NSP

MONTICELLO NUCLEAR GENERATING PLANT

Monticello, Minnesota

UNIT I
(USAEC DOCKET 50 – 263)

ANSWERS TO DRL QUESTIONS
OF JUNE 3, 1971

OCTOBER 1971

NORTHERN STATES POWER COMPANY

MINNEAPOLIS, MINNESOTA

ANSWERS TO

DRL QUESTIONS OF JUNE 3, 1971

MONTICELLO OFF-GAS MODIFICATION

October 12, 1971

Northern States Power Company
414 Nicollet Mall
Minneapolis, Minnesota

TABLE OF CONTENTS

COMMENT

1. a. We understand that all the equipment of the proposed waste gas system and the structure in which it will be housed will be designed to withstand the Design Basis Earthquake (seismic Class 1), the Probable Maximum Flood (PMF) as defined by the Army Corps of Engineers, and the Design Basis Tornado (300 mph rotational and 60 mph translational winds with a 3 psi pressure drop in 3 sec).

RESPONSE

This response affects Section XII of the FSAR.

Both new structures housing the major process stream of the offgas modification are designed to withstand 0.12g horizontal and 0.08g vertical ground acceleration earthquake loading, flooding to 939.2 feet above mean sea level and a tornado with 300 mph rotational winds, 60 mph translational winds, and a 3 psi pressure drop in three seconds. The wind-carried missile considered in the design is a 35 foot utility pole (14 inches in diameter, 35 lbs/ft^3) with an impact velocity of 200 miles/hr. In the recombiner building, all equipment in the main process flow stream, up to and including all normally closed valves and all liquid level control valves, is designed to withstand the above earthquake loading. In the offgas storage building, the offgas storage tanks and all equipment not normally isolated or remotely isolable from the tanks are designed to withstand the above earthquake loading.

The seismic analysis of the modified offgas system and structures is being performed by John A. Blume and Associates, Engineers, who performed the seismic analysis for the remainder of the plant. The analysis is based on the earthquake criteria for the main plant as presented in the FSAR. The

soil-structure interaction was studied as part of the storage building analysis as the building is below grade. The calculational methods and techniques employed are the same as those described in Appendix A to the FSAR.

COMMENT

1. b. You will provide us with data on the operation of the recombiner using BWR effluents (including trace amounts of iodine).

RESPONSE

This response affects Section 9.3 of the FSAR.

The reference design recombiner is designed to operate with an inlet off-gas, diluent steam mixture temperature of 270°F, which provides about 80°F of superheat. During operation at the design hydrogen flow rate of 76 cfm (Table 9-3-1 below), the recombiner bed will operate at an outlet temperature of about 700°F; at the measured hydrogen flow rate of 54 cfm (Table 9-3-1 below), the recombiner bed will operate at an outlet temperature of about 600°F.

The reference design recombiner for the Monticello modified off-gas system is one available from Air Products and Chemicals, Inc. (APCI) of Allentown, Pa. Catalytic recombiners have been employed by Air Products in gas processing systems since 1953. The vessel design and catalyst (NIXOX) to be provided have been used since 1962. The NIXOX catalyst is 0.5 weight percent palladium on Al_2O_3-SiO_2 (tradenamed Kaolin) pellets as a base material. Air Products and Chemicals has wide experience in the design of these catalysts and of similar catalytic recombiner systems. Some of the advantages seen in the APCI design are:

1. The all welded vessel design that can be utilized with a pelletized catalyst elimir.ates the full diameter closure flanges making the vessel less prone to leakage.

2. The Kaolin support material for the catalyst provides very large surface area-to-mass ratios, thus providing greater reaction completion per inch of bed depth.

3. The recombiner system in operation at KRB in Germany successfully uses Aluminum-S'licate as catalyst support material, and spherical Kaolin catalyst was tested in steam by General Nuclear Engineering Corporation in 1965 as part of a Euratom Program. (Report No. CEND-529 of March 1, 1965, entitled "Investigation of Catalytic Recombination of Radiolytic Oxygen and Hydrogen").

4. The reactance of the APCI recombiner catalyst is such that a reaction will occur at a lower temperature (270°F) than for some competing catalysts. As the conversion (hydrogen plus oxygen to water) efficiency increases with temperature, the conversion efficiency for a given temperature will be greater for the APCI recombiner.

The APCI design methods for setting bed size and depth have been reviewed. A computer program is utilized which has emperical diffusion and reaction constants for calculating reaction rate, bed depth, and effluent hydrogen concentration. The catalyst bed provided is three times that calculated to meet the warranted performance specification.

To reply to the specific comment, the design composition of the off-gas stream is given in Table 9-3-1 of the FSAR (repeated below together with the results of a typical off-gas sample from the Monticello Plant). Among these constituents, the ones of concern with respect to recombiner operation are the water vapor and the fission gases (halogens).

TABLE 9-3-1

GASEOUS RADWASTE SYSTEM
AIR EJECTOR OFFGAS COMPOSITION

	Design cfm at 130°F, 1atm	Measured cfm at 130°F, 1 atm
Hydrogen	76	54
Oxygen	37	27
Air (assumed condenser leakage)	12 - 28	6 - 7
Water Vapor	22 - 25	*
Fission and Activation Gases	Negligible	---
Total	147 - 166	87 - 88

* Data based on dried sample, so water vapor data not available.

Catalyst wetting is avoided by preheating the diluted offgas to at least 50°F superheat. Warming steam is retained on the standby recombiner to insure a dry catalyst bed for ready availability of the standby system. Recognizing that there will be infrequent occasions when recombiner trains are completely shut down and condensation will form on the catalyst, performance has been evaluated in this regard in the laboratory, viz, moisture has been allowed to form in the pores of the catalyst with no perciptible loss of activity noted following return to dry conditions. Drying is accomplished simply by restoring superheated flow conditions. This testing was accomplished using a bed of 3.26 in diameter and depth of 4.6 inches or about 0.022 ft^3. This results in a scale factor of about 750 with the reference design. Further testing of the reference design is being carried out by the prospective vendor.

With respect to iodine, a number of experiments were performed in Air Products' laboratories in early 1970 to determine the effect of trace amounts of iodine and methyl iodide on the activity of NIXOX (0.5 weight % palladium on Kaolin) and other recombination catalysts. Both platinum and palladium catalysts were found to be subject to poisoning by iodine and methyl iodide. The data provided a quantitative description of the poisoning effect so that poison capacity curves could be established which permit prediction of catalyst performance.

Most of the 1970 experiments were performed at 70°F and 30 psia with a reactor (recombiner) containing 10 grams of NIXOX catalyst. The reactor feed contained 5 to 25 ppm of oxygen and 0.33% (volume) of hydrogen in nitrogen. Poisons were introduced in water solutions which were vaporized to completely humidify the feed gas. Oxygen effluent concentrations were measured as a function of time during each run.

Figure 1 illustrates the cumulative poisoning effect of 0.14 ppm of iodine in the feed. The fraction of the bed poisoned was determined using the measured inlet and outlet concentrations of oxygen and calculating the required bed depth to achieve these conversions. The difference between the required bed depth and the actual bed depth was that portion of the bed which was poisoned.

Figure 2 illustrates the cumulative poisoning effect of 2.68 ppm of methyl iodide in the feed. The initial rate of poisoning here is much higher than that measured with iodine. As in the iodine run, the rate of poisoning slows with time and the fraction of the bed poisoned approaches a constant value.

Figure 3 illustrates the same data plotted on a poison capacity basis. These curves (and similarly derived curves) have been used to predict the fraction of NIXOX bed which will be poisoned as a result of cumulative addition of iodine or methyl iodide.

It is expected that the average concentration of iodine in the diluted offgas flow to the recombiner will be about 10^{-8} PPM. If the iodine concentration is considered to be 100 times higher than this maximum and the flow to the recombiner is continuous at the design rate for 10 years, the cumulative amount of iodine at the end of this period would be 3.6 grams. For a bed volume of 14.7 cubic feet, the iodine loading would be 0.24 grams per cubic foot of bed. From Figure 3, the fraction of the bed poisoned at this iodine level is extremely small, perhaps 1% of the total. Therefore, it is expected that the effect of iodine poisoning will be insignificant in this application.

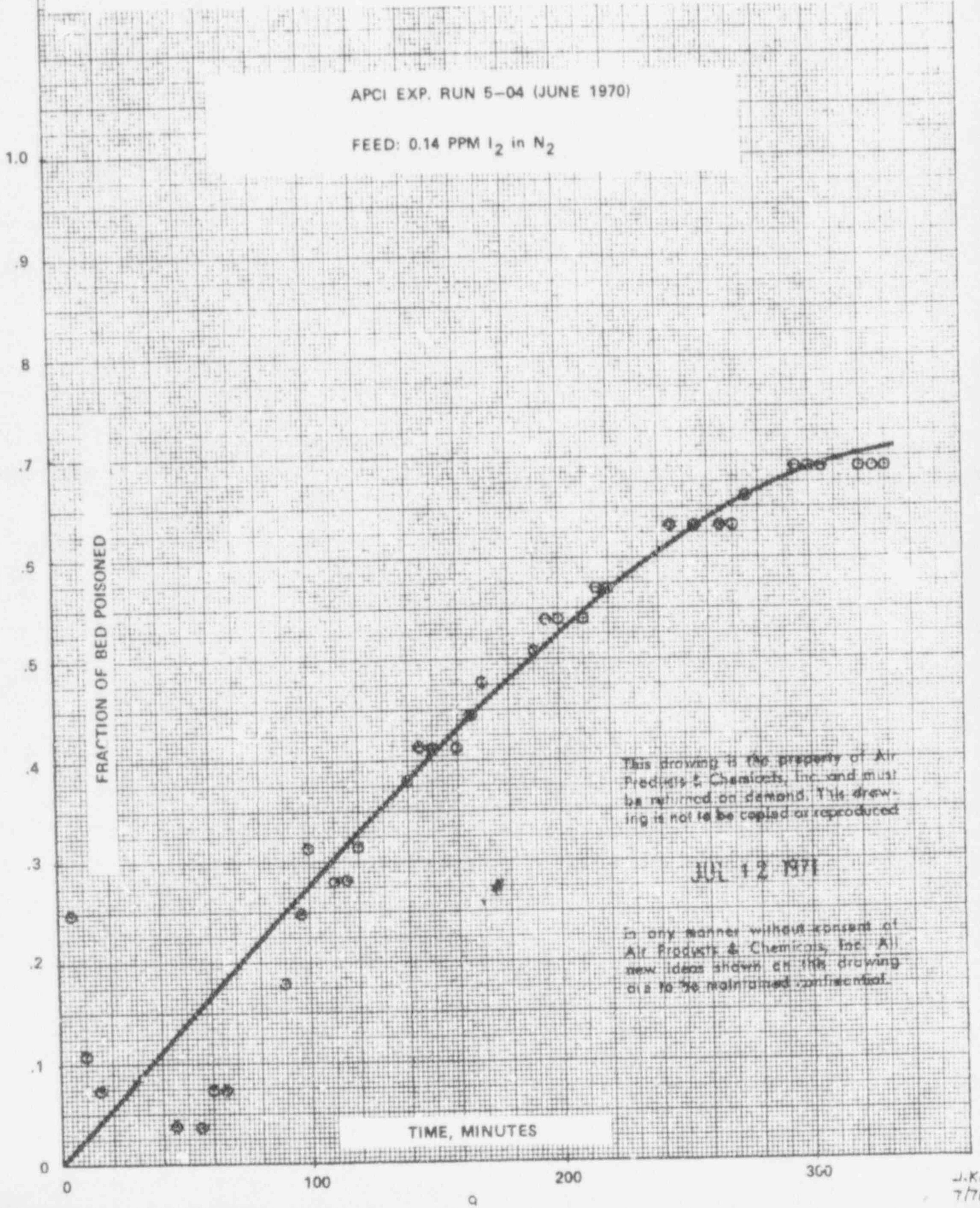
The 1970 experimental work also indicated that operation at elevated temperatures reduced the poisoning effect of i e and methyl iodide. Therefore, the use of low temperature poisoning data is considered conservative. In addition, there is some evidence that for the same loading (grams of iodine per cubic foot of bed), high feed concentrations are more detrimental to the catalyst activity than low feed concentrations. From this point of view, use of the laboratory data is again conservative.

Poisoning experiments were also performed in 1971 with a steam carrier gas containing 2.8 PPM of methyl iodide. The gas was fed to an adiabatic reactor (recombiner) containing 5 grains of NIXOX catalyst. Quantitative poisoning data were not obtained but it was demonstrated that at the experimental conditions the activity of the catalyst did not change radically with methyl iodide addition. Figure 4 illustrates data from one of the runs with a feed containing 1.9% hydrogen entering the recombiner at 295°F. As seen, the effluent hydrogen concentration remained relatively constant at about 4100 PPM despite the increasing load of I_2. These data further suggest that the use of the low temperature poisoning curves for the prediction of catalyst performance is conservative.

The expected radiation exposure to the catalyst bed is about 50,000 rads/year or an average of 6 rads/hr. At that incident dose level, the amount of energy absorbed in the reactant stream or the recombiner catalyst would not be expected to affect the activity of the catalyst. In addition, a similar recombiner catalyst has operated about 4 years at the KRB plant in Germany with negligible degradation from either radiation or other effects.

FIGURE 1

THE POISONING OF NIXOX CATALYST WITH IODINE

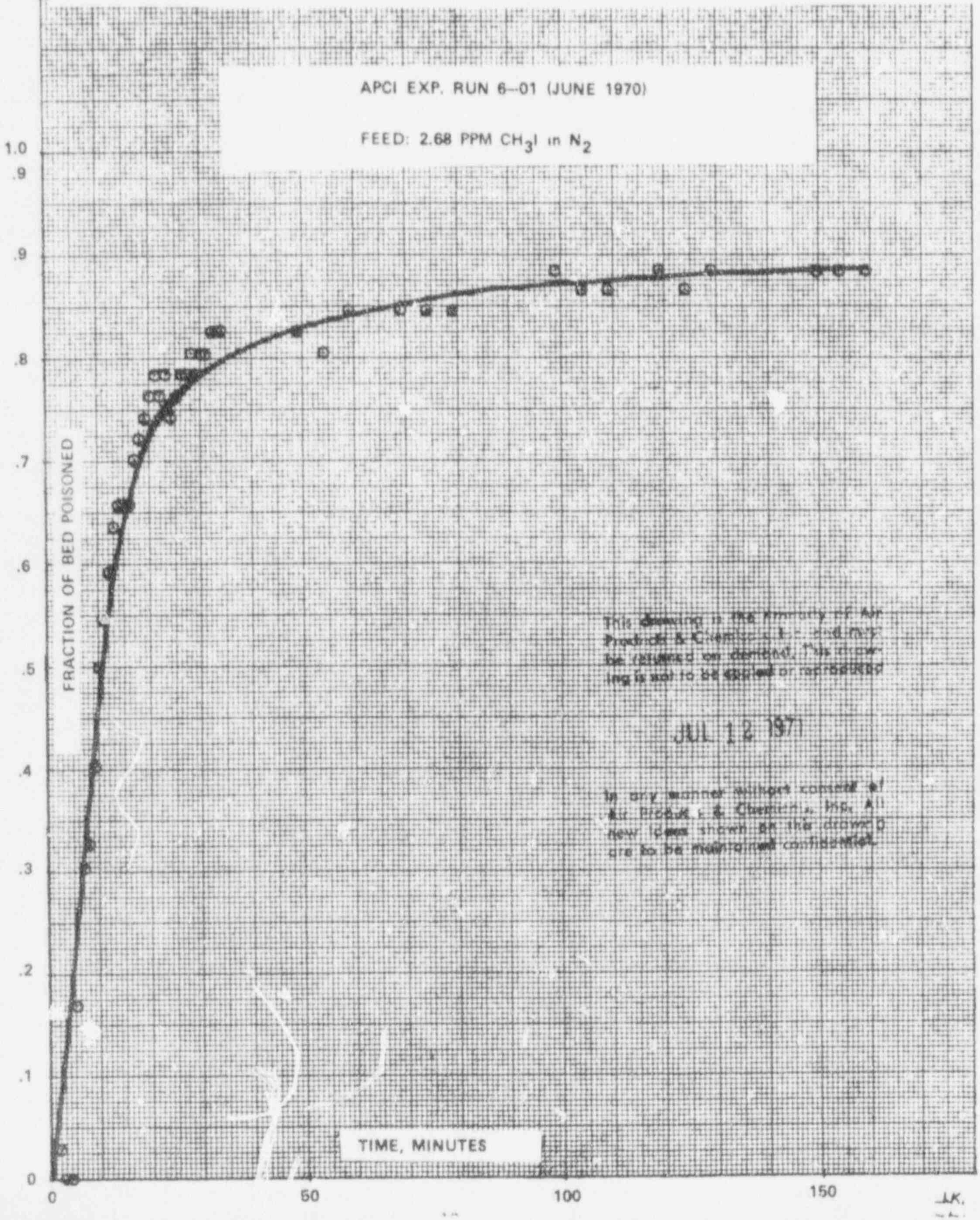


Air Products and Chemicals INC.

ALLENTOWN, PENNSYLVANIA, U. S. A.

FIGURE 2

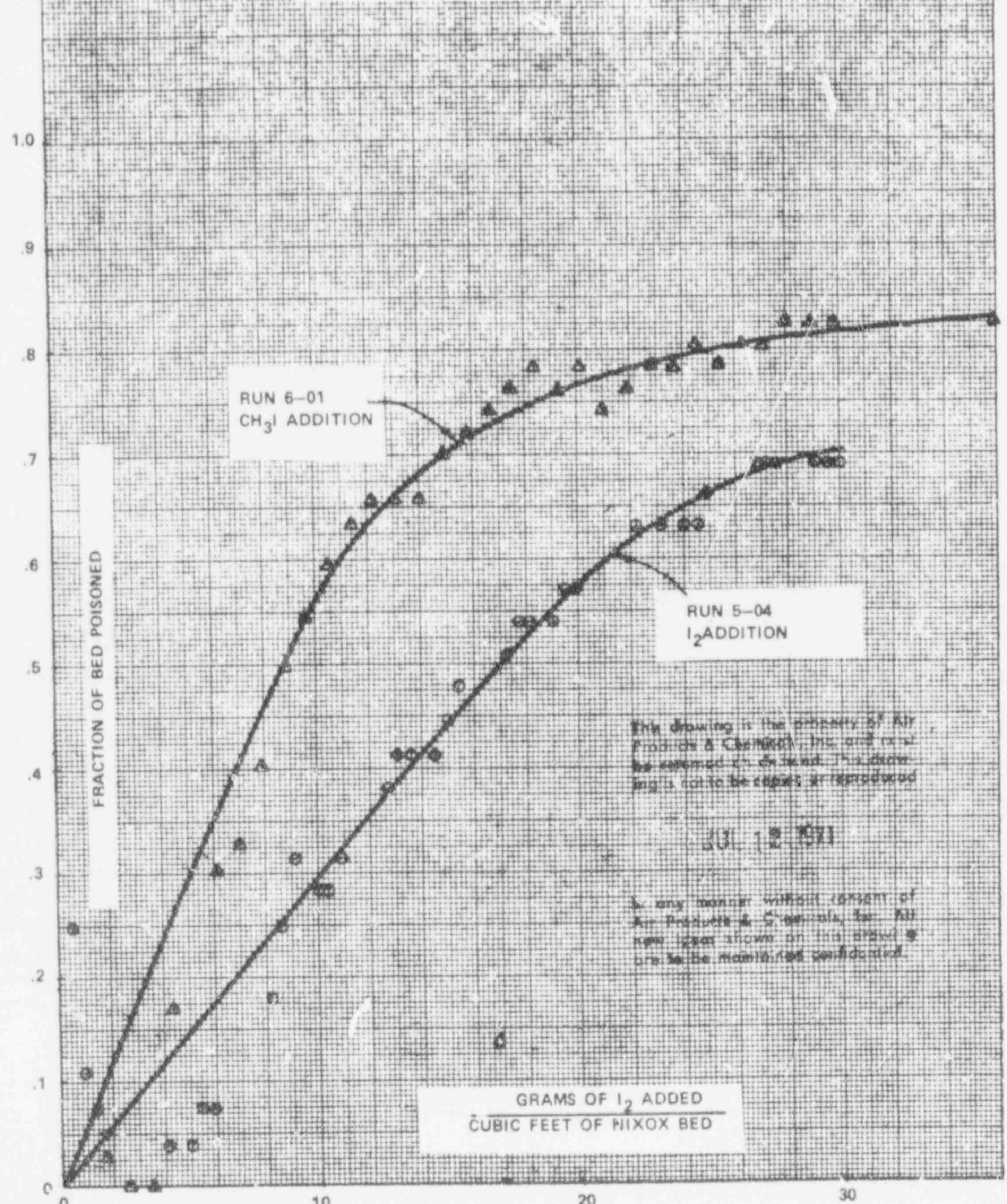
THE POISONING OF NIXOX CATALYST WITH METHYL IODINE



Air Products and Chemicals INC.

FIGURE 3

THE POISONING OF NIXOX CATALYST WITH IODINE AND METHYL IODINE

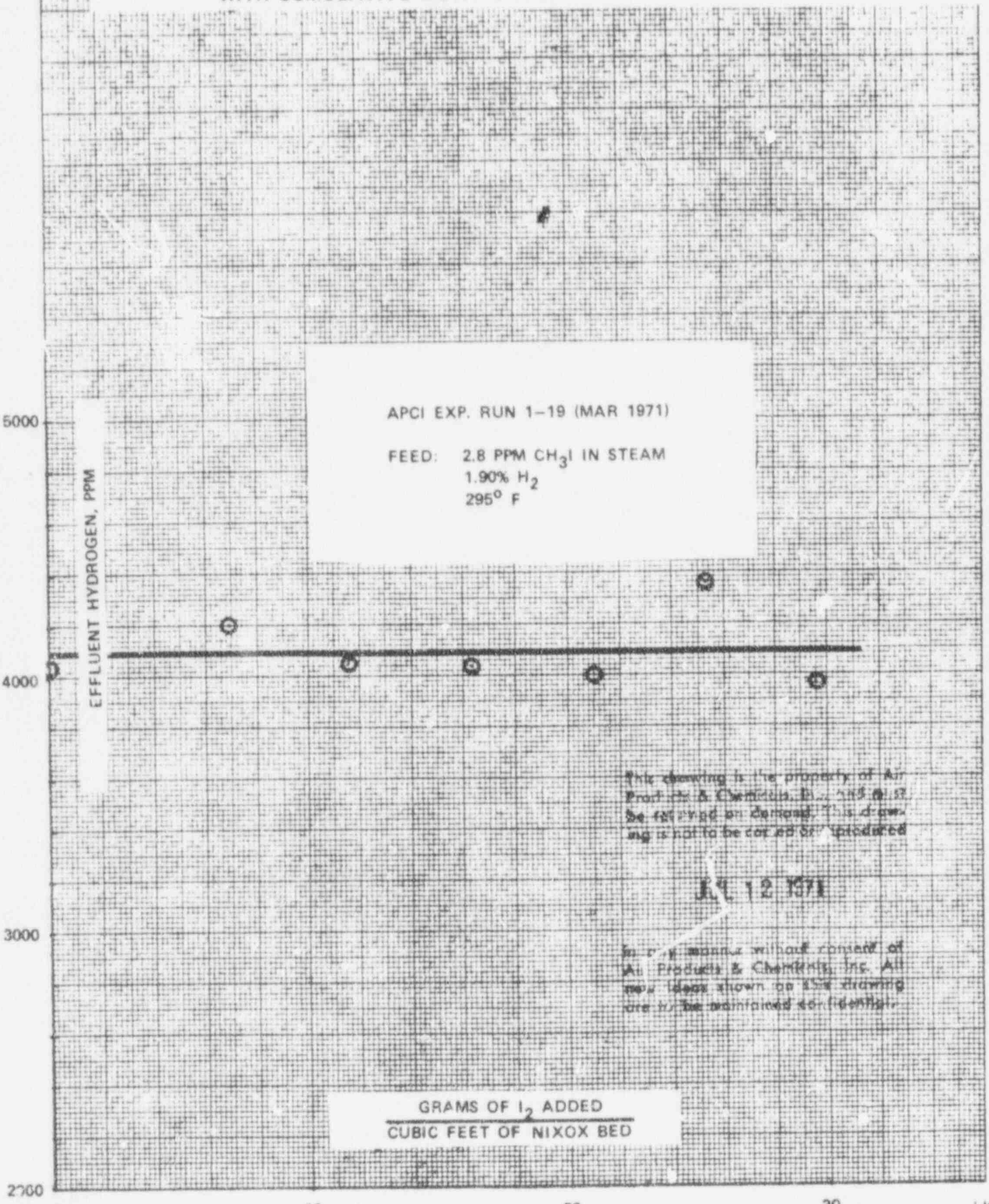


J.K.

Air Products and Chemicals INC.

FIGURE 4

THE VARIATION OF THE EFFLUENT HYDROGEN CONCENTRATION WITH CUMULATIVE METHYL IODINE ADDITION



COMMENT

1. c. The equipment from the air ejector to the compressor will be designed to 350 psig.

RESPONSE

This response affects Section 9.3 of the FSAR.

All offgas equipment and piping systems being installed for this modification from the air ejector condenser to the inlet to the air compressor will be designed to a minimum pressure of 350 psig in accordance with the 1971 edition of the ASME Boiler and Pressure Vessel Code, Section III, Class 3.

COMMENT

1. d. There will be a particulate filter upstream of the compressors.

RESPONSE

This response affects Section 9.3 of the FSAR.

Redundant high efficiency particulate filters are employed in the compressor suction header to preclude transport of significant quantities of radioactive daughter products into the offgas compressors or the storage tanks, and similarly redundant charcoal filters are provided within the same filter bodies to minimize the iodine and other halogen activities in the storage tanks.

The high efficiency particulate filters specified are MSA Model 15-85202 with a DOP removal efficiency of 99.97% for 0.3 micron particles. They have an original pressure drop of 0.9 inch of water at 40 cfm and a maximum design drop of 10 inches of water. Differential pressure across the filters will be alarmed in the main control room. The filters are expected to require replacement no more often than reactor refueling intervals, but one cartridge can be replaced with the other filter in operation. The filters have individual local lead shielding and provision for remote transfer of spent cartridges into a shielded cask has been made through an access plug in the building roof. ther filter assembly can be purged with air to the storage tanks prior cartridge replacement.

In addition, sampling taps are provided so that periodic efficiency tests can be performed on both the particulate and charcoal filters.

COMMENT

1. e. You will explain how liquid discharges are handled from dilution stream and from the recombiner.

RESPONSE

This response affects Section 9.3 of the FSAR.

The dilution steam and the water vapor produced from recombination of the radiolytic hydrogen and oxygen in the catalytic recombiner are condensed to liquid form in the recombiner condenser. A level control system on the recombiner condenser hotwell controls the discharge of these liquids into a drain flash tank, which also receives liquid discharges from the preheater and from steam traps serving the steam supply piping for this subsystem. Some flashing of the liquid drains will occur due to the lower pressure in the flash tank (approximately 8 psia). The flashed steam will be returned directly to the main turbine condenser via a pressure control valve. The remaining liquid will then be passed through a drain cooler, wherein it will be cooled to near main turbine condenser saturation temperature. A liquid level control system on the flash tank will control flow of the cooled liquid back to the main turbine condenser. The revised P&ID submitted in response to comment 1(g) reflects this system.

Return of these drains to the main turbine condenser is satisfactory because the drains are composed entirely of condensed reactor steam and chemically pure recombined water vapor. There are no materials in the recombiner subsystem to which the steam or the condensate are exposed which are not compatible with primary water chemical requirements. The recombiner aftercondenser and the flash tank drain cooler are both cooled with primary system condensate, so minor inleakage from these components presents no difficulty.

Particulates returned to the main condenser will be filtered out in the condensate demineralizers. Dissolved gases in the liquid will be released in the condenser and recycled to the air ejectors.

COMMENT

1. f. You will provide us with a list of changes made to the system since Change No. 2 was filed with the AEC.

RESPONSE

This response affects Section 9.3 of the FSAR.

A revised Offgas Modification Report is provided herewith in response to this comment. All changes made are designated as revision C in the text; the major changes are as follows:

1. The whole body dose calculations contained in the Offgas Modification Report and in the responses to AEC comments #4,5 and 6 herein have been normalized to the General Electric dose calculations contained in Appendix B to the FSAR rather than the AEC calculations that are the basis for the existing technical specification limits. This change was required because it was not possible to develop a calculational model that would reproduce the basis for the current limits and that could be used for subsequent calculations.
2. The accident doses were modified using a revised X/Q and to include the contribution of particulates and halogens, as requested by AEC comment #6.
3. Building and component design and fabrication criteria have been upgraded as defined in the responses to comments #1a and 1c.
4. The recombiner shutdown system has been designed to meet a single failure criteria.
5. Charcoal filters have been added in gas compressor inlet.

COMMENT

1. g. You will revise the existing drawings in Change Request No. 2 to include all instrumentation.

RESPONSE

This response affects Section 9.3 of the FSAR.

Revised piping and instrumentation drawings are included in the revised Design Modification Report submitted herewith.

COMMENT

1. h. You will provide us with information explaining the operation of the unit under normal and abnormal conditions.

RESPONSE

Please refer to the enclosed design report, Operating Concepts, which explains the operation of the modified offgas system.

COMMENT

2. In Change Request No. 2, you state that "the shock wave of a hydrogen detonation could conceivably travel through the recombiner and underground holdup pipe to the compressor suction." Designers of other similar systems have stated that there may be a possibility of a hydrogen explosion propagating throughout the system. It should also be noted that the flammable concentration of hydrogen rises as the mixture is compressed:

   a. Explain why a hydrogen explosion throughout the system should not be considered, and

   b. Explain your conclusion that the shock wave would not be propagated beyond the compressor suction.

RESPONSE

This response affects Sections 9.3 and 12 of the FSAR.

a. The possibility of a hydrogen explosion throughout the proposed system is considered incredible because the proposed control and instrumentation system has been designed to prevent an explosive mixture of hydrogen from propagating beyond the recombiner system; i.e. an explosive mixture of hydrogen will never propogate beyond the 42 inch, 30 minute decay pipe into the storage tanks.

This is accomplished by providing fully redundant hydrogen analyzers on the outlet from each recombiner system that initiate recombiner system shutdown and terminate all off-gas flow if the hydrogen concentration at the system outlet exceeds 2% by volume (the hydrogen flammability limit is 4% by volume and the detonation limit is ~15% by volume). These sensor and shutdown systems are designed with sufficient redundant equipment so that no one undetected fault in an active component will render the systems inoperable,

and the systems will be periodically tested to confirm continued operability. In the event of an automatic shutdown, three main stream process valves close to isolate the recombiner system (system flow control valve, FCV-12 or 13; recombiner inlet valve TCV-3B or 4B; and system outlet valve FCV-16 or 17 as shown on Drawing NF-51134-E). Additionally, the recombiner bed temperatures and recombiner outlet temperature provide insight into recombiner performance to insure that flammable hydrogen mixtures do not get beyond the recombiner.

b. Should a number of unlikely events occur, it would be hypothetically possible for a hydrogen explosion to occur in the recombiner system. Such an explosion within the recombiner system could result in an airborne shock wave propagating into the existing 42 inch decay pipe. There would not be an explosion in the decay pipe, and the shock wave from the recombiner system would be attenuated by its expansion into the 5000 ft^3 decay pipe and further attenuated in the interconnecting piping system and HEPA/ charcoal filter in the compressor suction.

Calculations indicate that the overpressure associated with any shock wave propogating from the recombiner system would be attenuated to about 1/10 of its initial value by the effects of expansion and subsequent propogation through the various piping systems to the air compressor inlet filter. To fully insure that no potential shock wave could reach the air compressors, the charcoal filter element has been designed to withstand the full 350 psig over-pressure without failure, and thus the filter element will reflect and/or absorb any potential shock wave to insulate the air compressor from the recombiner system.

COMMENT

3. Describe the mechanical and/or electrical interlocks that will be installed and explain the precautions that will be taken so that the wrong tank is not vented. Explain how you will reduce the potential for operator errors.

RESPONSE

This response affects Section 9.3 of the FSAR.

To prevent an operator error involving the simultaneous opening of the fill and discharge valves on a single tank, which could align the compressor discharge directly with the discharge header to the offgas stack, an electrical interlock has been provided which consists of a three-position switch for fill, isolate, and discharge modes. Since the switch can be set to only one mode at a time, the system will not energize both the fill and discharge valves at the same time.

To prevent opening of a tank fill valve when the solenoid operated, fail-closed discharge valve has stuck open, a second electrical interlock has been provided which prevents opening of the fill valve unless the closed position limit switch on the discharge valve has been actuated. This provides additional, positive assurance that both valves will not be opened simultaneously.

The normal operating procedure to be followed upon receipt of a signal in the control room that a tank has been filled is to: (1) isolate that tank, (2) open the fill valve to the tank previously emptied, (3) select the tank with the lowest radiation monitor reading, (4) open its discharge valve, and (5) adjust, if necessary, the discharge flow rate to a level slightly greater than the offgas flow rate at the inlet to the buried pipe so the tank will be empty by the time the next tank is filled. The tanks are not routinely sequenced because of the inherent advantage of being able to decay a tank containing an abnormally high quantity of radioactivity for a longer period of time.

To reduce the potential for releasing the wrong tank, eitner as a result of equipment malfunction or operator error, the radiation indicators for the tanks are positioned in a horizontal row on the offgas control panel; the fill-isolate-discharge valve switch for each tank is located directly below the indicator for that tank; position lights for the valves are also located in line with the indicator and switch for that tank. In addition, to reduce the consequences of selecting the wrong tank for discharge, a bank vault type of timing device has been provided which serves as an interlock to prevent opening of a tank discharge valve until the control switch has been in the isolate mode for at least twelve hours. For a diffusion mixture of offgas, a tank will have decayed to less than 10% of the dose potential of a newly filled tank after twelve hours; thus an error in the selection of a tank after at least twelve hours decay is relatively insignificant. This interlock has a key type over-ride for use under abnormal conditions where it might be desirable to release a tank with less than twelve hours of decay time.

COMMENT

4. You have calculated the radiological consequences at the nearest site boundary of routine and accidental releases. Provide the meteorological parameters and distances that were used to derive the atmospheric dispersion factors for these calculations.

RESPONSE

This response affects Section 14 and Appendix B of the FSAR.

A. Routine Releases

The routine releases from the plant include three types: (1) elevated stack release of noble gases and particulates, (2) ground level releases of noble gases and particulates, and (3) elevated stack releases of halogens and particulates.

(1) Elevated Stack Releases of Noble Gases and Particulates (Gamma)

These radiological doses have been evaluated based on the meteorological data presented in Section 2 of the Monticello FSAR for a receptor at 950 meters to the South South East, utilizing equation 7.63 of TID-24190 "Meteorology and Atomic Energy".

$$_{\gamma}D_{(R,\theta_1,0)} = \frac{0.2865\,\Delta t}{\theta R}\left[\sum_{i=1}^{l}\sum_{j=1}^{m}\sum_{k=1}^{n}\frac{P_{\theta_{t(j,k,\theta_1)}}\,Q'_{R(i,j,k)}}{\bar{u}_j} \times \mu_{a_i}\,\bar{E}_{\gamma_i}\,(I_1 + kI_2)_{(i,j,k)}\right]$$

where $Q_{R(i,j,k)}$ = source term (release rate) of isotope type i corrected for depletion by ground deposition and radioactive decay en route to receptor location

$= Q'_0\left[\exp\left(-\lambda_i \frac{R}{\bar{u}_j}\right)\right](Q_x/Q_0)_{d_{j,k}}$ (curie/sec)

$(Q_R/Q_0)_{d(j,k)}$ = depletion factor for ground deposition

$$= \exp\left[-\left(\frac{2}{\pi}\right)^{\frac{1}{2}} \frac{v_d}{\bar{u}_j} \times \int_0^R \frac{\exp\left(-\frac{h^2}{2\sigma_{z_k}^2}\right)}{\sigma_{z_k}} dR\right]$$

or equivalent Sutton form

$(\bar{I}_1 + k\bar{I}_2)_{i,j,k}$ = function of μ_i, σ_{z_k}, and $\bar{u}_j$ evaluated from Table 7.23 of TID-24190

$\bar{u}_j$ = average of wind speed range j (m/sec)

σ_{z_k} = standard deviation of plume concentration in vertical plane for stability class k (m)

$P_{\sigma_z(j,k,\theta_1)}$ = joint probability of wind speed and atmospheric stability into sector θ_1

Δt = exposure time interval (sec)

θ = angular width of sector θ_1 (radians)

R = distance from release point (m)

This calculational method was checked against the comparable calculations contained in Appendix B of the Monticello FSAR for the existing 30 minute off gas system. The results agreed within 4%, confirming the acceptability of the above method.

(2) Elevated Stack Releases of Noble Gases and Particulates (Beta)

Since beta radiation has a limited range of 1 to 10 meters in air, the beta dose at the fence post depends mainly upon the concentration of radioactive materials in the immediate vicinity of the receptor. Accordingly, the ground level concentrations at 950 meters to the South Southeast from Section 3.3 and Table B-3-4 of Appendix B of the Monticello FSAR were utilized to develop the suitable $X/Q = 4.37 \times 10^{-8}$ sec/m^3. Beta doses were then computed utilizing equation 7.21 of TID-24190 "Meteorology and Atomic Energy":

$$D = 0.23 \frac{X}{Q} Q \bar{E}$$

Where D = beta dose, rads /sec.

$\frac{X}{Q}$ = time integrated dilution factor, sec/m^3

Q = Radioactive source term, curie /sec.

$\bar{E}$ = average energy of beta particles per disintegration, Mev/dis

(3) <u>Ground Level Releases of Noble Gases and Particulates (Gamma and Beta)</u>

The average dilution factor X/Q was computed for the reactor building release height of 50 ft. for a receptor at 950 meters to the South Southeast using the following diffusion equation:

$$X/Q = \frac{\sqrt{2}\ \pi}{B} \sum \frac{F_i f_i}{\sigma_z \bar{u} x}$$

Where B = 0.397 for a 22.5° sector

F_i = wind direction frequency in 22.5° sector

f_i = diffusion regime frequency

$\bar{u}$ = wind speed in meter/sec

x = distance in meters; i.e. 950 meters

σ_z = vertical diffusion coefficient in meters

Metorological data for an elevation of 140 ft. from Tables 2-3-13 (Class F), 2-3-14 (Class E), 2-3-15 (Class D) and 2-3-16 (Class B) of Section 2 of the Monticello FSAR were utilized to develop, for the above four diffusion regimes, wind direction frequencies (F) and diffusion regime frequencies (f) for winds blowing from the North North West (i.e. a receptor in the South Southeast). To compensate the results for the height reduction (50 ft. release point compared to data at 140 ft.), the average wind speeds were reduced as follows:

$$\frac{\bar{u}\ (50\ ft)}{\bar{u}\ (140\ ft)} = \left(\frac{50}{140}\right)^n$$

where n varies with diffusion regime (n = 0.25 for Class B; n = 0.35 for Class D; n = 0.45 for Class E; and n = 0.50 for Class F). The vertical diffusion coefficient for each meteorological diffusion regime was obtained from Figure A.3 of TID-24190 "Meteorology and Atomic Energy".

The resulting X/Q was calculated to be 2.6×10^{-6} sec/m^3 and this value was utilized together with a standard, semi-infinite cloud model as in (2) above for computing both the beta and gamma doses.

(4) Elevated Stack Releases of Halogens and Particulates

Data presented in Section 3.3 and Table B-3-4 of Appendix B of the Monticello FSAR were utilized to compute the concentration of halogens at the worst case location - 950 meters to the South South East. For this location, a stack release rate of 1 Ci/sec results in an annual average air activity concentration of 4.37×10^{-8} μc/cc for any isotope; i.e., a X/Q of 4.37×10^{-8} sec/m^3.

B. Accident Releases

In the analysis of accident conditions, two different values for X/Q have been used. For ground level releases away from major structures on site, such as releases from the storage tanks, several conditions may be postulated. First, a slow release of the contents of the tanks will result in the lowest value for atmospheric dilution since the release is essentially a point source with no wake factor correction. For the closest site boundary distance of 500 meters during Class F stability with 1 meter/sec winds the resultant X/Q = 2.12×10^{-3} sec/m^3.

For rapid depressurization of the tanks, however, the initial expansion of the compressed gases will result in an initial cloud dimension which is dependent upon the number of tanks failing. Using the initial expanded gas cloud dimensions, a virtual source correction added to the 500 meter site boundard distance results in a X/Q = 1.13×10^{-3} sec/m^3 for the postulated five tank failure.

COMMENT

5. Evaluate the expected annual "fence post" doses at the most critical post offsite due to releases from 1) containment purging, 2) steam turbine gland seal leakage, 3) HPCI turbine testing, 4) plant ventilation systems, 5) plant startup, 6) leakage from the proposed pressurized off-gas system, 7) liquid radioactive waste system vents, and 8) direct radiation shine from unenclosed tanks containing radioactive fluids. Present the bases for these doses including assumed source terms, rates and duration of releases and type of release (ground level or elevated stack).

RESPONSE

The annual "fence post" doses from the seven plant sources of airborne activity listed above have been evaluated and are summarized in Table 5-1. The bases for these doses are given in the following sections and in the response to Comment #4. In all cases, the effective energies used in these evaluations were obtained from the "Table of Isotopes", Sixth Edition.

The overall plant "fence post" gamma whole body dose of 4.5 mrem/year and the overall plant "fence post" beta skin dose of 1.3 mrem/year are well within the recent AEC Guideline of 10 mrem/year.

5.1 Containment Purging

The estimated activity released to the plant stack for each containment purge operation is indicated in Table 5-2. The activity release to the containment is based on a technical specification limit leakage rate of 25gpm with fission product concentrations in the reactor coolant corresponding to a stack release rate of 0.27 Ci/sec at 30 min. A steam leak is assumed to have existed for 6 months prior to shutdown and after an instantaneous shutdown the leak decreases linearly until the reactor is depressurized in 6.7 hours. The activity concentration in the leaking steam is taken the same after shutdown as during operation. Containment purging at 4000 cfm through the standby gas treatment system is assumed to start at shutdown with only enough delay to allow N-16 decay. For the particulates, 50% plateout in the containment and a SBGT system removal efficiency of 99% are assumed.

Tritium release is based on 4000 cfm of air being saturated with water vapor at $100^{\circ}F$. The tritium in the water is taken as 1.3×10^{-2} $\mu Ci/cc$ which is estimated to be the concentration in the plant water after ten years of production at 0.15 $\mu Ci/sec$ with no release. Argon-41 was calculated from the equilibrium activity in the drywell due to activation of Argon in the air.

5.2 Turbine Gland Seal Packing Exhauster

The estimated activity released to the stack from the main turbine gland seal packing exhauster is shown in Table 5-3. These values are based on a steam flow to the gland seal packing exhauster of 4730 lb/hr and an air flow from the exhauster of 387 scfm, which are the system design values with normal glands. This steam flow is 0.07% of full power rated steam flow; hence the fission product activation gas source is 0.07% of the SJAE source presented in Table 6-1. The values in Table 5-3 are based on a SJAE source of 0.27 Ci/sec diffusion mixture after 30 minutes. This air flow (and associated vapor) results in a holdup time of 3.5 minutes in the buried holdup pipe. The particulates included in Table 5-3 are the total calculated to be born from decay of the noble gas fission products in the 3.5 minute delay line. There is assumed to be no plateout of particulates in the delay line.

5.3 HPCI Testing

The HPCI turbine utilizes a maximum of 112,000 lb/hr of primary steam during test operations. All but 500 lb/hr is condensed in the suppression pool. The activity associated with the steam condensed in the suppression pool accumulates in the torus where it decays with the remaining material discharged only when the torus is purged. (This activity is less than 1% of that due to primary system leakage discussed in section 5.1.) The 500 lb/hr is the HPCI turbine gland design leakage which is condensed in the HPCI gland seal condenser with the non-condensible gases exhausted to the main gland seal discharge holdup line. The non-condensible flow is estimated to be 25 cfm which has only a small effect on the 3.5 minute holdup time. The HPCI testing results in an additional activity release to the stack equal to 10% of the values indicated in Table 5-3 for the main gland seal exhauster. Monthly tests of the HPCI have been performed with test duration times between 1/2 hour and 3 hours with 1/2 hour the norm. Accordingly, a total of 6 hours of HPCI testing annually was assumed. The annual dose due to HPCI testing is therefore $(0.1 \times 6/8766)$ or 6.8×10^{-5} times the gland seal exhauster dose.

5.4 Plant Ventilation

Activity released in the plant ventilation air is shown in Table 5-4. The values are based on measured airborne concentrations at Dresden-1, as reported in Public Health Service Report BRH/DER 70-1, adjusted to account for increased offgas activity and the different containment design. In addition, the noble gas fission products from a 250 lb/hr steam leak are assumed mixed with the ventilation air and released after an average 30 minute delay. The tritium in this 250 lb/hr of steam is released along with an amount based on Humboldt Bay data for airborne tritium above the reactor during refueling.

As a check on these ventilation results, reactor building ventilation air activities measured at the Monticello plant during July, August and September 1971 were extrapolated on a straight line basis to activity levels that could be expected with stack noble gas activity levels of 270,000 uc/sec. The measured results (at several stack noble gas activity levels) are presented in Table 5.5 together with the extrapolated values. Comparison of the extrapolated results in Table 5.5 with the Iodine-131 and total particulate activities in Table 5.4 indicates that the values in Table 5.4 based on Dresden -1 data are lower for Iodine-131 and higher for total particulate activities than the results based on Monticello data. The "fence post" gamma and beta doses are dominated by the noble gas activities for which no measured data are available since the continuous air monitor measuring the reactor building ventilation activity levels is not reading above background of 50 CPM. Accordingly, the above comparison cannot be used to directly confirm the "fence post" dose estimates but does substantiate that the estimated doses are in the correct range.

5.5 Plant Startup and Shutdown

Startup and shutdown of the reactor involves use of the mechanical vacuum pump and of the bypass around the compressors and storage tanks of the SJAE offgas system. The estimated activity released during these operations is given in Table 5-6. Operation of the mechanical vacuum pump during shutdown occurs after reactor pressure drops below that required for SJAE supply (~100 psi) and continues until the reactor is essentially depressurized or from 1 until 4 hours after shutdown. During this three-hour period, it is assumed that the fission gas source is proportional to decay heat and that the mechanical vacuum pump and gland seal exhauster flows are twice normal. The result is a source of 1.6% of the full power source with a 1.9 minute holdup. Particulate buildup was also calculated for this source and holdup.

Startup operation of the mechanical vacuum pump results in release of activity which would have accumulated in the condenser as a result of previous operation plus that which is released from the fuel and reactor during the startup. Little data on fission product accumulation are available. Estimates based on Dresden-1 data indicate that an average of 6000 μCi/sec Xe-135 and 40,000 μc/sec of Xe-133 were released during 4 hours of vacuum pump operation with previous operating stack release rates of 60,000 to 100,000 uCi/sec. This total activity, increased by a factor of 2.7 (for a 270,000 uCi/sec 30 minute release rate), is assumed to be released for each startup. In addition, it is assumed that during mechanical vacuum pump operation, the reactor is releasing to the condenser fission and activation gases in amounts directly proportional to power level. The power level is assumed to vary from 4% rated to 8% rated during 5 hours of vacuum pump operation. Delay times vary from 46 seconds to 96 seconds. Particulates were calculated for these source strengths and delay times with no plateout.

The five hour duration of vacuum pump operation and the vacuum pump flow rate are based on an actual Monticello plant startup on June 25, 1971, which was found to be reasonably representative of the several Monticello plant startups that were examined. Similarly, the steam jet air ejector air flow for the dose model of 400 scfm for one hour was developed based on the actual air ejector flow rates and times for the startup and the off-gas flow limit of 400 scfm included in the proposed off-gas system design. Since this flow rate exceeds the compressor capability of the storage system, the storage tanks must be by-passed during the startup. The activity released during by-pass is based on a source of 8% reactor power and a hold up time of 10.8 minutes corresponding to 400 cfm flow. A removal efficiency of 99% for particulates was assumed for the stack filter assembly. A total of six startup operations per year requiring reestablishment of vacuum is estimated based on the plant experience of three such startups in three months during the recent plant shakedown period. Once the shakedown period is over, the estimated startup frequency of six per year is considered conservative.

5.6 Offgas System Leakage

Leakage from the pressurized offgas system will be carried to the offgas stack by the ventilation system. The amount of activity released is given in Table 5-7. Although no leakage is expected from the essentially all-welded system, a leak rate of 500 cc/h ($\sim 2.5 \times 10^{-4}$ cfm) at the compressor discharge has been assumed to be representative of all leaks. For the particulates, 90% plateout in the holdup pipe and 99% removal by the compressor suction filter are also assumed.

5.7 Liquid Radioactive Waste System Vents

The airborne activity estimated to be released from the liquid radioactive waste system via tank vents is given in Table 5-8. This activity was estimated from a calculation of the water vapor purged from the tank by changes in tank level based on system design processing loads and assuming the air space is saturated with vapor at 140°F. The volatile activity in the vapor was taken to be 10^{-3} times the liquid concentrations given in Table 9-2-2 of the FSAR. For tritium a concentration of 1.3×10^{-2} µCi/sec was used. Since essentially all liquid radwaste comes from either the primary system which is degassed by boiling in the reactor and by the condenser or from drain pumps which provide ample opportunity for degassing prior to being pumped to the radwaste system, the only gaseous activity in the liquid radwaste system vents would be from noble gases that are produced in the tanks from decay of the halogens present. Such releases would have been present in the Dresden-1 results that were utilized to develop the plant ventilation activities in Section 5.4 and accordingly are not included here.

5.8 Unenclosed Tanks

The site boundary dose contribution from the unenclosed condensate storage tanks was calculated for an estimated total contained activity of 1.5 curies for fuel leaks equivalent to an offgas release of 3×10^5 μCi/sec after 30 minutes with the isotopic breakdown as given in the FSAR (p 9-2.6). The estimated total annual dose at the nearest site boundary 500 meters from the tanks is 0.027 mrem, and the estimated annual dose at 950 meters is 0.0075 mrem.

TABLE 5-1

ESTIMATED ANNUAL FENCE POST DOES DUE TO

PLANT AIRBORNE RELEASES

(950 meters, SSE)

	Source	Duraction	Type	Annual Gamma Dose mrem/year	Annual Beta Dose mrem/year
1.	Containment Purging	periodic - 2 per year	elevated via SBGT	0.03	0.003
2.	Turbine Gland Seal Exhauster	continuous	elevated stack	1.4	0.40
3.	HPCI Turbine Testing	periodic - 6 hrs. per year	elevated stack	0.0001	0.00003
4.	Plant Ventilation System	continuous	ground level - reactor building vent & turbine building roof	0.15	0.13
5.	Plant Startup and Shutdown	periodic - 6 per year	elevated stack	1.0	0.3
6.	SJAE off-gas system leakage	continuous	elevated stack	0.002	0.0002
7.	Liquid Radwaste Vents	continuous	ground level reactor building vent	$\sim 10^{-5}$	$\sim 10^{-5}$
		Subtotal		2.6	0.8
8.	SJAE Off-Gas System (Comment #6)	continuous	elevated stack	1.9	0.5
		Total		4.5	1.3

TABLE 5-3

ACTIVITY RELEASED TO PLANT STACK FROM GLAND SEAL PACKING EXHAUSTER

Isotope	μCi/sec	Isotope	μCi/sec
N-16	1.3×10^{-4}	Rb-88	4.7
O-19	1.93	Rb-89	3.4×10^{1}
N-13	6.3×10^{-1}	Sr-89	6.0×10^{-4}
Ar-41	2.0×10^{-3}	Rb-90	8.6×10^{1}
H-3	4.3×10^{-2}	Sr-90	2.0×10^{-5}
Kr-83m	5.76	Rb-91	2.5×10^{1}
Kr-85m	1.18×10^{1}	Sr-91	2.8×10^{-1}
Kr-85	1.5×10^{-2}	Sr-92	4.7×10^{-1}
Kr-87	3.77×10^{1}	Sr-93	2.9
Kr-88	3.65×10^{1}	Sr-94	1.7
Kr-89	1.58×10^{2}	Cs-137	4.0×10^{-5}
Kr-90	1.06×10^{1}	Ba-137m	2.0×10^{-5}
Xe-131m	3.0×10^{-2}	Cs-138	1.2×10^{1}
Xe-133m	3.5×10^{-1}	Cs-139	4.4×10^{1}
Xe-133	9.5	Cs-140	3.3×10^{1}
Xe-135m	5.45×10^{1}	Ba-140	1.0×10^{-2}
Xe-135	3.42×10^{1}	Cs-141	2.2×10^{-1}
Xe-137	2.09×10^{2}	Ba-141	1.7
Xe-138	1.49×10^{2}		
Xe-139	2.49×10^{1}		
Xe-140	1.1×10^{-1}		

TABLE 5-4

ESTIMATED

ACTIVITY RELEASED WITH VENTILATION AIR

Isotope	μCi/sec	Isotope	μCi/sec
Co-58	2.0×10^{-3}	H-3	8.0×10^{-4}
Co-60	5.0×10^{-4}	Kr-83m	2.7×10^{-1}
Sr-89	6.0×10^{-3}	Kr-85m	6.1×10^{-1}
Sr-90	6.0×10^{-4}	Kr-85	8.0×10^{-4}
Cs-134	3.0×10^{-4}	Kr-87	1.6
Cs-137	2.0×10^{-3}	Kr-88	1.8
Ba-140	2.0×10^{-3}	Kr-89	3.0×10^{-2}
I-131	5.0×10^{-3}	Xe-131m	2.0×10^{-3}
I-132	1.0×10^{-4}	Xe-133m	2.0×10^{-2}
I-133	5.0×10^{-3}	Xe-133	5.3×10^{-1}
I-134	1.0×10^{-4}	Xe-135m	9.2×10^{-1}
I-135	2.0×10^{-4}	Xe-135	1.8
Br-83	2.0×10^{-5}	Xe-137	1.0×10^{-1}
Br-84	1.0×10^{-5}	Xe-138	2.8

TABLE 5-5

MEASURED

ACTIVITY RELEASED WITH VENTILATION AIR

EXTRAPOLATED TO STACK ACTIVITY LEVEL

OF 270,000 μc/sec

Date Filter Installed*	Stack Monitor μc/sec	Measured Reactor Building Ventilation Activity μc/sec		Extrapolated Reactor Building Ventilation Activity μc/sec	
		I-131	Particulate	I-131	Particulate
7/5/71	10,000	1.4×10^{-4}	1×10^{-4}	3.8×10^{-3}	2.7×10^{-3}
7/26/71		1.7×10^{-4}	4.7×10^{-5}		
8/2/71	20,000	6×10^{-4}	1.3×10^{-4}	8×10^{-3}	1.8×10^{-4}
8/9/71		5×10^{-5}	6.5×10^{-6}		
8/16/71		2×10^{-3}	2.3×10^{-4}		
8/23/71		1×10^{-3}	1×10^{-4}		
8/30/71		2.8×10^{-3}	1.9×10^{-4}		
9/6/71		2.4×10^{-3}	2.3×10^{-4}		
9/13/71	10,000	1.4×10^{-3}	2.4×10^{-4}	3.8×10^{-2}	6.5×10^{-3}

* Each filter in line for seven days; activities reported are weekly averages

TABLE 5-6

ACTIVITY RELEASE DURING STARTUP AND SHUTDOWN - CURIES

Isotope	Via Mechanical Vacuum Pump Shutdown	Via Mechanical Vacuum Pump Startup	Via Bypass of Compressors & Storage Tanks
N-16	---	1.6×10^{2}	---
N-13	---	8.0	1.1
O-19	---	5.4×10^{1}	---
H-3	---	1.3×10^{-3}	2×10^{-4}
Kr-83m	1.4	8.7	2.2
Kr-85m	2.9	1.8×10^{1}	4.7
Kr-85	3.5×10^{-3}	2.2×10^{-2}	5.8×10^{-3}
Kr-87	9.3	5.9×10^{1}	1.4×10^{1}
Kr-88	9.0	5.6×10^{1}	1.4×10^{1}
Kr-89	5.5×10^{1}	3.9×10^{2}	1.3×10^{1}
Kr-90	1.9×10^{1}	2.7×10^{1}	4.2×10^{-1}
Kr-91	1.0×10^{-1}	1.6×10^{1}	---
Kr-92	---	7.9×10^{-3}	---
Xe-131m	6.9×10^{-3}	4.3×10^{-2}	1.2×10^{-2}
XE-133m	8.7×10^{-2}	5.4×10^{-1}	1.4×10^{1}
Xe-133	2.3	1.5×10^{3}	3.9
Xe-135m	1.4×10^{1}	8.7×10^{1}	1.5×10^{1}
Xe-135	8.4	2.9×10^{2}	1.4×10^{1}
Xe-137	6.8×10^{1}	4.7×10^{2}	2.3×10^{1}
Xe-138	3.9×10^{1}	2.5×10^{2}	4.5×10^{1}
Xe-139	2.9×10^{1}	3.3×10^{1}	8.4×10^{-3}
Xe-140	1.6	6.2×10^{1}	---

TABLE 5-6
(continued)

ACTIVITY RELEASE DURING STARTUP AND SHUTDOWN - CURIES

Isotope	Via Mechanical Vacuum Pump: Shutdown	Via Mechanical Vacuum Pump: Startup	Via Bypass of Compressors & Storage Tanks
I-131	2.7×10^{-4}	2.0×10^{-2}	4.5×10^{-5}
I-132	1.6×10^{-3}	1.1×10^{-2}	2.5×10^{-4}
I-133	1.6×10^{-3}	2.8×10^{-2}	2.6×10^{-4}
I-134	2.0×10^{-3}	1.4×10^{-2}	3.0×10^{-4}
I-135	2.1×10^{-3}	2.0×10^{-2}	3.4×10^{-4}
I-136	8.0×10^{-5}	6.8×10^{-4}	---
Br-83	1.8×10^{-4}	1.1×10^{-3}	2.9×10^{-5}
Br-84	2.4×10^{-4}	1.5×10^{-3}	3.2×10^{-5}
Br-85	9.5×10^{-5}	6.8×10^{-4}	---
Br-87	3.5×10^{-5}	3.4×10^{-4}	---
Rb-88	6.4×10^{-1}	2.8	5.1×10^{-2}
Rb-89	3.5	2.6×10^{1}	1.9×10^{-1}
Sr-89	5.3×10^{-5}	1.8×10^{-4}	1.5×10^{-5}
Rb-90	2.7×10^{1}	1.6×10^{2}	6.2×10^{-2}
Sr-90	1.9×10^{-6}	7.3×10^{-6}	1.2×10^{-7}
Rb-91	6.2	4.1×10^{1}	3.9×10^{-2}
Sr-91	1.3×10^{-2}	5.7×10^{-2}	9.2×10^{-4}
Y-91m	9.7×10^{-5}	2.9×10^{-4}	4.6×10^{-5}
Rb-92	1.7×10^{-4}	1.2	---
Sr-92	1.2×10^{-1}	7.2×10^{-1}	1.9×10^{-3}
Rb-93	2.2×10^{-4}	5.8×10^{-1}	---
Sr-93	8.2×10^{-1}	5.4	6.3×10^{-3}

TABLE 5-6
(continued)

ACTIVITY RELEASE DURING STARTUP AND SHUTDOWN - CURIES

Isotope	Via Mechanical Vacuum Pump Shutdown	Startup	Via Bypass of Compressors & Storage Tanks
Y-93	1.7×10^{-3}	7.2×10^{-3}	1.2×10^{-4}
Cs-137	6.7×10^{-6}	3.1×10^{-5}	3.3×10^{-7}
Cs-138	1.6	7.2	1.2×10^{-1}
Cs-139	1.0×10^{1}	5.7×10^{1}	1.1×10^{-1}
Ba-139	1.1×10^{-1}	4.0×10^{-1}	1.3×10^{-2}
Cs-140	2.2×10^{1}	1.8×10^{2}	1.3×10^{-3}
Ba-140	2.0×10^{-3}	9.0×10^{-3}	5.5×10^{-5}
La-140	5.3×10^{-7}	1.6×10^{-6}	1.4×10^{-7}
Cs-141	8.5×10^{-1}	1.6×10^{1}	---
La-141	1.7×10^{-3}	6.6×10^{-3}	1.9×10^{-4}
Ce-141	1.9×10^{-8}	5.2×10^{-8}	1.5×10^{-8}
Ba-141	4.3×10^{-1}	2.5	5.3×10^{-3}

TABLE 5-7

ACTIVITY RELEASED FROM OFFGAS SYSTEM VIA LEAKAGE

Isotope	μCi/sec	Isotope	μCi/sec
Kr-83m	4.6×10^{-2}	Y-91m	2.4×10^{-6}
Kr-85m	1.47×10^{-1}	Y-91	3.3×10^{-9}
Kr-85	2.4×10^{-4}	Sr-92	4.8×10^{-5}
Kr-87	2.2×10^{-1}	Sr-93	2.0×10^{-9}
Kr-88	3.8×10^{-1}	Y-93	7.6×10^{-7}
Xe-131m	4.8×10^{-4}	Cs-137	1.6×10^{-9}
Xe-133m	5.8×10^{-3}	Ba-137	1.6×10^{-9}
Xe-133	1.59×10^{-1}	Cs-138	2.2×10^{-4}
Xe-135m	4.9×10^{-3}	Cs-139	1.6×10^{-7}
Xe-135	5.0×10^{-1}	Ba-139	4.5×10^{-5}
Xe-138	2.2×10^{-2}	Ba-140	2.3×10^{-7}
Rb-88	4.2×10^{-4}	La-140	7.6×10^{-9}
Rb-89	6.7×10^{-6}	Ba-141	1.8×10^{-6}
Sr-89	2.4×10^{-7}	La-141	1.9×10^{-6}
Sr-90	5.5×10^{-10}	Ce-141	2.9×10^{-9}
Y-90	1.0×10^{-11}	La-143	1.0×10^{-8}
Sr-91	4.9×10^{-6}	Ce-143	2.6×10^{-8}

TABLE 5-8

ACTIVITY FROM LIQUID RADWASTE SYSTEM TANK VENTS

Isotope	μCi/sec
I-131	1.7×10^{-5}
I-132	2.0×10^{-5}
I-133	2.0×10^{-5}
I-134	2.5×10^{-5}
I-135	2.3×10^{-5}
Br-83	2.0×10 [illegible]
F-18	1.9×10^{-8}
H-3	4.8×10^{-5}

COMMENT

6. Reevaluate the consequences of routine releases and accidental releases from the proposed off-gases system to include the dose contributions from halogens and particulates. Present and justify all assumptions used to make these evaluations. Include an analysis of accident doses that might be received by plant personnel and control room operators.

RESPONSE

A. Summary

The results of the re-evaluation to include halogens and particulates are presented in Tables 6-6 and 6-8. None of the isotopic activity concentrations of either halogens or particulates at the fence post is in excess of the recent AEC guidelines of 10 CFR 20 concentration divided by 100,000. The accident doses are well within the limits of 10 CFR 100.

B. Routine Releases

All activities and doses have been based on the technical specification annual average stack release limit of 0.27 Ci/sec. A summary of the gaseous and volatile activation and fission products to the modified off-gas system are presented in Table 6-1, and the reactor coolant fission product concentrations are presented in Table 6-2. The majority of the coolant activities were developed from information presented in paragraph 6.5.2 of Section XIV of the Monticello FSAR. These data and the cleanup system effectiveness (β=0.23 hr^{-1}) measured during initial operation were used to calculate values for the individual halogens which were grouped as "other halogens" in the FSAR.

These predicted coolant halogen activities of Table 6-2 have been compared to the actual coolant halogen activities of Table 6-3 that have been measured at the Monticello plant. The measured activities are characteristic of an equilibrium mixture which implies only pin-hole or crack type defects in the fuel cladding, while the predicted activities of Table 6-2 are based on a diffusion mixture which would be indicative of the more massive fuel failures that would be present if the stack activity level reached 0.27 Ci/sec. Halogen activity levels in the off-gas were computed from coolant activities by applying a DF of 2×10^4 between coolant activity and the off-gas. This DF was developed by comparing the measured reactor coolant iodine-131 activities of Table 6-3 and the measured stack activity levels reported in Table 6-4. The computed DF or distribution factor for three sets of comparative data is presented in Table 6-5 and averages about 2×10^4. As an additional check, a total system DF of 2×10^5 was obtained from similar coolant activity and off-gas iodine activity data for Dresden #1 reported in Public Health Service Report BRH/DER 70-1. No credit for halogen removal has been taken for the recombiners or plateout in the storage tanks, adding additional conservatism to the halogen results.

The release rates of particulates with half lives in excess of eight (8) days and halogens of interest from Table 6-1 are presented in Table 6-6; the halogen release rates are based on 90% halogen removal in the air compressor inlet charcoal filter and 90% removal in the stack charcoal filter; the particulate release rates are based on 90% plateout in the buried delay pipe, followed by 99% removal in the compressor suction HEPA filter, and followed by 99% removal in the stack HEPA filter.

Also included in Table 6-6 is a comparison between particulate and halogen activity concentrations at the worst case location (950 m, SSE) as defined in the response to Comment #4, and the recent AEC guidelines of MPC_a from 10 CFR 20 divided by 100,000. All isotopic activity concentrations are within the AEC guidelines.

The annual average whole body gamma dose has been computed for the worst case boundary location as presented in the response to Comment #4 (950 m, SSE). The yearly gamma dose for this worst case location is calculated to be 1.9 mrem/year and the beta dose is calculated to be 0.5 mrem/yr. Gamma dose results for other boundary locations have been estimated by ratioing the results for a release of 1.0 Ci/sec in Table B-3-2 of Appendix B of the Monticello FSAR, and these estimates are presented in Table 6-7.

C. <u>Accident Releases</u>

The maximum release to the environs from the modified off-gas system would result if all five storage tanks were assumed to undergo simultaneous discharge at ground level immediately after being filled to capacity with the plant operating at the Technical Specification annual average activity limit (0.270 Ci/sec after 30 minutes sample decay) at the condenser air ejectors and with maximum condenser air in-leakage (28 scfm). The calculated whole body (beta and gamma) dose at the nearest boundary for such a release occuring instantaneously is 0.45 rem, but if the release is assumed to occur more slowly so there is no diffusion due to the energy release, the dose increases to 0.88 rem. If release of the particulates is considered, these doses are increased to about 0.76 and 1.5 rem, respectively. If the halides are not assumed to be effectively removed by the recombiners, the inhalation thyroid doses for the instantaneous and slow release of the tank contents are

1.7×10^{-2} and 3.2×10^{-2} rem, respectively. These results are summarized in Table 6-8.

The calculated dose is based on a tank fill time of 15.7 hours (0 to 300 psig) with 28 scfm air in-leakage at the condenser and complete recombination of the radiolytic hydrogen. This dose was found to be higher than that resulting from longer holdup time (lower condenser in-leakage) because of the greater dose contribution from the shorter lived isotopes. Release was assumed to occur immediately after filling the fifth tank, with credit taken for decay in the previously installed holdup pipe, for decay during the filling operation, and for dead storage time in the first four tanks.

Doses were computed using finite cloud dimensions, Class F stability, one meter per second wind speed, 500 meter distance to site boundary, and no credit for storage building wake factor. The tank activities were based on the data presented in Table 6-1; meteorological data are presented in the response to comment #4.

Accident whole body doses to plant personnel were estimated by assuming that a plant operator is immersed in the virtual source cloud that is formed by the failure of either one or all five tanks and that he remains in the cloud as it passes at one meter/sec. No cloud growth with distance or personnel shielding has been assumed. The dose for this case from the failure of one tank is estimated to be 10 rem and from five tanks 4.2 rem.

All of the calculated accident doses are well within the limits of 10 CFR 100.

TABLE 6-1

ACTIVITY TO THE OFF-GAS SYSTEM

Isotope	Activity - μCi/sec No Decay	30 Min Decay	50 Hr Decay
Noble Gases			
Kr-83m	8.15×10^{3}	6.76×10^{3}	$6.60 \times\ ^{-5}$
Kr-85m	1.69×10^{4}	1.56×10^{4}	6.40
Kr-85	2.01×10^{1}	2.01×10^{1}	2.02×10^{1}
Kr-87	5.49×10^{4}	4.17×10^{4}	7.20×10^{-8}
Kr-88	5.23×10^{4}	4.62×10^{4}	2.21×10^{-1}
Kr-89	4.77×10^{5}	7.19×10^{2}	---
Kr-90	1.23×10^{6}	---	---
Kr-91	1.64×10^{6}	---	---
Kr-92	2.19×10^{6}	---	---
Kr-93	1.32×10^{6}	---	---
Kr-94	8.13×10^{5}	---	---
Xe-131m	4.03×10^{1}	4.02×10^{1}	3.56×10^{1}
Xe-133m	5.03×10^{2}	4.99×10^{2}	2.65×10^{2}
Xe-133	1.35×10^{4}	1.34×10^{4}	1.03×10^{4}
Xe-135m	8.53×10^{4}	2.24×10^{4}	---
Xe-135	4.85×10^{4}	4.84×10^{4}	1.18×10^{3}
Xe-137	5.49×10^{5}	2.65×10^{3}	---
Xe-138	2.44×10^{5}	7.16×10^{4}	---
Xe-139	1.04×10^{6}	---	---
Xe-140	1.33×10^{6}	---	---
Xe-141	1.46×10^{6}	---	---
Xe-143	2.72×10^{5}	---	---

TABLE 6-1
(continued)

ACTIVITY TO THE OFF-GAS SYSTEM

Isotope	Activity - μCi/sec No Decay	30 Min Decay	50 Hr Deca
Activation Gases			
N-16	7.0×10^{7}	---	---
N-17	1.14×10^{3}	---	---
N-13	8.1×10^{3}	1.0×10^{3}	---
O-19	4.2×10^{5}	---	---
A-41	2.8	2.3	1.7×10^{-8}
H-3 (1)	5.0×10^{-5}	5.0×10^{-5}	5.0×10^{-5}
Halogens	(2)	(2)	(3)
I-131	7.8×10^{-1}	7.8×10^{-1}	6.5×10^{-2}
I-132	4.6	3.9	1.1×10^{-7}
I-133	4.6	4.5	9.3×10^{-2}
I-134	6	4.1	---
I-135	6	5.2	4×10^{-3}
I-136	6×10^{-1}	2.2×10^{-2}	---
I-137	4.6×10^{-1}	---	---
I-138	1.8×10^{-1}	---	---
Br-83	5.5×10^{-1}	4.6×10^{-1}	3×10^{-9}
Br-84	7×10^{-1}	3.7×10^{-1}	---
Br-85	4.2×10^{-1}	4.2×10^{-4}	---
Br-87	4.2×10^{-1}	5.3×10^{-12}	---
Br-88	2.3×10^{-1}	---	---

(1) Based on amount of water vapor in 28 scfm of off-gas 55°F (anticipated delay pipe exit temperature) and a tritium concentration of 1.3×10^{-2} μCi/ml.

(2) Based on iodine concentration in reactor coolant from Table 6-2 corresponding to a stack discharge rate of 0.27 Ci/sec after 30 minute decay and a reactor coolant to off-gas distribution factor of 2 x 10 4 for halogens.

(3) Based on a 90% removal of halogens in the off-gas air compressor charcoal filter.

TABLE 6-2

FISSION PRODUCTS IN PRIMARY COOLANT

Isotope	μCi/cc
I-131	0.22
I-132	1.30
I-133	1.30
I-134	1.70
I-135	1.70
I-136	0.17
I-137	0.13
I-138	0.052
Br-83	0.15
Br-84	0.20
Br-85	0.12
Br-87	0.12
Br-88	0.067
Mo-99	1.00

Based on operation with sufficient fuel failures to give offgas activity of 0.27 Ci/sec at 30 minutes decay of a noble gas diffusion mixture.

TABLE 6-3

MEASURED REACTOR COOLANT IODINE ACTIVITIES

AT MONTICELLO PLANT

Date	I-131 µc/ml	I-132 µc/ml	I-133 µc/ml	I-134 µc/ml	I-135 µc/ml
5/8/71	3×10^{-5}	3.5×10^{-5}	1×10^{-4}	1×10^{-4}	8.6×10^{-5}
7/1/71	5.5×10^{-5}	1×10^{-4}	2.1×10^{-4}	3.4×10^{-4}	2.5×10^{-4}
7/5/71	2.3×10^{-4}		5×10^{-4}		
7/6/71	3.6×10^{-4}		5×10^{-4}		
7/7/71	2.3×10^{-4}		6.5×10^{-4}		
7/8/71	2.6×10^{-4}		5.2×10^{-4}		
7/9/71	2.3×10^{-4}		5.8×10^{-4}		
7/10/71	2.2×10^{-4}		5×10^{-4}		
7/11/71	4×10^{-4}		7.5×10^{-4}		
7/12/71	2×10^{-4}		4.8×10^{-4}		
8/16/71	2.4×10^{-3}		2×10^{-3}		
8/17/71	2.3×10^{-3}		1.8×10^{-3}		
8/18/71	2.8×10^{-3}		2.2×10^{-3}		
8/19/71	1.7×10^{-3}		1.6×10^{-3}		
8/20/71	1.8×10^{-3}		1.7×10^{-3}		
8/21/71*	4×10^{-2}		5×10^{-2}		
8/22/71	2×10^{-3}		1.3×10^{-3}		
8/23/71	2.2×10^{-3}		1.4×10^{-3}		
9/13/71	5.3×10^{-3}		4×10^{-3}		
9/14/71	3×10^{-3}		2.2×10^{-3}		
9/15/71	2.2×10^{-3}		1.9×10^{-3}		
9/16/71	2.7×10^{-3}	8.3×10^{-4}	1.8×10^{-3}	9.4×10^{-4}	1.5×10^{-3}
9/17/71	2.4×10^{-3}		1.7×10^{-3}		
9/18/71	2.2×10^{-3}		1.7×10^{-3}		
9/20/71	2.2×10^{-3}		1.6×10^{-3}		
9/21/71	1.8×10^{-3}		1.6×10^{-3}		

* High activity the result of a scram on 8/21/71.

TABLE 6-4

MEASURED STACK IODINE AND PARTICULATE ACTIVITIES AT MONTICELLO PLANT

Date Filter Installed	I-131 µc/sec	Particulates µc/sec
7/5/71	3.4×10^{-4}	5×10^{-6}
7/29/71	5.5×10^{-4}	5×10^{-6}
8/2/71	3.7×10^{-3}	1.5×10^{-5}
8/9/71	7.8×10^{-3}	1.4×10^{-5}
8/16/71	6.9×10^{-3}	1.6×10^{-5}
8/23/71	6.1×10^{-3}	4×10^{-5}
8/30/71	3.5×10^{-3}	4.8×10^{-5}
9/6/71	6.8×10^{-3}	3.5×10^{-5}
9/13/71	4.1×10^{-3}	3.8×10^{-5}

* Each filter in line for seven days; activities reported are weekly averages.

TABLE 6-5

COMPARISON OF REACTOR COOLANT I-131 ACTIVITY AND OFF-GAS I-131 ACTIVITY

Date Start of Weekly Average	Reactor Coolant[1] I-131 μc/ml	Off-Gas[2] I-131 μc/ml	DF= Reactor Coolant / Off-Gas
7/5/71	2.9×10^{-4}	9×10^{-9}	3×10^{4}
8/16/71	2.4×10^{-3}	1.8×10^{-7}	1.3×10^{4}
9/13/71	2.6×10^{-3}	1.1×10^{-7}	2.4×10^{4}

(1) Reactor coolant activity average of 8 days from Table 6.3

(2) Off-gas activity average based on release rate data from Table 6.4 and measured off-gas flow rate of 80 cfm (1atm, 80°F)

TABLE 6-6

COMPARISON OF ANNUAL AVERAGE CONCENTRATIONS
AND AEC GUIDELINES
HALOGENS AND PARTICULATES WITH $T_{\frac{1}{2}} > 8$ DAYS

Isotope	Estimated Release Rate μc/sec (1) (2)	Annual Average Concentration-950M μc/cc	AEC Guideline 10 CFR 20/100,000 μc/cc
I-131	6.5×10^{-3}	2.8×10^{-16}	1×10^{-15}
I-132	1.1×10^{-8}	5×20^{-22}	4×10^{-15}
I-133	9.3×10^{-3}	4×10^{-16}	4×10^{-15}
I-135	4×10^{-4}	1.7×10^{-17}	1×10^{-14}
Br-83	3×10^{-9}	1.3×10^{-22}	1×10^{-15}
Cs-137	1.4×10^{-6}	5.9×10^{-20}	5×10^{-15}
Sr-89	2.0×10^{-4}	8.7×10^{-18}	3×10^{-15}
Sr-90	4.6×10^{-7}	2×10^{-20}	3×10^{-16}
Y-91	3×10^{-5}	1.3×10^{-18}	1×10^{-14}
Ba-140	1.7×10^{-4}	7.5×10^{-18}	1×10^{-14}
Ce-141	9.8×10^{-6}	4.3×10^{-19}	5×10^{-14}
Pr-143	1.4×10^{-6}	6.2×10^{-20}	6×10^{-14}

(1) Halogen release rates include 90% removal of halogens in the charcoal filter in the off-gas stack; source term 50 decay estimate from Table 6.1

(2) Particulate release rates include 90% plateout in 30 minute delay pipe, 99% removal in the compressor suction HEPA filters, and further 99% removal in the stack HEPA filters.

TABLE 6-7

ESTIMATED ANNUAL AVERAGE GAMMA DOSE AT GROUND LEVEL AROUND SITE PERIMETER FOR PROPOSED OFF-GAS SYSTEM

0.27 Ci/sec @ 30 min. Decay

Direction from Stack	Distance to Off-Site Location (meters)	Estimated Annual Dose mrem/year
N	1610	0.83
NNE	1290	1.3
NE	1710	0.63
ENE	1460	1.1
E	1740	0.53
ESE	2740	0.42
SE	1480	1.3
SSE	950	1.9
S	580	1.8
SSW	510	1.5
SW	520	1.3
WSW	625	1.5
W	990	0.71
WNW	1830	0.60
NW	1890	0.54
NNW	1230	1.2

TABLE 6-8

ESTIMATED DOSES FROM OFF-GAS SYSTEM ACCIDENTS

	Whole Body Noble Gas Dose	Whole Body Particulate Gas Dose	Thyroid Dose
Case 1 - Rapid depressurization of five tanks that result in an initial cloud of finite size and a virtual source correction. $X/Q = 1.13 \times 10^{-3}$ sec/m^3	0.45 rem	0.31 rem	1.7×10^{-2} rem
Case 2 - Slow release of five tanks contents giving a point release with no source correction. $X/Q = 2.12 \times 10^{-3}$ sec/m^3	0.88 rem	0.58 rem	3.2×10^{-2} rem

COMMENT

7. Clarify the statement on page 4 of the report entitled "Gaseous Radwaste System Modification Report" dated March 1971, "The two remaining processes . . . . were judged essentially identical with regard to environmental effects, based on equal retention times ..... "

RESPONSE

The subject statement should have read "....based on dose-equivalent retention times...."

The charcoal adsorption process which was compared to the compressed storage process was based on a system which would yield a reduction of about 100:1 in that site boundary dose resulting from the discharge of condenser offgas. For the compressed storage system, this reduction factor requires 48-50 hours of decay for a diffusion mixture of noble gases. For a charcoal system operating at near ambient conditions, this reduction factor requires 30-35 tons of activated charcoal, which would delay the krypton for about 16 hours and the xenon for about 10 days. This equivalency is of course dependent on the adsorption credit allowed for the charcoal.

COMMENT

8. Clarify what the 1% carryover refers to in Table 1 (page 13) of the report mentioned in question 7.

RESPONSE

This response affects Section 9.3 of the FSAR.

The 1% carryover referred to is with respect to post-recombination vapor removal in the recombiner condenser. Moisture carryover is limited by design to a maximum of 1% of the condensed flow or about 65 lbs/hr under normal operating conditions which is within the design value for the existing plant. Approximately 45 lb/hr of this carryover will be vapor. An additional 20 lb/hr has been allowed for carryover in droplet form.

COMMENT

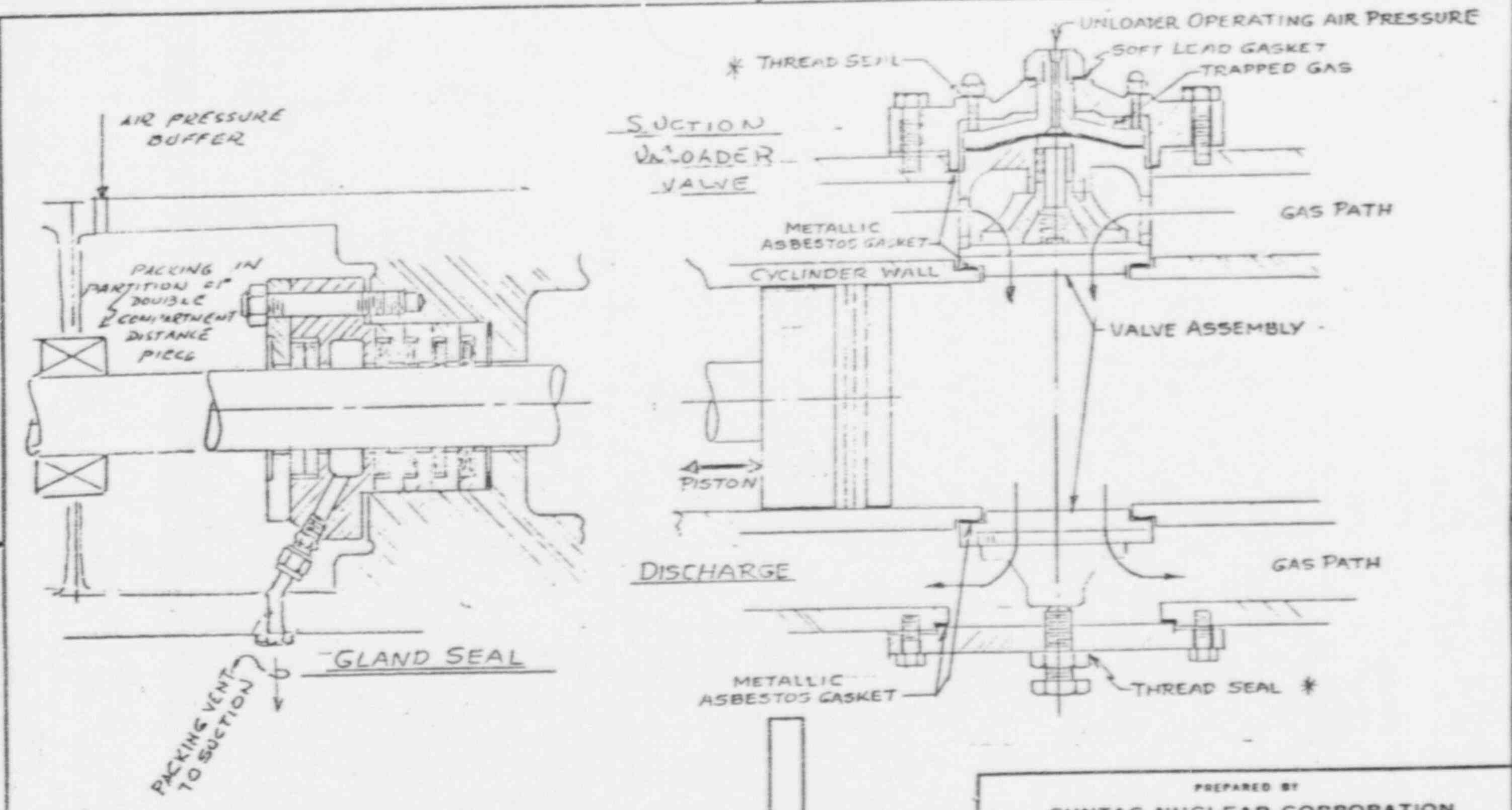
9. Provide the design details of the proposed gas compressors that will provide capability for essentially zero leakage. What type of valves will be used and what is expected leakage through the stem?

RESPONSE

This response affects Section 9.3 of the FSAR.

The compressor has a two compartment distance piece between the crank-case and the first stage cylinder and a single compartment piece between the first and second stage cylinders. The crankcase end of the two compartment piece is open to atmosphere and is isolated from the cylinder end by non-vented packing. The cylinder end of this piece is gas tight as is the piece between the two cylinders. The packing on both ends of the first stage cylinder and on the second stage cylinder is vented to the suction of the compressor. Oil-free purge air at 25 psig (this is in excess of the highest suction pressure), is introduced into the enclosed gas tight end of the two compartment distance piece. In this manner, external leakage of the offgas from the compressor is assured to be zero.

The valve type used on both suction and discharge is the concentric disc type. The areas of potential leakage on the discharge valve are in the valve clamp and cover assembly. The valve cover is sealed to the cylinder by a steel jacketed asbestos gasket and the threaded valve stop bolt is sealed to the cover by an elastometric thread seal supported by a washer. The design of the seal is such as to block leakage both parallel to the bolt axis and along the spiral channel formed by the bolt thread. Similarly, the areas of



PREPARED BY
SUNTAC NUCLEAR CORPORATION
1528 WALNUT STREET
PHILADELPHIA, PENNSYLVANIA 19102

SIGNIFICANT No.						
GROUP	1	2	3	4	5	6

SKETCH OF UNLOADING VALVE AND GLAND SEAL FOR ELIMINATING GAS LEAKAGE FOR OFF GAS COMPRESSOR

NORTHERN STATES POWER COMPANY
ENGINEERING DEPARTMENT
MINNEAPOLIS

ND-54812 A

REVISION	DRAWN	DATE
ESTIMATE	CHECKED	
WORK ORD		
DRAWN	ESTIMATE	
CHECKED	WORK ORDER	
DATE	APPROVED	
APPROVED		
FILMED	FILMED	

REVISIONS

ND-

potential leakage on the suction valve are sealed with an elastomeric diaphragm and steel jacketed asbestos gaskets. The valve cover provides a secondary seal and the valve cover hold down bolts feature the same thread seal as on the discharge valves. With these design features, leakage should be zero.

The above descriptions are illustrated in the attached drawing, NF-54812.

COMMENT

10. Provide design details of the air ejector offgas monitor and the stack monitors to show that representative samples of the noble gases, halogens and particulates can be obtained and that these monitors have sufficient sensitivity to detect plant releases at levels which will allow you to be confident of remaining within the new plant Technical Specifications limit (which will not allow an instantaneous release in excess of the calculated maximum allowable annual average release of 0.27 Ci/sec noble gases and 2.4 μ Ci/sec of halogens and particulates with half lives greater than 8 days).

RESPONSE

This response affects Sections 7.6 and 9.3 of the FSAR.

The proposed changes to Monticello Technical Specifications which were submitted as an Attachment to the Gaseous Radwaste System Modification Report did not modify the existing instantaneous release rate limit of 2.7 Ci/sec for more than 15 minutes/hour.

The steam jet air ejector (SJAE) offgas radiation monitor is exactly as described in the Monticello FSAR. The high radiation signal from the monitor will now be used to close the inlet valve(s) to the recombiner train(s). Previously the high radiation signal was used to close stack off-gas isolation valve CV-1928 (shown on FSAR Fig. 9-3-1).

The existing stack monitor will be used in the modified off-gas system design to close CV-1928 upon detection of high radioactivity concentration in the stack gas. The high radiation signals are arranged so that a shutdown signal (either upscale or downscale) from both stack monitors will close the stack valve.

The sensitivity of the existing stack gas monitors is approximately 1×10^{-6} μCi/cc Cps with Kr-85 and Xe-133 as the limiting radionuclides. The stack flow rate after the modified offgas system is installed will be not more than 2.95×10^{6} cc/sec. (6250 scfm). Therefore, the approximate conversion factor between monitor output (Cps) and release rate $\left(\frac{\mu Ci}{sec}\right)$ is 3 μ Ci/sec per Cps. The observed Monticello stack monitor background count rate is about 40 Cps. Using the assumption that the minimum detectable stack radioactivity release rate is that amount which yields a count rate equal to the background count rate, then:

$$\text{Minimum Detectable Release Rate} = 3 \times 40\ \mu\text{Ci/sec.}$$
$$= 120\ \mu\text{Ci/sec.}$$

Therefore, the margin between minimum detectable release rate and the existing and proposed Technical Specification limit of 2.7 Ci/sec is a factor of 22,500. It is concluded that the existing stack gas radioactivity monitors will have sufficient sensitivity to detect plant releases at levels which will allow confidence of being able to remain within the plant Technical Specification limits.

The flow rate through the isokinetic probes and the stack monitors will be adjusted to account for the increase in stack gas flow rate from 4000 to up to 6250 scfm to insure that representative samples can be taken via the stack sampler.

The halogens and particulates with half lives in excess of 8 days will be monitored by periodic sampling in accordance with the plant's standard sampling program.

COMMENT

11. Where will the ventilation system for the offgas system building discharge? What type filtration and radiation monitoring system will be included in the system to limit, monitor, and record the potential releases from this building?

RESPONSE

This response affects Sections 7.6 and 10.3.2 of the FSAR.

The recombiner building will be vented into the condenser room from which area it will be discharged via the reactor building vent which is monitored as discussed in Section 7.6 of the FSAR. The storage building ventilation system will discharge into the plant stack which is monitored as discussed in the response to comment # 10. As is the case with existing plant ventilation system, the two ventilation flows will be unfiltered.

In addition to the stack monitors, radiation monitoring of both ventilation flows will be provided by continuous air monitors (similar to other plant and stack ventilation duct monitors). The monitor read-outs are on the Offgas Control Panel in the main control room. Output is indicated on a separate indicator and recorded on a multipoint recorder. An adjustable alarm contact will trip and furnish an audible and visible alarm if activity level exceeds the set point. The monitor alarms only and has no control functions; corrective action must be initiated by the operators.

COMMENT

12. The storage room for the waste gas storage building will not be accessible when any of the storage tanks are pressurized. Discuss the safety implications of this design feature. Include operational situations which would require remedial action to avert an accident or to avert a significant release of radioactivity and provisions (such as interlocks and alarms) that would prevent access of unauthorized personnel.

RESPONSE

This response affects Sections 9.3 and 12 of the FSAR.

The inaccessibility of the storage tanks is a positive safety feature. There are no active components or moving equipment in the tank storage room and there is no accident-prevention action which would require access to the tank area. If deliberate access to the tank storage room is required, a removable roof slab will be utilized.

Access to the compressor, fan, and valve room(s) area is available at all times. These areas have been shielded from the tanks and from radioactive components within the areas themselves so that accessibility for maintenance or remedial actions is assured. Storage building equipment malfunctions are alarmed in the Main Control Room. As noted in the response to Comment No. 3, interlocks are provided to prevent simultaneous fill and discharge of a tank and the interlock is backed up by the stack monitor.

With respect to entry of unauthorized personnel, the storage building is within the fenced site property and is fenced to define the 0.5 mr/hr shield area. The building doors will be kept locked to preclude unauthorized entry.

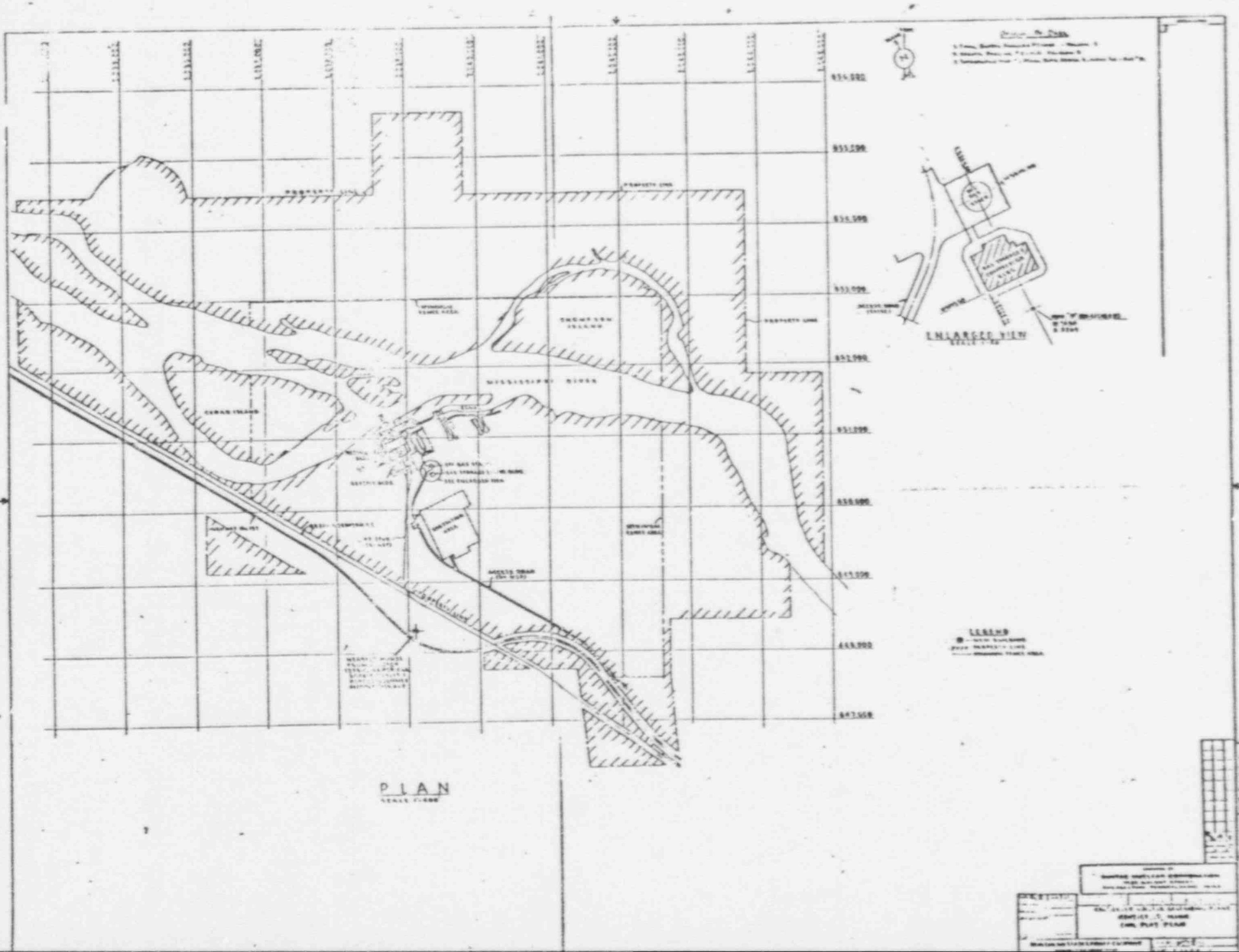
COMMENT

13. Provide a scaled plot plan indicating the location of the proposed facility relative to the stack, site property boundary, restricted area boundary, the exclusion radius, and the nearest residence.

RESPONSE

This response affects Section 2.0 of the FSAR.

A civil plot plan, Northern States Power Co. drawing NF-51144, is submitted herewith in response to the above comment.


MISSISSIPPI RIVER
THOMPSON ISLAND
PROPERTY LINE
ENLARGED VIEW
LEGEND
PLAN