NSP

NORTHERN STATES POWER COMPANY

MINNEAPOLIS, MINNESOTA 55401

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Director of Nuclear Reactor Regulation
U S Nuclear Regulatory Commission
Washington, DC 20555

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
Docket Nos. 50-282 License Nos. DPR-42
50-306 DPR-60

Containment Purging During Fuel Handling Operations

In a letter dated January 3, 1979 from Mr A Schwencer, Chief, Operating Reactors Branch #1, Division of Operating Reactors, USNRC, it was stated that a detailed evaluation of the potential consequences of a postulated fuel handling accident inside containment at the Prairie Island Nuclear Generating Plant was submitted by NSP on May 21, 1977 and that the results of the analysis indicated that charcoal filtration was required to show acceptable consequences (i.e., less than 100 Rem thyroid dose).

Our evaluation of this event for Prairie Island was submitted on March 21, 1977. This evaluation conformed to the recommendations of Regulatory Guide 1.25 and showed the consequences of the event (using extremely conservative assumptions) to be less than 100 Rem thyroid dose. The evaluation assumed the high volume purge system was in operation at the time of the event. A copy of this evaluation is attached.

Based on our March 21, 1977 evaluation, we continue to believe further restrictions on purge system operation are unnecessary. Please contact us if you have further questions related to this issue. If the Staff's evaluation of this event differs from our own, we request that we be provided with specific details of their analysis.

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LOM/DMM/deh

cc J G Keppler
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Attachment

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Appendix A

Thyroid Dose Resulting from Postulated FHA
Inside Containment Using Conservative Assumptions
(Regulatory Guide 1.25)

I. Containment Purge System Design and Operation

The purge system is shown schematically in Figure A-1. There are two subsystems shown which will purge the containment atmosphere. Both subsystems are subject to isolation by the radiation monitors in the exhaust stack. The isolation scheme is designed for long term low level release considerations. The isolation setpoint for the gas monitors (2.13 x 10^{-3} u Ci/cc) would certainly be exceeded during the assumed FHA release. It is not designed for rapid isolation as would be necessary for a FHA postulated to produce a "puff" release; the release is sampled downstream of the isolation valves.

The low flow purge subsystem injects 4000 cfm of outside air into containment above the refueling floor. The air flows without ducting to a location below the refueling floor where it is ducted through isolation valves and through particulate, absolute and charcoal filters to the exhaust stack.

The high flow purge subsystem injects 33,000 cfm of outside air into containment above the refueling floor. Air circulates without ducting in the upper level of the containment building. A fan unit directs 15,000 cfm across the refueling pool into an intake duct at the far side of the pool. An orificed duct draws another 18,000 cfm from that upper level in containment. The combined flow of 33,000 cfm passes through isolation valves and through particulate and absolute filters to the exhaust stack.

A third flow path shown on Figure A-1 is that of the spent fuel pool emergency ventilation. If high radiation is sensed in the normal exhaust from the spent fuel pool, flow is automatically directed to the 4,000 cfm containment purge system to be filtered (including charcoal) prior to being released.

During fuel handling either the high flow or low flow purge may be used to maintain the containment at a comfortable working temperature. While the low flow system generally accomplishes this purpose, the high flow system has occasionally been operated during fuel handling. Air mixing might also be due to circulating air fans with cooling units which are provided in four locations inside containment. One such unit is located on the refueling floor, drawing up to 61,500 cfm suction from the horizontal plane and ejecting cool air vertically into the containment dome.

II. Assumptions and Initial Conditions for the Bounding Dose Calculation

The following assumptions and initial conditions are conservative bounds selected on the basis of worst case operating conditions and

Regulatory Guide 1.25, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Fuel Handling Accident in the Fuel Handling and Storage Facility for Boiling and Pressurized Water Reactors":

1. The FHA occurs 100 hours after a shutdown, the minimum time permitted by Technical Specifications. Radioactivity decay is assumed during this time.

2. The high flow purge system is in operation during the FHA.

3. The gap activity consisting of 10% of the total radioactive iodine in the rods at the time of the accident is assumed to be released from damaged rods. All rods of the dropped fuel assembly are assumed to suffer damage.

4. The iodine fission product inventory is calculated assuming full power operation with a 1.65 radial peaking factor at the end of core life immediately preceeding shutdown.

5. The overall effective decontamination factor of iodine in the water is 100.

6. The entire radioactivity inventory released leaves the refueling pool as a puff and is swept into the purge system and released via the containment stack. No credit is taken for isolation.

7. No credit is taken for the elevated release from the stack; the releases are assumed to be ground level.

8. The atmospheric dilution factor for points at or beyond the 2340 ft exclusion radius is 3.850×10^{-4} sec/m^3 as discussed in Section 2 of the Prairie Island FSAR. This is based on site meteorology using Regulatory Guide 1.25 assumptions with a building wake shape factor of 0.5 and an area of 1500 m^2.

9. The inhalation thyroid dose is determined using the assumptions of Section C.3.a of Regulatory Guide 1.25.

III. Thyroid Dose Calculation

Using the Regulatory Guide 1.25 nomenclature, the inhalation thyroid dose is as follows:

$$D = \frac{F_g \; I \; F \; P \; B \; R \; (X/Q)}{(DF_p) \; (DF_f)}$$

where:

D = Thyroid dose, Rem

F_g = fraction of fuel rod iodine inventory in the fuel rod void space (0.1)

I = core iodine inventory at time of accident (see table below)

F = fraction of core damaged so as to release void space iodine (1 element out of 121)

P = fuel peaking factor (1.65)

B = breathing rate = 3.47×10^{-4} m^3/sec

R = adult thyroid dose conversion factor (see table below)

X/Q = atmospheric diffusion factor at receptor location (3.850×10^{-4} sec/m^3)

DF_p = effective iodine decontamination factor for pool water (100)

DF_f = effective iodine decontamination factor for filters (1.0, no filtration present)

The iodine at the time of the accident is calculated as follows:

$$I = I_o \ e^{-\lambda T}$$

where:

I_o = core iodine inventory at time of shutdown (see table below) taken from FSAR Appendix D Table D.1-1 which is calculated in accordance with TID-14844

λ = radioactive decay constant (see table below)

T = decay time from time of shutdown to the accident (100 hours = 3.6×10^5 sec)

Isotope	λ (sec^{-1})	I_o (curies)	I (curies)	R (Rem/Ci)	D (Rem)
I-131	9.96×10^{-7}	4.24×10^7	2.96×10^7	1.48×10^6	79.81
I-132	8.26×10^{-5}	6.46×10^7	7.87×10^{-6}	5.35×10^4	-----
I-133	9.20×10^{-6}	9.68×10^7	3.53×10^6	4.0×10^5	2.57
I-134	2.20×10^{-4}	11.7×10^7	4.70×10^{-27}	2.5×10^4	-----
I-135	2.86×10^{-5}	8.96×10^7	3.03×10^{-3}	1.24×10^5	-----
				TOTAL =	82.38

Total Thyroid Dose = 82 Rem

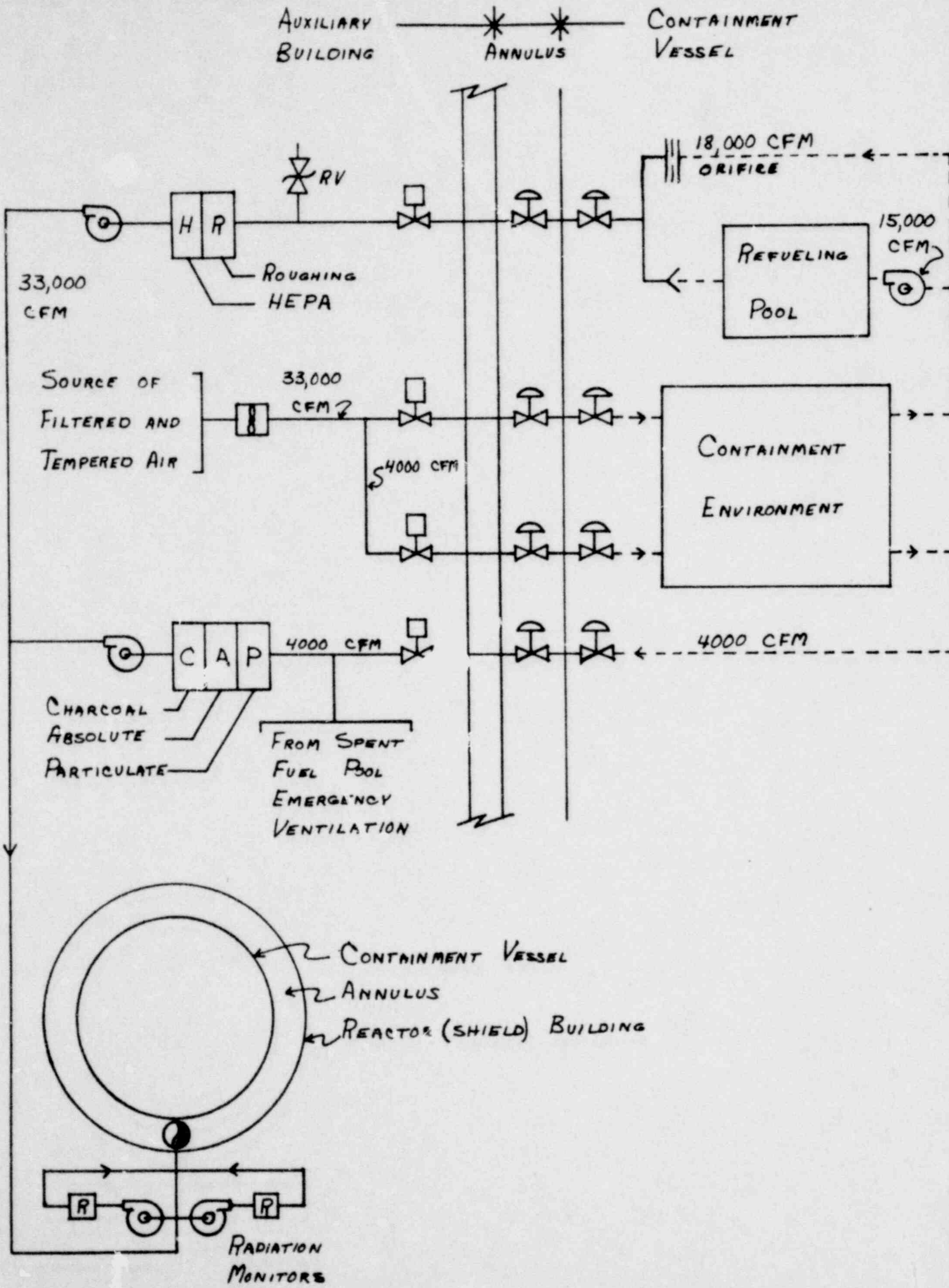

FIGURE A-1 CONTAINMENT PURGE SYSTEMS

Appendix B

Effect of Known Facility Operating Conditions on Thyroid Dose Calculation

I. Background

There are reasons for not taking credit for factors known to exist which would make the offsite consequences of a FHA inside containment less severe than calculated in Appendix A. These reasons include:

1. The conservative calculation done in Appendix A shows that the offsite dose would remain well within 10 CFR Part 100 guidelines without credit for additional factors.

2. It is difficult to model the gas release rate and confidently quantify conservative bounds short of the puff phenomena assumed in Appendix A.

3. The isolation and monitoring scheme installed is designed for reasons other than providing a rapid isolation function.

Despite the fact that the detection and isolation system is not required to provide a rapid closure, it would reduce the offsite release in the manner discussed below.

II. System Characteristics

As explained in Appendix A, the containment purge is monitored downstream of the isolation valves. The approximate time intervals for a given volume of gas to pass through various parts of the system and initiate isolation are as follows:

	Unit 1	Unit 2
Transit time from fuel pool to isolation valves	2.3 sec	2.3 sec
Transmit time from isolation valves to radiation monitor	5.2	8.6
Sampling and instrument response time	2.0	2.0
Valve closure time	7.5	7.5
Total time elapsed from passing isolation valves to isolation valve closure	14.7	18.1

Practically speaking, the existing plant isolation scheme can be expected to isolate after releasing the fission gas from damaged fuel rods which leaves the surface of the refueling pool during the initial 14.7 seconds in Unit 1 and 18.1 seconds in Unit 2.

III. Model of Release Rate of Iodine from the Refueling Pool Surface

In an attempt to describe and quantify the release rate of fission gas from damaged fuel rods a rather arbitrary model was established. The release of gas occurs over some finite time, leaving at a rapid rate initially on impact and at a lesser rate as gas pressure decreases, the fuel pellets reposition and the iodine diffuses from the fuel rod to the pool surface. It is assumed that gases reaching the surface of the refueling pool enter the purge duct immediately. The rate of iodine release from the pool surface as a function of time, r(t), is assumed to decrease linearly from an initial rate, R, to zero over a time T as:

$$r(t) = R - \left(\frac{R}{T}\right) t$$

The amount of gas released, a (t), is the integral

$$a(t) = \int_0^t r(t)\, dt = R\, t - \frac{R}{2T} t^2$$

Since the offsite release terminates after the first few seconds the initial portion of the curve is the most significant. The dose calculated in Appendix A is reduced by the isolation; a multiplier to determine the adjusted dose is

$$\frac{a(t)}{a(T)} = 2 \left(\frac{t}{T}\right) - \left(\frac{t}{T}\right)^2$$

The dose multiplier for various periods of time for release of iodine from the pool surface (T) and isolation times (t = 14.7 sec, Unit 1; t = 18.1 sec, Unit 2) is as follows:

	Dose Multiplier	
Duration of Release	Unit 1	Unit 2
1 min	0.43	0.51
3	0.16	0.19
10	0.048	0.059
30	0.016	0.020

These multipliers, times the un-isolated dose of 82 Rem, give the dose for the various durations of release.