PRAIRIE ISLAND NUCLEAR GENERATING PLANT NORTHERN STATES POWER COMPANY	EMERGENCY PLAN IMPLEMENTING PROCEDURES Number: TABLE OF CONTENTS Rev: 17 History Copy Retention Time: Lifetime
Reviewed By: D.A. Schultke Supt. Rad Protection 12-9-82	TITLE: EMERGENCY PLAN IMPLEMENTING PROCEDURES TABLE OF CONTENTS

PRAIRIE ISLAND NUCLEAR GENERATING PLANT NORTHERN STATES POWER COMPANY	EMERGENCY PLAN IMPLEMENTING PROCEDURES Number: F3-17 Rev: 1 Retention Time: History Copy Lifetime
Reviewed By: D.A Schuelke Supt. Rad Protection Approved By: [signature] Plant Manager OC Date: 12-10-83	TITLE: CORE DAMAGE ASSESSMENT

1.0 PURPOSE

The purpose of this procedure is to provide a means to best estimate the degree of reactor core damage from the measured fission product concentrations in water and gas samples taken from the primary system and containment under accident conditions.

2.0 APPLICABILITY

This procedure shall apply to the Nuclear Engineering Staff.

3.0 PRECAUTIONS

3.1 The numbers obtained using this procedure are at best, estimates only.

3.2 Whem making core damage calculations as per this procedure, considerations should be given to other plant indicators, for example:

(1) Incore Thermocouples
(2) Containment Radiation Monitors
(3) Hydrogen Concentration in the RCS And/Or Containment Atmosphere
(4) Radioisotopic Analysis

3.3 All formulas in this procedure are based upon equilibrium full power core isotopes. If fuel damage is suspected to have occurred during times of reduced power or near the time of a significant power change, the core nuclide inventory must be compensated accordingly.

3.4 Iodine spiking may occur after a shutdown or significant power change, usually during the 2 to 6 hour period following the power change. Do not misinterpret this change for fuel damage if there are no other fuel damage indications.

3.5 Chemistry samples should be taken as soon as fuel damage is suspected. All samples should be decay corrected back to the estimated time of fuel damage, or to a specified time, e.g. sample time.

4.0 GENERAL DISCUSSION

This procedure address two levels of core damage. The first level is a rupture of the fuel rod cladding (gap release) and the second is a failure of all or part of the fuel rod due to oxidation of the zirconium clad. Fisison products and actinides, contained in the reactor core, can be divided into typical release groups, based on the ease with which they are volatilized. One such grouping, in order of decreasing volatility is:

I	Noble gases (Kr, Xe)
II	Halogens (I, Br)
III	Alkali metals (Cs, Rb)
IV	Tellurium (Te)
V	Alkaline earths (Sr, Ba)
VI	Noble metals (Ru, Rh, Pd, Mo, Tc)
VII	Rare earths and actinides
VIII	Refractory oxides of Zr and Nb

The most volatile, the noble gases and to a lesser extent, the halogens are gaseous at room temperatures and can readily diffuse through the fuel pellet to collect in the gap. any clad perforation or rupture can release these fission products to the coolant.

The release of Cesium (Group III) is variable and not as well predictable. However, in order to have large releases of cesiums, it is believed overheating of the fuel would have to occur, i.e., temperatures greater than 2370°F.

At even higher temperatures (5200°F), liquefaction or melting of the fuel would occur, thus releasing other fission products, such as tellurium and ruthenium. Under oxidizing conditions, however, some tellurium and ruthenium may be released even before melt occurs. Therefore, the presence of tellurium and ruthenium does not prove that melt has occurred, but the absence of them is a good indicator that melt has not occurred.

5.0 PROCEDURE

5.1 As soon as core damage is suspected, request the Radiation Protection Group to obtain and analyze an RCS sample.

> NOTE: A complete isotopic analysis should be performed. The sample analysis should be decay corrected back to the estimated time of core damage or to a specific time, e.g. sample time.

5.2 Obtain the power history for the affected unit fcr the last 30 days.

5.3 All calculations as per this procedure are based upon equilibrium full power core radiosotopes. If fuel damaged is suspected to have occurred during times of reduced power or near the time of a significant power change, the core radioisotope inventory must be compensated according to Figure 1. This is the core nuclide correction factor, CNCF.

> NOTE: The core nuclide correction factor need only be completed for I-131 and Xe-133. Changes to the equilibrium full power core Cs-137 value will be negligible due to the long half life.

5.4 Calculate the best estimate of the number of failed fuel pins as follows:

$$\text{NO. FAILED PINS} = \frac{\text{COOLANT ACTIVITY(uCi/ml)xCOOLANT VOLUME (ml)}}{\text{NUCLIDE INVENTORY(uCi)xCNCFxESCAPE FACTION}} \text{x2.1659E4} \; \frac{\text{PINS}}{\text{CORE}}$$

Where: Coolant Activity in uCi/ml may be either of the following isotopes: I-131
Xe-133
Cs-137

Coolant Volume is in ml. RCS Volume = 45,000 Gallons or 45,000 Gal.x 3.785E3 ml/gal=1.703E8 ml.

Nuclide Inventory in uCi. This is equilibrium full power core nuclide inventory, obtained from Figure 2.

CNCF = Core Nuclide correction factor as determined by Figure 1.

Escape fraction = Total gap release value from Figure 3.

> NOTE: (1) If the coolant activity is based on an RCS sample while the RWST is injecting and prior to recirc., dilution of the coolant activity should be considered.
>
> (2) If long term recirculation has been established, assume a uniform activity in the RCS and containment sumps. The volume now must include the RCS plus the RWST.
>
> (3) For LOCA conditions, assume the liquid contains the iodine and cesium and the containment air contains the Xenon.
>
> (4) RWST = 3949 Gal/Ft or 2922 Gal./%
> Free Containment Volume at 14.7 PSIA = 3.91E10 CC.
> Corrected Containment Volume = $\frac{(14.7+\text{INITIAL PRESSURE})}{14.7}$ (3.91E10)cc

5.5 Calculate the best estimate of the fraction of fuel melt that may have occurred as follows:

$$\text{FRACTION FUEL MELT} = \frac{\text{COOLANT ACTIVITY(uCi/ml)} \times \text{COOLANT VOLUME (ml)}}{\text{NUCLIDE INVENTORY(uCi)} \times \text{CNCF} \times \text{ESCAPE FRACTION}}$$

Where: Coolant Activity in uCi/ml may be either of the following isotopes: I-131
Xe-133
Cs-137

Coolant Volume is in ml. RCS Volume = 45,000 gallons or 45,000 Gal.x3.785E3 ml/Gal= 1.703E8 ml.

Nuclide inventory in uCi. This is Equilibrium full power core nuclide inventory, obtained from Figure 2.

CNCF = Core Nuclide correction factor as determined by Figure 1.

Escape fraction = listed in Figure 4.

NOTE: (1) If the coolant acvitity is based on an RCS sample while the RWST is injecting and prior to Recirc., dilution of the coolant activity should be considered.

(2) If long term recirculation has been established, assume a uniform activity in the RCS and containment sumps. The volume now must include the RCS plus the RWST.

(3) For LOCA conditions, assume the liquid contains the iodine and cesium and the containment air contains the Xenon.

(4) RWST=3949 Gal/Ft or 2922 Gal./%
Free Containment Volume at 14.7 PSIA = 3.91E10CC.
Corrected Containment Volume =
$$\frac{(14.7+\text{INITIAL PRESSURE})}{14.7}\,(3.91\text{E}10)\text{CC}$$

5.6 Compare other plant indications along with professional judgement to now establish the beat estimate of core damage.

(1) The containment Hi range dome monitors (calibrated to Xe-133 equivalent) should be used to estimate the extent of core damage and/or the containment activity, using Figure 5.

(2) Using the incore thermocouples, determine if fuel overheating/melt may have occurred. Elevated fuel temperatures (>2370°F), may release reasonably large quantities of cesium. At even higher temperatures, (5200°F) liquefaction or melting of fuel may occur, with release of isotopes such as tellurium and ruthenium. The presence of tellurium and ruthenium does not prove that melt has occurred, since under some conditions, these isotopes can also be released before melt, however, the absence of them is a good indicator that melt has not occurred.

(3) Loss of subooling margin should be indicative of saturation conditions in the core and core uncovering.

(4) The RCS and the containment atmosphere hydrogen concentrations should be check, which would indicate zirconium degradation.

5.7 If any discrepencies occur between calculations and other plant indicators, recheck both the indications and calculations.

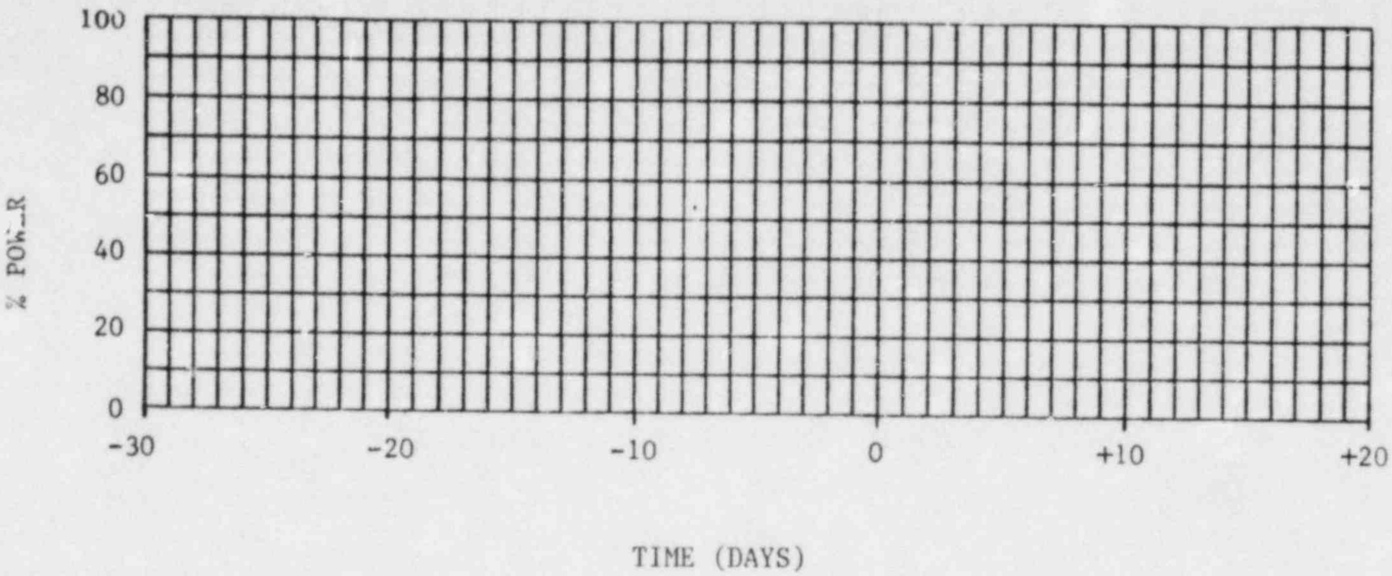
6.0 REFERENCES

6.1 WASH-1400, APPENDIX VII

FIGURE 1

CORE NUCLIDE CORRECTION FACTOR DETERMINATION

(1) PLOT POWER HISTORY FOR PREVIOUS 30 DAYS TO TIME OF ESTIMATED CORE DAMAGE



NOTE: Power reductions and return to power levels which occur in less than 24 hours should be ignored. Assume an average power level for these calculations.

(2) To correct for core radioisotope inventory if fuel damage is suspected to have occurred during times of any power level (except 0%) where the power level has not changed by greater than ±10% within the last 30 days, use the following core nuclide correction factor (CNCF):

$$CNCF = \frac{\%\ REACTOR\ POWER}{100\ \%}$$

(3) To correct for core radioisotope inventory when power changes have occurred (i.e. power history does not fit situation described in #2 above), perform the following:

NOTE: t= The median time to make a power change plus the time after the power change, in days.

NOTE: λ=Decay Constant For Particular Isotope in Days^{-1}

$\lambda_{I-131} = 0.0864$ Days^{-1}

$\lambda_{Xe-133} = 0.1315$ Days^{-1}

A. % POWER = ________%

Median Time For Power Change = ________HOURS

Time At New Power Level = ________HOURS

TOTAL TIME = ________HOURS÷24=_____DAYS

$(\%POWER)e^{-\lambda t} + (NEW\%POWER)(1-e^{-\lambda t})$ = __________%INVENTORY

B. % INVENTORY FROM ABOVE = __________%

Median Time For Power Change = ________HOURS

Time At New Power Level = ________HOURS

TOTAL TIME = ________HOURS÷24=_____DAYS

$(\%INVENTORY)e^{-\lambda t} + (NEW\%POWER)(1-e^{-\lambda t})$ = ________%INVENTORY

C. % INVENTORY FROM ABOVE = __________%

Median Time For Power Change = ________HOURS

Time At New Power Level = ________HOURS

TOTAL TIME = ________HOURS÷24=_____DAYS

$(\%INVENTORY)e^{-\lambda t} + (NEW\%POWER)(1-e^{-\lambda t})$ = ________%INVENTORY

D. CONTINUE AS ABOVE UNTIL %INVENTORY IS CALCUATED AT ESTIMATED TIME OF CORE DAMAGE.

E. CORE NUCLIDE CORRECTION FACTOR(CNCF) = $\dfrac{\text{\% INVENTORY AT TIME OF DAMAGE}}{100\%}$

FIGURE 2

TOTAL INVENTORY OF SELECTED RADIONUCLIDES IN THE NUCLEAR REACTOR

EQUILIBRIUM FULL POWER VALUES

RADIONUCLIDE	RADIOACTIVE INVENTORY SOURCE (curies)	HALF-LIFE (days)
Cobalt-58	4.04×10^{5}	71.0
Cobalt-60	1.48×10^{5}	1,920
Krypton-85	2.90×10^{5}	3,950
Krypton-85m	1.25×10^{7}	0.183
Krypton-87	2.45×10^{7}	0.0528
Krypton-88	3.53×10^{7}	0.117
Rubidium-86	1.37×10^{4}	18.7
Strontium-89	4.84×10^{7}	52.1
Strontium-90	1.93×10^{6}	11,030
Strontium-91	5.69×10^{7}	0.403
Yttrium-90	1.99×10^{6}	2.67
Yttrium-91	6.26×10^{7}	59.0
Zirconium-95	7.97×10^{7}	65.2
Nobium-95	7.97×10^{7}	35.0
Molybdenum-99	8.53×10^{7}	2.8
Technetium-99m	7.39×10^{7}	0.25
Ruthenium-103	5.69×10^{7}	39.5
Ruthenium-106	1.31×10^{7}	366
Tellurium-127	3.02×10^{6}	0.391
Tellurium-127m	5.69×10^{5}	109
Tellurium-129	1.59×10^{7}	0.048
Tellurium-129m	2.73×10^{6}	0.340
Tellurium-131m	6.83×10^{6}	1.25
Tellurium-132	6.26×10^{7}	3.25
Iodine-131	4.38×10^{7}	8.05
Iodine-132	6.26×10^{7}	0.0958
Iodine-133	8.53×10^{7}	0.875
Iodine-134	9.67×10^{7}	0.0366
Iodine-135	7.97×10^{7}	0.280
Xenon-133	8.53×10^{7}	5.28
Xenon-135	1.76×10^{7}	0.384
Cesium-134	3.87×10^{6}	750
Cesium-136	1.54×10^{6}	13.0
Cesium-137	2.45×10^{6}	11,000
Barium-140	8.53×10^{7}	12.8
Lanthanum-140	8.53×10^{7}	1.67
Cerium-141	7.97×10^{7}	32.3
Cerium-143	6.83×10^{7}	1.38
Cerium-144	4.38×10^{7}	284
Praseodymium-143	6.83×10^{7}	13.7

FIGURE 3

GAP RELEASE COMPONENT VALUES

FISSION PRODUCT SPECIES	GAP RELEASE FRACTION	GAP RELEASE FRACTION	TOTAL GAP RELEASE VALUE
Xe, Kr	0.03 [a]	1	0.03
I-Br	0.05[a]	1/3[c]	0.017
Cs, Rb	0.15[b]	1/3[c]	0.05
Sr, Ba	0.01[a]	10^{-4}(d)	0.000001
Te, Se, Sb	0.10[a]	10^{-3}(d)	0.0001
Others	-	-	Negligible[a]

(a) Values can be higher or lower by a factor of 4

(b) Value can be higher by a factor of 2 or lower by a factor of 4

(c) Values can be higher or lower by a factor of 3

(d) Values can be higher or lower by a factor of 100

(e) While no numerical value was developed for these various species, the number should not exceed that used for strontium-barium.

FIGURE 4

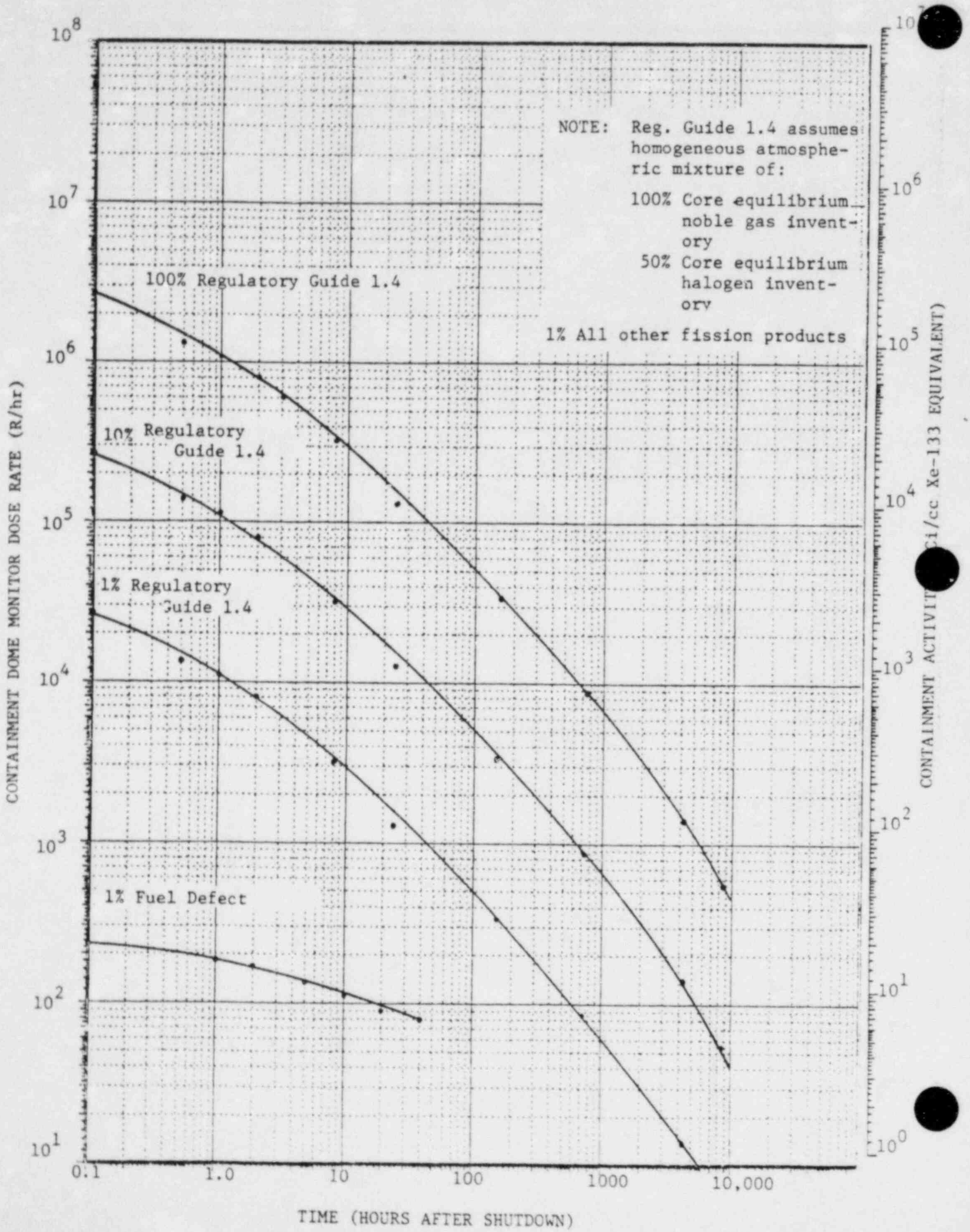
MELTDOWN RELEASE COMPONENT VALUES

ELEMENTS	RELEASE RANGE (PERCENT)	BEST ESTIMATE (PERCENT)
Xe, Kr	50-100	90
I, Br	50-100	90
Cs, Rb	40-90	80
Te[(a)]	5-25	15
Ba, Sr	2-20	10
Noble Metals [(b)]	1-10	3
Rare Earths [(c)]	.01-1	0.3
Zr, Nb	.01-1	0.3

(a) Includes Se, Sb
(b) Includes Ru, Rh, Pd, Mo, Tc
(c) Includes Y, La, Ce, Pr, Nd, Pm, Sm, Eu, Np, Pu

FIGURE 5

CONTAINMENT DOSE RATE VS TIME



PRAIRIE ISLAND NUCLEAR GENERATING PLANT NORTHERN STATES POWER COMPANY	EMERGENCY PLAN IMPLEMENTING PROCEDURES
	Number: F3-22 Rev: 2
	History Copy Retention Time: Lifetime
Reviewed By: D.A. Schuelke Supt. Rad Protection Approved By: [signature] Plant Manager OC Date: 12-10-82	TITLE: PRAIRIE ISLAND RADIATION PROTECTION GROUP RESPONSE TO A MONTICELLO EMERGENCY

1.0 PURPOSE

When an emergency occurs at Monticello resulting in a significant offsite release, the Prairie Island Radiation Protection Group SHALL be requested to respond with personnel and equipment to support the Monticello Radiation Protection Group. This support allows the Monticello personnel to concentrate their efforts in performing onsite sampling and monitoring and relieves them of the offsite monitoring requirements.

The purpose of this instruction is to describe the personnel, equipment, and procedures required to respond to a request for Radiation Protection assistance at Monticello.

2.0 APPLICABILITY

This instruction SHALL apply to Shift Supervisors, Supt Radiation Protection, and all Radiation Protection Group members.

3.0 PRECAUTIONS

3.1 Extra survey team kits are available at the Monticello EOF in case of equipment failure or if an additional field team is required to be activated.

3.2 Check operability of all portable radios and source check all meters prior to departing the Prairie Island plant site.

4.0 EQUIPMENT AND PERSONNEL REQUIRED

4.1 Two (2) offsite survey team sample kits.

4.2 Two (2) vehicles (NSP or personnel) for transport to Monticello.

4.3 Five (5) members of the Radiation Protection Group (four Radiation Protection Specialists and one person qualified to serve as the Radiation Protection Support Supervisor) are required to respond to a Monticello Emergency, to perform offsite surveys, and staff the Radiation Protection Support Supervisor position at the EOF.

4.4 Personnel TLD's and dosimeters.

5.0 PROCEDURE

5.1 When an emergency occurs at Monticello, the call for Radiation Protection Group assistance will be received in the Control Room by the Shift Supervisor.

(1) If the call for assistance occurs during normal working hours, the Shift Supervisor SHALL notify the Superintendent, Radiation Protection or his designee. The Superintendent, Radiation Protection or his designee SHALL direct the Radiation Protection Supervisor and/or Coordinators to mobilize a response team.

(2) If the call for assistance occurs during off-normal working hours, the Shift Supervisor SHALL contact the Superintendent, Radiation Protection or his designee at home. The Superintendent, Radiation Protection or his designee SHALL then request the Shift Supervisor to contact the members of the Radiation Protection Group, requesting four team members and one supervisory member (or as otherwise requested) to report to the plant site. (See the Prairie Island Radiation Protection Group Call List, Attachment A).

NOTE:	The Shift Supervisor may request the Shift Emergency Communicator to assist in notifying and activating the Radiation Protection Group to form a response team to Monticello.

5.2 All personnel requested to respond to the Monticello emergency SHALL assemble at the plant site to pick up to vehicles and equipment (as listed on Attachment B).

(1) Two (2) vehicles should be used to transport personnel to Monticello and to perform offsite surveys.

NOTE:	Other transportation arrangements may be made if necessary as long as all necessary equipment and personnel arrive at Monticello expeditiously.

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(2) Two (2) complete offsite survey team sample kits SHALL be taken to Monticello.

> NOTE: Response check all meters prior to departing the Prairie Island Plant site.

(3) Two (2) portable radios with mag-mount antennas.

> NOTE: Verify operability of the portable radios prior to departing the Prairie Island plant site.

5.3 The designated Radiation Protection Group members shall proceed to Monticello.

> NOTE: For reference to routes to Monticello and the location of the Monticello EOF, refer to the Minnesota road map and Monticello survey map, located in the field team survey kits.

5.4 When approaching the boundary of the Monticello 10 mile EPZ, attempt to contact the Monticello EOF using the portable radio. Identify yourself as the Prairie Island Survey teams.

5.5 If determined from the initial radio contact with the Monticello EOF that the plume may be encountered while enroute, conduct a search for the plume, in accordance with EPIP 1.1.10 and proceed directly to the EOF.

5.6 Upon arrival at the Monticello EOF, contact the Emergency Manager or his designee at the Nearsite EOF for further instructions.

5.7 Perform the required offsite surveys and dose assessment as required by the Emergency Manager in accordance with EPIP 1.1.10 "Offsite Surveys" and EPIP 1.1.11 "Accident Assessment."

> NOTE: All field sample analysis SHALL be performed in the EOF Count Room by Monticello Radiation Protection Specialists. If this facility becomes unavailable, make arrangements to transport the samples to the Monticello Plant Count Room (if available) or to Prairie Island.

5.8 Additional Prairie Island personnel should be augmented as soon as possible to supply short term 24 hour per day coverage (survey team positions and Radiation Protection Support Supervisor position).

> NOTE: Long term coverage for offsite survey teams shall be provided by contract Health Physics personnel. Arrangements for contract services will be handled by the Corporate Emergency Organization at the EOF.

5.9 Continue with all assigned duties until relieved by the Monticello Emergency Manager.

ATTACHMENT A

PRAIRIE ISLAND RADIATION PROTECTION GROUP

CALL LIST

> NOTE: All phone numbers for the Radiation Protection Group are programmed on the auto-dialers in the TSC.

Radiation Protection Support Supervisor (1 Required)

NAME

DELETED

Radiation Survey Team Members (4 Required)

NAME

DELETED

DELETED

DELETED

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ATTACHMENT B

MONTICELLO EMERGENCY SUPPORT

EQUIPMENT LIST

1. Personal TLD's and self-reading dosimeters (rezero)
2. Vehicles to be used for offsite monitoring purposes
3. Two (2) emergency survey team kits
4. Two (2) portable radios with mag-mount antennas