PSE&G

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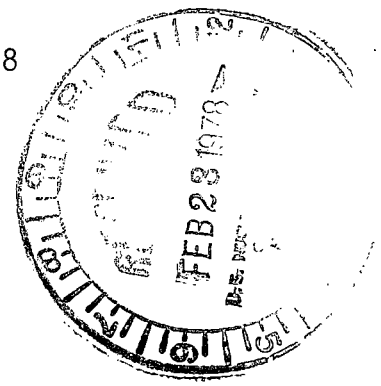
February 10, 1978



Director of Reactor Regulation
U. S. Nuclear Regulatory Commission
7920 Norfolk Avenue
Bethesda, Maryland 20014

Attention: Mr. George Lear, Chief
Operating Reactors Branch #3
Division of Operating Reactors

Gentlemen:

Please find enclosed, a rough copy of our calculations on the Pressurizer Overpressure Protection System (POPS) as requested by Mr. D. Verrelli in a telephone conversation with Mr. R. Melville on January 30, 1978.

Very truly yours,

F. P. Librizzi
General Manager -
Electric Production

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RCS OVERPRESSURIZATION
HEAT INPUT CASE

REFERENCE –
"SUPPLEMENT TO THE JULY 1977 REPORT, PRESSURE MITIGATING SYSTEMS, TRANSIENT ANALYSIS RESULTS", by (W), September 1977

A. (W) BOUNDS VS SALEM

	(W) low	Salem	(W) high
S Relief valve setpoint, psig	350	375	400
Δt Relief valve opening time, sec	1.5	2.0	3.0
V_{RCS} RCS volume, ft^3	6,000	12,800	13,000
⇒ f HT area, ft^2	—	51,500	58,000

B. CALCULATIONS

1. ΔP (S, Δt); Fig 2 & 4; @ V = 13,000, A_{HT} = 58,000

$T_{o,RCS}$ =	100°F	350 psig ⇒	13 psi	400 psig ⇒	16 psi
"	180°F	" ⇒	25 psi	" ⇒	42 psi
"	250°F	" ⇒	37 psi	" ⇒	57 psi

$$\Delta P_{375} = \Delta P_{350} + \left(\frac{375-350}{400-350}\right)(\Delta P_{400} - \Delta P_{350}) = \Delta P_{350} + 0.5\,(\Delta P_{400} - \Delta P_{350})$$

$T_{o,RCS}$ = 100°F	ΔP =	13 + 0.5 (16 − 13) = 14.5 psi
180°F	ΔP =	25 + 0.5 (42 − 25) = 33.5 "
250°F	ΔP =	37 + 0.5 (57 − 37) = 47.0 "

$T_{o,RCS}$ = 100°F: P_{MAX} = S + ΔP =	375 + 14.5 =	389.5 psig	V = 13 KFt³
180°F " =	375 + 33.5 =	408.5 psig	UA = 58,000
250°F " =	375 + 47.0 =	422.0 psig	S = 375
			Δt = 2.0

2. $\Delta P(V_{RCS}, \Delta t)$ @ $A_{INT} = 58{,}000\ FT^2$

(a) @ S = 350 psig

$T_{o,RCS}$	V = 6KFt³	13KFt³
100°F	⇒ 23 psi	⇒ 13 psi
180°F	⇒ 41 psi	⇒ 25 psi
250°F	⇒ 56 psi	⇒ 37 psi

$$P_{MAX,12,800} = \Delta P_{6K} - \left(\frac{12{,}800 - 6000}{13{,}000 - 6{,}000}\right)\left(\Delta P_{6K} - \Delta P_{13K}\right) + 350$$

$T_{o,RCS} = 100°F \Rightarrow 23 - (0.97143)(23-13) + 350 = 363.3$ psig
$180°F \Rightarrow 41 - (0.97143)(41-25) + 350 = 375.5$ psig
$250°F \Rightarrow 56 - (0.97143)(56-37) + 350 = 387.5$ psig

(b) @ S = 400 psig

$T_{o,RCS}$	V = 6KFt³	13KFt³
100°F	⇒ 23 psi	⇒ 16 psi
180°F	⇒ 49 psi	⇒ 42 psi
250°F	⇒ 76 psi	⇒ 57 psi

$P_{MAX,12,800}$ $T_o = 100°F \Rightarrow 23 - (0.97143)(23-16) + 400 = 416.2$ psig
$180°F \Rightarrow 49 - (0.97143)(49-42) + 400 = 442.2$ psig
$250°F \Rightarrow 76 - (0.97143)(76-57) + 400 = 457.5$ psig

(c) Non-Ⓦ : Averaging 350 psig & 400 psig setpoint results ⇒ S = 375 psig :

$T_o = 100°F \Rightarrow (363.3 + 416.2)/2 = 389.75$ psig
$180°F \Rightarrow (375.5 + 442.2)/2 = 408.85$ psig
$250°F \Rightarrow (387.5 + 457.5)/2 = 422.50$ psig

[(c) ⇒ $\Delta P(V_{RCS}, \Delta t, S)$]

3. ΔP (S, V_{ccs}) @ $A_{WT} = 58{,}000\ ft^2$:

(a) @ $\Delta t = 1.5$ sec

$T_{o,ccs} = 100°F$ $V = 6\ KFt^3 \Rightarrow 17.2$ psi $V = 13\ KFt^3 \Rightarrow 11.4$ psi

$180°F \Rightarrow$? $\Rightarrow$?

$250°F \Rightarrow \sim 49$ psi $\Rightarrow \sim 35$ psi

$$P_{max} = \Delta P + S = P_{6K} - \left(\frac{12{,}800 - 6000}{13{,}000 - 6{,}000}\right)(P_{6K} - P_{13K}) + 375$$

for $T_{o,ccs} = 100°F \Rightarrow 17.2 - (0.97143)(17.2 - 11.4) + 375 = \underline{386.6\ psig}$

$180°F \Rightarrow$?

$250°F \Rightarrow 49 - (0.97143)(49 - 35) + 375 = \underline{410.4\ psig}$

(b) $\Delta t = 3.0$ sec

$T_{o,ccs} = 100°F \Rightarrow V = 6\ KFt^3 \Rightarrow 33.6$ psi $V = 13\ KFt^3 \Rightarrow 22.4$ psi

$180°F \Rightarrow \Rightarrow 67$ psi $\Rightarrow 55$ psi

$250°F \Rightarrow \Rightarrow 101$ psi $\Rightarrow 78$ psi

for $T_{o,ccs} = 100°F \Rightarrow 33.6 - (0.97143)(33.6 - 22.4) + 375 = \underline{397.1\ psig}$

$180°F \Rightarrow 67 - (0.97143)(67 - 55) + 375 = \underline{430.3\ psig}$

$250°F \Rightarrow 101 - (0.97143)(101 - 78) + 375 = \underline{453.7\ psig}$

(c) non-(W) averaging [2 sec = 1.5 + (0.333)(3 − 1.5)]

for $T_{o,ccs} = 100°F$: $386 + (0.333)(397.1 - 386.6) = \underline{389.7\ psig}$

$180°F$: ?

$250°F$: $410.4 + (0.333)(453.7 - 410.4) = \underline{424.8\ psig}$

V = 12,800
UA @ 58,000
S = 375
$\Delta t = 2.0$

4. $\Delta P(UA, V_{acc})$

(a) 3 sec value at

(1) 350 psig S

		6K	13K
UA	T = 100°F	0.083	0.124
	180°F	0.0114	0.181
	250°F	0.140	0.222

$$f = 51,500/58,000 = 0.888$$

		6K	13K
UA'	T = 100°F	0.0737	0.1101
	180°F	0.0101	0.1607
	250°F	0.1249	0.1991

	6K	13K
T = 100°F:	ΔP = 29 psi	18 psi
180°F:	" = 56 "	34 psi
250°F:	" = 77 "	53 psi

$$\Delta P_v = \Delta P_{6K} - \left(\frac{V_{acc} - 6K}{13K - 6K}\right)\left(\Delta P_{6K} - \Delta P_{13K}\right)$$

$$P_{max} = S + [\Delta P] = 350 + \left[\Delta P_{6K} - (0.97143)(\Delta P_{6K} - \Delta P_{13K})\right]$$

$T = 100°F$: $P_{max} = 350 + 29 - (0.97143)(29-18) = 368.3$ psig

$180°F$: $= 350 + 56 - (0.97143)(56-34) = 384.6$ psig

$250°F$: $= 350 + 77 - (0.97143)(77-53) = 403.7$ psig

$V = 12,9$
$UA = 51,$
$S = 35$
$\Delta t = 3$

(2) 400 psig S

		6K	13K
UA	T = 100°F	0.083	0.119
	"	" 0.114	" 0.182
	"	" 0.198	" 0.222

$$f = 0.888$$

		6K	13K
UA'	T = 100°F	0.0737	0.1057
	180°F	" 0.1012	" 0.1616
	250°F	" 0.1225	" 0.1991

T = 100°F ⇒	6K ⇒ 30	13K ⇒ 18
180°F ⇒	6K ⇒ 67	13K ⇒ 58
250°F ⇒	6K ⇒ 104	13K ⇒ 83

T = 100°F : P_{max} = 400 + 30 − (0.97143)(30 − 18) = 418.3 psig
180°F : " = 400 + 67 − (0.97143)(67 − 58) = 458.3 psig
250°F : " = 400 + 104 − (0.97143)(104 − 83) = 483.6 psig

V = 12.8
UA & SI,
S = 40
Δt = 8

(b) 1.5 sec. value Δt

(1) 350 psig S

UA { T = 100°F : 6K ⇒ 0.084 ; 13K ⇒ 0.127
250°F : 6K ⇒ 0.139 ; 13K ⇒ 0.220

f = 0.888

UA' { T = 100°F : 6K ⇒ 0.0746 ; 13K ⇒ 0.1128
250°F : 6K ⇒ 0.1234 ; 13K ⇒ 0.1954

T = 100°F : 6K ⇒ 15 ; 13K ⇒ 8
250°F : " ⇒ 38 ; " ⇒ 24

T = 100°F : P_{max} = 350 + 15 − (0.97143)(15 − 8) = 358.2 psig
250°F : " = 350 + 38 − (0.97143)(38 − 24) = 374.4 psig

V = 1
UA
S =
Δt =

(2) 400 psig S

UA { T = 100°F : 6K ⇒ 0.084 ; 13K ⇒ 0.129
250°F : " ⇒ 0.140 ; 13K ⇒ 0.222

f = 0.888

UA' { T = 100°F : 6K ⇒ 0.0746 ; 13K ⇒ 0.1146
250°F : 6K ⇒ 0.1243 ; 13K ⇒ 0.1971

T = 100°F : 6K ⇒ 15 ; 13K ⇒ 13
250°F : 6K ⇒ 52 ; 13K ⇒ 30

T = 100°F : P_{max} = 400 + 15 − (0.97143)(15 − 13) = 413.1 psig
250°F : " = 400 + 52 − (0.97143)(52 − 30) = 437.4 psig

V = 12.8
UA & SI
S = 4
Δt = 1

5. $\Delta P(UA, \Delta t)$

(Using results from preceding section 4, for $13 KFt^3$)

(a) 350 psig S

100°F: 1.5 sec ⇒ 8 psi 3.0 sec ⇒ 18 psi
250°F: " ⇒ 24 psi " ⇒ 53 psi

$$P_{max} = 350 + [\Delta P] = 350 + \left[\Delta P_{1.5} + \left(\frac{\Delta t - 1.5}{3 - 1.5}\right)(\Delta P_3 - \Delta P_{1.5})\right]$$

$$= 350 + \Delta P_{1.5} + (0.333)(\Delta P_3 - \Delta P_{1.5})$$

100°F: $P_{max} = 350 + 8 + (0.333)(18 - 8) = 361.3$ psig
250°F: " $= 350 + 24 + (0.333)(53 - 24) = 383.7$ psig

$V = 13 KFt^3$
$UA \Rightarrow 51,500$
$S = 350$
$\Delta t = 2.0$

(b) 400 psig S

100°F: 1.5 sec ⇒ 13 psi 3.0 sec ⇒ 18 psi
250°F: " ⇒ 37 psi " ⇒ 83 psi

100°F: $P_{max} = 400 + 13 + (0.333)(18 - 13) = 414.7$ psig
250°F: " $= 400 + 37 + (0.333)(83 - 37) = 452.3$ psig

$V = 13 KFt^3$
$UA \Rightarrow 51,500$
$S = 400$
$\Delta t = 2.0$

6. ΔP (VA, S)

(a) 3 sec Δt, 13 KFt³

T = 100°F: 350 psi ⇒ 18 psi 400 psi ⇒ 18 psi
250°F: " ⇒ 53 psi " ⇒ 83 psi

$$P_{MAX} = 375 + [\Delta P] = 375 + \Delta P_{350} + \left(\frac{375-350}{400-350}\right)(\Delta P_{400} - \Delta P_{350})$$

$$= 375 + \Delta P_{350} + (0.5)(\Delta P_{400} - \Delta P_{350})$$

T = 100°F: $P_{MAX} = 375 + 18 + (0.5)(18-18) = 393$ psig
250°F: " $= 375 + 53 + (0.5)(83-53) = 443$ psig

V = 13 KFt³, VA ≤ 51,500, S = 375, Δt = 3

(b) 1.5 sec Δt, 13 KFt³

T = 100°F: 350 psi ⇒ 8 psi 400 psi ⇒ 13 psi
250°F: " ⇒ 24 psi " ⇒ 31 psi

T = 100°F: $P_{MAX} = 375 + 8 + (0.5)(13-8) = 385.5$ psig
250°F: " $= 375 + 24 + (0.5)(37-24) = 405.5$ psig

V = 13 KFt³, VA ≤ 51,500, S = 375, Δt = 1.5

(c) non-(W) averaging 2 sec = [1.5 + (0.33)(3 − 1.5)]

T = 100°F: $P_{MAX} = 385.5 + (0.83)(393 - 385.5) = 388$ psig
250°F: " $= 405.5 + (0.83)(443 - 405.5) = 418$ psig

CAUTION (W) V = 13 KFt³, VA ≤ 51,500, S = 375, Δt = 2.0

[redacted]
10/11/77