DUKE POWER COMPANY
P.O. BOX 33189
CHARLOTTE, N.C. 28242

HAL B. TUCKER
VICE PRESIDENT
NUCLEAR PRODUCTION

TELEPHONE
(704) 373-4531

September 14, 1984

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Ms. E. G. Adensam, Chief
Licensing Branch No. 4

Re: Catawba Nuclear Station
Docket Nos. 50-413 and 50-414

Dear Mr. Denton:

On December 20, 1983, Duke Power Company requested approval for application of the "leak-before-break" concept to Catawba Unit 2 to eliminate postulated pipe breaks in the Reactor Coolant System primary loop from the plant structural design basis. Attachment 4 to that submittal provided a summary of estimated cost savings and operational benefits for elimination of primary loop pipe breaks on Catawba Unit 2. Included in that summary was a projected occupational radiation dose reduction of 600 man-rem. Attached is a copy of the analysis which was the basis of the dose reduction estimate.

Very truly yours,

H.B. Tucker / BD

Hal B. Tucker

ROS:slb

Attachments

cc: Mr. James P. O'Reilly, Regional Administrator
U. S. Nuclear Regulatory Commission
Region II
101 Marietta Street, NW, Suite 2900
Atlanta, Georgia 30323

NRC Resident Inspector
Catawba Nuclear Station

Mr. Robert Guild, Esq.
Attorney-at-Law
P. O. Box 12097
Charleston, South Carolina 29412

cc: Palmetto Alliance
2135½ Devine Street
Columbia, South Carolina 29205

Mr. Jesse L. Riley
Carolina Environmental Study Group
854 Henley Place
Charlotte, North Carolina 28207

November 17, 1983 MDPE-83-599

Memo to File

Re: Catawba Nuclear Station
Removal of Rupture Restraints - Radiation
Dose and Cost Estimate
File No.: CN-1206.03-04, CN-1229.00

This analysis estimates the occupational radiation exposure and inherent cost associated with primary and non-primary loop rupture restraints.

Attached are three separate calculations involving: first, the dose assessment of twenty primary coolant loop rupture restraints; second, the cost savings associated with this occupational radiation exposure, and third, the dose assessment and cost savings associated with 140 non-primary coolant loop restraints.

The results of these calculations for a unit lifetime of 40 years are:

600 man-rem from 20 primary loop restraints and, 1.3 million dollars of radiation exposure cost,

and

270 man-rem from 140 non-primary loop restraints and, 670 thousand dollars of radiation exposure cost.

The cost estimates are based on the present value of money, that is, present station labor salaries. Occupational radiation exposure is based on expected average dose rates which may vary depending on system operation.

However, the respective dollars per man-rem values of 2100 and 2500 compare favorably to accepted Nuclear Production estimates of 2500 dollars per man-rem.

This assessment does not include loss of time or access to other equipment, loss of equipment laydown space, or other hazards associated with maintenance and inspection tasks due to pipe rupture restraints.

R. G. Eble

R. G. Eble, Design Engineer I
Mechanical & Nuclear Division

RGE/sr

Catawba - Occupational Radiation Exposure Associated with Pipe Rupture Restraints

Hypothesis:

Removal of main loop pipe rupture restraints inside containment at Catawba will eliminate personnel radiation exposure related to restraint inspection tasks, restraint disassembly for pipe weld inspections and provide greater access and laydown space for other maintenance activities.

Assumptions:

Restraint assembly and disassembly times are based on construction experience. Actual manpower will be higher due to protective clothing and access restrictions in high radiation areas.

Radiation dose rates are assumed for normal expected shutdown conditions with no crud traps or "hot spots" near the work area.

Manpower for a given task includes ingress and egress time to the work area.

Other assumptions are included in the calculation portion of this analysis.

References:

J. E. Cherry: Duke Power Company, QA Department, Design Engineering Department on inspection frequency and number of weld/restraint interferences.

Radiation Analysis Design Manual, Catawba Nuclear Station, Westinghouse, Dated 11-78.

NUREG/CR-0446, "Determining Effectiveness of ALARA Design and Operational Features." 4-79

NUREG-CR-3254, "Licensee Programs for Maintaining Occupational Exposure to Radiation As Low As Is Reasonably Achievable." 7-83

H. J. Dameron, Duke Power Company, Nuclear Production Department, Technical Services, telephone conversation on average wage of Nuclear Production Department employees.

Calculation:

I. Quality Assurance inspection Criteria states that primary piping welds will be inspected at the 10-year outages. All main loop pipe restraints considered in this analysis will impact weld inspection time and exposure. Each restraint will have to be partially disassembled and then reassembled to perform the inspection. Manpower necessary to remove/reinstall a restraint has been estimated to be:

2 men, 2½ days for maintenance labor and 4 men, 2½ days for field and engineering support.

The dose rate at shutdown near the primary coolant piping is approximately 100 mR/Hr. General area dose rates in lower containment is approximately 30 mR/Hr.

It is assumed that the maintenance labor is in the vicinity of the primary coolant piping and the support labor is maintained in the general area. The occupational exposure associated with the removal/reinstallation of pipe restraints for primary coolant weld inspection is:

$$\text{Maintenance Exposure} = \frac{\text{40 man-hours}}{\text{restraint}} \times 0.1\ \frac{\text{Rem}}{\text{Hr}} \times 20\ \text{Restraints} = 80\ \text{man-rem}$$

$$\text{Field Support Exposure} = \frac{\text{80 man-hours}}{\text{restraint}} \times 0.03\ \frac{\text{Rem}}{\text{Hr}} \times 20\ \text{Restraints} = 48\ \text{man-rem}$$

per inspection frequency of 1 every 10-year outage.

Additional exposure related to health physics personnel is discussed in Section III of this report.

II. Additional occupationsl exposure will be received by Quality Assurance personnel during inspection of pipe whip restraints. In discussion with QA personnel, pipe restraints will be visually inspected approximately once every 5 years for proper gap clearance. In the event of pipe/whip restraint (crush pad) interaction a more detailed inspection of the restraint will be performed. It is assumed that 1 restraint undergoes detailed inspection once every 10 years. Normal visual inspection takes 2 men ½ hour per restraint in a 100 mR/Hr radiation field with no additional field support. Detailed inspection takes two men approximately 5 hours near the primary coolant piping with additional 20 man-hours of field support in a general radiation field of 30 mR/Hr.

The occupational radiation exposure associated with pipe whip restraint inspection is:

<u>visual inspection:</u>

$$\text{QA exposure} = 20\ \text{men} \times 0.5\ \frac{\text{hours}}{\text{insp freq}} \times 0.1\ \frac{\text{Rem}}{\text{Hr}} \times 20\ \text{Restraints} = 2\ \frac{\text{man-rem}}{\text{inspec freq}}$$

inspection frequency of once every 5 years.

Detailed Inspection:

QA exposure = 2 men x 5.0 $\frac{\text{hours}}{\text{insp freq}}$ x 0.1 $\frac{\text{Rem}}{\text{Hr}}$ x 1 Restraint = 1.0 $\frac{\text{man-rem}}{\text{insp freq}}$

field support = 4 men x 5.0 $\frac{\text{hours}}{\text{insp freq}}$ x 0.03 $\frac{\text{Rem}}{\text{Hr}}$ x 1 restraint = 0.6 $\frac{\text{man-rem}}{\text{insp freq}}$

inspection frequency of once every 10 years.

III. Occupational exposure associated with health physics personnel support includes surveys, monitoring and normal HP support on the job. It is assumed that HP personnel will spend the same number of manhours as maintenance and Quality Assurance personnel but will spend most of that time in the general, 30 mR/Hr, radiation field.

For pipe weld inspection, maintenance and QA personnel HP support radiation exposure:

800 $\frac{\text{man-hours}}{\text{insp freq}}$ x 0.03 $\frac{\text{Rem}}{\text{Hr}}$ = 24 $\frac{\text{man-rem}}{\text{insp freq}}$

inspection frequency of once every 10 years.

For pipe whip restraint inspection:

visual: 20 man-hours x 0.02 $\frac{\text{Rem}}{\text{Hr}}$ = 0.6 $\frac{\text{man-rem}}{\text{insp freq}}$

inspection frequency of once every 5 years.

Detailed:

10 man-hours x .03 Rem/Hr. = 0.3 $\frac{\text{man-rem}}{\text{insp freq}}$

inspection frequency of once every 10 years.

IV. The total radiation dose associated with primary loop pipe whip restraints is:

	labor group	dose/insp freq (man-rem)	inspection frequency (insp/40years)	dose in plant life (man-rem)	
	maintenance	80	4	320	
weld insp	field support	48	4	192	
	HP support	24	4	96	
					608
	Quality Assurance	2	8	16	
Restr insp	Quality Assurance	1	4	4	
	field support	0.6	4	2.4	
	HP support	0.6	8	4.8	
	HP support	0.3	4	1.2	
					28

Total occupational exposure associated with primary loop pipe whip restraints is: 636 man-rem

per unit lifetime.

Catawba-Cost Savings Estimate for Radiation Exposure Associated with Primary Loop Rupture Restraints

Hypothesis:

Removal of primary loop piping rupture restraints inside containment at Catawba will provide cost savings associated with the ultimate reduction of radiation exposure. In the same way as exposure reduction, (see 9/14/83 correspondence), time spent in removing restraints for reactor coolant pipe weld inspection, gap clearance inspection, and associated support of these tasks will be eliminated thus saving employee time, protective clothing, radiation risk, and will provide the employee an opportunity to continue work in a radiation area.

The cost of these activities will provide the basis for savings associated with the approximate 600 man-rem exposure savings per unit life.

Assumptions:

Man-hours associated with each task and frequency of tasks from 9/14/83 correspondence used for dose reduction estimation.

Salaries for maintenance, health physics, QA/QC technician is $18/hr. Supervision is $22/hr. Engineering support is $20/hr. and covers Duke Power employees only -- no contracted work.

No outage cost associated with pipe restraint maintenance or inspection activities.

Personnel access inside containment is allowed during system shutdown conditions only.

Calculation:

I. Primary coolant pipe whip restraints

1.1 Cost associated with removal/reinstallation of restraints for weld inspections.

Manpower: 40 man-hours per restraint per inspection frequency of once every 10 years.

Radiation Dose: 40 man-hours x 0.1 $\frac{\text{Rem}}{\text{Hr}}$ = 4 man-rem per restraint per inspection frequency of once every 10 years.

Cost: A worker is allowed 1000 millirem per quarter (Duke limit) and restraint work is assumed to take place in one quarter of the year. Thus 4 man-rem of radiation exposure will eliminate 4 employees from additional radiation work in the quarter. It is assumed that an employee restricted from work in a radiation area is worth 3/4 of his normal capacity to the company. A cost of 1/4 of the worker's salary is then associated with the inability to perform in a radiation area. Therefore the cost associated with 4 man-rem of maintenance personnel exposure is:

$$\text{Cost} = \frac{4 \text{ man-rem}}{\frac{1 \text{ man-rem}}{\text{quarter}}} \times 520 \frac{\text{hours}}{\text{quarter}} \times \frac{\$18}{\text{Hr}} \times \frac{1}{4} = \$9360.$$

per restraint per inspection frequency.

For all 20 restraints: cost = $9360 x 20 = $187,000/insp freq. and for 4 inspections in 40 years,

Cost = $749,000 per unit lifetime.

All remaining calculations based on personnel exposure will follow this same methodology in an abbreviated format.

I. 1.2 Field support of restraint remove/install for weld inspection: ½ general labor @ $18/hr + ½ engr @ $20/hr = $19/hr.

Manpower: 4 men x 20 $\frac{\text{hours}}{\text{restraint}}$ in general area (.03 $\frac{\text{Rem}}{\text{Hr.}}$)

per restraint per inspection.

in one inspection: 20 restraints x 80 man-hours
= 1600 man-hours of support/I.F.
48 man-rem/inspection frequency.

$$\text{Cost} = \frac{1600 \text{ man-hours}}{\frac{1 \text{ man-rem}}{\text{quarter}}} \times 0.03 \frac{\text{Rem}}{\text{Hr}} \times 520 \frac{\text{Hrs.}}{\text{quarter}} \times \$19/\text{Hr} \times \frac{1}{4}$$

= 115,000/inspection frequency

inspection frequency 4 (in 40 yrs)

Total cost associated with loss of field support personnel is:

115,000 x 4 = $460,000 per unit lifetime.

I. 2. Inspection of pipe restraint gap clearance and detailed restraint inspection for pipe-restraint interaction.

2.1 Visual inspection of all pipe restraints, no field support.

Manpower: 2 men x 0.5 $\frac{\text{hours}}{\text{restraint}}$ in pipe area (0.1 $\frac{\text{Rem}}{\text{Hr}}$)

per inspection frequency of 8 in 40 years.

for inspection frequency: 20 restraints x 1 man-hour = 20 man-hours every 5 years

$$\frac{20 \text{ man-hours}}{\frac{1 \text{ man-rem}}{\text{quarter}}} \times 0.1 \frac{\text{Rem}}{\text{Hr.}} \times 520 \frac{\text{Hrs.}}{\text{quarter}} \times \$18/\text{hr} \times \frac{1}{4} = \$4500/\text{I.F.}$$

$4500 x 8 $\frac{\text{insp}}{\text{40 years}}$ = $36,000 per unit lifetime.

2.2.1 Detailed inspection - maintenance

manpower: 2 men x 5 hours = 10 man-hours/I.F. of 4 in 40 yrs.

assuming 1/20 restraints undergoes detailed inspection/ every 10 years.

$$\text{Cost} = \frac{10 \text{ man-hrs.}}{\frac{1 \text{ man-rem}}{\text{quarter}}} \times 0.1 \frac{\text{Rem}}{\text{Hr.}} \times 520 \frac{\text{Hrs.}}{\text{qtr.}} \times \$18/\text{Hr.} \times 1 = \$2250/\text{I.F.}$$

inspection frequency of 1 in 10 years or 4 in 40 yrs.

Cost = 2250 x 4 = $9,000 per unit lifetime.

2.2.2 Detailed pipe restraint inspection - field support in general radiation area.

Manpower: 2 x maintenance man-hours = 20 man-hours/I.F.

Rad. Dose: $0.03 \frac{\text{Rem}}{\text{Hr.}} \times 20$ man-hours = .6 man-rem.

Cost = $\frac{\$19}{\text{Hr}} \times \frac{1}{4} \times \frac{.6 \text{ man-rem}}{1 \text{ man-rem}} \times 520 \frac{\text{hrs.}}{\text{qtr.}}$ = \$1500/I. F. I.F.=4 in 40 yrs.

Cost = \$1500 x 4 = \$6000 per unit lifetime.

I. 3. Cost associated with health physics support:

Assume same manhours as maintenance and support personnel in a general radiation area of 0.03 Rem/Hr. This cost includes surveys, monitoring, badging, radiation work permits and normal HP support on the job.

3.1 Pipe inspection - maintenance and QA health physics support.

Manpower = 800 man-hours
Radiation Dose: 800 x .03 Rem/Hr. = 24 man-rem

Cost: $\frac{\$18}{\text{Hr}} \times \frac{24}{1} \frac{\text{man-rem}}{\frac{\text{man-rem}}{\text{quarter}}} \times 520 \frac{\text{hours}}{\text{ctr}} \times \frac{1}{4}$ = 56,000/I.F.

Insp. Freq. = 1 in 10 years

3.2 Restraint Inspection

3.2.1 Visual inspection of all restraints

Manpower: 20 man-hours/I.F.
Rad Dose: 20 x .03 Rem/Hr. = .6 man-rem

Cost: $\frac{\$18}{\text{Hr.}} \times \frac{1}{4} \times \frac{.6 \text{ man-rem}}{1 \frac{\text{man-rem}}{\text{quarter}}} \times 570 \frac{\text{Hrs.}}{\text{qtr.}}$ = \$1400/I.F.

I.F. = 1 in 5 years.

3.2.2 Detailed inspection - maintenance + quality assurance HP support.

Manpower: 10 man-hours
Rad. Dose: 10 x .03 Rem/Hr. = .3 man-rem
Cost: $\frac{\$18}{\text{Hr}} \times \frac{1}{4} \times \frac{.9}{1} \times 520$ = \$700/I.F.

I.F. = 1 in 10 years.

I. 4. Other associated cost will include cost for protective clothing.

Cost of protective clothing, i.e., material costs for throw-away objects and processing, cleaning and waste disposal is $13. per change out. If we assume one change out every 4 hours (since most tasks to be performed will extend to more than 4 hours) and assume radiation exposure limits will not be exceeded during this time period then the cost associated with protective clothing will be:

Total man-hours

		IF	man-hours/IF	cost/IF
from I. 1.1.	- 3200	4/40yrs	800	2600
1.2.	- 6400	4/40yrs	1600	5200
2.1.	- 160	8/40yrs	20	65
2.2.1	40	4/40yrs	10	32.50
2.2.2	80	4/40yrs	20	65+
3.1	1600	4/40yrs	40	130
3.2	1600	4/40yrs	40	130
3.3	80	8/40yrs	10	32.50
3.4	20	4/40yrs	5	16.25

Total

$$\text{Cost} : 13{,}200 \times \frac{1 \text{ change}}{4 \text{ man-hrs}} \times \frac{\$13}{\text{change}} = \$43{,}000.$$

I. 5. Total cost associated with 20 primary loop pipe restriants based on radiation exposure:

	cost	IF	Total(in1000's)
I.1.	180,000 + 115,000	1 in 10 yrs	1180
I.2.	4500	1 in 5 yrs	36
	+ 3750	1 in 10 yrs	15
I.3.	56,000 + 700	1 in 10 yrs	63
	+ 1400	1 in 5 yrs	11
I 4.	8200	1 in 10 yrs	33
	+ 100	1 in 5 yrs	1
			1,339,000

Total dose = 600 man-rem == $\frac{\$2200}{\text{man-rem}}$

- all cost assumed to be in present value of money.

- assessment does not include loss of time or access due to pipe restraints, loss of equipment laydown space or other hazards associated with maintenance and inspection tasks.

Occupational radiation exposure and cost estimate associated with non-primary coolant loop rupture restraints:

Assumptions:

1. Restraints are smaller; easier to remove/install it is assumed to take ½ the man-hours to remove/install RC pipe restraints.

2. 140 restraints evaluated in this cost savings estimate.

3. - dose rates will vary depending on location, background, and systems; we will assume 25 mR/Hr. general area dose rates.

4. - assumptions used for RC pipe restraints will also apply.

Method:

1. One in five restraints will have to be removed/reinstalled for pipe inspection with an inspection frequency of once every ten years.

2. All restraints will be visually inspected once every 5 years, one in twenty restraints will need further detailed inspection once every ten years.

3. Tasks (1) and (2) above will need field support by Health Physics technicians, supervisors and engineering.

4. Cost associated with anti-contamination clothing $13/4 man-hours.

Calculation:

1. Cost associated with non-primary coolant piping restraints. Cost for restraint removal/installation for pipe inspection:

   1.1 Maintenance

   Manpower: $\frac{1}{5} \times 140 \text{ restraints} \times \frac{1}{2} \times 40 \frac{\text{man-hrs}}{\text{restraint}} = 560 \frac{\text{man-hours}}{\text{insp freq}}$

   Radiation dose: $.025 \frac{\text{Rem}}{\text{Hr}} \times 560 \frac{\text{man-hours}}{\text{IF}} = 14 \text{ man-rem/IF}$

   Cost: $\frac{\$18}{\text{Hr}} \times \frac{1}{4} \times \frac{14 \text{ man-rem}}{\frac{1 \text{ man-rem}}{\text{quarter}}} \times 520 \frac{\text{Hrs}}{\text{qtr}} = \$33,000/\text{IF}$

   Inspection frequency is once every 10 years

   Total Dose = 56 man-rem
   Total cost = $132,000 per unit lifetime

1.2 Field Support:

Manpower: $\frac{1}{5} \times 140$ rest. $\times 80 \frac{\text{man-hours}}{\text{restraint}} \times \frac{1}{2} = 1120 \frac{\text{man hours}}{\text{IF}}$

Radiation Dose: $.025 \frac{\text{Rem}}{\text{Hr}} \times 1120 \frac{\text{man-hours}}{\text{IF}} = 28 \frac{\text{man-rem}}{\text{IF}}$

Cost: $\frac{\$19}{\text{Hr}} \times \frac{1}{4} \times \frac{28 \text{ man-rem}}{\frac{1 \text{ man-rem}}{\text{quarter}}} \times 520 \frac{\text{Hrs}}{\text{qtr}} = \$69,000/\text{IF}$

Inspection frequency: 1 every 10 years.

Total Dose = 112 man-rem
Total Cost = 276,000 per unit lifetime.

2. Inspection of pipe restraint

2.1 Visual inspection of all restraints once every 5 years, no field support.

Manpower: 140 restraints $\times \frac{.5 \text{ hour}}{2 \text{ restr}} \times 2$ men $= \frac{70 \text{ man-hours}}{\text{IF}}$

Radiation Dose: $.025 \frac{\text{Rem}}{\text{Hr}} \times 70$ man-hours $= 1.75 \frac{\text{man-rem}}{\text{IF}}$

Cost: $\$18/\text{hr} \times \frac{1}{4} \times \frac{1.75 \text{ man-rem}}{\frac{1 \text{ man-rem}}{\text{quarter}}} \times 520 \frac{\text{Hrs}}{\text{qtr}} = \$4000/\text{IF}$

Inspection frequency: 1 in 5 years

Total Radiation Dose = 14 man-rem
Total Cost = 32,000 per unit lifetime

2.2 Detailed inspection of 1 in 20 restraints.

2.2.1 Maintenance tasks.

Manpower: $\frac{1}{20} \times 140$ restraints $\times \frac{10 \text{ man-hours}}{2} = 35 \frac{\text{man-hours}}{\text{IF}}$

Radiation Dose: $.025 \frac{\text{Rem}}{\text{Hr}} \times 35 \frac{\text{man-hours}}{\text{IF}} = 1$ man-rem

Cost: $\$18/\text{hr} \times \frac{1}{4} \times \frac{1 \text{ man-rem/quarter}}{1 \text{ man-rem}} \times 520 \text{ hrs/qtr} = \$3200/\text{IF}$

Total Dose = $\frac{1 \text{ man-rem}}{10 \text{ yrs}} \times 40$ yrs = 4 man-rem
Total Cost = \$2300 x 4 = \$9200 per unit lifefime

Inspection Frequency: 1 in 10 year

2.2.2 Field support of detailed restraint inspection, 2 times maintenance man-hours.

Manpower: 35 man-hours/IF x 2 = 70 man-hours

Radiation Dose: .025 Rem/Hr x 70 man-hours = 1.8 man-rem

Cost: $\$19/\text{Hr} \times \frac{1.8}{4} \times 520 = \$4000/\text{IF}$ IF = 1 in 10 yrs

Total Dose = 1.8 man-rem x 4 = 7.2 man-rem
Total Cost = $4000 x 4 = $16,000 per unit lifetime

3. Health Physics and administrative support:

- Assume same as maintenance and support in same radiation field. This includes surveys, monitoring, badging, radiation work permits and normal HP support.

3.1 Pipe Inspection - maintenance and QA health physics support

Manpower: 560 man-hours/IF

Radiation Dose: 14 man-rem/IF

Cost: $33,000/IF

IF = 1 in 10 yrs

Total Radiation Dose = 56 man-rem
Total Cost = $132,000 per unit lifetime

3.2 Pipe restraint Inspection

3.2.1 Visual Inspection

Manpower: 70 man-hours/IF

Radiation Dose: 1.8 man-rem

Cost: $4000/IF   IF = 1 in 5 yrs.

3.2.2 Detailed inspection - maintenance support only

Manpower: 35 man-hours/IF

Radiation Dose: 0.9 man-rem/IF

Cost: $\$18/\text{hr} \times \frac{0.9}{4} \times 520 = \$2100/\text{IF}$

IF = 1 in 10 yrs.

Total Radiation Dose = 18 man-rem
Total Cost = $40,400 per unit lifetime

4. Cost associated wi..n personnel protection in the work area, i.e., protective clothing, air packs, etc.

- Assume as in I.4. that 1 change out occurs every 4 man-hours.

	manhours/IF	IF	Cost,Clothing/IF
From II.1.	1680	1 in 10 yrs	$5460
2.1	70	1 in 5 yrs	$ 230
2.2	105	1 in 10 yrs	$ 340
3.1	560	1 in 10 yrs	$1820
3.3.1	70	1 in 5 yrs	$ 230
3.3.2	35	1 in 10 yrs	$ 115

Total cost of protective clothing: $7735 every 10 yrs.
$ 460 every 5 yrs

or $30,940 + 3680 = $34,620 per unit lifetime.

5. Total cost associated with non-primary coolant loop pipe restraints based on radiation exposure:

Rad Dose	Tot	Cost	Total
1. 56 + 112 =	168	132,000+276,000	= 408,000
2. 14 + 4 + 7.2=	25	32,000+9200+16,000	= 57,000
3. 56 + 18 =	74	132,000+40,400 =	172,400
4.	0		34,600
Totals	267		$ 672,000

Total Radiation Dose = 267 man-rem
Total cost savings = $672,000 per unit lifetime

for 140 non-primary loop restraints or 2 man-rem and $4800 per non-primary loop restraint.

RGE/sr