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 AUTH. NAME: CURTIS, N.W. AUTHOR AFFILIATION: Pennsylvania Power & Light Co.  
 RECIP. NAME: YOUNGBLOOD, B.J. RECIPIENT AFFILIATION: Licensing Branch 1

SUBJECT: Forwards calculations which indicate adequate flow capacity for piping & valves required in alternate shutdown path & show that requirements for worst path resistances are met. Calculations close SER Outstanding Issue 38.

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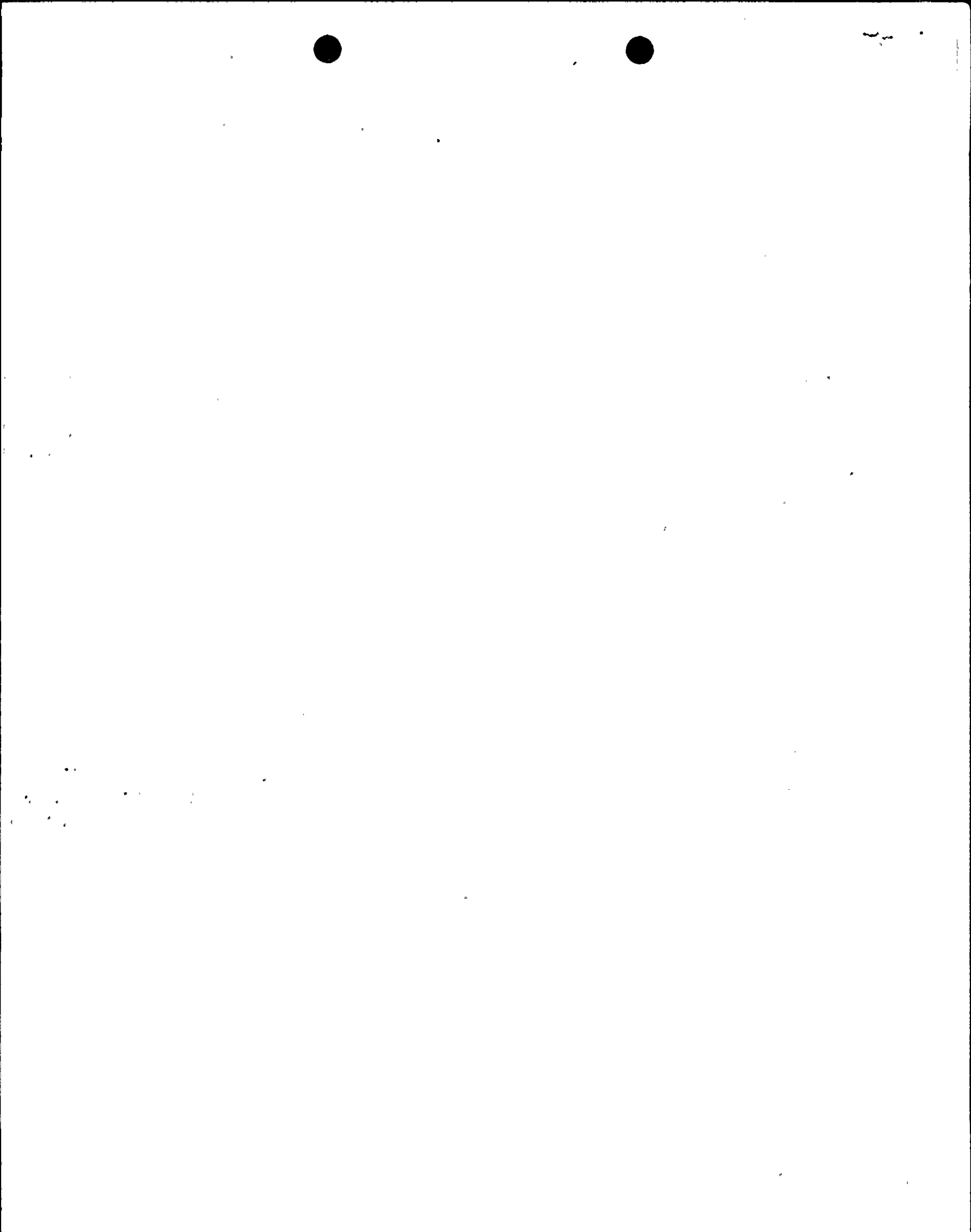
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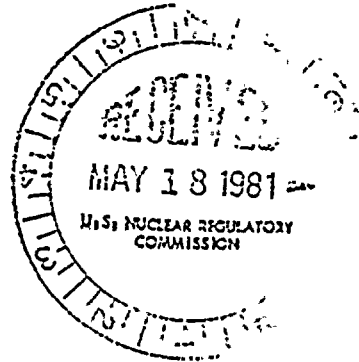
LJ





TWO NORTH NINTH STREET, ALLENTOWN, PA. 18101      PHONE: (215) 821-5151

NORMAN W. CURTIS  
Vice President-Engineering & Construction  
821-5381



May 15, 1981

Mr. B. J. Youngblood, Chief  
Licensing Branch No. 1  
U.S. Nuclear Regulatory Commission  
Washington, D.C. 20555

Docket Nos. 50-387  
50-388

SUSQUEHANNA STEAM ELECTRIC STATION  
SER OUTSTANDING ITEM 38  
ER 100450                      FILE 841-2  
PLA-782

Dear Mr. Youngblood:

Attached are the Susquehanna SES calculations to show sufficient flow capacity for all piping and valves required in the alternate shutdown path and which show that the pump head-flow requirements for the worst path resistances are met.

These calculations complete our action to close SER Outstanding Issue 38.

Very truly yours,

N. W. Curtis  
Vice President-Engineering and Construction-Nuclear

CTC/mks

Attachment

cc: R. M. Stark - NRC

Boo!  
s  
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E

8105190240



CALCULATION COVER SHEET

COVER SH. A OF A  
CALC. NO. M152-7  
NO. OF SHEETS 10  
Q NO. 510

NO. 8856

DISCIPLINE MECHANICAL

TITLE ALTERNATE SHUTDOWN COOLING MAY -4 '61

CALC. SHEET CONTROL:  
138930

SUBJECT CORE SPRAY PUMP OPERATION IN THE ALTERNATE SHUTDOWN COOLING MODE.

STATEMENT OF PROBLEM DETERMINE CORE SPRAY PUMP OPERATING POINTS IN ALTERNATE SHUTDOWN COOLING MODE WITH ONE OR MORE MAINSTEAM RELIEF VALVES OPEN.

SAR CHECKED

SAR CHANGE REQ'D.

SAR CHANGE NOTICE INITIATED

SOURCES OF DATA ISOMETRICS: HBB-104-1, REV. 8, GBB-101-2, REV. 3, DGB-113-1 REV. 3, DCA-109-1 REV. 5, DCA-107-1, REV. 11.

SOURCES OF FORMULAE & REFERENCES 1) CORE SPRAY PUMP CALCS M152-6, REV. 1  
2) CRANE TECHNICAL PAPER NO. 410, 1979 EDITION  
3) CORE SPRAY PUMP PERFORMANCE CURVE 8856-M1-E21-30-1  
4) CORE SPRAY PROCESS DIAGRAM 8856-M1-E21-15-2  
5) CROSBY VALVE ENGINEERING AND CAPACITY DATA, CAT. #302, SUP. 1  
6) PSU OUTLINE DWG. 8856-M1-B21-64-2

PRELIMINARY CALC.

FINAL CALC.

SUPERSEDES CALC. NO. \_\_\_\_\_

DATE	CALCULATION BY	**CHECKED BY	DATE	APPROVED BY	DATE
4/23/81	J. J. Brunner / [Signature]	David Yang	5/4/81	[Signature]	5/4/81

Primary calcs checked only at group supervisor's request. Covers PSAR, codes and standards, redundancy and separation, operability and maintainability, technical adequacy, accuracy and clarity.



# ( CALCULATION SHEET )

MAY -4 '81 138930

ORIGINATOR J. J. Brunner DATE 4/23/81  
 PROJECT SUSQUEHANNA  
 SUBJECT CORE SPRAY PUMPS IN  
ALTERNATE SHUTDOWN COOLING MADE

CALC. NO. M 152-7 REV. NO. 0  
 CHECKED G. Yang DATE 5-4-81  
 JOB NO. 8856  
 SHEET NO. 1 of 10

## ASSUMPTIONS

1. Based on vendor catalog information the  $C_v$  value for fully open main steam relief valve (PSV F013) is assumed to be within the range of 400 to 500 gpm. Both values (400 & 500) were used in these calculations. An estimate of the  $C_v$  value is presented in Appendix A of this calculation.
2. Backpressure in PSV discharge line is neglected because of large line diameter (12").
3. Friction losses in main steam piping are negligible and thus are omitted.
4. Calculation reflects a steady state condition. Inlet flow is equal to outlet flow. Water level in RPV is assumed to be 3 ft above center line of main steam nozzle.
5. No venting of RPV dome occurs.

## SUMMARY AND CONCLUSIONS

- a) With only one PSV open, pumps will pressurize RPV above shutdown initiation pressure of 98 psig. This could be prevented by throttling with core spray valve. It is preferable, however, that a second PSV be opened to lower reactor pressure below shutdown initiation pressure.
- b) Calculations show (see page 9) that with 4 PSV open, runout flow of 7900 gpm will be reached with a valve  $C_v$  of 500.



# ( CALCULATION SHEET )

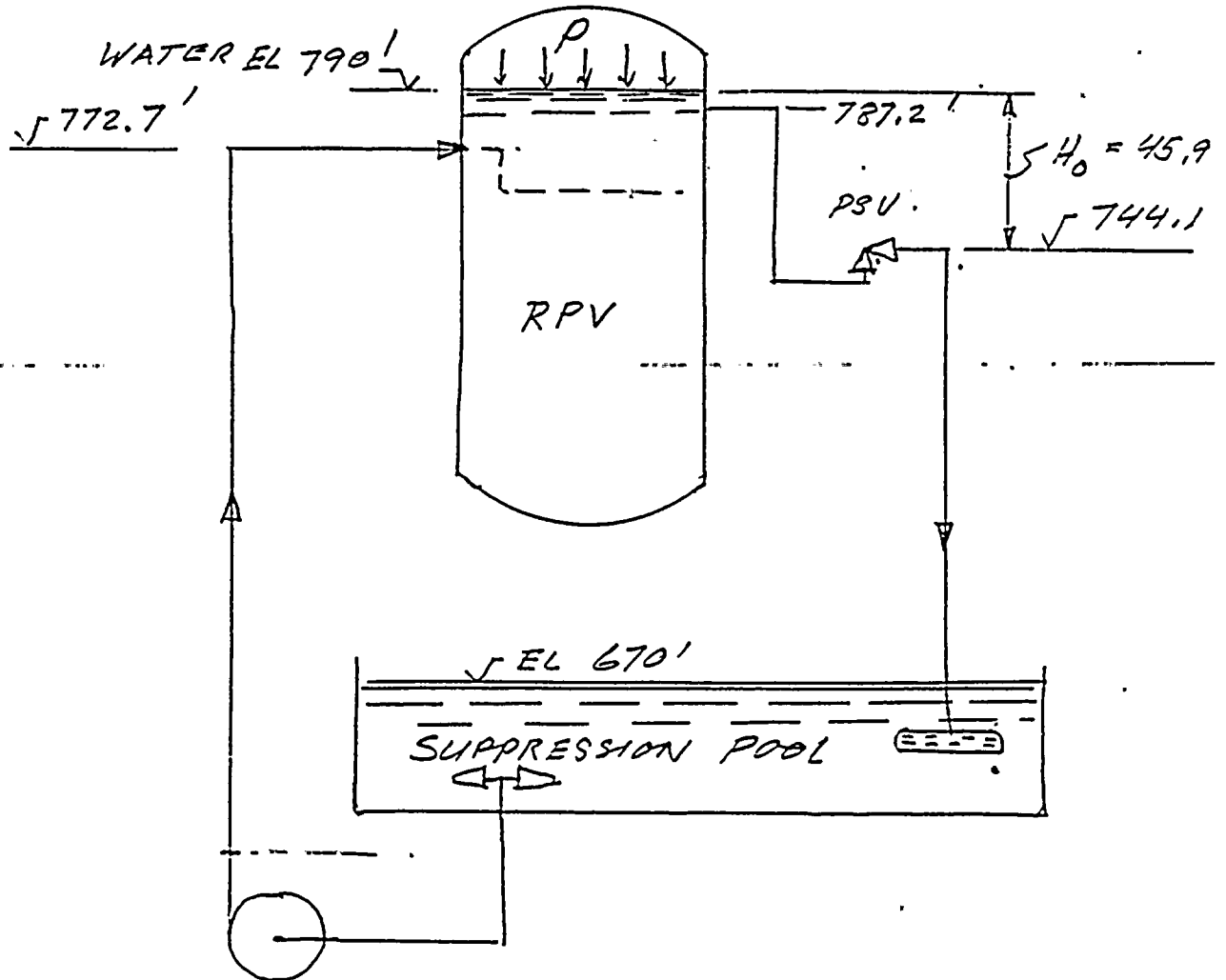
ORIGINATOR J. J. Brunner DATE 4/23/81 CALC. NO. M152-7 REV. NO. 0  
 PROJECT SUSQUEHANNA CHECKED JWJ DATE 5-4-81  
 SUBJECT Core Spray Pumps in Alt. Shutdown Cooling Mode JOB NO. 8856  
 SHEET NO. 2 OF 10

MAY -4 '81 138930

Use Core Spray Mode D

$P_{RPV} = 105 \text{ psig}$  (use 98 psig for shutdown cooling initiation)  
 $T_{RPV} = 332 \text{ } ^\circ\text{F}$   
 $T_{pool} = 170 \text{ } ^\circ\text{F}$   
 $P_{pool} = 14.7 \text{ psia}$  } (Ref. 4)

Assume water level ~ 3 ft above M.S. nozzle  $\frac{1}{2}$



CORE SPRAY  
 PUMP  
 (TWIN SET)



# CALCULATION SHEET

ORIGINATOR J. J. Brunner DATE 4/23/81 CALC. NO. M152-7 REV. NO. 0  
 PROJECT SUSQUEHANNA CHECKED DWG DATE 5-4-81  
 SUBJECT CORE SPRAY PUMPS IN JOB NO. 8856  
ALTERNATE SHUTDOWN COOLING MODE SHEET NO. 3 of 10

MAY -4 '81 138930

## TOTAL SYSTEM'S RESISTANCE

$$H_T = H_s + H_p + H_f$$

Static Head - with water level at approx. 3 ft above main steam nozzle  $\phi$

$$H_s = 790' - 670' = 120'$$

## Pressure Head

$$H_p = \frac{144}{\rho} P_{psv} - H_0$$

where:

$$\Delta P_{psv} = \frac{\rho}{62.4} \left( \frac{Q}{C_v} \right)^2 \quad (\text{Ref. 2})$$

with zero back pressure  $\Delta P_{psv} = P_{psv}$

$H_0 = \text{stat. head at psv } \phi = 45.9'$  (see page 9)

## Friction Head

$$H_f = \left( \frac{Q}{Q_c} \right)^2 H_{fc}$$

condition calculated for Mode D  
(see Ref 1 sht. 78)

$$Q_c (2 \text{ pumps}) = 6350 \text{ gpm}$$

$$H_{fc} = 277.3 \text{ ft}$$

$$H_T = H_s + \frac{144}{\rho} \left( \frac{Q}{C_v} \right)^2 - H_0 + \left( \frac{Q}{Q_c} \right)^2 H_{fc}$$

$$\text{RPV Pressure} = P_{psv} - \frac{\rho}{144} H_0$$



# CALCULATION SHEET

CALC. NO. M152-7 REV. NO. 0ORIGINATOR J. J. Brimmer DATE 4/23/81 CHECKED JWA DATE 5-4-81PROJECT SUSQUEHANNA JOB NO. 8856SUBJECT Core Spray Pumps in Alternate Shutdown Mode SHEET NO. 4 of 10ONE PSV IS OPEN

$$C_v = 400$$

MAY -4 '81 138930

Q	2000	4000	6000	8000
H <sub>s</sub>	120	120	120	120
H <sub>p</sub> = $\frac{144}{62.4} \left(\frac{Q}{400}\right)^2 - 45.9$	11.8	184.9	473.3	877
H <sub>f</sub> = $\left(\frac{Q}{6350}\right)^2 \times 277.3$	27.5	110	247.5	440
H <sub>tot</sub>	159.3	414.9	840.8	1437

$$C_v = 500$$

Q	2000	4000	6000	8000
H <sub>s</sub>	120	120	120	120
H <sub>p</sub> = $\frac{144}{62.4} \left(\frac{Q}{500}\right)^2 - 45.9$	-.9	101.8	286	545
H <sub>f</sub>	27.5	110	247.5	440
H <sub>tot</sub>	N/A	331.8	653.5	1105

PRPV with 1 PSV @ C<sub>v</sub> = 400 Q = 5,450 gpm

$$P = \frac{56.2}{144} \left[ \frac{144}{62.4} \left( \frac{5450}{400} \right)^2 - 45.9 \right] = 149.3 \text{ psig}$$

PRPV with 1 PSV @ C<sub>v</sub> = 500 Q = 6,130 gpm

$$P = \frac{56.2}{144} \left[ \frac{144}{62.4} \left( \frac{6130}{500} \right)^2 - 45.9 \right] = 117.4 \text{ psig}$$





# CALCULATION SHEET

CALC. NO. M152-7 REV. NO. 0ORIGINATOR I. J. Brunner DATE 4/23/81 CHECKED QWJ DATE 5-4-81PROJECT SUSQUEHANNA JOB NO. 8856SUBJECT Core Spray Pumps in Alternate Shutdown Cooling Mode SHEET NO. 5 of 10TWO PSU OPEN

MAY -4 '81 138930

$$CV = 400$$

Q TOTAL	2000	4000	6000	8000
---------	------	------	------	------

Q PSU	1000	2000	3000	4000
-------	------	------	------	------

H <sub>s</sub>	120	120	120	120
H <sub>p</sub> = $\frac{144}{62.4} \left(\frac{Q}{400}\right)^2 - 45.9$	-31.5	11.8	83.9	184.9
H <sub>f</sub> = $\left(\frac{Q}{6350}\right)^2 \cdot 277.3$	27.5	110	247.5	440
H <sub>tot</sub>	N/A	241.8	451.4	744.9

$$CV = 500$$

H <sub>s</sub>	120	120	120	120
H <sub>p</sub> = $\frac{144}{62.4} \left(\frac{Q}{500}\right)^2 - 45.9$	-36.7	-9	37.2	101.8
H <sub>f</sub> = $\left(\frac{Q}{6350}\right)^2 \cdot 277.3$	27.5	110	247.5	440
	N/A	N/A	404.7	661.8

PRPV @ CV = 400

$$Q_{PSU} = 7,150/2 = 3,575 \text{ gpm}$$

$$P_{RPV} = \frac{57.2}{144} \left[ \frac{144}{62.4} \left(\frac{3575}{400}\right)^2 - 45.9 \right] = 55 \text{ psig}$$

PRPV @ CV = 500

$$Q_{PSU} = 7420/2 = 3,710 \text{ gpm}$$

$$P_{RPV} = \frac{58}{144} \left[ \frac{144}{62.4} \left(\frac{3710}{500}\right)^2 - 45.9 \right] = 32.7 \text{ psig}$$



# CALCULATION SHEET

CALC. NO. M152-7 REV. NO. 0ORIGINATOR J. J. Brunner DATE 4/23/81CHECKED Jung DATE 5-4-81PROJECT SusquehannaJOB NO. 8856SUBJECT Core Spray Pumps in Alternate Shutdown Cooling ModeSHEET NO. 6 of 10

## THREE PSV OPEN

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$$C_V = 400$$

$Q_{TOTAL}$	3000	6000	9000
-------------	------	------	------

$Q_{PSV}$	1000	2000	3000
-----------	------	------	------

$H_s$	120	120	120
$H_p = \frac{144}{62.4} \left( \frac{Q_V}{400} \right)^2 - 45.9$	-31.5	11.8	83
$H_f = (Q_T/6350)^2 \cdot 277.3$	61.9	247.5	557
$H_{tot}$	N/A	379.3	760

$$C_V = 500$$

$H_s$	120	120
$H_p = \frac{144}{62.4} \left( \frac{Q_V}{500} \right)^2 - 45.9$	-9	37
$H_f = (Q_T/6350)^2 \cdot 277.3$	247.8	557
$H_{tot}$	N/A	714

$$PRPV @ C_V = 400 \quad Q_{PSV} = 7600/3 = 2,533 \text{ gpm}$$

$$P_{RPV} = \frac{58.4}{144} \left[ \frac{144}{62.4} \left( \frac{2,533}{400} \right)^2 - 45.9 \right] = 18.9 \text{ psig}$$

$$PRPV @ C_V = 500 \quad Q_{PSV} = 7720/3 = 2,590 \text{ gpm}$$

$$P_{RPV} = \frac{59.5}{144} \left[ \frac{144}{62.4} \left( \frac{2,590}{500} \right)^2 - 45.9 \right] = 6.6 \text{ psig}$$



# CALCULATION SHEET

ORIGINATOR J. J. Brunner DATE 4/23/81

CALC. NO. M152-7 REV. NO. 0

PROJECT Susquehanna

CHECKED Quj DATE 5-4-81

SUBJECT Core Spray Pumps in Alternate Shutdown Cooling Mode

JOB NO. 8856

SHEET NO. 7 of 10

MAY -4 '81 138930

FOUR PSV OPEN

$C_v = 400$

$Q_{TOT}$

6000 8000 9000

$Q_v$

1500 2000 2250

$H_s$

120 120 120

$H_p = \frac{144}{62.4} \left( \frac{Q_v}{400} \right)^2 - 45.9$

-13.4 11.8 27.1

$H_f = (Q_v / 6350)^2 \cdot 277.3$

247.8 440 557

$H_{tot}$

N/A 571.8 704.1

$C_v = 500$

$H_s$

120 120

$H_p = \frac{144}{62.4} \left( \frac{Q_v}{500} \right)^2 - 45.9$

-9 0.0

$H_f = (Q_v / 6350)^2 \cdot 277.3$

440 557

$H_{tot}$

N/A 677.0

$PRPV @ C_v = 400$

$Q_{psv} = 7780 / 4 = 1945$

$PRPV = \frac{59.6}{144} \left[ \frac{144}{62.4} \left( \frac{1945}{400} \right)^2 - 45.9 \right] =$

3.5 psig 9P

$PRPV @ C_v = 500$

$Q_{psv} = 7900 / 4 = 1975$

$PRPV = \frac{59.8}{144} \left[ \frac{144}{62.4} \left( \frac{1975}{500} \right)^2 - 45.9 \right] =$

atmospheric

(NEG)



# CALCULATION SHEET

ORIGINATOR J. J. Brunner DATE 4/23/81 CALC. NO. M152-7 REV. NO. 0  
 PROJECT SUPERUEHANNA CHECKED DWJ DATE 5-4-81  
 SUBJECT CORE SPRAY PUMPS IN ALTERNATE SHUTDOWN COOLING MODE JOB NO. 8856  
 SHEET NO. 8 of 10

MAY -4 '81 138930

Determine Amount of Throttling Required to Match Initiation Pressure of 98 psig with one PCV open.

With 0 back pressure:

$$P_{PSV} = P_{RPV} + \frac{P_{H_2O}}{144} = 98 + \frac{56.2 \cdot 45.9}{144} = 115.9 \text{ psi}$$

FLOW through PSV

$$P_{PSV} = \frac{P}{62.4} \left( \frac{Q}{C_V} \right)^2$$

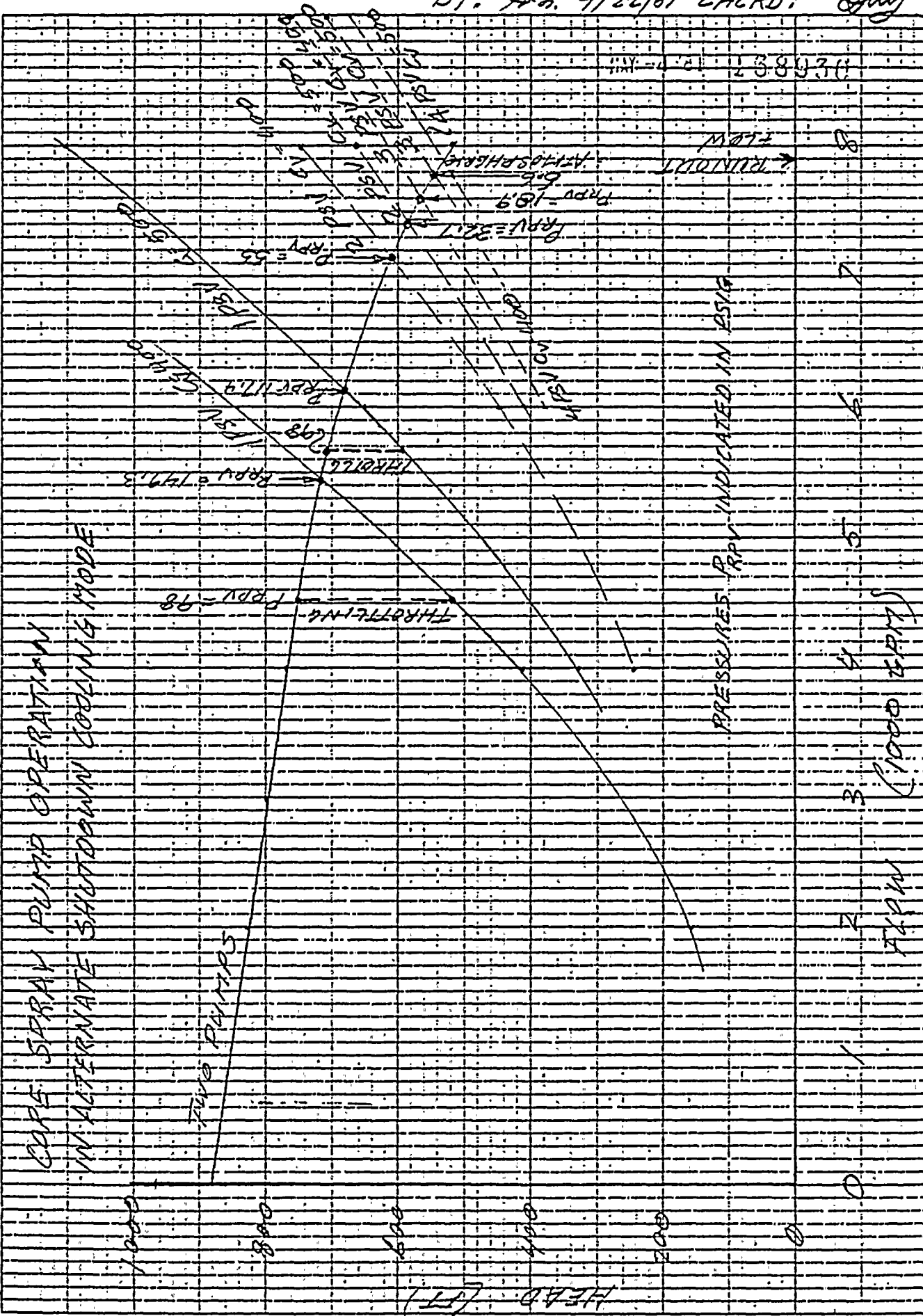
$$\therefore Q = \left( P_{PSV} \cdot \frac{62.4}{P} \cdot C_V^2 \right)^{0.5} = C_V \cdot \left( P_{PSV} \cdot \frac{62.4}{P} \right)^{0.5}$$

$$\text{For } C_V = 400: Q = 400 \cdot \left( 115.9 \cdot \frac{62.4}{56.2} \right)^{0.5} = 4,528$$

$$\text{For } C_V = 500: Q = 500 \cdot \left( 115.9 \cdot \frac{62.4}{56.2} \right)^{0.5} = 5,660 \text{ gpm}$$

Amount of throttling for above flows are shown on sht. 9.

BY: [Signature] 4/22/81 CHKD: [Signature] 4-4-8



CORE SPRAY PUMP OPERATION  
IN ALTERNATE SHUTDOWN COOLING MODE

PURE PUMPS

HEAD (FT)

FLOW (1000 GPM)

PRESSURES RPPV INDICATED IN PSIG

WATERION NOD

RPPV = 98

RPPV = 149.3

RPPV = 179.6

RPPV = 298

RPPV = 517.9

RPPV = 600

RPPV = 600

RPPV = 500

RPPV = 500

RPPV = 500

THROTTLING

MAY 8 1981

38931

PRINTED

FLOW



# ( CALCULATION SHEET )

ORIGINATOR J. J. Brunner DATE 4/30/81 CHECKED gmg DATE 5-4-81  
 PROJECT SISSQUEHANNA JOB NO. 8856  
 SUBJECT COKE SPRAY PUMPS IN ALTERNATE SHUTDOWN COOLING MODE SHEET NO. 10 OF 10

MAY -4 '81 138930

## APPENDIX A

### ESTIMATE OF VALVE FLOW COEFFICIENT CV

Valve capacity (per Ref. 5 for liquid)

$$Q = 27.2 C_A A K_{sg} \sqrt{\frac{P - P_b}{\Delta P}}$$

(gpm)

where:  $C_A$  = correction factor for accum. press. assume 1

$K_{sg} = 1$  (for water)

$P_b = 0$  assuming no back pressure.

$A = 16$  orifice area for Crosby style 6 R10HB-65-BP (see Ref. 5 & 6)

$$Q = 27.2 \cdot 16 \cdot \sqrt{\Delta P} = 435.2 \sqrt{\Delta P}$$

From flow equation  $\Delta P = \frac{\rho}{62.4} \left( \frac{Q}{C_v} \right)^2$

or:  $Q = C_v \sqrt{\frac{62.4}{\rho} \Delta P}$

By substitution:

$$435.2 \sqrt{\Delta P} = C_v \sqrt{\frac{62.4}{\rho} \Delta P}$$

$$\therefore C_v = \frac{435.2}{\sqrt{\frac{62.4}{\rho}}}$$

for:  $\rho = 59.8 \text{ lb/ft}^3$   
 $P = 14.7 \text{ psia}$   
 $T = 212^\circ F$

$$C_v = \frac{435.2}{\sqrt{\frac{62.4}{59.8}}} = \underline{\underline{427}}$$