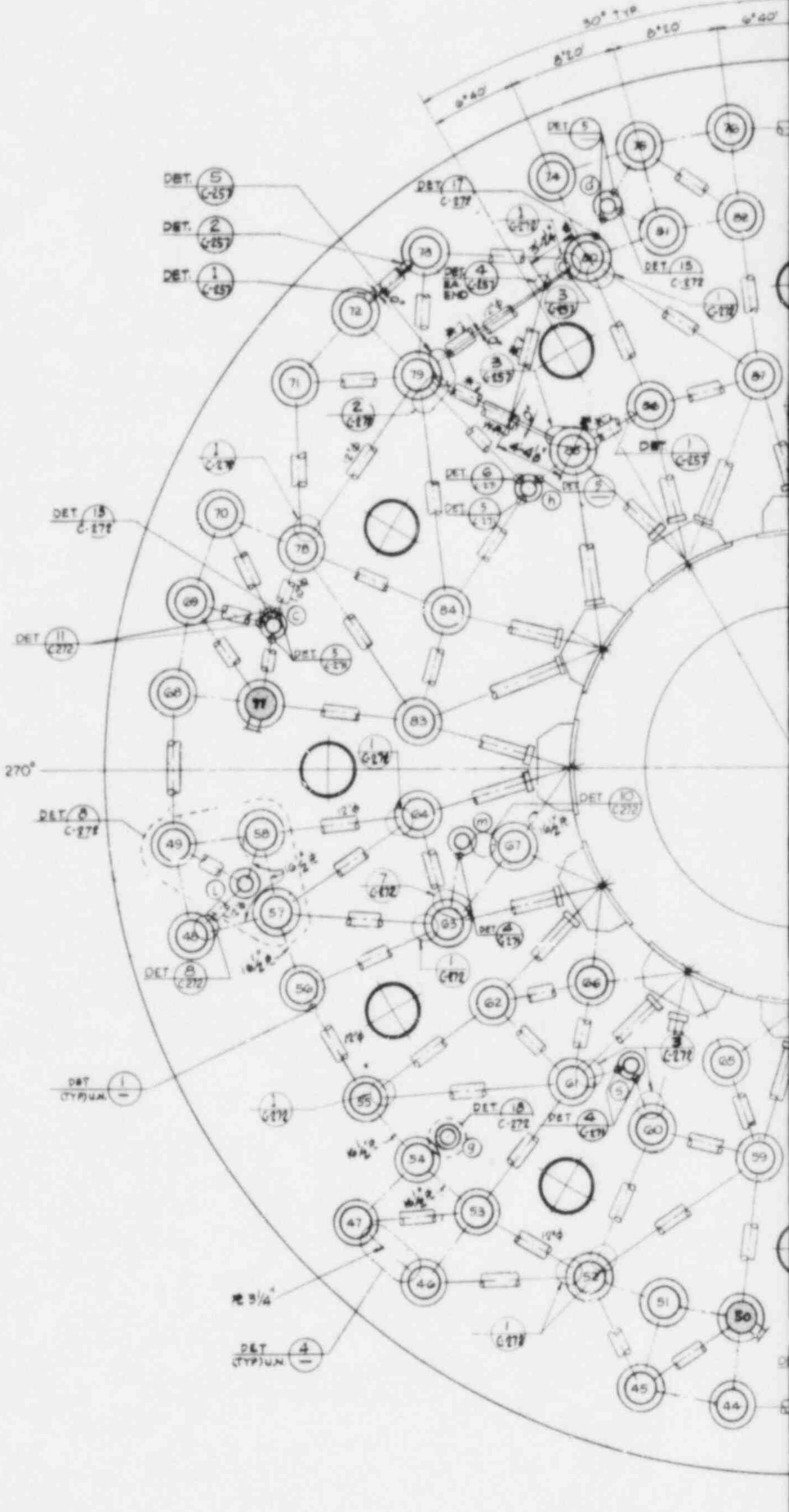
Bechtel's computer program COPDA was used to evaluate the drywell conditions based on 83 and 87 downcomers, respectively. The results indicate that there is no significant change in either drywell pressure and temperature or steam blowdown rate through the downcomers for the capped and uncapped situations.

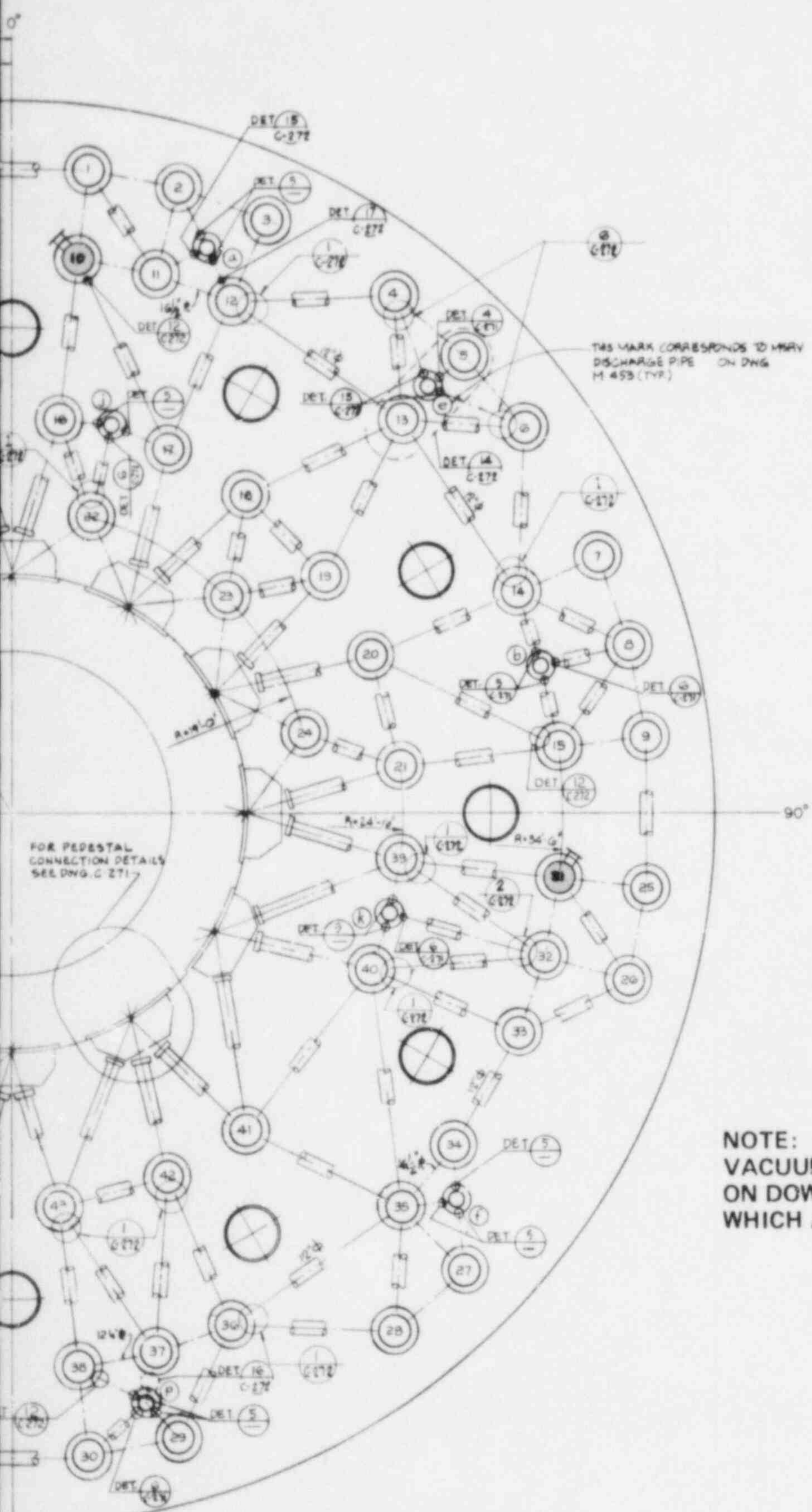
Based on this analysis, capping 4 out of 87 downcomers will have no adverse effects on the Limerick containment safety margins resulting from design basis LOCA loads, as defined in DAR Section 4.2, including poolswell loads, containment functional pressure, submerged structure loads, boundary loads, and asymmetric effects.

J.2.3 REFERENCES

J.2-1 Letter, D.M. O'Connor (Mark II Owners Group) to Dr. R.W. Houston (Assistant Director, Division of Systems Integration, NRC), "AGCo Vacuum Breaker Test Program," June 17, 1983.

J.2-2 Letter, J.S. Kemper (Philadelphia Electric Co.) to A. Schwencer (NRC), "AGCo Wetwell/Drywell Vacuum Breaker Test Program," July 6, 1983.


30° TYP
6°40'
8°20'
8°20'
6°40'
DET. 5 C-257
DET. 2 C-257
DET. 1 C-257
DET 13 C-272
DET 11 C-272
270°
DET 8 C-272
DET 8 C-272
DET 1 (TYP) U.N.
DET 4 (TYP) U.N.
DET 10 C-272



NOTE:
VACUUM BREAKERS ARE INSTALLED ON DOWNCOMERS 10, 31, 50 AND 77 WHICH ARE CAPPED (E.G., )

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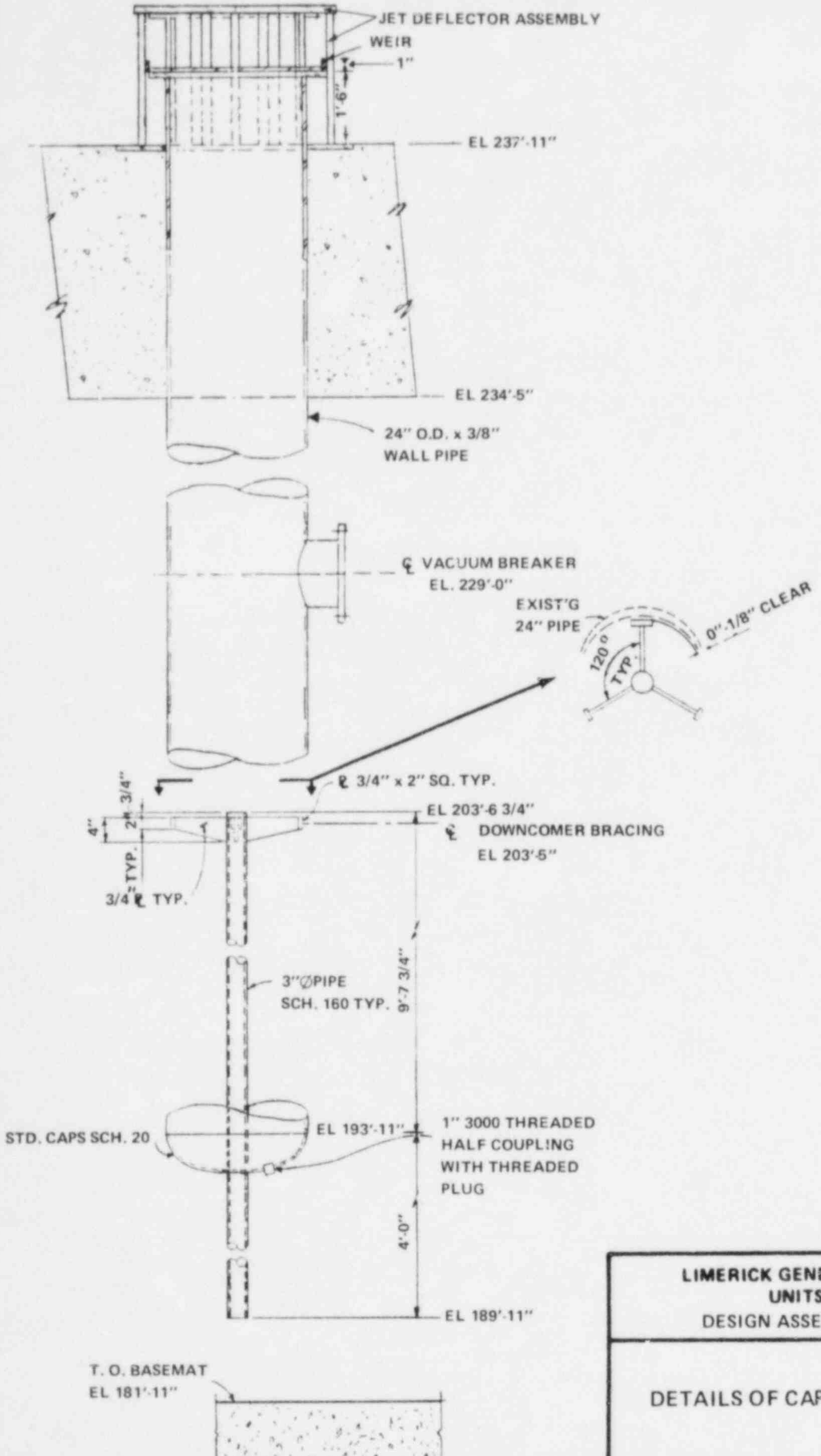
LOCATION OF CAPPED DOWNCOMERS WITH VACUUM BREAKERS

FIGURE J.2-1 REV. 6, 11/83



LIMERICK GENERATING STATION
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FIGURE J.2-2 REV. 6, 11/83