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REGULATORY DOCKET FILE COPY
Attachment C

June 30, 1978

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Rec'd 7/8/78

Mr. George E. Lear, Chief
Operating Reactors - Branch 3
Division of Operating Reactors
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: Dresden Station Units 2 and 3
Quad-Cities Station Units 1 and 2
Evaluation of the Consequence of a
Multiple Subsequent Relief Valve
Discharge on the Mark I Containments
NRC Docket Nos. 50-237/249 and 50-254/265

References (a): V. Stello, Jr. letter to Commonwealth Edison dated March 20, 1978

(b): R. L. Bolger letter to D. K. Davis dated November 1, 1978

Dear Mr. Lear:

Enclosed is Commonwealth Edison's evaluation of the potential for and consequence of multiple subsequent relief valve discharge on the torus and torus support systems on Dresden Units 2 & 3 and Quad-Cities Units 1 & 2. This evaluation provides the assessment requested in Reference (a). As described in Attachments A and B to this letter, transient analyses results for the subject plants indicate that only the low setpoint relief valve (setpoint - 1115 psig) will undergo a subsequent actuation. The remaining four valves do not undergo a subsequent actuation after the initial cold actuation. This result was described in Reference (b), at which time the commitment was made to reduce the setpoint of the lowest setpoint valve to 1115 psig. The factors developed to establish the response of the Dresden and Quad-Cities containments to a relief valve actuation are delineated in Attachment C.

Portions of Attachment C are marked "General Electric Company Proprietary Information" because it contains monticello ramshead test data. This Attachment contains test data from the monticello ramshead test report (NEDC-21581-P) which was transmitted to the NRC Staff on August 23, 1977. Therefore,

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the affidavit which accompanied that transmittal is applicable to the information in Attachment C.

The results of this assessment satisfy the criteria defined in Reference (a) and indicate that the strength ratios for the torus shell and torus support system are, as required, less than 0.5. For this reason no corrective action is required.

One (1) signed original and nine (9) copies of this letter and Attachments (including Attachment C) are provided for your use. An additional fifty (50) copies of this transmittal without Attachment C are also provided. Transmittals with Attachment C are appropriately marked.

Please direct any additional questions on this subject to this office.

Very truly yours,

M. S. Turbak

M. S. Turbak
Nuclear Licensing Administrator
Boiling Water Reactors

attachments

ATTACHMENT A

# DRESDEN UNITS 2 & 3
# EVALUATION OF CONSECUTIVE SRV
# VALVE ACTUATION

1.0 GENERAL: Based on results of General Electric transient analysis, one valve (valve with lowest set point, 1115 psig) will actuate for consecutive SRV actuation(s). The remaining four SRV valves are grouped in two set point groups, two at 1130 psig and two at 1135 psig. These four valves do not actuate subsequent to initial cold actuation.

The structural evaluation provided below has been performed in accordance with the procedures and using the multiples given in the GE supplied documents included in Attachment C.

2.0 MAXIMUM TORUS SUPPORT COLUMN COMPRESSION LOADS:

Outside Column = ($196.7^{(1)} \times 1.09^{(2)} \times 1.96^{(3)}$) SRV load

+ ($298^{(4)}$) Dead weight water and steel

+ ($64^{(5)}$) Seismic

= 782 kips (compression)

Inside Column = $[(\frac{.44}{.56})^{(6)} \times 196.7^{(1)} \times 1.09^{(2)} \times 1.96^{(3)}]$ SRV load

+ ($248^{(7)}$) Dead weight water and steel

+ ($47^{(8)}$) Seismic

= 625 kips (compression)

NOTES:

(1) Reference outside column compressive load from Attachment C.

(2) Dresden plant unique column factor from Attachment C.

(3) Torus support column consecutive valve actuation factor from Attachment C.

(4) Dead load in Dresden outside column at maximum water level, reference: Table 2 of NUTECH Report COM-01-051, September 76, "Dresden Station Units 2 & 3 Supplement to Short Term Program Plant Unique Torus Support and Attached Piping Analysis".

(5) Dresden outside column compressive load due to horizontal and vertical seismic, reference: (same as note 4 above).

(6) Ratio of percent of total load carried by inside column to percent of total load carried by outside column as observed from results of 3-D finite element analyzes for poolswell loads.

(7) Dead load in Dresden inside column at maximum water level, Reference: (same as note 4 above).

(8) Dresden inside column compressive load due to horizontal and vertical seismic, Reference: (same as note 4 above).

## 3.0 TORUS SHELL MEMBRANE STRESS:

Mid-bay at bottom - bay with actuating valve $= \left(4.36^{(9)} \times 2.37^{(10)} \times .89^{(11)} \times \frac{.584}{.653}^{(12)} \times \frac{180}{166}^{(13)}\right)$ SRV load

$+ (2.1)$ Hydrostatic + seismic

$= 11$ ksi

Notes (continued)

(9) Reference shell stress from Attachment C.

(10) Torus shell consecutive valve actuation factor from Attachment C.

(11) Dresden plant unique shell factor from Attachment C.

(12) Ratio of Monticello torus shell thickness to Dresden torus shell thickness.

(13) Ratio of Dresden torus radius to Monticello torus radius.

## 4.0 STRENGTH RATIOS:

Outside torus support column: $782/3300^{(14)} = 0.24$

Inside torus support column: $625/3000^{(14)} = 0.21$

## ATTACHMENT A
(concluded)

| | |
|---|---|
| Outside column-to-shell connection: | 782/3527[15] = 0.22 |
| Inside column-to-shell connection: | 625/2413[15] = 0.26 |
| Outside column pin connection: | 782/1970[16] = 0.40 |
| Inside column pin connection: | 625/2513[16] = 0.25 |

Notes (concluded)

(14) Ultimate column capacity, reference: Table 6.1.1-5 of NUTECH Report COM-01-040, Revision 1, August 76, "Dresden Nuclear Generating Plant Units 2 & 3, Short Term Program Plant Unique Torus Support and Attached Piping Analysis".

(15) Ultimate capacity of column-to-shell connection, reference: Section IV(A) of NUTECH Report COM-01-066, December 76, "Evaluation of As-Built Weld Sizes for Dresden Units 2 & 3 Torus Support Column/Torus Shell and Base Plate Connections".

(16) Ultimate capacity of pin connection at base of torus support column, reference: (same as note 14 above).

ATTACHMENT B

QUAD CITIES UNITS 1 & 2
EVALUATION OF CONSECUTIVE SRV
VALVE ACTUATION

1.0 GENERAL: Based on results of General Electric transient analysis, one valve (valve with lowest set point, 1115 psig) will actuate for consecutive SRV actuation(s). The remaining four SRV valves are grouped in two set point groups, two at 1130 psig and two at 1135 psig. These four valves do not actuate subsequent to initial cold actuation.

The structural evaluation provided below has been performed in accordance with the procedure and using the multipliers given in the GE supplied documents included in Attachment C.

2.0 MAXIMUM TORUS SUPPORT COLUMN COMPRESSION LOADS:

Outside Column = ($196.7^{(1)} \times 1.23^{(2)} \times 1.96^{(3)}$) SRV load

+ ($287^{(4)}$) Dead weight water and steel

+ ($74^{(5)}$) Seismic

= 835 kips (compression)

Inside Column = [$(\frac{.44}{.56})^{(6)} \times 196.7^{(1)} \times 1.23^{(2)} \times 1.96^{(3)}$] SRV load

+ ($241^{(7)}$) Dead weight water and steel

+ ($56^{(8)}$) Seismic

= 670 kips (compression)

NOTES:

(1) Reference outside column compressive load from Attachment C.

(2) Quad Cities plant unique column factor from Attachment C.

(3) Torus support column consecutive valve actuation factor from Attachment C.

(4) Dead load in Quad Cities outside column at maximum water level, reference: Table 2 of NUTECH Report COM-01-050, September 76, "Quad Cities Station Units 1 & 2 Supplement to Short Term Program Plant Unique Torus Support and Attached Piping Analysis".

(5) Quad Cities outside column compressive load due to horizontal and vertical seismic, reference: (same as note 4 above).

(6) Ratio of percent of total load carried by inside column to percent of total load carried by outside column as observed from results of 3-D finite element analyzes for poolswell loads.

(7) Dead load in Quad Cities inside column at maximum water level, reference: (same as note 4 above).

(8) Quad Cities inside column compressive load due to horizontal and vertical seismic, reference: (same as note 4 above).

## 3.0 TORUS SHELL MEMBRANE STRESS:

Mid-bay at bottom - bay with actuating valve $= (4.36^{(9)} \times 2.37^{(10)} \times 1.01^{(11)} \times \frac{.584}{.649}^{(12)} \times \frac{180}{166}^{(13)})$ SRV load

$+ (2.2)$ Hydrostatic + seismic

$= 12$ ksi

## Notes (continued)

(9) Reference shell stress from Attachment C.

(10) Torus shell consecutive valve actuation factor from Attachment C.

(11) Quad Cities plant unique shell factor from Attachment C.

(12) Ratio of Monticello torus shell thickness to Quad Cities torus shell thickness.

(13) Ratio of Quad Cities torus radius to Monticello torus radius.

## 4.0 STRENGTH RATIOS:

Outside torus support column: $= 835/2386^{(14)} = 0.35$

Inside torus support column: $= 670/2386^{(14)} = 0.28$

ATTACHMENT B
(concluded)

Outside column-to-shell connection: = 835/2165[15] = 0.39

Inside column-to-shell connection: = 670/2165[15] = 0.31

Notes (concluded)

(14) Ultimate column capacity, reference: Table 6.1.1-5 of NUTECH Report COM-01-039, Revision 0, August 76, "Quad Cities Station Units 1 & 2, Short Term Program Plant Unique Torus Support and Attached Piping Analysis".

(15) Ultimate capacity of column-to-shell connection, reference: NUTECH Report COM-01-021, Revision 3, May 77, "Suppression Chamber Support Column-Shell Connection Capacity Evaluation for The Quad Cities Station Units 1 & 2".

ATTACHMENT C
(Part 2)

# MARK I CONTAINMENT PROGRAM

## MULTIPLE CONSECUTIVE S/RV ACTUATION EVALUATION

## TASK 7.1.3

## PLANT UNIQUE HYDRODYNAMIC MULTIPLIER CALCULATIONAL PROCEDURE

LEGAL NOTICE

MARK I CONTAINMENT PROGRAM
MULTIPLE CONSECUTIVE S/RV ACTUATION EVALUATION
TASK 7.1.3

# PLANT UNIQUE HYDRODYNAMIC MULTIPLIER CALCULATIONAL PROCEDURE

## Introduction

The column plant unique multiplier (CPUM) is a single bay integrated load multiplier for safety relief valve air clearing loads evaluated under design conditions normalized to the load predicted for the Monticello test line under test conditions. The CPUM accounts for plant differences in peak positive torus shell pressure and variation in the longitudinal and radial pressure attenuations due to bay geometry (i.e. bay length, torus minor radius) and the distance of the ramshead from the torus floor. The following is the procedure used to calculate the CPUM as outlined in Figure 1.

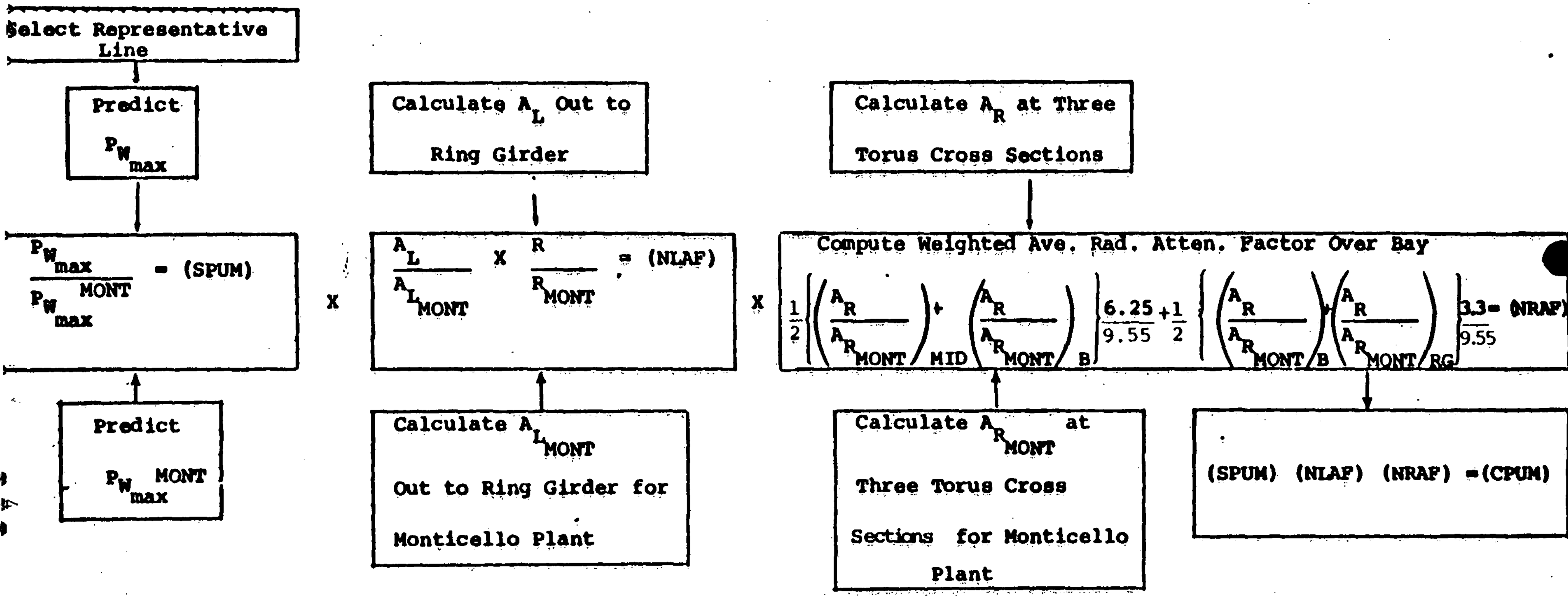
## S/RV Line Selection

The plant unique multipliers are based on selected representative safety relief valve (S/RV) lines which are expected to result in load magnitudes approximately equal to the average load for all lines in a specific plant. The S/RV parameters used to select the representative line in order of their importance are: pipe air volume, nominal water leg and valve mass flow rate (i.e. set point). Average values of air volume, water leg and mass flow rates were calculated for the S/RV discharge lines for each plant. The plant S/RV line which most closely matched these average values of air volume, water leg and mass flow rate was selected as the representative plant S/RV line. The justification for this procedure was that for multiple valve actuation analysis (3 valves) it is physically impossible that all three actuated valves will be the worst case or best case* lines in addition to being adjacent. Therefore, three adjacent valves of average geometry were assumed to actuate.

*The worst case line is defined to be that line which would result in the highest loads. The best case line is defined to be that line which would result in the lowest loads.

## Figure 1

Flowchart for Calculating Mark I Multiple
Consecutive S/RV Actuation Plant Unique Hydrodynamic Multipliers




R - Torus Minor Radius

$P_{W_{max}}$ - Peak Positive Torus Shell Pressure

$A_L$ - Area Under Longitudinal Press Atten. Curve

$A_R$ - Area Under Radial Press. Atten. Curve

MID - Mid bay

B - Directly Beneath the Bubble

RG - Ring Girder

SPUM - Shell Plant Unique Multiplier

NLAF - Normalized Longitudinal Atten. Factor

NRAF - Normalized Radial Atten. Factor

CPUM - Column Plant Unique Multiplier

Calculation of the Shell Plant Unique Multiplier (SPUM)

Once the representative S/RV line was selected, three computer programs (RVFORCE, BUBBLE and IMAGE) were run in series to obtain the maximum positive torus shell pressure ($P_{wmax}$) for design conditions. This maximum positive torus shell pressure was then divided by the maximum positive torus shell pressure calculated for the Monticello test conditions ($P_{wmax}$mont). This ratio of maximum positive torus shell pressures ($P_{wmax}/P_{wmax}$ mont) was designated as the shell plant unique multiplier (SPUM).

Inputs required for RVFORCE are pipe air volume, water leg, valve mass flow rate, valve set pressure and pipe friction losses. These inputs were determined assuming plant operation with a pressure differential between the drywell and wetwell and nominal values for set pressure and S/RV flowrate for the line selected (i.e., the midrange of the possible tolerances in these parameters). The important outputs from RVFORCE are discharge pressure, air-water interface pressure and the water clearing velocity. In addition to these three RVFORCE outputs, the ramshead radius, submergence and the density of air in the S/RV line are input into the BUBBLE program which calculates the minimum bubble radius ($R_{B_{min}}$) and the simultaneously occurring maximum bubble pressure ($P_{B_{max}}$). A parametric study was performed using the IMAGE program to obtain a plot of the ratio of maximum positive torus shell pressure to the product of maximum bubble pressure and minimum bubble radius ($P_{wmax}/P_{Bmax}\ R_{Bmin}$) versus vertical distance of the ramshead from the torus floor ($d_{TF}$). Therefore, knowing $P_{Bmax}$, $R_{Bmin}$ and $d_{TF}$, the maximum positive torus shell pressure ($P_{Wmax}$) could be determined. The plant unique $P_{Wmax}$ was divided by $P_{Wmax}$mont to obtain the SPUM.

$$SPUM = \frac{P_{wmax}}{P_{wmax}mont}$$

Calculation of the Normalized Longitudinal Attenuation Factor (NLAF)

Differences in the plant unique longitudinal pressure distribution are accounted for in terms of a normalized longitudinal attenuation factor (NLAF). The calculation of this factor is described in the following paragraph.

Figure 2 provides plots of normalized torus shell loading attenuation along the torus longitudinal axis for several ramshead distances from the torus floor. These curves were generated using the IMAGE program and measured wall pressure attenuation from previous full scale ramshead tests (Refer to references 1 and 2). A planimeter was used to determine the area under the longitudinal attenuation curve out to the ring girder, considering each plants bay length and distance of the ramshead from the torus floor. The plant unique areas under these curves were then normalized to the area calculated for Monticello and multiplied by the ratio of plant torus minor radius to the Monticello torus minor radius to give the NLAF.

$$NLAF = \frac{A_L}{A_{L_{MONT}}} \times \frac{R}{R_{MONT}} \qquad (2)$$

Note that this factor accounts for variations in torus radii (i.e., wider tori will receive higher total loading), but does not account for variations in the radial pressure distribution. The latter effect is discussed in the next section.

Calculation of the Normalized Radial Attenuation Factor (NRAF)

Differences in the radial pressure distribution due to variations in distance of the ramshead from the torus floor were accounted for with a normalized radial attentuation factor (NRAF). Parametric IMAGE program runs were performed varying the distance of the ramshead from the torus floor over the range found in Mark I plants. From these runs, normalized plots of torus shell pressure versus the radial distance from the torus vertical centerline were made at three torus cross sections (i.e., mid bay, directly beneath the bubble, and at the ring girder). The area under each of these curves was calculated using a planimeter and was normalized to the respective areas calculated for the Monticello plant. A value representative of the weighted average of the normalized areas under the radial pressure attenuation curves for each distance of ramshead from the torus floor was calculated using equation (3).

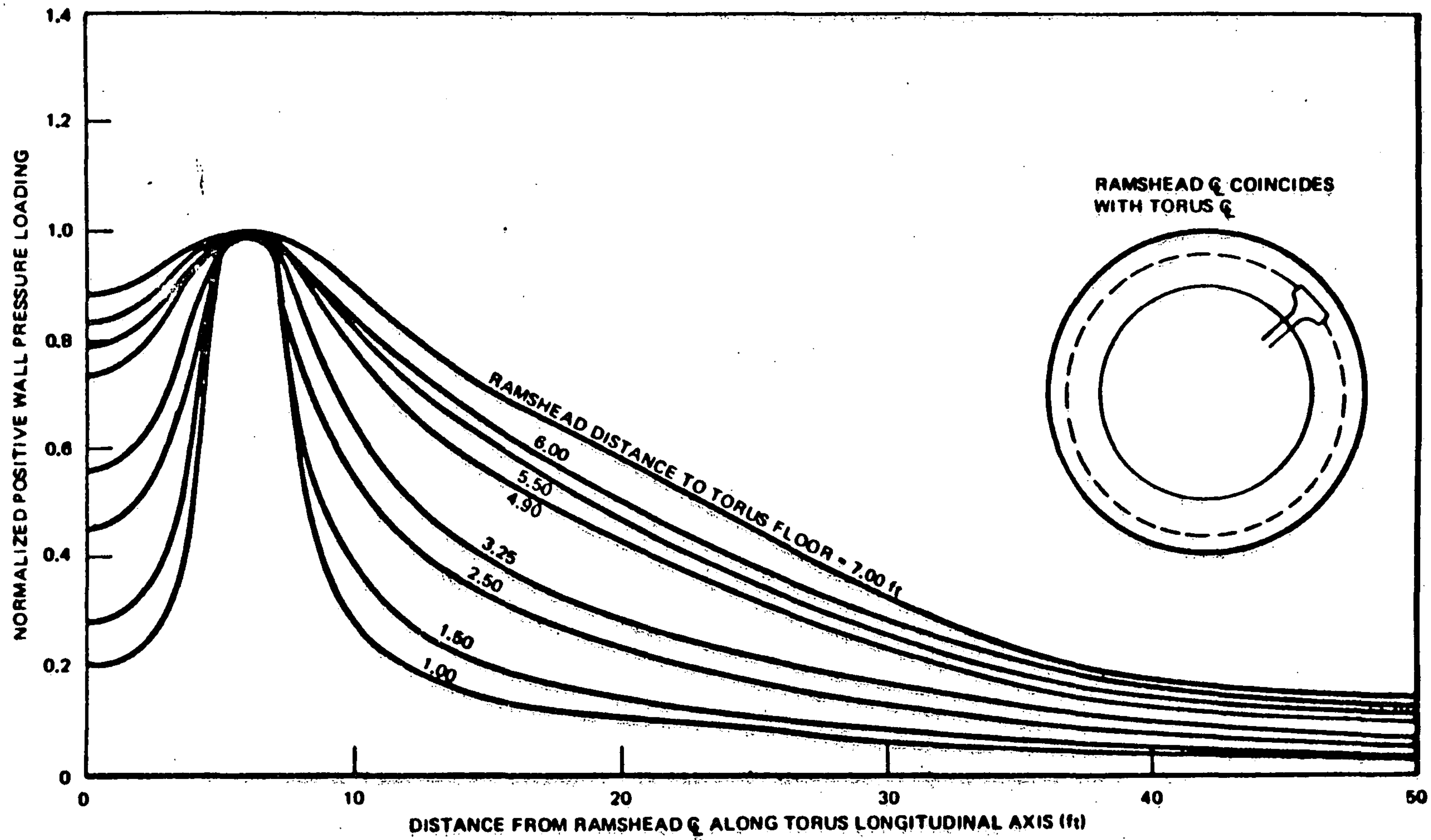



Figure 2 Normalized Wall Pressure Loading Attenuation along Torus Longitudinal Axis for Several Ramshead Distances off Torus Floor.

$$NRAF = \frac{\left\{\left(\frac{A_R}{A_{R_{MONT}}}\right)_{MID} + \left(\frac{A_R}{A_{R_{MONT}}}\right)_B\right\} 6.25 + \left\{\left(\frac{A_R}{A_{R_{MONT}}}\right)_B + \left(\frac{A_R}{A_{R_{MONT}}}\right)_{RG}\right\} 3.3}{(9.55)\ (2)} \qquad (3)$$

where: 6.25 = Distance from mid bay to bubble location

3.3 = Distance from bubble location to ring girder

9.55 = Total distance from mid bay to ring girder

These distances are for the Monticello plant, but do not vary significantly from plant to plant.

Calculation of the Column Plant Unique Multiplier (CPUM)

Having obtained plant unique values of the SPUM, NLAF and NRAF, the column plant unique multiplier (CPUM) was calculated using equation (4).

CPUM = (SPUM) X (NLAF) X (NRAF) (4)

Calculated Values for the Column Plant Unique Multiplier (CPUM) and the Shell Plant Unique Multiplier (SPUM).

Utilizing the procedures described above, CPUM and SPUM values were calculated for the applicable Mark I plants. A summary of these values is contained in Table 1.

TABLE 1

PLANT UNIQUE MULTIPLIERS

| PLANT NAME | COLUMN PLANT UNIQUE MULTIPLIER (CPUM) | SHELL PLANT UNIQUE MULTIPLIER (SPUM) |
|---|---|---|
| Monticello (Test) | 1.0 | 1.0 |
| NWL (No ΔP) | | |
| Monticello | 1.01 | 1.01 |
| Millstone (4.4) | 1.39 | 1.30 |
| Duane Arnold | .94 | 1.09 |
| Cooper | .54 | .53 |
| FitzPatrick | .71 | .63 |
| Nine Mile Point | .30 | .28 |
| Pilgrim | 1.61 | 1.78 |
| Vermont Yankee | 1.06 | .99 |
| Hatch 1 | 1.23 | 1.16 |
| Quad Cities 1, 2 | 1.23 | 1.01 |
| Dresden 2, 3 | 1.09 | .89 |
| Peach Bottom 2, 3 | .88 | .65 |
| Browns Ferry 1, 2, 3 | .82 | .62 |
| Hatch 2 | .83 | .78 |

## REFERENCES

1) J. L. McCready et al. "Steam Vent Clearing Phenomena and Structural Response of the BWR Torus (Mark I Containment)." NEDO-10859, April 1973

2) NEDC-21581-P "Final Report - In Plant Safety/Relief Valve Discharge Load Test - Monticello Plant." August 1977