COMMONWEALTH EDISON COMPANY

BYRON STATION, UNITS 1 AND 2
BRAIDWOOD STATION, UNITS 1 AND 2

VALUE IMPACT OF IMPLEMENTING "LEAK-BEFORE-BREAK" AND ELIMINATION OF ASSOCIATED PIPE WHIP RESTRAINTS AND JET DEFLECTORS ON THE RCS PRIMARY LOOP

JUNE 1985

VALUE IMPACT OF IMPLEMENTING "LEAK-BEFORE-BREAK" ON RCS PRIMARY LOOP AT BYRON AND BRAIDWOOD STATIONS

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I. Introduction

Generic Letter No. 84-04 provided the NRC safety evaluation concluding that an acceptable technical basis exists so that the blowdown loads resulting from double-ended pipe breaks in the RCS primary loop need not be considered as a design basis, provided that certain conditions can be met for plants such as our Byron and Braidwood Stations. The generic letter indicated that Applicants may request exemptions from the requirements of GDC-4 with respect to blowdown loads from discrete breaks in the RCS primary loop if they can demonstrate the applicability of the modeling used and conclusions reached in the generic Westinghouse analyses.

In a letter dated September 17, 1984, Commonwealth Edison provided the requisite plant specific analyses to demonstrate the applicability of the Westinghouse generic conclusions to our Byron and Braidwood Stations. That submittal technically supported the implementation of "leak-before-break" on these units based on the integrity of the primary piping. Upon review of our submittal, the NRC staff requested that we provide a safety balance evaluation of the consequences of eliminating the protective devices currently employed in our design to mitigate the dynamic effects associated with postulated breaks. The purpose of this submittal is to further pursue our exemption request and provide our assessment of the value impact of implementing "leak-before-break" on the RCS primary loops at Byron and Braidwood when considering the resultant public and occupational exposures due to elimination of the associated pipe whip restraints and jet deflectors.

The following value impact analysis utilizes methodology consistent with that utilized in Generic Letter No. 84-04 and confirms that the safety benefits outweigh the impacts of implementing "leak-before-break" on our units. Plant specific data and certain data contained in Generic Letter No. 84-04, along with various assumptions have been used to perform the value impact analysis for Byron and Braidwood. The evaluation has been performed in terms of increased public and occupational exposure attributable to elimination of the protection provided for dynamic effects associated with postulated breaks in the RCS primary loop given an accident, compared to the reduction in occupational exposure during operations due to improved access and increased work efficiency associated with elimination of the pipe whip restraints and jet deflectors. However, in contrast to Generic Letter No. 84-04, our analysis results are provided on a per plant year basis and not integrated over the expected 40 year plant life.

II. Value Impact Summary Conclusions

The value impact analysis results are summarized below. The annualized nominal dose estimates clearly indicate that implementation of "leak-before-break" on the RCS primary loop piping of each of our Byron and Braidwood units is justifiable when considering public and occupational exposure (both operational and accidental) over the 40 year life of these units. Detailed results are contained in Attachment D.

	Benefit Annual Reduction in Exposure Per Unit (man-rem/yr)	Impact Annual Increase in Exposure Per Unit (man-rem/yr)
Byron Unit 2 Braidwood Units 1 and 2	12.5	2.8E-2
Byron Unit 1	12.5	8.6

Additional benefits derived from removal of the pipe whip restraints and jet deflectors include the ability to more completely insulate the RCS primary loop piping. As such, lower containment temperatures should be achievable thus benefiting the thermal aging process of equipment. This advantage has not been directly factored into the evaluation.

III. Consideration of the Benefits Versus the Impacts of Implementing Leak-Before-Break

Attachment A provides the annualized estimate of increased exposure to the public and plant personnel should a major accident occur after removal of the RCS primary loop pipe whip restraints and jet deflectors associated with leak-before-break. This analysis is consistent with the methodology utilized in Generic Letter No. 84-04.

Attachment B provides the total and annualized estimate of increased exposure to plant personnel for removing the Byron Unit 1 primary loop pipe whip restraints and jet deflectors. (In contrast to the annualized exposures discussed in Attachments A and C, the estimated exposure to remove the Byron Unit 1 hardware is a one-time exposure event. In order to assess this one-time exposure with the annual exposures discussed in Attachments A and C, we have annualized the Byron Unit 1 hardware removal exposures for comparison purposes.) The majority of the man hours and resultant exposures are attributable to removal of the jet deflectors. Expected Byron Unit 1 exposure rates of 45mr/hr for activities near piping surfaces and 5mr/hr for activities at the floor level have been assumed based on our experiences at Zion Station. These estimates are comparable to the exposure rates utilized in the generic letter and do assume the application of shielding material to the primary piping in the vicinity of restraint removal activites. The man-rem exosures for shielding installation and removal as well as insulation removal and reinstallation have been included and are based upon our Zion Station 1984 actual and 1985 estimated outage exposure data for shielding and insulation work. Grinding activities after cutting have been minimized or eliminated where practicable to do so.

Attachment C provides the annualized estimate of reduced exposure to plant personnel during operations due to improved access and increased work efficiency once the pipe whip restraints and jet deflectors have been eliminated. The estimated annual exposures by various work functions have been taken from the Byron/Braidwood FSAR Table 12.4-3. The percentage of these annual exposures taken to be within containment are based upon our Zion Station experience. Also, one half of the special maintenance is assumed to be attributable to steam generator activities. Although difficult to quantify, we have assigned conservative values for improved access and increased work efficiency.

Attachment D provides a composite tabulation of the data contained in Attachments A, B and C. In this format, the annualized benefit of implementing leak-before-break in terms of reduced operational exposures is compared to the annualized impact of implementing leak-before-break in terms of increased exposures, both accidental and the occupational exposure to remove the hardware from our operating Byron Unit 1.

ATTACHMENT A

ESTIMATE OF RISK INCREASE ASSOCIATED WITH ELIMINATION OF PROTECTION FROM DYNAMIC EFFECTS ASSOCIATED WITH PIPE BREAKS IN RCS PRIMARY LOOP.

A. Public Health

Generic Letter No. 84-04 (Reference 1) has been used as a basis for calculating the potential increase in offsite dose to the general public resulting from employment of "Leak-Before-Break" and elimination of special design considerations for pipe breaks in the RCS primary coolant loops. However, several changes were necessary to calculate dose estimates applicable to our Byron and Braidwood Stations. The following basis was used for the calculation:

1. Byron and Braidwood Stations are four loop Westinghouse PWRs each with two units. Because the Reference 1 estimates are given in terms of one unit with two loops, adjustments have been made to consider the increased number of potential break locations in a four loop unit.

2. The most significant site specific effect is population density. Reference 1 assumed the U.S. average of 340 people per square mile with a uniform population density. As stated in the Byron/Braidwood FSAR and Environmental Report, in the year 2020, Byron is predicted to have a corresponding population density of 193 people per square mile in the 0 to 50 mile radius zone while Braidwood is predicted to have a population density of 653 people per square mile in the 0 to 50 mile radius zone. The Braidwood population density has been used throughout this calculation. As a consequence, the resulting offsite doses are conservative for Byron by a factor of approximately 3.4.

3. The assumption of uniform population density and a 50-mile radius release model was used for this calculation. Based on area, this would indicate that 96% of the population was located in the 10 to 50 mile radius segment. In actuality, approximately 97.9% and 99.4% of the population respectively is in this zone at Byron and Braidwood. This increases the conservatism of this calculation.

4. Reference 1 used the typical midwestern site meteorology of the Byron and Braidwood sites and is therefore directly applicable.

Reference 1 calculated the increase in risks associated with a large LOCA using the guidelines in WASH-1400 assuming no protection from the dynamic effects of pipe rupture. As used in Reference 1 and throughout this submittal, the term "plant" means a single unit. For a two loop plant, the nominal risk increase from a double-ended guillotine (DEG) large LOCA within the reactor cavity from Reference 1 was estimated to be 6E-3 man-rem/py (man-rem per plant year). Adjusting for the number of loops (4 vs 2) and the difference in population density (653 vs 340), the Braidwood nominal risk estimate is:

$$4/2 \times 653/340 \times 6E\text{-}3 = 2.3E\text{-}2 \text{ man-rem/py}$$

Similarly from Reference 1, the nominal risk from a DEG large LOCA outside the reactor cavity was estimated to be 2E-4 man-rem/py. The Braidwood nominal risk estimate is:

$$4/2 \times 653/340 \times 2E\text{-}4 = 7.7E\text{-}4$$

Therefore, the combined Braidwood nominal increase in risk estimate from DEG large LOCAs both within and outside of the reactor cavity is:

$$2.3E\text{-}2 + 7.7E\text{-}4 = 2.4E\text{-}2 \text{ man-rem/py}$$

The upper increase in risk estimate is calculated in Reference 1 with a procedure similar to that utilized for the nominal risk estimate, but based on a more conservative estimate of the probability of a large LOCA and core melt. The upper estimate in Reference 1 is 0.1 man-rem/py with no adjustments required for the number of loops per plant because this frequency is per plant year. Adjusting for the difference in population density, the Braidwood upper increase in risk estimate is:

$$653/340 \times 0.1 = 0.2 \text{ man-rem/py}$$

The lower increase in risk estimate is assumed to be 0. The increases in risk to the public as determined above are tabulated as follows:

	Risk Increase (man-rem/py)
Nominal Estimate	2.4E-2
Upper Estimate	0.2
Lower Estimate	0

B. Occupational Exposure

An increase in occupational exposure can be calculated as the increase in core melt frequency multiplied by the occupational exposure expected to occur as a result of a major accident. Reference 1 calculated an increase in core melt frequency by summing the contribution from the breaks inside the reactor cavity and the breaks outside the reactor cavity, and then adjusting for the number of loops. For Byron and Braidwood, the nominal core melt frequency increase would be:

$$4/2 \text{ X } (9E\text{-}8+0.2X(3E\text{-}6/250)) = 2E\text{-}7 \text{ events/py}$$

The upper estimate of 2E-6 events/py from Reference 1 is directly applicable because it is per plant year and is not dependent upon the number of loops. A lower bound estimate of 0 is assumed.

These estimates are then used with cleanup and decommissioning dose estimates from NUREG/CR-2601 (Reference 2) to give an estimate of occupational exposure increase per plant year. The dose estimates are given in two parts. The first is immediate occupational exposure (D_{IO}) during the span of the event and its short term control. The second is the long-term occupational exposure (D_{LTO}) associated with the cleanup and recovery from the accident. The increase in occupational exposure per plant year (D_{OA}) is calculated as follows:

$$D_{OA} = P(D_{IO} + D_{LTO})$$

where

D_{OA} = Increase in occupational exposure per plant year

P = Increase in core melt frequency

D_{IO} = Immediate occupational exposure

D_{LTO} = Long-term occupational exposure

The results of the calculations are shown below. Uncertainties are conservatively propagated by the use of upper bound D_{IO} and upper bound D_{LTO}.

	P (events/ plant-yr)	D_{IO} (a) (man-rem/ event)	D_{LTO} (a) (man-rem/ event)	D_{OA} (man-rem/ plant-yr)
Nominal Estimate	2E-7	1E+3	2E+4	4.2E-3
Upper Estimate	2E-6	4E+3	3E+4	6.8E-2
Lower Estimate	0	0	1E+4	0

(a) Based on cleanup and decommissioning estimates contained in Reference 2

References:

Reference 1: NRC Generic Letter 84-04, February 1, 1984

Reference 2: NUREG/CR-2601, (Murphy, 1982)

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TABLE 2.1-2 (Cont'd)

2020
RADIAL INTERVAL (mi)

SECTOR DESIGNATION	10-20	20-30	30-40	40-50	0-50
N	5,137	5,583	14,097	10,970	37,598
NNE	84,721	46,388	92,955	109,909	337,182
NE	213,715	53,284	9,628	29,153	307,853
ENE	9,258	33,713	14,386	51,054	111,272
E	2,376	10,157	19,621	64,028	97,381
ESE	2,403	69,315	29,405	30,811	132,724
SE	21,495	2,877	6,332	46,088	77,214
SSE	2,066	2,726	16,843	6,209	28,996
S	4,017	6,259	4,571	16,583	32,284
SSW	13,049	5,460	4,599	8,299	35,355
SW	12,475	45,376	18,220	10,228	89,417
WSW	5,247	4,740	9,088	44,712	67,409
W	1,989	4,278	7,209	13,407	30,684
WNW	3,617	5,650	3,402	6,496	20,153
NW	1,773	51,748	8,275	7,753	71,182
NNW	4,821	5,269	11,577	15,632	37,434
Sum for Radial Interval	388,159	352,823	270,208	471,332	1,514,138
Cumulative Total To Outer Radius	419,775	772,598	1,042,806	1,514,138	1,514,138
Average Density (people/mi^2) In Radial Region	412	225	123	167	193

TABLE 2.1-3 (Cont'd)

PREDICTED 2020 POPULATION BY ANNULAR SECTORS

DISTANCE RANGE FROM SITE(MILES)

SECTOR	10.0 TO 20.0	20.0 TO 30.0	30.0 TO 40.0	40.0 TO 50.0	10.0 TO 50.0	0.0 TO 50.0
N	27636	31225	209902	279945	548708	550758
NNE	20352	165147	304659	851067	1341225	1344634
NE	5974	51172	422941	1779099	2259186	2265561
ENE	1507	9665	171899	300466	483537	486260
E	1155	5149	9267	27773	43344	44637
ESE	34042	51349	11379	5025	101795	102201
SE	4215	7244	2860	10447	24766	24995
SSE	2357	2175	5966	2525	13023	13892
S	1449	1703	2905	2365	8422	9286
SSW	921	1472	6965	2169	11527	12724
SW	5779	2061	17175	6539	31554	34398
WSW	650	2673	22333	5654	31310	32135
W	1178	2623	10117	32749	46667	47865
WNW	2497	11326	20044	4667	38534	38942
NW	13028	4592	15843	5162	38625	43771
NNW	2370	8920	38954	16856	67100	72675
Sum for radial interval	125110	358496	1273209	3332508	5089323	5124734
Cummulative total to outer radius	160521	519017	1792226	5124734	---	5124734
Average density (people/mi^2) in radial region	133	228	579	1179	675	653

TABLE 2.1-4 (Cont'd)

2020

SECTOR DESIGNATION	RADIAL INTERVAL (miles) 10-20	20-30	30-40	40-50	0-50
N	5,137	5,583	14,097	10,970	37,598
NNE	84,721	46,388	92,955	109,909	337,182
NE	213,715	53,284	9,628	29,153	307,853
ENE	9,258	33,713	14,386	51,054	111,272
E	2,376	10,157	19,621	64,028	97,381
ESE	2,403	69,315	29,405	30,811	132,724
SE	21,495	2,877	6,332	46,088	77,214
SSE	2,066	2,726	16,843	6,209	28,996
S	4,017	6,259	4,571	16,583	32,284
SSW	13,049	5,460	4,599	8,299	35,355
SW	12,475	45,376	18,220	10,228	89,417
WSW	5,247	4,740	9,088	44,712	67,409
W	1,989	4,278	7,209	13,407	30,684
WNW	3,617	5,650	3,402	6,496	20,153
NW	1,773	51,748	8,275	7,753	71,182
NNW	4,821	5,269	11,577	15,632	37,434
Sum for Radial Interval	388,159	352,823	270,208	471,332	1,514,138
Cumulative Total to Outer Radius	419,775	772,598	1,042,806	1,514,138	1,514,138
Average Density (persons/mi^2) in Radial Region	412	225	123	167	193

TABLE 2.1-3 (continued)

Sector Designation	2020 RADIAL INTERVAL (miles) 10-20	20-30	30-40	40-50	0-50
N	27,636	31,225	209,902	279,945	550,758
NNE	20,352	165,147	304,659	851,067	1,344,634
NE	5,974	51,172	422,941	1,779,099	2,265,561
ENE	1,507	9,665	171,899	300,466	486,260
E	1,155	5,149	9,267	27,773	44,637
ESE	34,042	51,349	11,379	5,025	102,201
SE	4,215	7,244	2,860	10,447	24,995
SSE	2,357	2,175	5,966	2,525	13,892
S	1,449	1,703	2,905	2,365	9,286
SSW	921	1,472	6,965	2,169	12,724
SW	5,779	2,061	17,175	6,539	34,398
WSW	650	2,673	22,333	5,654	32,135
W	1,178	2,623	10,117	32,749	47,865
WNW	2,497	11,326	20,044	4,667	38,942
NW	13,028	4,592	15,843	5,162	43,771
NNW	2,370	8,920	38,954	16,856	72,675
Sum for Radial Interval	125,110	358,496	1,273,209	3,332,508	5,124,734
Cummulative Total to Outer Radius	160,521	519,017	1,792,226	5,124,734	5,124,734
Average Density (people/mi^2) in Radial Region	133	228	579	1,179	653

ATTACHMENT B

ESTIMATED OCCUPATIONAL EXPOSURE TO REMOVE BYRON UNIT 1 PRIMARY LOOP PIPE WHIP RESTRAINTS AND JET DEFLECTORS

1) PIPE WHIP RESTRAINT AND JET DEFLECTOR ACTIVITIES:

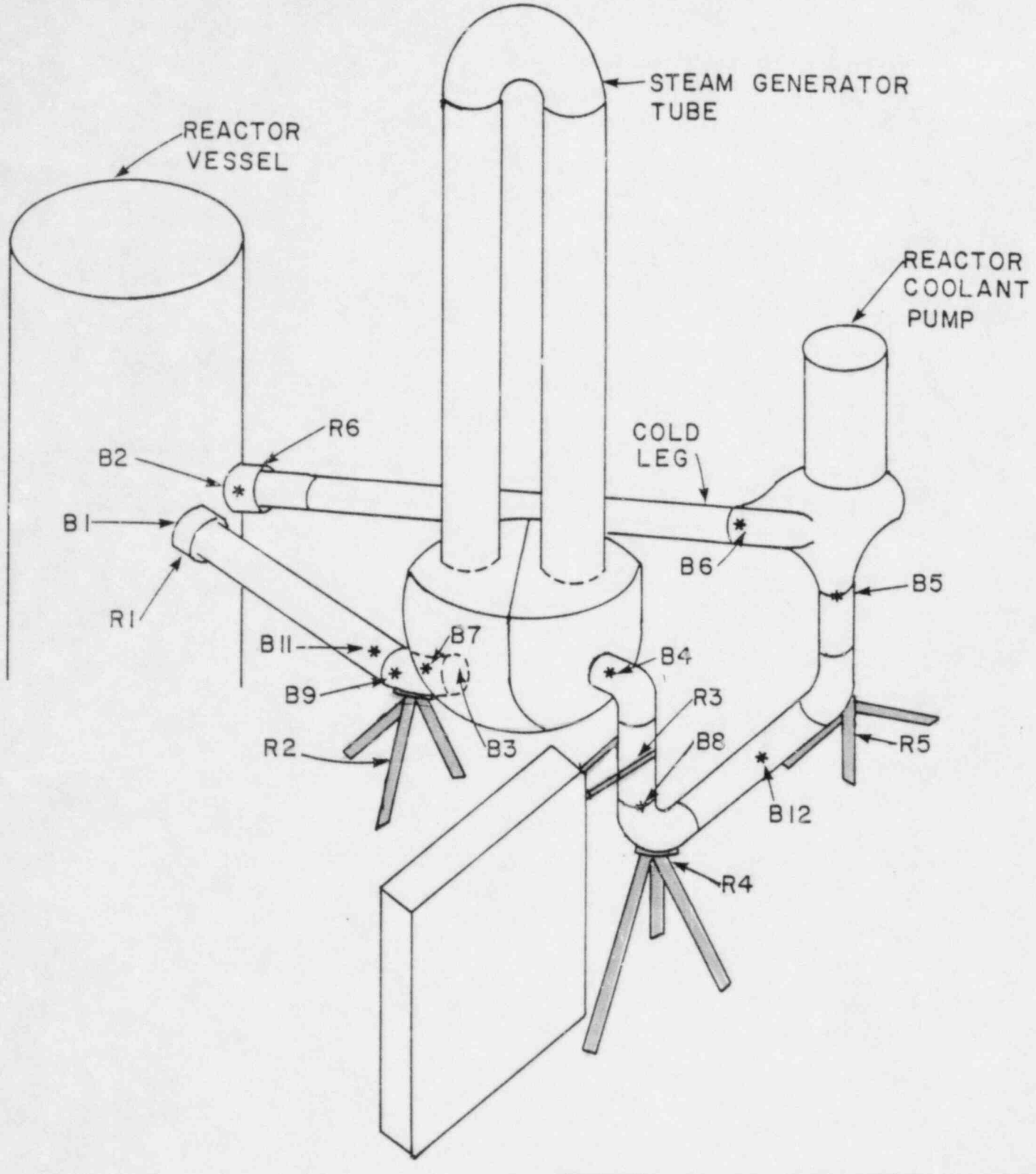
DEVICE/ ACTIVITY	ESTIMATED MANHOURS @ 45MR/HR	5MR/HR	EXPOSURE PER DEVICE (MAN-REM)	NUMBER OF DEVICES	TOTAL EXPOSURE (MAN-REM)
CROSS OVER (R4,R5)			1.2	8	9.6
a) RIGGING	15	5			
b) CUTTING		20			
c) REMOVAL		72			
d) GRINDING		16			
SUPER TOWER (R2)			3.0	4	12.0
a) RIGGING	40	40			
b) SCAFFOLDING		32			
c) CUTTING		40			
d) REMOVAL		108			
e) GRINDING		20			
HOOP (R3)			6.1	4	24.4
a) RIGGING	30				
b) SCAFFOLDING	40				
c) CUTTING	32				
d) REMOVAL	32	20			

DEVICE/ ACTIVITY	ESTIMATED MANHOURS @ 45MR/HR	5MR/HR	EXPOSURE PER DEVICE (MAN-REM)	NUMBER OF DEVICES	TOTAL EXPOSURE (MAN-REM)
JET DEFLECTOR (@R2)			70.9	4	283.6
a) RIGGING	48				
b) UNBOLT H&V TIES	168	144			
c) CUT H&V TIES AND LOWER TO EL. 377	144	144			
d) REMOVE SIDE RAILS TO EL. 377	260	28			
e) REMOVAL OF H&V TIES AND SIDE RAILS		216			
f) UNBOLT YOKE	180				
g) REMOVE YOKE TO EL. 377	691	77			
h) REMOVAL OF YOKE		144			
				SUBTOTAL ESTIMATED EXPOSURE (MAN-REM)	329.6
2) PROVIDE SHIELDING AS APPROPRIATE					5.0
3) REMOVE INSULATION AND RE-INSULATE AS APPROPRIATE					10.0
				TOTAL ESTIMATED EXPOSURE (MAN-REM)	344.6

ANNUALIZED EXPOSURE OVER 40 YEAR LIFE

NOTE: THIS ONE-TIME EXPOSURE IS PRESENTED AS AN ANNUALIZED EXPOSURE FOR COMPARISON PURPOSES ONLY.

ESTIMATED EXPOSURE (MAN-REM/PY) 3.6

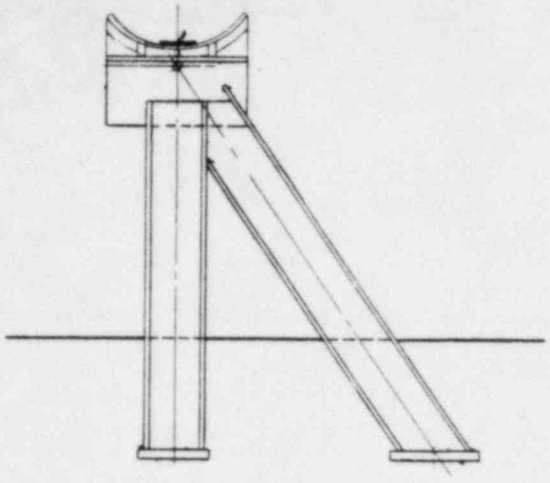


BYRON/BRAIDWOOD STATIONS

FINAL SAFETY ANALYSIS REPORT

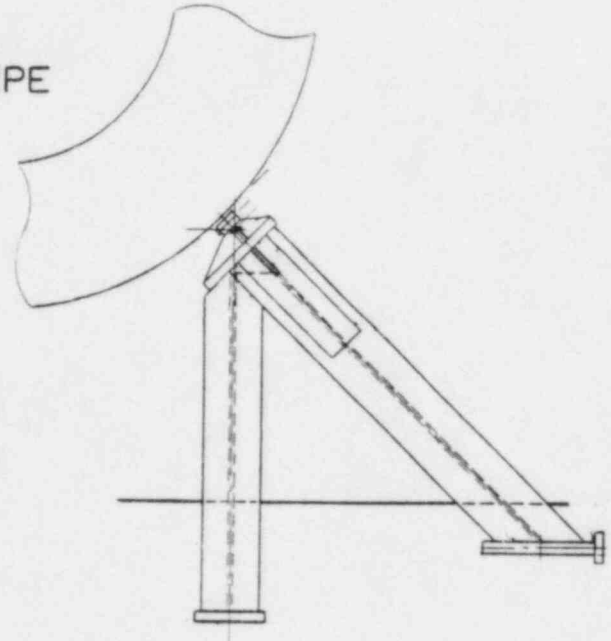
FIGURE 3.6-19

BREAK AND RESTRAINT LOCATIONS



SECTION B
FRONT VIEW

CROSS OVER PIPE

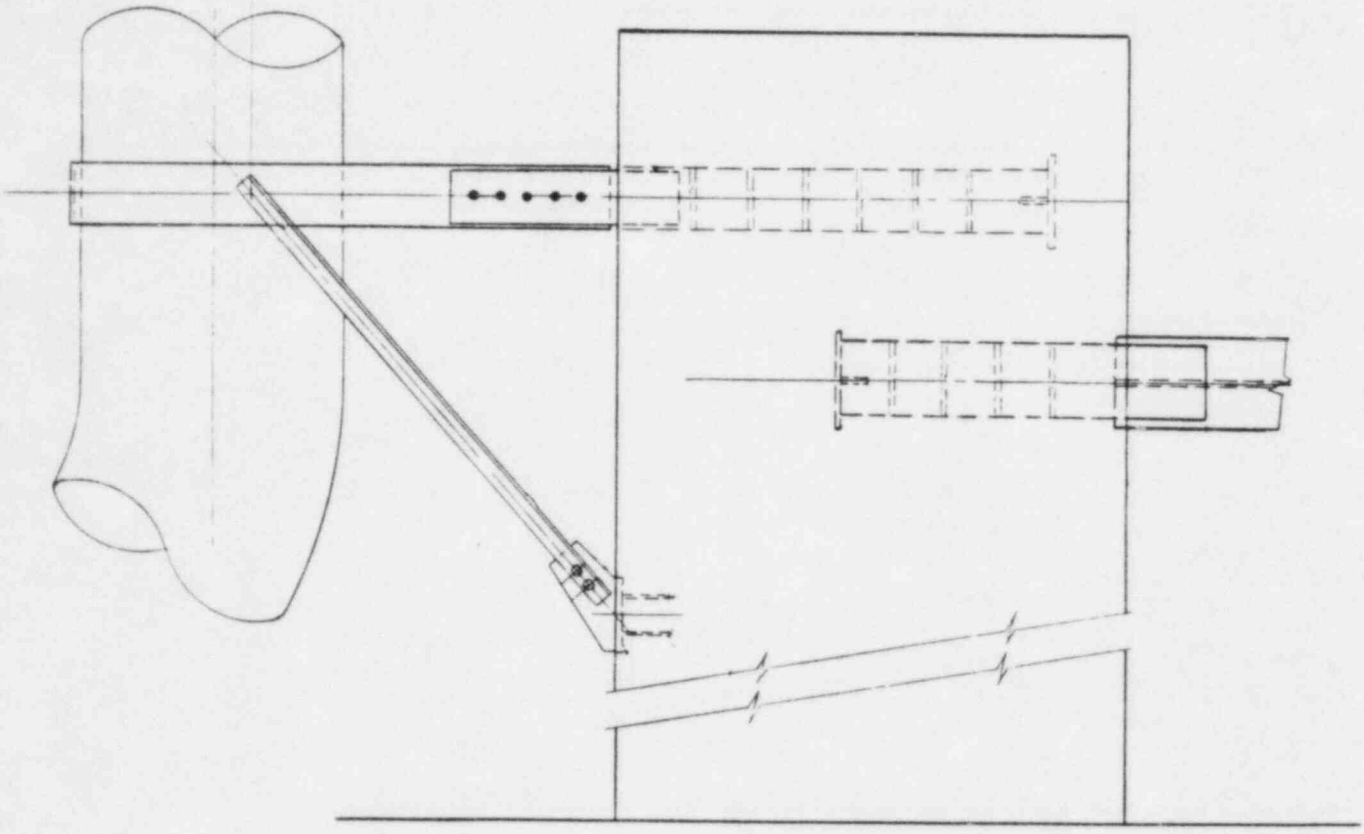


SECTION A
SIDE VIEW

BYRON/BRAIDWOOD STATIONS
FINAL SAFETY ANALYSIS REPORT

FIGURE 3.6-20

REPRESENTATIVE TRIPOD RESTRAINT



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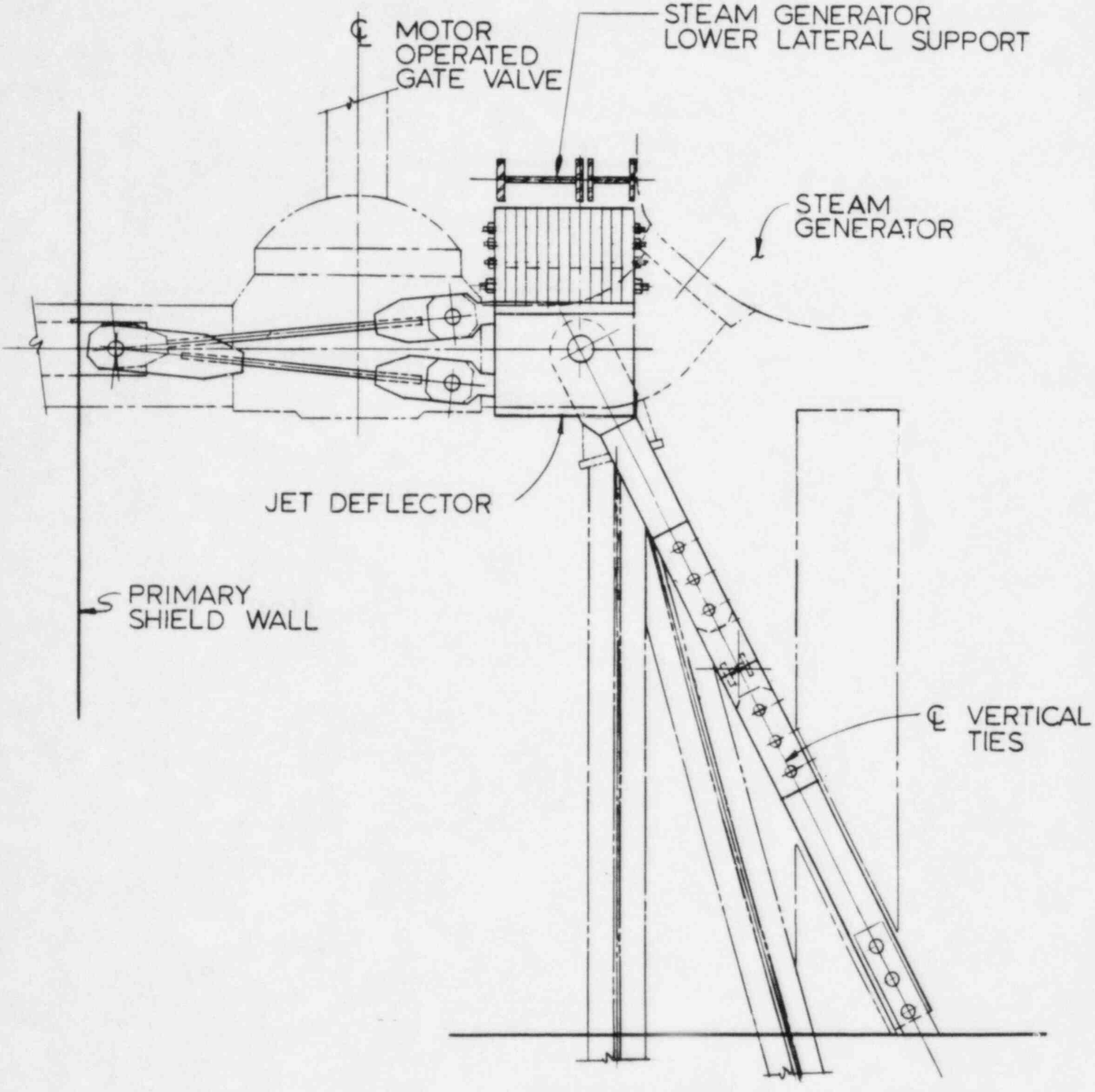
FINAL SAFETY ANALYSIS REPORT

FIGURE 3.6-21

STEEL BAND RESTRAINT



BYRON/BRAIDWOOD STATIONS

FINAL SAFETY ANALYSIS REPORT

FIGURE 3.6-22

JET DEFLECTOR
GENERAL ARRANGEMENT

ATTACHMENT C

ESTIMATED REDUCTION IN OCCUPATIONAL EXPOSURE DUE TO ELIMINATION OF PRIMARY LOOP PIPE WHIP RESTRAINTS AND JET DEFLECTORS

WORK FUNCTION	ESTIMATED ANNUAL[a] OCCUPATIONAL EXPOSURE PER 2 UNIT SITE (MAN-REM)	PERCENT OF ANNUAL EXPOSURE WITHIN CONTAINMENT/SG MAINTENANCE	ASSUMED PERCENT INCREASE IN IMPROVED ACCESS AND INCREASED WORK EFFICIENCY DUE TO REMOVAL	ANNUAL REDUCTION OCCUPATIONAL EXPOSURE PER PLANT (MAN-REM/PY)
1. ROUTINE OPERATIONS AND SURVEILLANCE	65	36 [b]	5	0.6
2. ROUTINE MAINTENANCE AND INSERVICE INSPECTION	300	36 [b]	15	8.1
3. SPECIAL MAINTENANCE	300	50 [c]	5	3.8
				12.5

NOTES:

(a) TAKEN FROM B/B FSAR TABLE 12.4-3

(b) IN CONTAINMENT EXPOSURE BASED ON ZION EXPERIENCE

(c) ASSUME 1/2 OF SPECIAL MAINTENANCE IS ATTRIBUTABLE TO STEAM GENERATORS

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TABLE 12.4-3 (Cont'd)

Byron/Braidwood Estimated Annual Man-rem

Routine Maintenance and Surveillance	65
Routine Maintenance and Inservice Inspection	300
Refueling	65
Radwaste Processing and Handling	20
Other	50
Special Maintenance	300
TOTAL	800

NOTES:

Exposures given were reported as the sum of individual exposures greater than .500 mrem, except for Zion.

Where the breakdown in the original report was more detailed, categories have been condensed as necessary to obtain the categories given here.

The category "other" includes training, miscellaneous, security, consultants, etc.

Where data was incomplete for one-half of the year, the data was prorated from the other complete half of the year, except for refueling.

NR means "not reported," that is, no data for this or any similar category was reported.

*"Normal surveillance" only was reported.

Data for Surry is not included in the averages, since the steam generator tube failures which resulted in high man-rem exposures at Surry are not expected to occur at Byron/Braidwood, which has a different steam generator design and an all-volatile chemistry for feedwater conditioning.

Estimates are conservative to account for exposures less than 100 mrem which are not generally included in reports of occupational exposure and thus are not included in the averages.

ATTACHMENT D

VALUE IMPACT PER UNIT OF IMPLEMENTING "LEAK-BEFORE-BREAK" ON RCS PRIMARY LOOP AND REMOVING ASSOCIATED PIPE WHIP RESTRAINTS AND JET DEFLECTORS

1) BYRON UNIT 2 AND BRAIDWOOD UNITS 1 AND 2

BENEFIT		IMPACT	
REDUCTION IN EXPOSURE (MAN-REM/PY)	NOMINAL ESTIMATE	NOMINAL ESTIMATE	INCREASE IN EXPOSURE (MAN-REM/PY)
OCCUPATIONAL EXPOSURE (OPERATIONAL)			
1. ROUTINE OPERATIONS AND SURVEILLANCE	0.6		
2. ROUTINE MAINTENANCE AND INSERVICE INSPECTION	8.1		
3. SPECIAL MAINTENANCE	3.8		
		2.4E-2	PUBLIC HEALTH
		4.2E-3	OCCUPATIONAL EXPOSURE (ACCIDENTAL)
ANNUAL REDUCTION	12.5	2.8E-2	ANNUAL INCREASE

2) BYRON UNIT 1

BENEFIT		IMPACT	
REDUCTION IN EXPOSURE (MAN-REM/PY)	NOMINAL ESTIMATE	NOMINAL ESTIMATE	INCREASE IN EXPOSURE (MAN-REM/PY)
TOTAL REDUCTION (FROM ABOVE)	12.5	2.8E-2	TOTAL INCREASE (FROM ABOVE)
		8.6	OCCUPATIONAL EXPOSURE DUE TO REMOVAL OF UNIT 1 PIPE WHIP RESTRAINTS AND JET DEFLECTORS (ANNUALIZED)
ANNUAL REDUCTION	12.5	8.6	ANNUAL INCREASE

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