NORTHERN STATES POWER COMPANY

MONTICELLO NUCLEAR GENERATING PLANT

SUMMARY TECHNICAL REPORT

TO

UNITED STATES ATOMIC ENERGY COMMISSION

DIRECTORATE OF LICENSING

ON

SECONDARY CONTAINMENT LEAK RATE TEST

JULY, 1973

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1.0 INTRODUCTION

Technical Specification 4.7.C.1.b for the Monticello Nuclear Generating Plant requires, with regards to the secondary containment capability test, that "Additional tests shall be performed during the first operating cycle under an adequate number of different environmental wind conditions to enable valid extrapolation of the test results." In compliance with this requirement, eight Secondary Containment Capability Tests were performed during the first operating cycle.

This summary technical report is submitted in accordance with the requirements of Section 6.7.C of the Technical Specifications, which requires that "Each integrated leak rate test of the secondary containment shall be the subject of a summary technical report. This report should include data on the wind speed, wind direction, outside and inside temperatures during the test, concurrent reactor building pressure, and emergency ventilation flow rate. The report shall also include analyses and interpretations of these data which demonstrate compliance with the specified leak rate limits."

2.0 SUMMARY OF RESULTS

Two sets of capability tests were conducted on eight separate occasions wherein the "A" Standby Gas Treatment System (SBGTS) train was operated at varying system flow conditions with either the outer or inner railway door open. On each occasion, an additional set of tests was conducted using the "B" SBGTS train with the outer railway door open. A total of 68 separate data sets are reported, each representing one test. The tests were conducted under varying wind and atmospheric conditions and provide an adequate basis for a valid extrapolation to calm conditions. The analysis will, of course, be updated to take advantage of improved statistics as data is collected from future tests. In all cases, it was found that on extrapolation to calm conditions, a 0.25 inch H_2O negative differential pressure could be maintained for a SBGTS flow under 4000 scfm.

3.0 GENERAL TEST METHODS

The Secondary Containment Capability Tests were accomplished by AUTO INITIATION of a respective SBGTS exhaust train and operator verification that the normal reactor building intake and exhaust air handling units had shut down as well as verification that the reactor building isolation dampers closed. The tests were conducted with at least one of the double airlock doors on each access to the secondary containment closed and with one of the reactor building railway doors alternately open. After building pressures had stabilized, differential pressures were measured between inside and outside of the building using an inclined tube water manometer located on the south building wall at 935' grade level elevation.

The SBGTS flowmeter was calibrated upon installation by measuring the differential pressure across the orifice with an inclined water tube manometer and calibrating against a pitot tube traverse of the piping. The flow transmitters have been subsequently calibrated and matched to the initial flow calibration curve. The pitot tube traverse procedures were obtained from the American Society of Heating, Refrigeration and Air Conditioning Engineers Handbook. Textbook accuracies for the flow orifice are ± ½% to ± 2% of full scale, and ± ½% to ± 5% for the pitot tube. The accuracy of the flow measurement is believed to be ± 5% or better. The measurements at grade level with no correction applied are consistent with the method of testing discussed in the Monticello FSAR (page 5-3.4).

4.0 TEST RESULTS

The test results are summarized in Tables 4.1, 4.2, and 4.3 which list results for the "A" train with the outer railway door open, the "A" train with the inner railway door open, and the "B" train with the outer railway door open, respectively. The vacuum at grade level is not corrected for stack effect. Tentative conclusions that can be drawn from these tests are that the "A" and "B" SBGTS trains are nearly equal in performance and that in-leakage is greater through the outer railway door.

5.0 ANALYSIS OF TEST RESULTS

There are four principal parameters which must be accounted for in the secondary containment leakage test in order to accurately determine the capability of the SBGTS to draw the required vacuum. These are SBGTS flow rate (Q), inside and outside air temperatures (Ti and To, respectively), wind velocity (v) and wind direction. Under calm conditions with inside and outside air temperatures equal, the SBGTS flow rate will equal building in-leakage at some differential pressure, ΔP_f.

Since pressure variations are quite small relative to ambient pressure, SBGTS flow rate can be related to ΔP_f through Bernoulli's equation for incompressible flow. This relation is of the form

$$Q = C \Delta P_f^{1/2} \qquad \text{where } C \text{ is a constant}$$

$$\text{or } \Delta P_f = K_1 Q^2 \qquad \text{where } K_1 = 1/C^2$$

The flow through buildings without mechanical aids is referred to as "stack effect." Stack effect is dependent on differences between the inside and outside air temperatures and the height of building openings where leakage can occur. Theoretical stack effect is given by:

$$\Delta P_s = 0.52\ HP \left\{ \frac{1}{T_o} - \frac{1}{T_i} \right\}$$

(Eq 9-16, Perry's Chemical Engineer's Handbook, Fourth Edition, p 9-43)

Where ΔP_s is referred to as stack draft in inches H_2O, H is the height of the stack, P is ambient pressure, and T_o and T_i are outside and inside air temperatures, respectively. To apply this equation to building leakage, H is regarded as a weighted average height of building openings, and the constant term must be reevaluated to account for the relative size of the openings. Since P is nearly constant, stack effect for this analysis is reduced to:

$$\Delta P_s = K_2 \left\{ \frac{1}{T_o} - \frac{1}{T_i} \right\}$$

Infiltration effects as a result of wind pressure were qualitatively evaluated for different wind directions. The data collected during testing show that the capability to pull vacuum is reduced for southerly winds. This signifies that in-leakage is greater for southerly winds. It is postulated that the principal leakage path into the building is via the railway doors located on the south face. In addition, it is recognized that most of the building north face is screened from direct wind impingement by the turbine building. At wind speeds above 0 mph, external velocity pressure can be either negative or positive with respect to its effect on the external building surfaces. On surfaces where wind impinges, the velocity pressure is positive, so total pressure is greater than the static pressure; on surfaces where wind does not impinge but sweeps by, the velocity pressure is negative so total pressure is less than static pressure. The higher in-leakage associated with southerly winds results in a higher measured (less negative) differential pressure. Exfiltration through the side walls is not sufficient to offset the in-leakage without an adjustment of

building pressure. If the wind was from the north, three walls could have exfiltration and only the largely unexposed north wall would have infiltration. Building internal pressure would have to decrease to allow enough infiltration to offset the stack release and the three wall exfiltration. It is apparent from the test data that wind pressure effects lead to lower measured differential pressure as wind velocity increases regardless of direction.

Velocity pressure has been determined to be nearly proportional to ρv^2, where ρ is the air density at T_o and v is the wind velocity. This effect on measured differential pressure (ΔP) is given by:

$$\Delta P_w = K_3 \rho v^2 \qquad \text{where } K_3 \text{ is dependent on wind direction.}$$

Thus, measured differential pressure is the sum of the three components discussed above, i.e.

$$\Delta P = \Delta P_f + \Delta P_s + \Delta P_w$$

Multiple linear regression was used to find coefficients of the above equation in the following form:

$$\Delta P = K_1 Q^2 + K_2 \left\{ \frac{1}{T_o} - \frac{1}{T_i} \right\} + K_3 \rho v^2$$

The data from Table 4.1 was split into two sets representing northerly and southerly winds. Data from "Secondary Containment Leak Rate Test, August 1970" was included in the set used to calculate coefficients for northerly winds.

Regression analysis determines the relative effect of each of the independent variables on the measured differential pressure. The method and the resulting equation are empirical and apply only to the data set used. If sufficient data are available, and the model is reasonable, a rather sophisticated prediction capability will evolve. Extrapolations based on regression analysis can be valid for limited ranges outside of the data set if the relative influence is reasonably well known.

For northerly winds, with the outer railway door open, it was found that:

$$\Delta P = 0.0206 \times w^{-6} Q^2 + 0.43 \times 10^4 \left\{ \frac{1}{T_o} - \frac{1}{T_i} \right\} + 0.0023 \rho v^2$$

where:
- Q = SBGTS flow (cfm)
- v = wind speed (ft/sec)
- T = temperature (^oR)
- ρ = density (lb/ft^3)

For calm conditions, as defined in the Technical Specifications ($v \leq 5$mph), the SBGTS flow rate required to maintain a 0.25 inch H_2O vacuum is approximately 3400 scfm. The average absolute percent deviation for predicted versus actual results was 5.5%. The maximum was 12%.

A similar analysis was conducted for southerly winds. However, less data was available and as can be seen on Table 4.1, southerly wind data was generally less stable and thus statistically more suspect. Theoretically the first two terms of the above equation should be independent of wind direction and thus equal for both equations. Since the statistics for northerly wind data are much better, it is tentatively proposed to test results of tests during southerly wind conditions with $K_3 = 0.0014$ and other terms the same until more data is collected. The above value of K_3 was derived in the analysis of sourtherly winds. Figure 5.1 demonstrates the relative effect of wind velocity for northerly and southerly winds.

As noted in Section 2.0, slightly higher leakage was seen with the inner railway doors open. Based on the above results, there is sufficient margin above 3400 scfm to insure that the 0.25 inch H_2O can be maintained under calm conditions even with the inner doors open; however, it should be recognized that the inner doors are normally kept closed.

6.0 CONCLUSIONS

On the basis of the information presented above, it can be concluded that the reactor building demonstrates adequate leak tightness under all environmental wind conditions and that a sufficient base of data has been developed to allow a valid extrapolation to calm conditions. However, model improvements should be anticipated as more data is collected. The above analysis is sufficiently reliable to evaluate the acceptability of future test results which will be submitted in six month reports.

TABLE 4.1

SECONDARY CONTAINMENT CAPABILITY TEST RESULTS

Train "A" With Outer Railway Door Open

SGTS Flow (cfm)	P (in H_2O)	Inside Air Temp (F)	Outside Air Temp (F)	Wind Speed (mph)	Wind Direction
3500	.29-.45	78	81	14-24	SW
3700	.40-.45	78	81	14-24	SW
3920	.42-.47	78	81	14-24	SW
3500	.45	70	-4.7	15	NNW
3300	.435	70	-4.7	13	NNW
3000	.40	70	-4.8	13	NNW
3000	.33	72	37.2	8	E
2500	.28	72	37.2	8	E
3500	.36	70	50	12	E
3300	.32	70	50	10	E
3000	.31	70	50	15	E
3500	.30	73	47	10	NNW
3300	.29	73	47	9	NNW
3000	.27	73	47	9	NNW
3500	.31	74	42	14	S
3300	.29	74	42	16	S
3000	.26	74	42	20	S
3500	.34	71	56	13	N
3300	.32	71	56	13	N
3000	.31	71	56	16	N
3500	.37	76	55	2-4	NNW
3300	.35	76	55	18	N
3000	.31	76	55	12	NNW

TABLE 4.2

SECONDARY CONTAINMENT CAPABILITY TEST RESULTS

<u>Train "B" With Outer Railway Door Open</u>

SGTS Flow (cfm)	P (in H_2O)	Inside Air Temp (F)	Outside Air Temp (F)	Wind Speed (mph)	Wind Direction
3500	.37-.44	78	81	8-26	SW
3700	.37-.45	78	81	8-26	SW
3950	.25-.45	78	81	8-32	SW
3500	.46	71	-4.6	15	NNW
3300	.41	70	-4.7	15	NNW
3000	.38	70	-4.7	15	NNW
3000	.32	72	37.	8	E
2500	.28	72	37	7	E
3500	.36	70	50	14	E
3300	.35	70	50	10	E
3000	.32	70	50	14	E
3500	.31	73	48	8	NNW
3300	.29	73	48	8	NNW
3000	.26	73	47	10	NNW
3500	.30	74	42	21	S
3300	.29	74	42	20	S
3000	.28	74	42	20	S
3500	.34	71	56	15	N
3300	.33	71	56	14	N
3000	.29	71	56	18	N
3500	.38	76	55	14	NW
3300	.37	76	55	14	NW
3000	.33	76	55	[illegible]	NW

TABLE 4.3

SECONDARY CONTAINMENT CAPABILITY TEST RESULTS

Train "A" With Inner Railway Door Open

SGTS Flow (cfm)	P (in H_2O)	Inside Air Temp (F)	Outside Air Temp (F)	Wind Speed (mph)	Wind Direction
3500	.24-.29	78	81	8-26	SW
3700	.26-.33	78	81	8-26	SW
3940	.39-.49	78	81	8-26	SW
3500	.36	68	-4.9	18	NNW
3300	.34	69	-4.9	15	NNW
3000	.32	69	-4.9	15	NNW
3000	.30	72	37	8	E
2500	.25	72	37	8	E
3500	.32	70	50	8	E
3300	.28	70	50	8	E
3000	.26	70	50	10	E
3500	.29	73	47	8	NNW
3300	.28	73	47	7	NNW
3000	.23	73	47	9	NNW
3500	.26	74	42	18	S
3300	.25	74	42	22	S
3000	.22	74	42	16	S
3500	.30	71	56	22	N
3300	.27	71	56	18	N
3000	.27	71	56	18	N

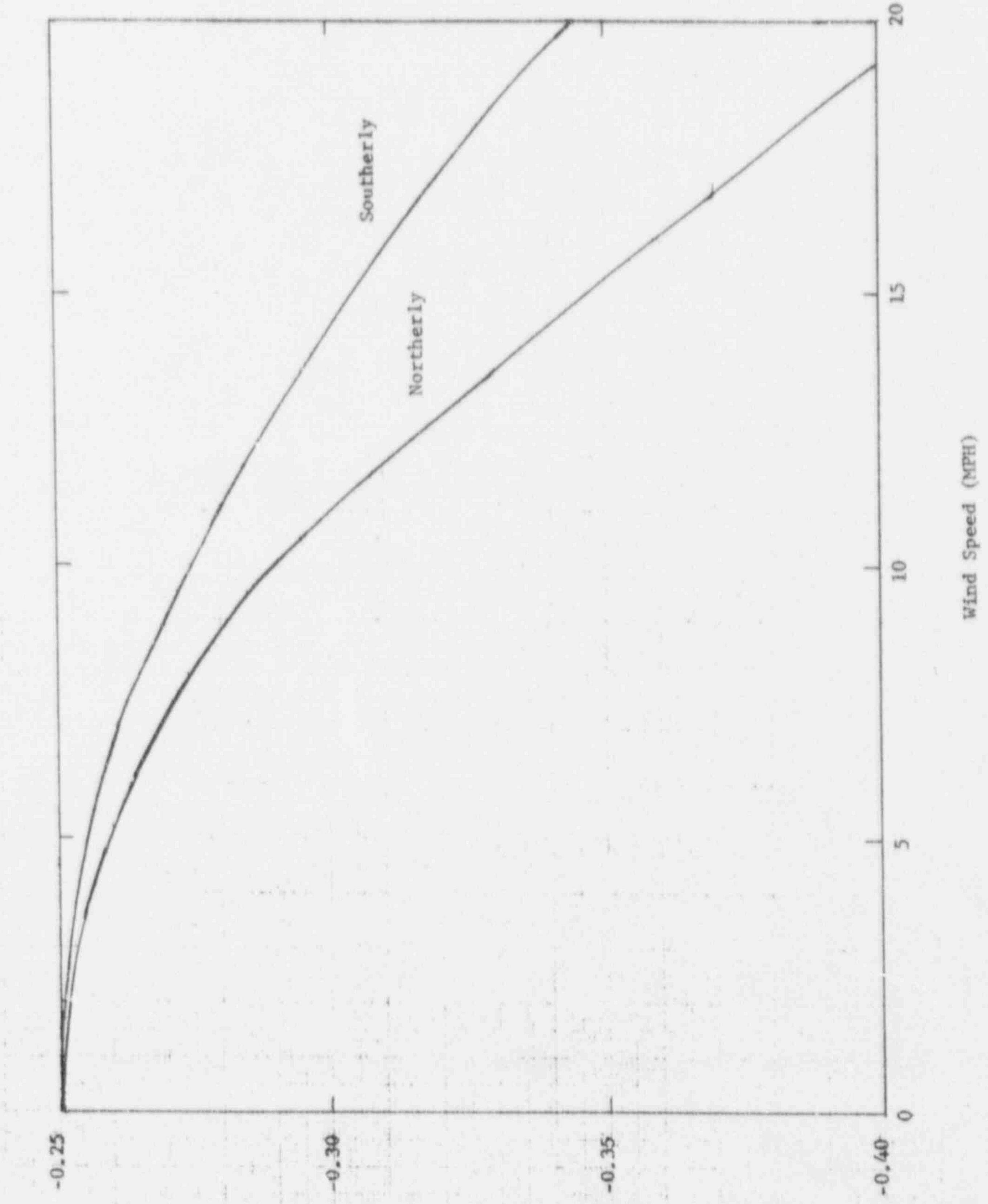
TABLE 4.3

SECONDAPY CONTAINMENT CAPABILITY TEST RESULTS

Train "A" With Inner Railway Door Open

SGTS Flow (cfm)	P (in H_2O)	Inside Air Temp (F)	Outside Air Temp (F)	Wind Speed (mph)	Wind Direction
3500	.24-.29	78	81	8-26	SW
3700	.26-.33	78	81	8-26	SW
3940	.39-.49	78	81	8-26	SW
3500	.36	68	-4.9	18	NNW
3300	.34	69	-4.9	15	NNW
3000	.32	69	-4.9	15	NNW
3000	.30	72	37	8	E
2500	.25	72	37	8	E
3500	.32	70	50	8	E
3300	.28	70	50	8	E
3000	.26	70	50	10	E
3500	.29	73	47	8	NNW
3300	.28	73	47	7	NNW
3000	.23	73	47	9	NNW
3500	.26	74	42	18	S
3300	.25	74	42	22	S
3000	.22	74	42	16	S
3500	.30	71	56	22	N
3300	.27	71	56	18	N
3000	.27	71	56	18	N

FIGURE 5.1 MONTICELLO NUCLEAR GENERATING PLANT REACTOR BUILDING PRESSURE AS A FUNCTION OF WIND SPEED FOR CONSTANT SBGTS FLOW RATE



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