REGULATORY INFORMATION DISTRIBUTION SYSTEM (RIDS)

ACCESSION NBR:8105190418 DOC.DATE: 81/05/15 NOTARIZED: NO DOCKET #
FACIL:50-387 Susquehanna Steam Electric Station, Unit 1, Pennsylva 05000387
50-388 Susquehanna Steam Electric Station, Unit 2, Pennsylva 05000388
AUTH.NAME AUTHOR AFFILIATION
CURTIS,N.W. Pennsylvania Power & Light Co.
RECIP.NAME RECIPIENT AFFILIATION
YOUNGBLOOD,B.J. Licensing Branch 1

SUBJECT: Forwards NPSH calculations for core spray & LPCI pumps, closing out SER Outstanding 33,in response to Reactor Sys Branch request.

DISTRIBUTION CODE: B001S COPIES RECEIVED:LTR 1 ENCL 1 SIZE: 18
TITLE: PSAR/FSAR AMDTS and Related Correspondence

NOTES:Send I&E 3 copies FSAR & all amends.1 cy:BWR-LRG PM(L.RIB) 05000387
Send I&E 3 copies FSAR & all amends.1 cy:BWR-LRG PM(L.RIB) 05000388

	RECIPIENT ID CODE/NAME		COPIES LTTR	COPIES ENCL	RECIPIENT ID CODE/NAME		COPIES LTTR	COPIES ENCL
ACTION:	A/D LICENSNG		1	0	LIC BR #2 BC		1	0
	RUSHBROOK,M.		1	0	STARK,R.	04	1	1
INTERNAL:	ACCID EVAL BR	26	1	1	AUX SYS BR	07	1	1
	CHEM ENG BR	08	1	1	CONT SYS BR	09	1	1
	CORE PERF BR	10	1	1	EFF TR SYS BR	12	1	1
	EMERG PREP	22	1	0	EQUIP QUAL BR	13	3	3
	GEOSCIENCES	14	1	1	HUM FACT ENG BR		1	1
	HYD/GEO BR	15	2	2	I&C SYS BR	16	1	1
	I&E	06	3	3	LIC GUID BR		1	1
	LIC QUAL BR		1	1	MATL ENG BR	17	1	1
	MECH ENG BR	18	1	1	MPA		1	0
	NRC PDR	02	1	1	OELD		1	0
	OP LIC BR		1	1	POWER SYS BR	19	1	1
	PROC/TST REV	20	1	1	QA BR	21	1	1
	RAD ASSESS BR	22	1	1	REAC SYS BR	23	1	1
	REG FILE	01	1	1	SIT ANAL BR	24	1	1
	STRUCT ENG BR	25	1	1				
EXTERNAL:	ACRS	27	16	16	LPDR	03	1	1
	NSIC	05	1	1				

MAY 21 1981

TOTAL NUMBER OF COPIES REQUIRED: LTTR 57 ENCL 51

[illegible]

PP&L

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 ISSUE 33
ER 100450 FILE 841-2
PLA-779

Dear Mr. Youngblood:

Attached are the NPSH calculations for the core spray and LPCI pumps. This additional information was requested during meetings with the Reactor Systems Branch.

These calculations complete our action to close SER Outstanding Issue 33.

Very truly yours,

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

CTC/mks

Attachment

cc: R. M. Stark - NRC

B001
s
1/1

8105190418
E

SUSQUEHANNA STEAM ELECTRIC STATION, UNITS 1 AND 2

CALCULATION COVER SHEET

934

COVER SH. A OF A-D
CALC. NO. 151-26
NO. OF SHEETS 263
Q NO. 49.0

JOB NO. 8856

DISCIPLINE MECHANICAL / NUCLEAR

TITLE R.H.R. SP CALCULATIONS
SUSQUEHANNA STEAM ELECTRIC STATION

MAY -4 '81 138921

SUBJECT PRESSURE DROPS IN THE R.H.R. SYSTEM OF UNITS 1 AND 2 FOR VARIOUS MODES (A-J) OF OPERATION

STATEMENT OF PROBLEM COMPUTE PRESSURE DROPS IN THE R.H.R. SYSTEM FOR UNITS 1 AND 2 UNDER VARIOUS MODES OF OPERATION IN ORDER TO SIZE FLOW ORIFICES AND TO VERIFY LINE SIZES.

CALC. SHEET CONTROL:

REVISION 1:
REVISED PAGES:
4, 6, 21, 34, 54, 66, 83, 86, 109, 174, 199, 209, 218, 223, 224, 226
ADDED PAGES:
4A, 5A

REVISION 2:
REVISED PAGES:
131-153
ADDED PAGES:
153 A, B, C, D, E

SAR CHECKED ☒ SAR CHANGE REQ'D. ☒ SAR CHANGE NOTICE INITIATED ☐

SOURCES OF DATA ISOMETRICS: 8856-DBB-107-1 Rev 3, DBB-107-2 Rev 3, DBB-115-1 Rev 7, DCA-105-1 Rev 7, DCA-110-1 Rev 6, DCA-110-2 Rev 9, DCA-111-1 Rev 8, DCA-111-2 Rev 5, DCB-102-1 Rev 4, GBA-104-1 Rev 7, GBB-104-2 Rev 4, GBB-104-3 Rev 7, GBB-104-4 Rev 4, GBB-105-1 Rev 5, GBB-105-2 Rev 5, GBB-106-1 Rev 7, GBB-106-2 Rev 7, GBB-107-1 Rev 9, GBB-107-2 Rev 4, GBB-108-1 Rev 5, GBB-109-1 Rev 6, GBB-109-2 Rev 7, GBB-110-1 Rev 7, GBB-110-2 Rev 6, GBB-111-1 Rev 7, GBB-111-2 Rev 4, GBB-112-1 Rev 7, GBB-112-2 Rev 5, GBB-115-1 Rev 4, GBB-116-1 Rev 5, GBB-116-2 Rev 5, GBB-117-1 Rev 2, GBB-118-1 Rev 5, GBB-119-2 Rev 2, GBB-118-3 Rev 1, GBB-118-4 Rev 2, GBB-120-1 Rev 3, HBB-110-1 Rev 8, HBB-110-2 Rev 6, CON'T NEXT PAGE

SOURCES OF FORMULAE & REFERENCES
(1) CRANE TECHNICAL PAPER NO. 410 (1965)
(2) G.E. PROCESS DIAGRAM & PROCESS DATA 8856-M1-E11-3(1)-8 ✓
(3) FLOW ORIFICE CURVE 8856-M1-E11-25-1
(4) PUMP PERFORMANCE CURVE 8856-M1-E11-53-1
(5) DANIEL STEAM-LIQUID ORIFICE FLOW CALCULATOR
(6) GLOVER, TRAVIS F., "UNDERSTANDING NPSH FOR PUMPS", PLANT ENGINEERING, DEC. 24, 1975.

*PRELIMINARY CALC. ☐ FINAL CALC. ☒

SUPERSEDES CALC. NO. 151-23, 151-22, 151-19, 151-16, 151-14, 151-13, 151-12 (CON'T NEXT PG.)

REV. NO.	DATE	CALCULATION BY	*CHECKED BY	DATE	APPROVED BY	DATE
2	12/11/79	G. KALINAUSKAS / G. Kalinauskas	[signature]	1/25/80	B.M. Jackson	1/23/80
1	6/20/79	G. KALINAUSKAS / G. Kalinauskas	[signature]	8/20/79	B.M. Jackson	8/21/79
0	1/16/79	G. KALINAUSKAS / G. Kalinauskas	JCM	4-4-79	B.M. Jackson	5/10/79

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

8856-QA-2(1/74)

MAY -4 '81 138920

SUSQUEHANNA STEAM ELECTRIC STATION, UNITS 1 AND 2
CALCULATION COVER SHEET

JOB NO. 8856

DISCIPLINE MECHANICAL / NUCLEAR

COVER SH. B OF A-D
CALC. NO. 151-26
NO. OF SHEETS —
Q NO. 49.0

TITLE R.H.R. ΔP CALCULATIONS

SUSQUEHANNA STEAM ELECTRIC STATION

CALC. SHEET CONTROL:

SUBJECT

STATEMENT OF PROBLEM

8105020

SAR CHECKED ☐ SAR CHANGE REQ'D. ☐ SAR CHANGE NOTICE INITIATED ☐

SOURCES OF DATA HBB-110-3 Rev 6, HBB-110-4 Rev 6, HBB-111-1 Rev 5, HBB-111-2 Rev 3, HBB-113-1 Rev 6, HBB-113-3 Rev 3, HBD-185-1 Rev 1, HBD-186-1 Rev 4, DBB-207-1 Rev 1, DBE-207-2 Rev 2, DBE-215-1 Rev 5, DCA-202-1 Rev 1, DCA-210-1 Rev 2, DCA-210-2 Rev 2, DCA-211-1 Rev 2, DCA-211-2 Rev 2, DCA-211-3 Rev 2, DCB-202-1 Rev 2, GBB-204-1 Rev 6, GBB-204-2 Rev 5, GBB-204-3 Rev 6, GBB-204-4 Rev 4, GBE-205-1 Rev 4, GBE-205-2 Rev 4, GBB-206-1 Rev 5, GBB-206-2 Rev 4, GBB-207-1 Rev 6, GBB-207-2 Rev 4, GBE-208-1 Rev 2, GBB-209-1 Rev 4, GBB-209-2 Rev 5, GBB-210-1 Rev 3, GBB-210-2 Rev 3, GBB-211-1 Rev 2, GBB-211-2 Rev 3, GBB-212-1 Rev 4, GBB-212-2 Rev 3, GBB-215-1 Rev 4, GBB-216-1 Rev 3, GBB-216-2 Rev 3, CON'T NEXT PAGE

SOURCES OF FORMULAE & REFERENCES

(7) POSTA, BEKENY, "BASIC GUIDANCE TO AVOID CAVITATION OF ORIFICES, VALVES" JUNE 21, 1974.
(8) SPRAY ENGINEERING COMPANY - CATALOG #73 - BURLINGTON, MASS. 01803.
(9) ASME STEAM TABLES (1967)
(10) P.+I.D. - RESIDUAL HEAT REMOVAL - M-151 Rev 12
(11) G.E. - P.+I.D. - RESIDUAL HEAT REMOVAL - M1-E11-2 Rev 6
(12) AREA DRAWING - M-257 Rev 3

*PRELIMINARY CALC. ☐ FINAL CALC. ☒

SUPERSEDES CALC. NO. 151-11, 151-10, 151-9, 151-8, 151-6, 151-5, 151-4, 151-3, 151-2, 151-1

REV. NO.	DATE	CALCULATION BY	**CHECKED BY	DATE	APPROVED BY	DATE

*Preliminary calcs checked only at group supervisor's request.

MAY -4 '81 138921

SUSQUEHANNA STEAM ELECTRIC STATION, UNITS 1 AND 2
CALCULATION COVER SHEET

JOB NO. 8856

DISCIPLINE MECHANICAL / NUCLEAR

COVER SH. C OF A-D
CALC. NO. 151-26
NO. OF SHEETS —
Q NO. 49.0

TITLE R.H.R. OP CALCULATIONS

SUSQUEHANNA STEAM ELECTRIC STATION

CALC. SHEET CONTROL:

SUBJECT

STATEMENT OF PROBLEM

SAR CHECKED ☐ SAR CHANGE REQ'D. ☐ SAR CHANGE NOTICE INITIATED ☐

SOURCES OF DATA GEE-217-1 Rev 2, GBB-218-1 Rev 1, GBB-218-2 Rev 2, GBB-218-3 Rev 2, GBB-218-4 Rev 2, GBB-220-1 Rev 3, HBB-210-1 Rev 5, HBB-210-2 Rev 5, HBB-210-3 Rev 5, HBB-210-4 Rev 5, HBB-211-1 Rev 3, HBB-211-2 Rev 3, HBB-213-1 Rev 4, HBB-213-2 Rev 1, HBD-285-1 Rev 1, HBD-285-2 Rev 1, HBD-286-1 Rev 3, 8856-M1-B31-16(2) Rev 10.

VALVE Cv: 8856-P10A-74-5 Rev C, P12A-11-7 Rev D, P12A-12-6 Rev C, P12A-13-5 Rev C, P12A-18-7 Rev D, P12A-20-10 Rev G, P12A-24-7 Rev E, P12A-60-6 Rev D, P12A-61-5 Rev D, P12A-62-6 Rev D, P12A-71-4 Rev B, P12A-72-1 Rev C, P12A-74-4 Rev B, P12A-75-5 Rev C, P12A-80-3 Rev B, P12BC-14-9 Rev G, P17A-14-5 Rev C

CON'T NEXT PAGE

SOURCES OF FORMULAE & REFERENCES

(13.) G.E. REACTOR VESSEL DRAWING - M1-B11-234 Rev 7.
(14.) CALCULATIONS - M-111-17 Rev 0
(15.) GB-76-171 (4/22/76)
(16.) GB-79-72 (3/29/79) and BLG-1999 (1/24/79)
(17.) CALCULATIONS - C-11-A Rev 6
(18.) SPRAY NOZZLE PURCHASE ORDER - 8856-M154-10-1

*PRELIMINARY CALC. ☐ FINAL CALC. ☒ SUPERSEDES CALC. NO. _____

REV. NO.	DATE	CALCULATION BY	**CHECKED BY	DATE	APPROVED BY	DATE

*Preliminary calcs checked only at group supervisor's request.

**Initial adequacy, accuracy and clarity.

MAY -4 '81 138924

SUSQUEHANNA STEAM ELECTRIC STATION, UNITS 1 AND 2
CALCULATION COVER SHEET

JOB NO. 8856

DISCIPLINE MECHANICAL / NUCLEAR

COVER SH. D OF A-D
CALC. NO. 151-26
NO. OF SHEETS —
Q NO. 49.0

TITLE R.H.R. ΔP CALCULATIONS
SUSQUEHANNA STEAM
ELECTRIC STATION

CALC. SHEET CONTROL:

SUBJECT

STATEMENT OF PROBLEM

0004

SAR CHECKED ☐ SAR CHANGE REQ'D. ☐ SAR CHANGE NOTICE INITIATED ☐

SOURCES OF DATA P17A-15-4 Rev B, P17A-16-4 Rev C, P17A-17-4 Rev B, P17A-18-6 Rev E P17A-23-5 Rev D, P17A-27-4 Rev C, P17A-62-3 Rev A, P17BC-2, J-28 Rev 1

SOURCES OF FORMULAE & REFERENCES
(19) SPRAY NOZZLE P.O. - 8856-MISH-2-2
(20) PIPING SPECIFICATION M-199 Rev 31.
(21) R.H.R. PUMPS - M1-E11-21-1
(22) R.H.R. HEAT EXCHANGER - M1-E11-23-2
(23) EMC-4262 (6/28/79)
(24) EQUIPMENT LOCATION DRAWING M-247 Rev 8.

*PRELIMINARY CALC. ☐ FINAL CALC. ☒ SUPERSEDES CALC. NO. —

REV. NO.	DATE	CALCULATION BY	**CHECKED BY	DATE	APPROVED BY	DATE

*Preliminary calcs checked only at group supervisor's request.

MAY -4 '81 138928

CALCULATION SHEET

CALC. NO. 151-26 REV. NO. 1

ORIGINATOR G. KALINAUSKAS DATE JAN 16 1979 CHECKED JCM DATE 4-4-79

PROJECT SUSQUEHANNA STEAM ELECTRIC STATION JOB NO. 8856

SUBJECT R.H.R. AP CALCULATIONS SHEET NO. 223

SECTION 3 - NPSH CALCULATIONS

MODE C-2

$$NPSHA = h_s - h_f + h_a - h_{vpa} \quad \text{(ref 6)}$$

h_f

TABLE C-2.1

NODE	EQ. LENGTH OR C_v	$\Delta P_{9260\ gpm}$ (psi)
2B-3B	ΔP = 2 psi	2.0
3B-41B.	C_v = 49,000	0.03
	299'	0.59
41B-5B	90'	0.18
	3'	1.79×10^{-3}

$\Delta P = 2.80$ psi

$$h_f = 2.80\ psi \left(\frac{1\ ft^3}{60.13\ lb}\right)\left(144\ \frac{in^2}{ft^2}\right)$$

$h_f = 6.70$ ft

$h_s = z_2 - z_1$ $z_2 = 670'$ (min. water level - assumed 1' below normal - M-247 Rev 5)

$h_s = (670' - 648'0\frac{1}{2}")$ $z_1 = 648'0\frac{1}{2}"$ (inlet level to pump - iso H6E-110-2 Rev 6.)

$h_s = 21.96$ ft

$h_a(670') = 33.16$ ft (by calculation from ref 6 Table I)

$$h_{vpa}(200°F) = 11.53\ psi \left(\frac{1\ ft^3}{60.13\ lb}\right)\left(144\ \frac{in^2}{ft^2}\right) = 27.61\ ft \quad \text{(ref 1 pg A-6)}$$

$\therefore NPSHA = h_s - h_f + h_a - h_{vpa} = 21.96 - 6.70 + 33.16 - 27.61$

$= 20.81$ ft.

NPSHR = 3 + 4 = 7 ft (ref. 2 and ref 4 - G.E. requires additional 4 ft).

CALCULATION SHEET

CALC. NO. 151-26 REV. NO. 1

ORIGINATOR G. KALINAUSKAS DATE JAN 16 1979 CHECKED JCM DATE 4-4-79

PROJECT SUSQUEHANNA STEAM ELECTRIC STATION JOB NO. 8856

SUBJECT R.H.R. ΔP CALCULATIONS SHEET NO. 224

NPSH CALCULATION

MODE G

$NPSHA = h_s - h_f + h_a - h_{vpa}$ (ref 6)

h_f

TABLE G-1

NODE	EQ. LENGTH OR C_v	ΔP (psi)
2A - 3A	ΔP = 2 psi	2.0
3A - 41A	C_v = 49,000	0.07
	380'	1.56
41A - 5A	90'	0.37
	3'	3.80×10^{-3}

$\Delta P = 4.00$ psi

$h_f = 4.00 \text{ psi} \left(\frac{1 \text{ ft}^3}{61.54 \text{ lb}}\right)\left(144 \frac{\text{in}^2}{\text{ft}^2}\right)$

$h_f = 9.36$ ft

$h_s = z_2 - z_1$ $z_2 = 670'$ (min. water level - assumed 1' below normal - M-247 Rev 8) 8/15 Δ2

$h_s = (670' - 648'0\frac{1}{2}")$ $z_1 = 648'0\frac{1}{2}"$ (inlet level to pump - ico HBB-110-1 Rev 8)

$h_s = 21.96$ ft

$h_a(670') = 33.16$ ft (by calculation from ref 6 Table I)

$h_{vpa}(130°) = 2.22 \text{ psi} \left(\frac{1 \text{ ft}^3}{61.54 \text{ lb}}\right)\left(144 \frac{\text{in}^2}{\text{ft}^2}\right) = 5.19$ ft (ref 1 pg A-6)

∴ $NPSHA = h_s - h_f + h_a - h_{vpa} = 21.96 - 9.36 + 33.16 - 5.19$

$= 40.57$ ft

$NPSHR = 5 + 4 = 9$ ft (ref 2. and ref. 4 - G.E. requires additional 4ft,

MAY -4 '81 138920

CALCULATION SHEET

CALC. NO. 151-26 REV. NO. 0

ORIGINATOR G. KALINAUSKAS DATE JAN 16 1979 CHECKED JCM DATE 4-4-79

PROJECT SUSQUEHANNA STEAM ELECTRIC STATION JOB NO. 8856

SUBJECT R.H.R. AP CALCULATIONS SHEET NO. 225

In a similar fashion, the following table was constructed for the other modes of operation with suction from the suppression pool.

TABLE 1

MODE	h_s (ft)	h_f (ft)	h_a (ft)	h_{vpa} (ft)	NPSHA (ft)	NPSH R (ft)
A	21.96	8.78	33.16	5.19	41.25	3
B	21.96	7.85	33.16	5.19	42.08	5
C_1	21.96	5.48	33.16	12.69	36.95	2
C_2	21.96	6.70	33.16	27.61	20.81	7
D_2	21.96	6.95	33.16	3.94	44.23	3
G	21.96	9.36	33.16	5.19	40.57	9
H	21.96	8.76	33.16	0.84	45.52	3

SUSQUEHANNA STEAM ELECTRIC STATION, UNITS 1 AND 2
CALCULATION COVER SHEET

JOB NO. 8856 DISCIPLINE MECHANICAL/NUCLEAR

COVER SH. A OF A-B
CALC. NO. 152-6
NO. OF SHEETS 102
Q NO. 51.0

TLE CORE SPRAY CALCULATIONS

MAY -4 01 13892

SUSQUEHANNA STATION UNITS 1 & 2
PENNSYLVANIA P & L JOB 8856

SUBJECT PRESSURE DROPS IN THE CORE SPRAY SYSTEM OF UNITS 1 AND 2 FOR VARIOUS MODES OF OPERATION.

STATEMENT OF PROBLEM COMPUTE PRESSURE DROPS IN THE CORE SPRAY SYSTEM FOR UNITS 1 AND 2 UNDER VARIOUS MODES OF OPERATION IN ORDER TO SIZE FLOW ORIFICES AND TO VERIFY LINE SIZES, NPSH, AND OPERATING CONDITIONS.

CALC. SHEET CONTROL:
REVISION 0:
REVISED PAGES:
3, 6, 12, 14, 15, 18, 26, 35, 36, 40, 48, 51, 56, 60, 68, 71, 77, 78
ADDED PAGES:
12A, 12B, 12C, 12D, 12E, 12F, 78A, 78B, 78C.
DELETED PAGE: 57
REVISION 1:
REVISED PAGES:
3, 35, 38, 49, 58, 69, 80
ADDED PAGE: 3A

SAR CHECKED ☒ SAR CHANGE REQ'D. ☐ SAR CHANGE NOTICE INITIATED ☐

SOURCES OF DATA ISOMETRICS: 8856-DBB-113-1 Rev 2, DBB-113-2 Rev 3, DCA-107-1 Rev 7, DCA-107-2 Rev 7, DCA-109-1 Rev 4, DCA-109-2 Rev 4, GBB-101-1 Rev 4, GBB-101-2 Rev 3, GBB-101-3 Rev 2, GBB-101-4 Rev 7, GBB-102-1 Rev 7, GBB-102-2 Rev 5, GBB-102-3 Rev 6, GBB-103-1 Rev 2, GBB-103-2 Rev 2, HBB-104-1 Rev 6, HBB-104-2 Rev 7, HBD-183-1 Rev 3, HBD-183-2 Rev 3, HCB-1[illegible]2 Rev 4, HCB-101-1 Rev 3, HCB-102-1 Rev 2, HCD-[illegible]-1 Rev 3, HCD-115-1 Rev 4, DBB-213-1 Rev 2, DBB-213-2 Rev 1, DCA-207-1 Rev 1, DCA-207-2 Rev 1, DCA-209-1 Rev 1, DCA-209-2 Rev 1, GBB-201-1 Rev 2, GBB-201-2 Rev 3, GBB-201-3 Rev 2, GBB-201-4 Rev 2, GBB-202-1 Rev 4, GBB-202-2 Rev 3, GBB-202-3 Rev 3, GBB-203-1 Rev 3, GBB-203-2 Rev 3, CON'T NEXT PAGE

SOURCES OF FORMULAE & REFERENCES
(1) CRANE TECHNICAL PAPER No. 410 (1965)
(2) G.E. PROCESS DIAGRAM & PROCESS DATA 8856-M1-E21-15-2 ✓
(3) GLOVER, TRAVIS F., "UNDERSTANDING NPSH FOR PUMPS" PLANT ENGINEERING, DEC. 24, 1975.
(4) PUMP PERFORMANCE CURVE 8856-M1-E21-30-1 (VPF No. 3308-149-1)
(5) DANIEL STEAM-LIQUID ORIFICE FLOW CALCULATOR
(6) PIPING SPECIFICATION M-199 Rev. 30
(7) POSTA, BERENY, "BASIC GUIDANCE TO AVOID CAVITATION OF ORIFICES & VALVES" JUNE 21, 1971

*PRELIMINARY CALC. ☐ FINAL CALC. ☒ SUPERSEDES CALC. NOS. 152-5, 152-4, 152-3, 152-2, 152-1

REV. NO.	DATE	CALCULATION BY	**CHECKED BY	DATE	APPROVED BY	DATE
1	6/21/79	G. KALINAUSKAS / G. Kalinauskas	[signature]	8/20/79	R.M. Jackson	8/21/79
0	3/27/79	G. KALINAUSKAS / G. Kalinauskas	J C McCune	3-30-79	R.M. Jackson	4/6/79
A	11/8/78	G. KALINAUSKAS / G. Kalinauskas	E. Connell	12-2-78	R.M. Jackson	11/21/79

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

8856-QA-2(1/74)

BECHTEL

SUSQUEHANNA STEAM ELECTRIC STATION, UNITS 1 AND 2
CALCULATION COVER SHEET

JOB NO. 8856

DISCIPLINE MECHANICAL / NUCLEAR

COVER SH. B OF A-B
CALC. NO. 152-6
NO. OF SHEETS —
Q NO. 51.0

TITLE CORE SPRAY CALCULATIONS

SUSQUEHANNA STATION UNITS 1 & 2
PENNSYLVANIA P & L JOB 8856

CALC. SHEET CONTROL:

SUBJECT

STATEMENT OF PROBLEM

0 2 0 0 9

SAR CHECKED ☐ SAR CHANGE REQ'D. ☐ SAR CHANGE NOTICE INITIATED ☐

SOURCES OF DATA CON'T FROM PAGE 1: HBB-204-1 Rev 4, HBB-204-2 Rev 5, HBD-283-1 Rev 2, HBD-283-2 Rev 1, HCB-201-1 Rev 5, HCD-211-1 Rev 3, HCD-215-1 Rev 6

VALVE Cv: 8856-P10A-18-6 Rev D, P12A-15-4 Rev B, P12A-19-4 Rev C, P12A-22-7 Rev E P12A-25-5 Rev C, P12A-56-3 Rev A, P12A-63-5 Rev C, P12BC-15-6 Rev D, P12A-17-4 Rev B P17A-21-6 Rev D, P17A-26-5 Rev D, P18AC-2-6 Rev H.

ORIFICE SIZES - J-30-39 Rev 0

SOURCES OF FORMULAE & REFERENCES

(8.) P.+I.D. – CORE SPRAY – M-152 Rev 9
(9.) AREA DRAWING – M-35-2 Rev 9
(10.) EQUIPMENT LOCATION DRAWING – M-247 Rev 8.
(11.) G.E. P.+I.D. – M1-E21-14-2
(12.) GE. DESIGN SPECIFICATION + DATA SHEETS – DOC. No. 22A3053 Rev 0
(13.) P.+I.D. – M-108 Rev 12

*PRELIMINARY CALC. ☐ FINAL CALC. ☒ SUPERSEDES CALC. NO. ______

REV	DATE	BY	CHECKED BY	DATE	APPROVED BY	DATE
1	6/21/79	G. Kalinauskas				
2	3/27/79	G. Kalinauskas	J C McCague	3-30-79	C.W. Jackson	4/6/79
A	11/8/78	G. Kalinauskas	E. Connelly	12-2-78	B.M. Jackson	1/2/79

CALCULATION SHEET

CALC. NO. 152-6 REV. NO. 0

ORIGINATOR G. KALINAUSKAS DATE NOV 08 1978 CHECKED E.C.C. DATE 12-8-78

PROJECT SUSQUEHANNA STATION UNITS 1 & 2 JOB NO. 8856

PENNSYLVANIA P & L JOB 8856

SUBJECT CORE SPRAY CALCULATIONS SHEET NO. 79

SECTION 3

NPSH CALCULATIONS

MODE A

$$NPSHA = h_s - h_f + h_a - h_{vpa} \quad \text{(ref 3)}$$

h_f (120°F)

TABLE A-1

NODE	EQ. LENGTH or C_v	d (in.)	d^5 (in^5)	v (ft/sec)	ΔP (psi)
STRAINER - 2.1	ΔP = 2 psi	15.25	8.25×10^5	11.14	2.0
	C_v = 20,700	15.25	8.25×10^5	11.14	0.09
	136'	15.25	8.25×10^5	11.14	1.15
2.1 - 2.2	36'	15.25	8.25×10^5	11.14	0.30
2.2 - 3B	127'	15.25	8.25×10^5	5.57	0.28
				TOTAL ΔP =	3.82 psi

ρ (120°F) = 61.73 lb/ft³ (ref 1 pg A-6)

μ (120°F) = 0.51 cp. (ref 1 pg A-3)

STRAINER - 2.1 FOR VALVE F008

$$\Delta P = \frac{\rho}{62.4}\left(\frac{Q}{C_v}\right)^2 \quad \text{(ref 1 pg 2.9)}$$

$$\Delta P = \frac{61.73}{62.4}\left(\frac{6350}{20,700}\right)^2$$

ΔP = 0.09 psi

FOR PIPE + FITTINGS:

$$v = 0.408\frac{Q}{d^2} = 0.408\frac{(6350)}{(15.25)^2} = 11.14 \text{ ft/sec.}$$

$$Re = 123.9\frac{dv\rho}{\mu} = 123.9\frac{(15.25)(11.14)(61.73)}{(0.51)} = 2.55 \times 10^6$$

f = 0.013 (from ref 1 pg A-25)

$$\Delta P = 0.000216\frac{fL\rho Q^2}{d^5} = 0.000216\frac{(0.013)(136)(61.73)(6350)^2}{8.25 \times 10^5}$$

ΔP = 1.15 psi

CALCULATION SHEET

BECHTEL

ORIGINATOR G. KALINAUSKAS DATE NOV 08 1978 CALC. NO. 152-6 REV. NO. 1

CHECKED ΣCC DATE 12-2-78

PROJECT SUSQUEHANNA STATION UNITS 1 & 2 JOB NO. 8856

SUBJECT CORE SPRAY PENNSYLVANIA POWER & LIGHT CONDITIONS JOB 8856 SHEET NO. 80

2.1 - 2.2

FOR PIPE + FITTINGS:

$$\Delta P = 0.000216 \frac{f L \rho Q^2}{d^5} = 0.000216 \frac{(0.013)(36)(61.73)(6350)^2}{8.25 \times 10^5}$$

$$\Delta P = 0.30 \text{ psi}$$

2.1 - 3B

FOR PIPE + FITTINGS:

$$v = 0.408 \frac{Q}{d^2} = 0.408 \frac{(3175)}{(15.25)^2} = 5.57 \text{ ft/sec} \rightarrow Q = 3175 \text{ gpm (ref 2)}$$

$$Re = 123.9 \frac{d v \rho}{\mu} = 123.9 \frac{(15.25)(5.57)(61.73)}{(0.51)} = 1.27 \times 10^6$$

$f = 0.0135$ (from ref 1 pg A-25)

$$\Delta P = 0.000216 \frac{f L \rho Q^2}{d^5} = 0.000216 \frac{(0.0135)(127)(61.73)(3175)^2}{8.25 \times 10^5}$$

$$\Delta P = 0.28 \text{ psi}$$

$$h_f = 3.82 \text{ psi} \left(\frac{1}{61.73} \frac{ft^3}{lb}\right)\left(144 \frac{in^2}{ft^2}\right)$$

$h_f = 8.91$ ft

$h_s = z_2 - z_1$

$z_2 = 670'$ (min. water level in pool - assumed 1' below normal M-247 Rev 8) 1 5/6/;

$z_1 = 646' 10\ 5/8"$ (inlet level to pump - iso HBB-104-2 Rev 6.

$h_s = (670' - 646' 10\ 5/8")$

$h_s = 23.11$ ft

$h_a = 33.16$ ft (by calculation from ref 3 Table I)

$$h_{vpa} = 1.692 \frac{lb}{in^2} \times \frac{1 \text{ ft}^3}{61.73 lb} \times 144 \frac{in^2}{ft^2} = 3.95 \text{ ft (ref 1 pg A-6)}$$

$\therefore$ NPSHA $= h_s - h_f + h_a - h_{vpa} = 23.11 - 8.91 + 33.16 - 3.95$

NPSHA $= 43.41$ ft NPSHR $= 2$ ft (ref 4) or pg 13

CALCULATION SHEET

CALC. NO. 152-6 REV. NO. 0

ORIGINATOR G. KALINAUSKAS DATE NOV 0 8 1978 CHECKED ECC DATE 12-2-78

PROJECT SUSQUEHANNA STATION UNITS 1 & 2 PENNSYLVANIA P & L JOB 8856 JOB NO. 8856

SUBJECT CORE SPRAY CALCULATIONS SHEET NO. 81

MAY -4 '81 138921

MODE B

$NPSHA = h_s - h_f + h_a - h_{vpa}$

h_f

NODE	TABLE B.1 OR TABLE B.1 OR C_v	ΔP (psi)
ENTRANCE	62'	0.27
15-16	250'	1.10
	C_v = 18,470	0.21
	124'	0.72
	C_v = 20,700	0.16
	108'	1.63
2.1-2.2	136'	0.54
2.2-3B	127'	0.51

TOTAL ΔP = 6.14 psi

$$h_f = 6.14 \text{ psi} \left(\frac{1 \text{ ft}^3}{62.27 \text{ lb}}\right)\left(\frac{144 \text{ in}^2}{1 \text{ ft}^2}\right)$$

h_f = 14.20 ft

$h_s = z_2 - z_1$ z_2 = 673' 9" (outlet level from tank - ISO HCB-1-2 Rev 4)

$h_s = (673'9" - 646'10\frac{5}{8}")$ z_1 = 646' 10 5/8" (inlet level to pump - ISO HBB-104-1 Rev 6)

h_s = 26.86 ft

$h_a(674') = 33.16$ ft (by calculation from ref 3 Table I)

$$h_{vpa}(70°F) = 0.363 \frac{\text{lb}}{\text{in}^2} \times \frac{1 \text{ ft}^3}{62.27 \text{ lb}} \times 144 \frac{\text{in}^2}{\text{ft}^2} = 0.84 \text{ ft}$$ (ref 1 pg A-6)

$NPSHA = h_s - h_f + h_a - h_{vpa}$

NPSHA = 26.86 − 14.20 + 33.16 − 0.84

NPSHA = 44.98 ft.

NPSHR = 19 ft (ref 2)

CALCULATION SHEET

CALC. NO. 152-6 REV. NO. 0

ORIGINATOR G. KALINAUSKAS DATE NOV 08 1978 CHECKED ECC DATE 12-2-78

PROJECT SUSQUEHANNA STATION UNITS 1 & 2 JOB NO. 8856

SUBJECT CORE SPRAY CALCULATIONS JOB 8856 SHEET NO. 82

MODE C

$NPSHA = h_s - h_f + h_a - h_{vpa}$

TABLE C.1

NODE	EQ. LENGTH or C_v	ΔP (psi)
STRAINER - 2.1	ΔP = 2 psi	2.0
	C_v = 20,700	9.2×10^{-4}
	136'	1.32×10^{-2}
2.1 - 2.2	36'	3.5×10^{-3}
2.2 - 3B	127'	3.35×10^{-3}
	TOTAL ΔP =	2.02 psi

$$h_f = 2.02 \text{ psi} \left(\frac{1 \text{ ft}^3}{60.13 \text{ lb}}\right)\left(144 \frac{\text{in}^2}{\text{ft}^2}\right)$$

$h_f = 4.84$ ft

$h_s = z_2 - z_1$ $z_2 = 670'$ (as before)

$h_s = 23.11$ ft $z_1 = 646' 10\frac{5}{8}''$ (as before)

$h_a (670') = 33.16$ ft

$$h_{vpa} (200°F) = 11.53 \frac{\text{lb}}{\text{in}^2} \times \frac{1 \text{ ft}^3}{60.13 \text{ lb}} \times 144 \frac{\text{in}^2}{\text{ft}^2} = 27.61 \text{ ft} \quad (\text{ref 1 pg A-6})$$

$\therefore NPSHA = h_s - h_f + h_a - h_{vpa}$

$NPSHA = 23.11 - 4.84 + 33.16 - 27.61$

$NPSHA = 23.82$ ft

$NPSHR = 2$ ft (ref 4) or pg 13

CALCULATION SHEET

CALC. NO. 152-6 REV. NO. 0

ORIGINATOR G. KALINAUSKAS DATE NOV 08 1978 CHECKED ECC DATE 12-1-78

PROJECT SUSQUEHANNA STATION UNITS 1 & 2 JOB NO. 8856

SUBJECT CORE SPRAY CALCULATIONS JOB 8856 SHEET NO. 83

MODE D

$NPSHA = h_s - h_f + h_a - h_{vpa}$

TABLE D-1

NODE	EQ. LENGTH OR C_v	ΔP (psi)
STRAINER - 2-1	$\Delta P = 2$ psi	2.0
	$C_v = 20,700$	0.09
	136'	1.09
2-1 - 2-2	36'	0.29
2-2 - 3B	127'	0.27
	TOTAL ΔP =	3.74 psi

$h_f = 3.74 \text{ psi} \left(\frac{1 \text{ ft}^3}{60.79 \text{ lb}}\right)\left(144 \frac{\text{in}^2}{\text{ft}^2}\right)$

$h_f = 8.86$ ft

$h_s = z_2 - z_1$ $\quad z_2 = 670'$ (as before)

$h_s = 23.11$ ft $\quad z_1 = 646' 10\frac{5}{8}''$ (as before)

$h_a (670') = 33.16$ ft

$h_{vpa} (170°F) = 5.99 \frac{\text{lb}}{\text{in}^2} \times \left(\frac{1 \text{ ft}^3}{60.79 \text{ lb}}\right) \times \frac{144 \text{ in}^2}{\text{ft}^2} = 14.19$ ft (ref 1 pg A-6)

$\therefore NPSHA = h_s - h_f + h_a - h_{vpa}$

$NPSHA = 23.11 - 8.86 + 33.16 - 14.19$

$NPSHA = 33.22$ ft

$NPSHR = 2$ ft (ref 4) or pg 13

CALCULATION SHEET

CALC. NO. 15λ-6 REV. NO. 0

ORIGINATOR G. KALINAUSKAS DATE NOV 08 1978 CHECKED ECC DATE 12-2-78

PROJECT SUSQUEHANNA STATION UNITS 1 & 2 JOB NO. 8856

SUBJECT CORE SPRAY CALCULATIONS JOB 8856 SHEET NO. 84

MODE E

$NPSHA = h_s - h_f + h_a - h_{vpa}$

TABLE E-1

NODE	EQ. LENGTH OR C_v	ΔP (psi)
STRAINER - 2-1	ΔP = 2 psi	2.0
	C_v = 20,700	0.09
	136'	1.08
2-1 - 2-2	36'	0.28
2-2 - 3B	127'	0.26
	TOTAL ΔP =	3.71 psi

$h_f = 3.71 \text{ psi} \left(\frac{1 \text{ ft}^3}{60.13 \text{ lb}}\right)\left(\frac{144 \text{ in}^2}{1 \text{ ft}^2}\right)$

$h_f = 8.88$ ft

$h_s = z_2 - z_1$ $\quad z_2 = 670'$ (as before)

$h_s = 23.11$ ft $\quad z_1 = 646' 10\frac{5}{8}"$ (as before)

$h_a (670') = 33.16$ ft

$h_{vpa} (200°F) = 11.53 \frac{\text{lb}}{\text{in}^2} \times \frac{1 \text{ ft}^3}{60.13 \text{ lb}} \times 144 \frac{\text{in}^2}{\text{ft}^2} = 27.61$ ft (ref 1 pg A-6)

$\therefore NPSHA = h_s - h_f + h_a - h_{vpa}$

$NPSHA = 23.11 - 8.88 + 33.16 - 27.61$

$NPSHA = 19.78$ ft

NPSHR = 11 ft. (ref 2)

CALCULATION SHEET

MAY -4 '81 138921

CALC. NO. 152-6 REV. NO. 0

ORIGINATOR G. KALINDRAS DATE NOV 08 1978 CHECKED ECC DATE 12-2-78

PROJECT SUSQUEHANNA STATION UNITS 1 & 2 JOB NO. 8856

SUBJECT CORE SPRAY CALCULATIONS PENNSYLVANIA P & L JOB 8856 SHEET NO. 85

MODE F

$NPSHA = h_s - h_f + h_a - h_{vpa}$

TABLE F-1

NODE	EQ. LENGTH OR C_v	ΔP (psi)
STRAINER - 2-1	ΔP = 2psi	2.0
	C_v = 20,700	0.12
	136'	1.50
2-1 - 2-2	36'	0.40
2-2 - 3B	127'	0.36
	TOTAL ΔP =	4.38 psi

$h_f = 4.38 \text{ psi} \left(\frac{1 \text{ ft}^3}{60.79 \text{ lb}}\right)\left(144 \frac{\text{in}^2}{\text{ft}^2}\right)$

$h_f = 10.38$ ft

$h_s = z_2 - z_1$ $z_2 = 670'$ (as before)

$h_s = 23.11$ ft $z_1 = 646' \ 10\frac{5}{8}''$ (as before)

$h_a(670') = 33.16$ ft

$h_{vpa}(170°F) = 5.99 \frac{\text{lb}}{\text{in}^2} \times \frac{1 \text{ ft}^3}{60.79 \text{ lb}} \times 144 \frac{\text{in}^2}{\text{ft}^2} = 14.19$ ft (ref 1 pg A-6)

$\therefore NPSHA = h_s - h_f + h_a - h_{vpa}$

$NPSHA = 23.11 - 10.38 + 33.16 - 14.19$

$NPSHA = 31.70$ ft

$NPSHR = 2.5$ ft (ref 4) or pg 13

CALCULATION SHEET

CALC. NO. 152-6 REV. NO. C

ORIGINATOR G. KALINAUSKAS DATE NOV 08 1978 CHECKED ΣCC DATE 12-2-78

PROJECT SUSQUEHANNA STATION UNITS 1 & 2 JOB NO. 8856

SUBJECT CORE SPRAY CALCULATIONS JOB 8856 SHEET NO. 86

MODE G

$NPSHA = h_s - h_f + h_a - h_{vpa}$

NODE	TABLE G-1 EQ. LENGTH OR C_v	ΔP (psi)
STRAINER - 2-1	$\Delta P = 2$ psi	2.0
	$C_v = 20,700$	0.14
	136'	1.68
2-1 - 2-2	36'	0.44
2-2 - 3B	127'	0.41
	TOTAL ΔP =	4.67 psi.

$h_f = 4.67 \text{ psi} \left(\frac{1}{60.57} \frac{ft^3}{lb}\right)\left(144 \frac{in^2}{ft^2}\right)$

$h_f = 11.10$ ft

$h_s = z_2 - z_1$

$h_s = 23.11$ ft

$z_2 = 670'$ (as before)

$z_1 = 646'\ 10\ 5/8"$ (as before)

$h_a(670') = 33.16$ ft

$h_{vpa}(180°F) = 7.51 \frac{lb}{in^2} \times \frac{1 ft^3}{60.57 lb} \times 144 \frac{in^2}{ft^2} = 17.85$ ft (ref 1 pg A-6)

$\therefore NPSHA = h_s - h_f + h_a - h_{vpa}$

$NPSHA = 23.11 - 11.10 + 33.16 - 17.85$

$NPSHA = 27.32$ ft

NPSHR = 16 ft (ref 2)