EXHIBIT A

MONTICELLO NUCLEAR GENERATING PLANT

License Amendment Request dated June 4, 1981

Proposed Changes to the Technical Specifications
Appendix A of Operating License DPR-22

Pursuant to 10 CFR 50.59 and 50.90, the holders of Operating License DPR-22 hereby propose the following changes to Appendix A, Technical Specifications:

1. Specification 3/4.7.A.4, Pressure Suppression Chamber-Drywell Vacuum Breakers

   Proposed Changes

   Revise Specification 3/4.7.A.4 as follows:

   a. Require eight vacuum breakers to be operable under normal conditions.

   b. Permit up to two vacuum breakers to be inoperable provided that inoperable valves are verified closed, secured in the closed position, or replaced by a blank flange.

   c. Change "...operating fuel cycle..." to "...operating cycle..." in 4.7.A.4.a(2).

   d. Revise the Bases on page 178 to reflect a reduction in the number of installed drywell-to-torus vacuum breakers from ten to eight.

   Reason for Changes

   Monticello currently has ten 18-inch Atwood & Morrill vacuum breakers mounted on the end of the vent lines in the pressure suppression chanber (torus). Six of the vent lines have one vacuum breaker and two of the vent lines have two vacuum breakers installed.

   Vacuum breaker sizing requirements have been reevaluated as part of the Mark I Containment Long Term Program. As noted in Exhibit C, six vacuum breakers are adequate to preserve containment integrity under the worst postulated condition (both drywell sprays initiated simultaneously in a steam filled drywell). This reassessment confirmed our long held belief that extremely conservative criteria were used in the original vacuum breaker sizing.

   Also as part of the Mark I Containment Long Term Program, the existing vacuum breaker locations will be strengthened to withstand post-accident impact loads.

Changes (a), (b), and (d) above revise the Technical Specifications to reflect modifications scheduled this autumn to remove two of the existing ten vacuum breakers. This will reduce the number of vacuum breaker locations requiring modification. It also reduces the potential for drywell-torus bypass leakage by removing unnecessary vacuum breakers. Following modification, two spare vacuum breakers will still be provided as required by existing Technical Specification requirements.

Change (c) above corrects the terminology used in 4.7.A.4.a(2) to use the term "operating cycle" which is defined in Section 1 of the Technical Specifications.

Safety Evaluation

Refer to Exhibit C, "Monticello Torus-to-Drywell Vacuum Breaker Requirements," prepared by NUTECH, Inc., which provided the basis for minimum Monticello vacuum breaker requirements.

2. Specification 3.5.A Bases, Downcomer Submergence

Proposed Changes

Revise the 3.6.A Bases on pages 175 and 176 to reflect the reduction in minimum vent header downcomer submergence from four feet to three feet.

Reason for Change

During the Autumn 1978 refueling outage the downcomers were shortened as part of the Monticello Mark I Containment Long Term Program modifications. A reduced downcomer submergence results in smaller postulated accident loading of the torus.

Safety Evaluation

This change revised the Bases to conform to the existing plant design. The basis for reduced downcomer submergence was contained in a General Electric report, NEDO-21885-P, "Mark I Containment Program Downcomer Reduced Submergence Functional Assessment Report", 1978, which was submitted by the Mark I Owner's Group for NRC review on July 31, 1978.

EXHIBIT B

License Amendment Request dated June 4, 1981

Docket No. 50-263
License No. DPR-22

Exhibit B consists of revised pages of Appendix A Technical Specifications as listed below:

Pages

164
175
176
178

3.0 LIMITING CONDITIONS FOR OPERATION	4.0 SURVEILLANCE REQUIREMENTS

4. Pressure Suppression Chamber-Drywell Vacuum Breakers

   a. When primary containment is required, all eight drywell-suppression chamber vacuum breakers shall be operable and positioned in the closed position as indicated by the position indication system, except during testing and except as specified in 3.7.A.4.b and c below.

   b. Any drywell-suppression chamber vacuum breaker may be nonfully closed as indicated by the position indication and alarm systems provided that drywell to suppression chamber differential pressure decay does not exceed that shown on Figure 3.7.1.

   c. Up to two drywell-suppression chamber vacuum breakers may be inoperable provided that: (1) the vacuum breakers are determined to be fully closed and at least one position alarm circuit is operable or (2) the vacuum breaker is secured in the closed position or replaced by a blank flange.

4. Pressure Suppression Chamber-Drywell Vacuum Breakers

   a. Operability and full closure of the drywell-suppression chamber vacuum breakers shall be verified by performance of the following:

      (1) Monthly each operable drywell-suppression chamber vacuum breaker shall be exercised through an opening-closing cycle.

      (2) Once each operating cycle, dry-well to suppression chamber leakage shall be demonstrated to be less than that equivalent to a one-inch diameter orifice and each vacuum breaker shall be visually inspected. (Containment access required)

      (3) Once each operating cycle, vacuum breaker position indication and alarm systems shall be calibrated and functionally tested. (Containment access required)

      (4) Once each operating cycle, the vacuum breakers shall be tested to determine that the force required to open each valve from fully closed to fully open does not exceed that equivalent to 0.5 psi acting on the suppression chamber face of the valve disc. (Containment access required)

Bases:

3.7 A. Primary Containment

The integrity of the primary containment and operation of the emergency core cooling system in combination, limit the off-site doses to values less than 10 CFR 100 guideline values in the event of a break in the primary system piping. Thus, containment integrity is specified whenever the potential for violation of the primary reactor system integrity exists. Concern about such a violation exists whenever the reactor is critical and above atmospheric pressure. An exception is made to this requirement during initial core loading and while the low power test program is being conducted and ready access to the reactor vessel is required. There will be no pressure on the system at this time which will greatly reduce the chances of a pipe break. The reactor may be taken critical during this period; however, restrictive operating procedures will be in effect again to minimize the probability of an accident occurring. Procedures and the Rod Worth Minimizer would limit incremental control worth to less than 1.3% delta k. A drop of a 1.3% delta k increment of a rod does not result in any fuel damage. In addition, in the unlikely event that an excursion did occur, the reactor building and standby gas treatment system, which shall be operational during this time, offers a sufficient barrier to keep off-site doses well within 10 CFR 100 guide line values.

The pressure suppression pool water provides the heat sink for the reactor primary system energy release following a postulated rupture of the system. The pressure suppression chamber water volume must absorb the associated decay and structural sensible heat released during primary system blowdown from 1000 psig.

Since all of the gases in the drywell are purged into the pressure suppression chamber air space during a loss of coolant accident, the pressure resulting from isothermal compression plus the vapor pressure of the liquid must not exceed 62 psig, the maximum allowable primary containment pressure. The design volume of the suppression chamber (water and air) was obtained by considering that the total volume of reactor coolant to be condensed is discharged to the suppression chamber and that the drywell volume is purged to the suppression chamber. Reference 5.2.3 FSAR.

Using the minimum or maximum water volumes given in the specification, containment pressure during the design basis accident is approximately 41 psig which is below the allowable pressure of 62 psig.

Bases Continued:

Vent system downcomer submergence is three feet below the minimum specified suppression pool water level. This length has been shown to result in reduced postulated accident loading of the torus while at the same time assuring the downcomers remain submerged under all seismic and accident conditions and possess adequate condensation effectiveness.[3]

The maximum temperature at the end of blowdown tested during the Humboldt Bay[1] and Bodega Bay[2] tests was 170°F and this is conservatively taken to be the limit for complete condensation of the reactor coolant, although condensation would occur for temperatures above 170°F.

Experimental data indicate that excessive steam condensing loads can be avoided if the peak temperature of the suppression pool is maintained below 160°F during any period of relief valve operation with sonic conditions at the discharge exit. Specifications have been placed on the envelope of reactor operating conditions so that the reactor can be depressurized in a timely manner to avoid the regime of potentially high suppression chamber loadings.

In addition to the limits on temperature of the suppression chamber pool water, operating procedures define the action to be taken in the event a relief valve inadvertently opens or sticks open. This action would include: (1) use of all available means to close the valve, (2) initiate suppression pool water cooling heat exchangers, (3) initiate reactor shutdown, and (4) if other relief valves are used to depressurize the reactor, their discharge shall be separated from that of the stuck-open relief valve to assure mixing and uniformity of energy insertion to the pool.

For an initial maximum suppression chamber water temperature of 90°F and assuming the normal complement of containment cooling pumps (2 LPCI pumps and 2 containment cooling service water pumps) containment pressure is not required to maintain adequate net positive suction head (NPSH) for the core spray, LPCI and HPCI pumps. However, during an approximately one-day period starting a few hours after a loss-of-coolant accident, should one RHR loop be inoperable and should the containment pressure be reduced to atmospheric pressure through any means, adequate NPSH would not be available. Since an extremely degraded condition must exist, the period of vulnerability to this event is restricted by Specification 3.7.A.1.b by limiting the suppression pool initial temperature and the period of operation with one inoperable RHR loop.

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(1) Robbins, C.H. "Tests of Full Scale 1/48 Segment of the Humboldt Bay Pressure Suppression Containment," GEAP-3596, November 17, 1960.

(2) Bodega Bay Preliminary Hazards Summary Report, Appendix 1, Docket 50-205, December 28, 1962.

(3) General Electric NEDE-21885-P, "Mark I Containment Program Downcomer Reduced Submergence Functional Assessment Report", June, 1978.

Bases Continued:

The purpose of the vacuum relief valves is to equalize the pressure between the drywell and suppression chamber and between the suppression chamber and reactor building during a loss of coolant accident so that structural integrity of the containment is maintained.

The vacuum relief system between the pressure suppression chamber and reactor building consist of two 100% vacuum relief breakers (2 parallel sets of 2 valves in series). Operation of either system will maintain the pressure differential less than 1 psi. The external design pressure is 2 psig. One valve may be out of service for repairs for a period of seven days. This period is based on the low probability that system redundancy would be required during this time. If repairs cannot be completed within seven days, the reactor coolant system is brought to a condition where vacuum relief is no longer required.

The capacity of the drywell vacuum relief valves is sufficient to limit the pressure differential between the suppression chamber and drywell during post-accident drywell cooling operations to less than the design limit of 2 psi. Capacity of the vacuum relief valves has been confirmed using a sizing model developed in conjunction with the Mark I Containment Long Term Program.[2] With six of the eight valves operable, the pressure differential is limited to less than 2 psi and containment integrity is assured.

In addition to the above considerations, postulated leakage through the vacuum breaker to the suppression chamber air space could result in a partial bypass of pressure suppression in the event of a LOCA or a small or intermediate steam leak. This effect could potentially result in exceeding containment design pressure. As a result of the leakage potential, the containment response has been analyzed for a number of postulated conditions. It was found that the maximum allowable bypass area for any postulated break size was equivalent to a six-inch diameter opening.[1] This bypass corresponds to a

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(1) Report on Torus to Drywell Vacuum Breaker Tests and Modifications for Monticello Nuclear Generating Plant, dated March 12, 1973, submitted to Mr D J Skovholt, AEC-DL, from Mr L O Mayer, NSP.

(2) "Monticello Torus-to-Drywell Vacuum Breaker Requirements," Nutech, Inc, December, 1980, submited as Exhibit C, Northern States Power Company License Amendment Request dated June 4, 1981.

EXHIBIT C

License Amendment Request Dated June 4, 1981

FOR INFORMATION ONLY

CONTROLLED COPY NO. ______

NSP-53-004
Revision 0
30.2353.0012

MONTICELLO TORUS-TO-DRYWELL VACUUM BREAKER REQUIREMENTS

MONTICELLO NUCLEAR GENERATING PLANT

Prepared for:
Northern States Power Company

Prepared by:
NUTECH
San Jose, CA

Approved by:

R. A. Malte, P.E.
Project Engineer

T. J. Mulford
Engineering Manager

Issued by:

J. R. Sheffield
Project Manager

Date: 12-8-80

nutech

REVISION CONTROL SHEET

SUBJECT: Monticello Torus-to-Drywell Vacuum Breaker Requirements

REPORT NUMBER: NSP-53-004

G. J. Uram
Senior Consultant
NAME/TITLE

GJU
INITIAL

R. A. Malte, P.E.
Engineer
NAME/TITLE

BAM
INITIAL

PAGE	REV	PRE-PARED	ACCURACY CHECK	CRITERIA CHECK	PAGE	REV	PRE-PARED	ACCURACY CHECK	CRITERIA CHECK
ii-iv	0	GJU	BAM	BAM	8.1-8.6	0	GJU	BAM	BAM
1.1	0				9.1-9.2	0			
2.1	0				10.1-10.5	0			
3.1-3.6	0				11.1	0	GJU	BAM	BAM
4.1-4.2	0								
5.1	0								
6.1	0								
7.1-7.11	0	GJU	BAM	BAM					

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[redacted]

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1.0 INTRODUCTION

The Monticello torus-to-drywell vacuum relief system consists of ten Atwood & Morrill (A&M) Company valves (18-inch diameter) mounted on the end of the vent lines. These valves provide the capability to vent the torus air space gases back to the drywell in order to assure pressure equilibrium between the compartments. Without this capability, the potential exists to exceed the design limits of the vent header and the drywell such that buckling would occur due to external pressure. For Monticello, the design differential pressure is 2 psid for the torus, drywell, and vent system.

An analysis of the drywell negative pressure protection requirements was performed using a computer program (described in Reference 1) developed by the General Electric Company as part of the Mark I Containment Program. The intent of the analysis was to both confirm the adequacy of the present vacuum breaker system and to determine the requirements for alternate vacuum breaker configurations.

2.0 SUMMARY

The analyses presented herein have verified that the current system of ten Atwood & Morrill vacuum breakers (18-inch diameter) satisfies the 2 psid design criteria (Reference 3) for the torus-to-drywell differential pressure for Monticello. In fact, six vacuum breakers are required to keep the differential pressure below 2 psi when both drywell spray loops are simultaneously actuated during a LOCA transient. If only one spray is assumed to operate, the number of required vacuum breakers is reduced to three.

A general set of sizing requirements was also developed for the Monticello plant. These requirements are specified in Table 10-1 and depicted in Figures 10-1 and 10-2 for both single and two spray loop operating conditions.

3.0 A&M VALVE CHARACTERISTICS

The flow area as a function of valve disk orientation and the overall pressure loss through the valve due to disk orientation and valve configuration were determined from testing conducted by FluiDyne Engineering Company (Reference 2). FluiDyne determined the valve flow area by direct measurements between the valve disk and the valve seat ring or the inner valve body, whichever was shorter. The measurements were then translated into pictorial composites from which the flow areas were determined using a planimeter. These measurements showed that the effective flow area varied approximately linearly with the valve disk angle. The resultant flow area versus disk orientation is reproduced from Reference 2 in Figure 3-1.

In addition, FluiDyne performed tests to establish the relationship between air flow rate, pressure drop across the valve, and valve disk orientation. Differential pressures across the valve were measured for mass flow rates ranging from 5 to 45 lb_m/sec. Corresponding flow area measurements were determined by indirect measurements of the disk angle and the previously developed disk angle versus valve flow area correlation. This data along with thermodynamic stagnation conditions, allowed the valve loss coefficient to be calculated from the incompressible flow relation, as follows.

$$K = 144 \frac{2\rho g_o A^2}{\dot{m}^2} \Delta P = \rho \left(\frac{96.3\ A}{\dot{m}} \right)^2 \Delta P \qquad (3-1)$$

where K = loss coefficient, dimensionless

A = valve flow area, ft^2

g_o = gravitation constant, 32.2 lb_m-ft/lb-sec^2

ρ = fluid density, lb_m/ft^3

ΔP = differential pressure, psid

$\dot{m}$ = air mass flow rate, lb_m /sec

Equation (3-1) is the same equation used to calculate the flow rate in Reference 1. The air density was determined from the perfect gas relation.

$$\rho = 144 \frac{P}{RT} \qquad (3-2)$$

where P = total pressure, psia

R = gas constant, 53.34 ft-lb_f/lb_m - °R

T = temperature, °R

Table 3-1 summarizes the FluiDyne test results along with the evaluations of Equations (3-1) and (3-2).

From Table 3-1, it is apparent that the valve disk becomes full open with approximately a 0.2 psi differential pressure across the valve. This is well below the 0.5 psid requirement for full open. The variance in the calculated loss coefficients when the valve is full open is approximately that which would be expected from normal experimental error. The maximum percent difference in the calculated effective flow area is 8 percent.

Since the existing vacuum breaker installation includes a 90° elbow internal to the vent line, the loss coefficient for the elbow must be included in the overall vacuum breaker loss coefficient. The elbow is made up of mitered sections of 18-inch I.D. pipe. From Reference 6 the loss coefficient for the elbow is:

$$K_{elbow} = 0.26$$

The elbow loss coefficient was added to the largest loss coefficient for the valve alone (see Table 3-1) to obtain the total loss coefficient for the vacuum breaker assembly.

$$K = 0.26 + 2.55 = 2.81$$

The resulting effective flow area is:

$$A/\sqrt{K} = 1.02$$

[redacted]

The vacuum breaker opening characteristic is modeled as a linear, time dependent relation in the Reference 1 computer program. From an initial opening set point differential pressure, the valve effective flow area (i.e., $A/\sqrt{K}$) linearly increases to its maximum value within a specified time increment. The FluiDyne data gives no indication of the valve response time. Therefore, the 1.0 second opening requirement stated in Reference 3 was used in the analysis of the adequacy of the present Monticello vacuum breakers (Section 7.0). The valve opening times were varied as a parameter to establish the requirement for time to full open (Section 8.0).

TABLE 3-1

FLUIDYNE TEST RESULTS FOR AN 18-INCH

A&M VACUUM BREAKER

Test No.	ΔP (psi)	P (psia)	T (^oR)	ρ (lb_m/ft^3)	$\dot{m}$ (lb_m/sec)	Θ (deg)	A (ft^2)	K	$A/\sqrt{K}$ (ft^2)
2	0.10	14.80	508	0.0786	5.2	21.5	0.757	1.55	0.61
1	0.16	14.86	508	0.0790	10.2	35.5	1.236	1.72	0.94
3	0.24	14.94	504	0.0800	15.5	45.0	1.711	2.17	1.16
4	0.43	15.13	490	0.0834	20.8	45.0	1.711	2.25	1.14
5	0.57	15.27	484	0.0852	24.1	45.0	1.711	2.27	1.14
7	0.61	15.31	494	0.0837	24.7	45.0	1.711	2.27	1.14
11	1.28	15.98	499	0.0865	34.8	45.0	1.711	2.48	1.09
9	2.00	16.70	493	0.0913	44.1	45.0	1.711	2.55	1.07

ΔP - Differential pressure across valve

P - Total pressure

T - Temperature at valve entrance

ρ - Air density

$\dot{m}$ - Air mass flow rate

Θ - Angular displacement of valve disk

A - Flow area corresponding to Θ

K - Loss coefficient

$A/\sqrt{K}$ - Effective flow area

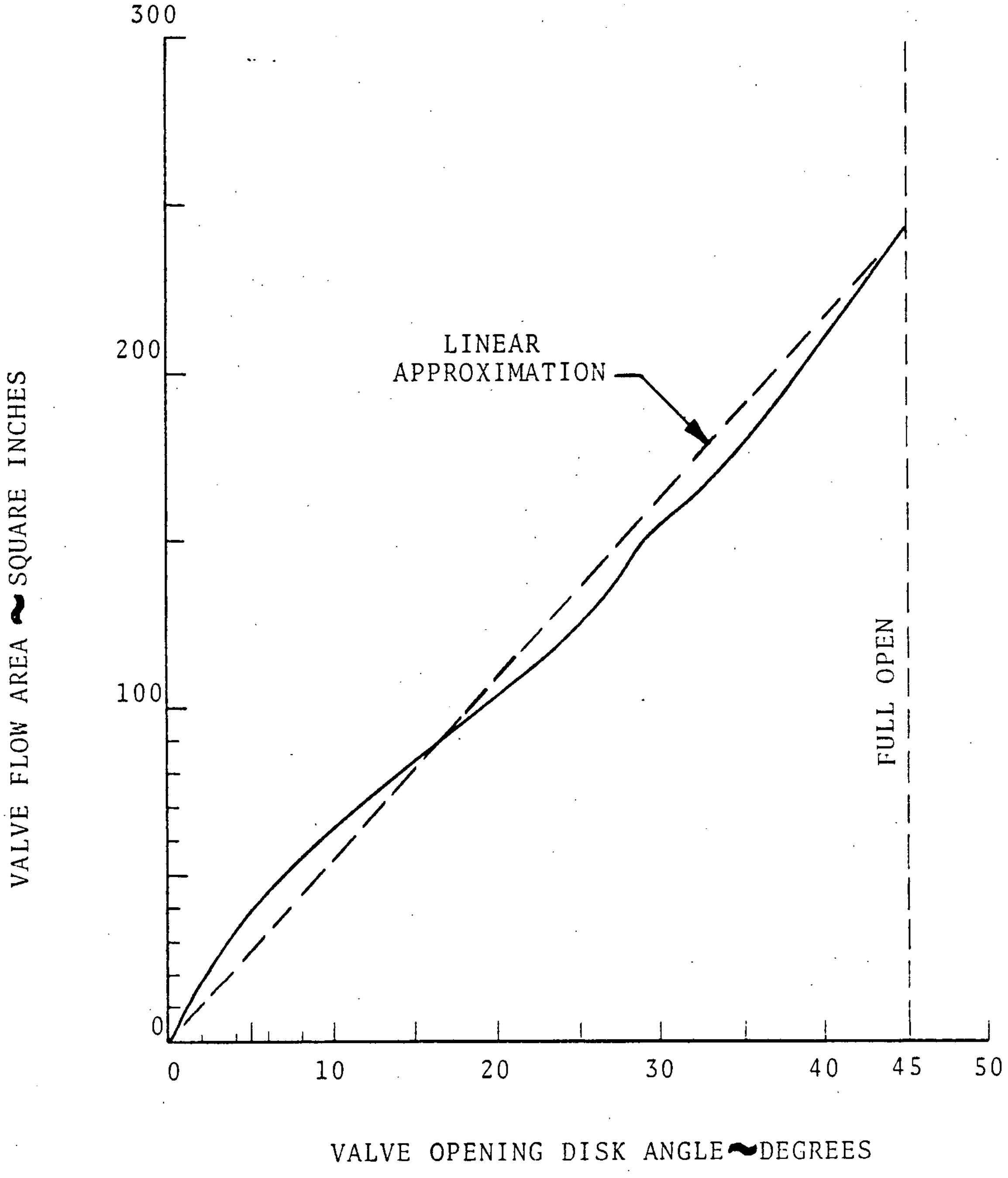

FIGURE 3-1 AVAILABLE A&M VALVE FLOW AREA

4.0 MONTICELLO PLANT CHARACTERISTICS

The basic Monticello containment characteristics used in the various sizing analyses are presented in Table 4-1 along with the appropriate references. In instances where a range of values is shown, the one chosen for these analyses is indicated with an asterisk.

TABLE 4-1

MONTICELLO PLANT PARAMETERS

PARAMETER	VALUE	REFERENCE
Drywell free volume, $ft.^3$	134200	3,5
Wetwell free volume, $ft.^3$ (min)	97580	5
Downcomer submergence, ft.	3	5
Downcomer length, ft.	8.26	5
Drywell spray flow rate, gpm/header	7200	3
No. of drywell spray headers	2	3
Drywell spray temperature (nominal), °F(max/min)	90/65*	3
Wetwell spray flow rate, gpm (1 header)	360	3
Wetwell spray temperature (nominal), °F(max/min)	90/65*	3
Low pressure ECCS flow rate (4 pumps), gpm	16000	3
Initial drywell pressure, psia (max/min)	16.2*/14.6	3
Initial wetwell pressure, psia (max/min)	15.7/14.6	3
Drywell-to-wetwell differential pressure, psi (max/min)	1.3/1.0	3
Initial drywell temperature, °F (max/min)	150/85	3
(normal)	135	5
Initial wetwell temperature, °F (max/min)	90/65*	3
Initial drywell relative humidity, percent	100/20(1)	3
Initial wetwell relative humidity, percent	100*/20	3
Actuation setpoint of vacuum breaker, psid (full open)	0.2	2
Vacuum breaker time to full open, seconds	1.0	3

*Value chosen for analyses

(1) Used to determine initial air content for inadvertent spray operation case.

5.0 AREAS OF CONSERVATISM

As with most analyses of this nature, a number of conservatisms were applied in order to both simplify the analyses and provide added assurance of design. No quantitative assessment of the individual contributors was made. However, the list below indicates the conservative assumptions so that areas of refinement are defined for possible future use.

1. The containment sprays and reflood are 100% effective, i.e., the entering water is completely vaporized before condensation occurs. In this way, all of the water mass is brought to the drywell (wetwell) temperature.

2. Following a LOCA, steaming from the break would slow the depressurization. Therefore, steaming was not included in the analyses presented herein.

3. The lowest allowable spray temperature was used.

4. Both sprays were simultaneously actuated and assumed operating at full capacity.

5. The minimum vacuum breaker effective flow area when fully open was assumed.

6.0 VERIFICATION OF VACUUM BREAKER SIZING PROGRAM

Reference 1 includes a listing of the computer program used for the vacuum breaker sizing analyses. In order to assure that the program was properly implemented on the CDC Cybernet computer system, it was verified against the test case presented in Reference 1 (a small steam break). The detailed input parameters are listed in Reference 1. Comparisons of both the digitized and graphical results for the calculated temperatures and pressures showed good agreement. Hence, it was concluded that the program was properly implemented on the CDC computer system.

7.0 ADEQUACY OF PRESENT MONTICELLO VACUUM BREAKERS

The adequacy of the present vacuum breaker sizing at Monticello was determined relative to the three transient events identified in Reference 1. These three events are:

1. Inadvertent Spray Operation - The plant is assumed to be operating at normal conditions and the drywell sprays are activated. For this event, the wetwell spray was not assumed to be activated, since this results in a less conservative response.

2. Drywell Spray Following a LOCA - The drywell spray is activated following a LOCA event. All of the drywell air is assumed to be purged to the torus free space and the drywell contains saturated steam. Two subevents were examined: 1) both drywell spray loops were assumed to be simultaneously activated, 2) a single spray loop was assumed to be activated.

3. Vessel Reflood Through Break - For this case, none of the sprays are used for condensation. Rather, following a LOCA, the Emergency Core Cooling System (ECCS) vessel reflood flow cascades through the break and condenses the drywell steam.

A summary of the input parameters required to evaluate each case for Monticello is listed in Table 7-1.

7.1 Inadvertent Spray Operation

During normal plant operation, the atmosphere in the drywell may be less than 100% saturated. If the drywell spray is inadvertently activated, evaporative cooling will cause a rapid decrease in drywell pressure and temperature. Evaporative cooling will continue until the drywell atmosphere is saturated. The vacuum breaker sizing program assumes that the drywell atmosphere is 100% saturated. Therefore, using the initial drywell conditions, the temperature and pressure at saturation must be calculated before the vacuum breaker sizing program can be employed. If the drywell temperature is still higher than the spray temperature when saturation is reached, the vacuum breaker sizing program (Reference 1) can be used to calculate the continuing drywell depressurization.

The drywell energy balance from Reference 1, shown below, can be iteratively solved for the drywell temperature corresponding to 100% humidity:

$$C_{V_A} T_i + \frac{\phi_i R_A}{R_V} \frac{P_{SAT}(T_i)}{(P_i - \phi_i P_{SAT}(T_i))} C_{V_v} T_i$$

$$+ \frac{R_A}{R_V} \frac{C_{P_{SPRAY}} (T_{SPRAY} - 492)}{(P_i - \phi_i P_{SAT}(T_i))} \left[\frac{P_{SAT}(T_f)\, T_i}{T_f} - \phi_i \; P_{SAT}(T_i) \right]$$

$$= C_{V_A} T_f + \frac{R_A}{R_v} \frac{P_{SAT}(T_f)}{(P_i - \phi_i P_{SAT}(T_i))} C_{V_v} T_i \qquad (7\text{-}1)$$

where C_{V_A} = specific heat at constant volume for air = 0.171 BTU/lb_m - °R

T_i = initial drywell temperature, °R

ϕ_i = initial relative humidity

R_A, R_V = gas constants for air and vapor, 53.3 and 85.8 ft-lb/lb_m - °R, respectively

P_{SAT} = saturation pressure, psia

C_{V_v} = specific heat at constant volume for steam = 0.335 BTU/lb_m - °R

$C_{P_{SPRAY}}$ = specific heat at constant pressure for spray = 1.0 BTU/lb_m-°R

T_f = final drywell temperature, °R

T_{SPRAY} = spray temperature, °R

Assuming the maximum drywell temperature and pressure of 150°F and 16.2 psia, respectively, the minimum spray temperature of 65°F, and an initial relative humidity of 20%; Equation (7-1) yields a drywell temperature of 117°F at 100% humidity. The corresponding drywell pressure is determined by:

$$P_f = P_{SAT}(T_f) + \frac{(P_i - \phi_i P_{SAT}(T_i))\, T_f}{T_i}$$

$$P_f = 1.56 + \frac{15.46\ (577)}{610} = 16.2 \text{ psia} \qquad (7\text{-}2)$$

This calculation indicates that the drywell temperature decreases significantly while the pressure remains essentially constant as the drywell atmosphere is brought up to 100% humidity. A series of scoping calculations were performed by assuming the extreme values (see Table 4-1) for the initial drywell temperature, pressure, humidity and spray temperature in Equation 7-1. The scoping runs indicated that the temperature decrease in bringing the drywell from the initial humidity to 100% was greatest for the minimum initial humidity. Invariably the drywell pressure change was slight. Also the temperature change was insensitive to the initial drywell pressure. Sensitivity runs with the vacuum breaker sizing program demonstrated that the initial pressure condition has a relatively minor effect upon the resultant peak differential pressure. Also the inadvertent spray case is not the limiting transient for determining the required number of vacuum breakers. A summary of the initial conditions for inadvertent spray operation is given in Table 7-1.

7.2 Drywell Spray Following LOCA

The initial conditions for this case assume that the drywell air has been purged to the torus air space. The drywell is full of steam. The air mass is calculated based on the following initial conditions:

	Drywell	Torus
Total pressure, psia (air & vapor)	16.2	15.0
Temperature, °F	135.0	90.0
Relative humidity, percent	20.0	100.0

Substituting these values into the perfect gas relation yields a drywell, torus, and total air mass of 9555 lb_m, 6849 lb_m, and 16404 lb_m, respectively. Using the intermediate break accident transient shown in the Monticello plant unique load definition (Reference 4), a torus temperature of 162°F was selected. This is the temperature at the end of reactor pressure vessel blowdown. Although the pool level would actually be lower at this time due to the ECCS flooding the reactor vessel, no change in the torus free space volume was assumed. The torus pressure was thus calculated as:

$$P_{WW} = \frac{(m_{AIR})\ (R_{AIR})\ (T_{AIR})}{(144)\ (V_{WW})} + P_{SAT}$$

$$P_{WW} = \frac{16404\ (53.34)\ (622)}{(144)\ (97580)} + 4.98 = 43.7 \text{ psia}$$

The drywell pressure was assumed to be greater than the wetwell pressure by an amount equal to the hydrostatic pressure corresponding to the vent submergence or:

$$P_{DW} = P_{WW} + \Delta P_{vents}$$

$$P_{DW} = 43.7 + 1.3 = 45.0 \text{ psia}$$

The values calculated above are somewhat higher than the predicted values (Reference 4) because pool drawdown has been conservatively neglected. This does not affect the results since the analyses herein examine relative changes between the drywell and torus rather than absolute values. Furthermore, as mentioned earlier, the sensitivity of the peak torus-to-drywell differential pressure to initial containment pressure is minimal. The input parameters for this case are summarized in Table 7-1.

7.3 Vessel Reflood Through Break

This case has the same initial conditions as the previous case. The only difference is that the condensing fluid cascades out through the break rather than entering the drywell through the spray header. It is assumed that four low pressure ECCS pumps are operating producing a total flow of 16000 gpm (2133 lb/sec). The fluid temperature is assumed to be 212°F (Reference 1). Table 7-1 summarizes the total input for this case.

7.4 Results

Each of the above cases was run for a certain quantity of assumed available vacuum breakers. This was accomplished by simply varying the $A/\sqrt{K}$ value. As evident in Figure 7-1, the limiting transient is the drywell spray after LOCA case. Figure 7-1 also indicates that for two spray headers operating, six vacuum breakers keep the torus-to-drywell differential pressure well below the 2 psid design limit. The Monticello operating procedures do not prohibit the use of both spray loops, but indicate that the preferred drywell spray operation is to use one of the spray loops. If this preferred practice was adhered to, or the second spray activation was delayed, only three vacuum breakers would be required.

In addition to meeting the torus-to-drywell differential pressure criteria, the vacuum breaker installation must also satisfy the drywell/torus-to-containment building criteria in order to avoid containment buckling. For Monticello, this value is also 2 psid. Two different analyses were performed to show that the 2 psi differential pressure is not exceeded.

The most severe transient in terms of containment buckling is the inadvertent spray operation. This is true because this transient has the most severe depressurization rate near the containment building atmospheric conditions. A conservative calculation can be performed using the vacuum breaker sizing code by simply lumping the drywell and torus volumes together as a single drywell volume and modeling the containment building as an infinitely sized torus. Air will flow back into the pseudo-drywell via the torus-to-containment building vacuum breakers that presently exist on the Monticello plant. These external vacuum breakers consist of 2 sets of 20-inch A&M valves. Each set has 2 vacuum breakers in series. The assumption made for this analysis was that the loss factors, K, of the 18-inch and 20-inch valves are approximately the same for a given differential pressure. Using the same conservative K-factor of 2.55 as determined previously (see Table 3-1), the $A/\sqrt{K}$ value for these 2 sets of valves is calculated as follows:

For 2 identical valves in series,

$$(A/\sqrt{K})_{series} = \frac{A_{20\ inch}}{\sqrt{n\ K_{18\text{-}inch}}}$$

$$(A/\sqrt{K})_{series} = \frac{2.182}{\sqrt{(2)(2.55)}}$$

$$(A/\sqrt{K})_{series} = 0.966\ ft^2$$

For 2 sets of valves in parallel,

$$(A/\sqrt{K})_{parallel} = n\ (A/\sqrt{K})_{series}$$

$$(A/\sqrt{K})_{parallel} = 2(0.966) = 1.93\ ft^2$$

This value together with the initial conditions of 14.7 psia and 100°F for the containment building and 15.0 psia and 123°F for the pseudo-drywell was used as input to the vacuum breaker sizing code. The drywell initial conditions are typical for the inadvertent spray case. The resulting peak calculated drywell/torus-to-containment building differential pressures were 1.2 psid and 1.6 psid for the situations of one and two drywell spray headers operating, respectively.

Another check of the adequacy of the Monticello design can be made by an end point calculation to determine the temperature the containment atmosphere would have to decrease to in order to produce a negative 2 psi differential pressure (i.e., 12.7 psia). Since the vapor pressure is small at low pressures, the air temperature was determined from:

$$T = \frac{(P_{AIR})\ (V_{AIR})\ (144)}{(m_{AIR})\ (R_{AIR})} - 460.$$

$$T = \frac{(12.7)\ (134200 + 97580)\ (144)}{(16404)\ (53.34)} - 460.$$

$$T = 24°F$$

Since this temperature would be impossible to reach, the containment will not exceed the design negative pressure.

TABLE 7-1

INITIAL CONDITIONS FOR VACUUM BREAKER SIZING ANALYSIS

PARAMETER	Inadvertent Spray Operation	Drywell Spray After LOCA	Vessel Reflood Through Break
D.W. Volume, ft^3	134200.	134200.	134200.
W.W. Volume, ft^3	97580.	97580.	97580.
Vent Submergence, ft	3.0	3.0	3.0
Downcomer Length, ft	8.26	8.26	8.26
$A/\sqrt{K}$, ft^2 (per V.B.)	1.02	1.02	1.02
V.B. Opening Pressure, psi	0.2	0.2	0.2
V.B. Opening Time, sec	1.0	1.0	1.0
D.W. Spray Flow Rate, lb/sec	1112.(1)	2000.(2)	2133.(3)
D.W. Spray Temp. °R	525.	525.	672.
Vessel Steaming Rate, lb/sec	0.	0.	0.
Vessel Steam Temp, °R	0.	0.	0.
Mass fraction of vapor	1.	1.	1.
Mass Fraction of Air in D.W.	-	0.	-
W.W. Spray Flow Rate, lb/sec	0.(4)	0.	0.
W.W. Spray Temp., °R	-	-	-
Initial D.W. Temp. °R	610	734.5	734.5
Initial D.W. Pressure, psia	16.2	45.	45.
D.W. Quality	1.0	1.0	1.0
Initial W.W. Temp, °R	530.	622.	622.
Initial W.W. Pressure, psia	15.0	43.7	43.7
W.W. Quality	1.0	1.0	1.0
h_{fg}, BTU/lb_m (5)	970.3	950.	950.
e_{fg}, BTU/lb_m (6)	897.5	875.	875.
PSTR, psia (7)	14.7	26.	26.
TSTR, °R (8)	672.	702.	702.
D.W. Relative Humidity, %	20	100	100

(1) Corresponds to 8000 gpm - the value used in the Monticello FSAR evaluation of containment response (see Table 5.2.4 of Reference 3).

(2) Corresponds to 14400 gpm - 2 spray headers

(3) Corresponds to flow from 4 LPCI pumps, 16000 gpm

(4) The addition of wetwell spray is non-conservative

(5) Value of enthalpy of vaporization used in analyses

(6) Value of internal energy of vaporization used in analyses

(7) Value of reference pressure used in analyses

(8) Value of reference temperature used in analyses

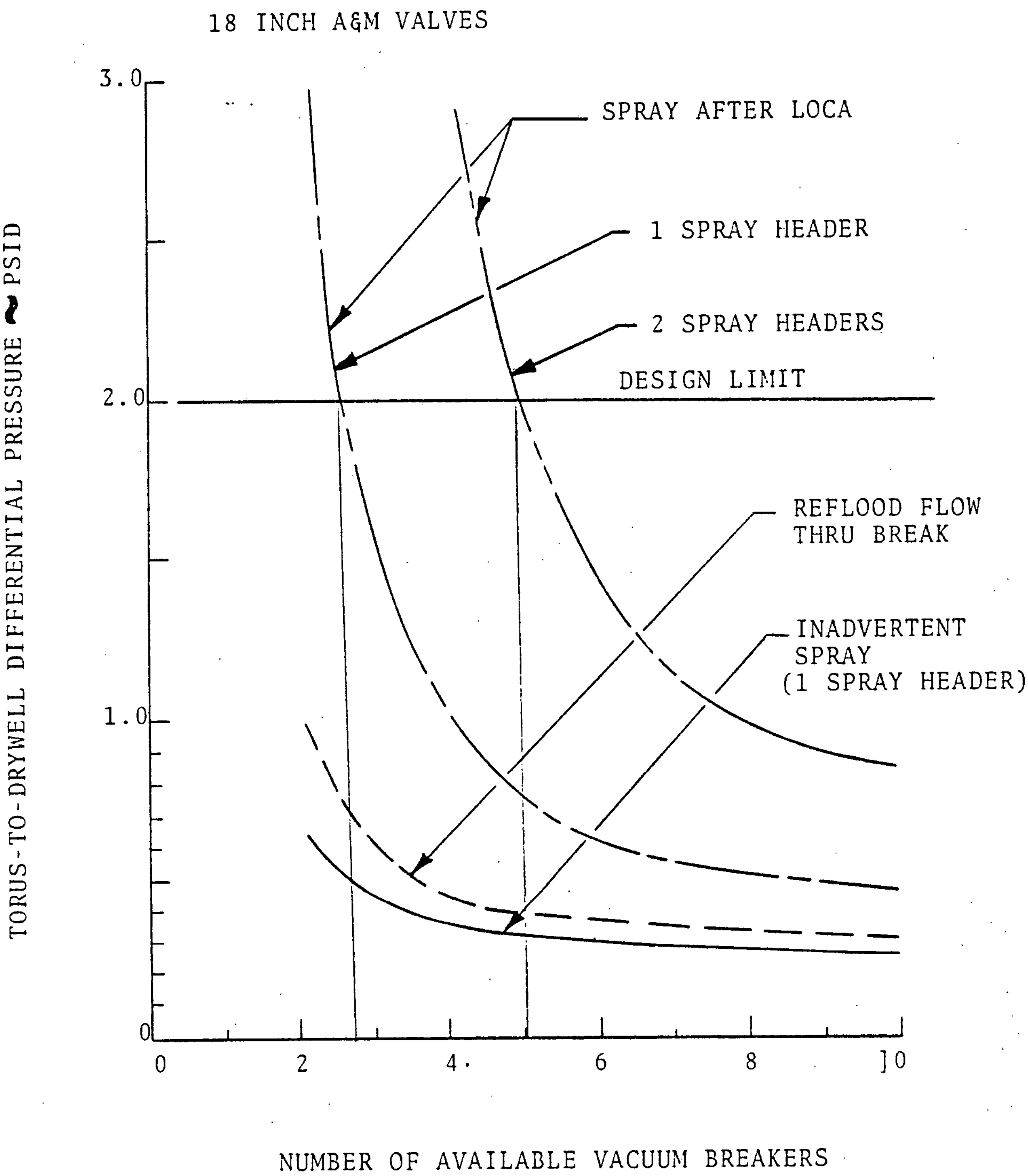

FIGURE 7-1 MONTICELLO VACUUM BREAKER EVALUATION

8.0 SENSITIVITY STUDIES

A series of runs was made with the vacuum breaker sizing program to determine the sensitivity of the results to vacuum breaker pressure set point and the effective flow area.

Vacuum breaker sizing requirements are depicted in Figures 8-1 through 8-4 for full open set points of 0.2 psid and 0.5 psid. These figures can be used to establish the allowable time increment for the valves to open based on a specified number of valves. For example, Figures 8-1 and 8-2 show that for 6 vacuum breakers, the required time to full open is in the 2 to 2-1/2 second range in order to limit the torus-to-drywell differential pressure to less than 2 psi.

Figure 8-3 depicts the differential pressure response for a single drywell spray loop in operation. The overall response is dramatically reduced from the 2 spray loop case. In fact, valve opening time requirements well beyond 4 seconds can be specified for as little as 5 available vacuum breakers. The single spray loop case is the most representative of the various transients, since it is unlikely that both spray loops would be initiated simultaneously. The analyses show that the peak differential pressures occur within the first 6 seconds of the transient for single spray activation. The activation of the second spray loop any time after this would cause a second peak in the differential pressure transient. Determination of the optimum time delay between activation of the first and second spray loops would require an extension of the current vacuum breaker sizing program.

Because there is an uncertainty in the overall determination of the $A/\sqrt{K}$ values, a series of computer runs were performed in order to provide an indication of the sensitivity of the sizing requirements. The results are presented in Figure 8-4. As shown, near the 2 psid design limit, changes of 10 percent in the $A/\sqrt{K}$ values for 6 and 8 valves available result in changes of approximately 0.1 psi in differential pressure. Based on these results, the uncertainty in pressure loss coefficient should not affect the choice of the number of vacuum breakers.

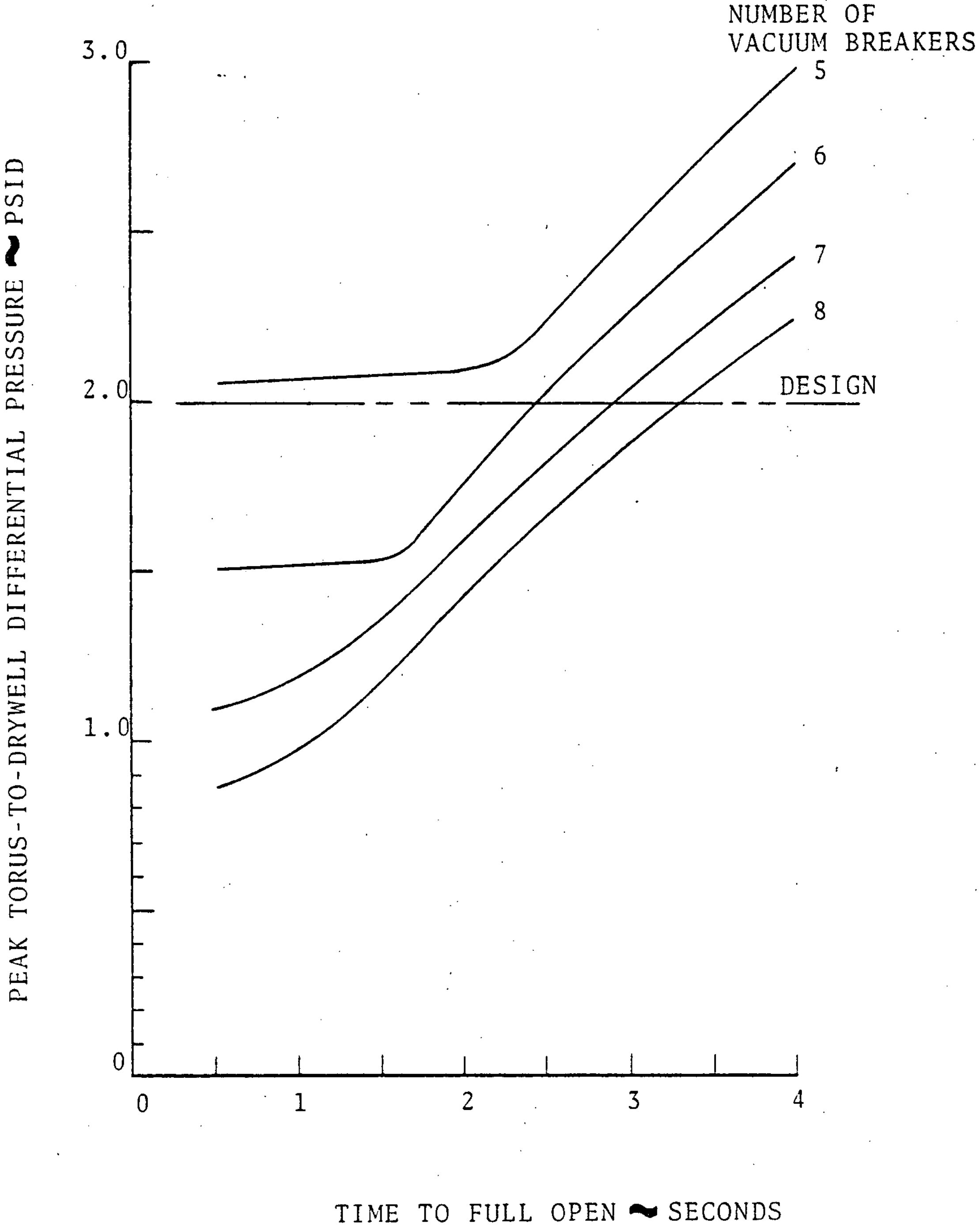

FIGURE 8-1 VACUUM BREAKER REQUIREMENTS FOR 0.2 PSID SET POINT - 2 SPRAY HEADERS

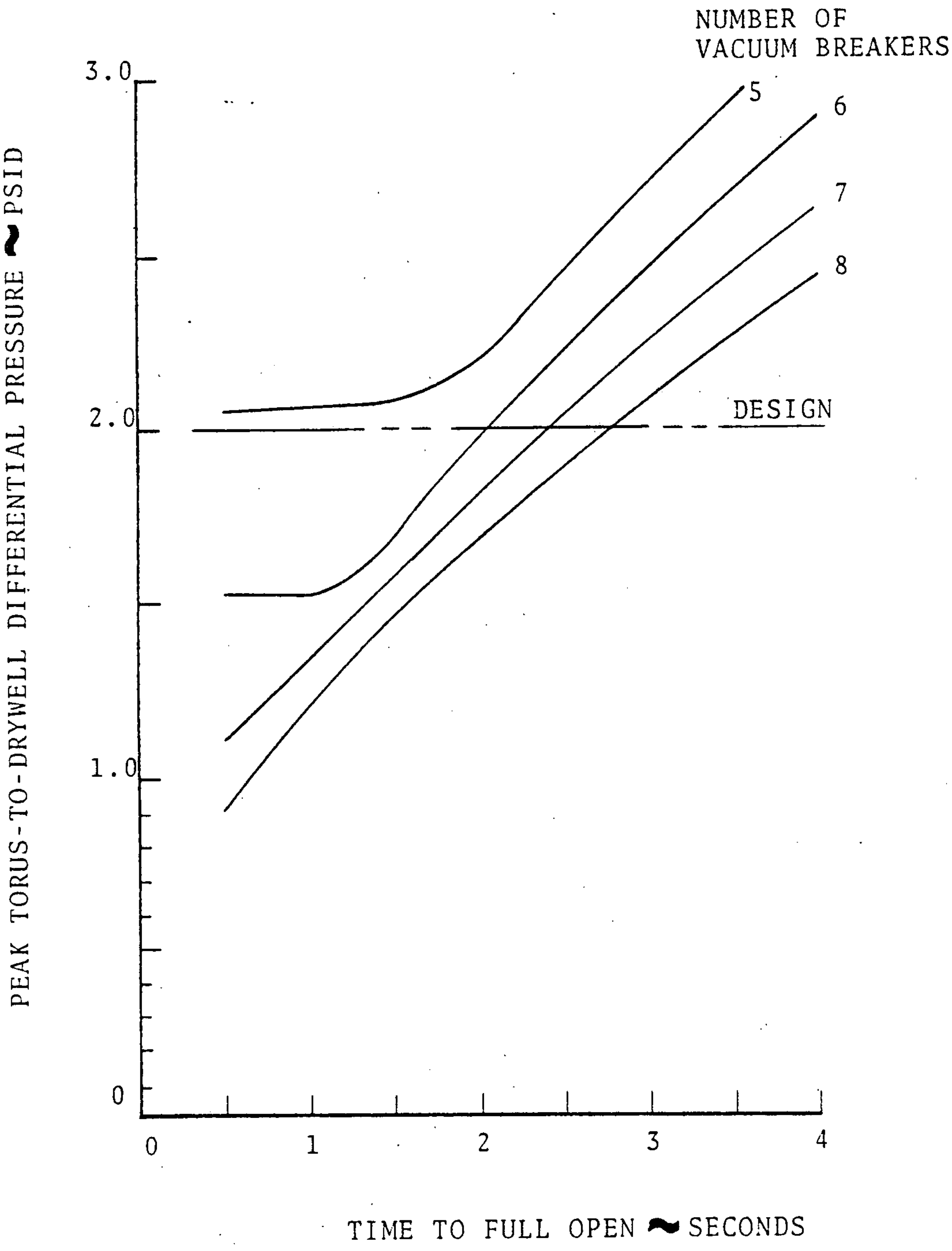

FIGURE 8-2 VACUUM BREAKER REQUIRMENTS FOR 0.5 PSID SET POINT - 2 SPRAY HEADERS

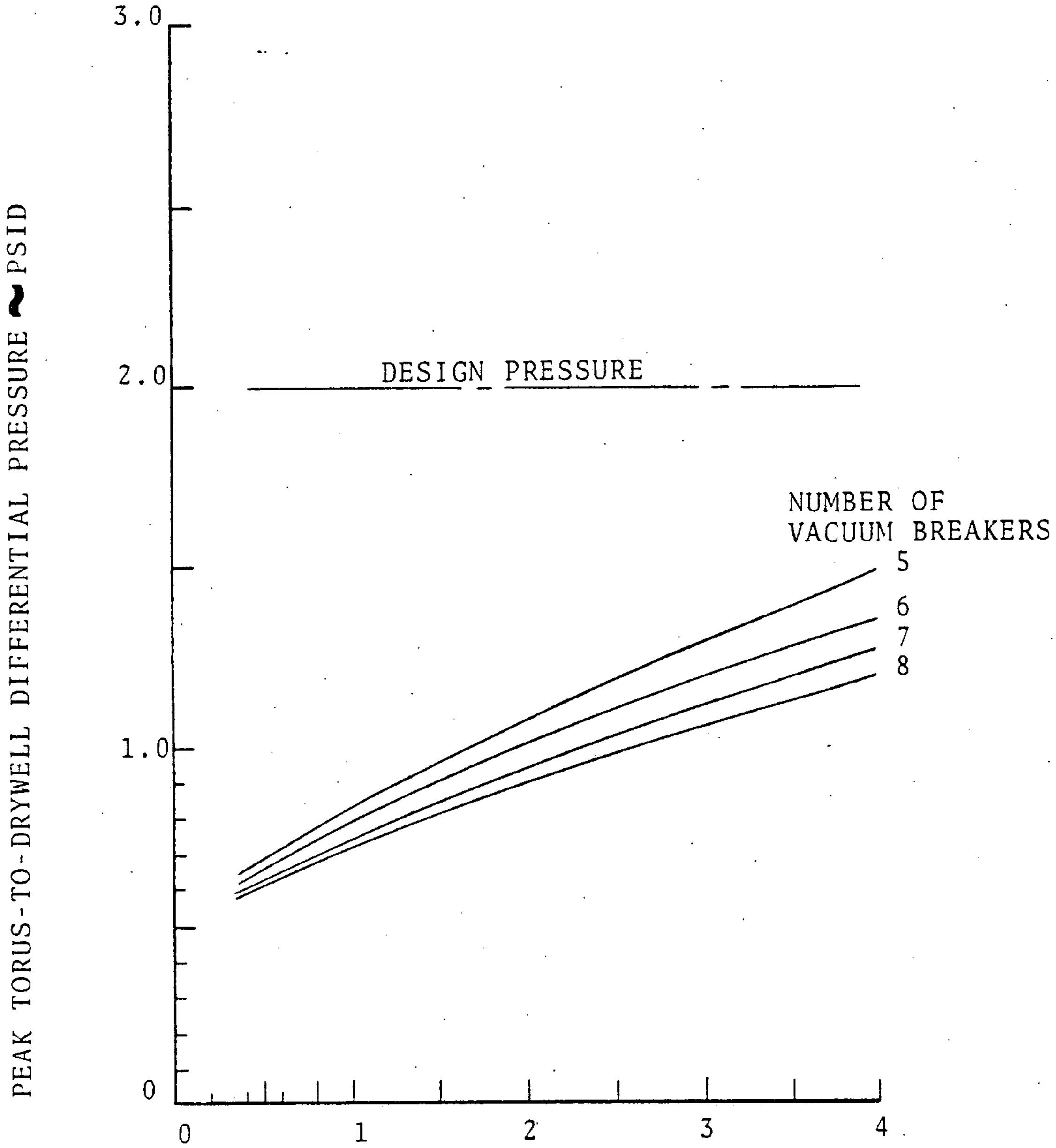

FIGURE 8-3 VACUUM BREAKER REQUIREMENTS FOR 0.5 PSID SET POINT - 1 SPRAY HEADER

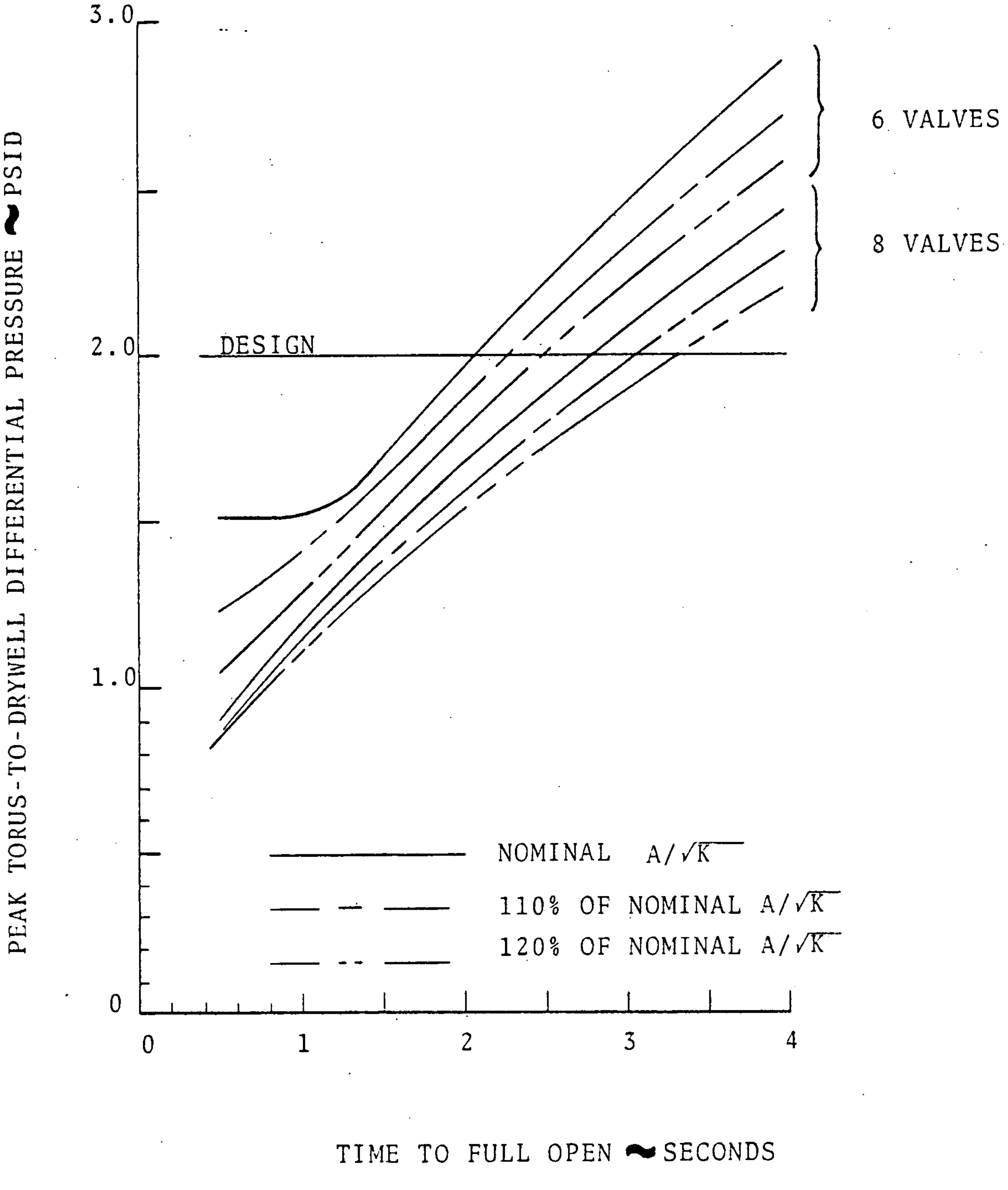

FIGURE 8-4 SENSITIVITY OF SIZING REQUIREMENTS FOR 0.5 PSID SET POINT - 2 SPRAY HEADERS

10.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the analyses presented earlier, the vacuum breaker sizing requirements are specified for both the one spray and two spray loop cases in Table 10-1. This table is separated into A&M valve unique sizing characteristics as well as general valve characteristics. Table 10-1 references Figures 10-1 and 10-2 which depict the vacuum breaker sizing requirements as a function of effective flow area and valve opening time. Valves whose characteristics fall into the acceptable region shown on the figures satisfy the 2.0 psid design criteria. Figure 10-1 illustrates the previous conclusion (Section 7.4) that with one drywell spray operating three A&M vacuum breakers are sufficient to limit the torus-to-drywell differential pressure to less than 2 psid. Similarly, Figure 10-2 indicates that six vacuum breakers satisfy the design criteria if two drywell sprays are operated.

Since the impetus for this vacuum breaker analysis stems from the vacuum breaker performance observed in the FSTF testing, any new requirements must assure that appropriate response characteristics are achieved. A general requirement is that the vacuum breaker response is minimized during the steam condensation oscillation or chugging phases experienced during a LOCA. In other words, the valve response to any pressure oscillations must be slow enough such that valve disk impact velocities are minimized. In addition, vacuum breaker valve closure must be assured in order to prevent possible steam bypass to the wetwell during a LOCA.

Since the number of vacuum breakers required is greatly dependent upon the number of drywell spray loops operating, it is recommended that operating procedures specifically state that two loop spray operation is strictly prohibited, or that a time delay be instituted between activation of the first and second spray loop. This change would greatly minimize the number of required vacuum breakers or, conversely, would provide additional margin for the allowed number of vacuum breakers out of service. The appropriate time delay, however, would have to be determined based on Monticello unique transients. In order to accomplish this, the vacuum breaker sizing program would have to be modified to account for a time variant spray flow rate. Additional changes to the program would be necessary so that vacuum breaker opening and closing characteristics (e.g., valve disk response as a function of differential pressure) could be included.

TABLE 10-1

WETWELL-TO-DRYWELL VACUUM BREAKER SIZING REQUIREMENTS

Requirement	ONE SPRAY HEADER		TWO SPRAY HEADERS	
	A&M (1)	General	A&M (1)	General
Number of Vacuum Breakers	3	N/A	6	N/A
Effective Flow Area, $A/\sqrt{K}$, ft^2	N/A	Figure 10-1	N/A	Figure 10-2
Time To Full Disk Opening, sec	$\leq$ 4	Figure 10-1	$\leq$2.4	Figure 10-2
Full Open Differential Pressure, psid	0.5	0.5	0.2	0.5
Valve Opening Setpoint, psid	0.5	0.5	0.2	0.5

(1) 18-inch Atwood & Morrill Valve.

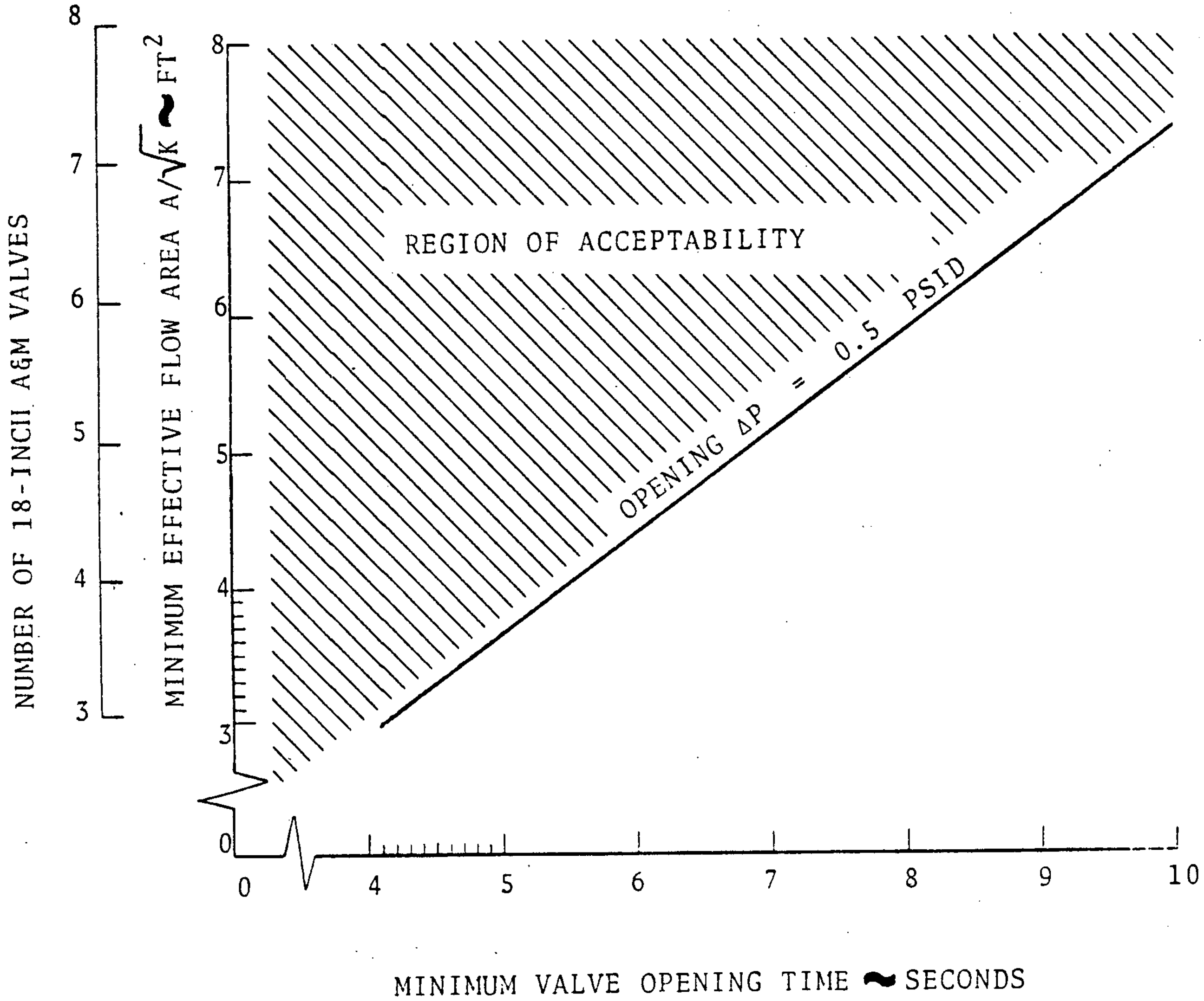

FIGURE 10-1 MONTICELLO VACUUM BREAKER SIZING REQUIREMENTS FOR 0.5 PSID SET POINT - 1 SPRAY HEADER

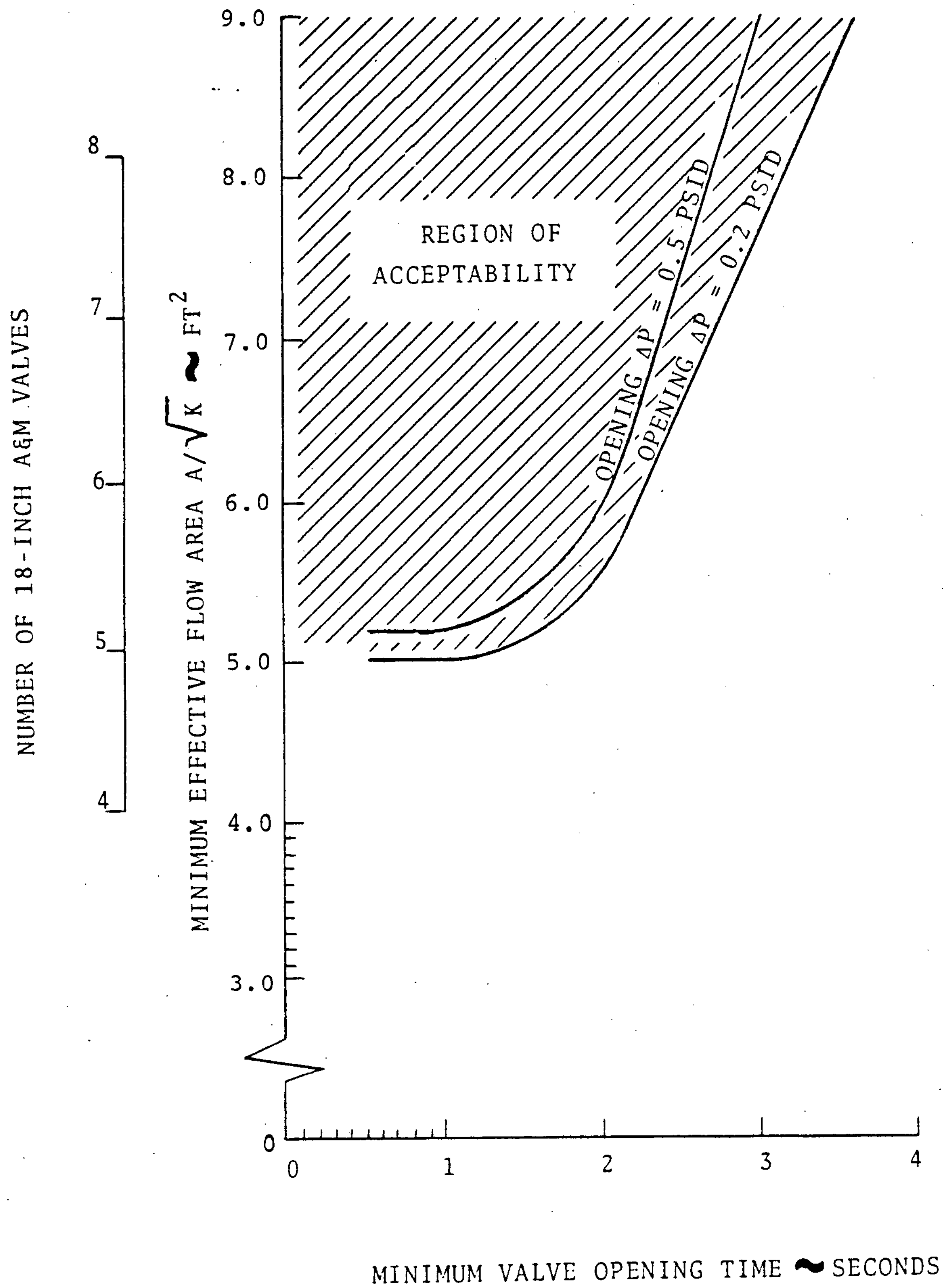

FIGURE 10-2 MONTICELLO VACUUM BREAKER SIZING REQUIREMENTS FOR TWO SPRAY HEADERS

11.0 REFERENCES

1. Wolfe, W. L., Mark I Containment Program, Mark I Wetwell-to-Drywell Vacuum Breaker Functional Requirements, Task 9.4.3, General Electric Co. Report No. NEDE-24802, April, 1980.

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5. Letter, R. A. Goranson (NSP) to R. H. Kohrs (GE), "Plant Unique Information in Support of 1/4 Scale 2-D LDR Tests," Feb. 10, 1978.

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