WASHINGTON PUBLIC POWER SUPPLY SYSTEM

P.O. Box 968 • 3000 George Washington Way • Richland, Washington 99352

January 30, 1987
G01-87-0010

Responds to: N/A
Response Requested: Yes

Docket No. 50-460

Director of Nuclear Reactor Regulation
Attention: John G. Stolz, Director
PWR Project Directorate No. 6
Division of PWR Licensing-B
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Subject: NUCLEAR PROJECT NO. 1
ELIMINATION OF POSTULATED PIPE BREAKS IN PRIMARY MAIN LOOPS - AN EXEMPTION FROM GENERAL DESIGN CRITERION 4

Reference: NRC letter from D. M. Crutchfield to L. C. Oakes, dated December 12, 1985, "Safety Evaluation of B&W Owners Group Reports Dealing with Elimination of Postulated Pipe Breaks in PWR Primary Main Loops" (GI1-85-0207)

The Supply System hereby requests an exemption, pursuant to 10CFR50.12(a), from General Design Criteria 4 to apply the "Leak-Before-Break" concept to WNP-1 to eliminate postulated pipe breaks in the RCS primary loop from the plant structural design basis.

The Supply System, as a member of the B&W Owners Group, submitted BAW-1847, Revision 1 "Leak-Before-Break Evaluations of Margins Against Full Break for RCS Primary Piping of B&W Designed NSS", and BAW-1889P "Piping Material Properties for Leak-Before-Break Analysis." These B&W generic reports conclude that large breaks will not occur, and that postulated flaws producing detectable leakage exhibit stable growth, thus allow a controlled plant shutdown before any potential exists for catastrophic piping failure. A favorable ruling was made by the Commission (see reference) in the subsequent Safety Evaluation Report of these B&W reports. The reference evaluation concludes that an acceptable basis has been provided to eliminate, as a design basis, the dynamic effects of large rupture in the main loop primary piping of the B&W Owners Group facilities (including WNP-1).

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Recd w/ check for $150.00

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As indicated in Generic Letter 84-04, the staff has accepted the utilization of the "Leak-Before-Break" concept on certain dockets as a means of obviating the need to install certain piping/equipment support systems. The attached Exemption Request utilizes such methodology to support the exclusion of dynamic loss of coolant accident (LOCA) loads from the RCS piping, which will allow the elimination of pipe whip restraints and jet shields, and allow a reduction in the number of hydraulic snubbers restraining the RCS. Attachment 'A' summarizes this Exemption Request. Attachment 'B' summarizes the WNP-1 plant design parameters which are under the B&W Owners Group umbrella. A safety balance in terms of accidental risk avoidance attributable to protection from dynamic effects of pipe rupture versus safety gain resulting from a decision not to use such protection is provided in Attachment 'C'. Note that the estimated cost and safety improvement for the life of the plant are:

Pipe Whip Restraint/Jet Shield

Cost Saving: $3.2 Million

Reduction in Radiation Exposure: 460 man-rem

RCS Hydraulic Snubbers

Cost Saving: $1.624 Million

Reduction in Radiation Exposure: 218 man-rem

The reactor coolant pressure boundary leakage detection system at WNP-1 is designed to conform with the requirements of Regulatory Guide 1.45 and is discussed in detail in Subsection 5.2.5 of the WNP-1 FSAR.

A summary of the potential benefits which can be realized specifically from the elimination of these pipe breaks for WNP-1 is provided in Attachment 'D'. Implementation of the "Leak-Before-Break" concept will therefore be cost effective as well as being technically justifiable. The plant piping, equipment, and structures will become more accessible and inspectable, thereby reducing occupational radiation exposures, costs, and the likelihood of undetected defects. The ultimate objective is to reduce the cost of construction and maintenance, reduce radiation exposure, improve thermal flexibility, reduce outage time, and increase plant safety and reliability.

Your prompt and favorable action on this request will be appreciated. Once the request is approved for application, the applicable criteria will be incorporated into a future FSAR revision.

Pursuant to 10CFR170.12, please find a check in the amount of $150.00.

G. C. Sorensen
Manager, Regulatory Programs

GCS:LCO:pd

Attachments: A. RCS Loop Pipe Break Design Basis Exemption
B. WNP-1 Plant Design Parameter used in Leak-Before-Break Evaluation
C. Safety Balance
D. Summary of Benefits from the Elimination of Primary Loop Pipe Breaks
Check in the amount of $150.00

cc: N. D. Amaria, UE&C (898)
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NRC Document Control Desk, Washington, D. C.
SDCC

Attachment A

Supply System
WNP-1
RCS Loop Pipe Break Design Basis Exemption

Exemption Request

Pursuant to 10 CFR 50.12(a), Supply System hereby applies for an exemption from the provisions to 10 CFR Part 50, Appendix A, authorizing alternative pipe break analyses utilized in the structural design of the WNP-1. The requested exemption is based upon the application of advanced fracture mechanics technology as evaluated in the Babcock & Wilcox Topical Report BAW-1847 Rev. 1.

Specifically, Supply System requests the elimination of postulated circumferential and longitudinal pipe breaks in the reactor coolant system primary loop from consideration in the structural design basis of WNP Unit 1. The impact on important aspects of implementing leak-before-break on WNP Unit 1 has been evaluated and is summarized in Attachment D. A summary list of affected pipe whip restraints, jet shields, and snubbers is provided in Attachment D.

The bases for the requested exemption are as follows:

1. Extensive operating experience has demonstrated the integrity of the RCS primary loop including the fact that there has never been a leakage crack.

2. In-shop, pre-service, and in-service inspections performed on piping for the WNP-1 minimize the possibility of flaws existing in such piping. The application of advanced fracture mechanics has demonstrated that if such flaws exist, they will not grow to a leakage crack when subjected to the worst case loading condition over the life of the plant.

3. If one postulates a through-wall crack, large margins against unstable crack extension exist for PWR primary coolant piping when subjected to the worst case loading conditions over the life of the plant.

4. The NRC sponsored research on probabilistic fracture mechanics studies was conducted by Lawrence Livermore National Laboratories (LLNL). These studies (Reference A1) confirm that both the probability of leakage (e.g., undetected flaw growth through pipe wall by fatigue) and probability of Double Ended Guillotine Break (DEGB) are very low for B&W plants. And those are nominally identical to those calculated for the Westinghouse and Combustion Engineering studies. The results given in Reference A2 are that the best-estimate leak probabilities for Westinghouse nuclear steam system (NSS) main loop piping range from 1.2×10^{-8} to 1.5×10^{-7} per plant year and the best-estimate DEGB probabilities range from 1×10^{-12} to 7×10^{-12} per plant year. Similarly, the best-estimate leak probabilities for Combustion Engineering NSS main loop piping range from 1×10^{-8} to 3×10^{-8} per plant year, and the best-estimate DEGB probabilities range from 5×10^{-14} to 5×10^{-13} per plant year. These results do not affect core melt probabilities in any significant way.

5. The Reference A3 study of probability of indirect Double-Ended Guillotine Break (DEGB) in RCS piping as a consequence of seismic-induced structural failures for Babcock & Wilcox supplied PWR shows that the median probability of indirect DEGB was estimated to range between 6×10^{-11} and 1×10^{-7} per year. These results do not affect core melt probabilities in any significant way.

The application of advanced fracture mechanics technology has demonstrated that small flaws or leakage cracks (postulated or real) will remain stable and will be detected either by in-service inspection or by leakage monitoring systems long before such flaws can grow to critical sizes which otherwise could lead to large break areas such as the double-ended rupture of the largest pipe of the Reactor Coolant System. To date, use of this advanced fracture mechanics technology has been limited by the definition of a LOCA in Appendix A to 10CFR Part 50 as including postulated double-ended ruptures of piping, regardless of the associated probability. Application of the LOCA definition without regard to this advanced technology to large diameter thick-walled piping, such as the primary coolant pipes of a PWR, imposes a severe penalty in terms of cost and occupational exposure because of the massive pipe whip restraints, jet shields, and supports it requires which must be removed for in-service inspection. This penalty is unreasonable because these piper do not have a history of failing or cracking and are conservatively designed. Accordingly, for design purposes associated with protection against dynamic effects, Supply System requests this exemption from the regulations to eliminate the need to postulate circumferential and longitudinal pipe breaks.

Implementation of the exemption will have the following effects on the structural design for WNP Unit 1:

1. Eliminate the need to postulate circumferential and longitudinal pipe breaks in the RCS primary loop (hot leg and cold leg piping).

2. Eliminate the need for associated pipe whip restraints and jet shields in the RCS primary loop and eliminate the requirement to design for the structural effects associated with RCS primary loop pipe breaks including jet impingement.

3. Removal or elimination of snubbers or support devices especially installed to resist combined earthquake and LOCA loads or specific load cases such as asymmetric blowdown or jet impingement.

4. Eliminate the need to consider dynamic effects and loading conditions associated with previously postulated primary loop pipe breaks. These effects include blowdown loads, jet impingement loads, reactor cavity and subcompartment pressurization, and pipe rupture generated missiles (insulation, support, etc.).

The exemption would not eliminate pipe breaks in the RCS primary loop as a design basis for the following:

1. Containment design
2. Sizing of Emergency Core Cooling System
3. Environmental qualification of equipment

As stated above, Supply System requests that the exemption authorize, with respect to the plant structural design basis, the elimination of pipe breaks in the RCS primary loop. The use of advanced fracture mechanics permits a deterministic evaluation of the stability of postulated flaws/leakage cracks in piping as an alternative to the current mandate of overly conservative postulations of piping ruptures. The requested exemption is, thus, consistent with the provisions of footnote 1 to 10 CFR Part 50, Appendix A, which refers to the development of "further details relating to the type, size and orientation of postulated breaks in specific components of the reactor coolant pressure boundary."

References:

A1. NRC letter from D.M. Crutchfield to L.C. Oakes "Safety Evaluation of B&W Owners Group Reports Dealing with Elimination of Postulated Pipe Breaks in PWR Primary Main Loops" dated December 12, 1985.

A2. T. Lo, H.H. Woo, G.S. Holman and C.K. Chou, "Failure Probabilities of PWR Reactor Coolant Loop Piping" ASME PVP Conference; June 17-21, 1984, San Antonio, Texas.

A3. M.K. Ravindra, R.D. Campbell, T.R. Kipp and R.U. Sues; "Probability of Pipe Failure in the Reactor Coolant Loops of Babcock & Wilcox PWR Plants" NUREG/CR-4290 Volume 2; July 1985.

Attachment B

Plant Design Parameters - Leak Before Break Evaluation
Supply System WNP-1

Supply System, as a member of the B&W Owner's Group submitted BAW-1847, Revision 1, "Leak Before Break Evaluation of Margins Against Full Break for RCS Piping of B&W Designed NSS," and "BAW-1889P "Piping Material Properties for Leak-Before-Break Analysis." These reports provide the technical basis for determining that a double-ended guillotine break will not occur and that flaws big enough to produce a detectable leakage rate are stable. This stability allows for controlled plant shutdown before any potential exists for a catastrophic piping failure.

BAW-1847 demonstrates that:

a. A substantial sized flaw in the piping would not grow through the wall nor extend significantly in length during the plant design lifetime.

b. Even if a flaw were to grow through the wall of the piping, it would open sufficiently to leak many times the minimum detectable leakage rate before extending to anywhere near the critical crack length.

c. A very long through-wall crack (many times longer than the longitudinal or circumferential crack length that produces a detectable leakage rate) would remain stable under normal operation plus safe shutdown earthquake (SSE) loadings.

These conclusions provide sufficient justification for elimination of large postulated breaks from the design basis for the RCS main loop piping. The approach follows a defense-in-depth philosophy by showing substantial margin in each of the analytical steps. The evaluation included structural and fracture mechanics analyses using generic bounding data, loads and material properties, for all B&W Owner's Group (B&WOG) plants. Supply System as a member of this Owner's Group is bounded by the conclusion of the B&W evaluation for its WNP Unit 1 plant. The following is a summary of WNP-1 plant parameters, which are enveloped by the B&WOG evaluation.

B.1 Design and Operating Conditions

The WNP-1 is a B&W two-loop designed 205 Fuel-Assembly pressurized water reactor plant. A general arrangement of the Nuclear Steam System is shown in Figure B-1.

Internal Pressure	2150 psi used for leak calculations 2250 psi used for stress and fracture mechanics calculations
System Temperature	600°F

B.2 RCS Primary Piping Sizes

Hot Leg	38" Inside Diameter 38.5" Inside Diameter Unclad 3.125" Wall Thickness Straight Pipe 4.1875" Wall Thickness Elbow-Curved Pipe
Upper Cold Leg	28" Inside Diameter 28.5" Inside Diameter Unclad 2.375" Wall Thickness Straight Pipe 3.125" Wall Thickness Elbow-Curved Pipe
Lower Cold Leg	32" Inside Diameter 32.5" Inside Diameter Unclad 2.6875" Wall Thickness Straight Pipe 3.625" Wall Thickness Elbow-Curved Pipe

B.3 RCS Primary Piping Material

Straight Piping Section	SA 106 Grade C
Elbow Curved Piping Section	SA 516 Grade 70
Safe Ends	SA 336 CL-F8

B.4 RCS Primary Pipe Weld Filler Material

The shop and field weld locations are shown in Figures B-2 to B-4.

Shop Weld:	HiMnMo NiCrFe E308 E309 E7015 E7018
Field Weld:	E308 E309 E7018 E70S-3 (Bounded by materials used in B&WOG analysis)

B.5 RCS Primary Piping and Weld Material Properties

The material properties in terms of stress-strain, the material resistance to fracture (J-R Curve), and J versus tearing modulus (J-T Curve) for the piping base and weld filler material is provided in B&W reports BAW-1847 Revision 1 and BAW-1889P.

B.6 RCS Primary Piping Structural Loads

The primary piping static loads (dead weight and thermal) and loads associated with safe shutdown earthquake (SSE) condition are tabulated in Table B-1.

B.7 RCS Leakage Detection System

The reactor coolant pressure boundary leakage detection system is designed to conform with the requirements of Regulatory Guide 1.45 and is discussed in detail in Section 5.2.5 of WNP-1 FSAR. The leak detection system is capable to detect a leak rate of one gallon per minute in an hour. The containment sump level sensors and the containment airborne radioparticulate and noble gas monitoring systems are qualified Seismic Category I, and will remain functional through the safe shutdown earthquake.

Table B-1

RCS Primary Piping Loads for Leak-Before Break Evaluation
Supply System WNF-1

Dead Weight, Thermal and Safe Shutdown Earthquake Loads

Piping	B&W Owners Maximum Moments	WNP-1 Maximum Moments	B&W Owners Minimum Moments(1)	WNP-1 Minimum Moments(1)	B&W Owners Maximum Axial Force	WNP-1 Maximum Axial Force(2)
	Ft.Kips	Ft.Kips	Ft.Kips	Ft.Kips	Kips	Kips
Hot Leg (38"ID)						
Straight	7253	6787	2407	3158	247	817
Curved	3882	3662	916	1011	692	603
Lower Cold Leg (32" ID)						
Straight	2260	2080	1159	1122	475	315
Curved	2080	2080	1122	1122	315	315
Upper Cold Leg (28" ID)						
Straight	3098	1591	560	914	250	303
Curved	2823	1591	1246	914	539	303

Notes:

1. The minimum moments are reported at the higheat stress location. The minimum moments at other locations results in a leak rate of at least 10 gpm.

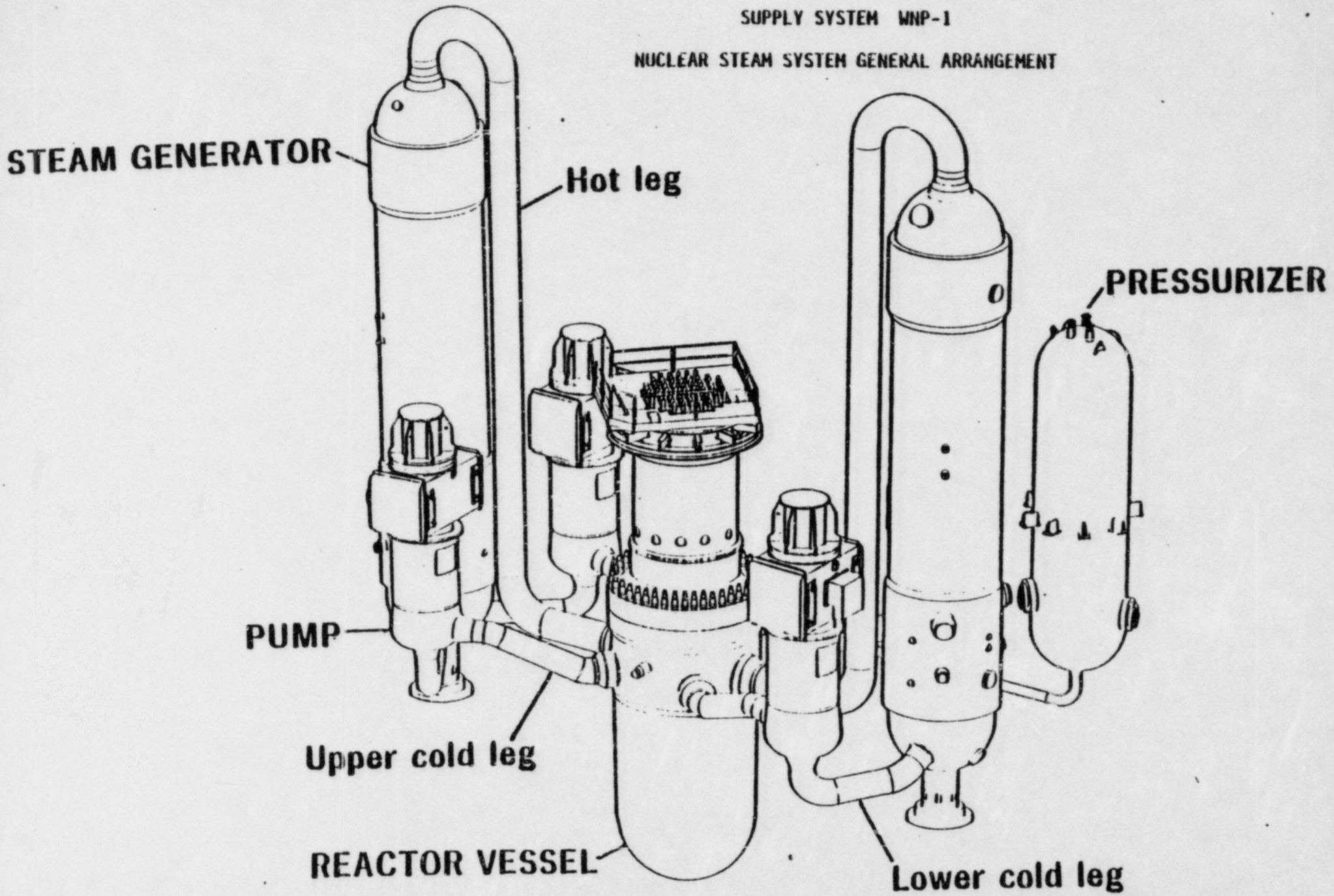
2. The Moment equivalent = (Applied Moment + 0.5 x Pipe Mean Radius x Geometry Factor x Axial Force) used in the tearing stability analysis. Even though WNP-1 axial force is higher than B&WOG, the Moment equivalent is lower. The axial force in this equation includes the mechanical force as well as the force due to pressure. The axial force reported above is only due to mechanical loadings.

3. Tabulated maximum forces and moments are due to dead weight, thermal and SSE loading conditions. The minimum moments are due to dead weight and thermal loading conditions.

FIGURE B-1

SUPPLY SYSTEM WNP-1

NUCLEAR STEAM SYSTEM GENERAL ARRANGEMENT



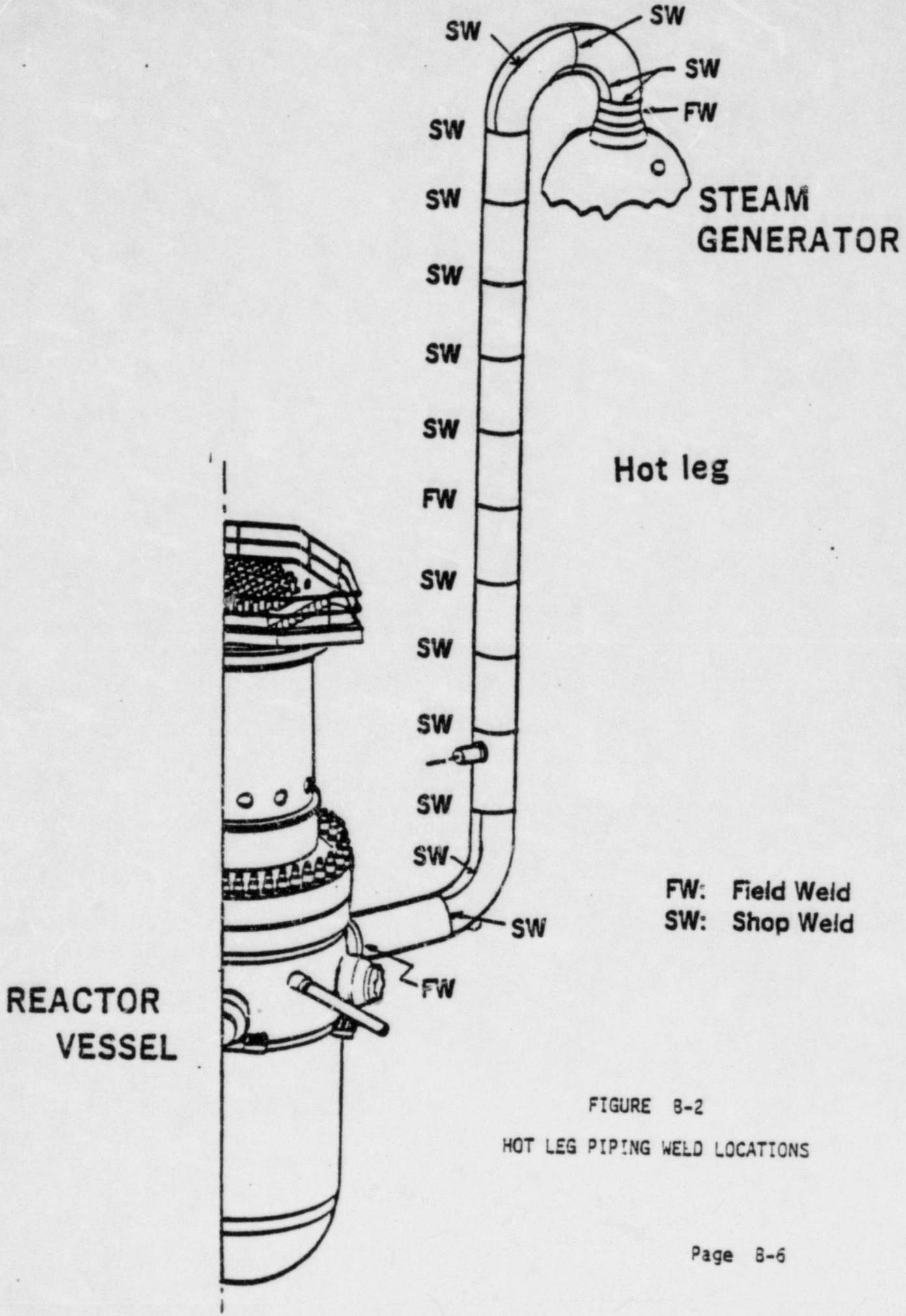


FIGURE B-2

HOT LEG PIPING WELD LOCATIONS

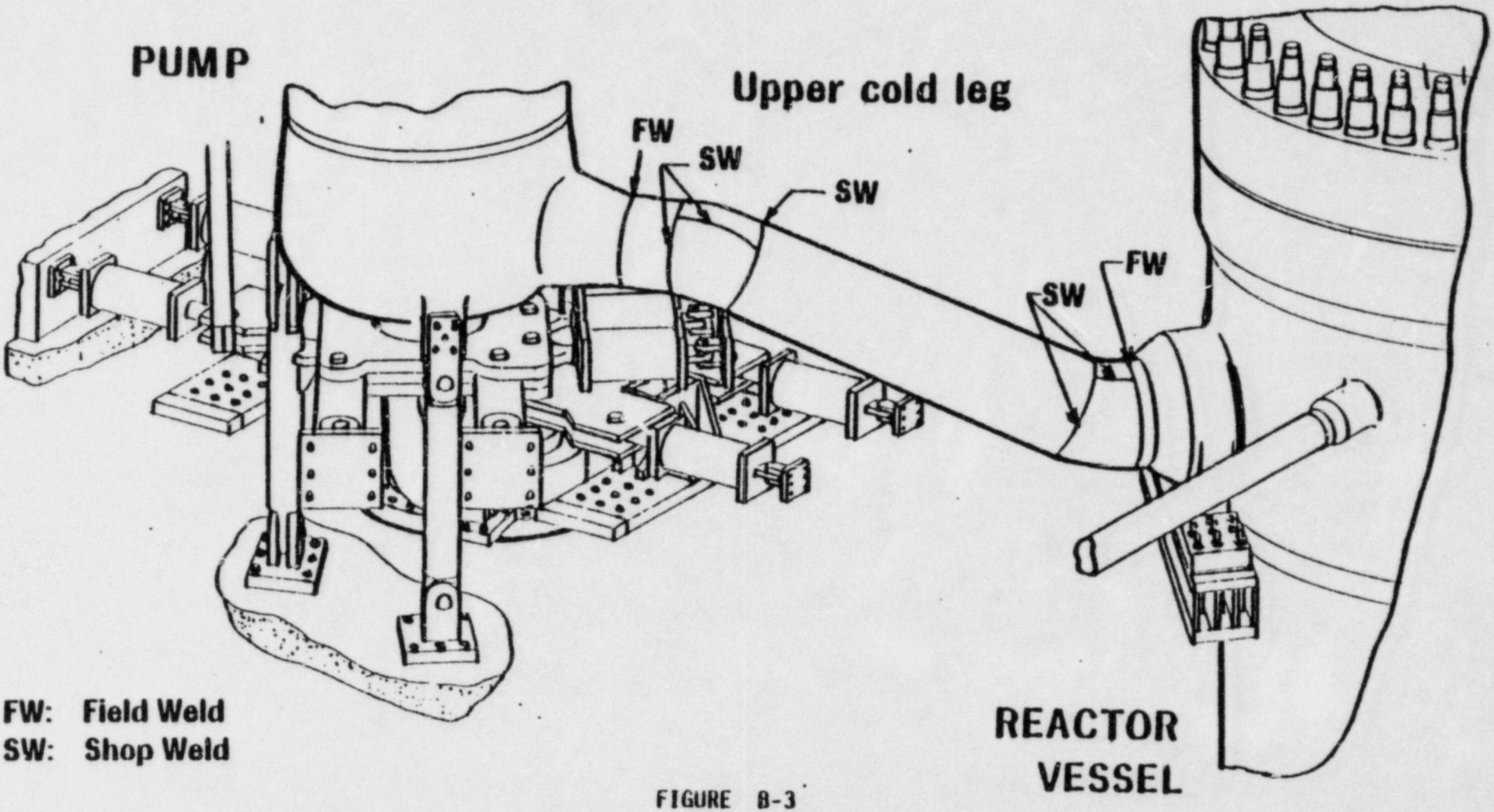


FIGURE B-3

UPPER COLD LEG PIPING WELD LOCATIONS

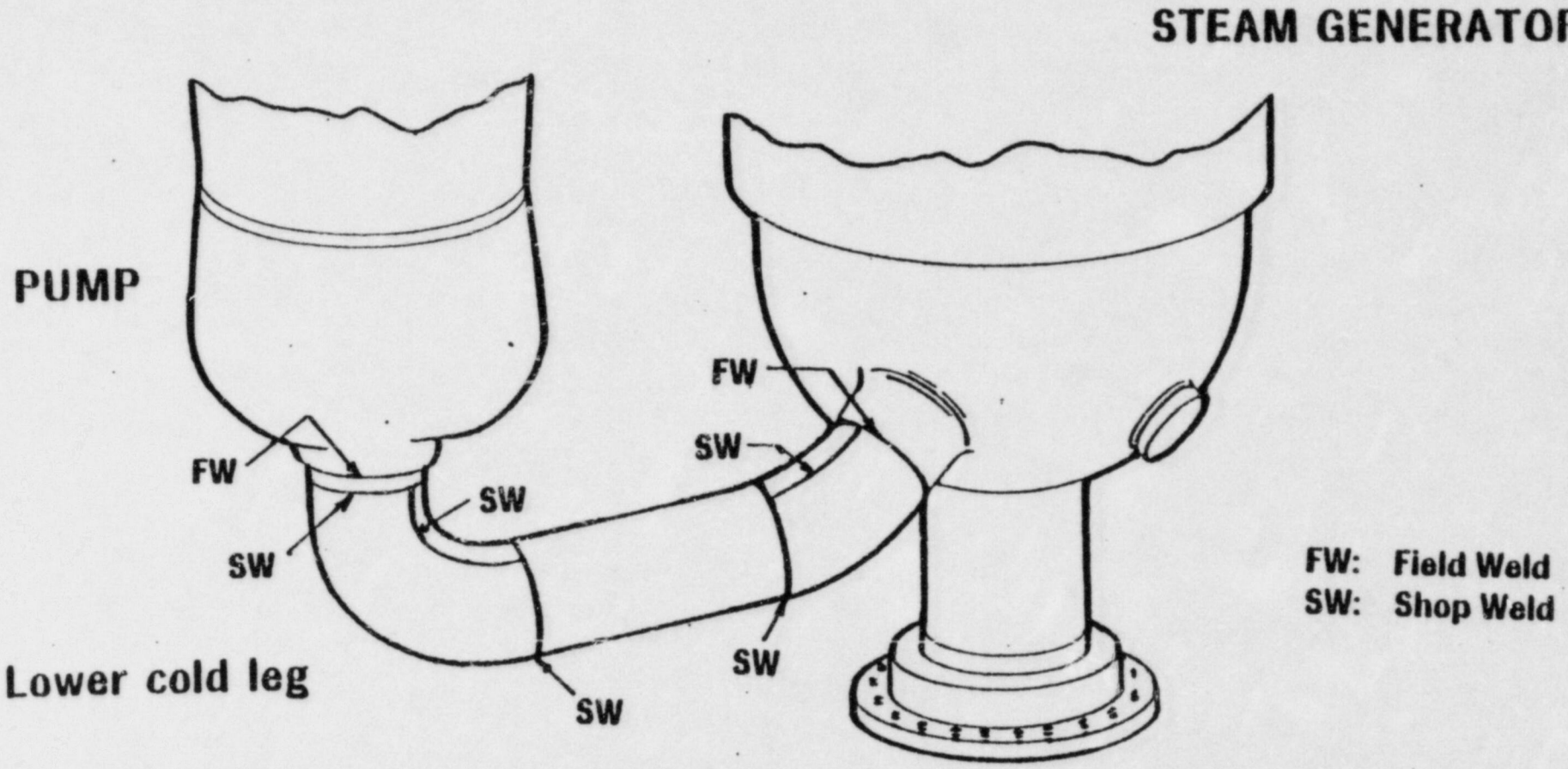


FIGURE B-4

LOWER COLD LEG PIPING WELD LOCATIONS

Attachment C

Safety Balance

Elimination of Primary Loop Pipe Breaks on WNP-1

Pursuant to 10CFR50.12(a), Supply System believes the requested exemption will not endanger life or property, or the common defense and security, and is in the public interest. The evaluation is performed in terms of public health and occupational accidental risk avoidance attributed to the protection provided for dynamic effects associated with postulated breaks in the RCS primary loop versus the reduction in Occupational Radiation Exposure (ORE) resulting from a decision not to use such protection. The estimated increase in public accident exposure associated with omitting RCS primary loop pipe whip restraints, jet shields, and reduction in hydraulic snubbers is only 3.4×10^{-3} to 0.38 man-rem for WNP-1. The value-impact assessment for WNP-1 is based on data from B&W Operating Plants Florida Power—Crystal River Unit 3, and Sacramento Municipal Utility District—Rancho Seco; and work performed by Lawrence Livermore National Laboratory (LLNL) Reference C1. The data for double ended guillotine break used was from LLNL work (Reference C1), the core melt frequency and dose estimates from WASH-1400 and cleanup and decommissioning estimates from NUREG/CR-2800. The safety balance assessment was performed in accordance with guidance provided in NRC Generic Letter 84-04.

The net benefit in avoidance of exposures for WNP Unit 1 associated with requested exemption is (best estimates) 678 man-rem of occupational exposure over plant life, based on Supply System studies. This eliminated radiation exposure is related to pipe whip restraint, jet shield and hydraulic snubber inservice inspection, testing, pipe weld inspection, improved personnel access for operation and maintenance. Consequently, the savings in exposure by granting the exemption far exceed the potentially small increase in public risk and avoided accident exposure associated with omitting these devices. Supply System (best) estimates the net cost savings for WNP Unit 1 of $4.824 million, as presented in Table C-1. This net benefit does not take benefit of the cost of replacement power, which will be needed due to stretchout of plant startup required due to inspection.

Additionally, with removal of pipe whip restraints, jet shields and snubbers, a substantial improvement in the quality of inservice inspection is anticipated. Also, simplified plant designs will result since removal of these devices will eliminate potential interferences with other plant structures. Reduced RCS heat loss to containment at pipe whip restraint location will result. The risk of unanticipated pipe contact with restraint and jet shield for thermal growth and seismic movement can be avoided. Also, risk of unanticipated locking for hydraulic snubber, and not locking during seismic can be avoided. Thus, the exemption will lead to an overall improvement in plant safety.

With these operational benefits and with a net reduction of radiation exposure of 678 man-rem, a net safety gain has been demonstrated for WNP Unit 1. Also, a cost saving of $4.824 million has been shown, and a technical basis for elimination of RCS primary loop pipe breaks has been demonstrated. Therefore, Supply System hereby requests NRC approval of an exemption to GDC-4 in order to apply the "leak-before-break" concept to WNP Unit 1 to eliminate postulated pipe breaks in the RCS primary loop from the plant structural design basis.

References:

C1 G.S. Holman and C.K. Chou "Assessment of Value-Impact Associated with the Elimination of Postulated Pipe Ruptures from the Design Basis for Nuclear Power Plants" Lawrence Livermore National Laboratory Report UCID-20397, March 1985.

C2 Andrews, W.B., et al, "Guidelines for Nuclear Power Plant Safety Issues Prioritization Information Development" NUREG/CR-2800 (1983).

Table C-1

Value Impact Summary—Reactor Coolant Piping
Supply System WNP-1

	Best Estimate	High Estimate	Low Estimate
Values (man-rem)			
Public Health	-4 E-6	-0.244	0
Occupation Exposure (accidental)	-3 E-5	-0.136	0
Occupation Exposure (Routine)			
Pipe Whip Restraint/Jet Shield	460	1,578	66
RCS Snubbers	218	435	196
Value Total	678	2,013	262
Impact ($)			
Implementation and Operating Cost			
Pipe Whip Restraint/Jet Shield	-3,200K	-4,800K	-2,880K
RCS Snubber	-1,624K	-3,248K	-1,462K
Power Replacement Cost	Benefit not taken in this evaluation		
Offsite Property	1	9K	0
Onsite Property	1	2K	0
Impact Total	-4,824K	-8,037K	-4,342K

Attachment D

Summary of Benefits from the Elimination of Primary Loop Pipe Breaks on WNP Unit 1

Category	Benefits
1. Plant Design	• Simplifies plant design by elimination of potential interferences with piping, hangers, impulse tubing, etc. • Optimized compartment ventilation.
2. Relief of congestion improving access for operation, maintenance, and inservice inspection.	678 man-rem reduction in radiation exposure over life of plant ($4.824 million cost savings).
3. Reduction in RCS heat loss to containment at whip restraint location.	Not quantitatively assessed. Insulation can be installed on piping at current locations of RCS pipe whip restraints.
4. Improvement in overall plant safety (NUREG/CR-2136)	Improvement in ISI quality. Elimination of potential for restricted thermal or seismic movement.
5. Simplification of analysis associated with dynamic effects and loading conditions.	Pressurization loadings reduced on primary shield wall, crane wall, operating floor, and subcompartment analysis.

Table D-1

Summary of Hardware Affected by
Elimination of Primary Loop Pipe Breaks

Supply System WNP-1

Component/Piping System	Total	To Be Removed
A. Reactor Coolant Loop		
a) Pipe Whip Restraints		
Hot Legs	8	8
Upper Cold Legs	4	4
Lower Cold Legs	4	4
b) Jet Impingement Barriers		
Hot Legs	2	2
Upper Cold Legs	8	8
Lower Cold Legs	4	4
B. Steam Generator		
Hydraulic Snubbers	8	Minimum 4 Maximum 8
C. RC Pump and Motor		
Hydraulic Snubbers	8	Minimum 4 Maximum 8