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U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

Subject: Response To Request For Additional Information – License Amendment Request No. 287 Suppression Chamber to Drywell Vacuum Breakers (TAC NO. MB2958)

Oyster Creek Generating Station (Oyster Creek)
Facility Operating License No. DPR-16
NRC Docket No. 50-219

This letter provides additional information in response to NRC request for additional information dated January 31, 2002, regarding Oyster Creek License Amendment Request No. 287, submitted to NRC for review on September 19, 2001. The additional information is provided in Enclosure 1.

No new regulatory commitments are established by this submittal. If any additional information is needed, please contact David J. Distel (610) 765-5517.

I declare under penalty of perjury that the foregoing is true and correct.

Very truly yours,

07-01-02
Executed On

Michael P. Gallagher
Michael P. Gallagher
Director, Licensing & Regulatory Affairs
Mid Atlantic Regional Operating Group

Enclosure: (1) Response to Request for Additional Information

cc: H. J. Miller, USNRC Administrator, Region I
P. S. Tam, USNRC Senior Project Manager, Oyster Creek
R. J. Summers, USNRC Senior Resident Inspector, Oyster Creek
File No. 01059

A001

ENCLOSURE 1

OYSTER CREEK

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION – LICENSE AMENDMENT REQUEST NO. 287, SUPPRESSION CHAMBER TO DRYWELL VACUUM BREAKERS

1. **NRC Question**

Please provide a brief description of the analytical methods of NEDE 24802. In particular, describe any empirical correlations and how they were derived and discuss any comparisons with experimental data and the methods of NEDE 24802.

Response

The methodology of NEDE-24802 uses the laws of conservation of mass and energy to determine the thermodynamic properties of the containment prior to and during the spray. The methodology models mass and energy addition to the drywell from steam blowdown and containment spray. Mass and energy addition to the wetwell is modeled with its own containment spray. Vacuum breaker flow to the drywell constitutes mass and energy loss from the wetwell and gain to the drywell. The vacuum breaker flow from the wetwell to the drywell assumes a homogenous mixture of vapor and air in the wetwell airspace.

Flow through the vacuum breakers is calculated from the Darcy formula for mass flow through valves, fittings, and pipe, assuming incompressible fluid flow. A conservative value for $A/\sqrt{K_{FO}}$ of 0.5570 sq. ft. per valve is determined for the Oyster Creek arrangement with the valve fully open. The opening of the vacuum breaker is modeled as a flow path with an $A/\sqrt{K}$ that increases linearly with time, from the time when the valve begins to open to the time when the valve is fully open, based on a fixed opening time (as if the valve were a motor-operated valve). Thus the expression for the valve flow area is,

$$\frac{A}{\sqrt{K}}(t) = \frac{A}{\sqrt{K_{FO}}} * \min\left(1, \frac{t - t_o}{\Delta t_{VB}}\right)$$

$$\dot{m}_{VB} = \begin{cases} \sqrt{2\rho_W (P_W - P_D)}\,\frac{A}{\sqrt{K}}(t) & P_W - P_D > P_{SET} \\ 0 & P_W - P_D \le P_{SET} \end{cases}$$

$$\rho_W = \frac{M_{N_W} + M_{L_W} + M_{V_W}}{V_W}$$

where t is the current time in the simulation, t_o is the time when the valve first begins to open (i.e., the drywell pressure minus the wetwell pressure just exceeds the vacuum breaker opening setpoint). Subsequent to this initial valve lift, if the differential pressure decreases to below the valve setpoint, the valve flow area is assumed to decrease linearly from the previous valve position until fully closed again. If, while closing, the differential pressure then increases above the setpoint, the valve flow area again begins to increase linearly from its previous position. If the pressure fluctuates around the setpoint, the valve will oscillate open and close. The valve stroke speed remains constant at the input stroke time and is independent of the differential pressure.

The thermodynamic properties of water and nitrogen are simply modeled in the code provided in NEDE-24802 (VBSizing). Nitrogen is modeled as an ideal gas, as is water vapor. In the original code provided in the NEDE, thermal constants for nitrogen and water were not code inputs but hard-coded into the program itself, and common values were used for both the wetwell and drywell. For the Oyster Creek analysis, the code was altered to make these constants inputs to the analysis, and different constants can be entered for the wetwell and the drywell. In addition, an output is included for the time-averaged temperatures and pressures for both the wetwell and drywell. These outputs are used to confirm the suitability of the input thermal constants. Thermal constants necessary for inputs include the ideal gas constant and specific heats with constant volume and pressure for nitrogen and the ideal gas constant for water vapor, the density and specific heats with constant volume and pressure for liquid water, and the enthalpy and internal energy of vaporization. In addition, the saturation pressure at a given temperature is determined using the Clausius-Clapeyron Relationship,

$$\ln\left(\frac{P_{SAT}}{P^*_{SAT}}\right)=\left(\frac{h_{fg}}{R_{vapor}}\right)\left(\frac{1}{T^*}-\frac{1}{T}\right)$$

where T^* and P^*_{sat} are a known input temperature and saturation pressure and T is the temperature for which a saturation pressure value is desired and P_{sat} is the desired result. This expression provides reasonable results compared to the ASME saturation pressures, provided T and T^* are not greatly different values. Again, the original code values for these constants were hard-coded whereas, the OCNGS method includes these constants as inputs. These inputs are varied for each case so that the input values are not greatly different from the initial conditions for the case.

The internal energies of nitrogen, liquid water, and water vapor, respectively, are modeled as,

$$u_N(T)=Cv_N*T$$
$$u_L(T)=Cv_L*T$$
$$u_V(T)=Cv_L*T+e_{fg}$$

where Cv_N is the specific heat at constant volume for nitrogen, Cv_L is the specific heat at constant pressure for liquid water, T is the temperature in degrees Rankine, and e_{fg} is the specific internal energy change due to vaporization. Values for Cv_N, Cv_L, and e_{fg} are input constants for the code.

The initial masses of nitrogen, vapor, and liquid water in the drywell are determined from the equations,

$$M_{N_D} = \frac{144 * P_{N_D} * V_D}{R_N * T_D}$$

$$M_{V_D} = \frac{144 * P_{V_D} * V_D}{R_V * T_D}$$

$$M_{L_D} = M_{V_D} * \left(\frac{1.0}{Q_D} - 1.0 \right)$$

where V_D is the drywell airspace volume, T_D is the initial drywell temperature, R_N and R_v are the ideal gas constants for nitrogen and water vapor, respectively, and Q_D is the initial quality of the vapor in the drywell. For initial conditions, M_{L_D} is assumed to be zero. The partial pressures are found with the equations,

$$P_{V_D} = \Phi_D P_{SAT}(T_D)$$

$$P_{N_D} = P_D - P_{V_D}$$

The initial total energy for the drywell is determined from the equation,

$$E_D = M_{N_D} * Cv_N * T_D + M_{V_D} * (Cv_L * T_D + e_{fg}) + M_{L_D} * Cv_L * T_D$$

Identical equations are used to determine the initial masses and total energy for the wetwell using values for the wetwell,

$$P_{V_W} = \Phi_W P_{SAT}(T_W)$$

$$P_{NW} = P_W - P_{V_W}$$

$$M_{N_W} = \frac{144 * P_{N_W} * V_W}{R_N * T_W}$$

$$M_{V_W} = \frac{144 * P_{V_W} * V_W}{R_V * T_W}$$

$$M_{L_W} = M_{V_W} * \left(\frac{1.0}{Q_W} - 1.0 \right)$$

$$E_W = M_{N_W} * Cv_N * T_W + M_{V_W} * (Cv_L * T_W + e_{fg}) + M_{L_W} * Cv_L * T_W$$

The mass additions to the drywell originate from steam blowdown, containment spray, and vacuum breaker flow such that the change in mass in the drywell is,

$$\frac{dM_D}{dt} = \dot{m}_{SP} + \dot{m}_{ST} + \dot{m}_{VB}$$

$$\frac{dM_{N_D}}{dt} = \beta * \dot{m}_{ST} + \dot{m}_{VB} * \left(\frac{M_{N_w}}{M_W}\right)$$

The variable β is the mass fraction of non-condensables of the steam blowdown in the drywell. Note that an equation for the change in vapor and liquid mass and energy is not necessary as the code always maintains vapor mass at saturation and any water mass in excess is assumed to be liquid. None of the cases modeled for Oyster Creek include any steam blowdown.

The change in the total energy in the drywell airspace is found in the equation,

$$\frac{dE_D}{dt} = \dot{m}_{SP}\, u_{SP} + \dot{m}_{ST}\, u_{ST} + \dot{m}_{VB}\, u_{VB}$$

$$u_{SP} = Cp_L\, T_{SP}$$

$$u_{ST} = \beta\, Cv_N\, T_{ST} + (1-\beta)\left[Cp_L\, T_{ST} + X_{ST}\, h_{fg}\right]$$

$$u_{VB} = \frac{M_{N_w}\, Cp_N\, T_W + \left(M_{V_w} + M_{LW}\right) Cp_L\, T_W + M_{V_W}\, h_{fg_w}}{M_{N_w} + M_{V_W} + M_{LW}}$$

where the first term represents addition from the spray water, the second, addition from the steam, and the third, addition from the vacuum breaker flow. X_{ST} is the quality of the steam blowdown in the drywell.

The mass and energy additions to the wetwell are similar to those of the drywell,

$$\frac{dM_w}{dt} = \dot{m}_{SW} - \dot{m}_{VB}$$

$$\frac{dM_{Nw}}{dt} = -\dot{m}_{VB} * \left(\frac{M_{Nw}}{M_W}\right)$$

$$\frac{dE_W}{dt} = \dot{m}_{SW}\, u_{SW} - \dot{m}_{VB}\, u_{VB}$$

$$u_{SW} = Cp_L\, T_{SW}$$

In addition to modeling the energies and masses in the wetwell and drywell airspaces, the code also models the water level in the downcomers in order to ensure that water level does not rise to an elevation that will interfere with the operation of the wetwell-to-drywell vacuum breakers. The wetwell-to-drywell vacuum breakers at Oyster Creek are external and cannot be hindered by water level rise in the downcomers. Nevertheless, water level in the downcomer is modeled by the code using Newton's Law of momentum. The sum of forces acting on the water column in the downcomer includes the differential pressure, the weight of the column, and a friction force that acts against the motion of the column of water. Thus, the equation modeling the water height in the downcomer is,

$$h_0 \frac{d^2h}{dt^2} = \frac{P_W - P_D}{\rho_L} + g(\text{Head} - h) - \left(\frac{dh}{dt}\right)\left|\frac{dh}{dt}\right|$$

where the first term is the differential pressure acting on the column of water, the second term is the weight of the column, and the third term is the friction damping acting on the column, with one dynamic head to account for entrance and exit losses at the end of the downcomer. For this equation, Head is the submergence of the downcomer below the surface of the pool, h is the height of the water column in the downcomer measured from the bottom of the downcomer, ρ_L is the density of the liquid water in the pool, and g is the acceleration due to gravity. The variable h_o is an effective acceleration length representative of the amount of water mass that is undergoing the acceleration. A sensitivity analysis on this variable has shown that the results are relatively insensitive to the value of this variable and the Oyster Creek analysis uses the value of 2.0 feet from the NEDE-24802.

The above differential equations are solved using standard numerical integration methods.

2. NRC Question

Why is it assumed that only one train of containment spray is activated for Case 1: Inadvertent drywell spray activation during normal operation? Explain why two drywell spray trains can not be inadvertently actuated? What would be the effect? Would it be more limiting than the drywell spray actuation after a loss-of-coolant accident?

Response

Only one train of containment spray was assumed for Case 1: Inadvertent drywell spray activation during normal operation (ISA) because it would require more than one single operator error to establish both containment spray trains during normal plant operation. There are no automatic initiation features for containment spray at Oyster Creek.

The Oyster Creek Containment Spray System consists of two independent systems, designated as Containment Spray System I and Containment Spray System II. It is unlikely that two trains will be inadvertently actuated during normal operation for the following reasons:

- The two trains are independent, including controls. The valves for each train are aligned for either Drywell Spray mode or Torus Cooling mode by a mode select switch. The mode select switch is normally in the Torus Cooling Mode.

- The system is normally idle, as it is only operated for accident mitigation and system testing. The only conceivable time the system could inadvertently start and spray into the Drywell would be during system testing. The procedures for performing pump operability/IST testing include the following steps to start a pump:

  1) Verify the mode select switch is in Torus Cooling.

  2) Verify Drywell Spray Valve is closed.

  3) Turn and Hold pump manual start permissive keylock switch.

  4) While holding permissive switch, turn and hold pump start switch (Two hands are needed to start one pump).

  These steps require several verifications and manual actions on the part of the operator in order to start the system. The mode select switch would have to be in the incorrect position (Drywell Spray) to spray into the Drywell, which would require two procedural errors (Mode switch in wrong position and failure to verify valve position). While it is possible to inadvertently initiate drywell spray with one train, it is highly unlikely that two trains would be started due to the complexity of the steps. In addition, both permissive switches would have to be in the wrong position (Drywell Spray). Furthermore, the system test procedures for each train are separate, such that the operators would not be operating controls for the train not being tested.

Although assuming two loops of containment spray during normal plant operation would be more conservative than a single loop, both of these ISA cases remain bounded by the design basis case of two loops of containment spray following a design basis loss of coolant accident (LOCA). This was confirmed by making several additional undocumented runs of the ISA case with two loops of containment spray.

3. <u>NRC Question</u>

What is the basis for the 45°F spray water temperature for Case 1? What would the expected water temperature be? How can the suppression pool temperature be 95°F and the spray temperature be 45°F? Isn't the water source for drywell spray the suppression pool?

Response

Case 1 is the ISA case, where it is assumed that an operator error initiates drywell spray cooling during normal plant operations. For this case, conservative inputs include hot, dry air (nitrogen) in the drywell, hot moist air (nitrogen) in the wetwell, and cold spray. Although it is true that the source for the spray is the suppression pool, the spray water may be cooled by the Emergency Service Water (ESW) system, which may be very cold. Since Case 1 is not limiting, a heat balance was not performed to estimate a worst-case spray temperature. Instead, a conservative spray temperature of 45°F is used.

4. **NRC Question**

What is the basis for 6.75-feet in the torus to prevent water from being drawn into the vent header? What is the consequence of water in the vent header?

Response

It is noted that the limit of 6.75 feet is a limitation on the water height in the downcomer, measured from the bottom of the downcomer, not a limitation of the water height in the torus itself.

According to NEDE-24802, water level in the downcomer is modeled to ensure that the water in the downcomer does not rise to a level that would interfere with the vacuum breaker performance. The wetwell-to-drywell vacuum breakers at Oyster Creek are located on external vent pipes connecting the wetwell airspace with the major vents from the drywell to the wetwell. Thus water height in the downcomer during containment spray events is not limited by the elevation of the vacuum breakers. For the purpose of the design calculation, water height in the downcomer was arbitrarily limited to the 6.75 feet such that the water level does not rise to the vent header and thus fill the vent header. This limitation was chosen as a conservative limitation. There is no adverse consequence of water in the vent header.

Note that the value of 6.75 feet is based on an elevation distance of 110 inches from the bottom of the downcomer to the elevation of the center of the vent header, minus the radius of the vent header (27.75 inches conservatively rounded to 29 inches), (110.0 – 29.0) / 12 = 6.75 feet.

5. **NRC Question**

The discussion for Case 1 states that the initial drywell air temperature is assumed to be 150°F which is the design maximum for normal operation. It further states that "the code input initial drywell temperature and pressure conditions were determined to be 115°F and 15.6 psia, respectively." Please explain the two initial drywell temperatures.

Response

The first value, 150°F, represents the event initial condition. However, the vacuum breaker sizing code (VBSizing) assumes saturated conditions in both the drywell and wetwell. A hand calculation is performed to determine the containment conditions following spray actuation at the time that saturation occurs. The hand calculation method is explained in NEDE-24802 using first-principle psychrometrics. This methodology involves an iterative process. The values of 115°F and 15.6 psia represent the code input initial conditions, which are the conditions in the drywell at some time following spray initiation wherein the drywell has only just become saturated. At this point in time the drywell temperature has decreased due to the evaporative cooling effect of the spray.

6. NRC Question

Describe how the 115°F and 15.6 psia values referred to in Question 5 were determined.

Response

In developing this response, an error in the hand calculation methodology as provided in the Reference NEDE-24802 Topical Report was identified and corrected. This correction impacted the 115°F and 15.6 psia values previously calculated for the code initial input conditions. The corrected input conditions for the Oyster Creek initial drywell temperature and pressure values are 97.63°F and 14.55 psia, respectively. The correction involved an incomplete expression for the internal energy of water vapor in the hand calculation methodology of the NEDE-24802 document text. The correction does not affect the code itself. A simple model of the Inadvertent Spray Actuation Case was informally developed and run using the EPRI GOTHIC Code, Version 6.1b, which confirmed the appropriateness of these corrected input conditions. These corrected values result in revised consequences for the Inadvertent Spray Actuation Case. However, this case is non-limiting and there is no impact on the evaluated number of wetwell-to-drywell vacuum breakers required to operate for Oyster Creek. This item has been entered into the corrective action program and General Electric has been notified of this condition. A detailed discussion of how these corrected values are determined is provided below.

The initial containment conditions prior to spray initiation are as follows.

	Variable	Value	Units
Drywell			
Airspace Volume	Vd	180,000.0	cuft
Temperature	Ti	150.0	°F
Pressure	Pi	1.0	psig
Relative Humidity	Xi	20.0	percent
Spray			
Temperature	Ts	45.0	°F

The partial pressures for the vapor and non-condensables are,

$$Pv_i = X_i * P_{sat}(T_i)$$
$$Pn_i = P_i + P_{atm} - Pv_i$$

The initial mass of non-condensables and vapor in the drywell is found as,

$$M_n = \frac{144 * Pn_i * V_d}{R_n * (T_i + T_o)}$$
$$M_{v_i} = \frac{V_d}{v(Pv_i, T_i)}$$

The energy of the system prior to spray initiation is determined by the equation,

$$E_i = En_i + Ev_i = M_n * u_n(T_i) + M_{v_i} * u(Pv_i, T_i)$$

where the specific internal energy of nitrogen is found as $u_n(T) = Cv_n * (T + T_o)$. The specific volume and specific internal energy for vapor, $v(Pv_i,T_i)$ and $u(Pv_i,T_i)$, respectively, are found using the ASME Steam Tables.

The final state, when the drywell becomes saturated immediately following spray initiation, is found by similar method with the exception that the final temperature must first be estimated and later iterated on. Given a final temperature estimate of T_f, the partial pressures for the vapor and non-condensables are,

$$Pv_f = P_{SAT}(T_f)$$
$$Pn_f = \frac{M_n * R_n * (T_f + T_o)}{144 * V_d}$$

The final mass of vapor in the drywell is found as,

$$M_{v_f} = \frac{V_d}{v(Pv_f, T_f)}$$

Note that the change in vapor mass is entirely due to the mass of spray water added to the drywell and is assumed to have evaporated by exchange of energy between the hot air and vapor initially in the drywell and the spray water added via the spray nozzles (assuming instantaneous and perfect heat transfer).

$$M_{spray} = M_{v_f} - M_{v_i}$$

The energy added to the system is due to the spray water, and assuming no heat sinks or heat transfer out of the containment, the energy added to the system is the spray energy,

$$E_{spray} = M_{spray} * u(P_{spray}, T_{spray})$$

where P_{spray} is the pressure of the spray water prior to injection into the drywell and is assumed as 200 psia. The final result (T_f, P_f) will not be greatly sensitive to this value. Thus the final energy of the system is found to be,

$$E_f = E_i + E_{spray}$$

Since the vapor in the drywell at final conditions is saturated, the final energy of the vapor in the drywell is,

$$Ev_f = Mv_f * u_g(T_f)$$

where $u_g(T_f)$ is the specific internal energy of saturated vapor at a temperature of T_f.

The final energy of the system must be greater than the energy contained in the vapor, and the remainder of the energy is necessarily that contained in the non-condensable gas.

$$En_f = E_f - Ev_f$$

Therefore the specific internal energy of the non-condensables is,

$$un_f = \frac{En_f}{Mn_f}$$

Using the above expression for the specific internal energy for nitrogen, it can be determined at what temperature the nitrogen must be at to have this specific internal energy,

$$Tn_f = \frac{un_f}{Cv_n} - T_o$$

It is necessary that the gas be at the same temperature as the vapor. Therefore this final temperature can be substituted for the estimated temperature and the evaluations continued until a solution is found.

Using the above noted case initial conditions and the above methodology, the temperature and pressure of the drywell upon saturation is T_f = 97.63°F and P_f=14.55 psia. This represents a drop in pressure of 1.14 psid. Thus, the code initial conditions for the drywell for this case should be a temperature of 97.63°F, a pressure of 14.55 psia, and a relative humidity of 100 percent.

7. **NRC Question**

For Case 2, why is the analysis done for both a single loop and two loops of drywell spray? Isn't the two-loop case always limiting?

Response

The single loop of containment spray following a LOCA was evaluated for information only. The example case for containment spray following a LOCA from NEDE-24802 included continuous steam blowdown into the containment to simulate the break and a single loop of containment spray. For the Oyster Creek analysis, no steam break flow and two loops of containment spray are modeled for conservatism.

8. NRC Question

What is the basis for the assumption of a suppression pool water temperature following blowdown of 105°F? Why is this conservative?

Response

The value of 105°F was selected as a conservatively low suppression pool water temperature immediately following reactor blowdown to the suppression chamber. A sensitivity study was performed for this input variable. Code runs were performed with an initial wetwell water temperature of 120°F and again with an initial wetwell water temperature of 115°F. All other inputs were kept the same with the exception of initial containment temperatures and pressures that are consistent with these water temperatures. The initial wetwell water temperature for the LOCA cases determine the initial wetwell airspace temperature and therefore the wetwell airspace pressure and the drywell airspace pressure and temperature. For this change in wetwell water temperature from 120°F to 115°F the maximum differential pressure changed from 1.98 psid to 2.00 psid, or +0.02 psid, and the peak vent water height changed from 8.69 feet to 8.72 feet, or +0.03 feet. Note that these values for peak differential pressure and vent water height were performed for early runs with only five vacuum breakers operating and for a spray temperature of 60°F. But the relative results remain appropriate in that, a decrease in the wetwell water temperature results in an increase in the peak differential pressure and vent water height.

Additional undocumented sensitivity runs were performed for current values of all input parameters with eight vacuum breakers operating and a spray temperature of 45°F. With a wetwell water temperature input as indicated, the maximum differential pressure and maximum vent height are listed below:

Suppression Chamber Water Temperature	Maximum dP	Maximum Vent Height
90.0	0.98	6.39
95.0	0.97	6.36
100.0	0.97	6.36
105.0	0.96	6.36
110.0	0.97	6.34
115.0	0.97	6.36
120.0	0.96	6.33
125.0	0.95	6.32

These results indicate that the analysis is not strongly dependent on the value of this input variable, and that the slight trend is such that lower values are conservative.

Since the analysis results are not greatly sensitive to this input parameter, and since lower values are conservative, engineering judgment was used to select a conservative value for this input parameter. The basis was to assume a water temperature prior to the LOCA of 45°F, which represents a very conservative minimum wetwell water temperature, and a post-blowdown wetwell water temperature rise of 60°F.

9. NRC Question

For the three cases considered, provide results of calculations showing the wetwell to drywell pressure as a function of the number of operable vacuum breakers and the peak vent water level as a function of the number of vacuum breakers. Also provide the results of calculations for eight vacuum breakers, showing the drywell and wetwell temperature versus time, the drywell and wetwell pressure versus time, the differential pressure between the wetwell and the drywell as a function of time and vent water level as a function of time.

Response

The following figures, extracted from the Oyster Creek analysis provide the requested results in graphic form. The results for eight vacuum breakers are provided for the most limiting case of LOCA with two loops of containment spray.

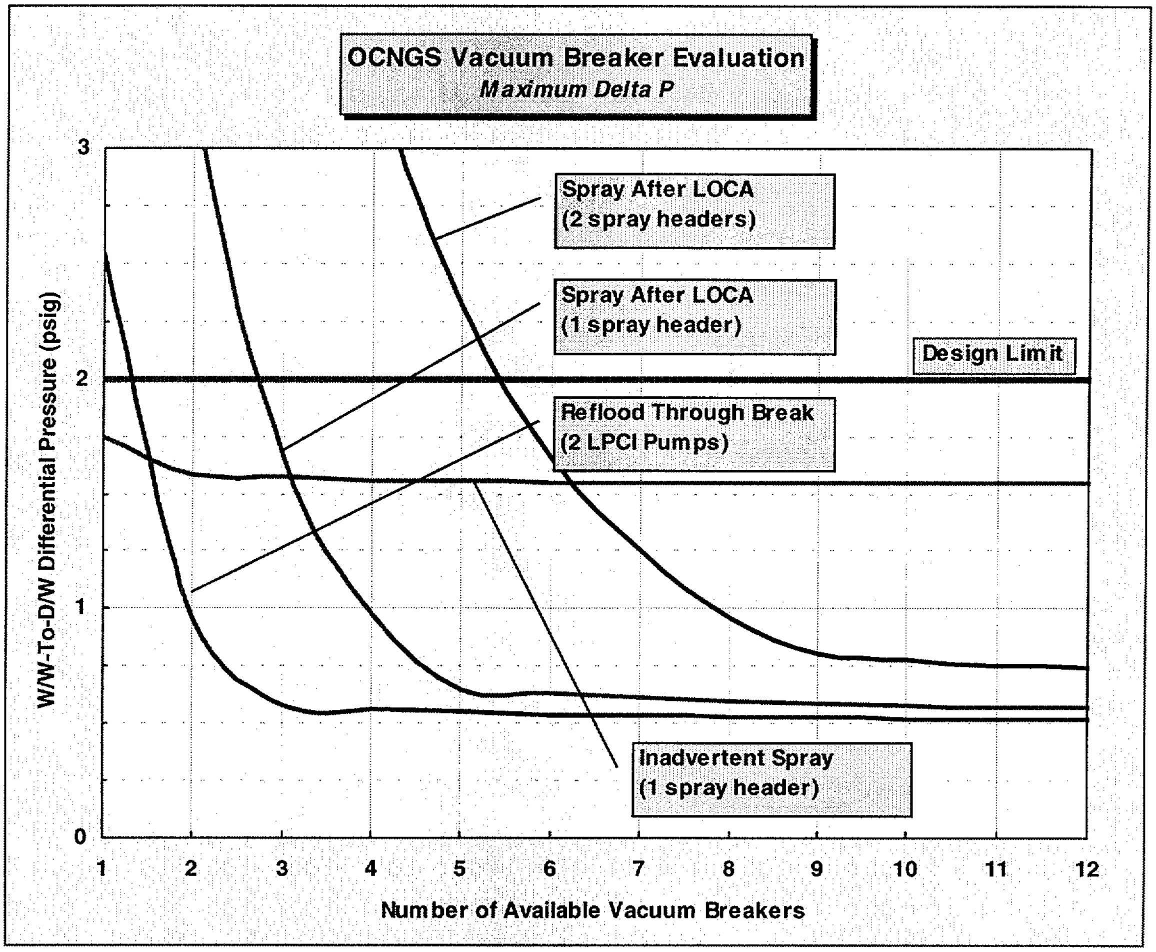


Figure 1 – Differential Pressure with Operable Vacuum Breakers

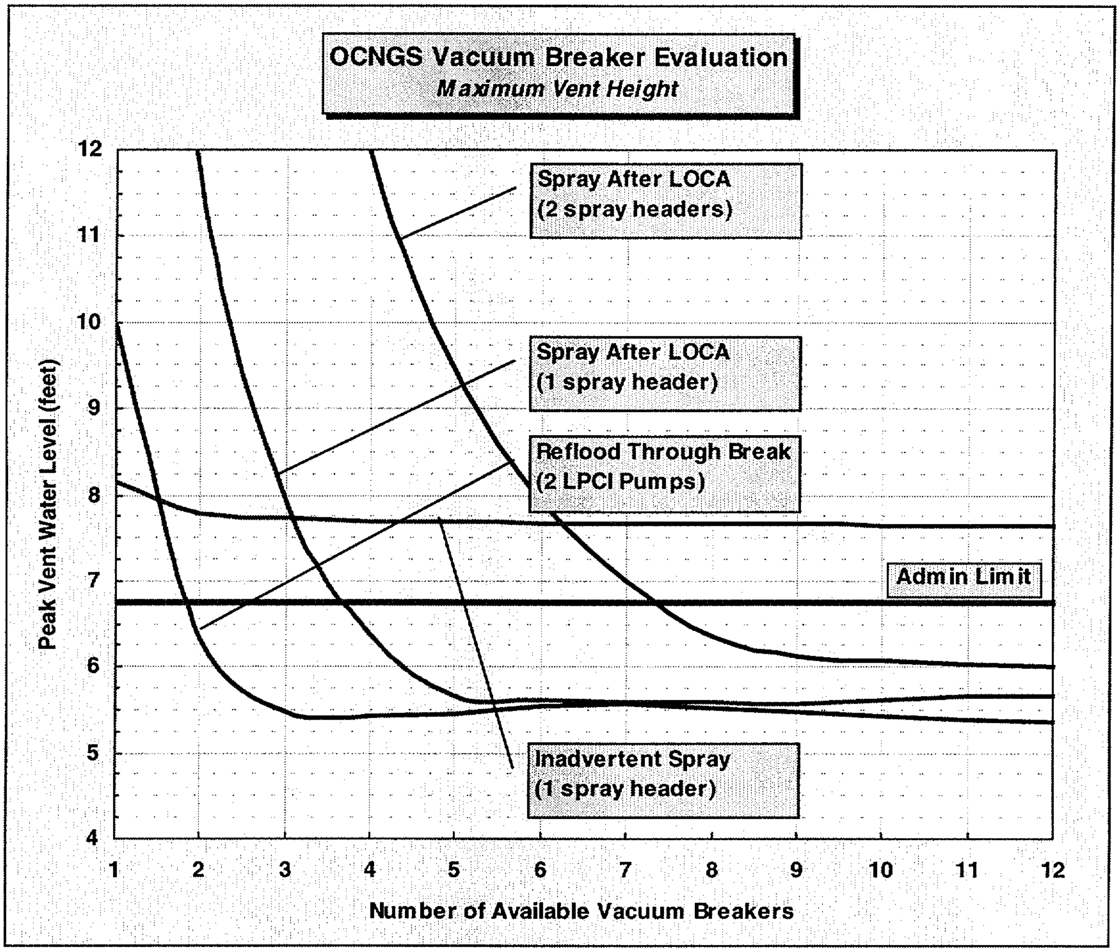


Figure 2 – Peak Vent Height with Operable Vacuum Breakers

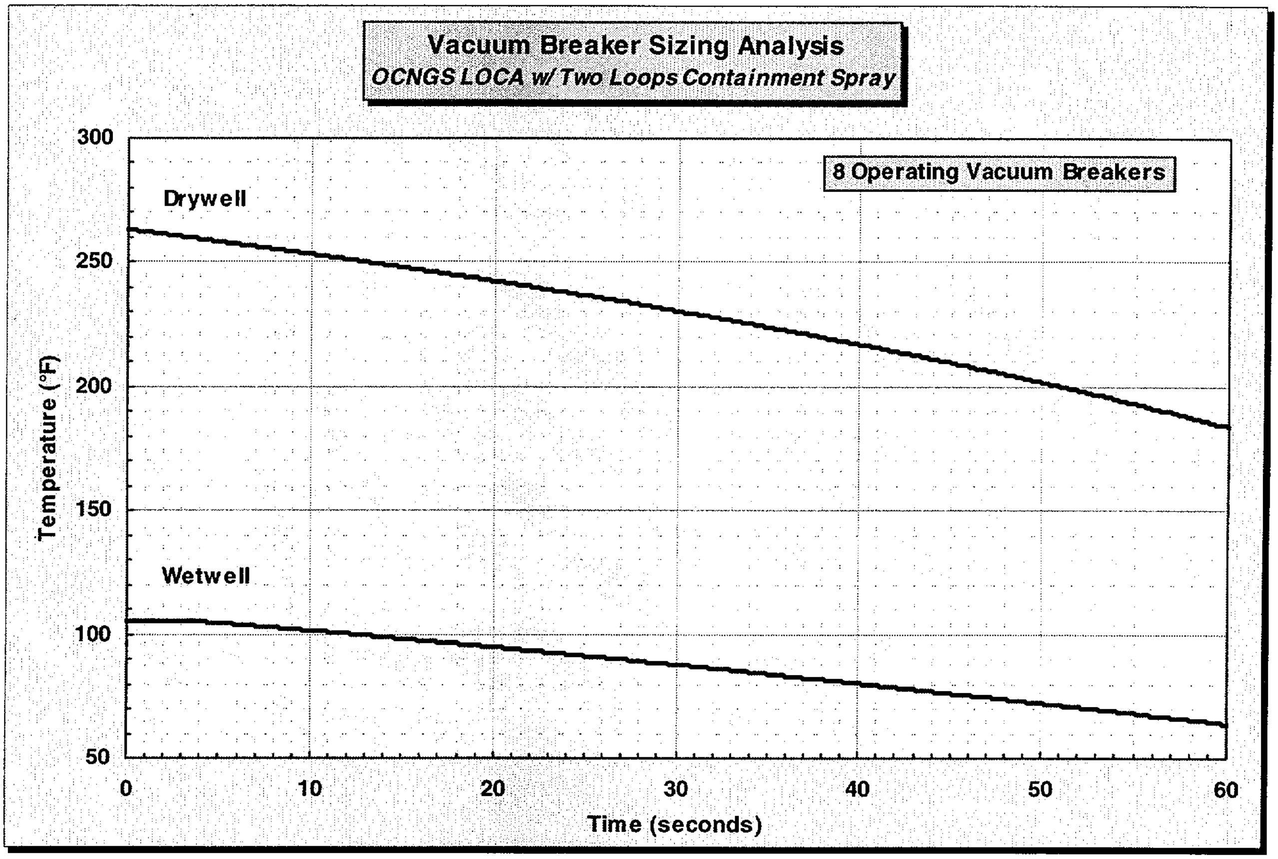


Figure 3 – LOCA Temperatures with Eight Operable Vacuum Breakers

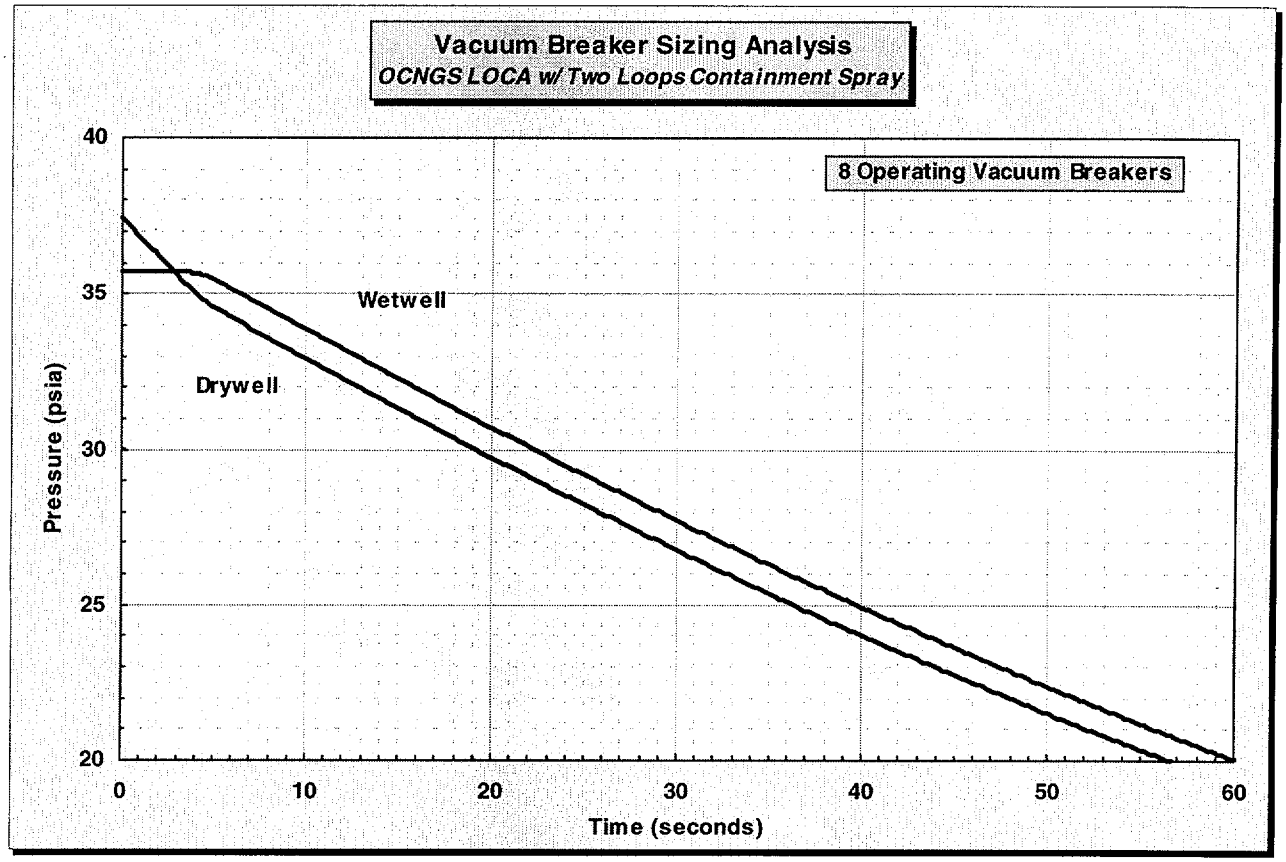


Figure 4 – LOCA Pressures with Eight Operable Vacuum Breakers

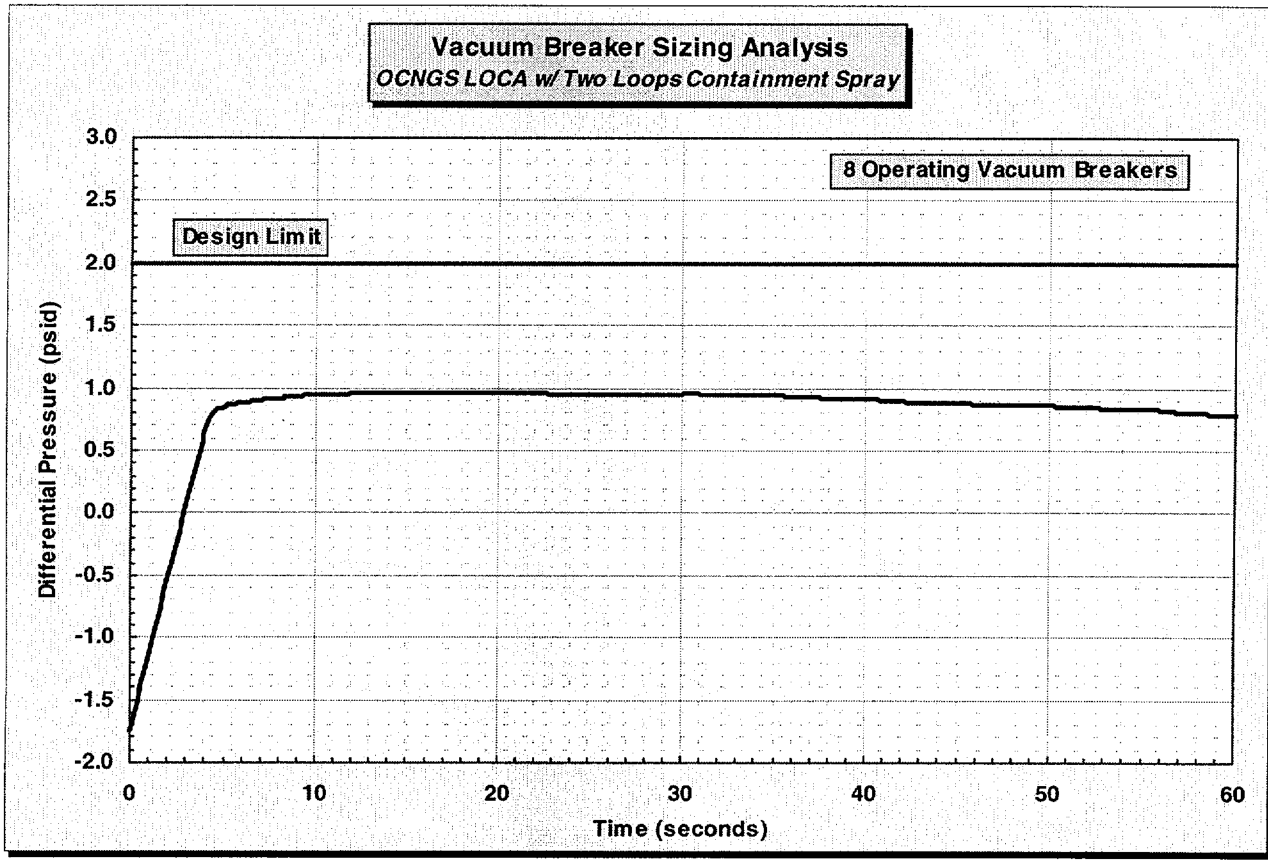


Figure 5 – LOCA Differential Pressure with Eight Operable Vacuum Breakers

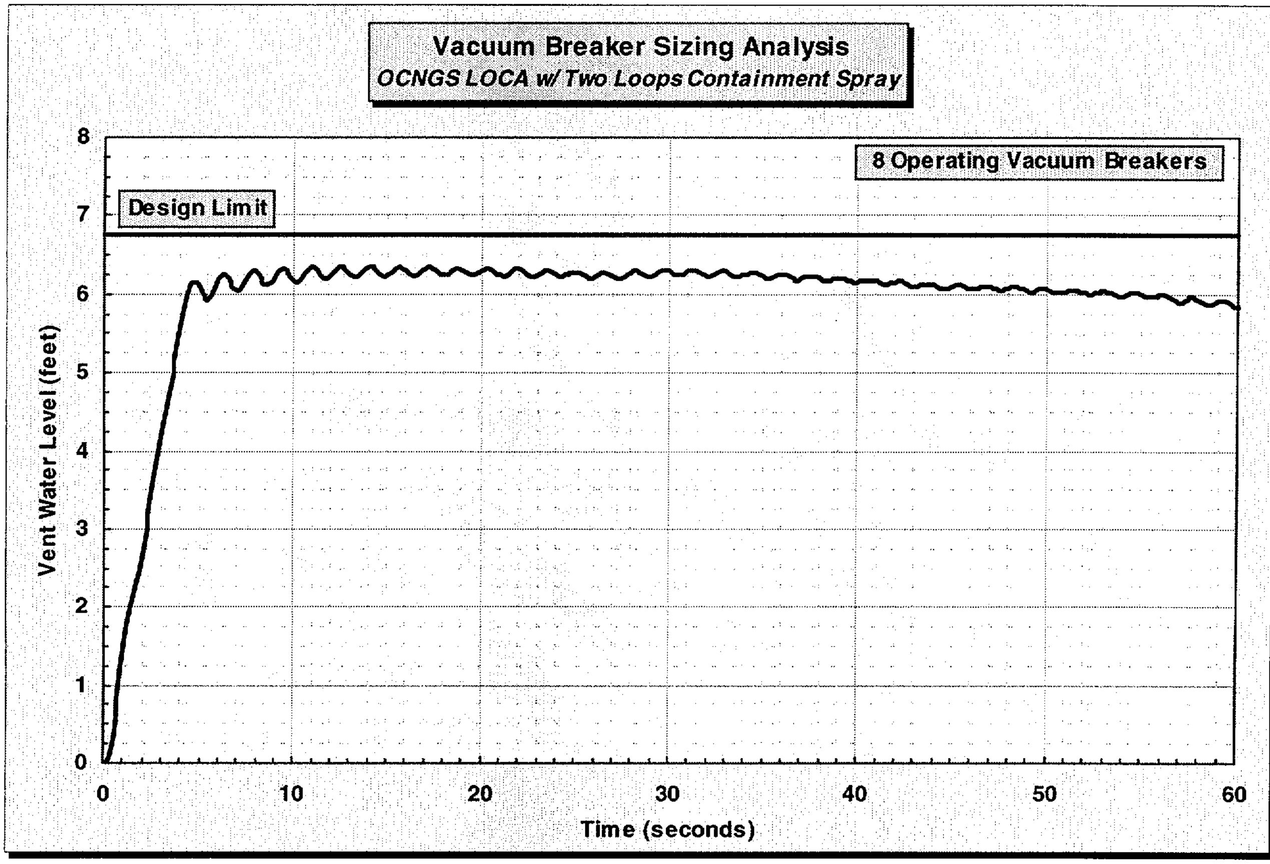


Figure 6 – LOCA Downcomer Water Level with Eight Operable Vacuum Breakers

10. NRC Question

Page 4/9: The description for Case 3 states that "a spray effect is assumed when the reactor vessel is reflooded with emergency core cooling injection *until* the injection flows out the break." Shouldn't this be *after* the injection flows out the break?

Response

The suggested word change is acceptable. The understanding is that, once ECCS has reflooded the vessel, the ECCS flow spills out of the break. This ECCS flow is assumed to result in a spray-like effect.

11. NRC Question

Page 4/9: Why is the assumption of a single failure beyond the existing licensing basis?

Response

The current licensing basis is found in the Oyster Creek Technical Specification, which requires 12 of 14 vacuum breakers to be operable. The basis for this is the design requirement for a vacuum break area equal to or greater than one-sixteenth the vent area. This design requirement finds its basis in the Bodega Bay tests.

The Oyster Creek vacuum breakers are 18" nominal diameter. Twelve of these vacuum breakers provide vacuum break area to meet the design required area of one-sixteenth of the vent area. Eleven vacuum breakers would result in less than the one-sixteenth of the vent area. Thus, in the current licensing basis, since as few as 12 vacuum breakers are required to be operable, the current licensing basis does not include allowance for a single failure of a vacuum breaker. It is, however, unknown whether the Bodega Bay design requirement of one-sixteenth of the vent area includes any allowance for single failure. The meaning of the statement is that the current licensing basis of 12 vacuum breakers does not, itself, provide for a single failure of a vacuum breaker and still meet the design requirement of one-sixteenth of the vent area.

The proposed change adds a single failure margin to the Technical Specification limit.

12. NRC Question

Page 2/9: If Bodega Bay tests, which "established the Oyster Creek design," are the basis for requiring 12 vacuum breakers to be operable, justify the validity of calculations that predict that the differential pressure and downcomer level criteria can be satisfied with six vacuum breakers.

Response

It is noted that the proposed change is to require nine (9) operable vacuum breakers based on limiting analysis which demonstrates eight (8) vacuum breakers are adequate. The Bodega Bay tests verified that a vacuum break area to vent area ratio of one-to-sixteen was an adequate vacuum break area. However, the Bodega Bay tests were not intended to determine the minimum required vacuum break area. Exactly how this vacuum break area ratio was determined for Bodega Bay is not known. However, during the Mark I Containment Program it was identified that this design basis requirement of a one-to-sixteen ratio may not be the minimum vacuum break area required. Therefore Task 9.4.3 of the Mark I Containment Program was established to identify the functional requirements for the Mark I Wetwell-to-Drywell Vacuum Breakers. NEDE-24802 is a product of this task, and includes a sizing code to be used to determine a true minimum required vacuum break area, setpoint, and opening time, based on first principles of thermodynamics.

In addition to the analysis performed for Oyster Creek using the vacuum breaker sizing code as provided in NEDE-24802 (VBSizing), an additional analysis has also been performed using the more general capabilities of the industry recognized GOTHIC code provided by EPRI. This GOTHIC analysis has been performed only as an alternate check of the Oyster Creek analysis, and as such is not a formal part of the Oyster Creek analysis. The intent of the GOTHIC analysis is only as an unverified check of the results of the Oyster Creek analysis using the vacuum breaker sizing code of NEDE-24802.

The GOTHIC model closely matches the model used in the VBSizing code, with three control volumes representing the drywell airspace, wetwell airspace, and downcomer. The following tables provide the important inputs for the GOTHIC model for Case IIb – Spray Following a LOCA – Two Spray Loops. Results for each case and for varying number of operating vacuum breaks are also provided in the figures following the tables. Results are provided for both the GOTHIC runs and the VBSizing runs for comparison.

The figures on the following pages provide a comparison of the GOTHIC results (bold) with the VBSizing results (light and dashed), and indicate very good comparison. The only significant deviation between the two results is for the initial peak in vent water height for the ISA case. For this figure (Figure 12), GOTHIC indicates a higher vent water height than VBSizing. This is attributed to the assumption in the VBSizing code that the initial conditions are stagnant, i.e., the vent water column velocity is initially set to zero. For the ISA case, the VBSizing code begins at some small time just following initiation of sprays, when the containment has become saturated. However, for this case the pressure in the drywell has rapidly dropped and the water column rises quickly such that the velocity (momentum) of the water column at saturation is enough to cause the column to continue to rise, even though the differential pressure no longer supports the height. Because VBSizing assumes the initial column velocity is zero, it cannot appropriately determine this initial peak height. The GOTHIC analysis, however, because it can begin at the true event initiation, with non-saturated conditions in the drywell, and because it models the column momentum, appropriately estimates the peak water column height. However, the vent water column height is not of any significance for Oyster Creek because the vacuum breakers are located externally and are not affected by the water column height.

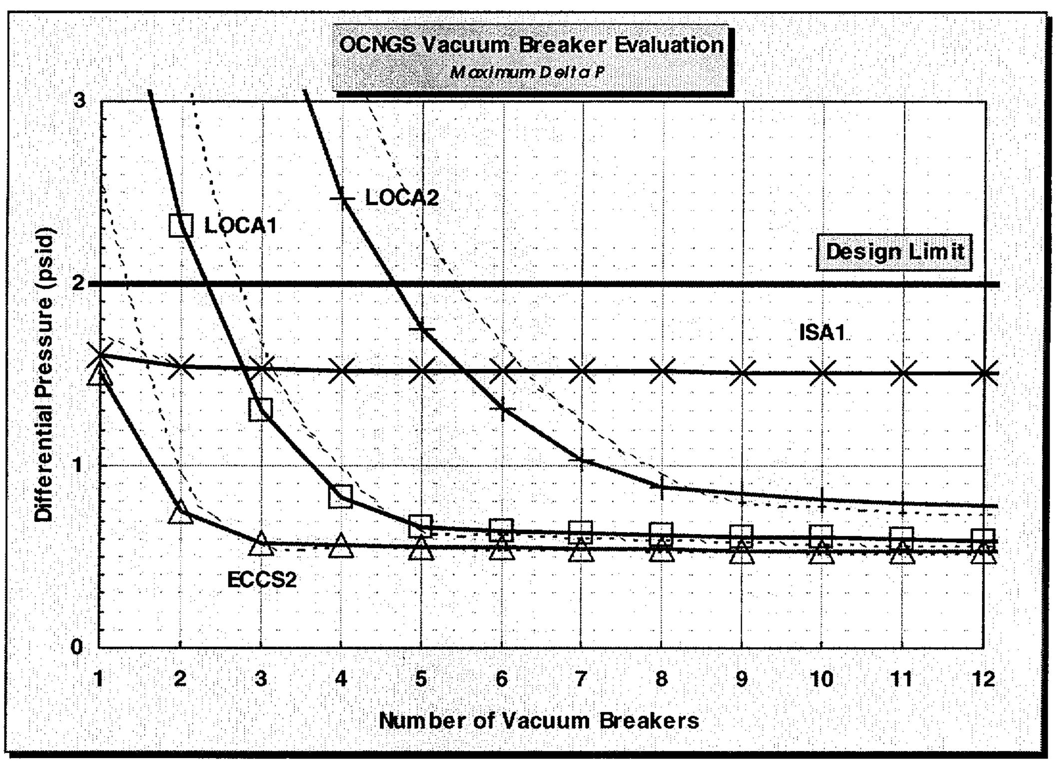


Figure 7

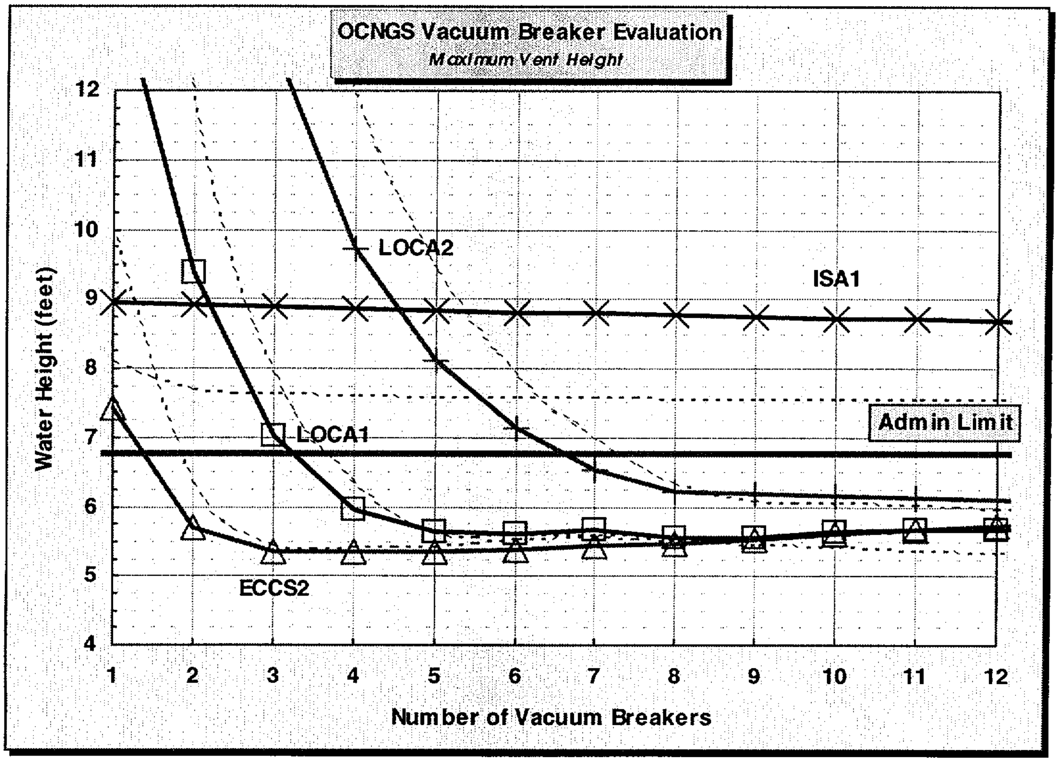


Figure 8

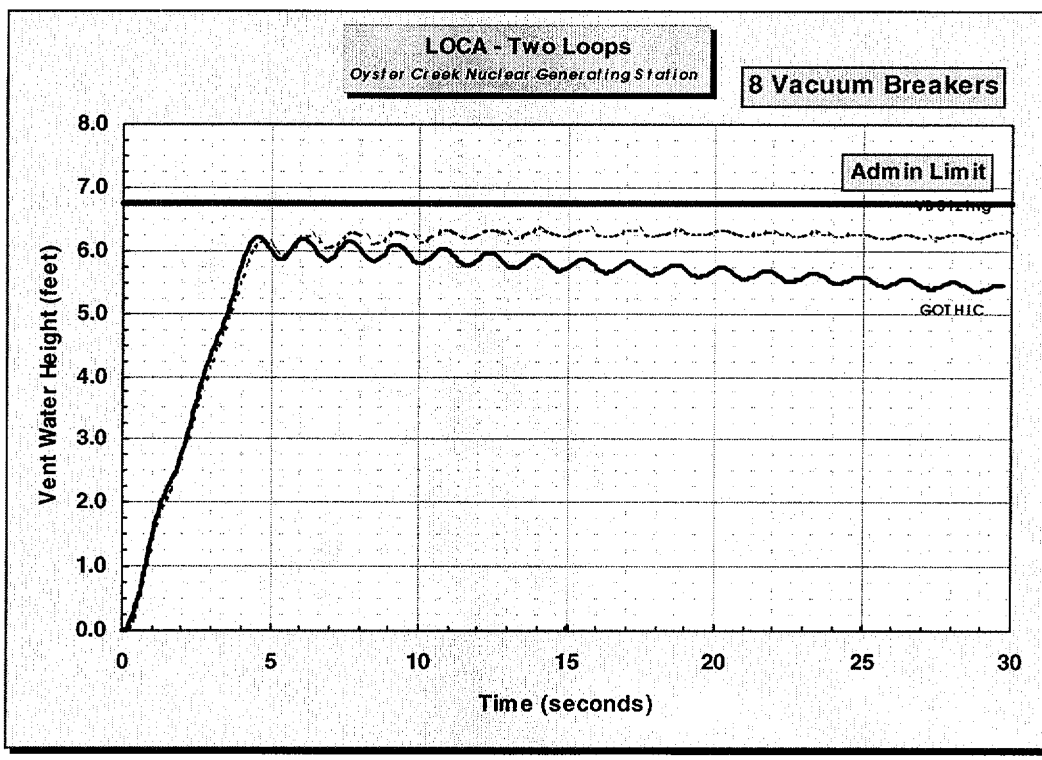


Figure 9

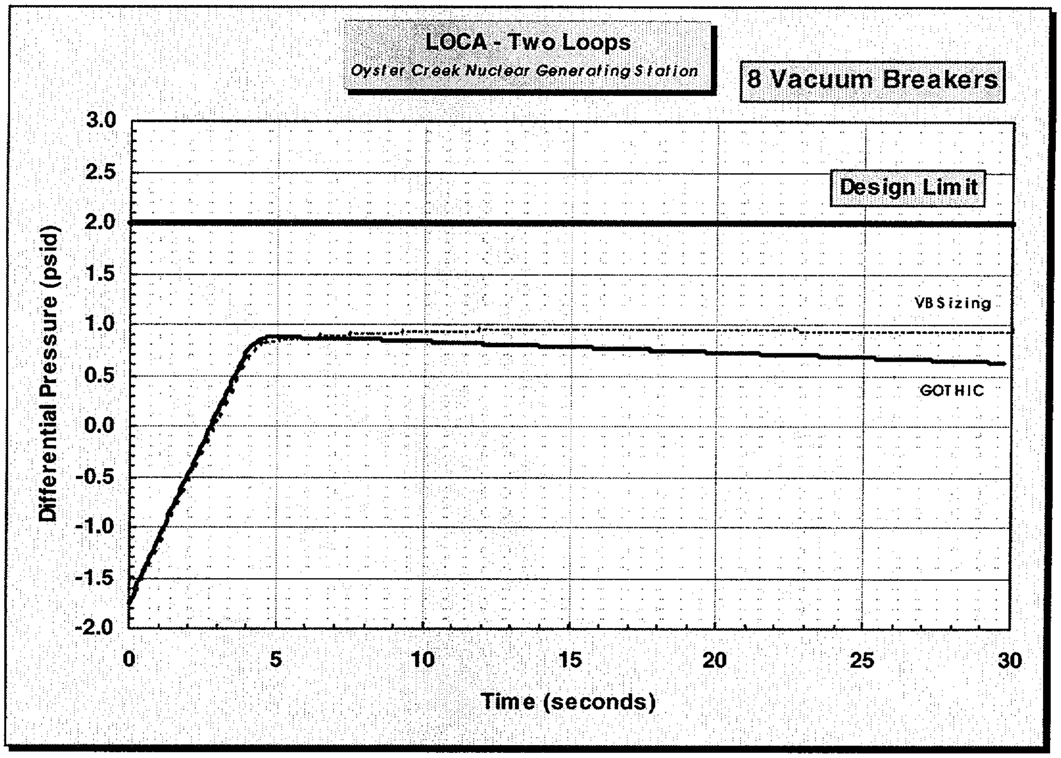
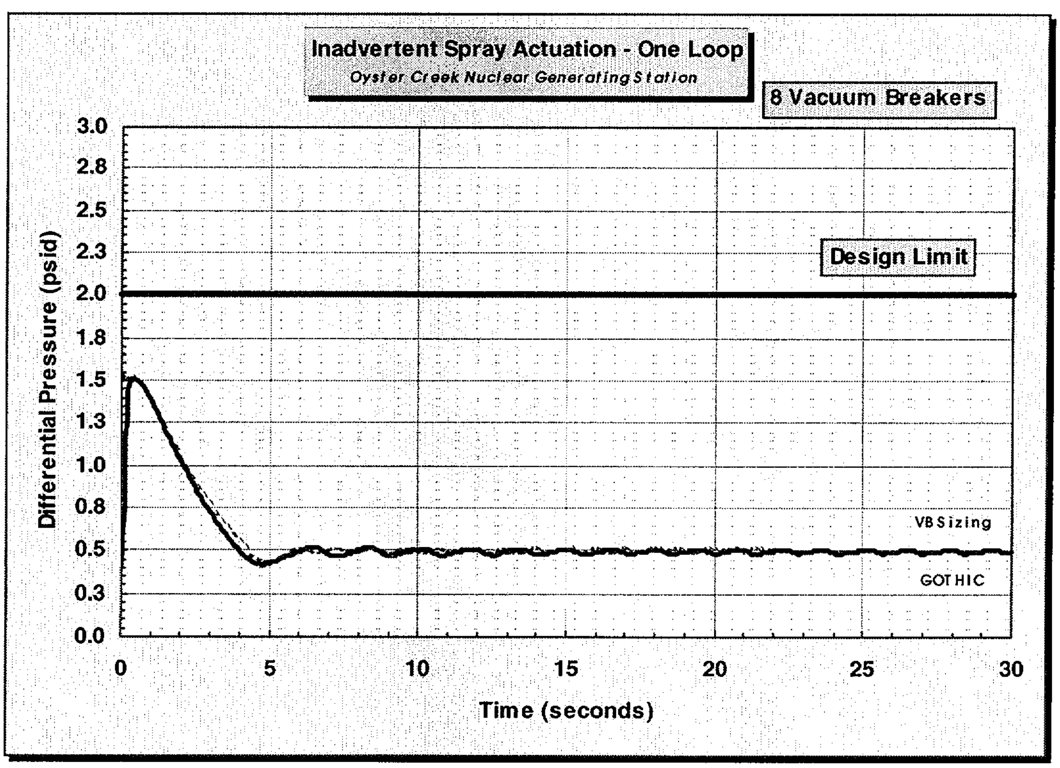


Figure 10



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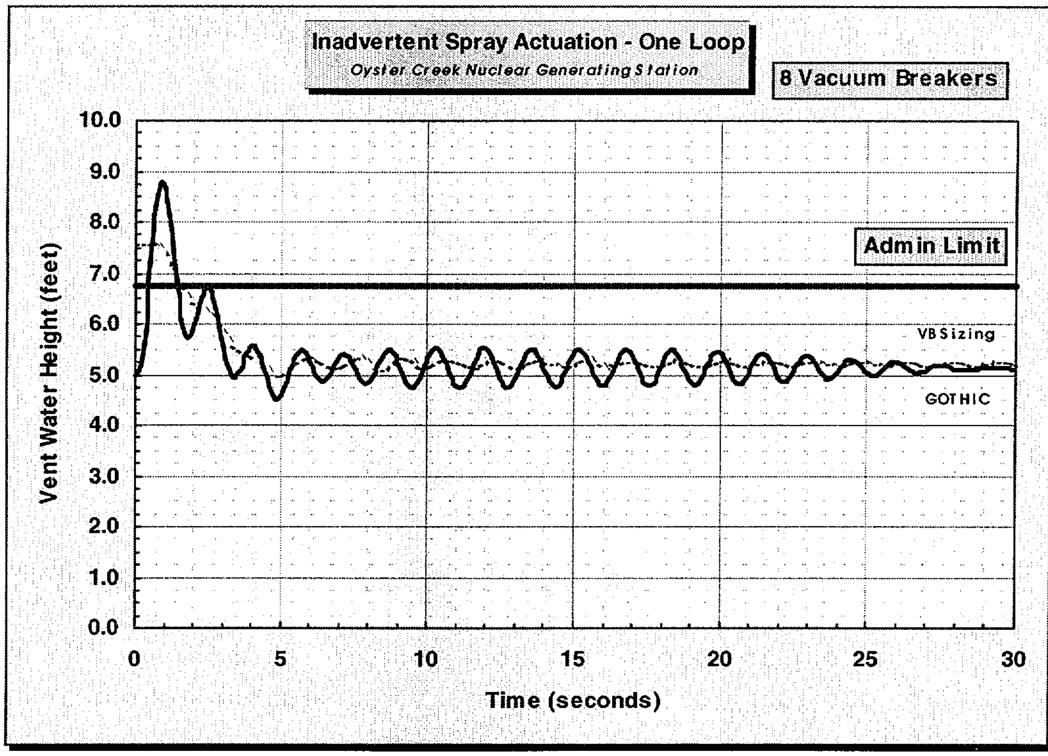

Figure 12

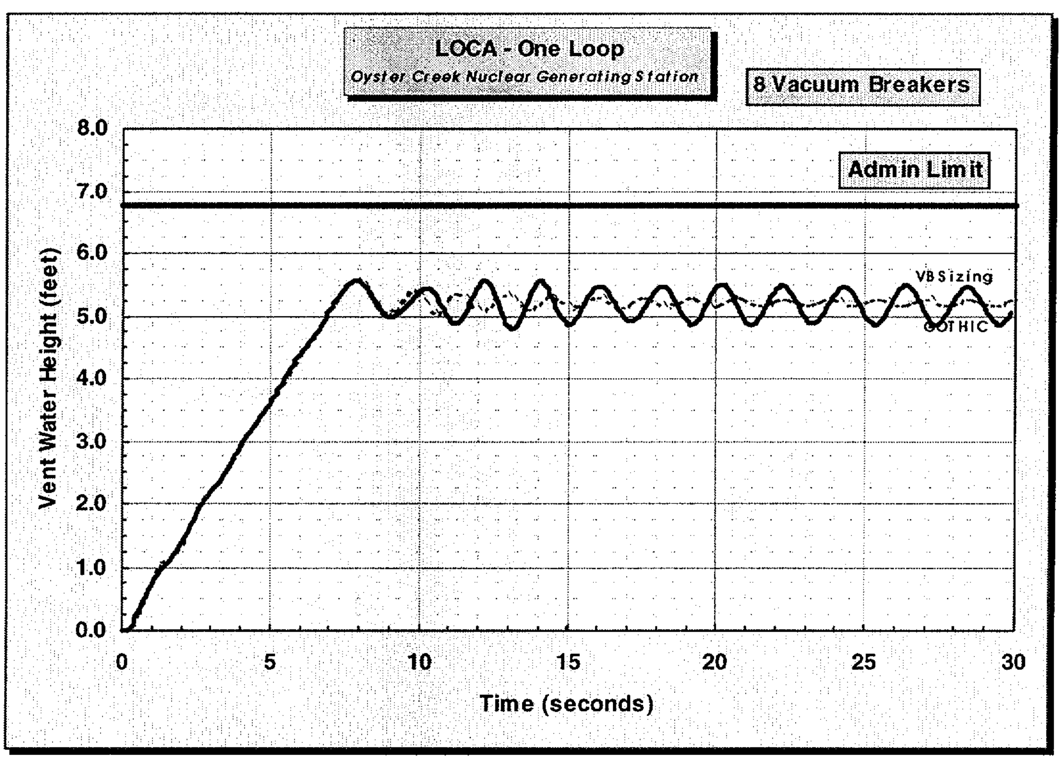

Figure 13

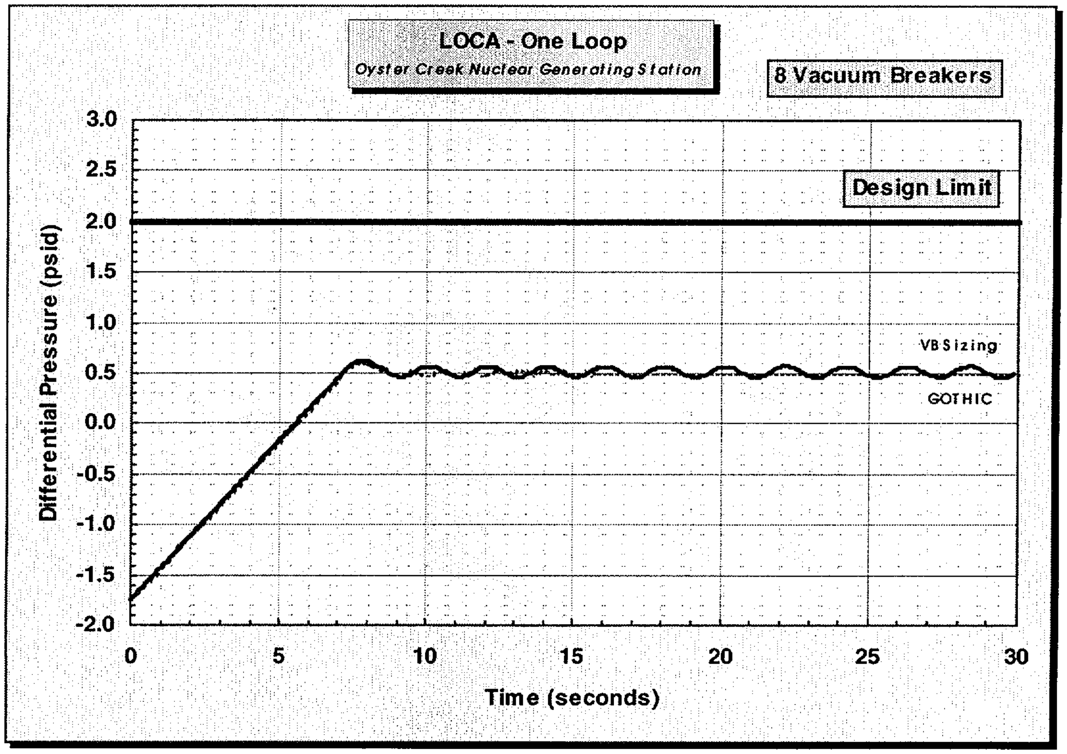

Figure 14

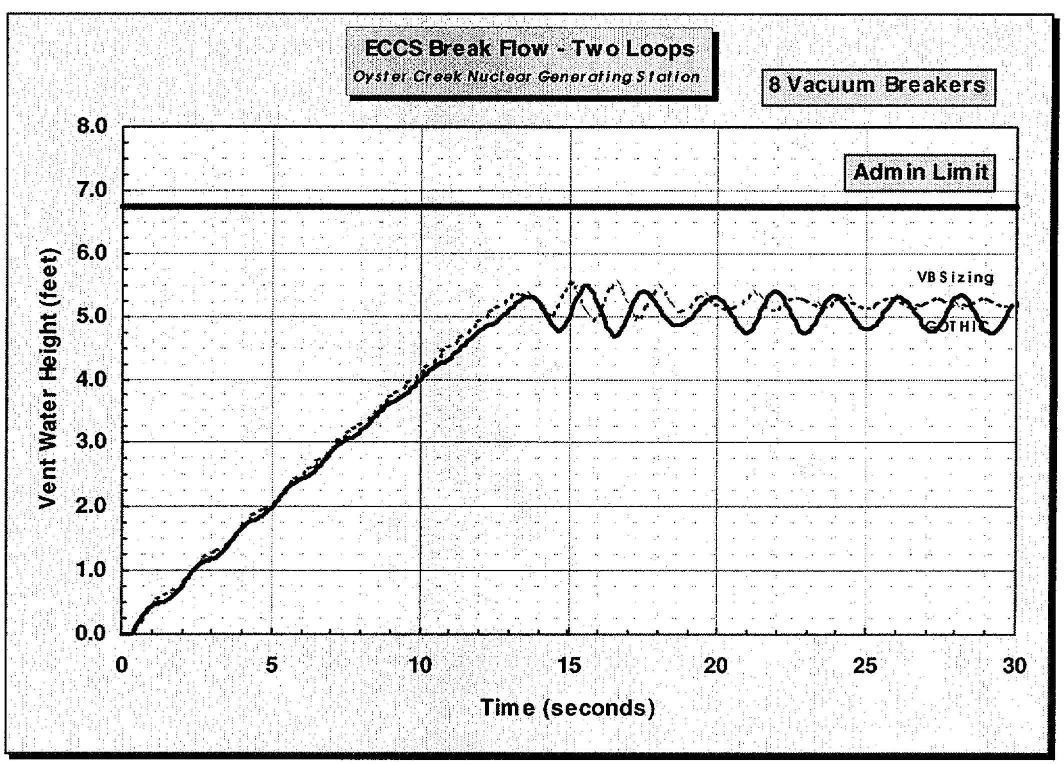

Figure 15

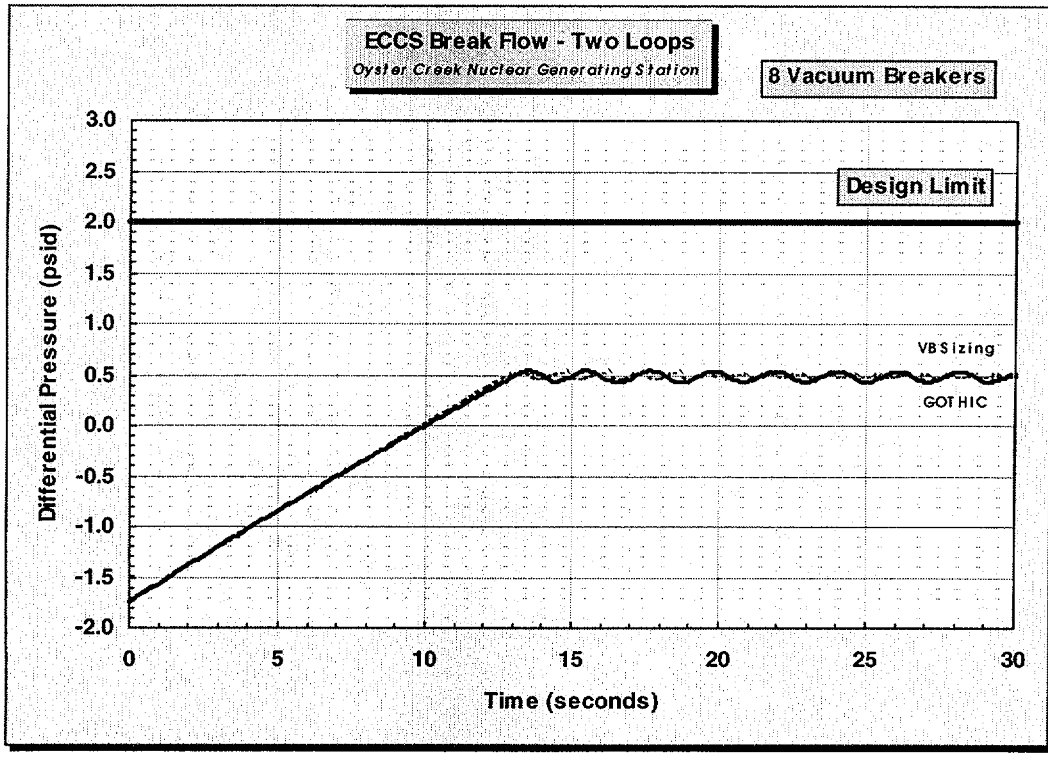
ECCS Break Flow - Two Loops
Oyster Creek Nuclear Generating Station
8 Vacuum Breakers
Design Limit
VB Sizing
GOTHIC
Differential Pressure (psid)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
0
5
10
15
20
25
30
Time (seconds)

Figure 16