FENOC
FirstEnergy Nuclear Operating Company

Perry Nuclear Power Plant
10 Center Road
P.O. Box 97
Perry, Ohio 44081

August 5, 2003
PY-CEI/NRR- 2728L

United States Nuclear Regulatory Commission
Document Control Desk
Washington, D. C. 20555

Perry Nuclear Power Plant
Docket No. 50-440
Submittal of Emergency Plan
Implementing Instructions

Gentlemen:

Pursuant to 10 CFR 50 Appendix E, enclosed are changes to the Emergency Plan Implementing Instructions (EPIs) for the Perry Nuclear Power Plant. These changes constitute revisions, temporary changes, or reissued pages. Please follow the updating instructions per the attached Controlled Document Instruction Sheet and return the signed Acknowledgment of Receipt form.

If you have questions or require additional information, please contact me at (440) 280-5589.

Very truly yours,

David L. Bauguess, Supervisor
Emergency Planning Unit

DLB:byr

Enclosure

cc: NRR Project Manager
NRC Resident Inspector
NRC Region III, Incident Response Center w/attachments

A045

FIRSTENERGY CORPORATION

PERRY NUCLEAR POWER PLANT

UNIT 1 & 2

ACKNOWLEDGMENT OF RECEIPT

Title Emergency Plan Implementing Instructions EPI-B13/ Rev.3

Control No. 60

Letter No./Date PY-CEI/NRR-2728L / August 5, 2003

Signature

Date

Title

Return to:

Perry Nuclear Power Plant
Attn: B.Y. Richardson, A240
P. O. Box 97
Perry, Ohio 44081

FIRSTENERGY CORPORATION

Perry Nuclear Power Plant

Controlled Document Instruction Sheet

Manual: Emergency Plan Implementing Instructions EPI-B13/ Rev.3

Control Number 60

Revision Number	Insert	Remove and Replace
3	EPI-B13 / Rev 3	Reissue Entire Document

PNPP
[redacted]
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No. 060
INFORMATION ONLY

DETERMINATION OF CORE DAMAGE UNDER ACCIDENT CONDITIONS

Effective Date: 7-31-03

Preparer: Joe Lynch / 5-27-03
Date

TABLE OF CONTENTS

1.0 PURPOSE

This instruction provides two methods to estimate reactor core damage.

Method #1 provides methods or indications of reactor core damage which may be utilized during the event. This method primarily utilizes increased radiation levels from the Containment (X) and/or Drywell (DW) detected by the "Post Accident Radiation Monitors" (D19).

Method #2 provides a manual method to estimate the extent of core damage. This method is based upon Iodine-131 and Cesium 137 concentration in the reactor coolant, and Xenon-133, Krypton-85 and Hydrogen in the Containment atmosphere. Core damage is determined/verified via calculated activity ratios of several isotopes and the presence or absence of hydrogen. This method relies on samples of reactor coolant and/or other designated samples. Method #2 is best utilized at the conclusion of the event to more accurately estimate reactor core damage.

1.1 Method #1

Radiation levels as indicated on Drywell and/or Containment D19 radiation monitors are compared against Attachment 1.

Attachment 1 illustrates dose projections for various reactor core states. Curve #1 is a projection for 100% Inventory Release, 100% Fuel Damage and potential core melt. Curve #4 is based upon No Clad failure, 100% Coolant Inventory Release. Attachment 1 is used as a reference to estimate the percentage or type of core damage.

> **NOTE**
>
> In conjunction with the instruction "Gross Cladding Failure" (ONI-J11-1), Process Radiation Monitors (D17s) on Main Steam Lines, and Area Radiation Monitors (D21) in Containment and Drywell can also be utilized as indicators of core damage.

1.2 Method #2

This method is based upon Iodine-131 and Cesium 137 concentration in the reactor coolant, and Xenon-133, Krypton-85 and Hydrogen in the Containment atmosphere. Core damage is determined/verified via calculated activity ratios of several isotopes and the presence or absence of hydrogen.

NOTE

Method #2 is best suited for estimating the extent of the core damage at the conclusion of the event. A sample of reactor coolant taken early in an event may generate results not representative of core conditions. Additionally reactor coolant samples may have to be shipped off site for accurate analysis.

Analyses in this procedure are based upon fission product inventories in the core of a Reference Plant. A BWR 6 with Mark III containment was used as the reference plant, operating at 102% of rated thermal power for 1095 days (3 years). Specifications of the Reference Plant vs. Perry Nuclear Power Plant (PNPP) are considered to be equivalent for the purposes of this procedure and any slight deviations in comparison to the uncertainties of fission products release fraction and other assumptions is insignificant. Either of these methods are qualitative in nature and are to be used as an estimate of fuel clad failure, fuel overheat, or fuel melt.

2.0 SCOPE

The use of Process Radiation Monitors (D17) on Main Steam Lines, D19 or Area Radiation Monitors (D21) in Containment and Drywell can be utilized as indicators of core damage.

NOTE

D17s on the Main Steam Lines should only be utilized for a core damage indicator if the Main Steam Isolation Valves (MSIVs) are not shut.

EPI-B13 and ONI-J11-1 can be utilized to project the extent of core damage during the early phase of an accident. EPI-B13 also provides methods to estimate the extent of core damage in an accident.

3.0 DEFINITIONS

3.1 Core Damage Categories

3.1.1 No damage refers to a condition in which no positive indication of core damage has been detected. Fuel cladding temperatures are below 1500°F and fission product releases are limited to radionuclides normally present in the reactor coolant. This includes small pinhole defects previously identified.

3.1.2 Cladding damage is a degradation of the fuel cladding resulting in the release of fission products normally present in the fuel rod gap. Significant cladding damage is expected to begin at temperatures of approximately 1500°F.

3.1.3 Fuel Melt (Overheating damage) occurs when fuel temperatures rise to approximately 2200°F and fission products are released from the fuel pellets themselves.

3.2 Reference Plant Specifications

BWR 6/Mark III

Rated Thermal Power (100% / 102%)	3579 / 3650 MWt
Number of Fuel Bundles	748 Bundles
Reactor Coolant Volume	2.46×10^{8} ml
Suppression Pool Volume	3.67×10^{9} ml
Total Primary Coolant Volume	3.92×10^{9} ml
Drywell Atmosphere Volume	7.77×10^{9} cc
Containment Atmosphere Volume	3.25×10^{10} cc
Total Atmospheric Volume	4.0×10^{10} cc

4.0 PROCEDURE DETAILS

4.1 Responsibilities

4.1.1 Core Thermal Hydraulics Engineer

Utilize Method 1 or Method 2 and provide the results to the Radiation Protection Coordinator or Emergency Coordinator as soon as available.

4.1.2 Post Accident Sampling Teams

Collect and analyze reactor coolant and/or containment atmosphere samples in accordance with SOI-P87, "Post Accident Sampling System" and CHI-0053, "Operation of the Gamma Spectroscopy System".

4.2 Actions

4.2.1 Assessment of Core Damage Based on Containment Dose Rate

NOTE
This is a quick and rough estimate of core damage.

Dose rate at the D19 Containment Radiation Monitor (Attachment 1) provides theoretical curves of gross gamma dose rate versus time for a range of potential source terms. To determine the meaning of the measured dose rates:

1. Obtain the time after reactor shutdown and Containment dose rate reading.

2. Locate the intersection point of the dose rate and time after shutdown on the graph.

3. Determine the percent fuel inventory released to the Containment (X) air corresponding to the measured dose rate. Interpolate between curves for a closer estimate. Relate the percent fuel inventory released to the approximate source and damage estimate as indicated below.

Curve No.	% Fuel Inventory Released Estimate	Approximate Source and Damage
1	100	100% Fuel Damage, potential core melt
2	10	Total clad failure, core partially uncovered
3	1	Approximately 10% clad failure
4	-	100% coolant release

NOTE 1

The curves represent direct readings from the Containment Post Accident Radiation Monitors (1D19-N200A&B), at elevation 689 feet, inside containment. The curves account for the finite Containment volume seen by the detector but do not account for any physical or shielding characteristics of the monitor or calibration uncertainties.

NOTE 2

The curves assume that only airborne noble gases and iodines are significant. Sprays (if used) would make the iodine and any particulate contribution insignificant. However, particulate plateout on surfaces and direct shine doses from components may make the readings unreliable. The calculation of monitor response does not include any particulates, since the noble gases and iodine are the most significant contributors to dose rate in the Containment.

NOTE 3

100% Fuel Inventory = 100% Noble Gas, 25% Iodine.

NOTE 4

If the radiation levels from the Containment Post Accident Radiation Monitors, (1D19-N200A&B) are below the maximum radiation levels predicted for release of 100% of the normal operating coolant activity, including the maximum allowable iodine spike, it is assumed that no core damage exists.

NOTE 5

See ONI-J11-1, "Gross Cladding Failure" for additional cladding failure indicators.

NOTE 6

Attachment 2 (Zirconium-Water Reaction Calculation) may be completed if the Hydrogen Monitoring System is operable, and registering hydrogen concentrations. This calculation generates the % of cladding reacted.

NOTE 7

Per RTM 96 (NRC Response Technical Manual), if the Hydrogen concentration is ≥ 2%, cladding failure may be indicated.

4.2.2 <u>Assessment of Core Damage Based on Sample Results</u>

1. Collect and analyze the post accident samples utilizing SOI-P87, "Post Accident Sampling System" and CHI-0053, "Operation of the Gamma Spectroscopy System". Use the time of reactor shutdown for sample time to achieve the correct decay time.

2. Using the Power Correction Factor Calculation equation (Attachment 3), perform the following Power Correction Factor Calculation for each isotope to be utilized in core damage assessment on the data obtained in Step 1 (I-131, Xe-133, Cs-137, Kr-85). Multiply these correction factors by the decay corrected uCi/unit volume to normalize the activities to the Reference Plant Data Base.

Correction Factor for Isotope:

$$i = \frac{3651\left(1-e^{-1095\lambda_i}\right)}{\sum_j \left\{P_j\left(1-e^{-\lambda_i T_j}\right)e^{-\lambda_i T_j^o}\right\}}$$

Where:

j = A given operating period where the steady state of power level variation is less than ±20%. A minimum of 60 days of power correction must be performed.

λ_i = Decay Constant for isotope i (day -1) (listed on Attachment 1)

P_j = Steady Reactor Power of operating period j (MWt)

T_j = Duration of operating period j (day)

T_j^o = Time between the end of operating period j and the time of last reactor shutdown (day) This equals zero for operating period immediately prior to accident.

3651 = Average operating power (MWt) for Reference Plant

1095 = Continuous operation time (day) for Reference Plant

NOTE

A spreadsheet may be used to perform the above calculation.

3. Utilize Activity vs. Core Degradation (Attachments 4 through 7) and the normalized activities calculated in Step 2 to obtain the Upper Release, Best Estimate and Lower Release values pertaining to core damage. Record these results on the Estimate of Core Damage Data Sheet (Attachment 8).

4. Perform "Activity Ratio for Noble Gases" calculations and "Activity Ratio for Iodines" calculations (Attachment 9), using non-normalized reactor water activities for each isotope listed in Attachment 9.

5. Determine the Best Estimate of core damage type by comparing the ratios calculated in Step 4 to the Core Inventory and Fuel Gap Ratios. A ratio equal to or greater than the listed Fuel Gap ratio indicates cladding failure and a ratio equal to or greater than the Core Inventory indicates fuel melt. Record results on Attachment 9.

6. Complete the Zirconium-Water Reaction Calculation (Attachment 2).

NOTE

Hydrogen concentrations are obtained from Containment Hydrogen Monitoring System or performed by grab sample analysis.

7. Utilizing all of the above information and/or calculations and the following discussion, complete the Estimate of Core Damage Data Sheet (Attachment 8), formulating the "Best Estimation of Core Damage".

   Plant parameters/indications that should be considered along with the analysis data include:

   - The loss of reactor coolant volume below the TAF region (Top of Active Fuel) can result in core overheat and subsequent clad and fuel damage.

- The presence of hydrogen, the result of a Zirconium - Water reaction, without significant amounts of less volatile elements, is indicative of a clad overheat condition without fuel melt.

- The presence of unusually high concentrations of Strontium-92 and Lanthanum-140 or other low volatile elements, such as Barium, Ruthenium and Tellurium, implies some degree of core melt.

5.0 RECORDS

5.1 Records Handling

None,

5.2 Records Capture

The following records are completed/generated by this document:

Quality Records

Power Correction Factor Calculation (Attachment 1)

Zirconium - Water Reaction Calculation (Attachment 2)

Estimate of Core Damage Data Sheet (Attachment 8)

Non-Quality Records

None

6.0 REFERENCES

6.1 Developmental

NEDC-33045P, Revision 0, "Methods of Estimating Core Damage in BWRs"

NEDO-22215, "Procedures for the Determination of the Extent of Core Damage Under Accident Conditions"

"NUS Drywell Radiation Plots and Technical Basis Dose Rate Plots" Memo # PY-NUS/CEI-705

PY-NUS/CEI-705 letter dated 5/10/83

Radioactive Decay Data Tables, David C. Kocher, 1981

USAR Table 6.2-5

6.2 Implementation

CHI-0053, "Operation of the Gamma Spectroscopy System"

ONI-J11-1, "Gross Cladding Failure "

RTM-96, USNRC Response Technical Manual

6.3 Commitments

L00053	All Sections	L02480	All Sections	L02481	All Sections
L02482	All Sections				

7.0 SCOPE OF REVISION

Rev. 3

1. Updated to new Writers Guide format.
2. Replaced reference to cancelled RPI-1313 to replacement instruction CHI-0053.
3. Updated reference to NEDC-3304P, "Methods of Estimating Core Damage in BWRs".
4. Added reference to "NUS Drywell Radiation Plots and Technical Basis" memo # PY-NUS/CEI-705, the basis of the origination of Attachment 1.
5. Added Note 4, page 8,indicating no cladding challenge when X/DW D19 indicate radiation levels are below projected levels for 100% coolant release.
6. Added Note 5, page 8 indicating ONI-J11-1 "Gross Cladding Failure for additional cladding failure indicators.

7. Referenced use of Hydrogen monitors and Attachment 2 as method to determine cladding activity %.
8. Added definitions in Section 3.1, clarifying core status.
9. Added a Note in Section 1.0 clarifying that reactor core coolant sampling should be performed at the conclusion of an event and may have to be shipped off site for analysis.
10. Added notes to Attachment 1, explaining what each curve represents. Notes are based upon procedure text explanations.
11. Added a Note in Section 2.0 stating D17s on the Main Steam Lines should only be utilized for a core damage indicator if the Main Steam Isolation Valves (MSIVs) are not shut.
12. Loose Parts monitoring has been eliminated. Reference to this system has been removed.
13. Note number 7 in Section 4.2.1 added to reference "RTM 96, Response Technical Manual (NRC) indicating possible cladding damage if 2% hydrogen concentration is present.
14. Added Note 6, page 8, referencing Attachment 2.
15. Updated commitments to reflect PASS updates.

ATTACHMENT 1: DOSE RATE AT CONTAINMENT MONITOR

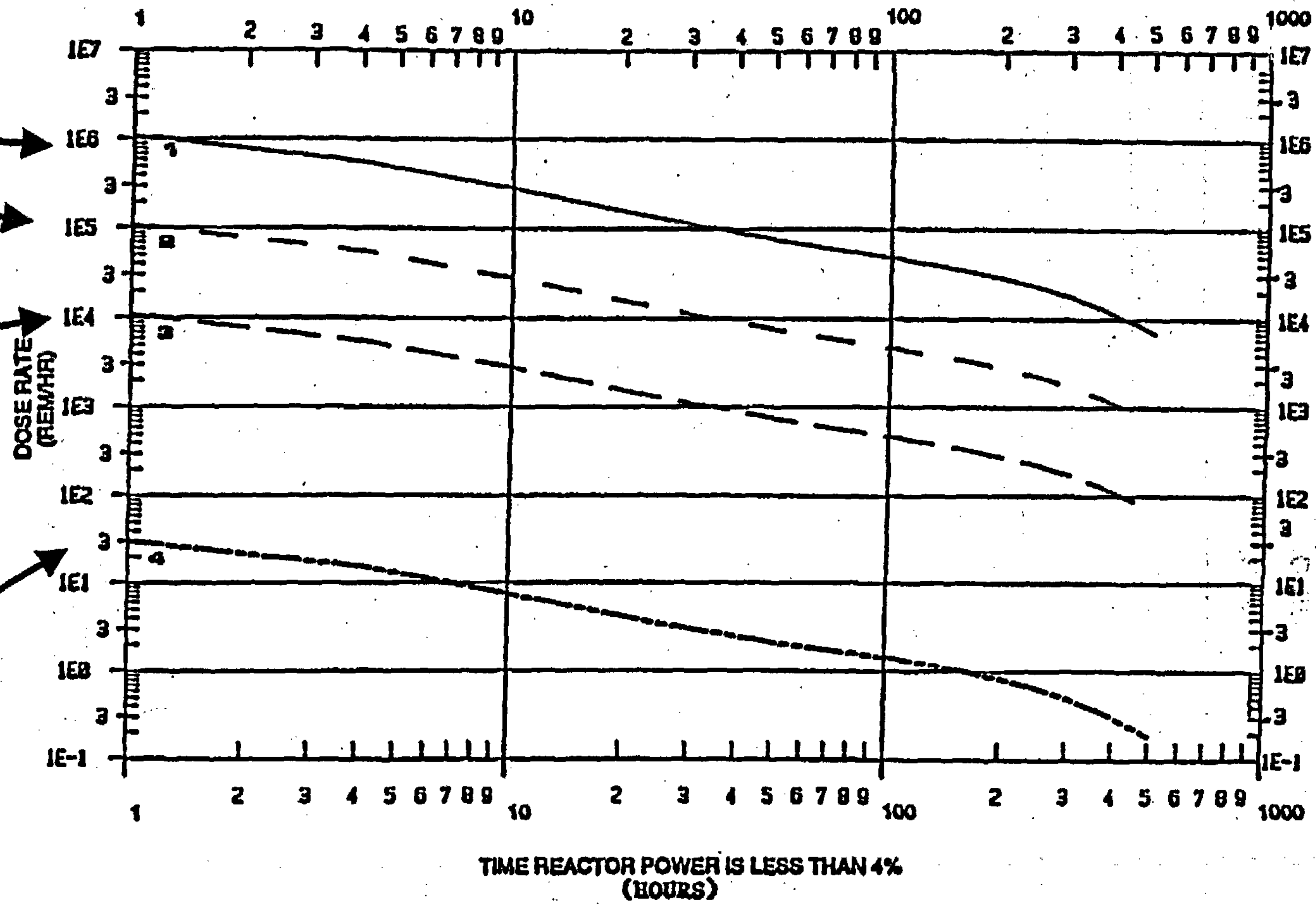
Page 1 of 1

Curve 1
100% Inventory release, 100% Fuel Damage, potential core melt.

Curve 2
10% Inventory release, Total clad failure (100%), core partially uncovered.

Curve 3
1% Inventory released, Approximately 10% clad failure.

Curve 4
No clad failure, 100% coolant inventory release.



ATTACHMENT 2: ZIRCONIUM - WATER REACTION CALCULATION

Hydrogen concentration: ______________% Date/Time: _____/_____

Calculation:

$$\%H = \frac{(F_{zr}) \times (M_{zr}) \times (C)}{[(F_{zr}) \times (M_{zr}) \times (C)] + V} \times 100$$

where:

F_{zr} = Fraction of Zirconium Reacted

M_{zr} = Total Mass of Zirconium = 1.60E5 lbm

C = SCF H2 per lbm of Zirconium = 8 SCF H_2/lbm

V = Dilution Volume = 1.42E6 ft3

$$F_{zr} = \frac{(1.42E6) \times (\%H_2)}{(1.28E8) - (1.28E6 \times \%H_2)}$$

$$F_{zr} = \frac{(1.42E6)(\quad\quad)}{(1.28E8) - (1.28E6 \times \quad\quad)}$$

F_{zr} = ______________

% Cladding Reacted = Fzr x 100 = ______________%

ATTACHMENT 3: POWER CORRECTION FACTOR CALCULATION

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Correction Factor for Isotope

$$i = \frac{3651\left(1-e^{-1095\lambda_i}\right)}{\sum_j \left\{P_j\left(1-e^{-\lambda_i T_j}\right)e^{-\lambda_i T_j^o}\right\}}$$

ISOTOPE	DECAY CONSTANT (λ_i)	DECAY CORRECTED ACTIVITY	CORRECTION FACTOR (i)	NORMALIZED ACTIVITY
I-131 Primary Coolant	8.62E-2			
Xe-133 Containment Gas	1.32E-1			
Cs-137 Primary Coolant	6.29E-5			
Kr-85 Containment Gas	1.77E-4			

NOTE: Some isotopes will be difficult to analyze immediately following an accident, specifically Cs-137 and Kr-85, which would be best utilized for core damage estimates several weeks after shutdown, allowing for sufficient decay of the shorter lived interfering isotopes.

ATTACHMENT 4: IODINE-131 ACTIVITY vs. CORE DEGRADATION
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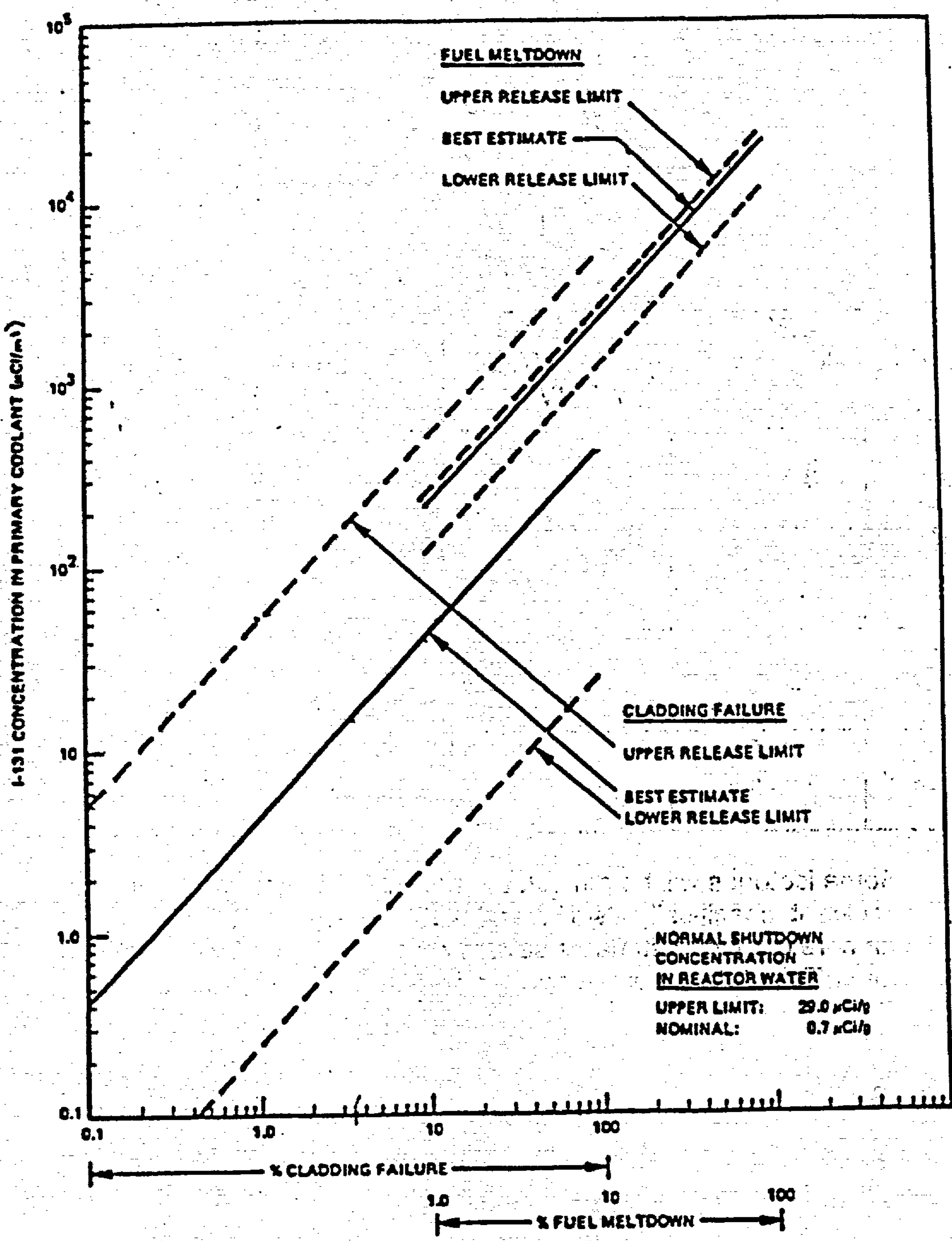

ATTACHMENT 5: XENON-133 ACTIVITY vs. CORE DEGRADATION

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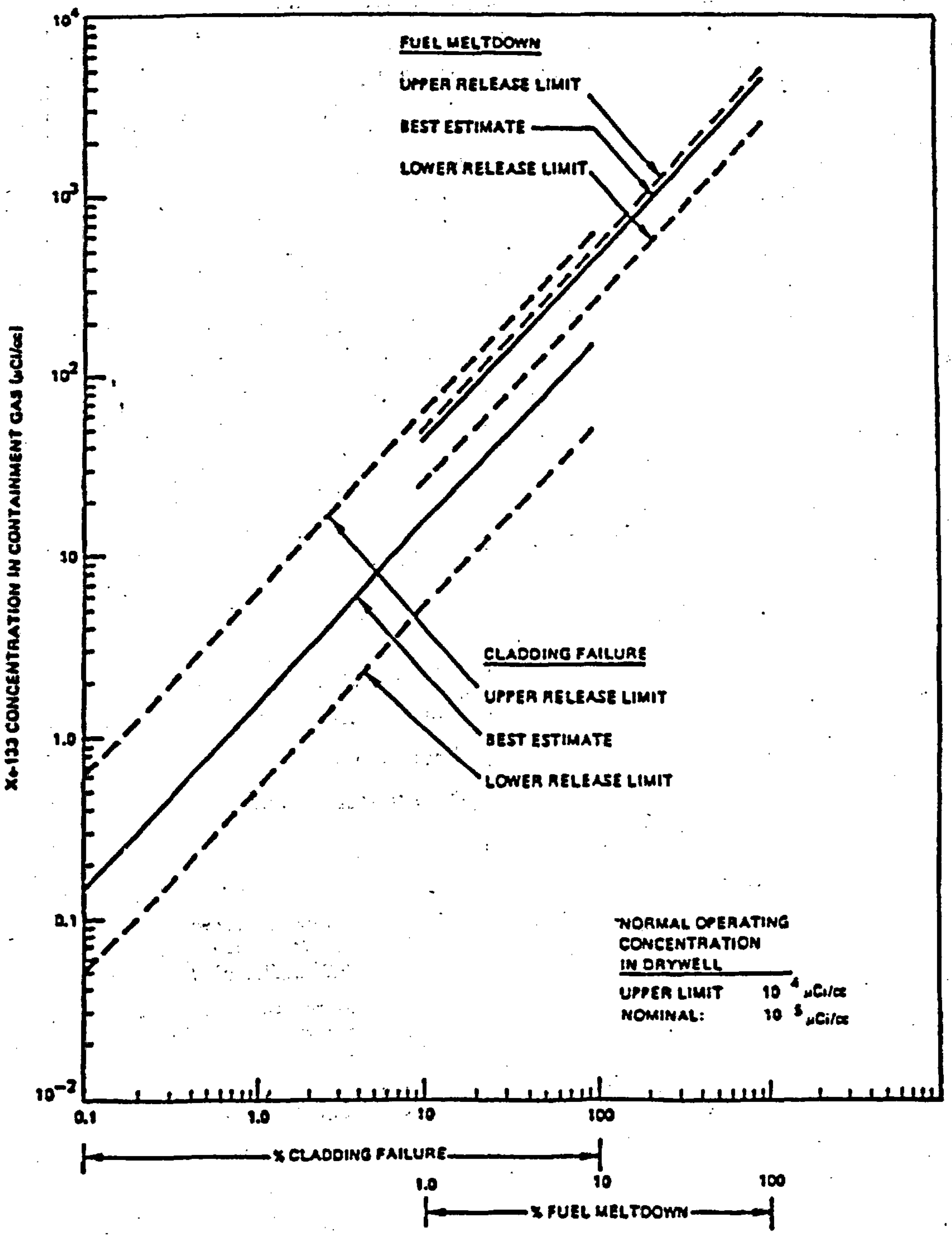
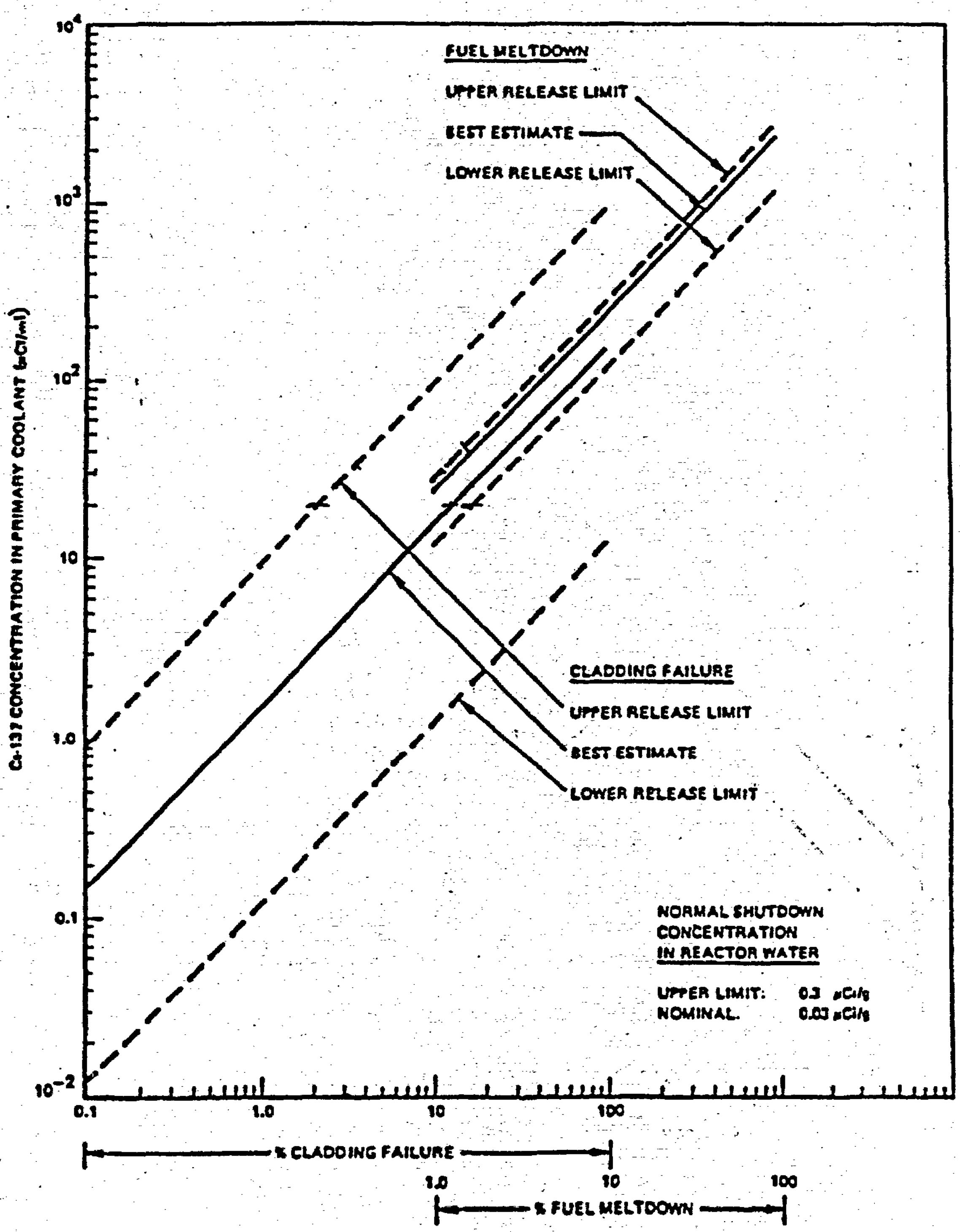


ATTACHMENT 6: CESIUM-137 ACTIVITY vs. CORE DEGRADATION



ATTACHMENT 7: KRYPTON-85 ACTIVITY vs. CORE DEGRADATION

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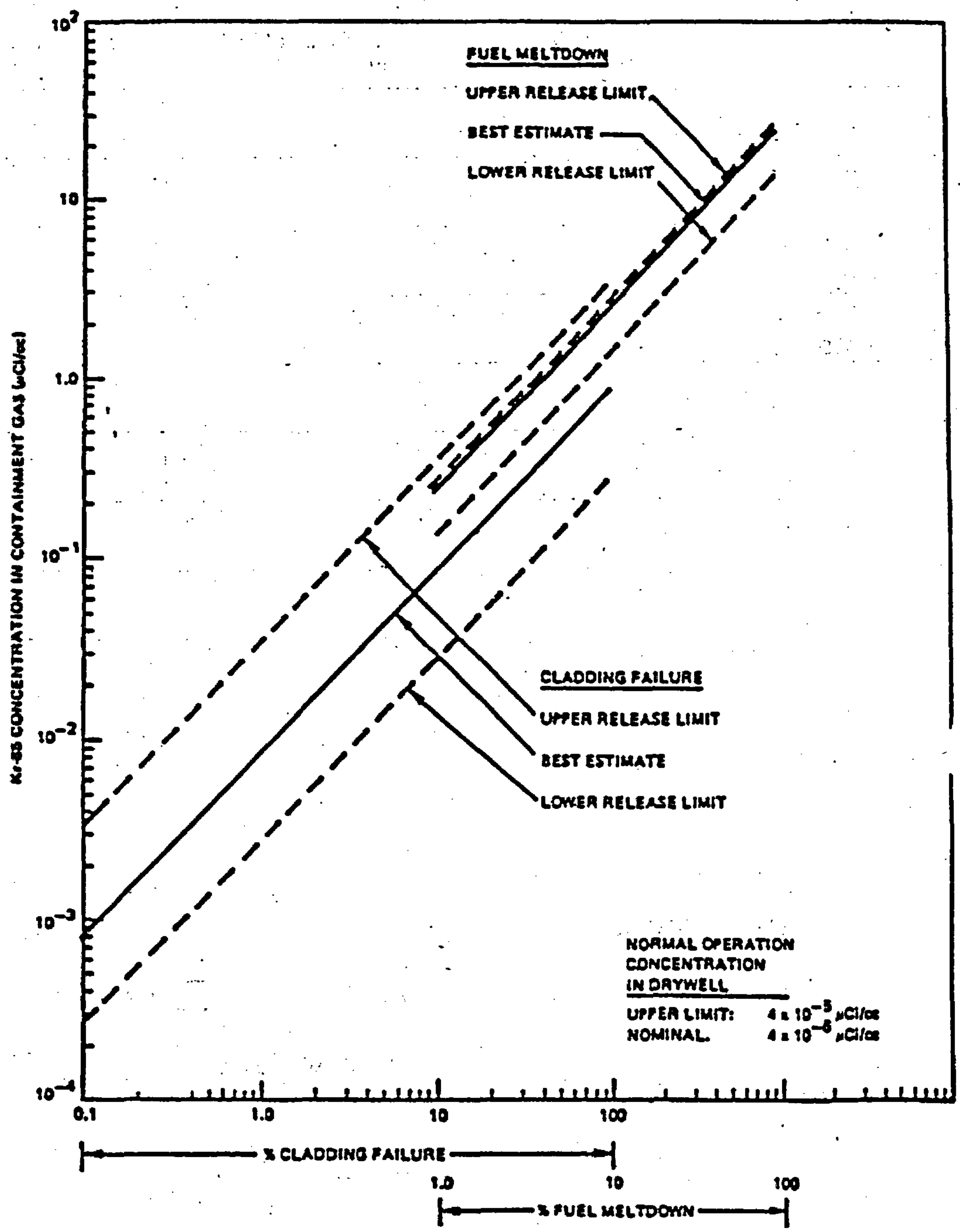

ATTACHMENT 8: ESTIMATE OF CORE DAMAGE DATA SHEET FOR ATTACHMENTS 4, 5, 6, 7

Page 1 of 2

		Upper Release %	Best Estimate %	Lower Release %
Iodine 131 (liquid)	Cladding Failure	%	%	%
	Fuel Meltdown	%	%	%
Xenon 133 (atmosphere)	Cladding Failure	%	%	%
	Fuel Meltdown	%	%	%
Optional Cesium 137	Cladding Failure	%	%	%
(liquid)	Fuel Meltdown	%	%	%
Krypton 85 (atmosphere)	Cladding Failure	%	%	%
	Fuel Meltdown	%	%	%

Attachment 9:
Cladding Failure: ☐Yes / ☐No
Fuel Meltdown: ☐Yes / ☐No

Attachment 2:
Cladding reacted: ________%

Additional Plant Parameters/Indications:

Did Reactor Coolant drop below the Top of Active Fuel? ☐Yes / ☐No

Lowest known level: ____________

Presence of low volatile elements? ☐Yes / ☐No

Isotopes:
____

ATTACHMENT 8: ESTIMATE OF CORE DAMAGE DATA SHEET FOR ATTACHMENTS 4, 5, 6, 7

Page 2 of 2

Best Estimation of Core Damage:

Fuel Overheat Indications ☐Yes / ☐No

___________% Cladding Failure ____________% Fuel Meltdown

Completed By: ____________________________ _______/_______

Date Time

ATTACHMENT 9: RATIOS OF ISOTOPES IN CORE INVENTORY AND FUEL GAP

Page 1 of 1

Isotope	Half life	Activity Ratio: Fuel Gap	Activity Ratio: Core Inventory	Calculated
Noble Gas:				
Kr-87	76.3 min.	0.0234	0.233	______
Kr-88	2.84 hr.	0.0495	0.33	______
Kr-85m	4.48 hr.	0.023	0.122	______
Xe-133	5.25 day	1.0	1.0	
Iodine:				
I-134	52.6 min.	0.155	2.3	______
I-132	2.3 hr.	0.127	1.46	______
I-135	6.61 hr.	0.364	1.97	______
I-133	20.8 hr.	0.685	2.09	______
I-131	8.04 day	1.0	1.0	

Activity Ratio for Noble gases = Noble gas isotope concentration / Xe-133 concentration

Activity Ratio for Iodines = Iodine isotope concentration / I-131 concentration

Type of core damage best estimate:

Fuel Gap (Cladding Failure) Yes / No
Core Inventory (Fuel Meltdown) Yes / No