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DUKE POWER COMPANY

EMERGENCY DOSE ASSESSMENT MANUAL

March 18, 1991

EMERGENCY DOSE ASSESSMENT MANUAL
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"Off-Site Dose Projections for Catawba Nuclear Station"

R E Harris
Approved By

3/30/90
Date

Rev. 5
March 30, 1990

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 = 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 an 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. Use survey meter reading (Reference 2.2) if 53A and 53B are not available.

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

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);

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

where:

ΔCPM = reading from EMF40 Delta Counts
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 x CF x LR

where;

PACS = (μCi/ml) (Reference 2.4)

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

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 x CF x 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 or compressor tripped.
CF = correction 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} = Unit Vent Sample x CF x CFM

where:

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

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

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 Delta Counts
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 or Class A computer printout)

4.5.1 On Item 1, record if this information is for a drill or real emergency.

4.5.2 On Item 4, record which unit is affected.

4.5.3 On Item 9:

4.5.3.1 If normal plant conditions exist, circle A. N/A Items 10 through 13. Go to step 4.5.8.

4.5.3.2 If an emergency event is occurring and releases are less than operational limits and:

4.5.3.2.1 Containment pressure is less than 1 psig, circle B or,

4.5.3.2.2 Containment pressure is greater than or equal to 1 psig with increased reactor building activity or steam generator tube leak exists or increased unit vent activity exists or field teams report activity, circle E, but do not provide dose calculations to state/counties.

4.5.3.3 If an emergency event is occurring and releases are greater than operational limits, circle C if releases are occurring or D if they have already occurred.

4.5.4 On Item 10, record what type of release has occurred.

4.5.5 On Item 11, record the noble gas and iodine release rates (curies per second) from all releases.

4.5.5.1 If available, record the highest iodine/xenon ratio.

4.5.6 On Item 12, record the reactor status.

4.5.6.1 If the reactor has not tripped, use the data sheet date/time as the time of reactor trip. On the computer printout, cross out the shutdown time/date and record the % Power from the data sheet.

4.5.7 On Item 13, record the dose rates and the integrated doses.

4.5.7.1 If new doses were calculated, check the NEW block.

4.5.7.2 The duration is the total time of previous releases plus the time estimated for the projected release.

4.5.7.3 The integrated dose (mrem) is the total dose from all releases plus the dose from the projected release.

4.5.7.4 If information is available contradicting the calculated doses, change the data to reflect the new values.

4.5.7.5 On Enclosure 5.1:

4.5.7.5.1 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 $\frac{rem\ m^3}{hr\ Ci}$

4.5.7.5.2 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

4.5.7.5.3 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 $\frac{rem\ m^3}{hr\ Ci}$

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

Dct = DRct x 2 hr

where:

dose is integrated over 2 hour time period

4.5.8 On Item 14, record the meteorological data.

4.5.9 On Item 16, this section is for the TSC Dose Assessment Coordinator or the CMC off-Site Dose Assessment Director.

4.6 Protective Action Recommendations (Enclosure 5.1 or Class A computer printout):

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 to consider evacuating pregnant women and children and shelter all other PAZs (actions OTHER and B).

4.6.4 If the projected dose in a PAZ is > 5 rem whole body or > 25 rem thyroid, then recommend evacuate everyone and shelter all other PAZs (actions C and B).

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

5.13 Integrated Dose

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EDA-2
ENCLOSURE 5.1
METEOROLOGY, SOURCE TERM AND DOSE ASSESSMENT

EMERGENCY NOTIFICATION

1. THIS IS A(N) DRILL EMERGENCY

4. SITE: Catawba Unit_____

9. EMERGENCY INVOLVES:
   A. NO RELEASE (If A, go to 14.)
   B. POTENTIAL RELEASE
   C. A RELEASE IS OCCURRING: Started__________ Expected Duration________
   D. A RELEASE HAS OCCURRED: Started__________ Stopped_________________
   E. THE RELEASE IS WITHIN NORMAL OPERATIONAL LIMITS

10. TYPE OF RELEASE: GROUND LEVEL
   A. RADIOACTIVE GASES
   B. RADIOACTIVE LIQUIDS
   C. RADIOACTIVE PARTICULATES
   D. OTHER__________________

11. RELEASE: CURIES PER SEC.
   A. NOBLE GASES__________
   C. IODINES________________
   B. IODINE/NOBLE GAS RATIO (If available)__________
   OTHER____

12. REACTOR STATUS:
   A. SHUTDOWN: TIME/DATE__________ (EASTERN) __/__/__ MM/DD/YY
   B. ________%POWER

13. ESTIMATE OF PROJECTED OFFSITE DOSE:
   _____NEW ______UNCHANGED DURATION: _____HRS.

Distance	Whole Body DOSE RATE mrem/hr	Child Thyroid DOSE RATE mrem/hr	Whole Body mrem	Child Thyroid mrem
Site Boundary	________	________	________	________
2 miles	________	________	________	________
5 miles	________	________	________	________
10 miles	________	________	________	________

14. METEROLOGICAL DATA: ______NOT AVAILABLE
   A. WIND DIRECTION (from) _____degrees
   B. WIND SPEED (mph) _____
   C. STABILITY CLASS_____
   D. PRECIPITATION (type)_____

15. RECOMMENDED PROTECTIVE ACTIONS:
   A. NO RECOMMENDED PROTECTIVE ACTIONS
   B. SHELTER A0 B1 E1 A1 C1 D1 F1 B2 A2 C2 D2 E2 F2 F3 A3
   C. EVACUATE A0 B1 E1 1A C1 D1 F1 B2 A2 C2 D2 E2 F2 F3 A3
   D. OTHER____

16. APPROVED BY:______________________ (NAME) ____________________ (TITLE)
   TIME/DATE:__________/____/____/____
   (EASTERN) mm dd yy

<u>NOTES</u>: 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.

Projection based on data on ___/___/____ Time since trip_______hrs.

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

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

2 hr Dose (rem) = 2 x DRwb (rem/hr) = 33.6 x TQ_{NG} (Ci/sec) x $\overline{X/Q}$ (sec/m³) 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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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	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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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

SG_{NG}

________ R/hr x $\left[\frac{1}{\_\_\_\_ sec}\right]$ x ________lbm x ________ $\frac{Ci}{lbm\ R/hr}$ (Encl. 5.5) = ________ $\frac{Ci}{sec}$

based on EMF27 or EMF11

________ R/hr x $\left[\frac{1}{\_\_\_\_ sec}\right]$ x ________lbm x ________ $\frac{Ci}{lbm\ R/hr}$ (Encl. 5.5) = ________ $\frac{Ci}{sec}$

based on EMF28 or EMF12

________ R/hr x $\left[\frac{1}{\_\_\_\_ sec}\right]$ x ________lbm x ________ $\frac{Ci}{lbm\ R/hr}$ (Encl. 5.5) = ________ $\frac{Ci}{sec}$

based on EMF29 or EMF13

________ R/hr x $\left[\frac{1}{\_\_\_\_ sec}\right]$ x ________lbm x ________ $\frac{Ci}{lbm\ R/hr}$ (Encl. 5.5) = ________ $\frac{Ci}{sec}$

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

IODINE

From all Steam Relief valves

Q_I

Q_{NG} x _______ I131 eqv./Xe 133 eqv. ratio (Encl. 5.6) = ________________ Ci/sec

□ Emergency   □ Drill   Prepared by: ____________

DUKE POWER COMPANY
CATAWBA NUCLEAR STATION
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 $\frac{Ci}{lbm\ R/hr}$

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

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

(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}

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

based on EMF40

$\frac{\_\_\_\_\_\_\Delta CPM}{\_\_\_\_\_\_\Delta min}$ x 9.82E-20 $\frac{Ci\ hr\ min}{sec\ ml\ cpm}$ x LR _________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 Core	LOCA	Melted
≥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 $\frac{\text{Ci hr}}{\text{sec ml cpm}}$ units in $\frac{\text{Ci hr}}{\text{sec ml cpm}}$ units in $\frac{\text{Ci hr}}{\text{sec ml R/hr}}$

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

NOTE: Reference 2.14.

If Time Since Trip is > 48 hours and EMF53A or EMF53B is less than or equal to 150 R/hr, add 150 R/hr to 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:

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

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" diameter 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" diameter 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" diameter 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" diameter 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" diameter 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" diameter 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" diameter 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" diameter 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 ________ (Encl. 5.12) 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 $\frac{\text{ml}}{\text{ft}^3} \times \frac{\text{min}}{\text{60 sec}} \times \frac{\text{Ci}}{\text{1E6 }\mu\text{Ci}}$

DUKE POWER COMPANY
CATAWBA NUCLEAR STATION
EDA-2
ENCLOSURE 5.13
INTEGRATED DOSE

Duration (hrs)										
A0										
B1										
E1										
A1										
C1										
D1										
F1										
B2										
A2										
C2										
D2										
E2										
F2										
F3										
A3										

Instructions:

1) Add the doses from previous releases to the projected release.

2) Add the times of releases to the time of the projected release.