Nebraska Public Power District

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NLS8400283

December 7, 1984

Office of Nuclear Reactor Regulation
Operating Reactors Branch No. 2
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Attention: Mr. D. B. Vassallo, Chief

Reference: 1) Letter from J. M. Pilant to D. B. Vassallo dated July 19, 1984 (NLS8400204), "Containment Purge and Vent System Unresolved Issues"

Enclosure: a) Evaluation of the effect on Standby Gas Treatment (SBGT) System from LOCA flow through isolation bypass valve.

Dear Mr. Vassallo:

Subject: Containment Purge and Vent System Unresolved Issues
Cooper Nuclear Station (CNS)
NRC Docket No. 50-298, DPR-46

Reference 1 provided the District's plan for resolving the remaining concerns relating to purging and venting the containment. This letter is a follow-up to Reference 1, providing additional information on two of those concerns at the request of the Staff.

1. Debris Strainers - In Reference 1, the District committed to install debris strainers to insure isolation valve closure will not be prevented due to debris entrained in the escaping air and steam during a LOCA. These strainers will be provided for the two drywell purge and vent penetrations. These strainers will be designed and mounted in the drywell so that any accident or seismic event will leave them intact and not cause significant deformation that allows damage to safety-related equipment to occur.

2. Standby Gas Treatment (SBGT) System Use While Purging - In Reference 1, the District stated its intention to test, by July, 1985, the feasibility of an alternate flow path around the SBGT system during inerting operations on certain start-ups so as to minimize operational constraints imposed by a 90 hour/year limit on SBGT use with reactor

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coolant temperature >200°F. If the tests show the alternate flow path is not feasible, the District will either supply analysis to show the SBGT system is protected during a LOCA in its present configuration or will commit to modify the SBGT system to ensure the filters are protected. If the tests show the alternate flow path is feasible, the District will submit a revision to the Technical Specifications incorporating the 90 hour/year limit.

To allow operation of the SBGT system using purge and vent bypass valves, the District submits for review Enclosure a, an evaluation of the effects on the SBGT system from the gas flow from a Design Basis LOCA through the two inch bypass line around the main isolation valve. This evaluation concludes that the SBGT system will remain operable after being subjected to the gas flow and, therefore, SBGT system operation with the bypass valves need not be constrained by the 90 hour/year limit.

If you have any questions on this subject, please contact me.

Sincerely,

Jay M. Pilant

Jay M. Pilant
Manager, Technical Staff
Nuclear Power Group

JMP:GRS:cmk

Enclosure

N.P.P.D.

DESIGN CALCULATIONS SHEET

Account No. 64125-4005 Calc. No. NED 84-055 Sheet 1 of 11

Prepare By John C Branch Date 10/25/84 Checked By S.P.A. 10/24 Date 10/29/84

Subject Standby Gas Treatment System LOCA Flow Analysis

Purpose:

The purpose of these calculations is to:

1. Determine the worst case gas flow rate through the Standby Gas Treatment System (SBGT) caused by a Design Basis Accident (DBA) during which time the SBGT system is taking its suction from the drywell via the 2 inch bypass line around 231 MV (24" inboard purge isolation valve).

2. Provide data to show that the above gas flow will not damage the SBGT filters.

Assumptions:

The following assumptions have been made for these calculations:

1. The gas to be analyzed is a Steam-Nitrogen mixture.

2. Gas flow is choked in the two inch bypass line.

3. All gas energy losses due to the piping configuration are neglected and assumed to be zero.

4. The 24" purge valve (246 AV) closes within 15 seconds as required by Technical Specifications.

5. The Steam-Nitrogen mixture reaches the SBGT filters almost instantaneously. In reality, there is approximately a seven second lag between the onset of the accident and the time the Steam-Nitrogen mixture reaches the SBGT filters, but this time lag will be neglected for conservation.

6. The Steam and Nitrogen form a homogenious mixture inside the drywell.

Scenario:

At the onset of the DBA, the SBGT system is lined up as follows: (See Attachment A)

1. 306 MV is open (2" bypass around purge valve 231 MV).

2. Purge Valve 231 MV is closed.

3. Purge Valve 246 AV is open.

4. Purge Valve 245 AV is closed.

5. Valve AD-R-1A is closed.

6. One SBGT train is in operation with its exhaust routed to the Elevated Release Point (ERP). The other SBGT train is isolated in an auto-standby mode.

7. The drywell is inerted with Nitrogen at approximately 1.4 psig and 150°F. These are average values during normal plant operations.

The following things happen after the start of the DBA:

1. The drywell temperature and pressure increase as shown on Attachment B (taken from the USAR) due to Steam being released into the drywell. In approximately ten seconds, the drywell pressure peaks at 62 psia and the drywell temperature peaks at 281°F.

2. Within a few seconds after the start of the accident, the mass flow rate of the Steam-Nitrogen mixture reaches a maximum value due to choked flow conditions in the two inch bypass line.

3. The second SBGT train fails to come on line within 15 seconds of the accident start. Credit for additional flow area will not be taken for the sake of conservatism.

4. Fifteen seconds after the start of the accident, the purge valve closes and the scenario is terminated. This closure time is very conservative as surveillance tests show the purge valves normally close within 5 seconds; however, Technical Specifications only require a 15 second closure time so 15 seconds will be used.

I. Calculation of the Worst Case Volumetric Flow Rate through the SBGT Train

The drywell contains a homogenious mixture of Steam and Nitrogen.

Using Dalton's Law, the partial pressures of both gases can be found:

P_D = Total drywell pressure (psia)

P_S = Partial pressure of the steam (psia)

P_N = Partial pressure of the Nitrogen (psia)

$$P_D = P_S + P_N \qquad \text{(Dalton's Law)} \qquad \text{(Eqn. 1)}$$

The partial pressure of the Nitrogen can be determined from the pre-accident state properties of the Nitrogen and the maximum post-accident drywell temperature.

$P_{N1} = P_{D1}$ = Average drywell pressure during normal operation (psia).

T_{D1} = Average drywell temperature during normal operation (°R drybulb).

T_{D2} = Maximum post-accident drywell temperature (°R drybulb).

P_{N2} = Post-accident partial pressure of the Nitrogen (psia).

V_D = Drywell free volume.

M_N = Mass of Nitrogen in the drywell (lbm).

R_N = Universal gas constant for Nitrogen.

Using the Ideal Gas Law:

$$P_{N1} V_D = M_N R_N T_{D1}$$

$$P_{N2} V_D = M_N R_N T_{D2}$$

Therefore:

$$\frac{P_{N1}}{T_{D1}} = \frac{M_N R_N}{V_D} = \frac{P_{N2}}{T_{D2}}$$

$$P_{N2} = \frac{P_{N1} \times T_{D2}}{T_{D1}} \qquad \text{(Eqn. 2)}$$

$$P_{N1} = (1.4 \text{ psig} + 14.7 \text{ psia}) = 16.1 \text{ psia}$$

$$T_{D1} = (150 + 460)°R = 610°R$$

$$T_{D2} = (281 + 460)°R = 741°R \qquad \text{(USAR)}$$

$$P_{N2} = \frac{(16.1)(741)}{(610)} = 19.6 \text{ psia}$$

Using Dalton's Law:

$$P_{S2} = P_{D2} - P_{N2} \qquad \text{(Eqn. 1)}$$

$$P_{D2} = 62.7 \text{ psia} \qquad \text{(USAR)}$$

$$P_{S2} = 62.7 - 19.6$$

$$P_{S2} = 43.1 \text{ psia}$$

Using the above information and the Steam Tables, the post-accident Steam to Nitrogen mass ratio in the drywell can be found:

M_r = Post-accident Steam to Nitrogen mass ratio

$\overline{V}_{N2}$ = Specific volume of Nitrogen in the drywell (ft^3/lbm)

$\overline{V}_{S2}$ = Specific volume of Steam in the drywell (ft^3/lbm)

ρ_{N2} = Density of Nitrogen in the drywell (lbm/ft^3)

ρ_{S2} = Density of Steam in the drywell (lbm/ft^3)

Using the Ideal Gas Law:

$$P_{N2} V_D = M_N R_N T_{D2}$$

$$\overline{V}_{N2} = \frac{V_D}{M_N} = \frac{R_N T_{D2}}{P_{N2}} \qquad \text{(Eqn. 3)}$$

$$R_{N2} = 55.2 \frac{ft\text{-}lb}{lb\text{-}°R}$$

$$T_{D2} = (281 + 460)°R = 741°R$$

$$P_{N2} = 19.6 \text{ psia} \times 144 \text{ in}^2/\text{ft}^2 = 2822.4 \text{ lb/ft}^2$$

$$\overline{V}_{N2} = \frac{(55.2)(741)}{(2822.4)} = 14.49 \text{ ft}^3/\text{lbm}$$

$$\rho_{N2} = 1/\overline{V}_N \qquad \text{(Eqn. 4)}$$

$$\rho_{N2} = .069 \text{ lbm/ft}^3$$

Using the Steam Tables: Compressed Air and Gas Data, Ingersoll-Rand.

$$P_{S2} = 43.1 \text{ psia}$$

$$T_{D2} = 281°F$$

Therefore:

$$\overline{V}_{S2} = 10.07 \text{ ft}^3/\text{lbm}$$

$$\rho_{S2} = .099 \text{ lbm/ft}^3$$

$$M_r = \frac{\overline{V}_{N2}}{\overline{V}_{S2}} \qquad \text{(Eqn. 5)}$$

$$M_r = \frac{14.49 \text{ ft}^3/\text{lbmn}}{10.07 \text{ ft}^3/\text{lbms}}$$

$$M_r = 1.44 \text{ lbms/lbmn}$$

Determination of the maximum mass flow rate through the SBGT system:

The maximum mass flow rate through the SBGT system at DBA drywell conditions will occur when choked flow exists in the two inch bypass line. This mass flow rate can be calculated by the following equation:

$$\dot{m} = CA_t \, (P_T \, \rho_{mix})^{\frac{1}{2}}$$

<u>Engineering Experimentation</u> by Tuve and Domholdt (Eqn. 6)

where:

$\dot{m}$ = Mass flow rate of steam-Nitrogen mixture (lbm/sec)

A_t = Flow area at the choke point (in^2)

P_T = Pressure upstream of choke point (psia)

ρ_{mix} = Density of Steam-Nitrogen mixture (lmb/ft^3)

$$C = \begin{cases} .32 \text{ for Air (or Nitrogen)} \\ .30 \text{ for Saturated Steam} \\ .315 \text{ for Superheated Steam} \end{cases}$$

For conservatism, C = .32 will be used.

$A_t = (3.14)(1 \text{ in})^2 = 3.14 \text{ in}^2$ (2" pipe)

$P_T = P_{D2} = 62.7$ psia

$\rho_{mix} = \rho_{S2} + \rho_{N2}$

$\rho_{mix} = .099 + .069$

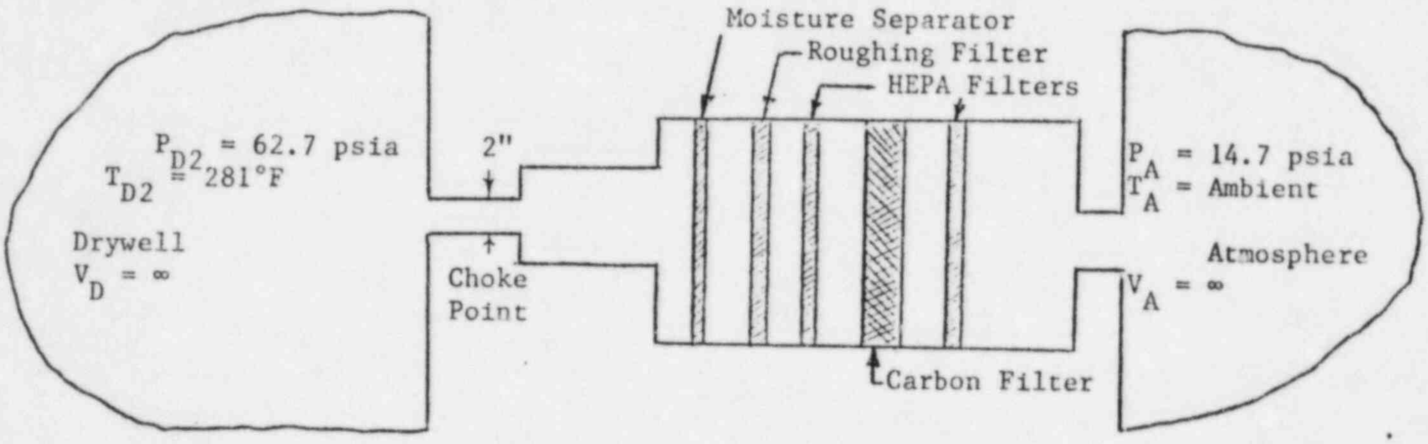
$\rho_{mix} = .168 \text{ lbm/ft}^3$

$\dot{m} = (.32)(3.14)[(62.7)(.168)]^{\frac{1}{2}}$

$\dot{m} = 3.26 \text{ lb/sec} \times 60 \text{ sec/min}$

$\dot{m} = 196 \text{ lbm/min}$

From the above data, a volumetric flow rate in standard cubic feet per minute can be calculated. For the purposes of this calculation, the system boundary will be defined as follows:



System Boundary

To simplify the analysis, several assumptions can be made.

1. The drywell volume is infinite when compared to the volume of the SBGT train and piping. This assumption allows use of the DBA drywell pressure and temperature responses as shown in the USAR without altering them to compensate for flows through the SBGT trains.

2. The volumetric flow rate will be calculated from the individual mass flow rates for standard steam conditions which will be defined here as dry saturated steam at 14.7 psia. This will allow comparison with the results of a 1962 study performed by DuPont Corporation, for the Atomic Energy Commission. This study will be discussed later.

3. All flows through the system are adiabatic and energy losses through the system are neglected. The assumption eliminates the need to evaluate a complex process involving heat transfer, mass transfer, and possible two phase flow.

It should be readily apparent that a large amount of conservatism is embodied in these assumptions.

To obtain the total standard volumetric gas flow rate, the volumetric flow rates of the Nitrogen and Steam will be calculated separately and then added.

Standard volumetric flow rate of the Nitrogen:

P_S = Standard Pressure (psia)

T_S = Standard Temperature (°R)

$\overline{V}_S$ = Standard Specific Volume (ft³/lbm)

Use the Ideal Gas Law:

$$P_{N2}\,\overline{V}_{N2} = R_N\,T_{D2} \qquad \text{(Eqn. 7)}$$

$$P_S\,\overline{V}_S = R_N\,T_S \qquad \text{(Eqn. 8)}$$

Therefore:

$$\frac{\overline{V}_{N2}}{\overline{V}_S} = \frac{R_N\,T_{D2}\,P_S}{R_N\,T_S\,P_{N2}} = \frac{T_{D2}\,P_S}{T_S\,P_{N2}} \qquad \text{(Eqn. 9)}$$

Knowing:

V_{N2} = 14.49 ft³/lbm

T_{D2} = 281 + 460 = 741°R

T_S = 212 + 460 = 672°R

P_{N2} = 19.6 psia

P_S = 14.7 psia

$$\frac{\overline{V}_{N2}}{\overline{V}_S} = \frac{(741)(14.7)}{(672)(19.6)} = .83$$

$$\overline{V}_S = 1.21\,\overline{V}_{N2}$$

$$\overline{V}_S = (1.21)(14.49) = 17.5 \text{ ft}^3/\text{lbm}$$

N.P.P.D.

DESIGN CALCULATIONS SHEET

Account No. 64125-4005 Calc. No. NED 84-055 Sheet 8 of 11

Prepare By John C. Brand Date 10/25/84 Checked By R.S.A. Date 10/29/84

Subject /Standby Gas Treatment System LOCA Flow Analysis

The mass flow rate of the Nitrogen can be determined from the total mass flow rate for the gas and the mass ratio M_r.

$\dot{M}_N$ = Mass flow rate of Nitrogen (lbm/min)

$M_r = 1.44$ lbm steam/lbm N_2

$\dot{M} = 196$ lbm/min

Therefore:

$$\dot{M}_N = \frac{\dot{M}\,(1/M_r)}{(1 + 1/M_r)} \qquad \text{(Eqn. 10)}$$

$$\dot{M}_N = \frac{(196 \text{ lbm/min})(.69 \text{ lbmn/lbm steam})}{(1 \text{ lb steam} + .69 \text{ lbmn})}$$

$$\dot{M}_N = 80 \text{ lbn/min}$$

The volumetric flow rate for the Nitrogen can now be calculated as:

$\dot{V}_N$ = Volumetric flow rate for Nitrogen (SCFM)

$$\dot{V}_N = \dot{M}_N \overline{V}_s \qquad \text{(Eqn. 11)}$$

$$\dot{V}_N = (80)(17.5)$$

$$\dot{V}_N = 1400 \text{ SCFM}$$

Standard volumetric flow rate of the steam:

The specific volume for dry saturated steam at 14.7 psia is:

$\overline{V}_S = 26.8$ ft³/lbm (Steam Tables)

The mass flow rate of the steam can be determined from the total mass flow rate for the gas and the mass flow rate determined for the Nitrogen.

$\dot{M}_S$ = Mass flow rate of steam (lbm/min)

$\dot{M}_N = 80\ lbN_2/min$

$\dot{M} = 196\ lbm/min$

Therefore:

$$\dot{M}_S = \dot{M} - \dot{M}_N \qquad \text{(Eqn. 12)}$$

$$\dot{M}_S = 196 - 80$$

$$\dot{M}_S = 116 \text{ lbm steam/min}$$

The volumetric flow rate for the steam can now be calculated as:

$\dot{V}_S$ = Volumetric flow rate for steam (SCFM)

$$\dot{V}_S = \dot{M}_S \overline{V}_S \qquad \text{(Eqn. 13)}$$

$$\dot{V}_S = (116)(26.8)$$

$$\dot{V}_S = 3109 \text{ SCFM}$$

The total volumetric flow rate for the gas mixture is then:

$\dot{V}_T$ = Total volumetric flow rate for mixture (SCFM)

$$\dot{V}_T = \dot{V}_N + \dot{V}_S \qquad \text{(Eqn. 14)}$$

$$\dot{V}_T = 1400 + 3109$$

$$\dot{V}_T = 4509 \text{ SCFM}$$

II. Discussion and Summary

In 1962, the United States Atomic Energy Commission contracted with E.I. du Pont de Nemours & Co. an experiment to determine the durability of certain carbon, particulate, and moisture separating filters when exposed to steam and air flow conditions (Contract AT(07-2)-1). One aspect of that testing was very similar to the problems confronted by this analysis. A nuclear power surge was simulated which exposed the filtering media to a 7000 SCFM steam flow for a short duration. In this test the gas flow (essentially all steam) was increased from 0 to 7000 SCFM in the first 10 seconds and then reduced to 0 SCFM in the next 15 seconds. All of this flow passed through 4 sq. ft. of moisture separator area. In the postulated scenario for CNS, the gas flow (Steam/Nitrogen mixture) increases from 0 to 4509 SCFM within a couple of seconds from the start of the accident and then abruptly falls to zero when the purge valve closes 15 seconds later. In the CNS case, all of the flow passes through 8 sq. ft. of moisture separator area. The flow through 4 sq. ft. of moisture separator area would only be:

$$\dot{V}_{\text{through 4 ft}^2\text{ MS area}} = .5\ \dot{V}_T \qquad \text{(Eqn. 15)}$$

$$\dot{V}_{4\text{ ft}^2} = .5\ (4509)$$

$$\dot{V}_{4\text{ ft}^2} = 2254 \text{ SCFM}$$

III. Conclusion

The 1962 tests conducted by du Pont Co. showed that if particulate and carbon filters are proceded by properly designed moisture separator filters, the filter arrangement can handle a 7000 SCFM steam flow for a short duration without damage. The worst case flow postulated for CNS is lower than this value by a factor of 3. Also, the moisture separators used in the SBGT system at CNS are the same model of filters that was recommended for use by the 1962 du Pont study. In conclusion, this analysis has shown that the CNS Standby Gas Treatment System will remain operable after being subjected to 15 seconds of gas flows resulting from a Design Basis Accident.

IV. References

1. December 1962 study by E.I. du Pont Nemours & Co. for the U.S. Atomic Energy Commission. Contract AT(07-2)-1 Title of Study - "Application of Moisture Separators and Particulate Filters in Reactor Containment."

2. Cooper Nuclear Station USAR.

3. Cooper Nuclear Station Operating Manual.

4. Engineering Experimentation by Tuve and Domholdt, McGraw-Hill, 1966.

5. Marks' Standard Handbook for Mechanical Engineers, McGraw-Hill, Eight Edition.

6. Cooper Nuclear Station Contract E-69-3, Off-Gas and Standby Gas Filter Units.

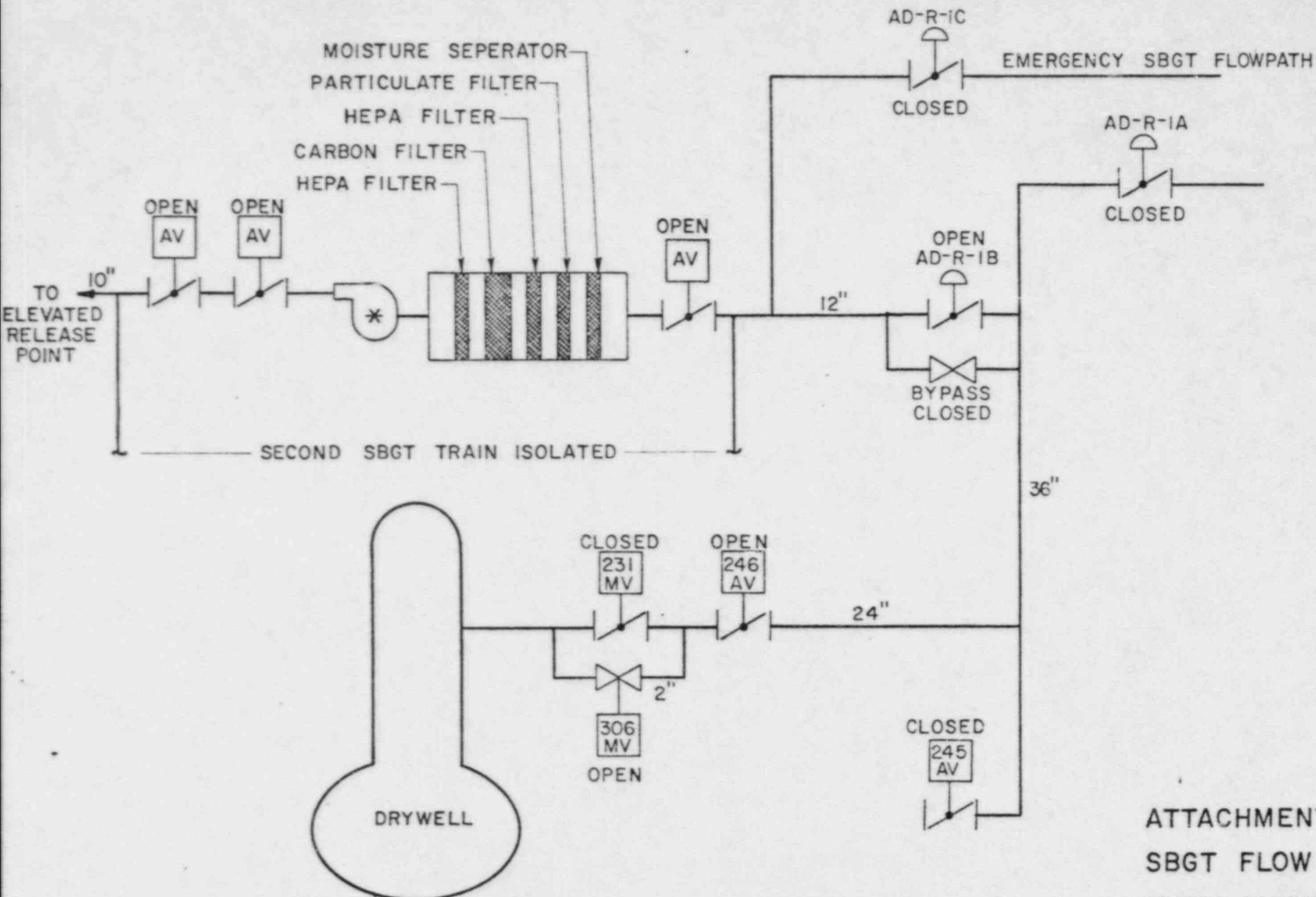
7. Telephone conversation between Mr. Albert H. Peters of du Pont Corp. and John C. Branch of Nebraska Public Power District dated October 17, 1984.

8. Drawing B&R 2022 (Rev. N20), Flow Diagram - Primary Containment Cooling and Nitrogen Inerting System.

9. Drawing B&R 2037 (Rev. N17), Flow Diagram - H&V Standby Gas Treatment & Off Gas Filters.

10. Drawing CVI Inc. A524-5901 Sheet 2 (Rev. C), Standby Gas Treatment Unit Assembly and Details.

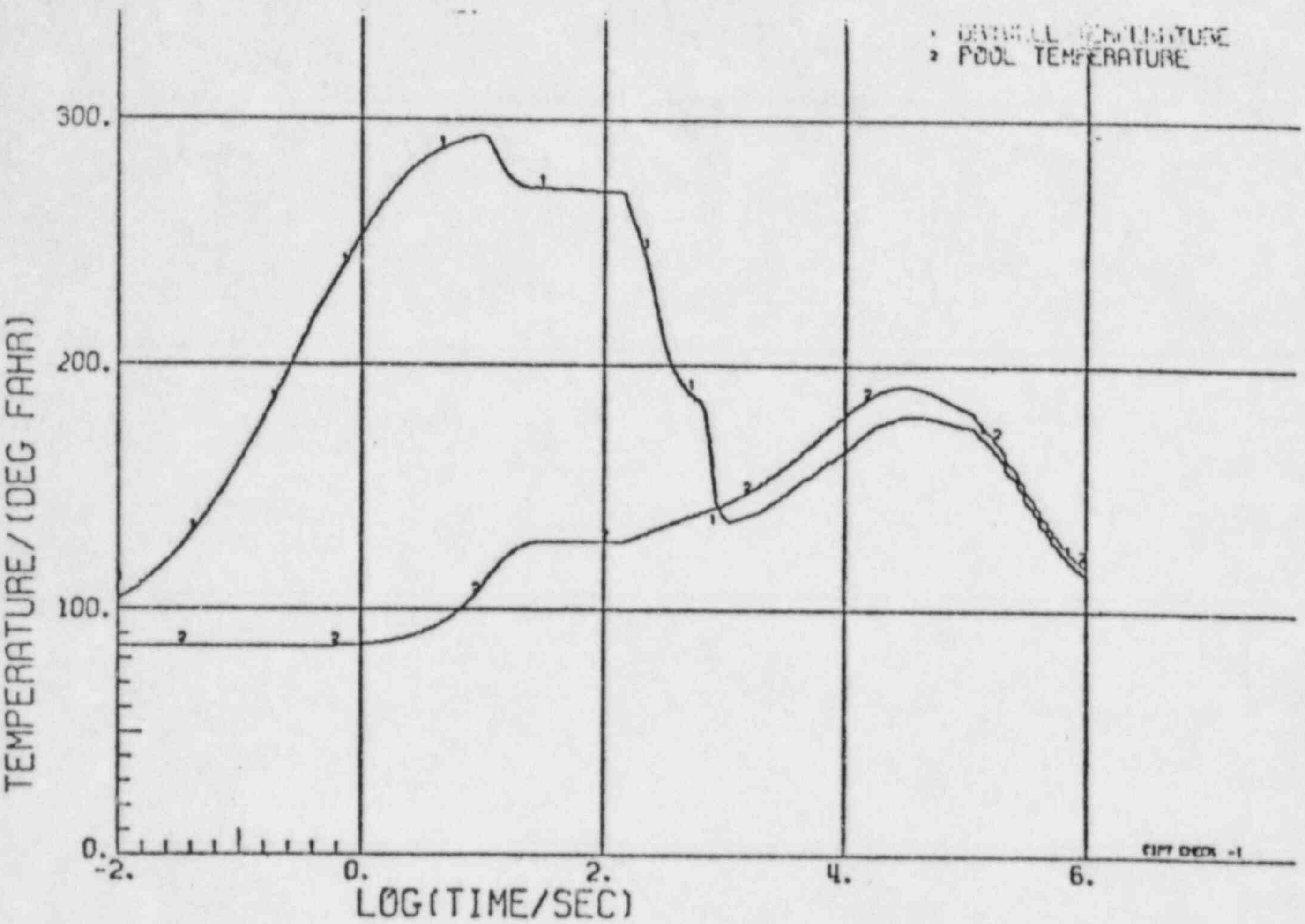
11. Drawing CVI Inc. A524-5901 Sheet 3 (Rev. D), Standby Gas Treatment Unit Assembly and Details.



ATTACHMENT A

SBGT FLOW PATH

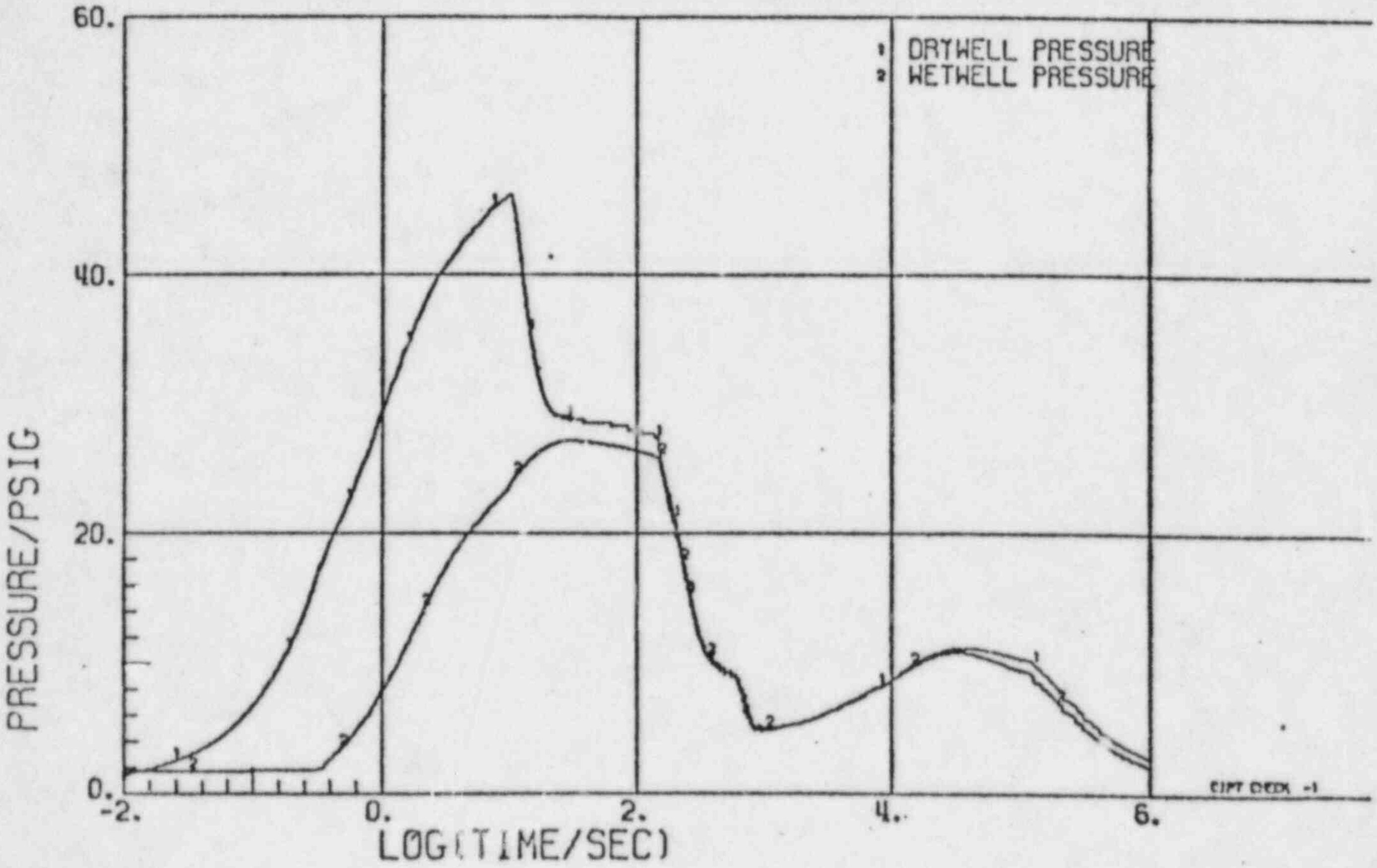
DESIGN CALCULATION NO.
NED 84-055



Case E Operation of one RHRS cooling loop with 1 RHRS pump, 1 RHR service water booster pump, 1 service water pump, and 1 RHRS heat exchanger - with containment spray

Nebraska Public Power District
COOPER NUCLEAR STATION
UPDATED SAFETY ANALYSIS REPORT (USAR

Loss of Coolant Accident
Primary Containment Pressure and
Temperature Response
Case E
Figure XIV-6-9



60.
40.
20.
0.
PRESSURE/PSIG
-2.
0.
2.
4.
6.
LOG(TIME/SEC)
1 DRYWELL PRESSURE
2 WETWELL PRESSURE