Met-Ed GPU

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January 4, 1980
TL002

Mr. John T. Collins
Deputy Director - TMI Support
Nuclear Regulatory Commission
Three Mile Island - Trailer #7
Middletown, Pennsylvania 17057

Dear Sir:

Three Mile Island Nuclear Station, Unit 2 (TMI-2)
License No. DPR-73
Docket No. 50-320
Reactor Containment Building Atmosphere Cleanup

Enclosed are the responses to the 33 questions raised in your letter of December 18, 1979. If you need further explanation of these responses to complete your Environmental Assessment, please contact Mr. Ed Fuller at (201) 263-6331. We would be pleased to meet with you to discuss our responses if that would expedite the NRC review and approval of our requests to proceed with purging the TMI-2 Reactor Building.

Sincerely,

R. F. Wilson
Director - TMI-2

1741 120

RFW:LWH:gp
Enclosures

cc: H. Denton
R. Vollmer
R. Walker
J. Lee
L. Bell

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1. Page 2, Section 1.4 paragraph 1.

Justify why solvent extraction process was not considered as one of the feasible methods.

The fluorocarbon solvent extraction system was considered as a possible Krypton removal method in the early evaluations conducted by Metropolitan Edison. After a preliminary review, the solvent extraction process was determined to be impractical due to its developmental stage and due to its unavailability on a commercial basis.

Subsequent to this initial conclusion on the solvent extraction process, Metropolitan Edison conducted a further review of the system which included a trip to Oak Ridge to discuss possible use of the system with its developers at the Oak Ridge National Laboratory. Our discussions with the cognizant personnel at Oak Ridge led Metropolitan Edison to the conclusion that although the fluorocarbon solvent extraction process could be used at TMI, it could not be placed into operation at TMI for a significant period of time. The estimate of the time period required to place the system into operation at TMI, assuming complete licensing, qualification, and NRC interfacing during the design and construction process was three to four years. This three to four year period was the time frame estimated by the personnel at Oak Ridge. Although the time period to place a system into operation that was fully licensed and qualified was estimated to be three to four years, Oak Ridge personnel indicated that this system could, if all licensing and qualification requirements were eliminated, be in operation in the neighborhood of one to two years. Using the information gathered from reports prepared by Oak Ridge personnel and from our direct discussion with the people at Oak Ridge, Metropolitan Edison has concluded that a two year time period for installation, start-up and test is optimistic and that the solvent extraction process, therefore, presents unacceptable delays in treatment of the Krypton-85 in the containment building. These delays,

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1. (continued)

as discussed in our November 13 submittal, present risks which overshadow the small doses associated with the controlled purge proposed by Metropolitan Edison. Additionally, it should be noted that the system used at Oak Ridge is a small (15 cfm) system which would not be suitable for use at TMI. Although the cognizant Oak Ridge personnel indicate that the current system could be scaled up, Metropolitan Edison considers that this scale up would require extensive engineering evaluation work which would further increase the time period required to place such a system in operation. Oak Ridge personnel also questioned the prudence of storing the Krypton-85 on site and could offer no solution for ultimate disposal of the gas.

In summary, the solvent extraction process was not considered to be sufficiently developed to place into operation at TMI in a time frame which would make the system useful as an alternate to the reactor building purge.

1741 122

2. Page 2, Section 1.4 paragraph 3.

Provide a technical evaluation which support your statement that "there is no assurance that containment integrity can be maintained for the 2-3 years necessary to implement storage".

Metropolitan Edison cannot guarantee containment integrity in the long term due to: 1) The reactor building is not designed to be leak tight. 2) Leakage control is currently maintained by keeping reactor building pressure negative relative to ambient pressure so that leakage occurs into the building rather than from the building. 3) The negative pressure in the building is dependent on reactor building cooling which cannot be assured. The reactor building allowable Technical Specification leakage rate is 0.13 weight percent per day. The start-up integrated leak rate test indicated that the upper confidence limit of maximum leakage was approximately 0.095 weight percent per day. These figures show that leakage through the reactor building should occur under normal conditions if a pressure differential exists. The negative pressure differential can be maintained in the short term with the reactor building cooling system operation. Although no calculation can be made to determine when the reactor building cooling fans (located inside the building) might fail, it is prudent and necessary to assume that fan failure will occur in the future. This fan failure is made more likely by the fact that the fans are operating in a 100% humidity environment and that the fans are inaccessible for normal maintenance such as lubrication. It should be noted that the reactor building cooling fans were only required to be qualified (by specification) for 3 to 4 hours of operation in a 100% humidity environment, and that the reactor building cooling fan manufacturer recommends lubrication of the bearings on a yearly basis. Due to the above qualification and maintenance requirements, the reactor building cooling fans are already operating outside their normal operating range. Since the reactor building is not air tight, it is reasonable to assume that a pressure buildup in the

2. (continued)

reactor building would cause leakage of Krypton-85 gas from the reactor building to the environment. It is important to note that this can occur without any deterioration of the seals of the reactor building.

Although seal deterioration is not a prerequisite for leakage from the reactor building, it is possible that the reactor building seals have deteriorated since the start-up integrated leak rate test. Further deterioration of the seals would increase the leak rate and increase the dose consequences of uncontrolled leakage from the reactor building. High Krypton activity in the number 2 personnel air lock has already been measured. This activity in the air lock could indicate minor leakage has already occurred from the containment building into the personnel air lock. In addition, Metropolitan Edison has performed preliminary calculations which show that a very small inleakage of air into the reactor building is occurring. Upon reversal of the pressure differential, Krypton could be expected to leak out of the building. Leakage paths which exist include equipment hatch seals, number 1 air lock seals, number 2 air lock seals, flanged penetrations which use seal gaskets, valves, such as the large purge system butterfly valves, which are required to seat tightly at their seats, valves which use diaphragms to prevent leakage around valve stems, and other leakage which may occur through penetrations and process systems.

The above points justify Metropolitan Edison's lack of confidence that long-term containment integrity can be guaranteed. A detailed technical evaluation which could quantify the exact leakage rates and risks of reaching those leakage rates is not believed to be feasible.

3. Page 3, Item 4.

The NRC staff realizes that disposal of Krypton-85 in the Containment Building is a prerequisite for RB decontamination. However, in the staff's opinion, the potential safety hazard and large increases in radiation dose to the work force if delays in cleanup are encountered, referenced in this section, should be quantified.

Disposal of Krypton-85 in the Containment Building is a prerequisite for Reactor Building decontamination. Delays in RB decontamination represent potential safety hazards that cannot be quantified without a better understanding of the actual core configuration. The additional safety hazard arises from the increased potential for reactor core deterioration the longer the core remains in an unexamined state. The longer it takes to gain access to the Reactor Building and determine the true state of the primary coolant system, reactor pressure vessel, core intervals and reactor fuel, the longer the uncertainty remains as to what the ultimate risk is for further releases of radioactive nuclides from the facility. Even without this quantified risk, however, it is believed that purging the Reactor Building of Krypton-85 represents the most prudent path to disposal of the Krypton-85 radioactive noble gas. The potential for delays represented by the other options represent additional risks of core deterioration that regardless of the magnitude, justify purging the reactor building atmosphere as soon as possible. The true answer to this question cannot be determined, in fact, until the Krypton-85 is disposed of and access is gained to the reactor building. Only then can the true safety hazard and radiation dose to the work force be assessed. It is not prudent to believe that the reactor core will remain in a safe condition indefinitely.

In addition to the safety hazard resulting from delay in cleanup discussed above, delays in cleanup also will result in increased radiation dose to the work force. The man-rem exposure for the cleanup operation without long delays has been estimated to be in the tens of thousands man-rem. Delays represented by the alternatives to purging the RB atmosphere will substantially increase this man-rem exposure to the work force. With additional delays,

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4. Page 6, Section 2.2.

(a) For current samples, provide references to procedures used and other available documentation that can serve as assurance for sample data.

(b) No SR-89/90 sample data is shown in Table 2.1. Provide data to show that these isotopes were not present. Provide data to show that gross beta analysis were performed. No indication was given that shows that I-129 was sampled for.

Reactor building air sampling takes place on a weekly basis using station procedure 1631.2. This procedure is used to routinely sample for gas, particulate, iodine, and tritium. In addition, a gross beta analysis is performed on the particulate filter from the sampling system. Reactor building air samples have not been analyzed for Strontium-89/90. A method and procedure for performing this analysis is currently being developed through subcontractors working at TMI. Upon verification of this method, a reactor building air sample will be analyzed for Strontium-89/90 and the results will be forwarded to NRC. The gross beta analysis results on the reactor building air samples are as follows:

TMI-2 Reactor Building

Air Sample

Gross Beta Analysis

Sample ID No.	Date of Sample	Gross Beta μCi/ml	Error ± Ci/ml
24456	11/8/79	2.27 E-9	1.40 E-10
24459	11/8/79	8.98 E-10	1.04 E-10
27888	12/20/79	1.78 E-9	5.44 E-10
27889	12/20/79	1.55 E-8	1.33 E-9
28381	12/28/79	4.77 E-9	8.77 E-10
28437	12/28/79	5.24 E-8	2.48 E-9

The above gross beta results indicate that very little Strontium-89/90 is airborne.

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4. (continued)

Metropolitan Edison has not analyzed a reactor building air sample for Iodine-129. Calculations have been performed which show that Iodine-129 in the reactor building atmosphere, if released at the rates contemplated for the controlled purge program, would remain less than the allowed unrestricted area MPC off-site by approximately a factor of ten. This calculation assumes a 100% release of the core inventory of Iodine-129 and Tellurium-129 into the reactor building and a partitioning of these isotopes such that 60% remains airborn and 40% is dissolved in the sump water or plated out. The analysis also assumes that meteorological conditions specified in the Technical Specifications occurs, although Metropolitan Edison intends to release the reactor building atmosphere only under conditions of favorable meteorology which provide much more dilution than that available from Technical Specification meteorological conditions. Due to the above, Metropolitan Edison does not currently intend to sample the reactor building atmosphere for Iodine-129.

1741 128

5. Page 6, Section 2.3.

A continuing sampling program should be in place to assure that the most recent data base is available.

Metropolitan Edison has a weekly reactor building atmosphere sampling program in place at TMI. This weekly sampling has provided a large data base which is currently being catalogued and evaluated by Metropolitan Edison. Upon completion of the evaluation, Metropolitan Edison intends to document the sample data in a technical data report. This technical data report will include all sample results since March 28th and should be available in February. Although this technical data report has not yet been formally documented, Metropolitan Edison has thoroughly evaluated information available to date and has concluded that the reactor building air sampling results substantiate the contention that negligible off-site doses and radiological impact will occur as a result of the proposed controlled reactor building purge.

1741 129

6. General Comments on Section 2.

No information was provided on the relative humidity on RB. High relative humidity condition can cause problems in the HEPA filters regardless of the disposal methods used. Since there are no heaters upstream of the HEPA filters, provide an evaluation as to the potential problems of moisture on the HEPA filters and what will be done to handle this problem.

Table 2.1.

(a) No sample provided since September 1979.

(b) No gross beta analysis given.

(c) Sr-89/90 results not included.

Provide information relative to (a), (b), and (c) above.

Upon verifying that 100% humidity existed in the reactor building, Metropolitan Edison conducted an evaluation of the effect of this high humidity on performance of the HEPA filters in the reactor building purge system. The evaluation performed by Metropolitan Edison shows that moisture formation on the filter media and the filter plenum and housing walls would only occur if the temperature of the surfaces was below the dew point of the air drawn through the plenum. These temperatures can be sufficiently elevated to ensure against moisture formation in the filter housing through the application of external heat. Metropolitan Edison intends to add external heat through the addition of five electric infrared type radiant heaters along the outside of the filter plenum. Metropolitan Edison will have heaters in place and operable to ensure that moisture formation does not decrease particulate removal efficiency of the HEPA filters during reactor building purge.

See the answer to Question 4 above for the answer to the remaining questions raised in Question 6.

7. Page 10, Section 3.1, Paragraph 1.

Provide a discussion as to what you mean by the statement, "radioactive gases will be released from the plant vent stack at times when wind and other meteorological conditions are most favorable for atmospheric dispersion.

The controlled purge of the reactor building atmosphere will be conducted in a manner that provides for variable flow rate of the purge system from zero to 1000 cfm depending on the radioactivity level of the released gases and the site meteorological conditions. A meteorological monitoring program is in place which allows hourly input of wind speed, wind direction and temperature differential with altitude. These parameters are used to calculate each hour in advance the atmospheric dispersion of the plant vent stack gas release to the environment surrounding the plant site in accordance with Regulatory Guide 1.111 "Methods For Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases From Light-Water-Cooled Reactors." The purge flow rate will be limited in each hour so that the peak off-site beta activity does not exceed 0.1 mrem/hr. As shown in table 5.2-5 cases 19 and 21 for typical October and November meteorologies, the total peak off-site beta skin dose is on the order of 5 mrem for complete purging.

1741 131

8. Page 10, Section 3.1, Second Paragraph.

(a) Provide a description of the modifications needed to reroute flow from the inlet of the supplementary vent filter to the plant vent.

(b) From where is AH-V36 controlled?

(c) Where is flow rate, temperature, and radiation level monitored during discharge?

(a) The flow from the inlet of the supplementary filters to the plant vent will be rerouted in the following steps:

1. Recommission the auxiliary building, fuel handling building, and hydrogen control purge system filter trains. This includes ANSI N510 testing of the filter trains.
2. Calibrate and reactivate stack monitor HPR-219A.
3. Secure the supplementary filter train by turning off the supplementary fans and closing the isolation door from the stack inlet plenum to the filters.
4. Uncap the stack by removing the existing cap.

(b) AH-V36 is being modified to allow remote control of the valve from a location in the southeast corner of the auxiliary building on the 328' level. The control station is located behind the shield wall just north the stairway from the 305' elevation up to the 328' elevation in the southeast corner of the auxiliary building. Sound power phone communications will be provided from this remote control location to the control room.

(c) Hydrogen control purge system flow rate and temperature are measured at the discharge of the hydrogen control fan and monitored in the control room on panel 25.

Radiation level is monitored in the filter housing and read out at a local readout station near the filter housing on the 328' level of the auxiliary building. General area radiation levels around the filter housing area will also be monitored by local radiation monitor HP-R-3236

1741 132

8. (continued)

(c) (continued)

which will be located near the hydrogen control filter plenum. This area radiation monitor has a local readout and a remote readout in the control room on panel 12.

It should be noted that general area radiation levels in the vicinity of the filter housing are not expected to appreciably increase during reactor building purge.

1741 133

9. Page 11, Section 3.3, Last Paragraph.

There is no heater or demister in the exhaust system design. What is the expected relative humidity of the RB exhaust air to be? If it is high, what impact will high relative humidity have on system operation?

See the answer for Question 6 for steps being taken to prevent moisture buildup from affecting operation of the HEPA filters. No other adverse effect or impact on system operation is expected due to the 100% humidity of the reactor building exhaust air.

1741 134

10. Page 12, Section 3.3.1, HEPA Filters.

Provide a commitment to in-place test the HEPA filters in accordance with ANSI N510.

Metropolitan Edison has committed to in-place test the HEPA filters in accordance with ANSI N510. The proposed Technical Specifications for Unit 2 currently under review by the NRC contain the following language under Surveillance Requirement 4.6.4.3c.

"The hydrogen purge cleanup system shall be demonstrated operable after each complete or partial replacement of HEPA filter banks by verifying that the HEPA filter banks remove greater than or equal to 99.95% of the DOP when they are tested in place in accordance with ANSI N510-1975 while operating the system at a flow rate of 1000 cfm ± 10%."

1741 135

11. Page 12, Section 3.3.1, Last Paragraph.

Provide information as to the type of impregnate for the charcoal adsorbers. Since there is essentially no iodine in the containment atmosphere, why is it necessary to use charcoal adsorbers?

The charcoal filters in the hydrogen control purge filter train are impregnated with tertiary amine complex and potassium iodide by Nuclear Consulting Services of Columbus, Ohio.

Metropolitan Edison agrees that there is essentially no iodine in the containment atmosphere and that it is not necessary to use charcoal adsorbers. Metropolitan Edison believes, however, that no detrimental effect accrues from the use of charcoal filters in the purge train. We have already replaced the charcoal and it will be in service during purge.

1741 136

13. Page 13, Section 3.3.1, Third Paragraph.

Provide the location of Panel No. 25.

Panel No. 25 is located in the control room. This panel is the control and monitoring panel for the reactor building normal ventilation and purge system and the hydrogen control purge system.

1741 137

12. Page 13, Section 3.3.1, First Paragraph, First Sentence.

Provide a description of the fire detection system in the filter housing.

The reactor building hydrogen control purge filter train is provided with a deluge water spray system in accordance with NFPA-13. A temperature sensing detector in the filter housing in the vicinity of the charcoal filter automatically operates the deluge system. An alarm is sounded in the control room and locally coincidental with operation of the deluge system.

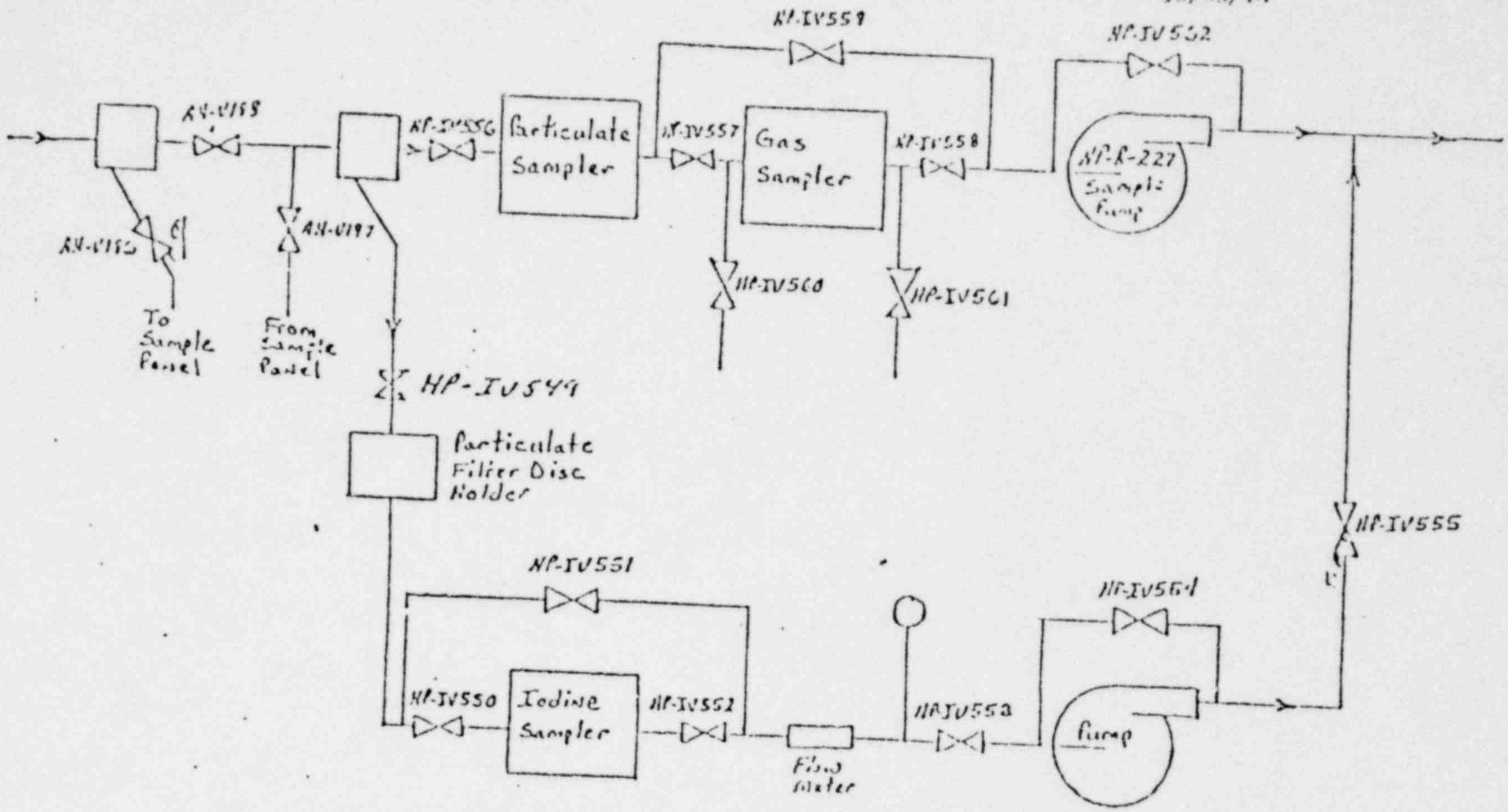
1741 138

14. Page 15, Section 3.3.3., First Paragraph.

Provide a description of the radiation monitor.

HP-R-227 is a sample panel, not a radiation monitor, which allows direct sampling of the reactor building atmosphere. The sample panel can be used to fill a sample bomb for gas analysis, to perform a particulate analysis by drawing containment air through a filter, or to perform a tritium analysis by using the installed bubbler. The attached system sketches provide details of the sample system.

1741 139



HP-R-227
REACTOR BUILDING

FIGURE 1

REACTOR BUILDING SAMPLING PANEL

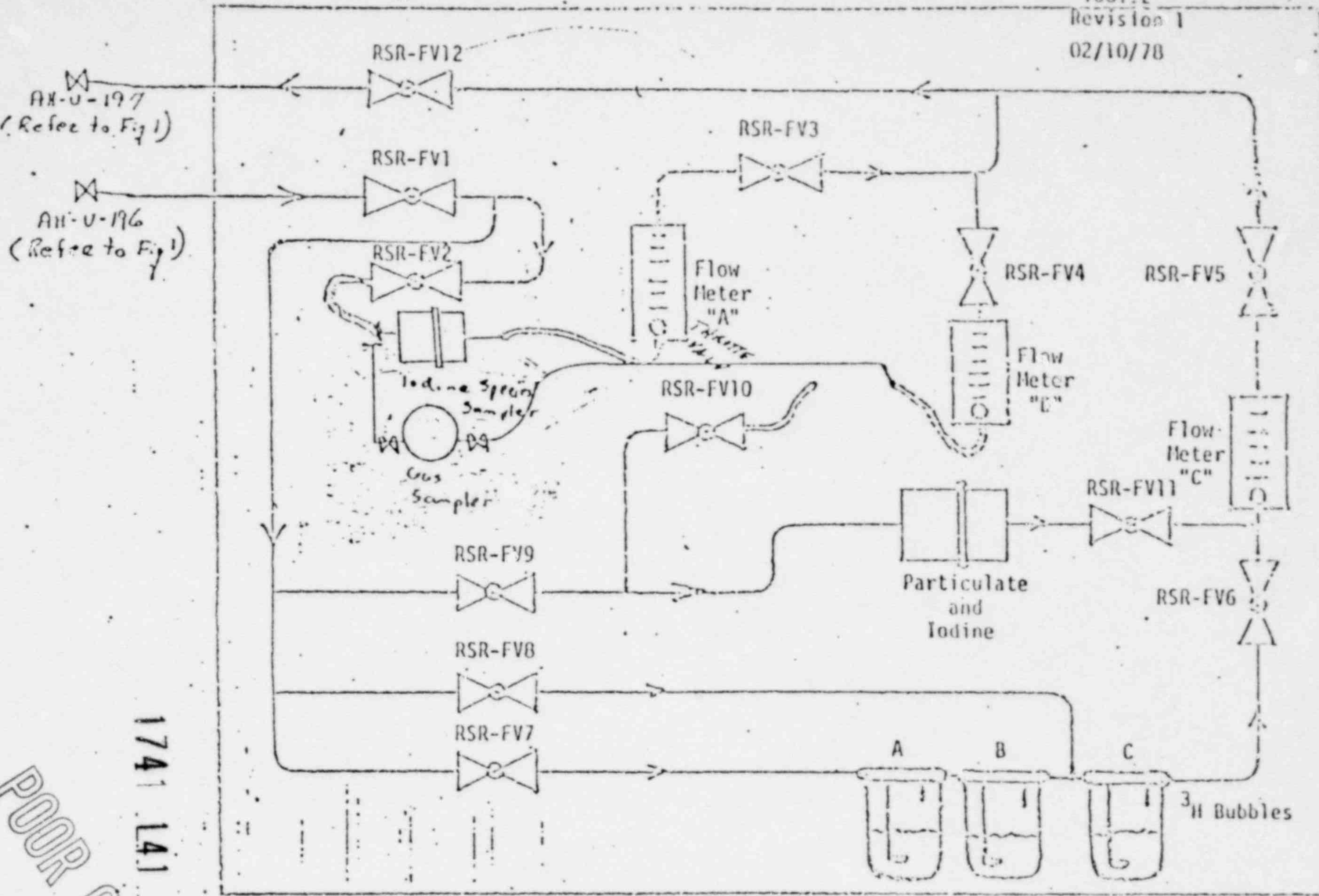


FIGURE 2

1741 141

15. Page 15, Section 3.3.3, Second Paragraph.

Will gross beta analysis be done? If not, justify the reason why it will not.

See the answer provided for Question 4. During purge, particulate samples will be analyzed for gross beta.

1741 142

16. Page 15, Section 3.3.3, Third Paragraph.

Will AH-V7 be throttled to control the flow of replacement air in the RB? If not, how will this flow be controlled?

AH-V7 will not be throttled to control the flow of replacement air to the reactor building. Upon commencement of reactor building purge, the reactor building will be at a small negative pressure relative to the auxiliary building. This small negative delta pressure will cause air flow from the auxiliary building into the reactor building through the AH-V7 replacement air path. The flow from the auxiliary building to the reactor building through this path will cause a tendency for equalization of the pressures in the two buildings. However, the flow removed from the reactor building by the hydrogen control purge fan is expected to maintain a very small negative pressure in the building, without throttling of AH-V7, so that flow will continue from the auxiliary building to the reactor building. If Krypton-85 should go from the reactor building into the auxiliary building, existing radiation monitors in the auxiliary building would detect the Krypton-85 in the auxiliary building and alarm in the control room. By procedure, this alarm in the auxiliary building will require shutdown of the purge until the cause of the alarm is investigated and understood. If this flow of Krypton-85 occurs into the auxiliary building, the auxiliary building ventilation system will remove the Krypton-85 and discharge it to the stack so that the end result of this leakage will be a discharge of the Krypton-85 through the stack.

Although AH-V7 is not throttled and is not controlled from the control room, the inner containment isolation valve AH-V3B can be shut from the control room if Krypton-85 leakage into the auxiliary building is suspected.

17. Page 18, Section 3.10, Item No. 7.

Will this gamma monitor alarm cause the exhaust fan to trip?

The filter housing gamma monitor probes will not alarm or cause the exhaust fan to trip. The gamma monitor will be monitored frequently, and by procedure the reactor building purge would be terminated if contact readings on the HEPA filter reaches a level of 1 rem per hour.

It should be noted that the 1 rem per hour upper limit imposed on the HEPA filter contact reading is an administrative limit which has been imposed by Metropolitan Edison as a precautionary measure only. If radiation levels higher than 1 rem per hour on contact with the HEPA filters occur, radiation exposure to workers during filter changeout should still be relatively small. Filter changeout can occur at higher radiation levels on the filter surface, therefore strict alarm and shutdown measures for this reading are not required.

1741 144

18. Page 18, Section 3.10, Item No. 8.

What is the range of the HPR-229?

HPR-229, which is the radiation monitor on the discharge of the hydrogen control fan is being modified to allow reading of Krypton-85 up to 1000 microcuries per cc. This modification is being accomplished under an ECM at TMI.

1741 145

19. Page 24, Section 4.2.

This section should be revised to reflect the limiting conditions of operation set forth in NUREG-0472, Standard Radiological Effluent Technical Specification for PWRs. Additional guidance on implementation of Appendix I to 10 CFR Part 50 and 40 CFR 190 is given to NUREG-0133.

Although NUREG-0472 "Standard Radiological Effluent Technical Specifications for PWRs" has not been incorporated into the Environmental Technical Specifications for TMI, this standard is consistent with the discussion of 10 CFR 20 and 10 CFR 50 App. I given in Section 4.3 and 4.4 of the Reactor Containment Building Atmosphere Cleanup Report.

1741 146

20. Page 27, Section 4.5.

> Since Appendix I dose design objectives are stated in terms of quarterly and annual values, it is clear how you intend to limit the releases to assure that these design objectives are not exceeded. Provide a discussion as to how you intend to implement the requirements of 40 CFR 190 including the contribution from direct radiation.

10 CFR 50 Appendix I addresses quarterly release limits in Section IV.A such that if one-half the design objective annual exposure is exceeded in any calander quarter, the licensee shall investigate, take corrective action, and report to the NRC. We do not believe that the purge operation will exceed one-half the annual design objective exposure of 15 millirem skin dose. Therefore, we will be within the quarterly allowable limit for 10 CFR 50 Appendix I. If the allowable conditions of Section IV.A are exceeded, then the required corrective action and reporting will be completed in accordance with this section.

40 CFR 190 requirements on direct radiation in paragraph 190.10 (a) limit the annual dose equivalent to 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public. These limits are greater than the limits allowed under 10 CFR 50 Appendix I.

1741 147

21. Page 69, Section 8.1, Paragraph 1.

Provide an analysis to justify the statement that "the risk to the entrant are quite high" if the containment is not purged prior to entry.

Metropolitan Edison is still conducting experiments through various penetrations and the air locks to quantify the exact exposures that would occur inside the reactor building. Upon completion of all these experiments, data gathered will be evaluated and hazards posed by the Krypton-85 atmosphere will be thoroughly evaluated.

It can be stated that radiation exposures as low as reasonably achievable can only be accomplished if the radiation exposure associated with Krypton-85 is eliminated prior to entry. Although the additional exposure caused by Krypton-85 should not cause significant risk to the entry team, assuming that all beta doses are shielded through the wearing of protective clothing, analyses have shown that a signification portion of the whole body dose associated with the reactor building entry prior to purge comes from radiation associated with the Krypton-85 in the atmosphere. Risk to the entry team does exist, however, due to the potential for accidents which could cause loss of suit integrity. Tearing the protective clothing or removing the face mask (inadvertently or due to loss of breathing air) would cause additional skin and internal exposure.

Metropolitan Edison has recently conducted experiments through penetration R626 designed to determine the effectiveness of clothing material to be worn by reactor building entry team members. The results of this experiment are not yet completely understood, however, they do show that the material is apparently effective in removing dose contribution from betas emitted by Krypton-85. The material did not, however, prevent the Krypton-85 from penetrating the material and contaminating the TLD case and chip wrapped inside. Also, some of the real time radiation measurement instruments were apparently affected by the presence of the Krypton-85 cloud, making their readings inaccurate.

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2. (continued)

Present sampling indicates the concentration of Krypton-85 in the TMI-2 containment building is approximately .8 μCi/cc. Without any protective clothing, the resultant dose rate to the skin is calculated to be 160 rem/hour. With protective clothing to reduce beta dose (10^3 protection $\approx$ 1.5 mm tissue equivalent material), the skin dose rate can be reduced to 1.6 rem/hr. The whole body dose rate with or without protective clothing would be calculated at 1.6 rem/hour. This dose rate would limit stay time to approximately 108 minutes to stay within the 10 CFR 20.101 dose limits assuming no other radiation source.

1741 149

22. Page 69, Section 8.1, Second Paragraph.

Provide or define in greater detail potential release points from containment.

See the answer provided in Question 2.

1741 150

23. Page 69, Section 8.2, Current Noble Gas Activity

Provide in the design basis consideration for particulates, H-3 (Sr-89/90), and Iodine.

Section 5.1 includes an analysis of allowable purge rates for the particulate CS-137, and Iodine-131. These analyses demonstrate that the Iodine and particulate contents are far below the Krypton-85 in terms of limiting flow rates to meet 10 CFR 20 Appendix B limits. Therefore, the system design basis does not address these potential radioactive isotopes. Sr-89/90 is addressed in Question 4. From the gross beta activity samples, it is not expected that airborne Sr-89/90 represents a sufficiently high concentration to be considered in the systems design basis for the non-purge alternates. Preliminary assessments of tritium level in the reactor building atmosphere indicate that tritium activity is sufficiently below Krypton-85 activity that tritium need not be considered in the design basis for the alternate system scoping studies.

It should be pointed out that from the standpoint of purging the reactor building atmosphere Krypton-85 is by far the dominant controlling isotope for determining acceptable purge flow rates and expected off-site dose consequences. If in the development of final designs for atmosphere storage options additional isotopes need to be considered, the effects will be to add additional complexity, costs, and risks which all tend to make the purging option even more favorable.

1741 151

24. Page 70, Section 8.2, Containment Volume.

If perfect mixing is not achieved, what would be the maximum volume to be processed?

The process volume is calculated based on perfect mixing of a continuous feed and bleed process to provide ultimate dilution of Krypton-85 from 1 μCi/ml to 1 x 10^{-5} μCi/ml.

The average rate of change of concentration within containment can be written as:

$$\frac{dC}{dt} = C \times \frac{(F)}{(V)}$$

where:

c = containment concentration μCi/ml

F/V = Fraction of containment volume removed per unit time

F = Discharge flow rate

V = Containment volume

t = time

This expression has the solution

$$C = Co\ e^{-\frac{F}{v}t}$$

Where Co is the initial concentration of 1 μCi/ml. For a final concentration of 10^{-5} μ Ci/ml

$$\frac{C}{Co} = 10^{-5} = e^{\frac{-F}{v}t}, \text{ for perfect mixing.}$$

For less than perfect mixing, we can introduce a mixing factor, MF, such that MF is the ratio of peak concentration to average concentration and C_L, the limiting concentration is given by

$$\frac{C_L}{Co} = 10^{-5} = MF\ e^{\frac{-F}{v}t}$$

Where MF $\geq$ 1.

Solving for $\frac{Ft}{v}$, the number of containment volumes to be processed

$$\frac{Ft}{v} = \text{Ln } 10^5 + \text{Ln MF}$$

$$= 11.5 + \text{Ln MF}$$

1741 152

For perfect mixing, MF = 1.0,

24. (continued)

$\frac{Ft}{v} = 11.5.$

For a mixing factor as high as five, or a peak concentration as high as five times the average concentration, the process volume increases to $\frac{Ft}{v} = 11.5 + 1.6 = 13.1$

or, additional processing of 3.2×10^6 cubic feet. For the purge option, this increases the process time by 2.2 days. The integrated dose consequences would be unchanged.

For the process and storage options, the compression storage volume increases by 14% and the charcoal storage volume increases by 14%. The cryogenic storage volume should be unchanged, because the total Krypton-85 content remains the same.

1741 153

25. Page 70, Section 8.2, Seismic Design Category.

Provide justification for the statement that Regulatory Guide 1.143 is not considered appropriate for the situation at TMI-2.

Metropolitan Edison considers regulatory approval to store the Krypton-85 in a vessel which is designed to less stringent requirements than the current vessel, i.e. the containment building, is not likely to be obtainable. As a result, Metropolitan Edison has concluded that at least the storage systems for the Krypton-85 would be required to meet seismic Category I and ASME code, Section III, Division I, Class III requirements. Since Regulatory Guide 1.143 imposes less stringent requirements on gaseous radioactive waste treatment systems, Metropolitan Edison concluded that it would not be prudent to invoke only those requirements on the design of these systems. Also, the hydrogen control purge system is a safety grade system which does meet requirements more stringent than those imposed by Regulatory Guide 1.143.

In the answer to Questions 30, 32 and 33, Metropolitan Edison did look at other design requirements for the alternate systems. The investigation of the time and money required to install these systems for the various design requirements scenarios showed that the imposition of requirements more stringent than Regulatory Guide 1.143 did not significantly impact the amount of money or time required, and therefore, was not a major factor in decisions to use the purge rather than any of the alternate systems.

If controlled venting is determined to be unacceptable, then the design alternatives for RB atmosphere cleanup should be of sufficient integrity that inadvertent release is protected against over the expected duration of storage. This has been the basis for selection of the design criteria for the alternatives examined. This basis will require more stringent conditions than provided in Regulatory Guide 1.143.

26. Page 70, Section 8.2, Design Code.

We do not agree that Regulatory Guide 1.143 is inappropirate for the design of alternative systems. Provide further justification to support your position.

See the answer provided to Question 25.

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27. Page 71, Section 8.2, Charcoal Adsorption.

Provide an analysis to show that it will take 11.5 times the reactor building atmosphere volume to achieve MPC levels.

See answer to Question 24.

1741 156

28. Page 71, Section 8.3, Charcoal Adsorption.

For the Adsorption and Storage System, where would the interface point with containment be?

The interface point for all the systems (cryogenic treatment, gas compression and charcoal adsorption) is the hydrogen control purge duct, after the containment air passes through the hydrogen control filter train. In other words, the existing HEPA filter system would be the same on all systems.

1741 157

29. Page 71, Section 8.3.1, System Description.

Provide the basis for the 34,000 tons of charcoal stated in this section. Provide justification as to why it is necessary to design and construct the tanks to Section III, Class 3.

Sufficient charcoal is required for processing 23×10^6 cubic feet of containment gas without the occurrence of "break-through," i.e., without detecting signification Krypton-85 at the exit of the charcoal beds.

From the 12th AEC Air Cleaning Conference, NEDO-12327, "Measurement of Dynamic Adsorption Coefficients for Noble Gases on Activated Carbon," D. P. Siegwarth, et. al., break-through occurs at some fraction of the mean residence time, t_m, of krypton in a charcoal bed. This is illustrated in enclosed Figure 10 from NEDO-12327, which shows the ratio of bed output activity to bed input activity as a function of time, given in dimensionless units of t/t_m.

The value of t_m, in turn, is given by:

$$t_m = \frac{K_d\ M}{F}$$

Where:

t_m = mean residence time, minutes

K_d = the dynamic adsorption coefficient for noble gas on charcoal cc @ stp/gm

M = mass of charcoal, gm

F = carrier gas flow rate, cc/min

From Figure 10 of NEDO-12327, the time to "break-through," t_b, is on the order of 0.7 t_m.

Using a minimal amount of conservatism, let $t_b = 0.65\ t_m$:

$$t_b = \frac{0.65\ K_d \times M}{F}$$

This expression is used to determine the required charcoal mass.

1741 158

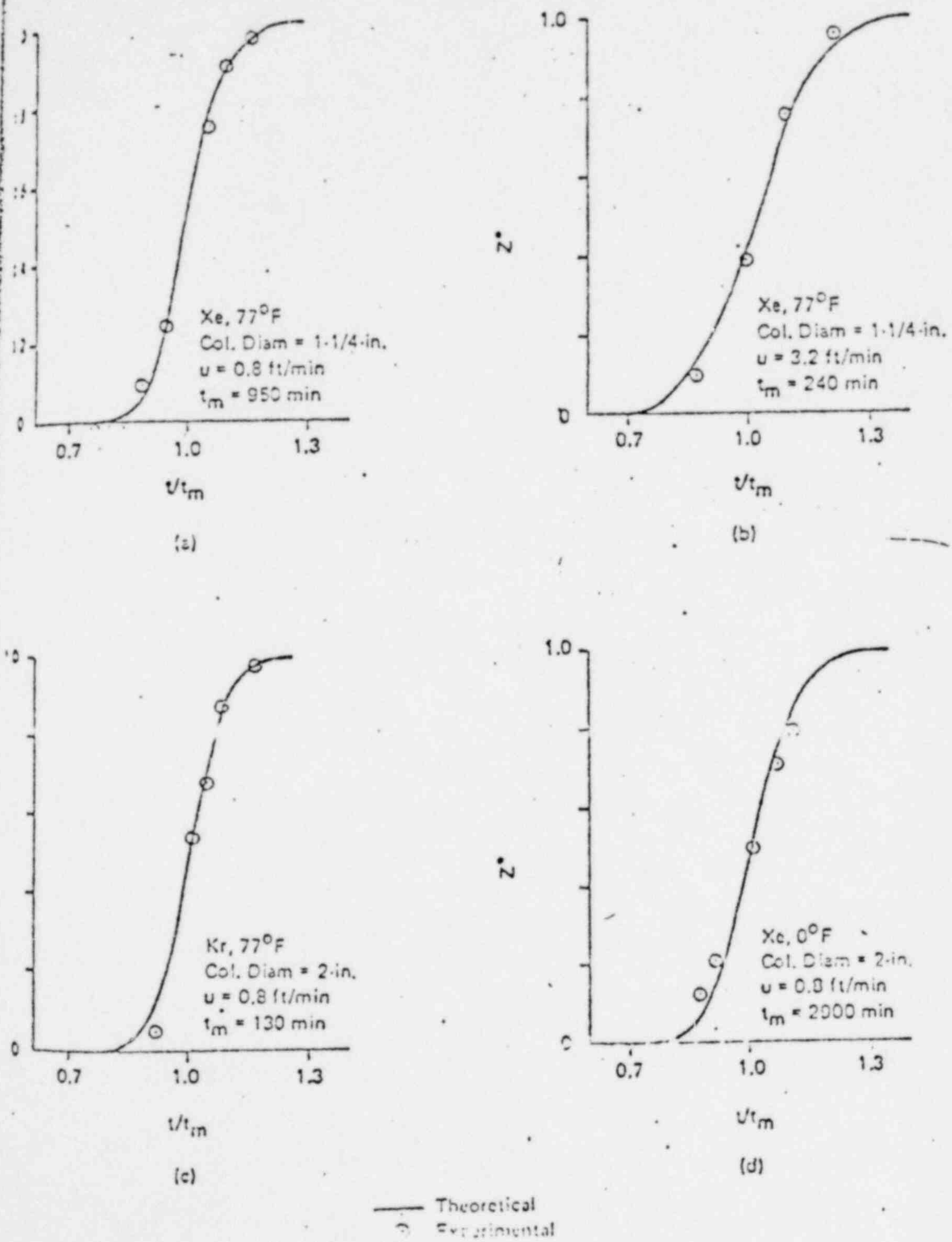

FIGURE 10. CALCULATED VERSUS EXPERIMENTAL BREAKTHROUGH CURVES

1741 159

29. (Continued)

Convert the expression to more convenient units, i.e., express M in tons of charcoal and F in scfm.

Therefore:

$$t_b = \frac{0.65 \times K_d \times M \times \overbrace{907.2 \times 10^3}^{[g/ton]}}{F \times \underbrace{2.832 \times 10^4}_{[cc/ft^3]}}$$

$$= \frac{20.8\ K_d \times M}{F}$$

Or,

$$M = \frac{F \times t_b}{20.8 \times K_d}$$

$F \times t_b$ equals the total processed volume of $23 \times 10^6\ ft^3$.

Therefore:

$$M = \frac{23 \times 10^6}{20.8 \times K_d} \text{ tons}$$

$$= \frac{1.11 \times 10^6}{K_d} \text{ tons}$$

The supplier of the Oyster Creek charcoal system indicated that the value of K_d for Krypton using a coal base type of activated charcoal operating at ambient temperature is 33 cc/gm.

Therefore:

$$M = \frac{1.11 \times 10^6}{33}$$

$$= 33{,}500 \text{ tons}$$

$$\cong 34{,}000 \text{ tons}$$

Also, the density of the charcoal used at Oyster Creek is 34 pounds per cubic foot. Based on discussions with a charcoal manufacturer, this represents an upper limit to the charcoal density which can be achieved by careful loading of the charcoal containers.

Accordingly, the charcoal volume is:

1741 160

29. (continued)

$$V = \frac{34,000 \times 2,000}{34}$$

$$= 2 \times 10^6 \text{ cubic feet}$$

The charcoal storage tanks would be designed to meet ASME Section III, Class 3 requirements in accordance with Table I of Regulatory Guide 1.143. Since these tanks would house Krypton-85 for an indefinite time period, it is felt that the design of these tanks should be consistent with the existing containment vessel. As indicated in the response to Question 25, Metropolitan Edison did look at other design requirements including both less stringent and more stringent requirements. The imposition of less stringent design requirements did not materially affect the cost or schedule for implementing the alternative storage options.

1741 161

30. Page 73, Section 8.3.3, Cost and Schedule Estimate.

Provide a detail breakdown to justify why it will take 30 to 40 months to design and construct this system.

In order to evaluate the effort required to place the alternate systems into operation, Metropolitan Edison performed a scoping evaluation which included a preliminary system design for each alternate. These preliminary systems were then evaluated by Metropolitan Edison's architect engineer to determine schedule and costs for implementing the systems. The schedule determined is as shown in the attached bar chart. Our architect engineer used standard industry estimating and scheduling techniques to determine the times and costs presented. The cost and schedule estimates are based on years of expe.'ence and considered judgement and are considered adequate for use by Metropolitan Edison. A more detailed estimate would require greater design detail, which would impose additional, unwarranted delays in solving the Krypton-85 problem.

In order to complete the cost and schedule estimates, the architect engineer assumed as a base (or most probable) case that the buildings, equipment, piping, supports, and electrical service were seismic Category I and that the piping design code was ASME Section III, Division I, Class 3. The reasons for these assumptions are presented in the answer to Question 25. Additionally, shortest schedule/least cost and longest schedule/maximum cost estimates were also made. For the shortest schedule evaluation, buildings, equipment, piping, supports, and electrical service were non-seismic, and the piping design code was ANSI B-31.1/ASME VIII. For the longest schedule evaluation, the same seismic and code requirements as used for the most probable case were used, but aircraft hardening for the building was also assumed. In each case, the schedules and costs are considered to be the additional time/cost required for the alternates as compared to the base case of performing a controlled vent of the containment.

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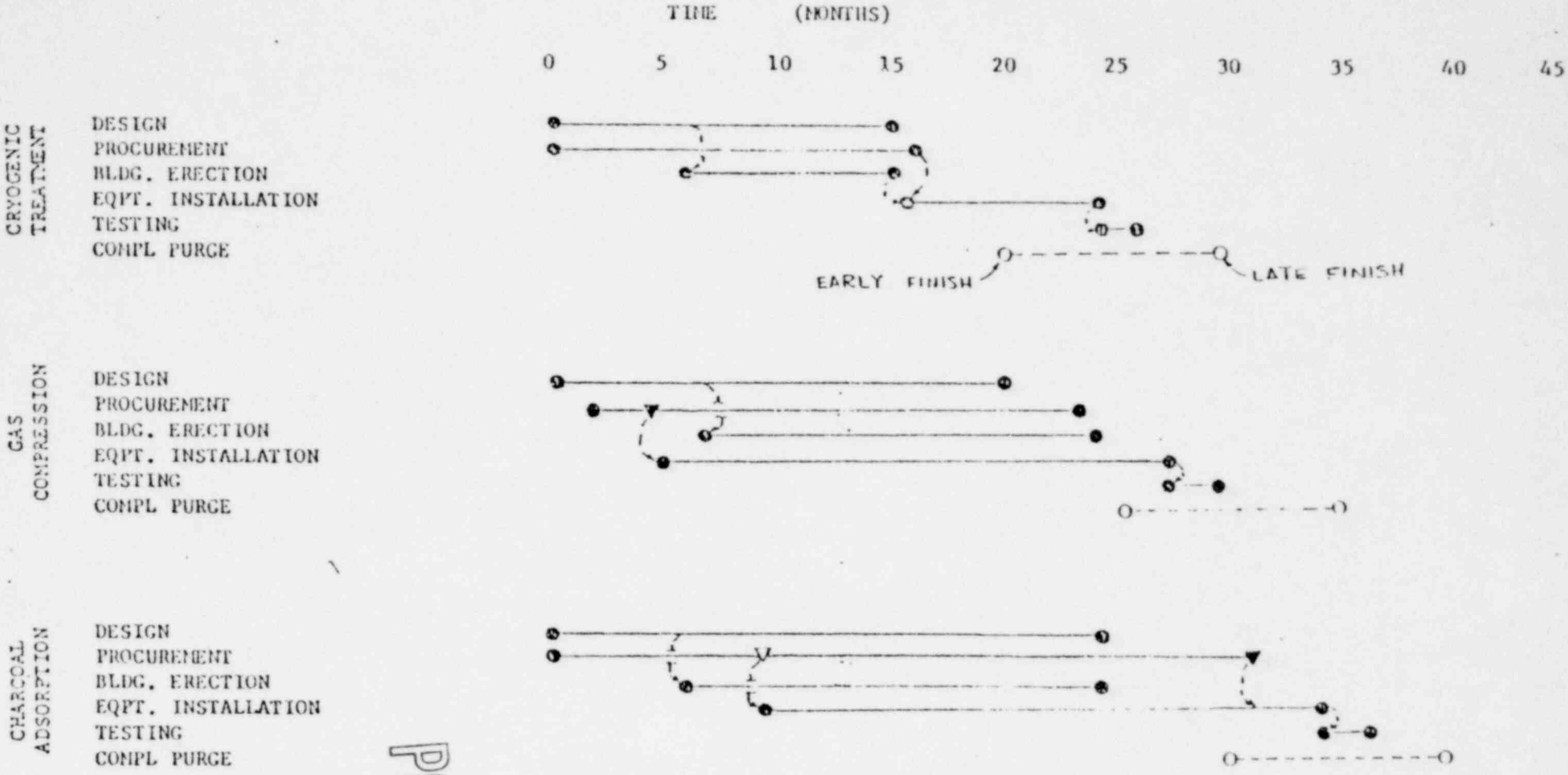
PRELIMINARY SCHEDULE



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30. (continued)

The following additional qualifications apply to the schedule and direct cost estimates for all the alternative systems:

- o All buildings are located at grade level.
- o All structures are assumed to be located approximately 1,000 feet from the containment.
- o Interconnecting piping for containment atmosphere from the power plant to the system will be buried and encased in concrete.
- o Cost of charcoal/HEPA filters are excluded since they are common to all systems.
- o All costs associated with the following items have been excluded from the estimate.
  - Security
  - Fire Protection
  - Demolition of facilities and salvage of equipment upon demobilization of systems.
  - Major site work (excavation, backfill, etc.)
  - Operation and maintenance of systems.
  - Licensing
  - Permits, fees and insurance.
  - Disposal of radioactive materials.
- o Schedule is based on industry standards for lead times and construction methods and has not been optimized.
- o Power supply will be from existing equipment in the plant.
- o All estimated costs are in present day dollars (September 1979).
- o All allowance for contingency is included at 33 percent.

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30. (continued)

For the cryogenic system, the following additional qualifications apply:

- o Cost for existing equipment procurement is for the specified equipment (Specification 8031-M-95) delivered to the TMI site in operating condition.
- o Cryogenic equipment will be provided on skids with valves, controls and instrumentation included.
- o Product compressor is included with the existing equipment.
- o Instrument air will be provided from local compressor.
- o Cooling water and demineralized water will be provided from existing equipment in the power plant.
- o The utility costs are for operation phase only. Construction and start-up utilities are excluded.

For the gas compression system, the following additional qualifications apply:

- o 36-inch pipe wall thickness is 3/8 inches.
- o Pipe will be supported by a structural steel grid system.
- o Pipe will be run in 200-foot lengths, capped at each and interconnected with 4-inch pipe.

For the charcoal adsorption system, the following additional qualifications apply:

- o Tanks will be supported by building floor and roof truss system.
- o Tanks are arranged in 45 rows of 10 and are not staggered as shown in sketch.
- o All valves will be manually operated at the valve.
- o Tank orders to be issued to several vendors to optimize production time.

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- o Charcoal will be available at jobsite as required for construction.
- o Cost of storage and handling of charcoal at jobsite is excluded.
- o In all cases (least cost, most probable cost, and maximum cost), $61.2 million for charcoal is included in the cost of components.

30. (continued)

It should also be pointed out that only direct costs were shown in the original submittal. Since cost considerations were not the major determining factor in rejecting the alternates, other costs such as replacement power and revenue losses were not included. Metropolitan Edison did, however, evaluate <u>all</u> costs associated with implementing the alternative systems. A tabulation of all these costs is attached. The following additional qualifications apply to these more detailed cost estimates.

- An escalation alowance of 7½% per year compounded has been provided.
- AFUDC (incremental) of 12% per year compounded has been used. It is assumed the plant will be commissioned in 42 months after the working entry.
- An allowance of $10 million per month has been included for replacement power in 1979 dollars and has not been escalated.
- Credit for fuel has been provided at the rate of two mills per KWHR based on historical fuel cycle costs. Plant rating of 959 MWe, along with 60% capacity factor, has been assumed for this calculation. Fuel costs are 1979 dollars not escalated.
- Differences in O&M costs have not been evaluated and are not considered to be significant at this time.
- Loss of revenue due to TMI-2 being out the rate base is $8 million per month. This includes capital cost, depreciation, income tax, operations and maintenance costs and other taxes.

The resultant cost estimate ($ millions) for the cryogenic treatment system are:

30. (continued)

	Components	Building	Utilities	Escalation	AFUDC	Additional Replacement Power	Fuel Cost	Revenue Loss	Total
Least Cost[1]	5.2	4.8	0.4	0.6	7.0	200	(16.7)	160	361.3
Most Prob. Cost[2]	5.7	5.0	0.4	0.9	8.0	250	(20.8)	200	449.2
Max. Cost[3]	5.7	7.2	0.4	1.3	10.4	300	(25.0)	240	540.0

[1] Twenty months [2] Twenty-five months [3] Thirty months

The resultant cost estimates ($ millions) for the gas compression system are:

	Components	Building	Utilities	Escalation	AFUDC	Additional Replacement Power	Fuel Cost	Revenue Loss	Total
Least Cost[1]	43.1	12.4	---	4.3	40.3	250	(20.8)	200	529.3
Most Prob. Cost[2]	53.6	13.0	---	6.3	52.0	300	(25.0)	240	639.9
Max. Cost[3]	53.7	26.2	---	8.9	67.0	350	(29.2)	280	756.6

[1] Twenty-five months [2] Thirty months [3] Thirty-five months

The resultant cost estimates ($ millions) for the charcoal adsorption system are:

	Components	Building	Utilities	Escalation	AFUDC	Additional Replacement Power	Fuel Cost	Revenue Loss	Total
Least Cost[1]	107.6	20.9	---	12.2	100.3	300	(25.0)	240	756.0
Most. Prob. Cost[2]	117.0	22.0	---	15.4	116.4	350	(29.2)	280	871.6
Max. Cost[3]	117.3	42.2	---	20.4	143.2	400	(33.3)	320	1009.8

[1] Thirty months [2] Thirty-five [4] Forty months

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31. Page 76, Section 8.4.1.

Provide additional details on the Compression and Storage System evaluated. Provide interface information.

For interface information see the responses to Question 28. A more detailed cost and schedules breakdown is given in the response to Question 30. The conceptual design of the Compression and Storage System is shown in Figures 8.4-1, 2, and 3. The Design Basis for this system is given in Section 8.2 and is the same as for the other alternate systems. Additional details of the evaluation of selected storage pressure, resulting storage volume, and length and weight of storage piping are given below. Finally, details of the shielding evaluation are provided.

As a first approximation, the high pressure storage system which would be most economical is the one which contains the smallest weight of metal. Accordingly, the effect of the main system variable, i.e., storage pressure, on storage vessel weight was evaluated as follows.

For a container initially filled with air at atmospheric pressure, the storage volume required is:

$$V_S = V_P \times \frac{P_0}{P}$$

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31. (continued)

Where:

V_S = required storage volume, ft^3

V_P = processed volume = 23×10^6 ft^3

P_0 = initial container pressure = 14.7 psia

P = storage pressure, psig

Therefore $V_S = 23 \times 10^6 \times 14.7/P$

The required container wall thickness, t, is given by:

$$t = \frac{PR}{\sigma}$$

Where:

R = container radius, in

σ = allowable stress, psi

= 15,000 for a typical carbon steel in accordance with the ASME Code, Section III, Subsection NA

Neglecting the steel contained in the container ends, which is reasonable for containers such as piping with high length-to-diameter ratio, the total container steel volume (V_0) is:

$$V_0 = 2\pi R \times L \times t$$

Where L = container length, in

$$= \frac{\text{required container volume, in}^3}{\text{volume per unit length}}$$

$$= \frac{23 \times 10^6 \times 14.7}{P} \times \frac{1728}{\pi R^2}$$

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31. (continued)

Accordingly, using $t = PR/\sigma$

$$V_0 = 2\pi R \times \frac{23 \times 10^6 \times 14.7 \times 1728}{P\pi R^2} \times \frac{PR}{\sigma}$$

$$= \frac{2 \times 23 \times 10^6 \times 14.7 \times 1728}{15,000}$$

$$= 78 \times 10^6 \text{ in}^3$$

At 0.28 pounds per ft^3, the weight = 22×10^6 pounds.

This evaluation shows that the total container weight is independent of the storage pressure and also independent of the specific container radius selected.

It is considered that standard wall piping would be the type of storage component which could be most readily obtained in a timely manner for the system. Use of 36-inch O.D. standard wall piping (0.375-inch thick) was selected based on the following considerations:

- Use of a smaller diameter standard wall pipe would result in a higher storage pressure, which has a higher potential for inadvertent system leakage. In addition, while the total volume of piping would decrease, the total length of piping would increase. Accordingly, the number of field welds which would be required would increase.
- Use of a larger diameter standard wall pipe is desirable in that the storage pressure and number of field welds would be reduced. However, the availability of piping decreases in the larger sizes, and the difficulty of performing field welds increases.
- Accordingly, while not optimized, use of 36-inch O.D. piping is considered a reasonable balance between availability, storage pressure, and ease of installation.

31. (continued)

Pertinent parameters for a system which employs 36-inch standard wall piping are as follows:

Storage Pressure

In accordance with the ASME Code, Section III, Subsection ND, (Class 3 components), Paragraph ND-3640:

$$P_a = \frac{2 \times S \times Et}{D_0 - 2\,yt}$$

Where:

P_a = allowable pressure, psig

S = allowable stress

= 15,000 psig for typical carbon steel material

E = weld joint efficiency

= 1, with 100% radiography and arc-welded joints

t = wall thickness = 0.375 inch

D_0 = pipe outside diameter = 36 inches

y = 4 for pipe with $D_0/t > 6$

Accordingly:

$$P_a = \frac{2 \times 15,000 \times 1 \times 0.375}{36 - 2 \times 4 \times 0.375}$$

$$= 340 \text{ psig}$$

Storage Volume

From above:

$$V_S = \frac{23 \times 10^6 \times 14.7}{P} \text{ ft}^3$$

$$= \frac{23 \times 10^6 \times 14.7}{340}$$

$$= 0.994 \times 10^6 \text{ ft}^3$$

$$\cong 1.0 \times 10^6 \text{ ft}^3$$

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31. (continued)

Length of Pipe

$$\text{Internal area} = \frac{\pi}{4}(36 - 2 \times 0.375)^2$$

$$= 975.91 \text{ in}^2$$

$$= 6.78 \text{ ft}^2$$

Therefore:

$$\text{Required length} = \frac{1 \times 10^6 \text{ ft}^3}{6.78 \text{ ft}^2}$$

$$= 147{,}000 \text{ feet}$$

$$\cong 150{,}000 \text{ feet}$$

Weight of Pipe

From ANSI B36.10-1975, the weight of standard wall 36-inch pipe is 142.68 lbs/ft. Therefore:

$$\text{Pipe weight} = 150{,}000 \times 142.68$$

$$= 21.4 \times 10^6 \text{ lbs}$$

Design Alternates

Parameters for various design alternates are defined in this section including (1) use of higher pressure piping, (2) use of a single large container, and (3) use of many standard gas storage bottles.

(1) Use of Higher Pressure Piping

The design pressure for 1.0-inch thick 36-inch piping is, in accordance with the previous section:

$$P = \frac{2 \times 15{,}000 \times 1.0}{36 - 2 \times 4 \times 1}$$

$$= 1{,}070 \text{ psig}$$

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31. (continued)

The weight of such piping compared to standard wall piping would be proportional to the wall thickness and inversely proportional to the design pressure, i.e.:

$$\text{Weight} = 21.4 \times 10^6 \frac{1.0}{0.375} \times \frac{340}{1,070}$$

$$= 18.1 \times 10^6 \text{ lbs}$$

Accordingly, there is no significant weight savings associated with thicker walled piping.

(2) Use of a Single Large Container

Assume a vessel equivalent in volume to the existing containment vessel, i.e., 2×10^6 ft^3.

In accordance with Section 3.a., the storage pressure for such a container would be:

$$P = \frac{23 \times 10^6 \times 14.7}{2 \times 10^6}$$

$$= 170 \text{ psig}$$

With a radius of about 60 feet (720 inches), the wall thickness of such a container would be:

$$t \cong \frac{170 \times 720}{15,000}$$

$$= 8.2 \text{ inches}$$

Such a container would likely be significantly more costly and would take longer to construct than a system which employs standard wall piping.

(3) Use of Standard Gas Bottles

Standard high pressure gas storage bottles per ICC-2265 have the following parameters:

- Storage pressure: 2,500 psig
- Hydro pressure: 5,000 psig
- Capacity: 277 ft^3 at STP

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31. (continued)

The required number of such bottles is therefore:

$$\frac{23 \times 10^6}{277}$$

Or 83,000.

The pipe and valve arrangement for a system which employed such bottles would be very complex because of the large number of bottles required.

Summary of Results

a. Design Parameters of Basic System

Pipe Size: 36-inch O.D. standard wall pipe (0.375-inch thick walls)

Storage Pressure: 340 psig

Storage Volume: 1×10^6 ft^3

Length of Pipe: 150,000 ft^3

Weight of Pipe: 21.4×10^6 lbs

b. Use of Higher Pressure Piping

Pipe Size: 36-inch O.D., 1.0-inch thick wall

Storage Pressure: 1,070 psig

Weight Savings: Negligible

c. Use of a Single Large Container

Container Volume: 2×10^6 ft^3

Storage Pressure: 170 psig

Required Wall Thickness (if carbon steel): >8 inches

d. Use of Standard Gas Bottles

Number of bottles required: 83,000

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Conclusions

Use of standard wall piping, about 36-inch diameter, is considered the most reasonable approach.

31. (continued)

Shielding Evaluation

The shielding evaluation contains a term which is related by geometry to the total gammas per second from Kr-85 disintegrations, S.

For 1 μCi/ml of Kr-85 and 2×10^6 ft^3 of containment volume, the total curies of Kr-85, C, is:

$$C = 1 \times 10^{-6} \times 2 \times 10^{6} \times 2.832 \times 10^{4}$$

$$= 56.6 \times 10^{3} \text{ curies}$$

With 3.7×10^{10} disintegrations per second, and 0.01 λ's produced per disintegration:

$$S = 56.6 \times 10^{3} \times 3.7 \times 10^{10} \times 0.01$$

$$= 2.1 \times 10^{13} \text{ λ's/sec}$$

1741 175

31. (continued)

Another common term in the shielding evaluation is D_R, the dose received in R/hr as a result of a gamma flux of 1 gamma per square centimeter per second. For the 0.5 Mev gammas from Kr-85, D_R equals 10^{-6}.

The subsequent evaluation is based on the methods and physical parameters contained in ANS/SD-76/14, "A Handbook of Radiation Shielding Data," dated July, 1976. This is referred to as "Ref. 1" in the following evaluation.

From Ref. 1, the dose for an infinitely long cylinder is:

$$D = \frac{D_R \times S_V \times R_0^2 \times B}{2\,(a + Z)}\ F\,(\pi/2,b)$$

Where:

S_V = volumetric source, λ's/cm^3-sec

R_0 = cylinder radius

B = buildup factor

$F(\pi/2,b)$ = Sievert's integral (Ref. 1, Page 2-9)

a = distance from outer surface to receptor

Z = effective cylinder radius considering self-shielding

$\cong$ R_0 for gas in 36-inch diameter pipe

b = μt

μ = attenuation coefficient for shielding materials, cm^{-1}

t = shielding material thickness, cm

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31. (continued)

(1) <u>High Activity Piping with Six-Inch Concrete Shielding</u>

As shown in Figure 8.4-1, the outer section of high activity piping contains 8/21 of the total high activity piping volume (which consists of 20 % of the total volume). Therefore, the volume of these outer pipes:

$$= 8/21 \times 0.2 \times V_S$$

$$= 0.076\ V_S$$

Where V_S = total storage volume

$= 1 \times 10^6\ ft^3$ @ 340 psig

Also, the fraction of activity removed from containment is:

$$f = [1 - e^{-V^1/V}]$$

Where V^1 = volume processed

V = containment volume

Therefore, the activity removed by the centermost building pipe sections, where V^1 is (0.2 - 0.076), or 0.124 of the total process volume ($23 \times 10^6\ ft^3$ @ stp), is:

$$f = [1 - e^{-(0.124 \times 23 \times 10^6 / 2 \times 10^6)}]$$

$$= 0.76$$

When 20% of the total volume is processed:

$$f = [1 - e^{-(0.2 \times 23 \times 10^6 / 2 \times 10^6)}]$$

$$= 0.90$$

Therefore, the outermost pipe sections contain (0.90 - 0.76) or 0.14 of the total activity.

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31. (continued)

The volume of these outer pipes is $0.076 \times 1 \times 10^6$ ft^3, or 2.15×10^9 ml.

Therefore:

$$S_V = \frac{0.14 \times S}{2.15 \times 10^9}$$

$$= \frac{0.14 \times 2.1 \times 10^{13}}{2.15 \times 10^9}$$

$$= 13.7 \times 10^2 \ \lambda\text{'s/cc-sec}$$

<u>a + Z</u>

$Z = R_0 = 1.5$ feet

$a = \sim 2$ feet minimum

$a + Z = 3.5$ feet $= 107$ cm

<u>R_0^2</u>

$R_0 = 1.5$ feet $= 45.7$ cm

$R_0^2 = 2.1 \times 10^3$

<u>F(π/2,b)</u>

The shielding consists of 0.375 inches of carbon steel pipe plus 6 inches of concrete.

Iron:

μ(0.5 Mev λ's) = 0.659 (Ref. 1, Page 5-10)

$t = 0.375 \times 2.54 = 0.953$

Concrete:

μ(0.5 Mev λ's) = 0.202 (Ref. 1, Page 5-11)

$t = 6 \times 2.54 = 15.24$

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31. (continued)

b:

$$b = 0.659 \times 0.953 + 0.202 \times 15.24$$

$$= 3.71$$

$F(\pi/2, 3171) = 1.5 \times 10^{-2}$ (Ref. 1, Page 2-9)

B

From Ref. 1, Page 5-22, B = 7.3.

Dose

Using values determined above:

$$\text{Dose} = \frac{10^{-6} \times 13.7 \times 10^{2} \times 2.1 \times 10^{3} \times 7.3 \times 1.5 \times 10^{-2}}{2 \times 10^{7}}$$

$$= 14.7 \times 10^{-4} \text{ R/hr}$$

$\cong$ 1.5 mr/hr from a single pipe

There are seven rows of pipes at the outer face of the building, the highest being approximately 30 feet elevation. Accordingly, the total dose would be about equivalent to that from three rows of pipes, or ~4.5 mr/hr.

This is less than the dose for a radiation area of 5 mr/hr and is acceptable.

(2) Low Activity Piping with No Concrete Shielding

As shown in Figure 8.4-3, the outermost sections of the low activity piping contain 40% of the total processed volume, or 400,000 ft^3. This is the last gas processed. The fraction of total activity contained in other pipe sections is thus:

$$f = [1 - e^{-(0.5 \times 23 \times 10^6/2 \times 10^6)}]$$

$$= 0.9990$$

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31. (continued)

Accordingly, the low activity piping contains 0.1% of the total activity.

$$S_V = \frac{1 \times 10^{-3} \times S}{V}$$

$$= \frac{1 \times 10^{-3} \times 2.1 \times 10^{13}}{400{,}000 \times 2.832 \times 10^{4}}$$

$$= 1.85 \ \gamma\text{'s/cc-sec}$$

The ratio of source strength from high and low activity sections is:

$$\frac{13.7 \times 10^{2}}{1.85} = 740$$

The results in the previous section show that with no concrete shielding, the dose would be increased by a factor of $1/[B \times F(\pi/2,b)]$, or:

$$\frac{1}{7.3 \times 1.5 \times 10^{-2}} = 9.1$$

Accordingly, the dose from low activity piping will be less than 9.1/740 x 100

= 1.2% of high activity piping

$\cong$ 0.012 x 4.5 = 0.05 mr/hr which is acceptable.

1741 180

32. Page 77, Section 8.4.3, Cost and Schedule Estimate.

Provide a detail breakdown to justify why it will take 25 to 35 months to design and construct this system.

Our architect engineer used standard industry estimating and scheduling techniques to determine the times and costs presented. The cost and schedule estimates are based on years of experience and considered judgement and are considered adequate for use by Metropolitan Edison. A more detailed estimate would require greater design detail, which would impose additional, unwarranted delays in solving the Krypton-85 problem.

See the answer to Question 30 for additional details.

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33. Page 85, Section 8.5.3, Cost and Schedule Estimates.

Provide a detail breakdown to justify why it will take 20 to 30 months to design and construct this system.

Our architect engineer used standard industry estimating and scheduling techniques to determine the times and costs presented. The cost and schedule estimates are based on years of experience and considered judgement and are considered adequate for use by Metropolitan Edison. A more detailed estimate would require greater design detail, which would impose additional, unwarranted delays in solving the Krypton-85 problem.

See the answer to Question 30 for additional details.

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