NUREG-0662
Addendum 2

Environmental Assessment for Decontamination of the Three Mile Island Unit 2 Reactor Building Atmosphere

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Draft NRC Staff Report
For Public Comment

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6.6 Reactor Building Purge System

6.6.1 Introduction

The reactor building purge system is an existing system originally installed for purging the reactor building atmosphere during normal operation or maintenance conditions. Use of the reactor building purge system in conjunction with the hydrogen control subsystem evaluated in Section 6.1 represents a variation in the purging alternative for decontaminating the Unit 2 reactor building atmosphere. This variation in the purging alternative would function only under meteorological conditions favorable to atmospheric dispersion. The reactor building purge system is capable of purging the building at flow rates of 5,000-50,000 cfm. Actual purge rates authorized during any time interval would be dependent on meteorological conditions and reactor building concentrations. Like the hydrogen control subsystem, this system would remove reactor building atmosphere through a filter system and discharge it through the 160-ft plant vent stack to the environment. The advantage of using the reactor building purge system in conjunction with the hydrogen control system is that it could decontaminate the reactor building atmosphere in a total elapsed purge time as short as approximately 5 days, as compared with the 60 days that would be required if the hydrogen purge subsystem were used alone.

Use of this variation in the purge alternative would result in the release of radioactive materials to the environment. However, calculations based on actual meteorological and release-rate data would be used to monitor radioactive releases so that they do not exceed the requirements of 10 CFR Part 20 (Ref. 1), the design objectives of 10 CFR Part 50, Appendix I (Ref. 2) and the applicable requirements of 40 CFR 190.10 (Ref. 3).

6.6.2 System Description and Operation

The hydrogen control subsystem, which would be used in conjunction with the reactor building purge system, has been described in Section 6.1.2. The reactor building purge system consists of two air-moving units, each of which has a flow rate that can be varied from 5,000 to 25,000 cfm. These units can be operated separately or simultaneously. During operation of this system, radioactive gases purged from the reactor building would be diluted with less contaminated exhaust air and released via the Unit 2 vent stack, which is 160 feet above grade level. This purge system can be operated from the Unit 2 control room; however, an auxiliary operator would be stationed in the auxiliary building to control the purge flow rate. This auxiliary operator would have communication ties with the control room and would be stationed in a low-radiation area.

Figure 6-6 provides a flow diagram of the reactor building purge system. The major components of this system include two air supply fans and filter units, two isolation valves in each purge air supply duct, two air exhaust fans and filter units, and two isolation valves in each purge air exhaust duct. The exhaust filter units consists of a prefilter, a HEPA filter bank, activated charcoal filters, and a second HEPA filter bank.

The purging method evaluated in Section 6.1 was based upon not exceeding the existing Appendix B Technical Specification limit (45,000 μCi/sec) for krypton-85 (Kr-85) releases through an elevated vent stack. These Technical Specification limits are based on conservative annual average meteorological conditions, where $X/Q = 6.7 \times 10^{-6}$ sec/m^3. However, by controlling the purge rates to account for actual meteorological conditions, significantly higher purge rates can be achieved while still not exceeding the requirements of 10 CFR Part 20 (Ref. 1), the design objectives of 10 CFR Part 50, Appendix I (Ref. 2) and the applicable requirements of 40 CFR Part 190.10 (Ref. 3).

The rates for purging the Kr-85 under favorable meteorological conditions would be controlled solely by the hydrogen control system at a maximum rate of 1,000 cfm until the Kr-85 concentration in the reactor building was reduced to 0.22 μCi/cc. This portion of the purge would require approximately 50 hours to complete. After this initial purge was completed, the reactor building purge system could then be operated to increase the purge rate to 5,000 cfm. This rate could in turn be increased as Kr-85 concentrations in the reactor building atmosphere decreased further. As a result of the controlled purge rates, the total elapsed purge time using both systems would be approximately 120 hours, as opposed to the 60 days that would be required if the alternative described in Section 6.1 were used.

As part of its evaluation of this variation in the purging alternative, the staff also considered increasing the height of the point at which the building atmosphere was released either by extending the present vent stack by approximately 150 feet or by installing an auxiliary stack with a release point approximately 300 feet above grade. The plant's location in a river valley surrounded by higher elevation terrain and the presence of the cooling towers, diminish the effects of an elevated release point. Therefore, such an increase in stack height would most likely only result in decreasing the dose to the maximum exposed individuals by a factor of 2 to 4. The licensee estimates that such a modification would require a minimum of 2 months for design, construction, and erection. However to delay the purge beyond mid-May would offset the potential advantage of decreasing the dose factor by from 2 to 4 because by then meteorological conditions at the site would no longer be as advantageous for atmospheric dispersion. For these reasons, as well as for those outlined in Section 4.0, delays in decontaminating the reactor building atmosphere are considered undesirable. Therefore, extending the height of the purge release point is not considered a viable variation of the purging alternative. The purging alternative, which combines use of the hydrogen control subsystem and reactor building purge system, can be accomplished within the requirements of 10 CFR Part 20 (Ref. 1), the design objectives of 10 CFR Part 50, Appendix I (Ref 2), and the applicable requirements of 40 CFR Part 190.10 (Ref. 3). Therefore, no further modifications to existing plant systems are required if adequate operating procedures are established (see Section 6.6.4).

6.6.3 Occupational Exposure

The occupational exposure associated with purging at 1,000 cfm through the hydrogen control subsystem would be limited to that received by the auxiliary operators when the two HEPA filters used in the hydrogen control system are changed at the end of the purge. These filters would have a surface dose rate of approximately 0.13 R/hr and each would require approximately one-half hour to change. This process would result in an exposure of approximately 0.4 person-rem.

During the high-volume purge through the reactor building purge system, at a minimum flow rate of 5,000 cfm, the operator in the auxiliary building controlling the exhaust flow rate would receive approximately 0.05 person-rem. Assuming that the first bank of 20 filters in the purge air exhaust unit is changed at the end of the purge, the staff calculates that this process would result in an exposure of approximately 0.6 person-rem. Therefore, the exposure for processing and filter change for this variation in the purge alternative would be approximately 1.1 person-rem.

6.6.4 Environmental Impact

Based on data from samples taken in the reactor building atmosphere, the radioactive contaminants are particulates at concentrations on the order of 1×10^{-9} μCi/cc, and krypton gas at a concentration of about 1 μCi/cc.

The installed filter system, which would remove particulates from the process stream, is expected to have a particulate removal efficiency of at least 99.9%, although, in our evaluation, we used a conservative removal efficiency of 90%. However, these filters would not be effective in removing the noble gas contaminant, Kr-85. Therefore, the primary isotope that would be released during a purge operation would be Kr-85.

Staff calculations show that in order to keep within the requirements of 10 CFR Part 20 (Ref. 1), the design objectives of 10 CFR Part 50, Appendix I (Ref. 2) and the applicable requirements of 40 CFR Part 190.10 (Ref. 3), the controlling doses for the proposed purging operation would be the beta skin dose which must be limited to 15 mrem per year. Since other releases may occur from TMI-2 during the remainder of this year, the staff has allocated one-third of applicable limits for these other potential releases. Based on this assumption, the maximum relative concentration (X/Q) value averaged over the entire time of the purge could not exceed 5.7×10^{-6} sec/m^3. Assuming an occupancy factor of 0.7, an average X/Q value of 5.7×10^{-6} sec/m^3 corresponds to a beta skin dose of approximately 10 mrem and a total body dose of approximately 0.1 mrem.

In addition, it would be prudent to limit the maximum beta skin dose received by any individual in an hour to approximately 3 mrem. Such a dose corresponds to a Kr-85 air concentration of approximately 2.0×10^{-5} μCi/cc. This air concentration is about 65 times the annual average concentration in 10 CFR

Part 20, Table B (i.e., 3×10^{-7} μCi/cc). However, as long as the cumulative beta skin dose of 15 mrem is not exceeded, the annual average concentration would not exceed the concentration limits in 10 CFR Part 20, Table B.

At an initial reactor building concentration of 1 μCi/cc of Kr-85 and a purge rate of 1,000 cfm, the maximum allowable hourly X/Q value would be about 4.1×10^{-5} sec/m^3. The maximum allowable hourly X/Q value would increase as the reactor building concentration decreased. After approximately 50 hours of purging at 1,000 cfm, the reactor building concentration would be about 0.22 μCi/cc and the maximum allowable hourly X/Q would be about 1.9×10^{-4} sec/m^3. If the purge rate is increased to 5,000 cfm after the above 50-hour purge, then the maximum allowable hourly X/Q value would decrease to about 3.8×10^{-5} sec/m^3. After 5 hours of purging at 5,000 cfm the maximum allowable hourly X/Q would increase to about 8.3×10^{-5} sec/m^5. The maximum X/Q values are given in Table 6.6-1.

During a purge, the NRC staff would require that all parameters relating to dose be monitored. Constant monitoring would be required for such parameters as meteorological conditions, reactor building isotopic content (calculations and sampling), purge system flow rate, and concentrations at the site boundary (combination of calculation and environmental monitoring). This monitoring would be done to control release rates to assure that doses are within regulatory requirements and are as low as is reasonably achievable.

The staff has determined that the meteorological conditions dictated by the release scenario of a flow rate of 1,000 cfm for approximately 50 hours and

Table 6.6-1

Limiting Meteorological Dispersion Factor to Meet Assumed Skin Dose Rate Limits[a]

Purge Rate (cfm)	Reactor Building Concentration[b] (μCi/cc)	Maximum Release Rate[c] (KCi/hr)	Maximum Allowable Hourly X/Q[d] (sec/m^3)
1000	1.0	1.7	4.1×10^{-5}
1000	0.46	0.8	9.0×10^{-5}
1000	0.22	0.4	1.9×10^{-4}
5000	0.22	1.9	3.8×10^{-5}
5000	0.10	0.9	8.3×10^{-5}

[a] A maximum dose rate of 3 mrem/hr (skin) was assumed.

[b] The reactor building concentration is calculated with the following equation: $C = C_o e^{-\lambda t}$ where $\lambda = 0.03$ hr^{-1} for a purge rate of 1,000 cfm, $\lambda = 0.15$ hr^{-1} for a purge rate of 5,000 cfm, and it is in hours.

[c] The maximum release rate is equal to the produce of the purge rate times the containment concentration times a conversion factor.

[d] The maximum X/Q $= \dfrac{3 \text{ mrem} \times 8760 \text{ hours/yr}}{1.34 \times 10^{-3} \text{ mrem - m}^3\text{/pCi-yr} \times Q}$

where Q is in pCi/sec.

5,000 cfm for approximately 70 hours to provide acceptable dose rates and total doses are achievable within a total elapsed period of about two weeks. In addition, the highest average relative concentration for the release (an elapsed time of approximately 5 days) at any location in the unrestricted area surrounding the plant would have to be approximately the maximum annual average concentration to assure that the total doses meet the requirements of 10 CFR Part 20 (Ref. 1). In order to ensure that neither the maximum allowable hourly nor the annual average X/Qs are exceeded, the release would have to be controlled to account for periods of poor dispersion conditions and persistent wind directions. With these release rates and meteorological conditions taken account of, it is reasonable to assume that the reactor building could be purged within 5 days over a two-week period, provided the purging occurs before arrival of summer meteorological conditions (about mid-May). Once summer conditions set in, good diffusion because of moderate to strong winds occurs less frequently. Therefore, in order to increase the likelihood of achieving a release period of about two weeks it would be prudent to initiate the purge period as soon as possible.

6.6.5 Accident Analysis

The worst-case accident scenario would be the same as that assumed in Section 6.1.5 and therefore its results are not repeated here.

Summary

One variation in the purging alternative for decontaminating the Unit 2 reactor building atmosphere would use the reactor building purge system in conjunction with the hydrogen control subsystem evaluated in Section 6.1. Use of the proposed variation in the purging alternative would be limited to periods when meteorological conditions were favorable to atmospheric dispersion. The resultant doses would be closely monitored during purging operations. This variation in the purging alternative offers the advantage of decontaminating the reactor building atmosphere in a shorter period of time than the purge alternative of using the hydrogen control subsystem alone. While limiting the unrestricted offsite doses to within applicable Federal regulations by controlling releases so that they occur during favorable meteorological conditions, we estimate that the complete release would take approximately 5 days and could be accomplished within a two-week period, providing the purging occurs before the arrival of the less favorable summer meteorological conditions. Therefore it would be prudent to initiate the purge period as soon as possible.

Because this variation can accomplish the purge in the least amount of time of the purge alternatives evaluated, and can do so while limiting doses from krypton releases to within applicable Federal regulations, we believe that it offers the best opportunity to minimize the degree of psychological distress to persons in the vicinity of the plant. The other advantages and disadvantages of purging the reactor building atmosphere with the hydrogen control subsystem discussed in Section 6.1 would be applicable to this variation.

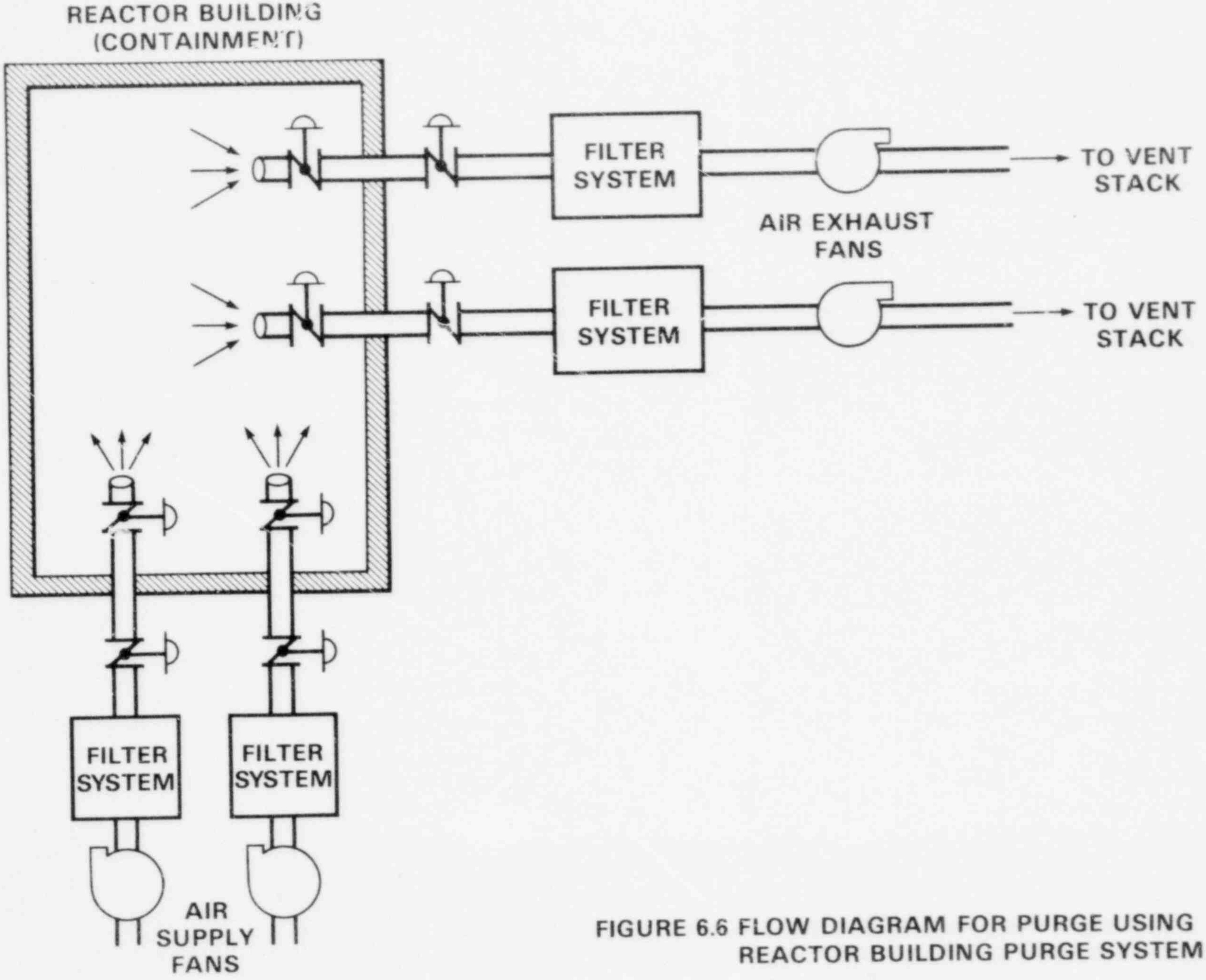

FIGURE 6.6 FLOW DIAGRAM FOR PURGE USING REACTOR BUILDING PURGE SYSTEM

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