CRISIS MANAGEMENT PLAN

IMPLEMENTING PROCEDURE

EDA - 02

"Off-Site Dose Projections for
Catawba Nuclear Station"

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Approved By

3/28/89
Date

Rev. 4
August 28, 1989

OFFSITE DOSE PROJECTIONS FOR CATAWBA NUCLEAR STATION

1.0 PURPOSE

To describe a method for projecting dose commitment from a noble gas and/or iodine release, through the containment, the unit vent and/or the steam relief valves, during an emergency.

2.0 REFERENCES

2.1 HP/0/B/1000/10, Determination of Radiation Monitor Setpoints

2.2 HP/0/B/1009/06, Alternative Method for Determining Dose Rate Within the Reactor Building

2.3 HP/0/B/1009/14, Health Physics Actions Following an Uncontrolled Release of Liquid Radioactive Material

2.4 HP/0/B/1009/17, Unit 1 Post-Accident Containment Air Sampling System

2.5 HP/0/B/1009/21, Abnormal Unit Vent Sampling

2.6 CNS Technical Specification 3.6.1.2

2.7 Offsite Dose Calculation Manual (ODCM)

2.8 Regulatory Guide 1.4, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Pressurized Water Reactors"

2.9 Regulatory Guide 1.109, "Calculations of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10CFR Part 50, Appendix I"

2.10 NuReg-0396, EPA 520/1-78-016, "Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants"

2.11 NuReg-0654, FEMA-REP-1, Rev. 1, "Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants"

2.12 Letter from F. G. Hudson, September 30, 1985, re: Release Rate Information for McGuire and Catawba Nuclear Station (File: CN-134.10)

2.13 Catawba Nuclear Station Class A Computer Model Validation (File: NUC-0306)

2.14 Letter from J. E. Thomas, May 19, 1987, File: CN-1346.05 and personal conversation with Frank Poley

2.15 Radioiodine and Particle Transmission Through Plant Vent Sampling Lines at Catawba Nuclear Station, prepared by SAIC, dated July 1989.

3.0 LIMITS AND PRECAUTIONS

3.1 This procedure is an alternative method of dose assessment to the Catawba Class A Atmospheric Dispersion Model computer code.

3.2 This procedure applies to releases made from Catawba Nuclear Station only. Many of the values contained in this procedure are site specific.

3.3 It is assumed that the whole body dose from an iodine release is very small compared to the thyroid dose; therefore, iodine whole body dose is not considered here.

3.4 This procedure considers all releases to be ground level releases and that meteorological data are 15 minute averages.

3.5 Once a zone has been added to the list of affected zones, it shall not be removed except under the direction of the Dose Assessment Coordinator.

3.6 Once the Crisis Management Center (CMC) has been activated, the doses calculated by the Technical Support Center (TSC) dose assessment group, should be compared with those calculated by the CMC before an evacuation recommendation is made.

4.0 PROCEDURE

4.1 Meteorology Assessment

4.1.1 Acquire the following information and record on the Dose Assessment Worksheet (Enclosure 5.1):

4.1.1.1 Lower tower wind speed (WS) in miles per hour.

4.1.1.1.1 Use upper tower wind speed if lower tower wind speed is not available.

4.1.1.2 Upper tower wind direction in degrees from North (North = 0).

4.1.1.2.1 Use lower tower wind direction if upper tower wind direction is not available.

4.1.1.2.2 If the wind speed or wind direction cannot be obtained from plant systems, obtain them from the National Weather Service (phone 704-359-8466). If the NWS information is unavailable, then obtain data from McGuire Nuclear Station Control Room (73 or 78, then 875, then ext. 4262, or 4263, or 4264).

4.1.1.3 Temperature gradient (ΔT) in degrees centigrade.

4.1.1.4 Using Enclosure 5.2, record the stability class based on ΔT.

4.1.1.4.1 If the temperature gradient is unknown, the following applies:

If between 1000 - 1600 hours, use stability class D;

If between 1600 - 1000 hours, use stability class G.

4.1.1.5 If necessary, use forecasted meteorological data for calculating doses due to changing meteorological conditions.

4.1.2 Determine the atmospheric dispersion parameter, $\overline{X/Q}$ (sec/m^3), for .5, 2, 5 and 10 miles (record on Enclosure 5.1, page 2):

4.1.2.1 Use ΔT, determine the two hour relative concentration value (C_H) from Enclosure 5.2.

4.1.2.2 Convert the C_H values to $\overline{X/Q}$:

$$\overline{X/Q} = \frac{C_H}{WS}$$

4.2 Source Term Assessment - Steam Relief Valve (Enclosure 5.4)

4.2.1 Determine the Sub-Noble Gas Release Rates, SQ_{NG} (Ci/sec), by the following method:

4.2.1.1 For Unit 1-EMF26, EMF27, EMF28 and EMF29 or for Unit 2-EMF10, EMF11, EMF12, EMF13:

$$SQ_{NG} = R/hr \times \frac{1}{VOPEN} \times LBM \times CF \; \frac{Ci}{lbm\ R/hr}$$

where:

R/hr	=	EMF26, EMF27, EMF28, EMF29, EMF10, EMF11, EMF12, EMF13 reading
VOPEN	=	time the valve is open in seconds
LBM	=	lbm released for the time the valve was open
CF	=	the correction factor per Enclosure 5.5.

4.2.2 Determine the Noble Gas Release Rate, Q_{NG}(Ci/sec):

$$Q_{NG} = SQ_{NG}(EMF26) + SQ_{NG}(EMF27) + SQ_{NG}(EMF28) + SQ_{NG}(EMF29)$$

4.2.3 Determine the Iodine release rate, Q_I(Ci/sec):

$$Q_I = Q_{NG} \times Irat$$

where:

Irat = ratio of I131 eqv./Xe133 eqv. from Enclosure 5.6.

4.2.4 Record Q_{NG} and Q_I on Enclosure 5.1, page 2.

4.3 Source Term Assessment - Containment (Enclosure 5.7)

4.3.1 Determine the Noble Gas Release Rate, Q_{NG}(Ci/sec) based on one of the following methods;

4.3.1.1 Based on and EMF reading, where;

$$Q_{NG} = EMF \times CF \times LR$$

Where;

EMF = 39(L), if EMF39(L) <1E7 cpm and flowpath not isolated,
EMF = 39(H), if EMF39(L) is offscale and EMF39(H) > 100 cpm and flowpath not isolated,
EMF = 53A or 53B, if EMF39(H) is offscale,

CF = the correction factor per Enclosure 5.8.

LR = Leak Rate x BYPASS,
Leak Rate, (ml/hr), by one of the following methods:

based on containment pressure:
LR = RLR (from Enclosure 5.9)

based on an opening in containment:
LR = OIC (from Enclosure 5.10)

based on design leak rate:
LR = 2.449E6 (Reference 2.13)

BYPASS = Bypass leakage, default is 7% or 0.07 (Reference 2.6)

4.3.1.2 Based on PACS sample, where;

$$Q_{NG} = PACS \times CF \times LR$$

where;

PACS = μCi/ml (Reference 2.4)

CF = 2.78E-10 $\frac{\text{Ci hr}}{\text{sec } \mu\text{Ci}}$

LR = Leak rate, as determined in Step 4.3.1.1 above

4.3.2 Detemine the Iodine Release Rate, Q_I (Ci/sec) based on one of the following methods:

4.3.2.1 Based on Q_{NG};

$$Q_I = Q_{NG} \times Irat$$

where:

Q_{NG} = Noble Gas Release Rate as determined in Step 4.3.1 above

Irat = ratio of I131 eqv./Xe 133 eqv. from Enclosure 5.6.

4.3.2.2 Based on EMF 40 (if flowpath is not isolated);

$$Q_I = \frac{\Delta CPM}{\Delta min} \times 9.82E\text{-}20 \ \frac{\text{Ci hr min}}{\text{sec ml cpm}} \times LR$$

where:

ΔCPM = reading from EMF40
Δmin = the time interval for EMF40 observation (normally 15 minutes)

9.82E-20 = 4.0E-5 μCi/cpm x .25 min/ft^3 (inverse of EMF flow rate) x 3.53-5 ft^3/ml x 1Ci/1E6 μCi x 1 hr/3600 sec.

4.0E-5 = correlation factor for EMF40 from Reference 2.1.

LR = Leak rate, as determined in Step 4.3.1.1 above

4.3.2.3 Based on PACS sample;

$$Q_I = PACS \times CF \times LR$$

where;

PACS = (μCi/ml) (Reference 2.4)

$$CF = 2.78E\text{-}10 \ \frac{Ci\ hr}{sec\ \mu Ci}$$

LR = Leak rate as determined in Step 4.3.1.1 above

4.3.3 Record Q_{NG} and Q_I on Enclosure 5.1, page 2.

4.4 Source Term Assessment - Unit Vent (Enclosure 5.11)

4.4.1 Determine the Noble Gas Release Rate, Q_{NG}(Ci/sec) based on one of the following methods:

4.4.1.1 Based on as EMF reading, where;

$$Q_{NG} = EMF \times CF \times CFM$$

where:

EMF = 36(L) if EMF36(L) < 1E7 cpm,
EMF = 36(H) if EMF36(L) is offscale and EMF36(H) > 100 cpm and compressor not tripped,
EMF = 54 if EMF36(H) is offscale,
CF = unit vent factor per Enclosure 5.12
CFM = unit vent flow rate (ft^3/min)

4.4.1.2 Based on unit vent sample, where;

$$Q_{NG} = \text{Unit Vent Sample} \times CF \times CFM$$

where:

Unit Vent Sample = (μCi/ml) per Reference 2.5

$$CF = 4.72E\text{-}4 \ \frac{Ci\ min\ ml}{sec\ ft^3\ \mu ci}$$

CFM = unit vent flow rate (ft^3/min)

4.4.2 Determine the Iodine Release Rate, Q_I (Ci/sec), based on one of the following methods:

4.4.2.1 Based on Q_{NG};

$Q_I = Q_{NG} \times Irat$

where:

Q_{NG} = Noble Gas Release Rate as determined in Step 4.4.1 above

Irat = ratio of I131 eqv./Xe133 eqv. from Enclosure 5.6.

4.4.2.2 Based on EMF 37 (if compressor not tripped);

$$\frac{\Delta CPM}{\Delta min} \times 1.33E\text{-}13 \ \frac{Ci\ min\ min}{sec\ ft^3\ cpm} \times CFM = Q_I$$

where:

ΔCPM = reading from EMF37
Δmin = the time interval from EMF37 observation (normally 15 minutes)

1.33E-13 = 4.0E-5 μCi/cpm x 0.1667 min/ft^3 (inverse of EMF flow rate) x 1Ci/1E6 μCi x 1 min/60 sec. x 1.2

where:

4.0E-5 = correlation factor for EMF37 from Reference 2.1.

1.2 = inverse of iodine transmission factor (see Reference 2.15)

CFM = unit vent flow rate (ft^3/min)

4.4.2.3 Based on unit vent sample:

$$Q_I = \text{Unit vent sample} \times 4.72E\text{-}4 \ \frac{Ci\ min\ ml}{sec\ ft^3\ \mu Ci} \times CFM$$

where:

Unit vent sample = (μCi/ml) (Reference 2.5)

CFM = unit vent flow rate (ft^3/min)

4.4.3 Record Q_{NG} and Q_I on Enclosure 5.1, page 2.

4.5 Dose Assessment (Enclosure 5.1)

4.5.1 Determine the total Noble Gas and Iodine Release Rates (TQ_{NG} and TQ_I) from all releases and record on Enclosure 5.1, page 1.

4.5.2 Determine the Projected Whole Body Dose Rate, DRwb (rem/hr), due to the noble gases for .5, 2, 5 and 10 miles:

$$DRwb = 33.6 \frac{rem\ m^3}{hr\ Ci} \times TQ_{NG} \times \overline{X/Q}$$

where:

33.6 is the adult whole body dose conversion factor from Reference 2.9 in $\frac{rem\ m^3}{hr\ Ci}$

4.5.3 Determine the Projected Whole Body Dose, Dwb(rem), due to noble gases for .5, 2, 5 and 10 miles:

$$Dwb = DRwb \times 2\ hr$$

where:

dose is integrated over 2 hour time period

4.5.4 Determine the Projected Thyroid Dose Rate, DRct (rem/hr), due to iodine for .5, 2, 5 and 10 miles:

$$DRct = \overline{X/Q} \times TQ_I \times 2.26E6 \frac{rem\ m^3}{hr\ Ci}$$

where:

2.26E6 is the child thyroid dose conversion factor from Reference 2.13 in $\frac{rem\ m^3}{hr\ Ci}$

4.5.5 Determine the Projected Thyroid Dose, Dct(rem), due to iodine for .5, 2, 5 and 10 miles:

$$Dct = DRct \times 2\ hr$$

where:

dose is integrated over 2 hour time period

4.6 Protective Action Recommendations (Enclosure 5.1):

4.6.1 Circle on Enclosure 5.1 the Protective Action Zones (PAZ), based upon 1) the wind speed and wind direction, using Enclosure 5.3; and 2) the projected dose from Enclosure 5.1 compared to the following.

4.6.2 If the projected dose in a PAZ is < 1 rem whole body or <5 rem thyroid, then recommend no protective action (action A).

4.6.3 If the projected dose in a PAZ is 1 - 5 rem whole body or 5 - 25 rem thyroid, then recommend evacuate children and pregnant women and shelter others (actions B and E).

4.6.4 If the projected dose in a PAZ is > 5 rem whole body or > 25 rem thyroid, then recommend evacuate everyone (action C).

4.6.5 Recheck meteorology conditions approximately every 15 minutes to ensure that other sectors have not been affected.

4.7 Emergency Classification (Enclosure 5.1)

4.7.1 Check the box indicating the emergency classification based upon the following.

4.7.2 If the dose rate at the site boundary is ≥ 5.0E-4 rem/hr whole body then recommend an Alert.

4.7.3 If the dose rate at the site boundary is ≥ .05 rem/hr whole body or ≥ .25 rem/hr thyroid, then recommend a Site Area Emergency if readings last 30 minutes.

4.7.4 If the dose rate at the site boundary is ≥ .5 rem/hr whole body or ≥ 2.5 rem/hr thyroid, then recommend a Site Area Emergency if readings last 2 minutes.

4.7.5 If the dose rate at the site boundary is ≥ 1 rem/hr whole body or ≥ 5 rem/hr thyroid, then recommend a General Emergency.

5.0 ENCLOSUES

5.1 Sample of Meteorology Source Term and Dose Assessment Worksheet

5.2 Two-hour Relative Concentration Factors (C_H)

5.3 Protective Action Zones Determination

5.4 Sample of Source Term Assessment - Steam Relief Valves

5.5 EMF26, EMF27, EMF28, EMF29 or EMF10, EMF11, EMF12, EMF13 Noble Gas Correction Factor

5.6 I131 eqv./Xe 133 eqv. Ratio

5.7 Sample of Source Term Assessment - Containment

5.8 Containment Noble Gas Correction Factor

5.9 Containment Leakage Rate versus Pressure

5.10 Containment Leakage Rate versus Pressure and Size Opening

5.11 Sample of Source Term Assessment - Unit Vent

5.12 Unit Vent Noble Gas Correction Factor

Catawba Nuclear Station ☐ Emergency ☐ Drill

Meteorology, Source Term and Dose Assessment Report #________

Approved for release to state/counties by ______________________
Unit Date/Time of reactor trip ______ ______ Prepared by ____________
Projection based on data on ________ ________ Time since trip ______ hrs.

PART 1

7. The emergency condition:
   ____(a) Does not involve the release of radioactive materials from the plant.
   ____(b) Involves the potential for a release, but no release is occurring.
   ____(c) Involves the release of radioactive materials.

8. Recommended Protective Actions (based on Dose Projections only)
   (a) - In zones A0, B1, E1, A1, C1, D1, F1, B2, A2, C2, D2, E2, F2, F3, A3 no action is recommended.
   (b) - In zones A0, B1, E1, A1, C1, D1, F1, B2, A2, C2, D2, E2, F2, F3, A3 remain indoors with the doors and windows closed, turn off air conditioners and other ventilation monitor EBS stations.
   (c) - In zones A0, B1, E1, A1, C1, D1, F1, B2, A2, C2, D2, E2, F2, F3, A3 evacuate their homes and businesses and go to a designated shelter.
   (e) - In zones A0, B1, E1, A1, C1, D1, F1, B2, A2, C2, D2, E2, F2, F3, A3 pregnant women and children evacuate and go to a designated shelter.

NOTES: 1) For all evacuations, recommend that the remainder of the 10 mile emergency planning zone stay indoors.
2) Compare these recommendations with other groups' recommendations that the Emergency Coordinator/Recovery Manager reviews.

PART 2

4. Dose Projection Data
   Windspeed ____ mph Wind Direction ____ degrees from North
   Release Type: Ground Weighted Dose 33.6 (R/hr/Ci/m^3) whole body
   Conversion Factor 2.26E6 (R/hr/Ci/m^3) thyroid
   Stabillity Class ____
   Radiological Release: Noble Gas Equivalent - ________ Ci/sec
   Iodine Equivalent - ________ Ci/sec

5. The type of actual or projected release is:
   __(a) Airborne __(b) Waterborne __(c) Surface Spill __(d) Other______
   __(e) No release is in progress or expected at this time.

6. Release (a)___ will begin/ (b)___ began at: ________.

7. The estimated duration of the release is ______ hours.

8. The source and description of the release is: ____________________
   ____
   ____

9. Dose Projections

Distance	Dose Commitment Whole Body rem/hr	Dose Commitment Child Thyroid rem/hr	Projected Integrated Dose Base on ______ hrs of release Whole Body rem	Projected Integrated Dose Child Thyroid rem
Site Boundary	______	______	______	______
2 miles	______	______	______	______
5 miles	______	______	______	______
10 miles	______	______	______	______

10. Field measurement of dose rate (mr/hr) or contamination (dpm/100 cm^2)

Time	Zone	Distance	Direction	Whole Body	Child Thyroid
____	____	________	________	________	________
____	____	________	________	________	________
____	____	________	________	________	________

Miles	.5	1	2	4	5	7	8
PAZ	A0	B1 E1	A1 C1 D1 F1	B2	A2 C2 D2 E2 F2	F3	A3

Total Source Term Assessment ☐ Current ☐ Hypothetical

Steam Relief Encl. 5.4		Containment Encl. 5.7		Unit Vent Encl. 5.11		
________Ci/sec	+	________Ci/sec	+	________Ci/Sec	=	______ Ci/Sec (TQ_{NG})
________Ci/sec	+	________Ci/sec	+	________Ci/Sec	=	______ Ci/Sec (TQ_I)

Source Term Based on

1. LOCA
2. LOCA (charcoal)
3. Melted Core
4. Melted Core (charcoal)
5. Tube Rupture
6. New Fuel Accident (< 100 days old)
7. Old Fuel Accident (> 100 days old)
8. Waste Gas Decay Tank

Dose Assessment $\frac{C_H}{WS} = \bar{X}/Q$

<----< Adult whole body <----< >----> Child thyroid >---->

2 hr Dose (rem) = 2 x DRwb (rem/hr) = 33.6 x TQ_{NG} (Ci/sec) x $\bar{X}/Q$ (sec/m^3) x TQ_I (Ci/sec) x 2.26E6 = DRct (rem/hr) x 2 = 2 hr Dose (rem)

				Distance miles					
______	=2 x ______	= 33.6 x TQ_{NG}		.5	______	TQ_I x 2.26E6 =	______	x 2=	______
______	=2 x ______	= 33.6 x TQ_{NG}		2	______	TQ_I x 2.26E6 =	______	x 2=	______
______	=2 x ______	= 33.6 x TQ_{NG}		5	______	TQ_I x 2.26E6 =	______	x 2=	______
______	=2 x ______	= 33.6 x TQ_{NG}		10	______	TQ_I x 2.26E6 =	______	x 2=	______
______	=2 x ______	= 33.6 x TQ_{NG}		1	______	TQ_I x 2.26E6 =	______	x 2=	______
______	=2 x ______	= 33.6 x TQ_{NG}		4	______	TQ_I x 2.26E6 =	______	x 2=	______
______	=2 x ______	= 33.6 x TQ_{NG}		7	______	TQ_I x 2.26E6 =	______	x 2=	______
______	=2 x ______	= 33.6 x TQ_{NG}		8	______	TQ_I x 2.26E6 =	______	x 2=	______

Review with Emergency Coordinator the recommended Emergency Classification.

☐ Recommend Alert

☐ Recommend Site Area Emergency if readings last 30 minutes

☐ Recommend Site Area Emergency if readings last 2 minutes

☐ Recommend General Emergency

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ENCLOSURE 5.2
TWO-HOUR RELATIVE CONCENTRATION FACTORS(C_H)

Temperature Gradient (C)	Stability Class	Distance (miles)										
		.5	1	2	3	4	5	6	7	8	9	10
1) $\Delta T < -0.6$	A	1.4E-5	1.2E-6	5.9E-7	4.1E-7	3.2E-7	2.5E-7	2.0E-7	1.9E-7	1.8E-7	1.6E-7	1.5E-7
2) $-0.6 \leq \Delta T < -0.5$	C	1.5E-4	4.5E-5	1.3E-5	6.3E-6	3.9E-6	2.7E-6	1.9E-6	1.4E-6	1.1E-6	8.3E-7	7.8E-7
3) $-0.5 \leq \Delta T < -0.2$	D	3.8E-4	1.4E-4	4.9E-5	2.7E-5	1.7E-5	1.2E-5	9.2E-6	7.3E-6	6.0E-6	5.0E-6	4.3E-6
4) $-0.2 \leq \Delta T < +0.4$	E	6.9E-4	2.5E-4	9.6E-5	5.5E-5	3.5E-5	2.5E-5	2.0E-5	1.6E-5	1.3E-5	1.1E-5	9.7E-6
5) $+0.4 \leq \Delta T < +1.2$	F	1.1E-3	5.1E-4	2.0E-4	1.2E-4	8.2E-5	6.3E-5	5.1E-5	4.3E-5	3.8E-5	3.3E-5	3.0E-5
6) $+1.2 \leq \Delta T$	G	1.8E-3	1.1E-3	4.3E-4	2.7E-4	2.0E-4	1.7E-4	1.3E-4	1.2E-4	8.6E-5	7.8E-5	7.3E-5

NOTE: If ΔT is unavailable use: 1000-1600 hours Use Stability Class D

1600-1000 hours Use Stability Class G

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EDA-2
ENCLOSURE 5.3
PROTECTIVE ACTION ZONES DETERMINATION

Determine the affected zones (based on wind direction) from the table below and record on Enclosure 5.1.

NOTE: If wind speed is less than or equal to 5 mph, the affected zones for 0-5 miles shall be A0, A1, B1, C1, D1, E1, F1.

Wind Direction (degrees from North)	PAZ's 0-5 miles	PAZ's 5-10 miles
0.0 - 22	A0, C1, D1	C2, D2
22.1 - 73	A0, C1, D1, E1	C2, D2, E2, F2
73.1 - 108	A0, C1, D1, E1, F1	D2, E2, F2, F3
108.1 - 120	A0, D1, E1, F1	D2, E2, F2, F3
120.1 - 159	A0, E1, F1	D2, E2, F2, F3, A2
159.1 - 207	A0, E1, F1, A1	E2, F2, F3, A2, B2
207.1 - 247	A0, F1, A1, B1	F2, F3, A2, B2
247.1 - 265	A0, A1, B1	F3, A2, B2, A3, C2
265.1 - 298	A0, A1, B1, C1	A2, B2, A3, C2
298.1 - 338	A0, B1, C1	B2, A3, C2, D2
338.1 - 359.9	A0, B1, C1, D1	B2, C2, D2

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CATAWBA NUCLEAR STATION
EDA-2
ENCLOSURE 5.4
SOURCE TERM ASSESSMENT - STEAM RELIEF VALVES

Report # ________

Reactor Trip ______/______ (Date/Time)   Projection based on data on ______/______ (Date/Time)

Calculations based on ______ Melted Core ______ LOCA

NOBLE GAS

based on EMF26 or EMF10

$$\_\_\_\_\ \text{R/hr} \times \left[\frac{1}{\_\_\_\ \text{sec}}\right] \times \_\_\_\_\ \text{lbm} \times \_\_\_\_\ \frac{\text{Ci}}{\text{lbm R/hr}} = \_\_\_\_\ \frac{\text{Ci}}{\text{sec}}$$

(SG_{NG} (Encl. 5.5))

based on EMF27 or EMF11

$$\_\_\_\_\ \text{R/hr} \times \left[\frac{1}{\_\_\_\ \text{sec}}\right] \times \_\_\_\_\ \text{lbm} \times \_\_\_\_\ \frac{\text{Ci}}{\text{lbm R/hr}} = \_\_\_\_\ \frac{\text{Ci}}{\text{sec}}$$

(Encl. 5.5)

based on EMF28 or EMF12

$$\_\_\_\_\ \text{R/hr} \times \left[\frac{1}{\_\_\_\ \text{sec}}\right] \times \_\_\_\_\ \text{lbm} \times \_\_\_\_\ \frac{\text{Ci}}{\text{lbm R/hr}} = \_\_\_\_\ \frac{\text{Ci}}{\text{sec}}$$

(Encl. 5.5)

based on EMF29 or EMF13

$$\_\_\_\_\ \text{R/hr} \times \left[\frac{1}{\_\_\_\ \text{sec}}\right] \times \_\_\_\_\ \text{lbm} \times \_\_\_\_\ \frac{\text{Ci}}{\text{lbm R/hr}} = \_\_\_\_\ \frac{\text{Ci}}{\text{sec}}$$

(Encl. 5.5)

Total from all Steam Relief Valves, Q_{NG} = ________ Ci/sec

IODINE

From all Steam Relief valves

Q_{NG} x ______ I131 eqv./Xe 133 eqv. ratio (Encl. 5.6) = ____________ Ci/sec (Q_I)

☐ Emergency   ☐ Drill   Prepared by: ________

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EDA-2
ENCLOSURE 5.5
EMF26, EMF27, EMF28, EMF29 or
EMF10, EMF11, EMF12, EMF13 NOBLE GAS CORRECTION FACTOR

Time Since Trip (hrs)	Correction Factor based on Melted Core or LOCA
≥0	3.622
≥2	3.971
≥4	4.041
≥8	4.029
≥24	3.332
≥48	2.647
≥100	2.438
≥250	2.438
≥500	2.438
≥720	2.438

* units in $\frac{\text{Ci}}{\text{lbm R/hr}}$

* Enclosure 5.5 is the correlation factor per Reference 2.13 x
$2.83E4 \frac{\text{ml}}{\text{ft}^3} \times .41 \frac{\text{ft}^3}{\text{lbm}} \times \frac{\text{m}^3}{\text{1E6 ml}}$

.41 = specific gravity of steam per Reference 2.13.

DUKE POWER COMPANY
CATAWBA NUCLEAR STATION
EDA-2
ENCLOSURE 5.6
I131 eqv./Xe133 eqv. RATIO

Time Since Trip (hrs)	Ratio based on LOCA (Column 1)	Ratio based on Melted Core (Column 2)
≥0	2.74E-3	2.24E-3
≥2	3.42E-3	9.66E-3
≥4	3.82E-3	1.59E-2
≥8	4.34E-3	2.85E-2
≥24	4.79E-3	7.52E-2
≥48	4.84E-3	1.11E-1
≥100	5.06E-3	1.33E-1
≥250	6.55E-3	1.80E-1
≥500	1.02E-2	2.90E-1
≥720	1.44E-2	4.33E-1

* Enclosure 5.6 is from Reference 2.13.

NOTE: For unit vent releases in which Irat is utilized to determine I-131 equiv. concentration, apply the appropriate correction from the table below:

1. LOCA, use column 1 (based on LOCA).
2. LOCA through charcoal filters, divide column 1 value by 100.
3. Core damage, use column 2 (based on Core Melt).
4. Core damage through charcoal filters, divide column 2 value by 100.
5. Tube rupture, use 1.44E-5
6. New fuel accident, use 2.217E-4
7. Old fuel accident, use 7.217E-4
8. Gas decay tank, assume no radioiodine released, only noble gases are considered to be released from gas tank, use 0.

NOTE: For steam releases in which Irat is utilized to determine I-131 equiv. concentration, apply the appropriate correction from the table below:

1. LOCA divide column 1 value by 100.
2. Core damage, divide column 2 value by 100.

DUKE POWER COMPANY
CATAWBA NUCLEAR STATION
EDA-2
ENCLOSURE 5.7
SOURCE TERM ASSESSMENT - CONTAINMENT

Report # ______________

Reactor Trip ________/________ (Date/Time)

Projection based on data on ______/______ (Date/Time)

Calculations based on ______Melted Core ________LOCA

Containment pressure ________psig

LR = ________ml/hr x BYPASS ______ (default = .07)

LR based on _____ Realistic Leak Rate
(check one)

____ 1" 2" 4" 6" 8" 12" 18" 34" diameter opening
(circle one) Personnel Hatch opening
Equipment Hatch opening

____ Design Leak Rate (2.449E6)

NOBLE GAS

based on (check one)

☐ EMF39(L) if < 1E7 cpm ☐ EMF39(H) if > 100 cpm ☐ EMF53 if 39(H) is off scale

EMF			CF		LR		Q_{NG}
________	cpm or R/hr	x	________ (Encl. 5.8)	x	_______ml/hr	=	________ $\frac{Ci}{sec}$

(Note on Encl. 5.9)

based on
PACS sample

________ µCi/ml x 2.78E-10 $\frac{Ci\ hr}{sec\ \mu Ci}$ x ________ml/hr = ________ $\frac{Ci}{sec}$

IODINE

based on
Q_{NG} Q_I

________ $\frac{Ci}{sec}$ x ________ I131 eqv./Xe133 eqv. ratio (Encl. 5.6) = ________ $\frac{Ci}{sec}$

based on EMF40 LR

$\frac{\_\_\_\_\_\ \Delta cpm}{\_\_\_\_\_\ \Delta min}$ x 9.82E-20 $\frac{Ci\ hr\ min}{sec\ ml\ cpm}$ x ________ml/hr = ________ $\frac{Ci}{sec}$

based on PACS sample

________ $\frac{\mu Ci}{ml}$ x 2.78E-10 $\frac{Ci\ hr}{sec\ \mu Ci}$ x ________ml/hr = ________ $\frac{Ci}{sec}$

☐ Emergency ☐ Drill Prepared by: ______________

DUKE POWER COMPANY
ENCLOSURE 5.8
CATAWBA CONTAINMENT NOBLE GAS CORRECTION FACTOR

Time Since Trip (hours)	EMF 39(L) based on		EMF 39(H) based on		EMF 53 based on	
	LOCA	Melted Core	LOCA	Melted Core	LOCA	Melted Core
≥0	6.389E-18	6.672E-17	5.56E-14	1.429E-13	3.781E-10	1.190E-9
≥2	6.389E-18	4.448E-17	5.56E-14	1.003E-13	3.114E-10	5.894E-10
≥4	6.389E-18	3.058E-17	5.56E-14	1.232E-13	2.780E-10	4.726E-10
≥8	6.389E-18	2.113E-17	5.56E-14	1.195E-13	2.446E-10	3.392E-10
≥24	6.389E-18	1.112E-17	5.56E-14	7.339E-14	2.335E-10	1.890E-10
≥48	6.389E-18	1.056E-17	5.56E-14	6.060E-14	2.335E-10	1.668E-10
≥100	6.389E-18	1.390E-17	5.56E-14	5.699E-14	2.335E-10	1.612E-10
≥250	6.389E-18	1.446E-17	5.56E-14	5.588E-14	2.335E-10	1.557E-10
≥500	6.389E-18	9.730E-18	5.56E-14	5.560E-14	2.335E-10	1.251E-10
≥720	6.389E-18	6.394E-18	5.56E-14	5.560E-14	2.335E-10	1.056E-10
	Units in $\frac{Ci\ hr}{sec\ ml\ cpm}$		units in $\frac{Ci\ hr}{sec\ ml\ cpm}$		units in $\frac{Ci\ hr}{sec\ ml\ R/hr}$	

Enclosure 5.8 is the correlation factor per Reference 2.13 x $\frac{hr}{3600\ sec}$ x $\frac{Ci}{1E6\ \mu Ci}$

<u>NOTE</u>: Reference 2.14

Case I) If from 0-2 days since reactor trip, use EMF53A or EMF53B reading as is.

Case II) If after 2 days since reactor trip and EMF53A or EMF53B is ≤150 R/hr, add 150 R/hr to the reading.

DUKE POWER COMPANY
CATAWBA NUCLEAR STATION
EDA-2
ENCLOSURE 5.9
CONTAINMENT LEAKAGE RATE VERSUS PRESSURE

PSIG	ml/hr
≥ 0	*2.081E5
≥ 2	4.536E5
≥ 4	8.316E5
≥ 8	1.397E6
≥ 10	1.591E6
≥ 11	1.663E6
≥ 12	1.713E6
≥ 13	1.764E6
≥ 14	1.800E6
≥ 15	1.836E6

Enclosure 5.9 is the realistic leakage rate (m^3/sec) per Reference 2.12 x 1E6 ml/m^3 x 3600 sec/hr.

* 2.081E5 ml/hr is derived as follows:

$$2.081E5 \frac{ml}{hr} = 0.017 \text{ \%/day} \times 3.4E-3 \frac{m^3\text{-day}}{\text{\%-sec}} \times 1E6 \frac{ml}{m^3} \times 3600 \frac{sec}{hr}$$

where:

0.017 is determined from containment leakage rate vs pressure curve from Reference 2.13 for an assumed 1 psig. 3.4E-3 is from Reference 2.12.

DUKE POWER COMPANY
CATAWBA NUCLEAR STATION
EDA-2

ENCLOSURE 5.10
CONTAINMENT LEAKAGE RATE VERSUS PRESSURE AND SIZE OPENING

For 1" opening

PSIG	ml/hr	PSIG	ml/hr	PSIG	ml/hr
>1.25	2.209E8	>5.0	3.908E8	>12.5	5.862E8
>2.50	2.889E8	>7.5	4.588E8	>15.0	6.287E8
>3.75	3.483E8	>10.0	5.268E8		

For 2" opening

PSIG	ml/hr	PSIG	ml/hr	PSIG	ml/hr
>1.25	8.496E8	>5.0	1.512E9	>12.5	2.243E9
>2.50	1.121E9	>7.5	1.784E9	>15.0	2.464E9
>3.75	1.342E9	>10.0	2.022E9		

For 4" opening

PSIG	ml/hr	PSIG	ml/hr	PSIG	ml/hr
>1.25	3.144E9	>5.0	5.692E9	>12.5	8.496E9
>2.50	4.248E9	>7.5	6.797E9	>15.0	9.176E9
>3.75	5.098E9	>10.0	7.731E9		

For 6" opening

PSIG	ml/hr	PSIG	ml/hr	PSIG	ml/hr
>1.25	7.137E9	>5.0	1.291E10	>12.5	1.937E10
>2.50	9.516E9	>7.5	1.529E10	>15.0	2.124E10
>3.75	1.138E10	>10.0	1.716E10		

For 8" opening

PSIG	ml/hr	PSIG	ml/hr	PSIG	ml/hr
>1.25	1.257E10	>5.0	2.243E10	>12.5	3.381E10
>2.50	1.648E10	>7.5	2.634E10	>15.0	3.568E10
>3.75	1.971E10	>10.0	3.042E10		

For 12" opening

PSIG	ml/hr	PSIG	ml/hr	PSIG	ml/hr
>1.25	2.719E10	>5.0	5.012E10	>12.5	7.476E10
>2.50	3.738E10	>7.5	5.947E10	>15.0	8.156E10
>3.75	4.452E10	>10.0	6.712E10		

For 18" opening

PSIG	ml/hr	PSIG	ml/hr	PSIG	ml/hr
>1.25	5.522E10	>5.0	1.003E11	>12.5	1.529E11
>2.50	7.476E10	>7.5	1.189E11	>15.0	1.665E11
>3.75	8.836E10	>10.0	1.351E11		

For 34" opening

PSIG	ml/hr	PSIG	ml/hr	PSIG	ml/hr
>1.25	1.869E11	>5.0	3.398E11	>12.5	5.132E11
>2.50	2.583E11	>7.5	4.078E11	>15.0	5.607E11
>3.75	3.093E11	>10.0	4.588E11		

For Personnel Hatch opening

PSIG	ml/hr	PSIG	ml/hr	PSIG	ml/hr
>1.25	2.379E12	>5.0	4.690E12	>12.5	6.967E12
>2.50	3.398E12	>7.5	5.573E12	>15.0	7.646E12
>3.75	4.111E12	>10.0	6.372E12		

For Equipment Hatch opening

PSIG	ml/hr	PSIG	ml/hr	PSIG	ml/hr
>1.25	1.121E13	>5.0	2.022E13	>12.5	3.059E13
>2.50	1.478E13	>7.5	2.379E13	>15.0	3.398E13
>3.75	1.767E13	>10.0	2.719E13		

* Enclosure 5.10 is the containment leakage for an opening size in standard cubic feet per min (scfm) x 2.83E4 ml/ft^3 x 60 min/hr.

DUKE POWER COMPANY
CATAWBA NUCLEAR STATION
EDA-2
ENCLOSURE 5.11
SOURCE TERM ASSESSMENT - UNIT VENT

Report # ______________

Reactor Trip ________/________ (Date/Time)   Projection based on data on ______/______ (Date/Time)

Calculations based on ______ Melted Core ________ LOCA

CFM = ____________ ft^3/min

NOBLE GAS

based on (check one)

☐ EMF36(L) if < 1E7 cpm   ☐ EMF36(H) if > 100 cpm   ☐ EMF54 if 36(H) is offscale

EMF   CF   CFM Q_{NG}

________ cpm or R/hr x $\underset{\text{(Encl. 5.12}}{\underline{\hspace{3cm}}}$ x ____________ $\frac{ft^3}{min}$ = ____________ $\frac{Ci}{sec}$

based on Unit Vent Sample

________ μCi/ml x 4.72E-4 $\frac{Ci\ min\ ml}{sec\ ft^3\ \mu Ci}$ x ________ $\frac{ft^3}{min}$ = ____________ $\frac{Ci}{sec}$

IODINE

based on

Q_{NG} Q_I

________ $\frac{Ci}{sec}$ x ____________ I131 eqv./Xe133 eqv. ratio (Encl. 5.6) = ________ $\frac{Ci}{sec}$

based on
EMF37   CFM

$\frac{\_\_\_\_\_\_}{\_\_\_\_\_\_}$ $\frac{\Delta cpm}{\Delta min}$ x 1.33E-13 $\frac{Ci\ min\ min}{sec\ ft^3\ cpm}$ x ________ $\frac{ft^3}{min}$ = ________ $\frac{Ci}{sec}$

based on Unit Vent Sample

_____ μCi/ml x 4.72E-4 $\frac{Ci\ min\ ml}{sec\ ft^3\ \mu Ci}$ x ________ $\frac{ft^3}{min}$ = ________ $\frac{Ci}{sec}$

☐ Emergency   ☐ Drill   Prepared by: ______________

DUKE POWER COMPANY
ENCLOSURE 5.12
CATAWBA UNIT VENT NOBLE GAS CORRECTION FACTOR

Time Since Trip (hours)	EMF36(L) based on Melted Core	EMF36(H) based on Melted Core	EMF54 based on Melted Core
≥0	1.133E-10	2.426E-7	1.887E-3
≥2	7.552E-11	1.704E-7	1.179E-3
≥4	5.192E-11	2.091E-7	9.905E-4
≥8	3.587E-11	2.030E-7	6.367E-4
≥24	1.888E-11	1.246E-7	2.931E-4
≥48	1.794E-11	1.029E-7	2.405E-4
≥100	2.360E-11	9.676E-8	2.358E-4
≥250	2.454E-11	9.487E-8	2.358E-4
≥500	1.652E-11	9.440E-8	2.358E-4
≥720	1.086E-11	9.440E-8	2.358E-4

If accident is:

1. Melted core use table.
2. Melted core through charcoal use table.
3. New Fuel Accident (less than 100 days old) use 2.358E-11 for EMF36(L), use 9.67E-8 for EMF36(H), use 2.358E-4 for EMF54.
4. All other accidents use 1.086E-11 for EMF36(L), use 9.44E-8 for EMF36(H), use 2.358E-4 for EMF54.

Units in $\frac{\text{Ci min}}{\text{sec ft}^3\text{ cpm}}$ units in $\frac{\text{Ci min}}{\text{sec ft}^3\text{ cpm}}$ units in $\frac{\text{Ci min}}{\text{sec ft}^3\text{ R/hr}}$

Enclosure 5.12 is the correlation factor per Reference 2.13 x 2.83E4 $\frac{\text{ml}}{\text{ft}^3} \times \frac{\text{min}}{\text{60 sec}} \times \frac{\text{Ci}}{\text{1E6 }\mu\text{Ci}}$