EXAMPLE OF CORE DAMAGE ASSESSMENT

The following hypothetical example is intended to illustrate the use of BZP 380-19, "Core Damage Assessment."

Simulated Accident Scenario

The Station has experienced a reactor accident during which the core temporarily became uncovered and safety injection has initiated. Some degree of fuel damage is likely to have occurred. All indications are that a large break LOCA has taken place. The temperature of the reactor coolant is now 200°F. Samples are requested 4 hours after the reactor was shutdown.

Sampling and Sample Activities

From page 1b of BZP 380-A8, "Suggested Sampling Locations," (page 5 of this appendix) a reactor coolant sample is requested at the containment sump sample point as the containment sump contents are now providing core cooling. Also the containment atmosphere sample is requested. All samples are analyzed 2 hours after they are drawn.

The results of the analysis are as follows:

Reactor Coolant (Containment Sump)		Containment Atmosphere	
Kr 87	6.91E-6 Ci/gm	Kr 87	2.79E-6 Ci/cc
Xe 133	9.95E-4 Ci/gm	Xe 133	4.01E-4 Ci/cc
I 131	1.97E-3 Ci/gm	I 131	4.07E-6 Ci/cc
I 132	4.88E-4 Ci/gm	I 132	4.00E-6 Ci/cc
Ba 140	9.99E-4 Ci/gm		

All sample activities reported represent the activity of the sample at the time of the analysis and have not undergone a decay correction back to time of sampling.

Specific activities from the chemistry gamma isotopic analysis report are recorded in the measured specific activity column of the RCS and Containment Atmosphere Activity Worksheets (pages 6 and 7 of this appendix).

Time elapsed from reactor shutdown to time of analysis (6 hours) is recorded in column 2.

Ingrowth and decay correction factors are calculated using the equations found on page 10 of BZP 380-A8, (page 8 of this appendix).

The corrected specific activity is then determined by multiplying the measured specific activity by the correction factor. The corrected specific activity is recorded in column 5 (pages 6 and 7).

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Initial Assessment

From a brief review of the nuclides and activities present in samples and BZP 380-A8 page 8, Selected Nuclides for Core Damage Assessment (page 9 of this appendix), it is likely that some degree of fuel melting has occurred. The presence of a large concentration of Ba-140 in the reactor coolant sample is an indication of a fuel melt condition.

Total Liquid Mass Determination

The RCS mass and all RCS mass additions are identified and calculated using the Estimate of RCS Mass' worksheet (page 10 of this appendix). Reactor coolant specific gravity is determined from the "Specific Gravity of Water vs Temperature graph (page 11). Reactor coolant specific gravity is approximately 1.0 at 200°F. The total liquid mass is recorded on the RCS Activity Worksheet (page 6).

Total Activity Released From Fuel

The total activity released to the coolant and containment atmosphere is calculated from the decay and ingrowth corrected specific activities, reactor coolant system mass and the containment atmosphere free volume. The total activities released are then recorded in column 7 of the activity worksheets (page 6 and 7) and columns 2 and 3 of "Release Activity/Percent Released (page 12 of this appendix)". The sum of the liquid and containment atmosphere activity is recorded in column 4 (page 12).

Total Core Inventory

The reactor power history is obtained from the control room and used to calculate the core inventory of the nuclides used in the assessment. The reactor power history for the period prior to the accident for this example is as follows:

The Plant has been operating at 100% reactor power for approximately 1300 hours prior to experiencing abnormal conditions.

Reactor power was reduced to 90% for a period of 4 hours.

Reactor power was reduced to 80% for the period of 30 minutes prior to the reactor trip.

The reactor power history is recorded and core inventory determined for each nuclide in the Power History/Data Sheets (pages 13 through 22 of this appendix). Average power levels are recorded in column 1 of the Power History Sheet. The duration at each power level is recorded in column 2. The time between the end of each power level and the reactor shutdown is recorded in column 3. The duration of the power history that must be considered for core inventory determinations varies with each nuclide and is specified on the Power History Sheet.

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Factors A_i and B_i are determined from the graphs on the Data Sheet following each Power History sheet. A_i and B_i are recorded in columns 4 and 5 respectively. The product of A_i, B_i and P_i is recorded in column 6.

The corrected core inventory is then calculated from the Power Correction Factor and the equilibrium core inventory given.

The total corrected inventory is recorded in column 5 of the Release Activity/Percent Released data sheet (page 12).

Release percentages are then calculated and recorded in column 6.

Damage Estimates From Nuclide Release Percentages

With the nuclide release percentages determined, the core damage graphs may be used.

The percent released for each nuclide is used with the appropriate graph (pages 23 through 28) to determine the category and estimate the extent of damage.

Estimates are entered in the appropriate column of the "Core Damage Assessment Summary Sheet" (page 30 of this Appendix).

Non-Radiological Indicators of Core Damage

The non-radiological indicators of core damage are determined to be the following:

Containment atmosphere hydrogen	7%
Containment High Range Monitor	7E4 R/hr
Core Exit Thermocouple Readings	1700°F

The above values are compared to values in table on page 31 "Characteristics of Categories of Fuel Damage" and recorded in the appropriate column of the "Core Damage Assessment Summary Sheet" (page 30).

Radionuclide Ratios

A radionuclide ratio is examined and compared to ratio's in the "Characteristics of Categories of Fuel Damage" (page 31) of the appendix table. The Kr87/Xe133 ratio is recorded in the appropriate column of the Summary Sheet. Page 29 of this appendix lists radionuclide ratios in the fuel gap and fuel pellet. These ratios help to indicate the category of fuel damage.

The Kr87/Xe133 ratio of 0.18 is recorded under the fuel melt category (page 30).

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Final Assessment

All data collected on the "Core Damage Assessment Summary Sheet" is now evaluated to make the final assessment.

Nuclide release percentages indicate that a large amount of clad damage has occurred. This is supported by the following:

1. It was determined from reactor level instrumentation that the core had been uncovered at some point in the accident.

2. Core thermocouple temperatures reached 1700°F.

3. The containment atmosphere contained 7% hydrogen which indicates a 54% zirconium cladding reaction with water (from page 28).

The damage to the core is beyond the extent that can be attributed to clad failure alone. Nuclide release percentages indicate that between 28% and 47% of the fuel had reached an overtemperature condition. This estimate is supported by the following:

1. The Kr87/Xe133 release ratio approximated the ratio typical of fuel pellets (see page 29).

2. The containment high range monitors indicated dose rates typical of the fuel overtemperature conditions.

The Ba-140 release percentage (5%) corresponds to a 20% fuel-melt condition. Other nuclide release percentages indicate a 15% to 27% pellet melt. The non-radiological damage indicators (uncovered core, core exit thermocouple readings, and containment hydrogen measurements) support this estimate.

Therefore, for this example, the final fuel damage assessment is:

1. Greater than 50% fuel clad failure.

2. A maximum of 50% fuel overtemperature.

3. Less than 50% fuel melt.

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SCENARIO	SAMPLING LOCATIONS(S)	SAMPLE PROCEDURES(S)	COMMENTS
Large break LOCA			
Rx Power >1%	Containment sump 1(2)PS156	NONE	
	and		
	Containment Atmosphere	BZP 380-18 BCP 800-7	
	and		
	RCS Hot Leg Loop 1 1(2)PS9351A or Loop 2 1(2)PS9351B	BZP 380-12/ Diluted R/C and BXP 380-15 R/C Stripped Gas	If Containment Sump is providing cooling to core, do not include hot leg sample activity in damage assessment calculations.
Rx Power <1%	Containment Atmosphere	BZP 380-18 BCP 800-7	
	and		
	Containment Sump 1(2)PS156	NONE	Provided Containment Sump supplying core cooling
	or		
	RHR System 1(2)PS9353A or 1(2)PS9353B		Provided RHR taking suction from Containment Sump.
	or		
	RCS Hot Leg Loop 1 1(2)PS9351A or Loop 2 1(2)PS9351B	BZP 380-12, Diluted R/C BZP 380-15 R/C Stripped Gas 1B	

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RCS ACTIVITY WORKSHEET

Nuclide	Elapsed Time Shutdown to Sample Count, t (hours)	Measured Specific Activity Ci/gm	Ingrowth and Decay Correction Factor (from BZP 380-A8, Pg 10)	Decay & Ingrowth Corrected Sp Activity Ci/gm	RCS Mass, (grams)	RCS Activity, (Ci)
Kr-85m						
Kr-87	6	6.91E-6	266	184E-4	1.13E9	148E6
Kr-88						
Xe 131M						
Xe 133	6	995E-4	1.00	995E-4	1.13E9	798E6
Xe 133M						
Xe 135						
I 131	6	197E-3	1.02	2.01E-3	1.13E9	1.61E7
I 132	6	488E-4	4.17	203E-3	113E9	163E7
I 133						
I 135						
Cs 134						
Te 129						
Te 132						
Ba 140	6	999E-4	1.01	1.01E-3	1.13E9	8.10E6
La 140						
La 142						
Pr 144						

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CONTAINMENT ATMOSPHERE ACTIVITY WORKSHEET

Nuclide	Elapsed Time Shutdown to Sample Count, (hours)	Measured Specific Activity Ci/cc	Ingrowth and Decay Correction Factor (from BZP 380-A8, Pg. 10)	Decay & Ingrowth Corrected Sp. Activity Ci/cc	Containment Atmosphere Volume, cc	Containment Atmosphere Activity, Ci
Kr-85m					7.95E10	
Kr-87	6	2.79E-6	26.6	7.42E-5	7.95E10	5.90E6
Kr-88					7.95E10	
Xe 131M					7.95E10	
Xe 133	6	4.01E-4	1.00	4.01E-4	7.95E10	319E7
Xe 133M					7.95E10	
Xe 135					7.95E10	
I 131	6	4.07E-6	1.02	4.15E-6	7.95E10	3.30E5
I 132	6	4.0E-6	4.17	1.67E-5	7.95E10	3.33E5
I 133					7.95E10	
I 135					7.95E10	
Cs 134					7.95E10	
Te 129					7.95E10	
Te 132					7.95E10	
Ba 140					7.95E10	
La 140					7.95E10	
La 142					7.95E10	
Pr 144					7.95E10	

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CALCULATION OF INGROWTH AND DECAY CORRECTION FACTORS

Kr-85 ⟶ $e^{0.157t}$

Kr-87 ⟶ $e^{0.547t} = e^{0.547(t)} = \text{(26.6)}$

Kr-88 ⟶ $e^{0.247t}$

Xe-131M ⟶ $\dfrac{1}{-2.62e^{-(3.54E-3)t} + 3.62e^{-(2.45E-3)t}}$

Xe-133 ⟶ $\dfrac{1}{-0.185e^{-(3.41E-2)t} - 0.10e^{-(1.28E-2)t} + 1.285e^{-(5.48E-3)t}} = \dfrac{1}{.994} = \text{(1.00)}$

Xe-133M ⟶ $\dfrac{1}{-0.1e^{-(3.41E-2)t} + 1.1e^{-(1.28E-2)t}}$

Xe-135 ⟶ $\dfrac{1}{-9.26e^{-(1.04E-1)t} - 0.033e^{-(2.66)t} + 10.293e^{-(7.58E-2)t}}$

I-131 ⟶ $e^{0.00359t} = e^{0.00359(6)} = \text{(1.02)}$

I-132 ⟶ $\dfrac{1}{0.103e^{-(8.91E-3)t} + 0.897e^{-(0.307)t}} = \text{(4.17)}$

I-133 ⟶ $e^{0.0341t}$

I-135 ⟶ $e^{0.104t}$

Cs-134 ⟶ 1

Te-129 ⟶ $\dfrac{1}{1.09e^{-(0.161)t} + 0.16e^{-(8.47E-4)t} - 0.25e^{-(0.605)t}}$

Te-132 ⟶ $e^{0.00892t}$

Ba-140 ⟶ $e^{0.00225t} = e^{0.00225(6)} = \text{(1.01)}$

La-140 ⟶ $\dfrac{1}{1.09e^{-(2.25E-3)t} - 0.09e^{-(1.72E-2)t}}$

La-142 ⟶ $\dfrac{1}{-0.14e^{-(3.78)t} + 1.14e^{-(0.449)t}}$

Pr-144 ⟶ $\dfrac{1}{0.91e^{-(1.04e-4)t} + 0.09e^{-(2.4)t}}$

Where:

t = the number of hours between reactor shutdown and time of sample count (from column 2 of BZP 380-T4, pages 1 and 2).

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SELECTED NUCLIDES FOR CORE DAMAGE ASSESSMENT

Core Damage Stage	Nuclide	Half-Life*	Predominant Gammas (Kev) Yield (%)*
Clad Failure	Kr-85m**	4.4 h	150(74), 305(13)
	Kr-87	76 m	403(84), 2570(35)
	Kr-88**	2.8 h	191(35), 850(23), 2400(35)
	Xe-131m	11.8 d	164(2)
	Xe-133	5.27 d	81(37)
	Xe-133m**	2.26 d	233(14)
	Xe-135**	9.14 h	250(91)
	I-131	8.05 d	364(82)
	I-132	2.26 h	773(89), 955(22), 1400(14)
	I-133	20.3 h	530(90)
	I-135	6.68 h	1140(37), 1280(34), 1460(12), 1720(19)
	Rb-88	17.8 m	898(13), 1863(21)
Fuel Overheat	Cs-134	2 yr	605(98), 796(99)
	Cs-137	30 yr	662(85)
	Te-129	68.7 m	455(15)
	Te-132	77.7 h	230(90)
Fuel Melt	Sr-89	52.7 d	
	Sr-90**	28 yr	
	Ba-140	12.8 d	537(34)
	La-140	40.22 h	487(40), 815(19), 1596(96)
	La-142	92.5 m	650(48), 1910(9), 2410(15), 2550(11)
	Pr-144	17.27 m	695(1.5)

* Values obtained from Table of Isotopes, Lederer, Hollander, and Perlman, Sixth Edition.

** These nuclides are marginal with respect to selection criteria for candidate nuclides; they have been included on the possibility that they may be detected and thus utilized in a manner analogous to the candidate nuclides.

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Estimate of RCS Mass

1. Obtain the reactor coolant volume additions for the following:

Tank	Estimated Volume Added	Maximum Volume Added (gallons)
a. Refueling Water Storage Tank	180,000	495,000
b. Accumulator A	7,217	7,217
c. Accumulator B	7,217	7,217
d. Accumulator C	7,217	7,217
e. Accumulator D	7,217	7,217
f. Boric Acid Storage Tank	-0-	48,000
g. Residual Heat Removal System	5000	5,000
h. Other source NA	-0-	
	213,868 Total	

2. Convert gallons to grams as follows:

   Total reactor coolant system volume added:

   213,868 gallons x 3785gms/gal = 8.1E8 gms

3. Determine the Reactor Coolant System Mass as follows:

   3.22E8 grams x system specific gravity* 1.0 = 3.22E8 grams

4. Determine the Total Liquid Mass as follows:

   RCS Mass 3.22E8 grams + Added Mass 8.1E8 grams= 1.13E9 grams

* System Specific Gravity is determined from BZP 380-A8, page 2.

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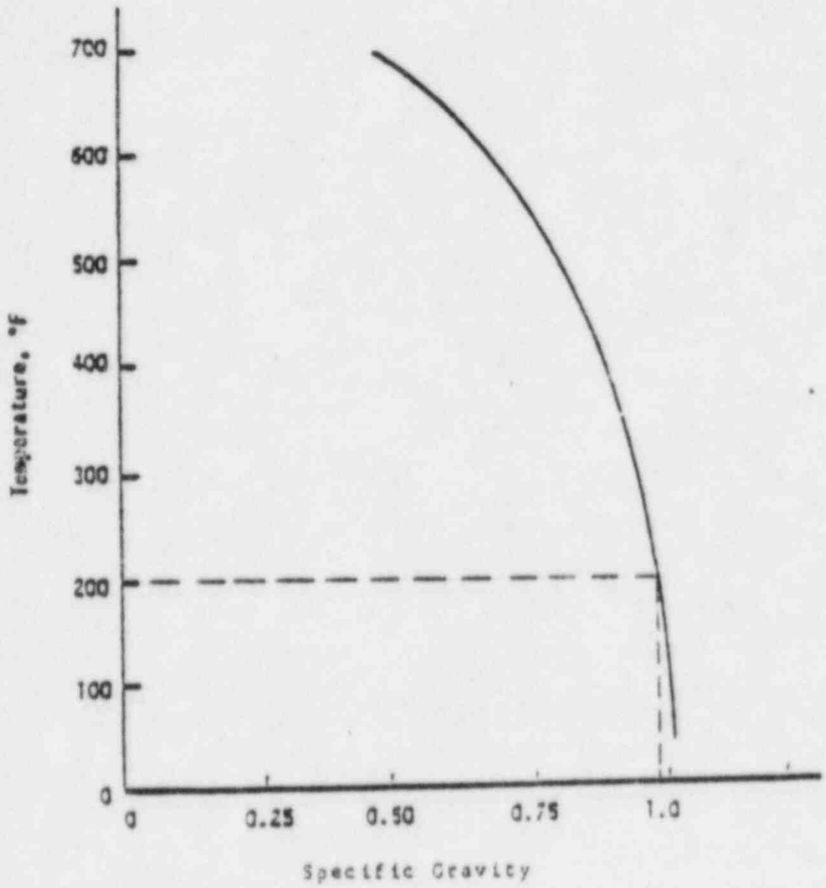
Revision



SPECIFIC GRAVITY OF WATER VS TEMPERATURE

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RELEASE ACTIVITY/PERCENT RELEASED

Isotope	Atmosphere, Ci	RCS, Ci	Total Activity Released, Ci	Total Corrected Core Inventory, Ci	Release Percentage, %
Kr 85M					
Kr 87	5.9E6	1.48E6	7.38E6	3.21E7	23%
Kr 88					
Xe 131M					
Xe 133	3.19E7	7.98E6	3.99E7	1.84E8	21%
Xe 133M					
Xe 135					
I 131	3.30E5	1.61E7	1.64E7	9.17E7	17.9%
I 132	3.33E5	1.63E7	1.66E7	1.23E8	13.5%
I 133					
I 135					
Cs 134					
Te 129					
Te 132					
Ba 140	None	8.10E6	8.10E6	1.58E8	5.1%
La 140					
La 142					
Ce 144					

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POWER HISTORY SHEET

Nuclide: Kr 87

AVERAGE % POWER DURING ith POWER INTERVAL, P_i (% P)	DURATION AT ith POWER INTERVAL (HOURS)	TIME BETWEEN END OF ith POWER INTERVAL AND SHUTDOWN (HOURS)	FACTOR A_i (SEE DATA SHEET)	FACTOR B_i (SEE DATA SHEET)	PRODUCT TERMS $P_i \times A_i \times B_i$ (SEE COL. 1,4,&5)
Complete this column from Power Log Data. Include enough power history prior to shutdown to satisfy minimum time indicated under Column 2.	Record the time in hours corresponding to each power level indicated in column 1. Add times to insure adequate history (see *).	Record the time between the end of each power level, listed in column 1 and shutdown.	Enter value of "A" corresponding to time between each ith power interval and shutdown.	Enter value of "B" corresponding to duration at each ith power interval.	Enter product of % power x"A"x"B" and add products to get $\Sigma P_i \times A_i \times B_i$.
80%	0.5	0	1.00	0.20	18
90%	4.0	0.5	0.80	0.88	56.3
100%	5.5	4.5	0.10	0.95	9.5
Σ_i Duration$_i$ =	10			$\Sigma_i P_i \times A_i \times B_i$ =	83.8

* Must be at least 5.0 hours

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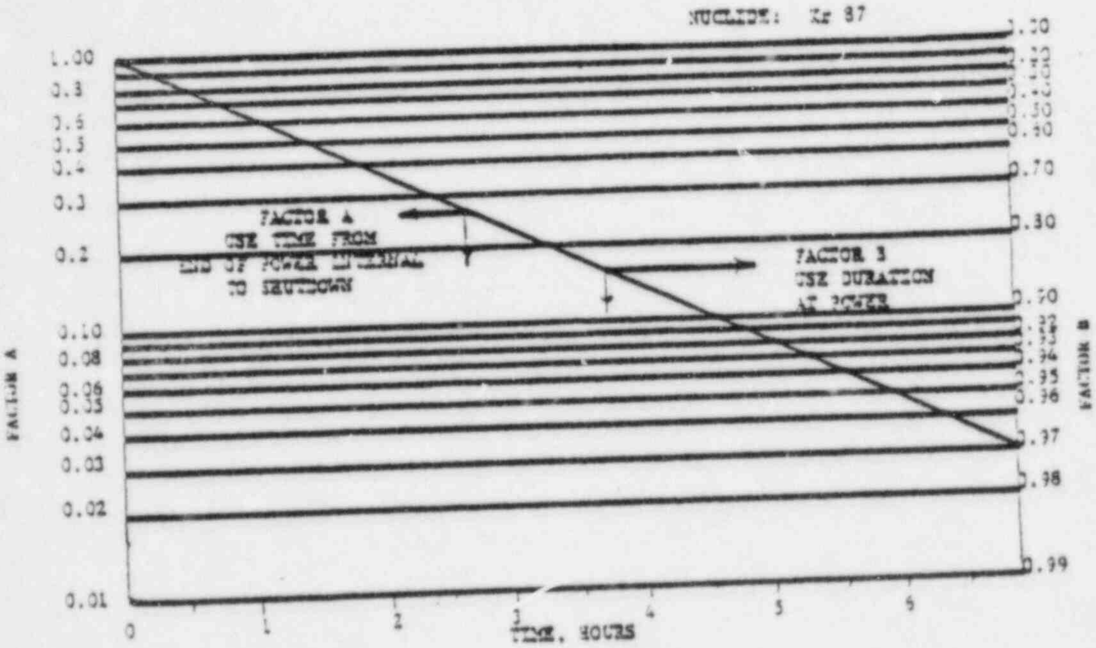
DATA SHEET

NUCLIDE: Kr 87



POWER CORRECTION FACTOR (PCF) = 83.8 ÷ 100 = 0.838

$\sum_i P_i \times A_i \times B_i$

CORE INVENTORY = 1.81 E7 × 0.838 = 32/67 .Ci

PCF

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POWER HISTORY SHEET

Nuclide: Xe 133

AVERAGE % POWER DURING ith POWER INTERVAL, P_i (% P)	DURATION AT ith POWER INTERVAL (HOURS)	TIME BETWEEN END OF ith POWER INTERVAL AND SHUTDOWN (HOURS)	FACTOR A_i (SEE DATA SHEET)	FACTOR B_i (SEE DATA SHEET)	PRODUCT TERMS $P_i \times A_i \times B_i$ (SEE COL. 1,4,&5)
Complete this column from Power Log Data. Include enough power history prior to shutdown to satisfy minimum time indicated under Column 2.	Record the time in hours corresponding to each power level indicated in column 1. Add times to insure adequate history (see *).	Record the time between the end of each power level, listed in column 1 and shutdown.	Enter value of "A" corresponding to time between each ith power interval and shutdown.	Enter value of "B" corresponding to duration at each ith power interval.	Enter product of % power x"A"x"B" and add products to get $\Sigma P_i \times A_i \times B_i$.
80%	0.5	0	1.00	0	0
90%	4.0	0.5	1.00	0	0
100%	600	45	1.00	0.94	96.5
Σ_i Duration$_i$ =	604.5			$\Sigma_i P_i \times A_i \times B_i$ =	96.5

* Must be at least 506 hours

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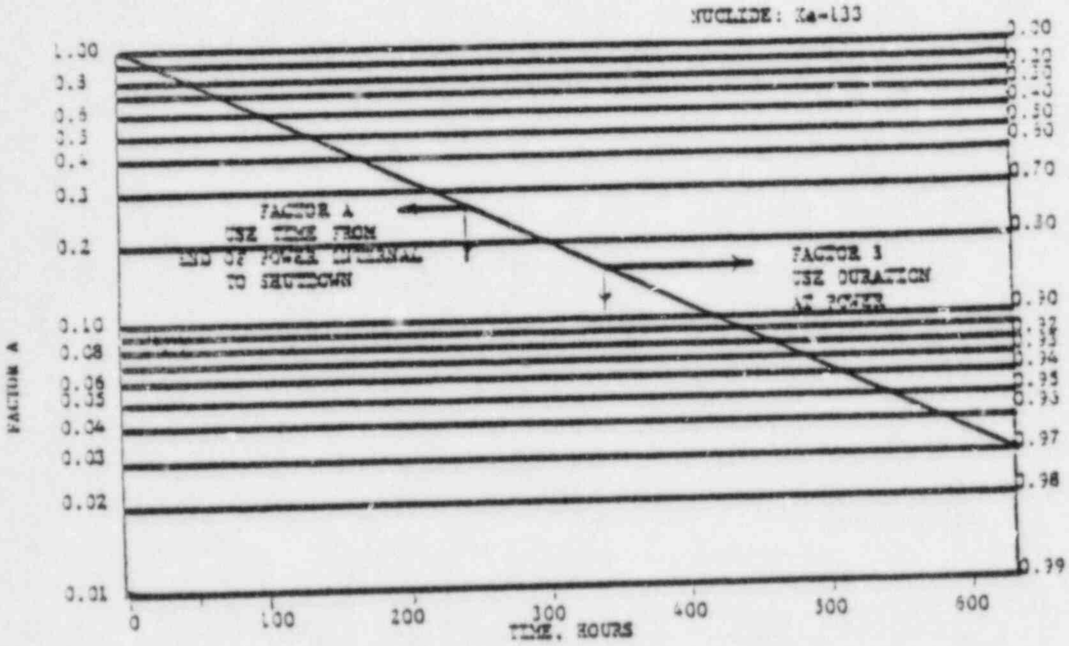
DATA SHEET



POWER CORRECTION FACTOR (PCF) = 96.5 ÷ 100 = .965

$\sum_i P_i \times A_i \times B_i$

CORE INVENTORY = 1.91E8 × .965 = 1.84E8 Ci

PCF

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POWER HISTORY SHEET

Nuclide: I 131

AVERAGE % POWER DURING ith POWER INTERVAL, P_i (% P)	DURATION AT ith POWER INTERVAL (HOURS)	TIME BETWEEN END OF ith POWER INTERVAL AND SHUTDOWN (HOURS)	FACTOR A_i (SEE DATA SHEET)	FACTOR B_i (SEE DATA SHEET)	PRODUCT TERMS $P_i x A_i x B_i$ (SEE COL. 1,4,&5)
Complete this column from Power Log Data. Include enough power history prior to shut-d...n to satisfy minimum time indicated under Column 2.	Record the time in hours corresponding to each power level indicated in column 1. Add times to insure adequate history (see *).	Record the time between the end of each power level, listed in column 1 and shutdown.	Enter value of "A" corresponding to time between each ith power interval and shutdown.	Enter value of "B" corresponding to duration at each ith power interval.	Enter product of % power x"A"x"B" and add products to get $\Sigma P_i x A_i x B_i$.
80%	0.5	0	1.0	0	0
90%	4.0	0.5	1.0	.02	1.8
100%	870	4.5	1.0	.94	96
Σ_i Duration$_i$ =	874.5			$\Sigma_i P_i x A_i x B_i$ =	97.8

* Must be at least 771 hours

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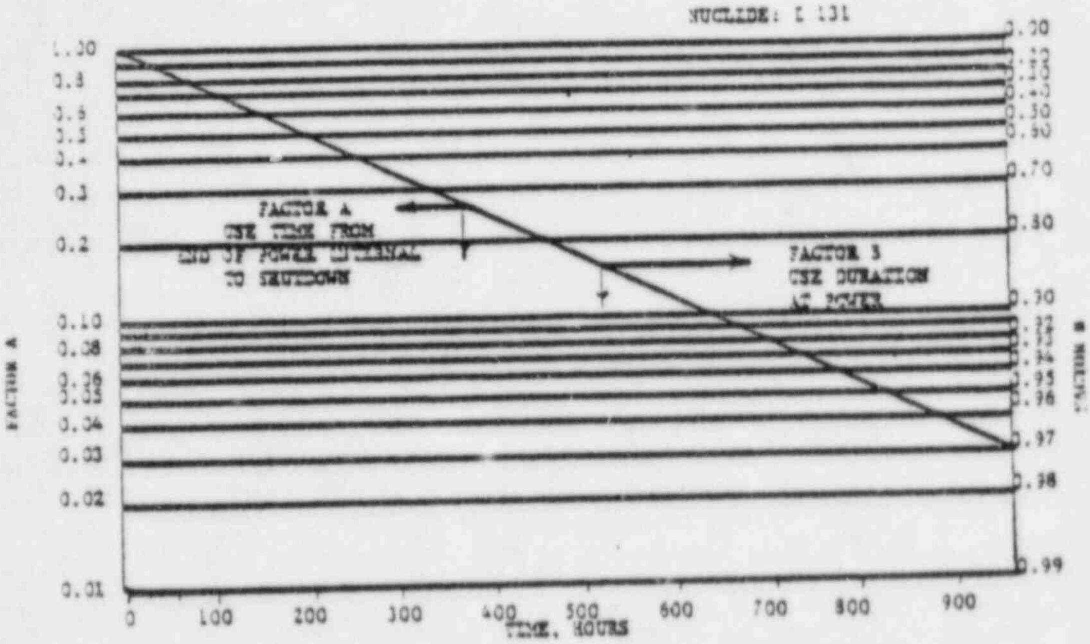
DATA SHEET

NUCLIDE: I 131



POWER CORRECTION FACTOR (PCF) = 97.8 ÷ 100 = .978
$\Sigma P_i \times A_i \times B_i$

CORE INVENTORY = 9.38E7 × .978 = 9.17E7 Ci
PCF

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POWER HISTORY SHEET

Nuclide: I 132

AVERAGE % POWER DURING ith POWER INTERVAL, P_i (% P)	DURATION AT ith POWER INTERVAL (HOURS)	TIME BETWEEN END OF ith POWER INTERVAL AND SHUTDOWN (HOURS)	FACTOR A_i (SEE DATA SHEET)	FACTOR B_i (SEE DATA SHEET)	PRODUCT TERMS $P_i x A_i x B_i$ (SEE COL. 1,4,&5)
Complete this column from Power Log Data. Include enough power history prior to shutdown to satisfy minimum time indicated under Column 2.	Record the time in hours corresponding to each power level indicated in column 1. Add times to insure adequate history (see *).	Record the time between the end of each power level, listed in column 1 and shutdown.	Enter value of "A" corresponding to time between each ith power interval and shutdown.	Enter value of "B" corresponding to duration at each ith power interval.	Enter product of % power x"A"x"B" and add products to get $\Sigma P_i x A_i x B_i$.
80%	0.5	0	1.0	.25	20.0
90%	4.0	0.5	.85	.70	53.5
100%	4.5	4.5	.25	.74	18.5
Σ_i Duration$_i$ =	9.0			$\Sigma_i P_i x A_i x B_i$ =	92.0

* Must be at least ≥ 9 hours

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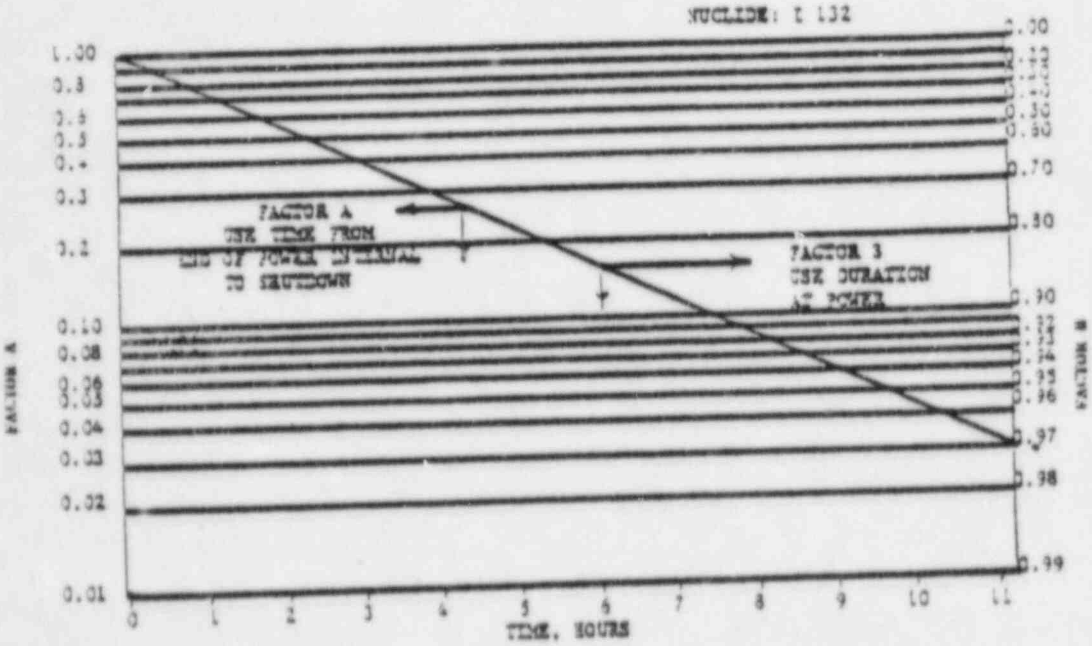
DATA SHEET

NUCLIDE: I 132



POWER CORRECTION FACTOR (PCF) = 92.0 ÷ 100 = .920
$\Sigma_i P_i x A_i x B_i$

CORE INVENTORY = 1.34E8 x .920 = 1.23E8 Ci
PCF

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POWER HISTORY SHEET

Nuclide: Ba 140

AVERAGE % POWER DURING ith POWER INTERVAL, F_i (% P)	DURATION AT ith POWER INTERVAL (HOURS)	TIME BETWEEN END OF ith POWER INTERVAL AND SHUTDOWN (HOURS)	FACTOR A_i (SEE DATA SHEET)	FACTOR B_i (SEE DATA SHEET)	PRODUCT TERMS $F_i x A_i x B_i$ (SEE COL. 1,4,&5)
Complete this column from Power Log Data. Include enough power history prior to shutdown to satisfy minimum time indicated under Column 2.	Record the time in hours corresponding to each power level indicated in column 1. Add times to insure adequate history (see *).	Record the time between the end of each power level, listed in column 1 and shutdown.	Enter value of "A" corresponding to time between each ith power interval and shutdown.	Enter value of "B" corresponding to duration at each ith power interval.	Enter product of % power x"A"x"B" and add products to get $\Sigma F_i x A_i x B_i$.
80%	0.5	0	1.0	0	0
90%	4.0	0.5	1.0	0	0
100%	1300	4.5	1.0	.95	95

$\sum_i \text{Duration}_i$ = 1304.5

$\sum_i F_i x A_i x B_i$ = 95

* Must be at least 1230 hours

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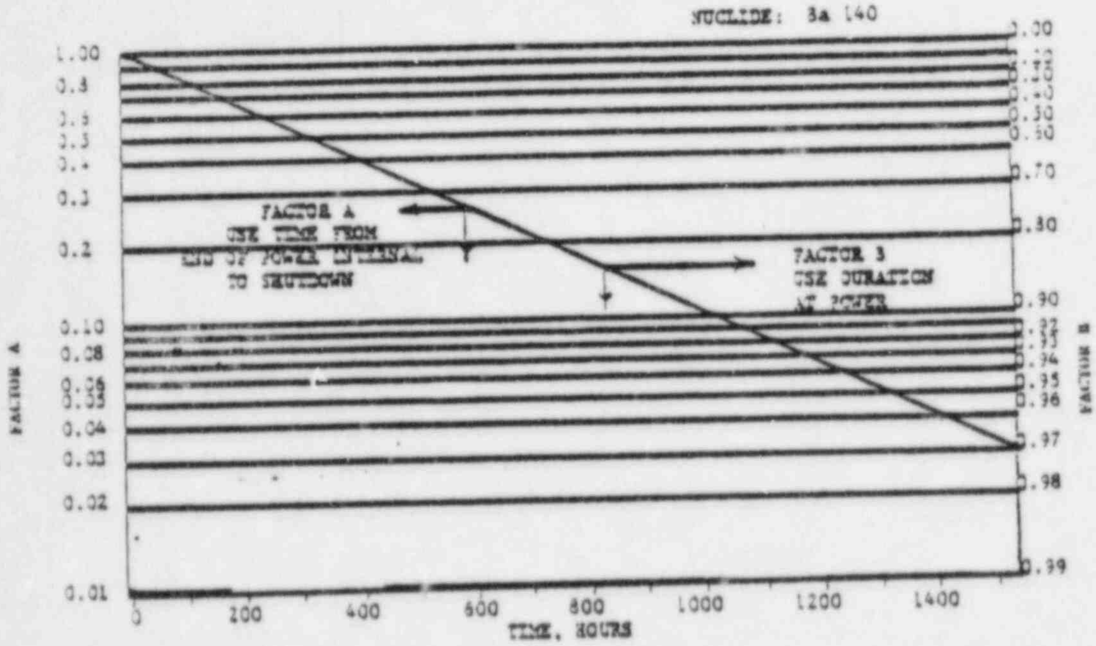
DATA SHEET

NUCLIDE: Ba 140



POWER CORRECTION FACTOR (PCF) = 95 ÷ 100 = .95

$\sum_i P_i x A_i x B_i$

CORE INVENTORY = 1.63E8 x .95 (PCF) = 1.55E8 Ci

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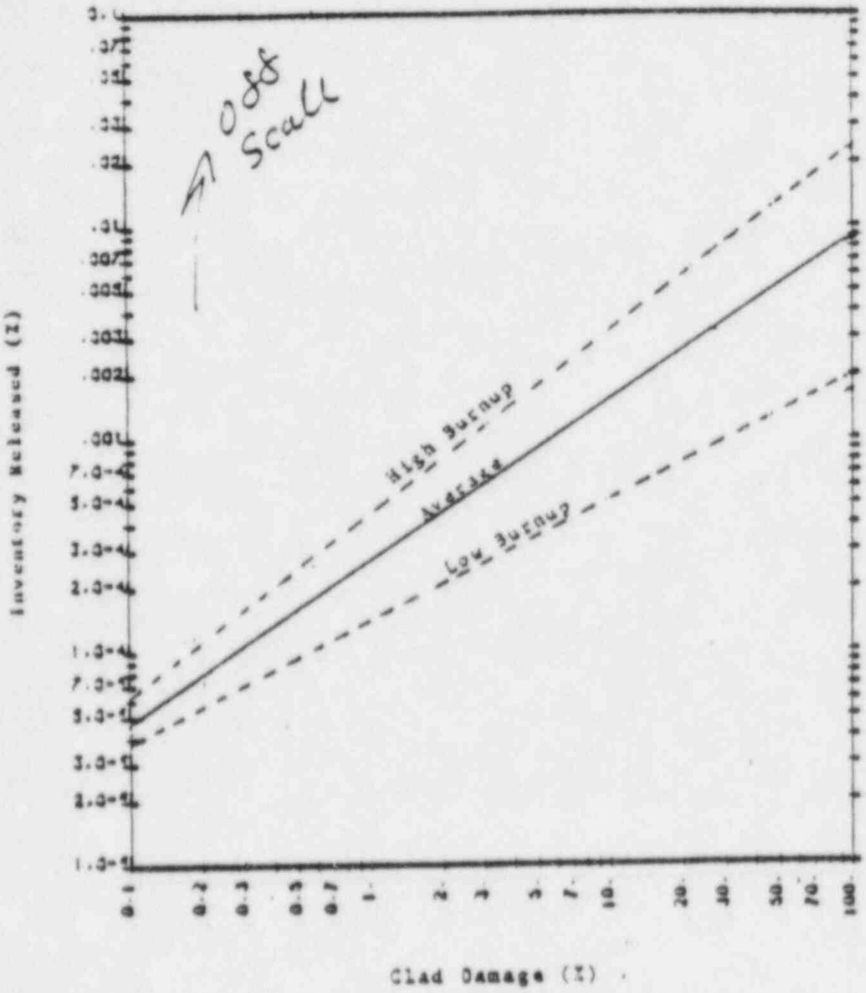

RELATIONSHIP OF % CLAD DAMAGE WITH % INVENTORY RELEASED OF KR-87

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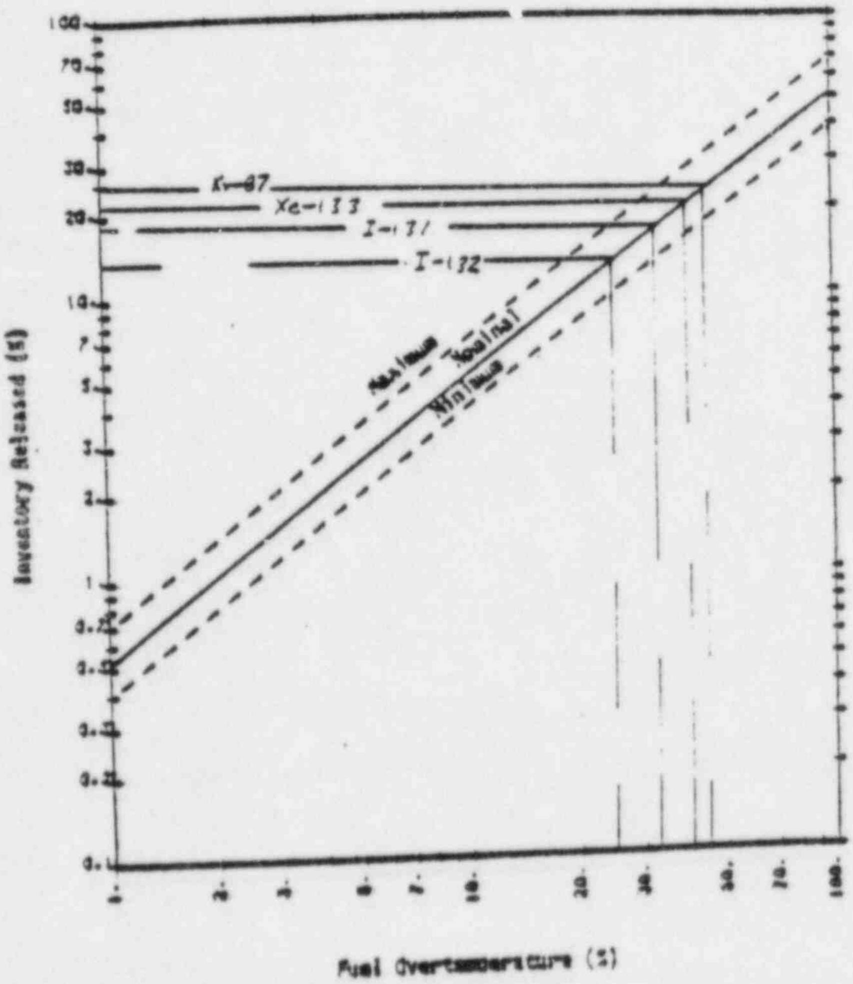
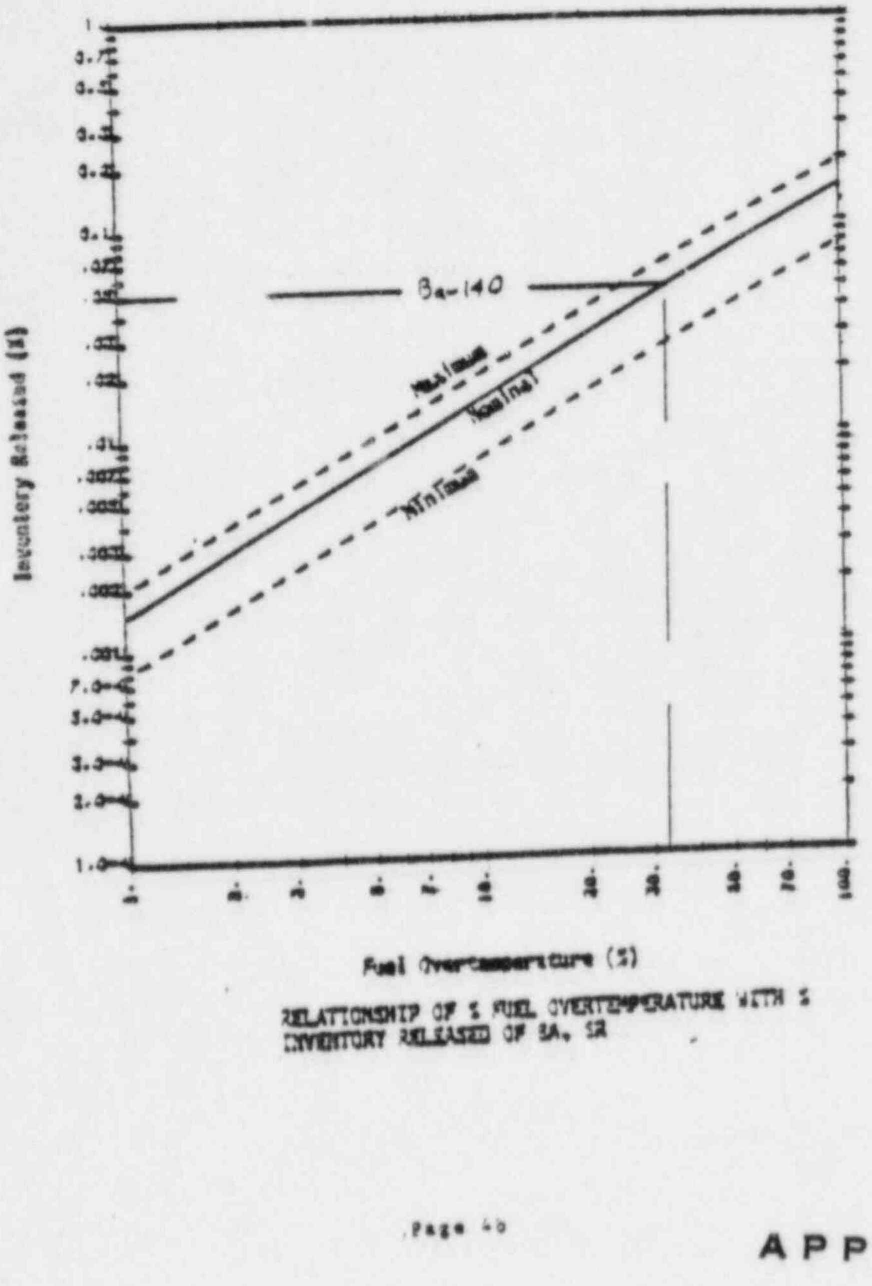


RELATIONSHIP OF % FUEL OVERTEMPERATURE WITH %
INVENTORY RELEASED OF XE, KR, I, CS



RELATIONSHIP OF % FUEL OVERTEMPERATURE WITH %
INVENTORY RELEASED OF BA, SR

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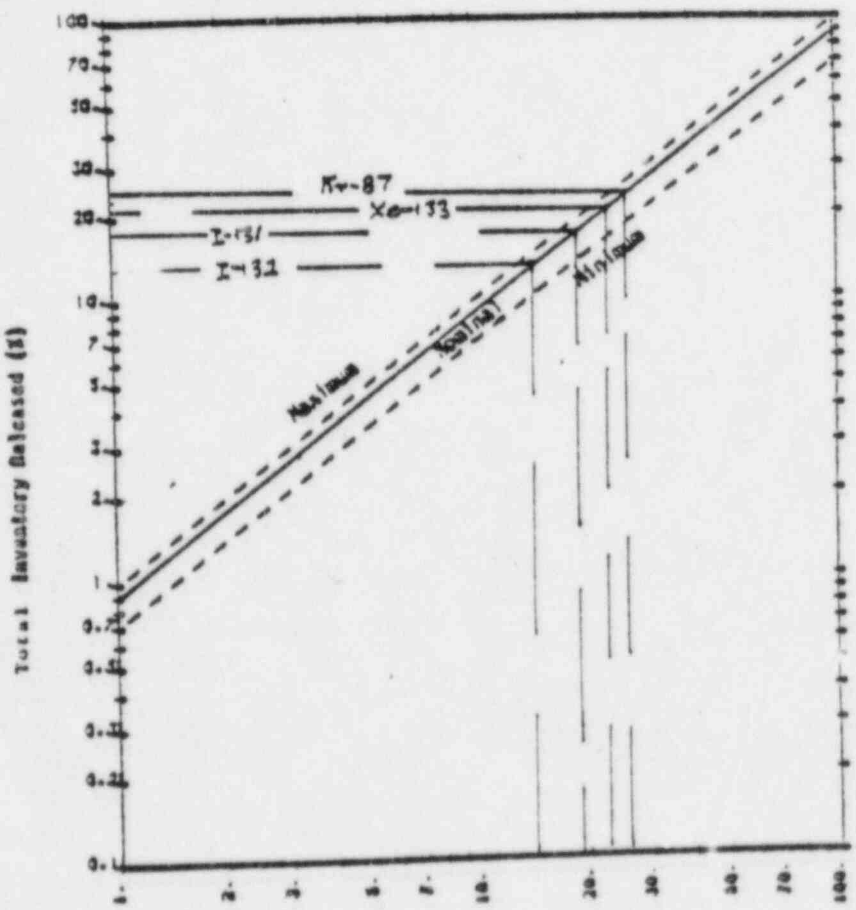

Fuel Melt (%)

RELATIONSHIP OF % FUEL MELT WITH % INVENTORY
RELEASED OF XE or KR or I or CS or TE

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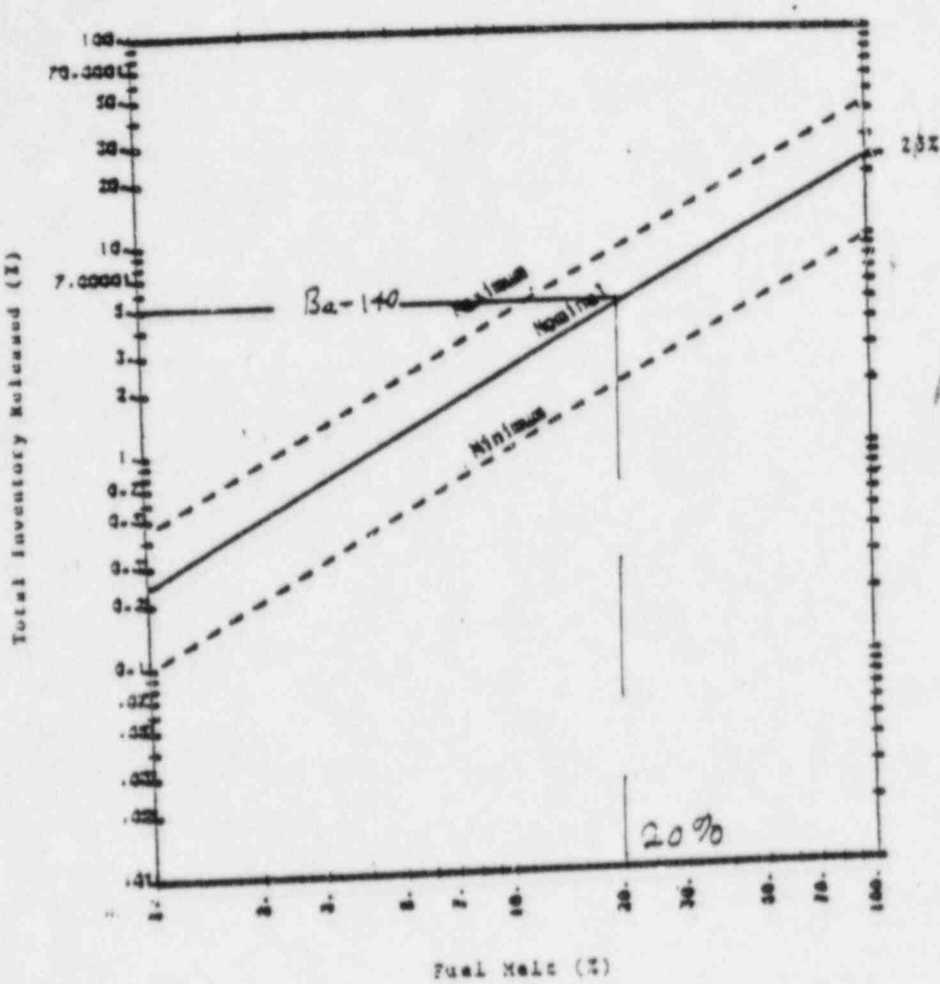

RELATIONSHIP OF % FUEL MELT WITH % INVENTORY RELEASED OF BA or SR

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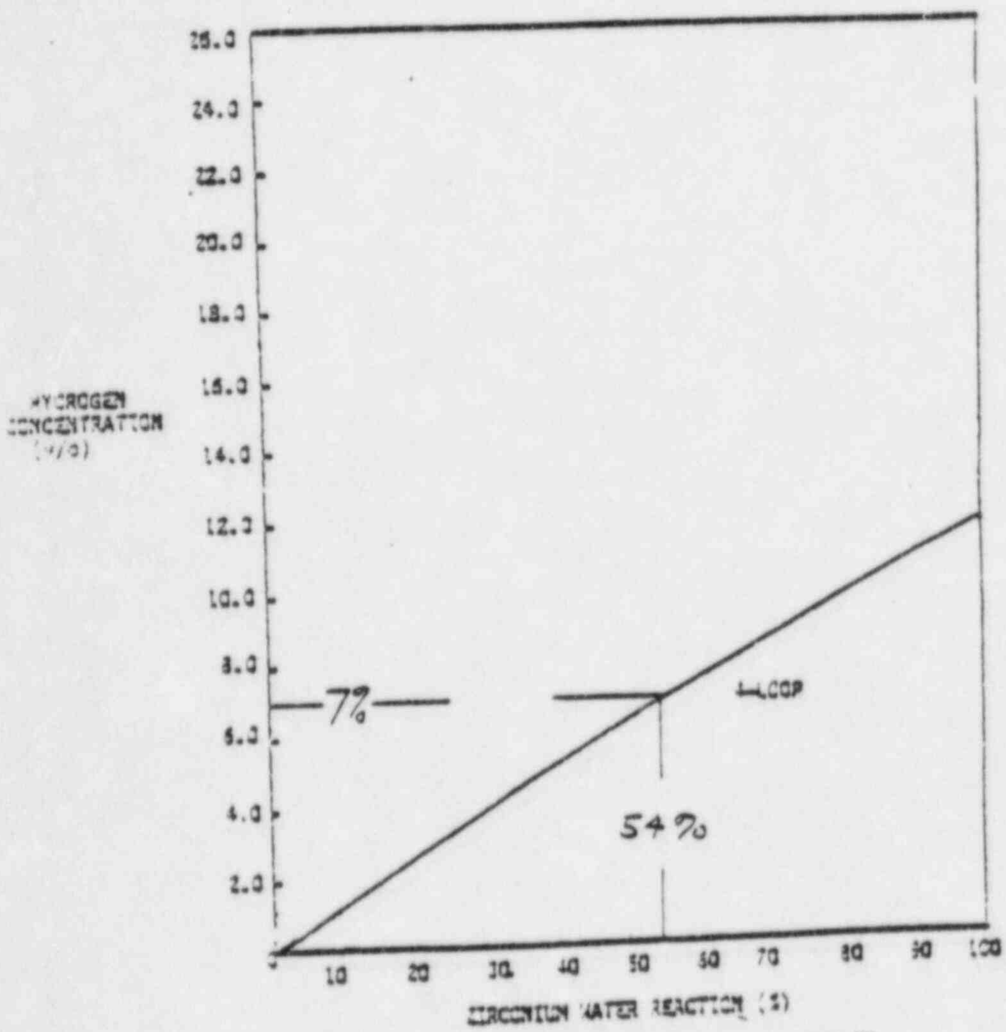

CONTAINMENT HYDROGEN CONCENTRATION BASED ON ZIRCONIUM WATER REACTION

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Revision 0

ISOTOPIC ACTIVITY RATIOS OF FUEL PELLET AND GAP

Nuclide	Fuel Pellet Activity Ratio	Gap Activity Ratio
Kr-85m	0.11	0.022
Kr-87	0.22	0.022
Kr-88	0.29	0.045
Xe-131m	0.004	0.004
Xe-133	1.0	1.0
Xe-133m	0.14	0.096
Xe-135	0.19	0.051
I-131	1.0	1.0
I-132	1.5	0.17
I-133	2.1	0.71
I-135	1.9	0.39

Where:

$$\text{Noble Gas Ratio} = \frac{\text{Noble Gas Isotope}}{\text{Xe-133 Inventory}}$$

$$\text{Iodine Ratio} = \frac{\text{Iodine Isotope Inventory}}{\text{I-131 Inventory}}$$

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BZP 380-T4
Revision 2

Date: 4/16/84

Time: 1330

Performed by: J. Van Laere

CORE DAMAGE ASSESSMENT SUMMARY SHEET

Mode of Estimation	Percent Clad Damage <50%	Percent Clad Damage >50%	Percent Overtemperature <50%	Percent Overtemperature >50%	Percent Fuel Melt <50%	Percent Fuel Melt >50%
Kr 85m						
Kr 87	(off Scale)		47		27	
Kr 88	----	----				
Xe 131m						
Xe 133	----	----	42		.23	
Xe 133m	----	----				
Xe 135	----	----				
I 131	(off scale)		35		18	
I 132	(off Scale)		28		15	
I 133						
I 135						
Cs 134	----	----				
Te 129	----	----	----	----		
Te 132	----	----	----	----		
Ba 140	----	----	34		20	
La 140	----	----	----	----	----	----
La 142	----	----	----	----	----	----
Pr 144	----	----	----	----	----	----
Kr 87 Ratio			←	0.18	→	
I 131 Ratio						
% Zirc - H_2O Reaction	←		54		→	
Core Exit Temp. °F			←	1700	→	
Core Uncovered	←			Yes		→
Cont. Monitor (Hi Range R/hr)				7E4		
Containment Atmos., H_2 %		←		7		→

Final Assessment: Greater than 50% Clad failure; A maximum of 50% fuel over temperature; Less than 50% fuel melt

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(3958P)

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CHARACTERISTICS OF CATEGORIES OF FUEL DAMAGE

CORE DAMAGE CATEGORY	PERCENT AND TYPE OF FISSION PRODUCTS RELEASED	FISSION PRODUCT RATIO	CONTAINMENT HIGH RANGE ARE MONITOR, R/hr*	CORE EXIT THERMOCOUPLE READINGS (DEG F)	CORE UNCOVERED (YES/NO)	HYDROGEN MONITOR I(2) AI PS 343 or 344 (VOL % H_2)
No Clad Damage	Kr-87<1X10-3 Xe-133<1X10-3 I-131<1X10-3 I-133<1X10-3	Kr-87-0.022 I-133-0.71	----	<750	No Uncovery	Negligible
0-50% Clad Damage	Kr-87 10^{-3}-0.1 Xe-133 10^{-3}-0.1 I-131 10^{-3}-0.3 I-133 10^{-3}-0.1	Kr-87-0.022 I-133-0.71	0-97	750-1300	Core Uncovery	<6%
50-100% Clad Damage	Kr-87 0.1-0.2 Xe-133 0.1-0.2 I-131 0.3-0.5 I-133 0.1-0.2	Kr-87-0.022 I-133-0.71	97-194	1300-1650	Core Uncovery	6%-11%
0-50% Fuel Pellet Overtemperature	Xe, Kr, Cs, I 1-20 Sr, Ba 0-0.4	Kr-87-0.22 I-133-2.1	194-25,000	>1,650	Core Uncovery	6%-11%
50-100% Fuel Pellet Overtemperature	Xe,Kr,Cs,I 20-40 Sr, Ba 0.4-0.8	Kr-87-0.22 I-133-2.1	2.5E4-5.0E4	>1,650	Core Uncovery	6%-11%
0-50% Fuel Melt	Xe, Kr, Cs, I 40-70 Sr, Ba 0.2-0.8 Pr, Rb, 0.1-0.8	Kr-87-0.22 I-133-2.1	5.0E4-8.5E4	>1,650	Core Uncovery	6%-11%
50-100% Fuel Melt	Xe, Kr, Cs, I, Te >70 Sr, Ba >24 Pr, Rb >0.8	Kr-87-0.22 I-133-2.1	>8.5E4	>1,650	Core Uncovery	6%-11%

*10 hours after shutdown.

(3956P)

BZP 380-A9
Revision 1

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