NSP

MONTICELLO NUCLEAR GENERATING PLANT

Monticello, Minnesota

UNIT I
(USAEC DOCKET 50 – 263)

GASEOUS RADWASTE SYSTEM
MODIFICATION REPORT

MARCH 1971

NORTHERN STATES POWER COMPANY
MINNEAPOLIS, MINNESOTA

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GASEOUS RADWASTE SYSTEM MODIFICATION REPORT

1.0 SUMMARY

This report describes a plant modification being undertaken by the Northern States Power Company at the Monticello Nuclear Generating Plant for the purpose of reducing the quantities of radioactive gaseous effluents released to the atmosphere at the plant site. The modification consists bas ally of the addition of equipment to increase the holdup time of the non-condensible gases removed by the main condenser air ejectors from 30 minutes to a minimum of 50 hours during normal plant operation.

The design objective of this modifcation is to reduce the plant boundary radioactive dose rates to about one percent of the dose rates that would be experienced without the modification. Based on AEC-DRL boundary dose calculations which yield 0.5 Rem/year for an annual average release rate of 0.270 Ci/sec, the boundary dose contribution from the plant operating under design conditions following the modification is about 0.004 Rem/year, corresponding to an annual average release rate of 0.012 Ci/sec. This dose value is less than variations in the yearly dose from natural cosmic and terrestrial sources existing prior to construction of the plant.

The Technical Specifications for the Monticello Plant permit a stack release rate of 0.270 Ci/sec to the atmosphere. This is equivalent

to an annual release of about 8.53 megacuries. Following accomplishment of this modification, and taking into account expected operating conditions it is expected that the average annual release rate will be reduced to 0.005 Ci/sec or 0.16 megacuries per year. A continuous release of 0.005 Ci/sec results in a boundary dose contribution of about 0.001 Rem/yr.

Northern States Power Company will maintain and use the equipment described in this report in such a manner as to reduce the release of radioactive materials to the atmosphere to the lowest practicable levels. This, it is expected, will limit atmospheric releases from the plant to an annual average of 0.16 megacuries. At the same time, certain flexibility of operation is required compatible with consideration of health and safety to assure that the public is provided a dependable source of power, even under the unusual operating conditions which may temporarily result in releases higher than those described above, but still well within the limits specified in 10 CFR Part 20.

The proposed changes to the Technical Specifications which would be associated with this modification are contained in the attachment to this report.

2.0 INTRODUCTION

The gaseous radwaste system initially installed in the Monticello plant provides for disposal of potentially radioactive gases through the plant stack, with appropriate monitoring, dilution, and automatic shutoff facilities. There are normally three sources discharged to this stack: offgas from the main steam condenser air ejectors, offgas from the main steam turbine gland seal system, and dilution air from the turbine building ventilation system. During plant startup the condenser mechanical vacuum pump is also discharged to the stack, and during some operating conditions offgas from the HPCI turbine and the SGTS systems may be discharged to the stack, as described in the Final Safety Analysis Report, USAEC Docket 50-263. Very small quantities of radioactive gases may also be released with ventilation air from the non-contained portions of the plant, but these releases are monitored and controlled, and are rarely significant when compared to the stack releases.

Operating experience with plants similar to the Monticello plant design has shown that about 99% of the radioactive gases discharged come from the main steam condenser air ejectors. These gases are currently delayed for a minimum of 30 minutes prior to their release at Monticello and at other similar plants. The radioactivity of these gases and the resultant boundary dose rates can be further reduced by retaining the gases for an additional period of time. This report describes modifications being undertaken voluntarily by Northern States Power Company at the Monticello Plant to retain the radioactive gases from the main steam condenser air ejectors for an additional period of time, so as to reduce the plant boundary doses to the lowest practicable levels.

3.0 DESIGN BASIS

The gaseous radwaste system initially installed in the Monticello plant was designed to collect, process, store, monitor and dispose of radioactive gaseous wastes generated in the operation of the plant. The system was designed such that radioactive gases could be discharged without exceeding the annual environs radiation dose rate as set forth in 10 CFR 20.

The modified system as described herein is designed to further reduce the gaseous radioactivity release rates to the lowest practicable levels commensurate with the state of technology, the economics as they are related to the degree of public benefit, and the availability and reliability of the process and the equipment for timely incorporation into an operating power plant.

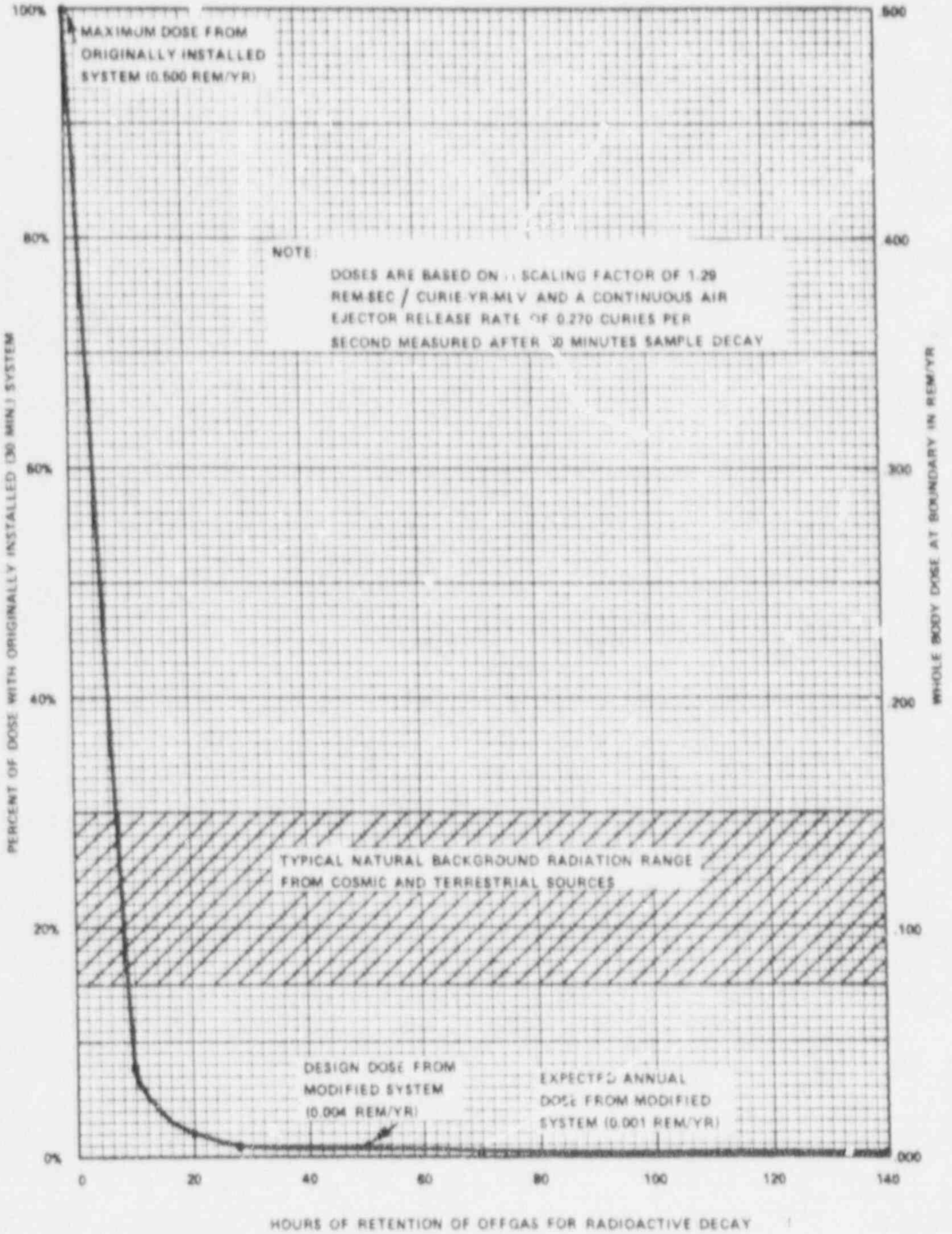
Four processes for krypton and xenon radioactivity reduction were considered for application to this modification: removal by cryogenic distillation, removal by fluorocarbon absorption, selective retention by charcoal adsorption, and total gas retention by compressed storage. The first two of these processes were eliminated from further consideration for incorporation into an operating plant based on the state of those technologies, or more specifically, on the absence of operating experience with the proposed equipment in radioactive service of this nature. The two remaining processes for retention of radioactive gases were judged essentially identical with regard to environmental effects, based on equal retention times, with both processes capable of decaying all of the noble gas isotopes except Krypton 85.

The length of retention time required was determined by computation of the potential dose at the nearest plant boundary under the worst combination of operating and meteorological conditions that will exist for any significant period of time. The computation was based on the Technical Specification limit of 0.27 Ci/sec at the air ejectors, measured after 30-minute sample decay. The result of this computation, which is for a diffusion mixture, is shown graphically in Figure 1. The releases from other sources were also examined, but not included in the computation because their contributions to the boundary dose were not considered significant. For example, the release rate from the turbine gland seal system was estimated to be 0.1% of the 0.27 Ci/sec, or 0.00027 Ci/sec (see FSAR), which would produce a boundary dose rate contribution of about .0005 Rem/yr. The ventilation contribution is expected to be less than this amount. Intermittent, short-term releases from the standby gas treatment system and the main steam condenser mechanical vacuum pump (used during plant startup only) could result in short-term releases near the Technical Specification limits, but experience with operating BWR's has indicated that the infrequency of these releases results in insignificant contributions to average boundary doses.

This evaluation revealed that by modification of the air ejector offgas system to obtain a minimum of 50 hours holdup, the typical dose would be only about 1% of the typical dose from the plant prior to such a modification. This dose would be about 0.004 Rem/year and should occur only if and when the following events occurred simultaneously:

- Maximum fuel clad failure condition at which the plant could be operated sustained for one year.

FIGURE 1
EFFECT OF MONTICELLO OFF–GAS SYSTEM MODIFICATION
ON RADIATION DOSE CONTRIBUTION AT PLANT BOUNDARY



- Continuous presence of the dose recipient at the nearest plant boundary for one year.

It was noted that under these extreme conditions the dose received from the plant release would constitute only about 4% of the total dose from natural sources. Furthermore, the dose from the plant release would be almost wholly from Xenon 133, which has a half life of 5.3 days. Neither of the processes for retention can hold Krypton 85 for a period sufficient to reduce its activity appreciably, but the Krypton 85 contributes less than 1/500 of the reduced boundary dose from the plant release; thus it does not present a significant local problem.

Based on the foregoing considerations, a minimum retention time of 50 hours was selected as a design basis for modification of the air ejector offgas system. Modification of the systems handling offgases from sources other than the air ejectors was concluded to be unnecessary because of the relatively low dose rate contributions from these sources when compared to the air ejector offgas releases or to natural background levels.

Both the charcoal and compressed storage processes were found to require hydrogen-oxygen recombination to eliminate combustion hazards and to reduce component sizes to the most economical ranges. In the final analysis, the compressed gas storage process was selected, based on the following additional considerations:

- Gas storage is a passive process involving methods and equipment which represent a highly developed state-of-the-art.

- Performance of a compressed gas retention process for radioactive decay can be accurately predicted for all conceivable operating conditions and is not subject to significant variation due to component configuration or leakage characteristics, nor is it subject to deterioration with use.

- Design information, performance characteristics, and component reliability data were all freely available from U.S. manufacturers for gas storage system components.

- Positive segregation of the offgas in separate tanks in a passive state permits any short-term releases of higher-than-normal radioactivity levels to be selectively decayed for longer periods of time, without unavailability of generating capacity.

- Positive segregation of the offgas in separate tanks provides an opportunity, under abnormal operating conditions, for more complete analyses of the gases prior to their release.

- The compressed gas storage process is the least subject to possible degradation from gaseous contaminants that could be present in the air leaked into the condenser.

- The compressed gas storage system could be designed and installed in less time than was required for the other processes.

The design objective for the modification is a reduction of the maximum air ejector offgas release rate from 0.27 Ci/sec to 0.012 Ci/sec, with a corresponding maximum boundary dose rate reduction from 0.500 Rem/year to 0.004 Rem/year. These rates are based on air ejector discharge rate of 0.27 Ci/sec (30 minute sample decay) with a condenser in-leakage rate of 28 scfm. However, as stated in Section 1.0, it is expected the annual average release rate will be reduced to 0.005 Ci/sec. corresponding to an off-site dose contribution of 0.001 Rem/yr. The calculation of these rates and the average quantity of each of the principal radionuclides of the gases expected to be released annually are presented in Section 6.0 of this report.

4.0 SYSTEM MODIFICATION DESCRIPTION

4.1 Summary

The modification to the originally installed offgas system consists of a hydrogen dilution and recombiner sub-system inserted in the 6" offgas line from the condenser air ejectors immediately upstream of the 30 minute holdup pipe, and an underground gas compressor and storage tank sub-system inserted at the outlet to the 30 minute holdup pipe. Figure 2 is a P&ID of this modification. The originally installed system, as depicted in the FSAR Figure 9-3-1, P&ID Off-Gas System, will be otherwise unchanged except for the electrical signal to the emergency shut-off valves in the off-gas line to the stack, which is discussed below.

4.2 Hydrogen Dilution and Recombiner Sub-System

This sub-system consists of two parallel flow paths for hydrogen dilution and recombination, each capable of operating independently of the other and each capable of handling the condenser combined offgas and vapor design flow rate of 146 scfm (166 cfm at 130°F). The major components of each flow path are a steam jet eductor, a preheater, a hydrogen-oxygen recombiner, a desuperheater, and a condenser. Pertinent design and operating parameters for the sub-system are given in Table 1.

The steam jet eductor is designed to dilute the hydrogen content of the mixture to a value below the flammable limit. The preheater downstream of the eductor is used to assure that the vapor entering the recombiner is slightly superheated for effective operation of the recombiner, which is a catalyst bed type. The spray desuperheater is designed to bring the vapor temperature, substantially increased by the heat of recombination,

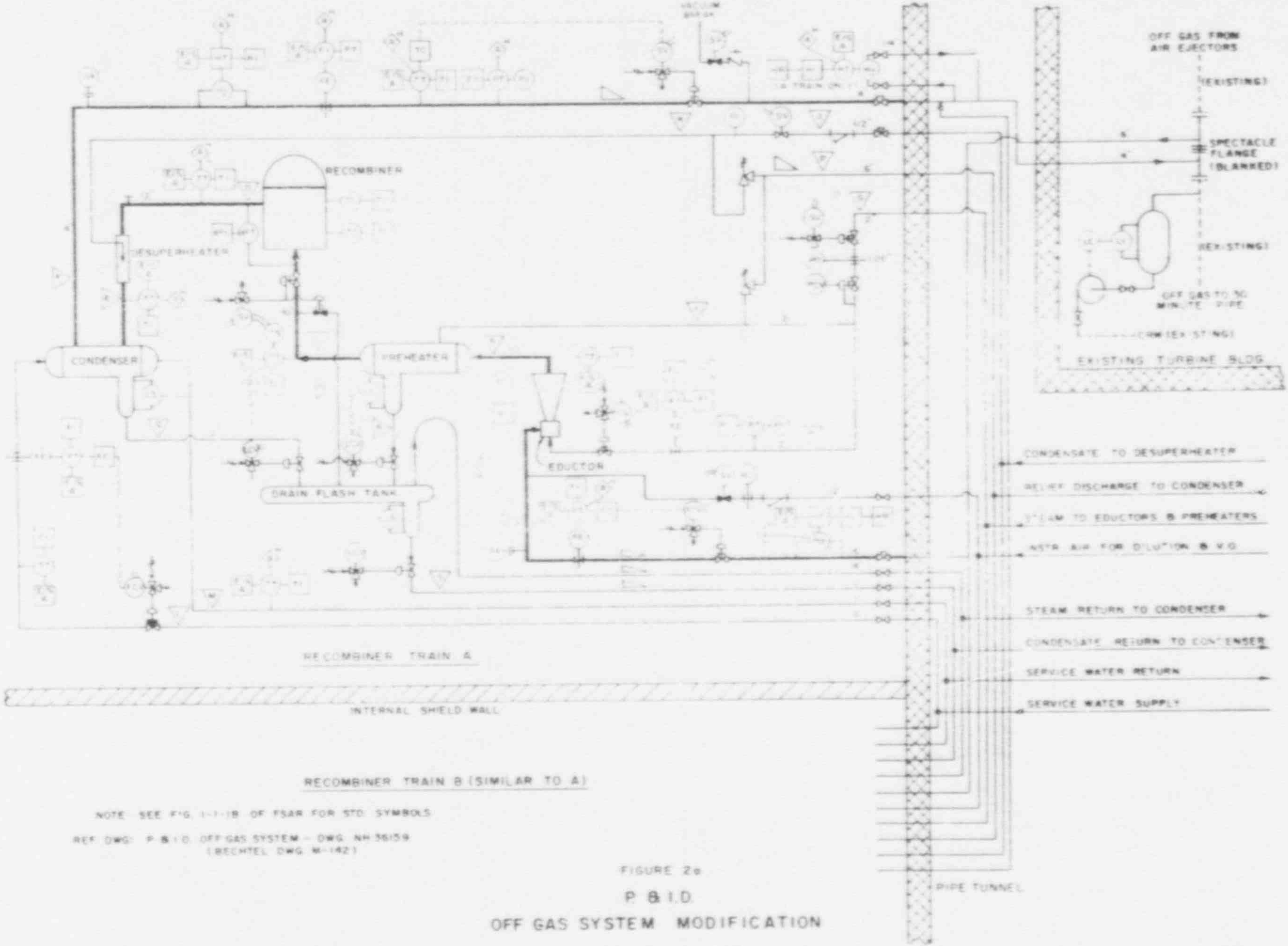
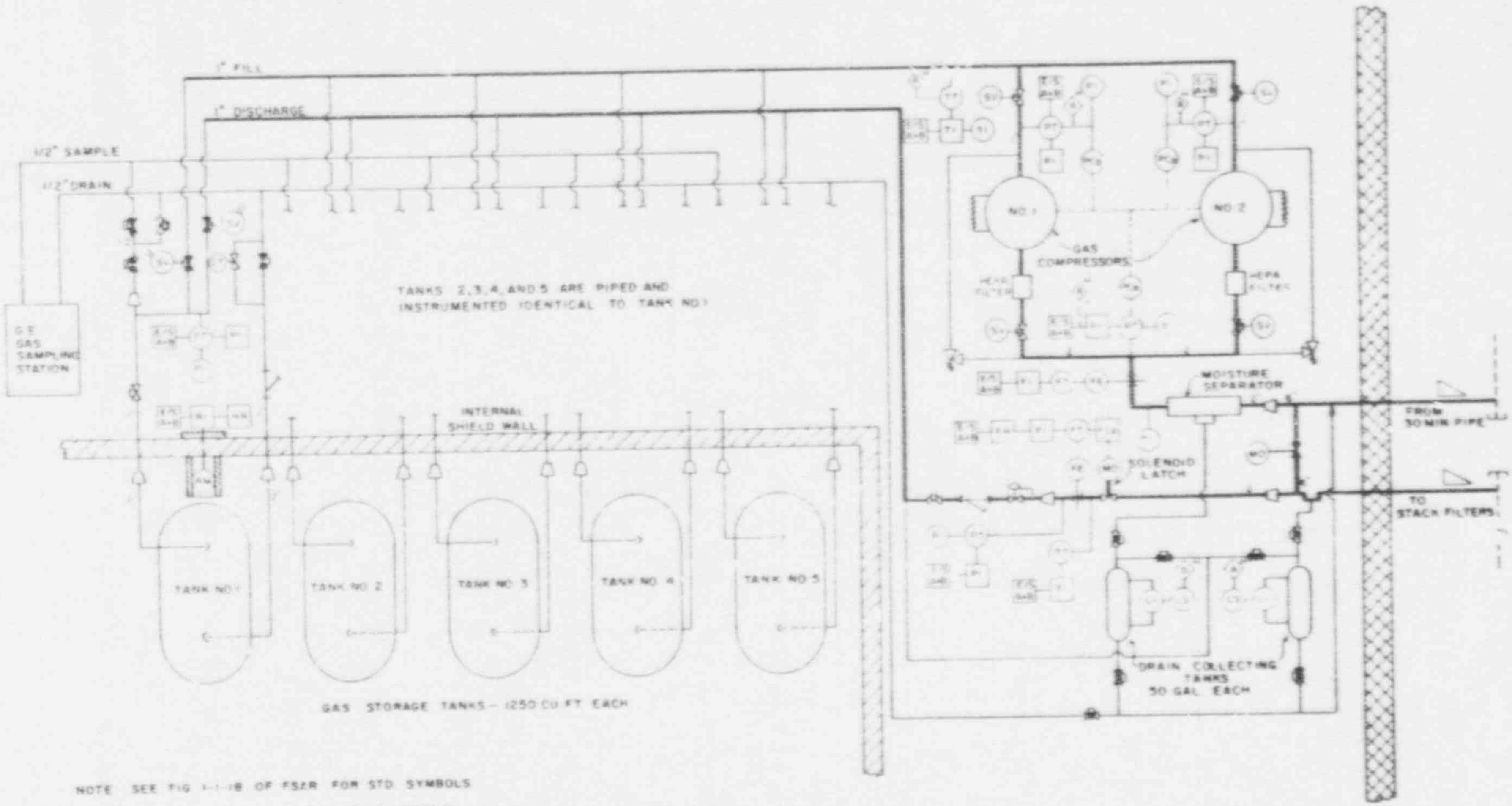


FIGURE 2a

P & I.D.

OFF GAS SYSTEM MODIFICATION

RECOMBINER SUB-SYSTEM



NOTE: SEE FIG 1-1-18 OF FSAR FOR STD SYMBOLS

REF DWG: P.&.I.D. OFF GAS SYSTEM - DWG NH36159 (BECHTEL DWG M-142)

FIGURE 26

P & I.D.

OFF GAS SYSTEM MODIFICATION

GAS STORAGE SUB-SYSTEM

TABLE I

MONTICELLO OFFGAS MODIFICATION DESIGN AND OPERATING PARAMETERS

(Flows are per train)

Point	Fluid	Normal Operating				Standby Condition				Plant Startup				Design Maximum			
		PSIA	°F	Lb/Hr	%H_2 Vol	PSIA	°F	Lb/Hr	%H_2 Vol	PSIA	°F	Lb/Hr	%H_2 Vol	PSIA	°F	Lb/Hr	%H_2 Vol
A	Offgas & Carryover	14.0	139	235 - 355	0-70	13.0	90	0	-	20	225	800	0-70	300	417	800	100
B	Offgas & Steam	14.0	178	6800	0-4	13.0	206	500	-	18	228	7300	0-4	300	417	8000	4
C	Offgas & Steam	13.5	306	6800	0-4	13.0	306	500	-	17	270	7300	0-4	300	432	8000	4
D	Offgas & Steam	13.0	70	6800	<0.1	12.8	300	500	-	16.5	306	7300	0-2	300	900	8000	< 2
E	Offgas & Steam	13.0	206	6800	<0.1	12.8	205	2500	-	16.5	218	9300	0-2	300	900	10,000	< 2
F	Offgas + 1% Carryover	12.5	184	136	<0.1	12.5	80	< 5	-	16.0	198	893	0-2	300	417	1000	< 2
G	Steam	1015	545	8500	-	1015	545	600	-	300	417	8500	-	1265	575	10,000	-
H	Steam	315	417	6500	-	315	417	500	-	300	417	6500	-	350	432	7500	-
I	Steam	315	417	2000	-	315	417	100	-	300	417	2000	-	350	432	2500	-
J	Desuperheater Condensate	430	92	2000	-	430	92	2000	-	430	92	2000	-	450	144	2500	-
K	Desuperheater Condensate	300	92	2000	-	300	92	2000	-	300	92	2000	-	350	144	2500	-
L	Service Water	55	70	293M	-	55	70	30M	-	55	70	293M	-	150	95	300M	-
M	Service Water	35	100	293M	-	35	90	30M	-	35	100	293M	-	150	358	300M	-
N	Steam	8	183	0	-	8	183	0	-	17	270	500	-	300	432	6500	-
O	Steam	8	183	800	-	8	183	250	-	17	270	500	-	300	432	8000	-
P	Steam	< 1	90	0	-	< 1	90	0	-	20	90	0	-	350	432	33,000	-
Q	Condensate	12.5	204	8500	-	12.5	204	2500	-	16	217	8500	-	350	432	10,000	-
R	Condensate	300	417	2000	-	300	417	100	-	300	417	2000	-	350	432	2500	-
S	Condensate	8	183	10,000	-	8	183	2250	-	15	212	10,000	-	350	432	12,000	-

down to saturation to enhance heat transfer in the condenser. The condenser is designed to remove the heat of recombination and to condense the diluent vapor from the stream. The condensers discharge the offgas into the originally installed underground holdup pipe. This entire subsystem will be operated at sub-atmospheric pressures to prevent outleakage of radioactive gases.

4.3 Gas Compressor and Storage Tank Sub-System

This sub-system consists of two parallel gas compressors and five parallel gas storage tanks, with sampling facilities and a controlled rate discharge station. The gas compressors are multi-stage piston-type with zero out-leakage provisions. Each compressor is capable of handling the system design flow rate, and one compressor is normally maintained in standby. The five tanks are located in a below-grade building near the plant stack. All valves are either hermetically sealed or capped to reduce leakage. The compressors are rated at 30 scfm each at 300 psig discharge pressure. The tanks are designed for 330 psig at -50 to 250°F.

4.4 Instrumentation and Control

Each recombiner train is equipped with sufficient remote instrumentation and control equipment to permit remote operation from the reactor control room. Alarms are provided to alert the control room operator to abnormal conditions of hydrogen concentration in the recombiner train inlet and outlet, low recombiner inlet temperature, high or low recombiner outlet temperature, high desuperheater outlet temperature, high condenser offgas temperature, and high condenser cooling water outlet temperature. The recombiner will be automatically bypassed back to the main steam condenser if the inlet superheat is insufficient. The train will be automatically isolated if the hydrogen content at the inlet to the recombiner exceeds 4%, if the hydrogen content at the train outlet exceeds 2%, if the train outlet gas exceeds 200°F, or if the train static pressure exceeds 20 psia.

The gas compressors may be operated in parallel or with either unit in standby. They automatically maintain the pressure in the 30 minute pipe between 10 and 12 psia during normal operation. A signal is sounded in the reactor control room when the pressure of the storage tank being filled approaches 300 psig, and the operator remotely diverts the flow to another tank. Alarms are sounded in the control room for high and low compressor suction pressure and high discharge pressure or temperature.

Each gas storage tank is remotely monitored for pressure and radioactivity level. Interlocks are provided to prevent simultaneous filling and discharge of any tank. Tank discharge rate is remotely set from the reactor control room and automatically controlled and recorded. Alarms indicate when drain tanks serving the plant stack and the compressor suction moisture separator are full.

The previously installed radiation monitors in the air ejector off-gas header will be modified to close the recombiner train inlet valves. The stack monitors will be modifed to close the stack isolation valves, the gas storage tank discharge header valve (to prevent blowing the loop seals), and to sound an alarm in the reactor control room. If the Technical Specification release rate limits are exceeded at either the air ejector or the stack the associated isolation will occur automatically. Alarms will sound in the control room when the high alarm settings are reached by these monitors.

Area radiation monitors will be provided in the new buildings and monitors will also be installed in the ventilation discharge ducts from these buildings. All radiation monitors will have both local and remote (reactor control room) alarms.

4.5 Arrangement, Structures, and Ventilation

The recombiner trains will be located in a new building located near the air ejector room. The building will be divided by a shield wall so that one train can be maintained while the other is operating. The offgas will be brought from the air ejector room and returned there after recombination for entry into the existing 30 minute pipe. Ventilation from the building will be designed to maintain the recombiner building at a slightly negative pressure and will discharge into the condenser space of the turbine building. Doors to the recombiner building will be kept locked except during maintenance operations or plant outages.

The outlet from the underground holdup pipe is diverted to a new gas storage building located near the base of the stack. The storage tank room is located below grade and is separated from the valve room by a radiation shield wall; the valve room is separated from the compressor room by a partition to permit ventilation flow control. The tank storage room will not be accessible during plant operation because of the high radiation levels. Ventilation from the building will be designed to maintain the storage building at slightly negative pressure, and will discharge to the stack to serve as part of the 4000 cfm dilution flow. Air will be directed from the compressor room, to the valve room, and then to the tank room. A flapper valve will protect the discharge duct from overpressurization in the event of storage tank ruptures.

4.6 Codes and Standards

The gas storage tanks and all piping and components which are not normally isolated or remotely isolable from the tanks will be designed, fabricated, and installed per ASME Boiler and Pressure Vessel Code, Section III, Class C and USAS B 31.7, Class II. The remaining piping and components will be designed, fabricated, and installed per ASME Boiler and Pressure Vessel Code, Section VIII and USAS B 31.7, Class III.

The recombiner building will be a Class II structure with structural integrity consistent with that of the turbine building. The gas storage building will be designed for Class I seismic conditions and tornado loads. Supporting system design will conform to the standards of the previously installed systems. Quality control will be consistent with that employed for design and construction of the previously installed offgas and supporting systems. The prime contractor for system design is Suntac Nuclear Corporation, 1528 Walnut Street, Philadelphia, Pennsylvania.

5.0 SYSTEM OPERATION

The hydrogen dilution and recombiner sub-system will receive non-condensible offgases from the main condenser air ejectors at a maximum design flow rate of 146 scfm per train, but at a reduced pressure of about 12 psia. A steam jet eductor will immediately dilute the offgas with about 6500 lb/hr of steam. The eductor will exhaust the gas-vapor mixture at near saturation temperature and about 14 psia, with a maximum hydrogen concentration of 4% by volume. The vapor will be heated to a few degrees superheat in the preheater and delivered to a recombiner. The recombiner will reduce the dry hydrogen content to a nominal 0.1% (maximum 2%), while heating the mixture to a maximum temperature of 900°F. The temperature will subsequently be reduced to near saturation by a condensate flow addition of about 2000 lb/hr in a desuperheater. This mixture will then enter a condenser where the majority of the vapor will be removed, leaving a maximum design gas flow of about 28 scfm at 12.5 psia and 200°F. The other dilution and recombiner train will be in hot standby condition with reduced steam flow.

Should condenser in-leakage decrease to less than 5 scfm, instrument air will be bled manually into the offgas stream upstream of the recombiners to assure a sufficient supply of oxygen for complete recombination and to prevent excessive concentration of the radioactive gases following recombination.

The 28 scfm offgas flow will then enter the previously installed 30 minute holdup pipe, but due to the decreased design flow resulting from H_2-O_2 recombination, the pipe holdup time will be increased to about 2 hours (about 5 hours with condenser air in-leakage at 10 scfm). Following this holdup, the offgas is compressed to 300 psig by the operating compressor and delivered to one of the five 1250 ft^3 holdup tanks.

Under design operating conditions, each tank will undergo a minimum charging period of 12 hours (5 to 300 psig) followed by 36 hours of dead storage, and will then be released with approximately 12 hours of discharge time. This yields a minimum mean holdup time of 48 hours in the tanks, plus over two hours in the holdup pipe. This holdup time will be increased to about 140 and 280 hours for condenser in-leakage rates of 10 and 5 scfm, respectively.

Under actual operating conditions, the tank with the lowest activity will be discharged, and the discharge flow rate will be selected to be only slightly greater than the rate of offgas flow after recombination. The discharge will be initiated from the reactor control room by opening the appropriate tank discharge solenoid valve, followed by remote adjustment of the motor-operated throttle valve to achieve the desired discharge flow rate. A pressure reducing valve in the discharge line maintains a constant pressure through the flow rate sensor and an orifice limits the maximum discharge flow rate to 150 scfm in the event of reducing valve failure. The charging solenoid valves are also opened from the reactor control room, following a signal indicating that the previous tank is fully charged. An electrical interlock prevents simultaneous opening of both the charging and discharge valve on the same tank. Discharge flow can be terminated from the reactor control room by closing the tank solenoid valve or by tripping the motor operated throttle valve.

Startup of the modified offgas system from cold conditions requires local operator action. The main steam condenser is evacuated to about 5" Hg absolute with the mechanical vacuum pump. As soon as reactor steam pressure reaches 300 psig, the piping and components upstream of the recombiners are heated by bypassing the diluent steam back to the condensers. Condensate flow is then established to the desuperheaters and the recombiner condensers, and the recombiner bypasses are closed and flow is established through both recombiner trains. The compressor and storage tank bypass valve at the outlet to the 30-minute holdup pipe is opened directly to the stack filters and the stack. The main condenser steam jet air ejectors are then brought on the line and the suction lines to the eductors are opened. The main steam condenser vacuum is then pulled down to the operating level and as soon as the offgas flow drops to below 50 scfm at the recombiner outlet, the bypass around the compressors and storage tanks is closed and both compressors are started. The reactor power can then be increased to significant power levels. The recombiner system should reach normal operating vacuum in less than one hour after the bypass valve is closed. There is no opportunity for out-leakage past the bypass valve to the stack during reactor power operation because of the sub-atmospheric pressure in the 30 minute holdup pipe, which will be achieved in less time than would be required for flow of radioactive gases through the holdup pipe following closure of the bypass valve.

Bypass of the compressors and storage tanks will not be permitted until the 30 minute delay pipe has been purged with at least one volume of air and a sample taken at the compressor outlet header and shown to contain less than 0.010 Ci/ft^3. This is to prevent the gases remaining in the 30 minute pipe from being pushed out by the air ejector startup (initial discharge rate of about 400 scfm) at a release rate in excess of 0.27 Ci/sec. Failure to observe this precedural limitation would result in closure of the stack isolation valves by the stack radiation monitoring system if the limits of the Technical Specifications were exceeded.

Offgas sampling will be performed at the air ejectors in accordance with the Technical Specifications. The quantities of the isotopes released will be recorded based on the average storage time of each tank and the most recent isotopic analysis.

6.0 SYSTEM PERFORMANCE

The modified offgas system is designed to provide holdup of the offgas from the condenser air ejectors for between 50 and 280 hours, depending upon the quantity of condenser air in-leakage experienced. Figure 1 shows the site boundary dose reduction as a function of holdup time. The quantities of activation gases released from the modified system are insufficient to affect total release rates or the boundary dose rates.

Based on an offgas release rate at the air ejector discharge which would produce the Technical Specification limit of 0.27 Ci/sec after 30 minute delay and a diffusion mixture, the activity discharged to the stack will be 0.012 Ci/sec at the maximum condenser air in-leakage of 28 scfm. It is expected the annual average stack release rate will not exceed 0.005 Ci/sec as both the air ejector release rate and the air in-leakage should be less than the aforementioned values. The estimated noble gas nuclide release rates are presented in Table II for both the originally installed and the modified offgas systems. It is also expected that the majority of the gaseous iodides and tritium will be removed by the recombiner, but there are insufficient data available for an accurate prediction of this removal efficiency.

Northern States Power Company will maintain and use the equipment described in this report in such a manner as to reduce the release of radioactive materials to the atmosphere to the lowest practicable levels. This, it is expected, will limit atmospheric releases from the plant to an average annual release of 0.16 megacuries. At the same time, certain flexibility of operation is required compatible with consideration of health and safety to assure that the public is provided a dependable source of power, even under the unusual operating conditions which may temporarily result in releases higher than those described above, but still well within the limits specified in 10 CFR Part 20.

TABLE II

EFFECT OF OFF-GAS SYSTEM MODIFICATION ON
NOBLE GAS NUCLIDE RELEASE RATE AND BOUNDARY DOSE RATE

			Originally Installed System		Modified System			
Isotope	Decay Factor sec^{-1}	Effective Energy γ + β Mev	Max. Stack Release Rate - μCi/sec*	Max. Boundary Dose - mRem/yr**	Design Objective Stack Release Rate μCi/sec*	Design Objective Boundary Dose mRem/yr**	Expected Annual*** Release Ci/yr	Expected Boundary*** Dose - mRem/yr**
Condenser In-Leakage			28 scfm	28 scfm	28 scfm	28 scfm	21.5 scfm	21.5 scfm
Total Delay			0.5 hrs	0.5 hrs	50 hrs	50 hrs	65 hrs	65 hrs
Kr-89	3.61E-03	1.13	7.12E2	1	<1	0.0	<1	0.00
Kr-87	1.50E-04	2.80	4.25E4	154	<1	0.0	<1	0.00
Kr-83m	1.03E-04	.05	6.83E3	0	<1	0.0	<1	0.00
Kr-88	6.88E-05	2.45	4.68E4	148	<1	0.0	<1	0.00
Kr-85m	4.36E-05	.44	1.57E4	9	5.80E0	0.0	<1	0.00
Kr-85	2.11E-09	.24	2.00E1	0	2.00E1	0.0	3.16E2	2.00
Xe-137	3.04E-03	1.44	2.32E3	4	<1	0.0	<1	0.00
Xe-138	6.80E-04	1.37	7.20E4	127	<1	0.0	<1	0.00
Xe-135m	7.70E-04	.53	2.16E4	15	<1	0.0	<1	0.00
Xe-135	2.09E-05	.62	4.74E4	38	1.30E3	1.0	5.85E3	0.15
Xe-133m	3.49E-06	.23	5.09E2	0	2.85E2	0.1	3.58E3	0.03
Xe-133	1.52E-06	.19	1.35E4	3	1.05E4	2.6	1.50E5	1.16
Xe-131m	6.17E-07	.16	4.00E1	0	3.50E1	0.0	5.35E2	9.00
Total			2.70E5	500	1.21E4	3.7	0.16E6	1.34

* Rate which would produce 0.27 Ci/sec with diffusion mixture after 30 minute holdup.
** Based on a scaling factor of 1290 mrem · sec/Ci · year · Mev and actual effective energies of each isotope.
*** Based on an average release rate of 0.005 Ci/sec after 65 hours holdup.

7.0 SAFETY ANALYSES

7.1 Accident Analysis

The maximum release to the environs from the modified offgas system would result if all five storage tanks were assumed to undergo instantaneous and 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 minute sample decay) at the condenser air ejectors and with maximum condenser air in-leakage (28 scfm). The calculated dose at the nearest boundary for this instantaneous release is 0.802 rem, which is well within the guideline of 10 CFR 100.

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 1.78 hours decay in the previously installed holdup pipe, for decay during the filling operation, and for dead storage time in the first four tanks.

Dose was computed by the equation:

$$\text{Dose (Rads)} = 0.246 \cdot \frac{X}{Q}\ (\text{sec/m}^3) \cdot \text{Curies} \cdot E_{eff}\ (\text{mev } \gamma + B)$$

where: A_i = isotope activity release, Ci (from Table III)

E_i = isotope effective energy, Mev/dis (from Table II)

$\frac{X}{Q}$ = dispersion factor, sec/m^3 (8.86×10^{-4})

7.2 Hydrogen Handling

The waste gas system handles potentially flammable mixtures of hydrogen, oxygen, and air up to the eductor of the modified system, where the mixture is diluted with steam to less than 4% hydrogen concentration by volume. Although ignition of the mixture where it is above 4% hydrogen concentration is highly improbable and has not been experienced in operating BWR's, the shock wave from such a detonation could conceivably travel through the recombiner and underground holdup pipe up to the compressor suction. Although such a shock wave would be considerably attenuated before reaching most parts of the modified system, all new components up-stream of the compressors will be designed and tested to withstand the full force (20 atmospheres) of such a detonation.

Under normal operating conditions, the hydrogen concentration at the condenser outlet following recombination will be less than 0.1% hydrogen by volume. During transient conditions when the inlet concentration of hydrogen is very low and the air flow is simultaneously low, the recombiner will not function as efficiently and there will be less dilution air following condensation of the steam. Under these conditions, the hydrogen concentration at the condenser outlet may rise to 0.5%. This is significantly below the flammable limit, however, and the flammable limit rises as the mixture is compressed.

TABLE III

WORST CASE RADIOACTIVITY RELEASE FROM ACCIDENT RESULTING IN SIMULTANEOUS RUPTURE OF ALL OFF-GAS STORAGE TANKS

(28 scfm condenser air in-leakage and 0.27 Ci/sec after 30 minute)

	Tank Inventory						Boundary Dose	
Tank No.	1 Ci	2 Ci	3 Ci	4 Ci	5 Ci	Total Ci	1 rem/yr	Total rem/yr
Kr-89	1.15E-08	-	-	-	-	1.15E-08	-	-
Kr-87	1.41E+02	3.07E-02	6.66E-06	-	-	1.41E+02	0.086	0.086
Kr-83m	4.12E+01	1.26E-01	3.83E-04	-	-	4.13E+01	-	-
Kr-88	4.84E+02	1.01E+01	2.11E-01	4.40E-03	9.19E-05	4.94E+02	0.259	0.264
Kr-85m	2.69E+02	2.29E+01	1.95E+00	1.66E-01	1.41E-02	2.94E+02	0.026	0.028
Kr-85	1.15E+00	1.15E+00	1.15E+00	1.15E+00	1.15E+00	5.75E+00	-	-
Xe-137	6.11E-07	-	-	-	-	6.11E-07	-	-
Xe-138	4.59E+00	1.13E-16	-	-	-	4.59F+00	0.001	0.001
Xe-135m	7.98E-01	1.24E-19	-	-	-	7.98E-01	-	-
Xe-135	1.49E+03	4.60E+02	1.42E+02	4.39E+01	1.35E+01	2.15E+03	0.201	0.291
Xe-133m	2.54E+01	2.08F+01	1.71E+01	1.41E+01	1.16E+01	8.90E+01	0.001	0.004
Xe-133	7.28E+02	6.70E+02	6.17E+02	5.67E+02	5.22E+02	3.10E+03	0.030	0.128
Xe-131m	2.25E+00	2.17E+00	2.09E+00	2.02E+00	1.95E+00	1.05E+01	-	-
Sum						6.33E+03	0.604	0.802

Formula: $\text{rem/yr} = 0.246 \left(\frac{\chi}{Q}\right) (\text{Ci}) (\bar{E}_{eff}\ \gamma + \beta)$

Redundant hydrogen analyzers are provided in the outlet from the condensers to assure that the recombiners are operating satisfactorily. These monitors are set to alarm in the reactor control room if the hydrogen concentration reaches 1% by volume. Shutdown of the operating recombiner train is required if the concentration reaches 2%. Other alarmed instruments, such as the recombiner outlet temperature, will also indicate recombiner failure as a backup to the analyzers.

7.3 Shielding

The storage room of the new waste gas storage building will not be accessible when any of the tanks are pressurized. The shield wall between the storage room and the compressor room will be designed to maintain less than 5.0 mrem/hr within two feet of the compressor room side of the wall. The building will be underground with sufficient shielding or area access restriction to assure personnel protection.

The new recombiner building will be designed to limit radiation levels on contact with outside walls to a maximum of 2 mrem/hr. An inside shield wall between the trains will permit limited occupancy for maintenance of one train while the other train is operating.

PROPOSED CHANGES

TO

TECH. CAL SPECIFICATIONS

Attachment

to

Gaseous Radwaste System

Modification Report

Monticello Nuclear Generating Plant
Unit No. 1

Northern States Power Company
Minneapolis, Minnesota

3.0 LIMITING CONDITIONS FOR OPERATION	4.0 SURVEILLANCE REQUIREMENTS
B. Emergency Core Cooling Subsystems Actuation When irradiated fuel is in the reactor vessel and the reactor water temperature is above 212°F, the limiting conditions for operation for the instrumentation which initiates the emergency core cooling subsystems are given in Table 3.2.2. C. Control Rod Block Actuation The limiting conditions of operation for the instrumentation that initiates control rod block are given in Table 3.2.3. A-1 D. Off-Gas System At least one stack radiation monitor shall be operating at any time off-gas is being discharged from the plant from sources other than the ventilation system. The trip settings for the stack monitors shall be set at a value not to exceed the instantaneous value associated with the 15-minute release limit specified in Specification 3.8.1.	

D. Off-Gas System (con't)

Both off-gas radiation monitors in the common discharge line from the condenser air ejectors shall be operable or operating during power operations. The trip settings for the monitors shall be set at a value not to exceed the 15 minute release limit specified in Specification 3.8.A.1. The time delay setting for closure of the off-gas inlet valves to the recombiner subsystem shall not exceed 15 minutes.

A-2

Table 4.2.1 - Continued

Minimum Test and Calibration Frequency For Core Cooling Rod Block and Isolation Instrumentation

Instrument Channel	Test (3)	Calibration (3)	Sensor Check (3)
3. Steam Line Low Pressure	Note 1	Once/3 months	None
4. Steam Line High Radiation	Once/week (5)	Note 6	Once/shift
HPCI ISOLATION			
1. Steam Line High Flow	Note 1	Once/3 months	None
2. Steam Line High Temperature	Note 1	Once/3 months	None
RCIC ISOLATION			
1. Steam Line High Flow	Note 1	Once/3 months	None
2. Steam Line High Temperature	Note 1	Once/3 months	None
REACTOR BUILDING VENTILATION			
1. Radiation Monitors (Plenum)	Note 1	Once/3 months	Once/shift
2. Radiation Monitors (Refueling Floor)	Note 1	Once/3 months	(4)
OFF GAS ISOLATION			
1. Radiation Monitors	Notes (1,5,6)	Once/3 months	Once/shift

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Notes:

(1) Initially once per month until exposure hours (M as defined on Figures 4.1.1) is 2.0×10^5, thereafter according to Figure 4.1.1, with an interval not greater than three months.

Bases Continued:

3.2 For effective emergency core cooling for the small pipe break the HPCI or Automatic Pressure Relief system must function since for these breaks, reactor pressure does not decrease rapidly enough to allow either core spray or LPCI to operate in time. The arrangement of the tripping contacts is such as to provide this function when necessary and minimize spurious operation. The trip settings given in the specification are adequate to assure the above criteria is met. Reference Section 6.2.4 and 6.2.6 FSAR. The specification preserves the effectiveness of the system during periods of maintenance, testing, or calibration, and also minimizes the risk of inadvertent operation; i.e., only one instrument channel out of service.

Two air ejector offgas monitors are provided and when their trip point is reached the flow to the recombiners is terminated, resulting in subsequent reactor scram due to loss of condenser vacuum. This precludes operation of the plant at offgas rates in excess of plant design. Two stack monitors are provided and when their trip point is reached, discharge of offgas to the stack is terminated. This precludes discharges in excess of the limits of Specification 3.8 due to high flow rates from the offgas storage system or from the 30-minute pipe when the storage system is bypassed. In both locations, isolation is initiated on two high trips, two low trips, or one high and one low trip.

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Four radiation monitors are provided which initiate isolation of the reactor building and operation of the standby gas treatment system. The monitors are located in the reactor building and ventilation plenum and on the refueling floor. Any one upscale trip will cause the desired action. Trip settings of 26 mr/hr for the monitors in the ventilation duct are based upon initiating normal ventilation isolation and standby gas treatment system operation so as not to exceed a dose rate of five percent of the dose rate allowed by 10 CFR 20 at the most restrictive site boundary. Trip settings of 100 mr/hr for the monitors on the refueling floor are based upon initiating normal ventilation isolation and standby gas treatment system operation so that none of the activity released during the refueling accident leaves the reactor building via the normal ventilation stack but that all the activity is processed by the standby gas treatment system.

Although the operator will set the set points within the trip settings specified on Tables 3.2.1, 3.2.2, 3.2.3, and 3.2.4, the actual values of the various set points can differ appraciably from the value the operator is attempting to set. The deviations could be caused by inherent instrument error, operator setting error, drift of the set point. etc. Therefore, these deviations have been accounted for in the various transient analyses and the actual trip settings may vary by the following amounts.

Bases Continued:

4.2 The most likely case would be to stipulate that one channel be bypassed, tested, and restored, and then immediately following the second channel be bypassed, tested, and restored. This is shown by Curve No. 4. Note that there is no true minimum. The curve does have a definite knee and very little reduction in system unavailability is achieved by testing at a shorter interval than computed by the equation for a single channel.

The best test procedure of all those examined is to perfectly stagger the tests. That is, if the test interval is four months, test one or the other channel every two months. This is shown in Curve No. 5. The difference between Cases 4 and 5 is negligible. There may be other arguments, however, that more strongly support the perfectly staggered tests, including reductions in human error.

The conclusions to be drawn are these:

1. A 1 out of n system may be treated the same as a single channel in terms of choosing a test interval; and

2. More than one channel should not be bypassed for testing at any one time.

A-5

The radiation monitors in the ventilation plenum and on the refueling floor which initiate building isolation and standby gas treatment operation are arranged in two 1 out of 2 logic systems. The bases given above for the rod blocks applies here also and were used to arrive at the functional testing frequency.

The air ejector and stack offgas radiation monitor channel logic is so arranged that a closure of the off-gas line or the stack isolation valves, respectively, is initiated by two upscale, two downscale, or one upscale and one downscale trip signals. Based on experience at other nuclear power plants with instruments of similar design, a testing interval of once every three months has been found to be adequate. However, for additional margin a test interval of once per month will be used initially until a trend is established and thereafter according to Figure 4.1.1 (see Section 3.1/4.1) with an interval not greater than three months.

The automatic pressure relief instrumentation can be considered to be a 1 out of 2 logic system and the discussion above also applies.

3.0 LIMITING CONDITIONS FOR OPERATION	4.0 SURVEILLANCE REQUIREMENTS

1. The annual average release rates of gross beta-gamma activity, except halogens and particulates with half lives longer than eight days, shall not exceed:
Average Annual Rate (Q in curies/sec):

$$\frac{Q1}{0.27} + \frac{QRS}{0.021} \leq 1$$

Any one fiften minute period per hour (Q in curies/sec):

$$\frac{Q1}{2.7} + \frac{QRS}{0.21} \leq 1$$

In addition to the above limits, the effluent rate at the air ejector monitors, except halogens and particulates with half lives longer than eight days, shall not exceed an annual average rate of 0.27 Ci/sec or an instantaneous rate of 2.7 Ci/sec for more than 15 minute per hour, based on 30 minute sample decay.

1. Station records of gross stack release rate of gaseous activity shall be maintained on an hourly basis to assure that the specified rates are not being exceeded, and to yield information concerning general integrity of the fuel cladding. Records of isotopic analysis shall be maintained. The off-gas stack and reactor building monitoring systems shall be functionally tested and calibrated in accordance with Specification 4.2, Table 4.2.1.

Within one month of initial commercial service of the unit, an isotopic analysis will be made of the gaseous activity release rate. From this sample a ratio of long-lived and short-lived activity will be established. Weekly samples of off-gas will be taken and gross ratio of long-lived and short-lived activity determined. When the weekly samples indicate a change of greater than 20% from the previous isotopic analysis, a new isotopic analysis will be performed. An isotopic analysis of off-gas will be performed at least quarterly. Gaseous release of tritium shall be calculated on a monthly basis from measured data.

3.0 LIMITING CONDITIONS FOR OPERATION	4.0 SURVEILLANCE REQUIREMENTS
	Release of noble gas radioisotopes will be calculated from the isotopic samples taken at the air ejectors, based on the recorded decay times prior to release of the gas to the atmosphere.

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3.0 LIMITING CONDITIONS FOR OPERATION	4.0 SURVEILLANCE REQUIREMENTS
3. Two independent samples of each tank shall be taken and analyzed for gross beta-gamma activity and the valve line-up checked prior to discharge of liquid effluents.	3. The performance and results of independent samples and valve checks shall be logged.
4. If the limits of 3.8.C cannot be met, radioactive liquid effluents shall not be released.	
D. Radioactive Waste Storage	D. Radioactive Waste Storage
The maximum amount of radioactivity in liquid storage in the Waste Sample Tanks, Floor Drain Sample Tanks, Waste Surge Tanks and the Condensate storage tanks shall not exceed 2 curies. If this condition cannot be met, the liquids in these tanks shall be recycled to tanks within the radwaste facility until the specification is met.	(1) A sample from each of the Waste Sample, Floor Drain, Condensate Storage and Waste Surge Tanks shall be taken, analyzed and recorded every 72 hours. If no additions to one of the above tanks has occurred since the last sample, that tank need not be sampled until the next addition.
E. General	
The releases of radioactive material in all effluents will be kept at small fractions of the limits specified in 20.106 of 10 CFR Part 20. Radioactive effluents in gaseous releases will be maintained below the design objective of an annual average rate of	

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3.0 LIMITING CONDITIONS FOR OPERATION	4.0 SURVEILLANCE REQUIREMENTS
E. General (cont.)	E. General
12,100 μCi/sec, except during periods of abnormal or emergency operation of the plant when such releases may approach the limits of 3.8. At the same time the licensee is permitted the flexibility of operation, compatible with considerations of health and safety, to assure that the public is provided a dependable source of power even under unusual operating conditions which may temporarily result.	Operating procedures shall be developed and used, and equipment which has been installed to maintain control over radioactive materials in gaseous and liquid effluents produced during normal reactor operations, including expected operational occurrences, shall be maintained and used, to keep levels of radioactive material in effluents released to unrestricted areas as low as practicable.

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(3) Percentage of the maximum annual limit released and MPC value.
(4) Results of all isotopic analyses and estimates total curies of each identified nuclide released.
(5) Such other information as may be required by the Commission to estimate maximum potential annual radiation doses to the public resulting from effluent releases.
(6) Specific information will be reported if quantities of radioactive materials released during the reporting period are significantly above design objectives.

g. Solid Radioactive Waste

(1) Total volume (in cubic feet) of solid waste generated.
(2) Gross curie activity involved.
(3) Dates and disposition of the materials if shipped off-site.

h. Environmental Monitoring

(1) A narrative summary, including correlation with effluent releases of the results of off-site environmental surveys performed during the report period.
(2) Tabulation of the results of the environmental monitoring program, including a figure showing location of the monitoring stations.
(3) For any Samples which indicate statistically significant levels of radioactivity above established background levels, a comparison with applicable 10 CFR 20 limits shall be provided.

E. Special Reports (in writing to the Director, Division of Reactor Licensing, USAEC, Washington D. C. 20545):

1. In the event a redundant component (or system) covered by these Technical Specifications is determined to be out of service for periods longer than those specified in other sections, it shall be the subject of a special maintenance report. This report shall be submitted within seven days of the above determination and shall describe:

a. The nature of the problem and the specific steps to be taken to remedy the situation

b. An estimate of the time required to return the component (or system) to an operable condition.