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SUBJECT: Forwards annual const noise progress rept, "Sound Level Measurements Near Susquehanna Steam Electric Station Site Const 1980."

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Mr. A. Schwencer, Chief
Licensing Branch No. 2
Division of Project Management
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

SUSQUEHANNA STEAM ELECTRIC STATION
CONSTRUCTION NOISE PROGRESS REPORT
ER 100450 FILE 991-2
PLA-837

Dear Mr. Schwencer:

Enclosed for your information are forty copies of the annual Construction Noise Progress Report, "Sound Level Measurements Near Susquehanna Steam Electric Station Site Construction 1980."

Very truly yours,

B. H. Henrikson for
N. W. Curtis
Vice President-Engineering & Construction-Nuclear

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Attachments (40)

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PENNSYLVANIA POWER & LIGHT COMPANY

Bolt Beranek and Newman Inc.

Report No. 3024A-5

Sound Level Measurements Near Susquehanna Steam Electric Station Site Construction 1980

Construction Noise Progress Report

J.D. Barnes and E.W. Wood

March 1981

Prepared for:
Pennsylvania Power and Light Company

8106120202

SUBJECT: Study on Torsional effect on the seismic response analysis of (1) ESSW Pumphouse
(2) Diesel Generator Building

As requested by NRC analysis has been performed to study the effects of including torsion in the dynamic response analysis for (a) ESSW Pumphouse (b) Diesel Generator Building.

The Analytical Procedure used in this study consists of:

(i) The eccentricities of these structures were calculated.

(ii) The structures were represented by a fixed base 3-D stick models with structural masses properly lumped at the calculated eccentricities, as shown in Figure 1 and 2.

(iii) Modal frequency analyses of the 3-D stick models were performed to determine the structure frequencies.

(iv) The frequencies determined are then compared with the corresponding frequencies associated with the fixed base models having zero eccentricities.

The results of comparison for the ESSW Pumphouse is shown on Table-1 and for the Diesel Generator building is shown on Table-2. These results indicate that there are insignificant shifts in the structural frequencies by including the eccentricities in the dynamic analysis.

From the results of this study, it is concluded that the structures modeled by lumped stick models without the inclusion of eccentricities in the dynamic analysis is adequate for the prediction of desired structural responses.

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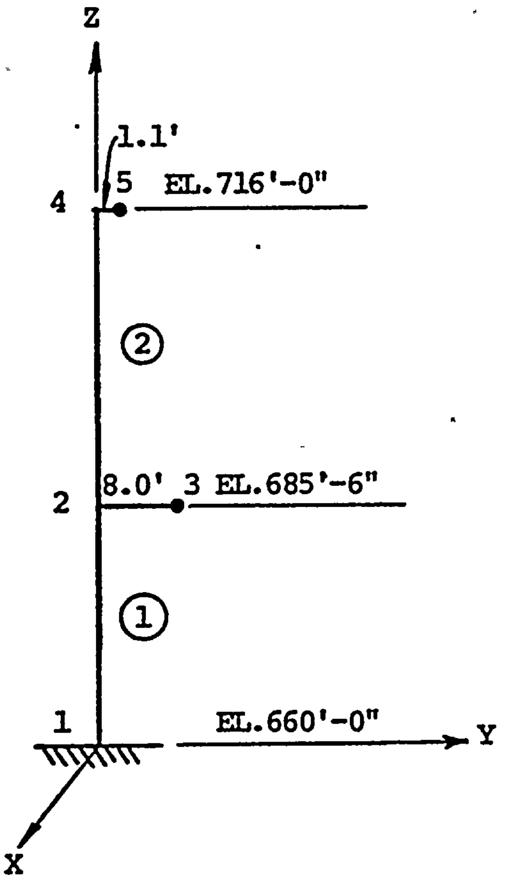


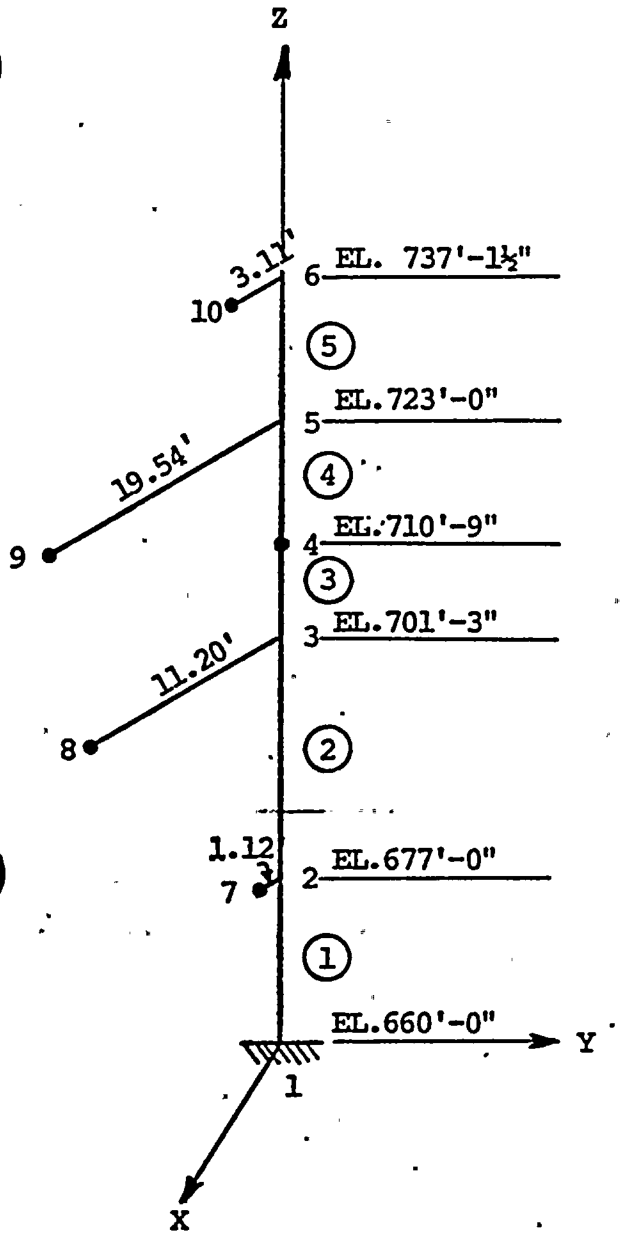
COORDINATES			
NODES	X	Y	Z
1	0.0	0.0	660.0
2	0.0	0.0	685.5
3	0.0	8.0	685.5
4	0.0	0.0	716.0
5	0.0	1.1	716.0

MASSES AT NODES 3 AND 5

FIGURE-1

ESSW PUMP HOUSE

3-D STICK MODEL



MASSES AT NODES 4,8,9,10

COORDINATES			
NODES	X	Y	Z
1	0.0	0.0	660.0
2	0.0	0.0	677.0
3	0.0	0.0	701.3
4	0.0	0.0	710.8
5	0.0	0.0	723.0
6	0.0	0.0	737.1
7	0.5	-1.0	677.0
8	8.9	-6.8	701.3
9	19.5	-1.3	723.0
10	0.3	-3.1	737.1

FIGURE 2

DIESEL GENERATOR BUILDING

3-D STICK MODEL

Table-1: ESSW PUMPHOUSE:
Frequencies with and without eccentricities
(See Figure-1)

Mode #	Frequencies (cps)	
	With Eccentricity	Without Eccentricity
1	13.93	13.94
2	18.05	18.06
3	28.94	28.97
4	38.83	40.01

Table-2: DIESEL GENERATOR BUILDING:
Frequencies with and without eccentricities
(See Figure-2)

Mode #	Frequencies (cps)	
	With Eccentricity	Without Eccentricity
1	8.86	8.96
2	9.65	9.71
3	22.56	23.42
4	31.69	32.04
5	33.45	33.66

SUBJECT: Equivalence of Fixed Base and Flexible Base Models used for the analysis of Primary Containment for seismic loads.

In continuation of our response to the NRC question 130.20 as desired by NRC, a study has been made on the above subject. The object of this study is to demonstrate that as the shear wave velocity is increased, the results from the flexible base model converge to the results of the fixed base model.

The study considers the vertical seismic analysis for SSE for (a) a fixed base model (b) flexible base models for various foundation flexibililites defined by shear wave velocities V_s, $2V_s$, $5V_s$, $10V_s$ where V_s for the Susquehanna site is 6200 ft./sec. This corresponds to an equivalent vertical spring constant as shown in Table-1. A sketch of the flexible base vertical seismic model is shown in figure 3.7b-8 of FSAR (See Attachment #1).

A damping value of 5% of critical was used for all fixed base structural modes. The damping determination technique described in reference 3.7b-3 of FSAR [BC-Top-4A, Rev. 3, Appendix D] has been used to calculate the composite modal damping for the flexible base model.

The results for the fixed base and the flexible models are shown in Table-2 and Table-3, in terms of frequencies and modal damping values. The seismic (SSE) responses in terms of axial forces are presented in Table-4. The results indicate the following:

(a) Table-2: Frequencies values approach fixed base conditions for $5V_s$.

(b) Table-3: Modal damping values approach the fixed base condition for $5V_s$.

(c) Table-4: Seismic responses approach fixed base conditions for $2V_s$.

These results demonstrate that as the shear wave velocity is increased to 2 to 5 times the actual site shear wave velocity, the results from the flexible base model converge to the results of the fixed base model. Thus use of the flexible base model for the seismic analysis of the containment structure is more realistic.

Table-1: CONTAINMENT: Equivalent Vertical Spring Constants.

From FSAR Section 3.7b.5, Reference 3.7b-3
(BC-Top-4-A, Page 3-15)

Equivalent Vertical Spring Constant, $k_z = \frac{4GR}{(1-\nu)}$

Where ν = Poisson's ratio = 0.3

R = Radius of Circular base mat = 50 ft.

G = Shear Modulus = ρV_s^2

V_s = Shear Wave Velocity = 6200 ft./sec.

ρ = Mass density of foundation medium = 4.3478E-3 $k.sec^2/ft^4$ (γ = 140 lbs/cft.)

$V_s = V_s$ $\quad k_z$ = 4.78E07 k/ft.

$V_s = 2V_s$ $\quad k_z$ = 1.912E08 k/ft.

$V_s = 5V_s$ $\quad k_z$ = 1.195E09 k/ft.

$V_s = 10V_s$ $\quad k_z$ = 4.78E10 k/ft.

Table-2: CONTAINMENT: Vertical Seismic Model
Flexible Base Vs. Fixed Base Frequencies. (Cps)

Frequencies (Cps)

Mode #	Flexible Base				Fixed Base
	V_s = 6200 ft/sec.	$2V_s$	5Vs	$10V_s$	
1	16.19	17.24	17.45	17.47	17.48
2	20.95	23.18	24.09	24.23	24.28
3	38.24	38.63	38.75	38.77	38.78

Table-3: CONTAINMENT: Vertical Seismic Model
Flexible Base Vs. Fixed Base
Modal Damping (% Critical)

Modal Damping (% Critical)

Mode #	Flexible Base				Fixed Base
	V_s = 6200 ft/sec.	$2V_s$	5Vs	$10V_s$	
1	9.3	5.3	5.0	5.0	5.0
2	9.1	6.1	5.0	5.0	5.0
3	5.0	5.1	5.0	5.0	5.0

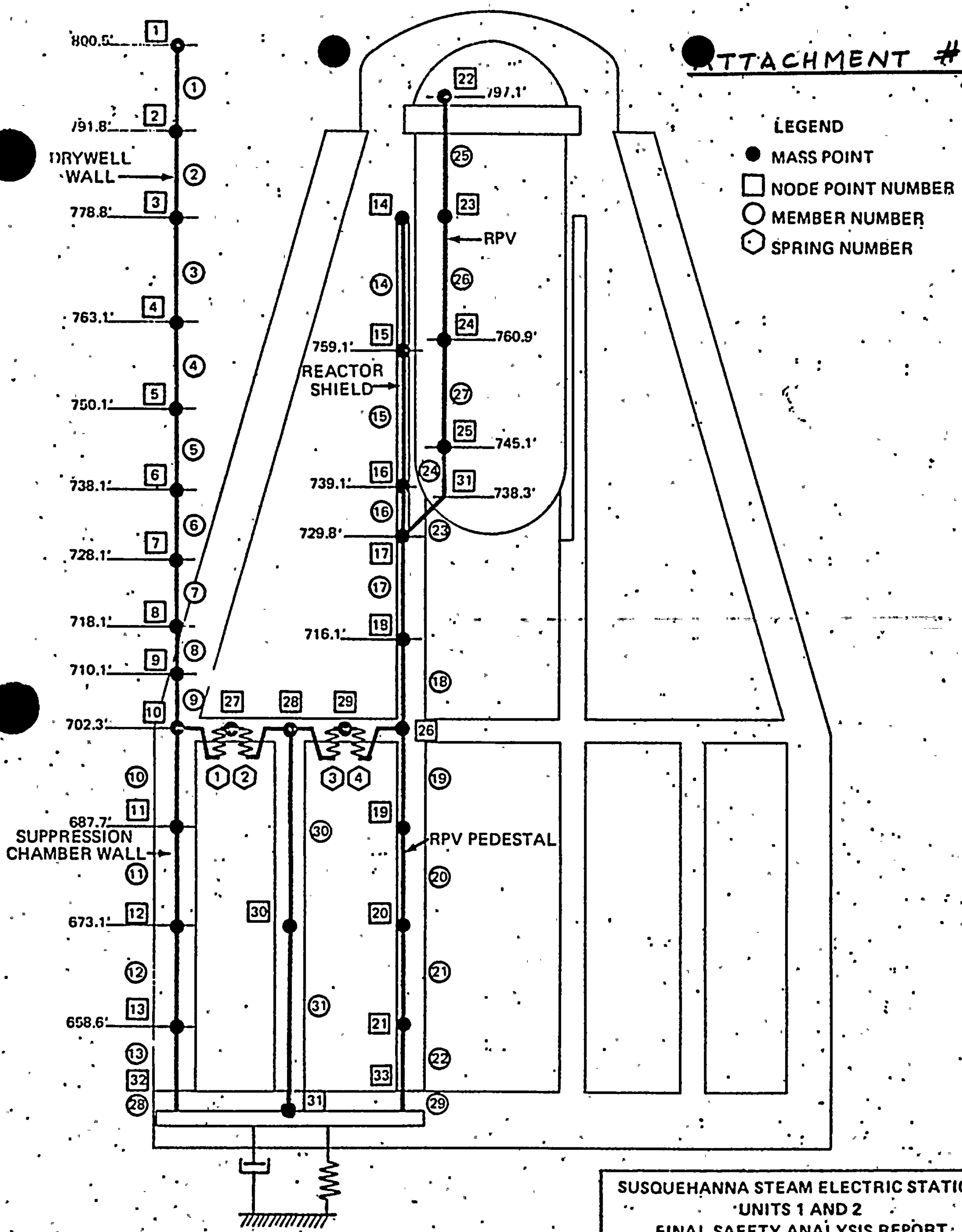
Table-4: CONTAINMENT: Axial Forces (SSE) (kips)
See Figure 3.7b-8 of FSAR, (Attachment #1)
for location of members.

Member #	Flexible Base				Fixed Base
	V_S = 6200 ft/sec.	$2V_S$	5Vs	$10V_S$	
1	14.5	21.8	22.2	21.9	21.9
2	84.7	127.5	130.0	127.7	127.8
3	239.9	360.7	367.7	360.8	361.1
4	412.2	617.9	629.1	617.0	617.6
5	576.5	860.7	874.9	857.7	858.4
6	734.5	1090.8	1106.6	1084.3	1085.1
7	866.9	1280.4	1296.1	1269.5	1270.3
8	991.5	1454.3	1468.5	1437.7	1438.4
9	1095.4	1595.9	1607.5	1573.1	1573.7
10	1319.0	1773.8	1774.7	1733.2	1733.2
11	1479.1	1968.3	1956.7	1909.4	1908.7
12	1611.6	2107.5	2078.2	2025.5	2024.0
13	1701.4	2177.3	2128.2	2071.5	2069.0
14	34.9	34.8	33.1	31.7	31.6
15	127.3	126.3	119.6	114.3	113.8
16	201.3	197.3	185.9	176.9	176.2
17	843.4	842.7	787.2	743.4	739.6
18	899.6	895.0	835.9	789.3	785.2
19	759.5	727.5	680.6	642.5	639.2
20	799.1	762.2	712.5	672.5	669.1

TABLE-4 (Cont'd)

Member #	Flexible Base				Fixed Base
	V_s = 6200 ft/sec.	$2V_s$	5Vs	$10V_s$	
21	829.5	786.9	734.8	693.5	689.9
22	845.3	797.2	743.3	701.5	697.8
23	602.9	611.5	571.5	540.0	537.3
24	602.9	611.5	571.5	540.0	537.3
25	76.9	78.2	73.2	69.3	68.9
26	234.2	238.4	223.1	211.0	209.9
27	418.5	426.1	398.4	376.6	374.7
28	1701.3	2177.3	2128.2	2071.5	2069.0
29	845.3	797.2	743.3	701.5	697.8
30	83.2	82.6	80.9	77.1	77.5

ATTACHMENT #1.



SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 AND 2
FINAL SAFETY ANALYSIS REPORT

VERTICAL SEISMIC
MODEL OF CONTAINMENT
WITH FLEXIBLE BASE

FIGURE 3.7b-8

SUSQUEHANNA SES UNIT 1 AND 2
DOCKET NUMBERS 50-387 AND 50-388
CATEGORY I MASONRY WALLS

PREAMBLE:

Safety related masonry walls are interior partitions whose primary function is to provide shielding and fire protection. Masonry walls are not used as primary shear walls for seismic resistance of the structure. All category I masonry walls are reinforced with all cells fully grouted. The infill material of double wythe walls is either grout or concrete. The minimum specified compressive strength for grout, concrete, and mortar is 2500 psi. Mortar infill is not used on SSES masonry walls. Metal ties, between the wythes of double wythe walls, are provided at 24" spacing maximum in horizontal and vertical directions. Seismic design is in accordance with SSES FSAR Section 3.7. Allowable stresses are as noted in FSAR Section 3.8, Table 3.8-8 and Table 3.8-9. Safety related masonry walls are Q-listed and have been added to the FSAR Design Criteria Summary (Table 3.2-1), in response to NRC, Quality Assurance Branch, Question No. 260.1-b (34).

QUESTION NO. 1:

In your response to Question 2, you indicated that Sm is the allowable stress as specified in UBC. For extreme and/or abnormal loading combinations, you increase the allowable stress by a factor of 1.67, which is in conformance with the practice of SRP Sections 3.8.3 and 3.8.4, for reinforced concrete structures. However, concrete masonry walls are quite different from reinforced concrete walls, particularly the unreinforced ones, the use of such a practice may not result in an adequate design. Depending on the types of stress, that is, tensile, shearing or axial compressive, the factor may vary from 0 to 2.5 (see enclosure 2). Specify the masonry design strength f'_m used in Susquehanna masonry walls and the allowable values for all types of stresses.

RESPONSE:

Code allowable stresses for masonry tension, shear, compression, and bond are increased by a factor of 1.67 for load combinations involving abnormal and/or extreme environmental conditions which are credible but highly improbable. Since code allowable stresses are generally associated with a factor of safety of 3, the 1.67 increase provides a factor of safety against failure of 1.8 (3 ÷ 1.67) (see Table 4 for the increase allowed for each type of stress). There are no unreinforced masonry walls on SSES project. Susquehanna SES masonry walls are designed based on an ultimate compressive strength, f'_m, of 1500 psi as specified in UBC 1976, for solid grouted hollow masonry. Minimum compressive strength at 28 days for mortar, grout, and concrete is 2500 psi. Materials are in accordance with FSAR Appendix 3.8C. The allowable stresses are as listed in Table 1.

TABLE 1.

SSES ALLOWABLE STRESSES

Materials and Stress Type	Allowable Stress: UBC - 1976 (1) psi
1. **Masonry:**	$f'_m = 1500$ (see note 2)
Compression:	
Flexural	$.33f'_m = 500$
Axial	$.20f'_m \times (1-(h/40t)^3)$ h = clear height, in. t = wall thickness, in.
Flexural Shear	$1.1 \sqrt{f'_m} = 43$
Bond (deformed bars)	140
Bearing	$.25f'_m = 375$
Bed Joint tension	
Normal	(See note 3)
Parallel	25
Modulus of elasticity, E_m	$1000f'_m = 1{,}500{,}000$
Modulus of rigidity, E_v	$400f'_m = 600{,}000$
2. **Reinforcement:**	
Tension:	
Grade 40 Steel	20,000 (used for ties only)
Grade 60 Steel	24,000
Compression:	
Grade 40 Steel	16,000 (used for ties only)
Grade 60 Steel	24,000

Notes:
(1) For stress increase allowed for abnormal, or extreme environmental load combinations - See Table 4.

(2) Ultimate compressive strength as specified in UBC - 1976 for solid grouted hollow concrete units - Grade N.

(3) Zero tension normal to bed joint is used.

QUESTION NO. 2

In the note to your response to Question 2, you stated that the allowable shear or tension between masonry block and concrete or grout infill is considered to be equal to three percent of the compressive strength of the block. The allowable shear or tension as specified by you is in the staff's opinion too high. To specify the allowable shear or tension of the vertical joint between wythes in terms of the compression strength of the block is in the first place unconservative and the use of seemingly low percentage of 3% may actually result in an allowable shearing stress greater than its corresponding strength. Therefore, a revision of the stress criterion is required.

RESPONSE:

The specified shear and tension, for the interface of masonry block and concrete or grout infill, of three percent of compressive strength, f'_m, is based on the relationship $1.1\sqrt{f'_m}$ given in ACI-531-79. For $f'_m = 1500$ psi, this relationship yields a value of 43 psi compared to 45 psi (.03 x 1500) allowed for evaluation of project masonry walls. The difference of 2 psi is justified by the fact that the ultimate compressive strength of masonry f'_m, is generally higher than 1500 psi.

The values for shear and tension as specified above have been used only as a guide in evaluating double wythe walls, where infill thickness is greater than 8 inches (24" thick walls and larger). For walls having an infill thickness of less than 8 inches (total of four walls), zero tension/shear is assumed for evaluation purposes.

For SSES masonry walls, the actual shear stress, as determined by VQ/Ib for uncracked sections, and in the compression zone of cracked sections ranges from 5-10 psi; except for three walls. For these three walls shearing stress is in the range of 10-15 psi.

QUESTION NO. 3

In your response to Question 4: (1) It is indicated that response spectrum method is used for the dynamic analysis of the concrete masonry walls. However, there is no mention as to which of the response spectra is used, upper floor or lower floor response spectrum or the average of the two. It is required that an upper bound envelope of the individual floor is used. (2) Though the use of ACI 318 formula the cracking of concrete masonry wall is considered. The use of such a formula is questionable in view of the fact that in a concrete masonry wall the weakest section is the bed joint and the modulus of rupture is equal to that of neither the concrete block nor the mortar. Indicate how the modulus of rupture is established in your computation.

RESPONSE ITEM (1):

Response spectrum for the lower floor has been used for evaluation of cracked/uncracked behavior of masonry walls, as applicable, for vertical motion, and for walls cantilevered from the floor. For horizontal motion, the lower floor response spectrum has been used in the initial evaluation of cracked/uncracked behavior, as applicable, for walls spanning between two floors and walls having side connection at concrete walls. These walls have also been re-evaluated based on the average acceleration of the upper and lower floors. Where the upper floor acceleration is less than the lower floor acceleration, the lower floor acceleration is used. For justification of using average acceleration, see Enclosure 1.

RESPONSE ITEM (2):

Although ACI-318 formula is derived for cracked concrete sections, the use of the formula for masonry walls takes into consideration the difference in material strengths. The difference between masonry behavior and concrete behavior is recognized and allowances are provided in selection of seismic acceleration within a frequency variation of plus or minus fifteen percent of the natural frequency.

The modulus of rupture (f_r) for masonry is approximated by increasing the UBC allowable flexural tensile stress by a factor of safety of 3 and then applying a 33% reduction to arrive at a lower bound value. This value is used only for stiffness and frequency calculations of the cracked section and not for strength. Allowance for uncertainties in the modulus of rupture is accounted for in the frequency variation of ± 15% of the natural frequency.

QUESTION NO. 4:

In response to Question 5, it is stated that when the design stresses of masonry walls exceed the allowable stresses, fixes are designed such that the criteria is satisfied. Indicate the number of walls where such fixes are needed and provide examples.

RESPONSE:

The number of masonry walls requiring fixes for cracked section criteria is 36. Wall location, thickness, and elevation are as shown in Table 2. Typical fixes are shown in details type 1, type 2, type 3, and type 4 (see Enclosure 2).

TABLE 2

SSES - MASONRY WALLS
WALLS WHICH REQUIRED FIXES FOR CRACKED SECTION CRITERIA

BLDG.	FLOOR ELEVATION	WALL THICKNESS	NO. OF WALLS	REF. DWG.
Control	656'-0	8"	2	C-1301
Control	741'-0	6"	2	C-1304
Control	741'-0	8"	3	C-1304
Control	753'-0	8"	1	C-1304
Control	771'-0	8"	16	C-1304
Control	783'-0	1'-0"	3	C-1307
Control	806'-0	8"	3	C-1308
Control	806'-0	1'-0"	1	C-1308
Reactor	728'-0	8"	1	C-1202
Reactor	799'-0	8"	4	C-1205

QUESTION NO. 5:

Provide justification for any deviation from the attached staff's interim criteria in your design and analysis of the masonry walls.

RESPONSE:

Deviations and justification for differences between SSES criteria and SEB interim criteria are as noted in the following paragraphs.

Items which are not specifically addressed are in accordance with the criteria or not applicable to the project.

ITEM NO. 1: General Requirments

The materials, testing, analysis, design, construction and inspection related to the design and construction of safety-related concrete masonry walls shall conform to the applicable requirements contained in Uniform Building Code - 1979, unless specified otherwise, by the provisions in this criteria.

RESPONSE:

Uniform Building Code, 1976 edition, has been used for design and evaluation of Susquehanna masonry walls. A comparison of 1976 and 1979 editions of UBC shows no significant difference in criteria applicable to SSES masonry walls. In addition, ACI-531-79 is used to supplement UBC allowable stresses, and ACI-318 1977 in stiffness calculations.

ITEM NO. 2: Loads and Load Combinations

The loads and load combinations shall include consideration of normal loads, severe environmental load, extreme environmental load, and abnormal loads. Specifically, for operating plants, the load combinations provided in plant's FSAR shall govern. For operating license applications, the following load combinations shall apply for definition of load terms, (see SRP Section 3.8.4.11-3).

RESPONSE:

For comparison of SEB interim load combinations and load combinations used for masonry walls evaluation see Table 3. Definition of terms is as shown below.

Notation

D = Dead load of structure plus any other permanent loads contributing stress.

L = Live loads expected to be present when the plant is operating, including movable equipment, piping, cables.

P = Design basis accident pressure loads.

R = Steam/water jet forces or reactions resulting from rupture of process piping.

T_o = Thermal effects during normal operating conditions including temperature gradient and equipment and pipe reactions.

H_o = Force on structure due to thermal expansion of pipes under operating conditions.

T_a = Added thermal effects (over and above operating thermal effects) which occur during a design accident.

H_a = Force on structure due to thermal expansion of pipes under accident conditions.

E = Load due to Operating Basis Earthquake.

E' = Load due to Design Basis Earthquake.

W = Wind load.

W' = Tornado wind load.

D_s = Force on blockwall due to story drift under Operating Basis Earthquake Loading.

D'_s = Force on blockwall due to story drift under Safe Shutdown Earthquake Loading.

TABLE 3. - LOAD COMBINATION COMPARISON

LOAD COMBINATION	SEB INTERIM CRITERIA	SSES FSAR CRITERIA	COMMENTS
Service Load Condition	1. $D + L$	1. $D + L$	
	2. $D + L + E$	2. $D + L + E + D_s$	
	3. $D + L + W$	3. Not Applicable	No wind pressure
	1a. $D + L + T_o + R_o$	1a. $D + L + T_o + H_o$	
	2a. $D + L + T_o + R_o + E$	2a. $D + L + T_o + H_o + E$	
	3a. $D + L + T_o + R_o + W$	3a. Not Applicable	No wind pressure
Extreme environmental	4. $D + L + T_o + R_o + E'$	4. $D + L + T_o + H_o + E' + D'_s$	
	5. $D + L + T_o + R_o + W_t$	5. $D + L + T_o + H_o + W'$	See note 2
abnormal	6. $D + L + T_a + R_a + 1.5\ P_a$	6. $D + L + (T_o + T_a) + R + 1.25\ P_a + H_a$	See note 1
abnormal/severe environmental	7. $D + L + T_a + 1.25\ P_a + 1.0\ (Y_r + Y_j + Y_m) + 1.25E + R_a$	7. $D + L + (T_o + T_a) + 1.25\ P_a + R + 1.25\ E + D_s$	
abnormal/ extreme environmental conditions	8. $D + L + T_a + R_a + 1.0\ P + 1.0\ (Y_r + Y_j + Y_m) + 1.0E'$	8. $D + L + (T_o + T_a) + R + 1.0\ P + 1.0\ E' + D'_s$	

Notes: (1) Abnormal load combination in SSES-FSAR Table 3.8-9. Part C will be revised to read $D + L + (T_o + T_a) + R + 1.5\ P_a + H_o$. All other load combinations will remain unchanged.

(2) W' does not include W_m, tornado missile. Masonry walls are not used for protection of safety related equipment against tornado missiles.

ITEM NO. 3: Allowable Stresses

Allowable stresses provided in chapter 24 of UBC-79, as supplemented by the following modifications/exceptions shall apply.

(a) When wind or seismic loads (OBE) are considered in the loading combinations, no increase in the allowable stresses are permitted.

RESPONSE:

Design and evaluation of masonry walls is based on a 33% increase in the allowable stress. This increase is permissible per UBC, 1979 and per ACI-531-79. The factor is also compatible with the 25% increase in stress noted in SSES FSAR for Working Stress Design Method.

ITEM NO. 3: (b) Use of allowable stresses corresponding to special inspection category shall be substantiated by demonstration of compliance with the inspection requirements of the NRC criteria.

RESPONSE:

Stresses corresponding to special inspection have been used in the design and evaluation of SSES masonry walls. Inspection required to assure that masonry construction is in accordance with Appendix "D" and amendments to the PSAR, and to assure that materials are in accordance with FSAR Appendix 3.8C is implemented. Documentation of this inspection is in project jobsite files.

ITEM NO. 3: (c) For load conditions, which represent extreme environmental, abnormal, abnormal/severe environmental, and abnormal/extreme environmental conditions the allowable working stresses may be multiplied by the factors shown in the following table: (See table 4).

TABLE 4.

STRESS INCREASE FACTOR COMPARISON

	SEB	SSES	
	FACTOR	FACTOR	JUSTIFICATION/COMMENT
Axial or flexural compression	2.5	1.67	See Response Question #1
Bearing	2.5	1.67	"
Reinforcement stress except shear	2.0	1.67	See note 1
Shear Reinforcement and/or bolts	1.5	1.5	Anchor bolts are not used in safety related masonry walls
Masonry tension Parallel to bed joint	1.5	1.5	
Shear carried by masonry	1.0	1.67	See note 2
Masonry tension perpendicular to bed joint			
For reinforced masonry	0	0	
For unreinforced masonry	1.0	N/A	No unreinforced masonry walls

(1) Shall not exceed .90 fy

(2) The actual shear stress carried by masonry is within the allowable shear stress given in UBC Table 24-H with no increase factor applied.

RESPONSE:

See table above.

QUESTION NO. 5: Design and Analysis Considerations

ITEM 4g:

In new construction, no unreinforced masonry wall is permitted, also all grout in concrete masonry walls shall be compacted by vibration.

RESPONSE:

a. There are no unreinforced masonry walls in SSES project.

b. Cell grout and/or infill grout or concrete is compacted by either mechanical vibrators or by rodding.

ITEM 4i:

Special constructions (e.g., multiwythe, composite) or other items not covered by the code shall be reviewed on a case by case basis for their acceptance.

RESPONSE:

Double wythe walls are designed as composite sections, except as noted in response to Question No. 2. Allowable stresses are per ACI-531-79.

ITEM 4j:

Licensees or applicants shall submit QA/QC information, if available, for staff's review.

RESPONSE:

Applicable QA/QC information is available at SSES jobsite and will be submitted upon request.

ENCLOSURE 1.

JUSTIFICATION FOR THE USE OF

AVERAGE RESPONSE SPECTRA

(13 PAGES)

JUSTIFICATION OF USING APPROXIMATION METHOD TO DETERMINE MAXIMUM WALL PANEL RESPONSES TO SEISMIC MOTION

The evaluations herein demonstrate that: (1) The use of the average floor acceleration response spectra to calculate the response of the wall panel is appropriate, and (2) The use of uniform inertia load with magnitude equal to the average spectral acceleration for the fundamental mode, in calculating the maximum seismic responses is a good approximation, even considering the higher mode effect.

For the purposes of this evaluation, the seismic response of a simply-supported, uniform beam simulating a strip of the wall panel with unit width is considered, as shown in Figure 1.

(1) Use of Average Spectra

The equation of motion of an undamped, simply-supported beam can be written in terms of the total displacement with respect to some fixed reference axis as:

$$m \frac{\partial^2 u}{\partial t^2} + EI \frac{\partial^4 u}{\partial x^4} = 0 \qquad (1)$$

Where m and EI are the mass density and flexural rigidity of the beam. Denote the seismic excitations at the ends of the

EC-9

the beam as U_a and U_b. Then the total displacement u(x,t) can be expressed in terms of the two seismic motions and the relative displacement to the seismic motions as:

$$u(x,t) = (x/L) \ U_b + (1 - x/L) \ U_a + r(x,t) \tag{2}$$

Where L is the length of the beam. The relation expressed by the above equation is shown in Figure 2. The relative displacement r(x,t) needs to satisfy the following simply-supported conditions:

$$r(o,t) = r(L,t) = 0 \tag{3}$$

$$\left.\frac{\partial^2 r}{\partial x^2}\right|_{x=o} = \left.\frac{\partial^2 r}{\partial x^2}\right|_{x=L} = 0 \tag{4}$$

Substitute Equation 2 into Equation 1, the equation of motion in terms of relative displacement r(x,t) can be expressed as:

$$m\frac{\partial^2 r}{\partial t^2} + EI\frac{\partial^4 r}{\partial x^4} = - m(x/L) \ \ddot{U}_b - m(1 - x/L)\ddot{U}_a \tag{5}$$

The eigen-function solutions for the homogeneous equation associated with Equation 5 that satisfy the boundary conditions specified by Equations 3 and 4 are:

$$\sin \frac{n\pi x}{L} , \ n = 1, 2, 3, \ldots ,$$

and the corresponding frequencies of vibration are:

$$\omega_n = n^2 \pi^2 \sqrt{\frac{EI}{mL^4}} \qquad n = 1, 2, 3, \ldots \tag{6}$$

So, the solution of Equation 5 can be expressed as:

$$r(x,t) = \sum_{n=1}^{\infty} a_n(t) \sin \frac{n\pi x}{L} \tag{7}$$

Substitute Equation 7 into Equation 5, and multiply the latter by $\sin \frac{n\pi x}{L}$, and then integrate it with respect to x over the full length of the beam, the equation of motion can be transformed into modal equations of motion as:

$$\ddot{a}_n + \omega_n^2 a_n = \Gamma_n\left(\frac{\ddot{U}_a + \ddot{U}_b}{2}\right) \qquad n = 1, 3, 5, \cdots \tag{8a}$$

and

$$\ddot{a}_n + \omega_n^2 a_n = \Gamma_n\left(\frac{\ddot{U}_a - \ddot{U}_b}{2}\right) \qquad n = 2, 4, 6, \cdots \tag{8b}$$

where Γ_n = participation factor

$$= \frac{4}{n\pi} \tag{9}$$

If damping in the form of modal damping ratio is included, Equations 8a and 8b becomes:

$$\ddot{a}_n + 2\xi_n\omega_n\dot{a}_n + \omega_n^2 a_n = \Gamma_n\left(\frac{\ddot{U}_a + \ddot{U}_b}{2}\right) \qquad n = 1,3,5,... \tag{10a}$$

and

$$\ddot{a}_n + 2\xi_n\omega_n\dot{a}_n + \omega_n^2 a_n = \Gamma_n\left(\frac{\ddot{U}_a - \ddot{U}_b}{2}\right) \qquad n = 2,4,6,... \tag{10b}$$

Where ξ_n is the damping ratio of the nth mode.

Equation 10a means that the odd-number modes which are symmetrical about the mid-span of the beam will be excited by the average of the two seismic excitations; while equation 10b means that the even-number modes which are antisymmetrical about the mid-span of the beam will be excited by half of the difference between the two seismic excitations.

Expressing the maximum modal displacement response in equations 10a and 10b in terms of absolute acceleration response spectra gives:

$$|a_n|_{max} \leqslant |\Gamma_n| \left[\frac{S_a(\xi_n, \omega_n)}{2\omega_n^2} + \frac{S_b(\xi_n, \omega_n)}{2\omega_n^2} \right]$$

$$< \frac{4mL^4}{n^5 \pi^5 EI} \left[\frac{S_a(\xi_n, \omega_n) + S_b(\xi_n, \omega_n)}{2} \right] \qquad (11)$$

$$n = 1,2,3,\ldots$$

This illustrates that the use of the average of two floor acceleration response spectra to calculate the modal response of a wall panel is appropriate.

(2) Contribution of Higher Modes

From Equation 11, the relative importance of modes can be evaluated by examining the frequency ratios, modal participation ratios, and maximum modal response ratios for constant acceleration which can be shown as:

$$\omega_1 : \omega_2 : \omega_3 : \ldots = 1 : 4 : 9 : \ldots \qquad (12)$$

$$\Gamma_1 : \Gamma_2 : \Gamma_3 : \ldots = 1 : -1/2 : 1/3 : \ldots \qquad (13)$$

$$\frac{\Gamma_1}{\omega^2{}_1} : \frac{\Gamma_2}{\omega^2{}_2} : \frac{\Gamma_3}{\omega^2{}_3} : \ldots = 1 : -\frac{1}{32} : \frac{1}{243} : \ldots \qquad (14)$$

For an SRSS method of combining maximum response, the contribution of higher modes is clearly negligible.

If for example, the fundamental frequency ω_1 is above 8 H_z, the second frequency is above 32 H_z which is already in the rigid range, i.e., in the range of no amplification. Thus the S_a and S_b values associated with modes other than the fundamental will be the Zero-Period-Acceleration (ZPA) values of the two seismic motions U_a and U_b. Using the absolute sum (ABS) method of combining the modal maximum responses In this case, the contribution of higher modes is not more than 4% of the fundamental mode.

The relative importance of modes can also be evaluated by examining the moment and shear responses in the beam for each mode, as shown in the following.

The moment in the beam due to the n^{th} mode can be evaluated by:

$$M_n(X) = EI \frac{\partial^2}{\partial X^2} \left[a_n \sin \left(\frac{n\pi X}{L} \right) \right]$$

$$< \frac{4mL^2}{n^3\pi^3} \left[\frac{S_a(\xi_n, \omega_n) + S_b(\xi_n, \omega_n)}{2} \right] \sin \left(\frac{n\pi X}{L} \right) \tag{15}$$

$$n = 1,2,3,...$$

The moment at the mid-span of the beam is contributed only by the symetrical modes and can be expressed as follows:

$$M_n\left(\frac{L}{2}\right) < \frac{4mL^2}{n^3\pi^3} \left[\frac{S_a(\xi_n, \omega_n) + S_b(\xi_n, \omega_n)}{2} \right] \tag{16}$$

$$n = 1,3,5,...$$

For a constant spectral acceleration, the contibution to the mid-span moment of the beam from each mode can be expressed in the following ratio:

$$M_1\left(\frac{L}{2}\right) : M_3\left(\frac{L}{2}\right) : M_5\left(\frac{L}{2}\right) : \cdots = 1 : \frac{1}{27} : \frac{1}{125} : \cdots \quad (17)$$

Using the SRSS Method of combining modal responses, the contribution of the higher modes to the mid-span moment is less than 1% of that from the fundamental modes. Using the ABS method of combining modal responses, the contribution of higher modes is less than about 5%.

The shear force in the beam due to the n^{th} mode can be evaluated as:

$$Q_n(X) = EI \frac{\partial^3}{\partial X^3}\left[a_n \sin\left(\frac{n\pi X}{L}\right)\right]$$

$$< \frac{4mL}{n^2\pi^2}\left[\frac{S_a(\xi_n,\omega_n) + S_b(\xi_n,\omega_n)}{2}\right]\cos\left(\frac{n\pi X}{L}\right) \quad (18)$$

$$n = 1,2,3,4,\ldots$$

The maximum shear occurs at the support of the beam and can be expressed as:

$$Q_n(0) < \frac{4mL}{n^2\pi^2} \left[\frac{S_a(\xi_n,\omega_n) + S_b(\xi_n,\omega_n)}{2} \right] \quad (19)$$

$$n = 1,2,3,4,...$$

The contribution of the higher modes to the maximum shear at the beam support relative to that of the fundamental mode can be evaluated by comparing the modal effective masses (MEM) associated with the fundamental mode and the higher modes. The modal effective mass of the fundamental mode is

$$MEM_1 = \frac{8mL}{\pi^2} = 0.81\ mL \quad (20a)$$

The modal effective mass associated with modes higher than the fundamental mode can be calculated as

$$MEM'_1 = (1 - 0.81)mL = 0.19\ mL \quad (20b)$$

The ratio of MEM'_1 TO MEM_1 is 0.19/0.81 = 23%. That is the contribution of higher modes to the maximum shear is at most 23% of the contribution due to the fundamental mode. This ratio does not take into account the ratio of the spectral acceleration for the fundamental mode to the ZPA value for the higher modes. When the difference in spectral accelerations is accounted for, the contribution of higher modes to the maximum shear would be less than 23%. For example, if the spectral acceleration for the fundamental mode is 1.5 ZPA, then the ratio of higher mode contribution would be 0.19/(0.81 x 1.5) = 16%.

(3) Uniform Inertia Load Approximation

Using the modal responses, the maximum moment and shear of the beam can be calculated. This moment and shear can then be compared to the moment and shear based on a uniform inertia load using the average of the two floor spectral accelerations at the fundamental mode of the beam.

The maximum moment occured at the mid-span of the beam induced by a uniform load with the following magnitude:

$$f(X) = m\left[\frac{S_a\ (\xi_1,\omega_1)\ +\ S_b\ (\xi_1,\omega_1)}{2}\right] \qquad (21)$$

can be expressed as:

$$M^*\left(\frac{L}{2}\right) = \frac{mL^2}{8}\left[\frac{S_a\ (\xi_1,\omega_1)\ +\ S_b\ (\xi_1,\omega_1)}{2}\right] \qquad (22)$$

From Equation 16, the moment at the mid-span of the beam due to the fundamental mode is:

$$M_1\left(\frac{L}{2}\right) < \frac{4mL^2}{\pi^3} \left[\frac{S_a\ (\xi_1,\omega_1) + S_b\ (\xi_1,\omega_1)}{2}\right] \qquad (23)$$

The maximum difference between the moments from Equations 22 and 23 is about 3%.

The maximum shear occurred at the support of the beam induced by the uniform load expressed in Equation 21, can be written as:

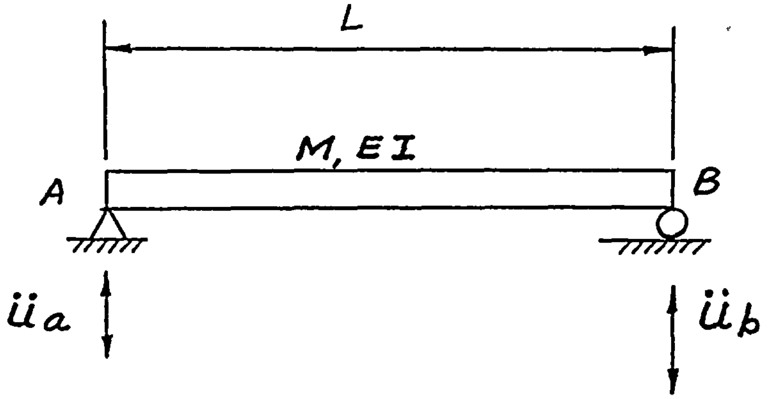
$$Q^*(0) = \frac{mL}{2} \left[\frac{S_a\ (\xi_1,\omega_1) + S_b\ (\xi_1,\omega_1)}{2}\right] \qquad (24)$$

From Equation 19, the shear at the support of the beam due to the fundamental mode is:

$$Q_1(0) < \frac{4mL}{\pi^2} \left[\frac{S_a\ (\xi_1,\omega_1) + S_b\ (\xi_1,\omega_1)}{2}\right] \qquad (25)$$

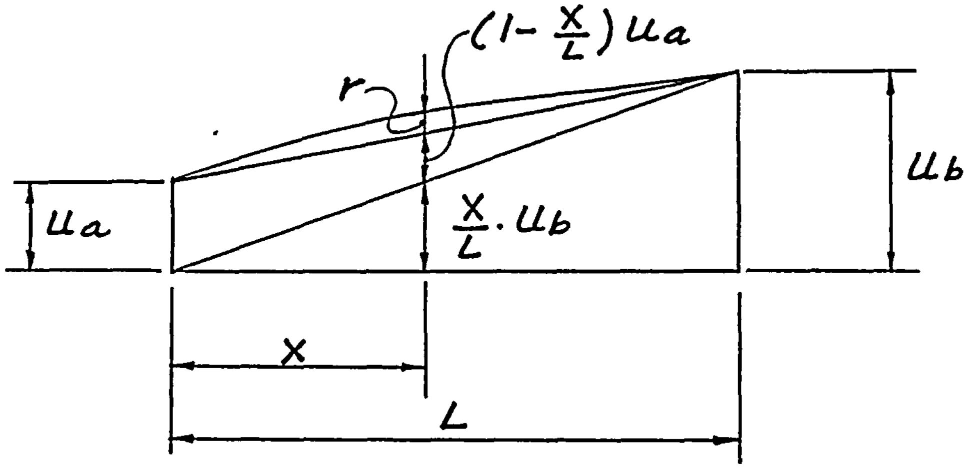
The shear from Equation 24 is greater than the shear from Equation 25 by about 25%. This margin can well cover the contribution to the shear due to the higher mode effect, as discussed previously.

From the above comparison, it can be concluded that the use of a uniform inertia load with the magnitude of the averaged floor spectral acceleration at the fundamental mode, provides a good approximation for calculating the seismic response in the wall panel.



IDEALIZED SIMPLY-SUPPORTED UNIFORM BEAM

FIGURE Nº 1



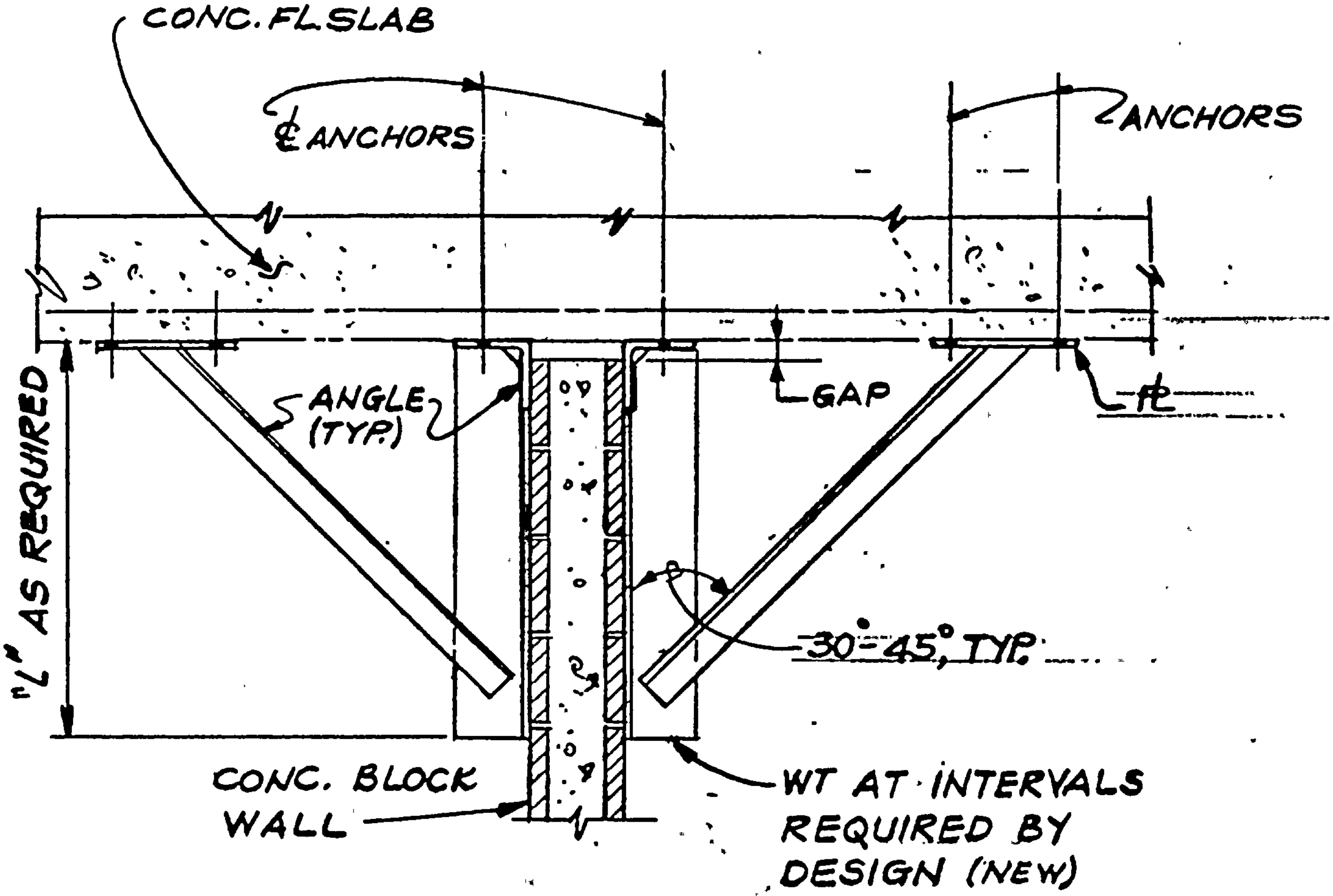
RELATION BETWEEN SEISMIC EXCITATION AND RELATIVE DISPLACEMENT

FIGURE Nº 2

ENCLOSURE 2

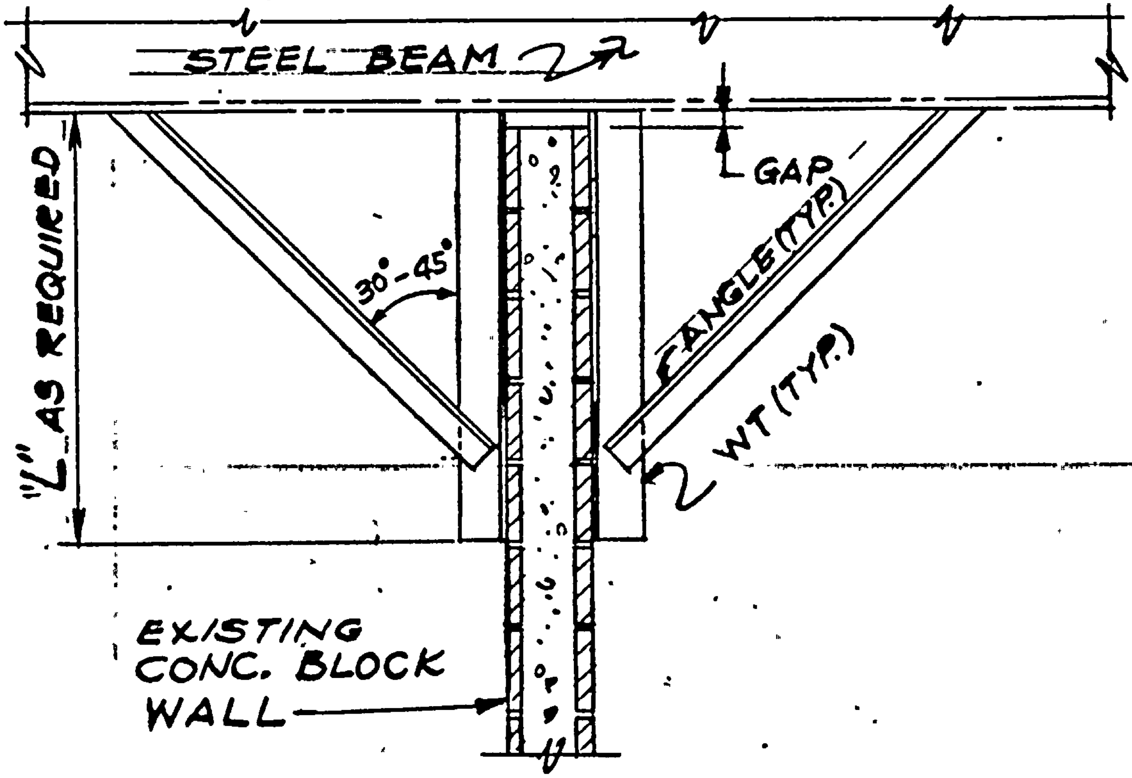
TYPICAL WALL FIXES

TYPE 1
TYPE 2
TYPE 3
TYPE 4



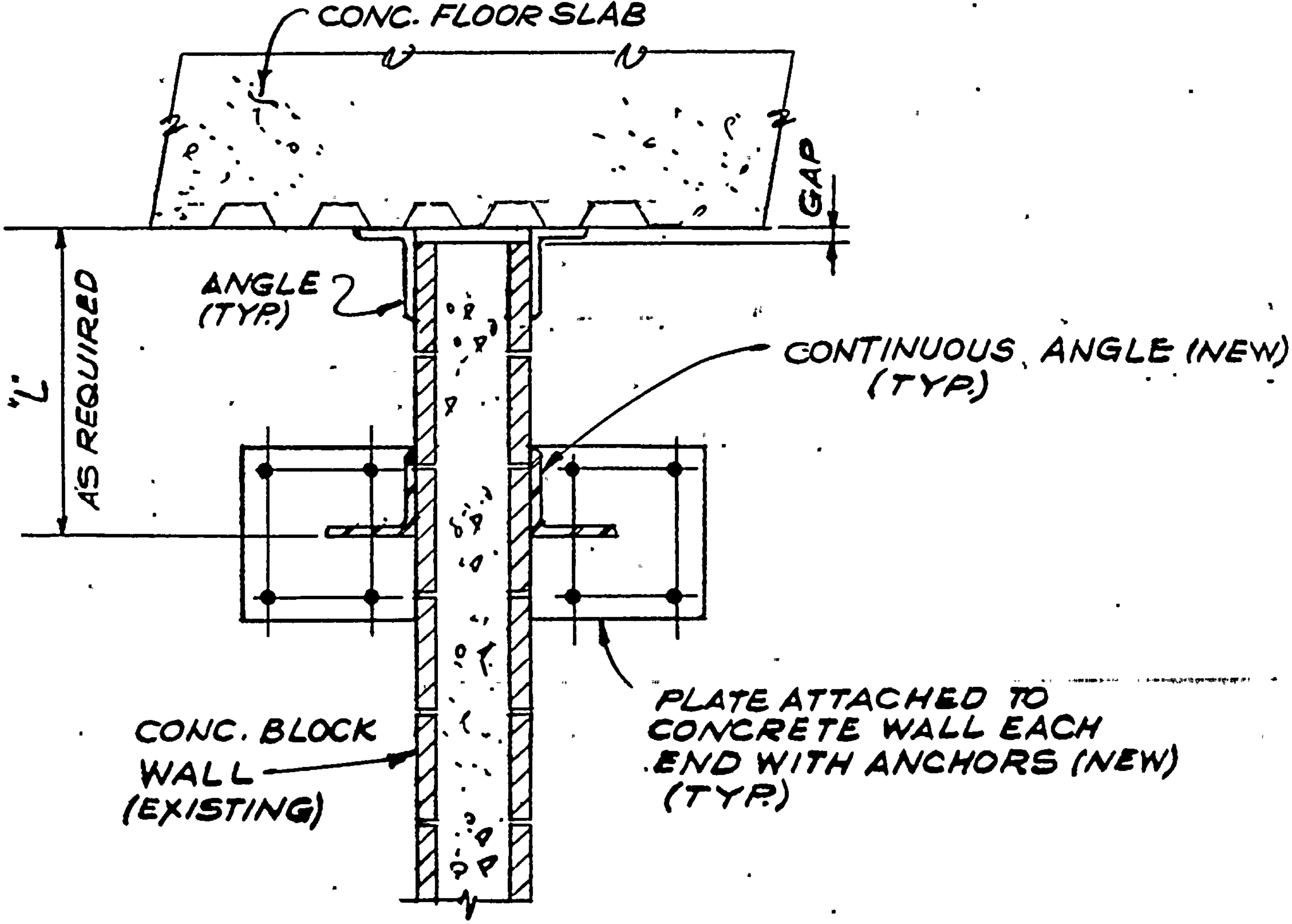
TYPE 1

ANGLE BRACING TO CONCRETE



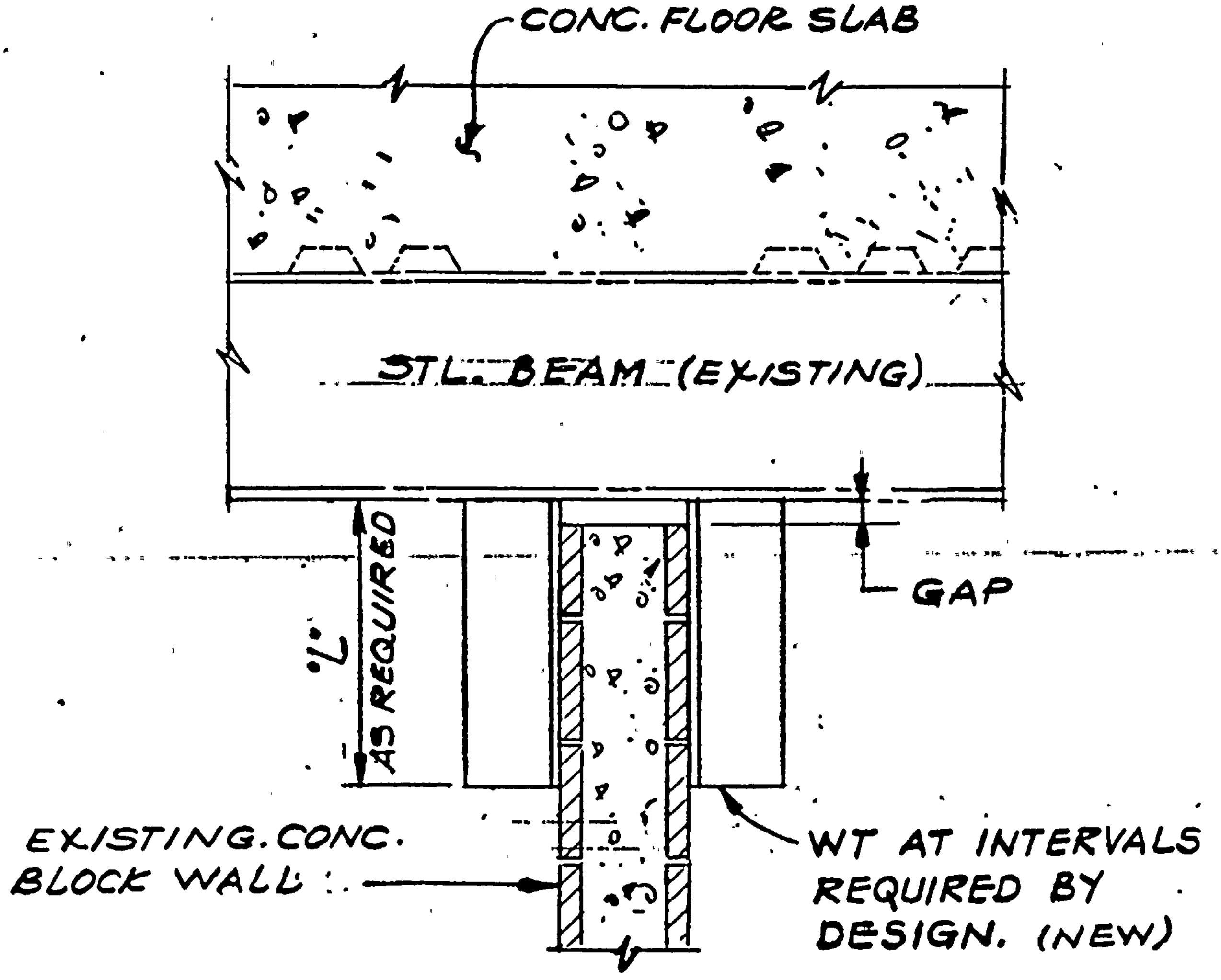
TYPE 2

ANGLE BRACING TO STEEL



TYPE 3

CONTINUOUS ANGLE



TYPE 4

INTERMITTENT SUPPORTS

CALCULATION COVER SHEET

OB NO. 8856

DISCIPLINE MECHANICAL

COVER SH. A OF A
CALC. NO. M152-7.
NO. OF SHEETS 10
Q NO. 5L.D

TITLE ALTERNATE SHUTDOWN COOLING

CALC. SHEET CONTROL:

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 ☐

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

SOURCES OF FORMULAE & REFERENCES
1) CORE SPRAY PUMP CALCS M 152-6, REV. 1
2) CRANE TECHNICAL PAPER No. 410, 1979 EDITION
3) CORE SPRAY PUMP PERFORMANCE CURVE 8856-M1-E21-30-1
4) GE CORE SPRAY PROCESS DIAGRAM 8856-M1-E21-15-2
5) CROSBY VALVE ENGINEERING AND CAPACITY DATA, CAT. #302, SUP. 1
6) PSV OUTLINE DWG. 8856-M1-B21-64-2

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

	4/23/81	J. J. Brunner /	David Yang	5/4/81	E Connell Jr	5/4/81
REV. NO.	DATE	CALCULATION BY	**CHECKED BY	DATE	APPROVED BY	DATE

*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)

CALCULATION SHEET

CALC. N M 162-7 REV. NO. 0

ORIGINATOR J. J. Brunner DATE 4/23/81 CHECKED Q. Yang DATE 5-4-81

PROJECT SUSQUEHANNA JOB NO. 8856

SUBJECT CORE SPRAY PUMPS IN ALTERNATE SHUTDOWN COOLING MODE 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 negleted because of large line diameter (12").

3. Friction losses in main steam piping are negligeable 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

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

ORIGINATOR J. J. Brunner DATE 4/23/81 CHECKED DATE 5-4-81

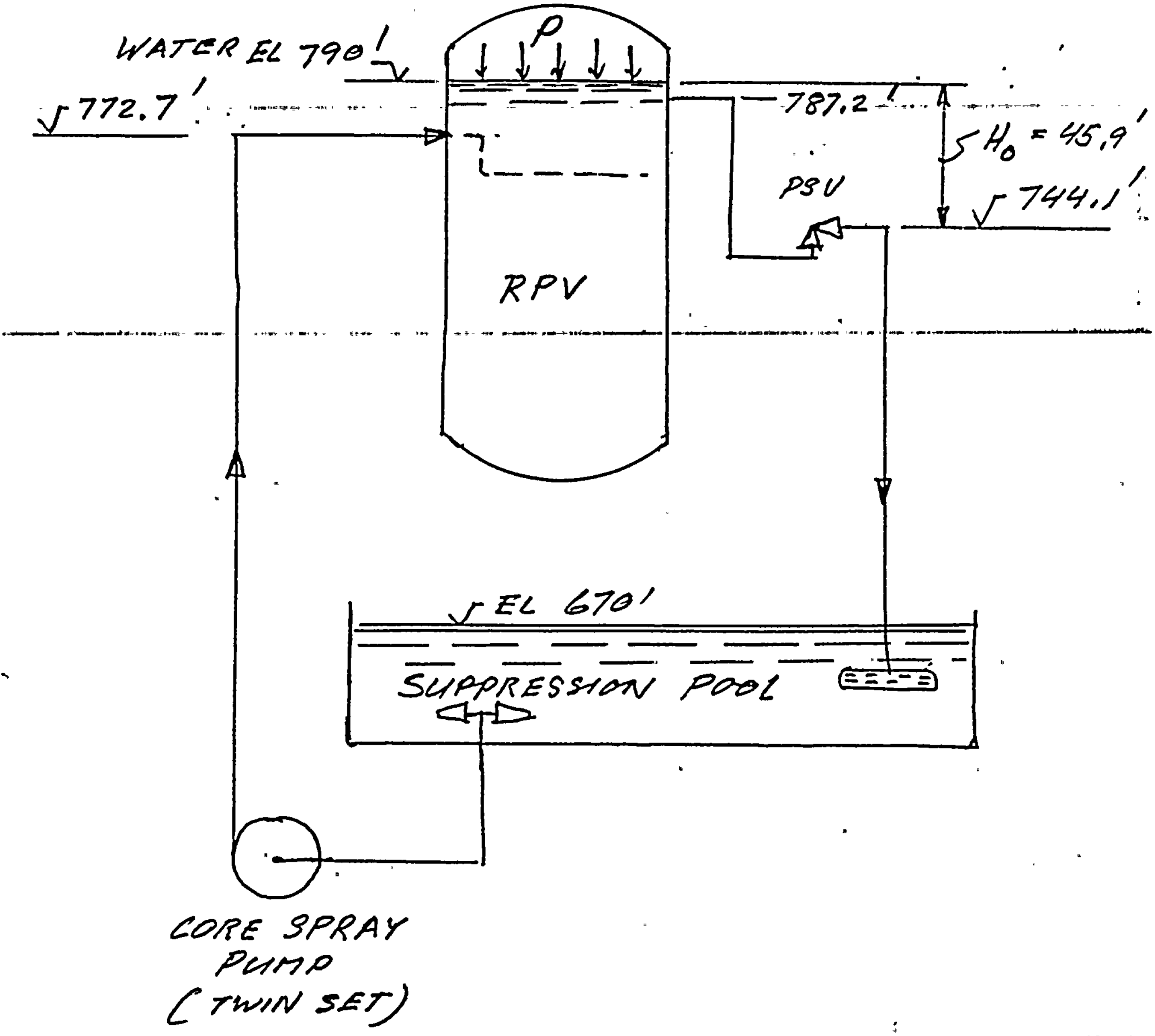
PROJECT SUSQUEHANNA JOB NO. 8856

SUBJECT Core Spray Pumps in Alt. Shutdown Cooling Mode SHEET NO. 2 OF 10

Use Core Spray Mode D

P_{RPV} = 105 psig (use 98 psig for shutdown coolg. initiation)
T_{RPV} = 332 °F
T_{pool} = 170 °F
P_{pool} = 14.7 psia } (Ref. 4)

Assume water level ~3 ft above M.S. nozzle ℄



CALCULATION SHEET

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

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

CHECKED DATE 5-4-81

PROJECT SUSQUEHANNA JOB NO. 8856

SUBJECT CORE SPRAY PUMPS IN ALTERNATE SHUTDOWN COOLING MODE SHEET NO. 3 of 10

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 ℄

$$H_S = 790' - 670' = 120'$$

Pressure Head

$$H_P = \frac{144}{\rho} \cdot P_{PSV} - H_0$$

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 = stat. head at PSV ℄ = 45.9' (see page 9)

Friction Head

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

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

Q_C (2 pumps) = 6350 gpm

H_{fc} = 277.3 ft

$$\boxed{H_T = H_S + \frac{144}{62.4}\left(\frac{Q}{C_V}\right)^2 - H_0 + \left(\frac{Q}{Q_C}\right)^2 \cdot H_{fc}}$$

RPV Pressure $= P_{PSV} - \frac{\rho}{144} \cdot H_0$

CALCULATION SHEET

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

ORIGINATOR J. J. Brunner DATE 4/23/81 CHECKED DWJ DATE 5-4-81

PROJECT SUSQUEHANNA JOB NO. 8856

SUBJECT Core Spray Pumps in Alternate Shutdown Mode SHEET NO. 4 of 10

ONE PSV IS OPEN

$C_V = 400.$

Q	2000	4000	6000	8000
H_s	120	120	120	120
$H_p = \frac{144}{62.4}\left(\frac{Q}{400}\right)^2 - 45.9$	11.8	184.9	473.3	877
$H_f = \left(Q/6350\right)^2 \times 277.3$	27.5	110	247.5	440
H_{tot}	159.3	414.9	840.8	1437

$C_V = 500$

H_s	120	120	120	120
$H_p = \frac{144}{62.4}\left(\frac{Q}{500}\right)^2 - 45.9$	−9.	101.8	286.	545
H_f	27.5	110	247.5	440
H_{tot}	N/A	331.8	653.5	1105

P_{RPV} with 1 PSV @ $C_V = 400$ $Q = 5{,}450$ gpm

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

P_{RPV} with 1 PSV @ $C_V = 500$ $Q = 6{,}130$ gpm

$$P = \frac{56.2}{144}\left[\frac{144}{62.4}\left(\frac{6{,}130}{500}\right)^2 - 45.9\right] = 117.4 \text{ psig}$$

CALCULATION SHEET

CALC. N M152-7 REV. NO. 0

ORIGINATOR J.J. Brummer DATE 4/23/81 CHECKED DATE 5-4-81

PROJECT SUSQUEHANNA JOB NO. 8856

SUBJECT Core Spray Pumps in Alternate Shutdown Cooling Mode SHEET NO. 5 of 10

TWO PSV OPEN

$C_V = 400$

Q_{TOTAL}	2000	4000	6000	8000
Q_{PSV}	1000	2000	3000	4000
H_S	120	120	120	120
$H_p = \frac{144}{62.4}\left(\frac{Q_V}{400}\right)^2 - 45.9$	−31.5	11.8	83.9	184.9
$H_f = (Q_T/6350)^2 \cdot 277.3$	27.5	110	247.5	440
H_{tot}	N/A	241.8	451.4	744.9

$C_V = 500$

H_S	120	120	120	120
$H_p = \frac{144}{62.4}\left(\frac{Q_V}{500}\right)^2 - 45.9$	−36.7	−9	37.2	101.8
$H_f = (Q_T/6350)^2 \cdot 277.3$	27.5	110	247.5	440
	N/A	N/A	404.7	661.8

P_{RPV} @ $C_V = 400$ $Q_{PSV} = 7,150/2 = 3,575$ gpm

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

P_{RPV} @ $C_V = 500$ $Q_{PSV} = 7420/2 = 3,710$ gpm

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

BECHTEL

CALCULATION SHEET

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

ORIGINATOR J. J. Brunner DATE 4/23/81 CHECKED Guy DATE 5-4-81

PROJECT Susquehanna JOB NO. 8856

SUBJECT Core Spray Pumps in Alternate Shutdown Cooling Mode SHEET NO. 6 of 10

THREE PSV OPEN

$C_V = 400$

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	83.9
$H_f = (Q_T/6350)^2 \cdot 277.3$	61.9	247.5	557.0
H_{tot}	N/A	379.3	760.9

$C_V = 500$

H_S	120	120
$H_P = \frac{144}{62.4}\left(\frac{Q_V}{500}\right)^2 - 45.9$	− 9	37.2
$H_f = (Q_T/6350)^2 \cdot 277.3$	247.8	557.
H_{tot}	N/A	714.2

P_{RPV} @ $C_V = 400$ $Q_{PSV} = 7600/3 = 2{,}533$ gpm

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

P_{RPV} @ $C_V = 500$ $Q_{PSV} = 7770/3 = 2{,}590$ 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

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

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

CHECKED DATE 5-4-81

PROJECT Susquehanna JOB NO. 8856

SUBJECT Core Spray Pumps in Alternate Shutdown Cooling Mode

SHEET NO. 7 of 10

FOUR PSV OPEN

$C_V = 400$

Q_{TOT}	6000	8000	9000
Q_V	1500	2000	2250
H_S	120	120	120
$H_P = \frac{144}{62.4}\left(\frac{Q}{400}\right)^2 - 45.9$	−13.4	11.8	27.1
$H_f = (Q_T/6350)^2 \cdot 277.3$	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	0.8
$H_f = (Q_T/6350)^2 \cdot 277.3$	440	557
H_{tot}	N/A	677.8

P_{RPV} @ $C_V = 400$ $\qquad Q_{PSV} = 7780/4 = 1945$ gpm

$$P_{RPV} = \frac{59.6}{144}\left[\frac{144}{62.4}\left(\frac{1945}{400}\right)^2 - 45.9\right] = 3.5 \text{ psig}$$

P_{RPV} @ $C_V = 500$ $\qquad Q_{PSV} = 7900/4 = 1975$ gpm

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

(NEG)

BECHTEL

CALCULATION SHEET

CALC. N M152-7 REV. NO. 0

ORIGINATOR J. J. Brunner DATE 4/23/81 CHECKED DATE 5-4-81

PROJECT SUSQUEHANNA JOB NO. 8856

SUBJECT CORE SPRAY PUMPS IN ALTERNATE SHUTDOWN COOLING MODE SHEET NO. 8 of 10

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

With 0 back pressure:

$$P_{PSV} = P_{RPV} + \frac{\rho H_0}{144} = 98 + \frac{56,2 \cdot 45,9}{144} = 115,9 \text{ psig}$$

Flow through PSV

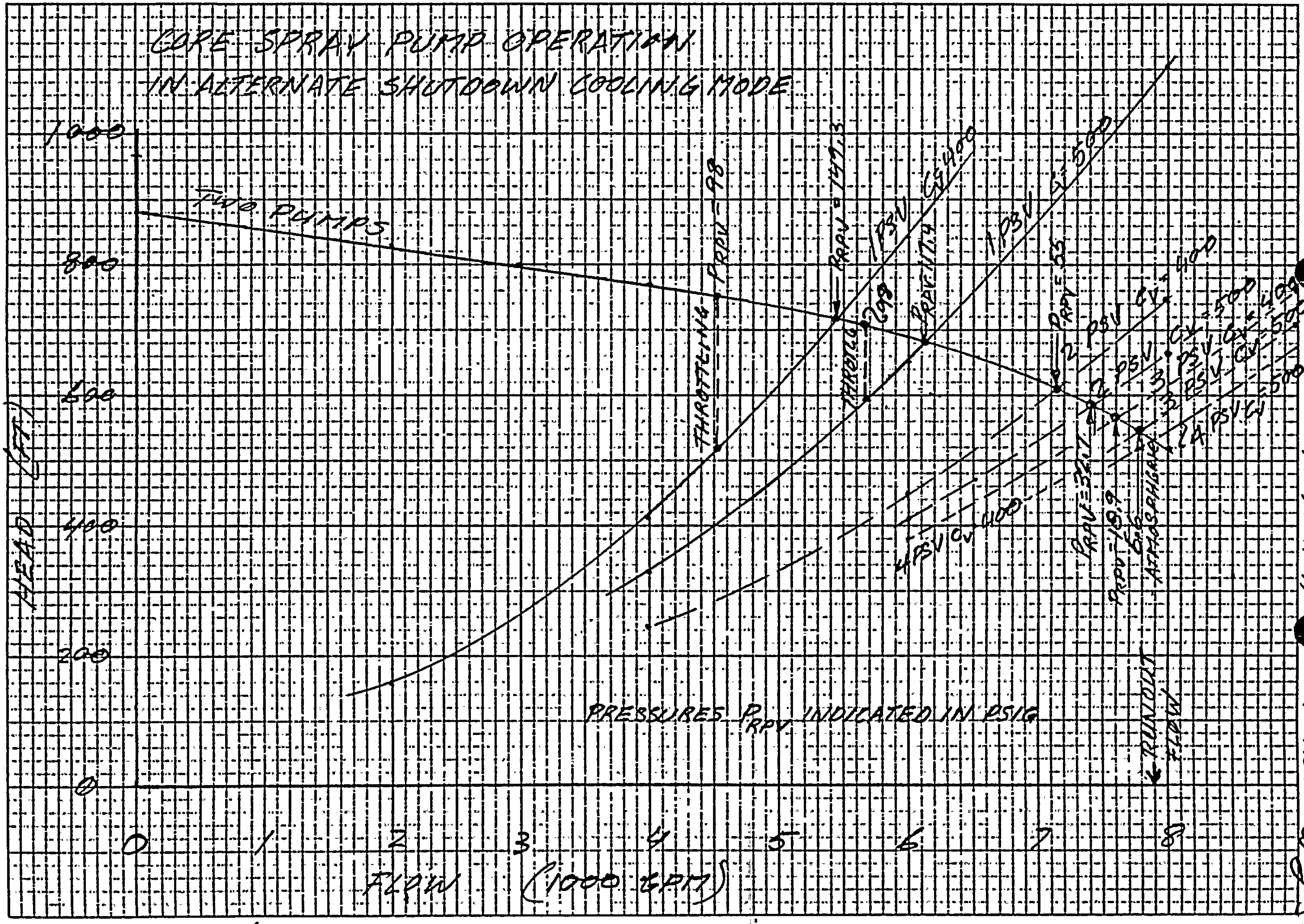
$$P_{PSV} = \frac{\rho}{62,4}\left(\frac{Q}{C_V}\right)^2$$

$$\therefore \quad Q = \left(P_{PSV}\,\frac{62,4}{\rho} \cdot C_V^2\right)^{0,5} = C_V \cdot \left(P_{PSV} \cdot \frac{62,4}{\rho}\right)^{0,5}$$

For $C_V = 400$: $Q = 400 \cdot \left(115,9 \cdot \frac{62,4}{56,2}\right)^{.5} = 4,528$

For $C_V = 500$: $Q = 500 \left(115.9 \cdot \frac{62,4}{56,2}\right)^{.5} = 5,660$ gpm

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



CALCS M152-7, REV 0

BY: 4/2/81 CHCK'D: 6-4-81

SHEET 9 OF 10

BECHTEL

CALCULATION SHEET

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

ORIGINATOR J.J. Brunner DATE 4/30/81 CHECKED DATE 5-4-81

PROJECT SUSQUEHANNA JOB NO. 8856

SUBJECT CORE SPRAY PUMPS IN ALTERNATE SHUTDOWN COOLING MODE SHEET NO. 10 OF 10

APPENDIX A

ESTIMATE OF VALVE FLOW COEFFICIENT C_V

Valve capacity (per Ref. 5 for liquid)

$$Q = 27.2\, C_A\, A\, K_{sg} \sqrt{\underbrace{P - P_b}_{\Delta p}}$$

(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 R10 HB-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:

$$435.2 \cancel{\sqrt{\Delta p}} = C_V \sqrt{\frac{62.4}{\rho}} \cancel{\sqrt{\Delta p}}$$

$$\therefore \quad \boxed{C_V = \frac{435.2}{\sqrt{\frac{62.4}{\rho}}}}$$

[illegible]t; $\rho = 59.8$ lb/ft3

P = 14.7 psia

T = 212°F

$$C_V = \frac{435.2}{\sqrt{\frac{62.4}{59.8}}} = 427$$

BECHTEL

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

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

JOB NO. 8856

DISCIPLINE MECHANICAL/NUCLEAR

TLE CORE SPRAY CALCULATIONS

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

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

OURCES 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-1:2 Rev 4, HCB-101-1 Rev 3, HCB-102-1 Rev 2, HCD-111-1 Rev 2, 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, BEKENY, "BASIC GUIDANCE TO AVOID CAVITATION OF ORIFICES & VALVES" JUNE 21, 1974.

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

	6/21/79	G.KALINAUSKAS / G. Kalinauskas		9/20/79	B.M. Jackson	8/21/79
	3/27/79	G.KALINAUSKAS / G. Kalinauskas	J C McC	3-30-79	B.M. Jackson	4/6/79
A	11/8/78	G.KALINAUSKAS / G. Kalinauskas	E. Connell	12-2-78	B.M. Jackson	1/2/79
REV. NO.	DATE	CALCULATION BY	**CHECKED BY	DATE	APPROVED BY	DATE

*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)

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

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 4.
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.

1	6/21/79	G. Kalinauskas				
0	3/27/79	G. Kalinauskas	J C McCague	3-30-79	B.M. Jackson	4/6/79
A	11/8/78	G. Kalinauskas	E. Connell	12-2-78	BM Jackson	1/2/79
REV			CHECKED BY	DATE	APPROVED BY	DATE

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
PENNSYLVANIA P & L JOB 8856 JOB NO. 8856

SUBJECT Core Spray Calculations SHEET NO. 79

8305929

SECTION 3

NPSH CALCULATIONS

MODE A

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

h_f (120°F)

TABLE A-1

NODE	EQ. LENGTH or Cv	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
	Cv = 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 F001B

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

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

$$\Delta P = 0.09 \text{ psi}$$

FOR PIPE + FITTINGS:

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

$$Re = 123.9\frac{dv\rho}{\mu} = 123.9\frac{(15.25)(11.14)(61.73)}{(0.51)} = 2.55\times10^6$$

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

$$\Delta P = 0.000216\frac{fL\rho Q^2}{d^5} = 0.000216\frac{(0.013)(136)(61.73)(6350)^2}{8.25\times10^5}$$

$$\Delta P = 1.15 \text{ psi}$$

CALCULATION SHEET

CALC. NO. 152-6 REV. NO. 1

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 PENNSYLVANIA P&L JOB 8856 SHEET NO. 80

2.1 - 2.2

FOR PIPE + FITTINGS:

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

$\Delta P = 0.30$ psi

2.1 - 3B

FOR PIPE + FITTINGS:

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

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

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

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

$\Delta P = 0.28$ psi

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

$h_f = 8.91$ ft

$Z_2 = 670'$ (min. water level in pool - assumed 1' below normal M-247 Rev 8) △1 5/9/79

$h_s = Z_2 - Z_1$

$Z_1 = 646' 10\,5/8''$ (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)

$$h_{vpa} = 1.692 \frac{\text{lb}}{\text{in}^2} \times \frac{1 \text{ ft}^3}{61.73 \text{ lb}} \times 144 \frac{\text{in}^2}{\text{ft}^2} = 3.95 \text{ ft}$$ (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

BECHTEL

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 JOB NO. 8856

PENNSYLVANIA P & L JOB 8856

SUBJECT CORE SPRAY CALCULATIONS SHEET NO. 81

MODE B

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

h_f

NODE	TABLE B·1 TABLE B·1 OR C_v	ΔP (psi)
ENTRANCE	62'	0.27
15-16	250'	1.10
	$C_v = 18,470$	0.21
	124'	1.72
	$C_v = 20,700$	0.16
	108'	1.63
2·1-2·2	136'	0.54
2·2-3B	127'	0.51

TOTAL ΔP = 6.14 psi

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

$$h_f = 14.20\ ft$$

$h_s = z_2 - z_1$ $z_2 = 673'\ 9''$ (outlet level from tank - ie HCB-1-2 Rev4)

$h_s = (673'9'' - 646'10\frac{5}{8}'')$ $z_1 = 646'\ 10\frac{5}{8}''$ (inlet level to pump - ie HBB-104-1 Rev6)

$h_s = 26.86 ft$

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

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

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

$$NPSHA = 26.86 - 14.20 + 33.16 - 0.84$$

$$NPSHA = 44.98\ ft.$$

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
PENNSYLVANIA P. & L. JOB 8856 JOB NO. 8856

SUBJECT CORE SPRAY CALCULATIONS 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	$\Delta P = 2$ 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

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

ORIGINATOR G. KALINAUSKAS DATE NOV 08 1978
CALC. NO. 152-6 REV. NO. 0
CHECKED ECC DATE 12-6-78
PROJECT SUSQUEHANNA STATION UNITS 1 & 2
PENNSYLVANIA P & L
JOB 8856
JOB NO. 8856
SUBJECT CORE SPRAY CALCULATIONS
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 - 38	127'	0.27
	TOTAL ΔP =	3.74 psi

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

$$h_f = 8.86 \text{ ft}$$

$$h_s = Z_2 - Z_1 \qquad Z_2 = 670' \text{ (as before)}$$

$$h_s = 23.11 \text{ ft} \qquad Z_1 = 646' 10\tfrac{5}{8}'' \text{ (as before)}$$

$$h_a (670') = 33.16 \text{ ft}$$

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

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

$$NPSHA = 23.11 - 8.86 + 33.16 - 14.19$$

$$NPSHA \cdot 33.22 \text{ ft}$$

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 ZCC DATE 12-2-78
PROJECT SUSQUEHANNA STATION UNITS 1 & 2 JOB NO. 8856
PENNSYLVANIA P & L
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	$\Delta P = 2$ 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

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

$$h_f = 8.88\ ft$$

$$h_s = Z_2 - Z_1 \qquad Z_2 = 670' \text{ (as before)}$$

$$h_s = 23.11\ ft \qquad Z_1 = 646'\ 10\tfrac{5}{8}'' \text{ (as before)}$$

$$h_a(670') = 33.16\ ft$$

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

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

$$NPSHA = 23.11 - 8.88 + 33.16 - 27.61$$

$$NPSHA = 19.78\ ft$$

$$NPSHR = 11\ ft. \quad \text{(ref 2)}$$

CALCULATION SHEET

ORIGINATOR G. KALINAUSKAS DATE NOV 08 1978
CALC. NO. 152-6 REV. NO. 0
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. 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	$\Delta P = 2$ psi	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

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

$h_f = 10.38$ ft

$h_s = Z_2 - Z_1$ $Z_2 = 670'$ (as before)
$h_s = 23.11$ ft $Z_1 = 646'\ 10\,5/8''$ (as before)

$h_a(670') = 33.16$ ft

$$h_{vpa}(170°F) = 5.99 \frac{\cancel{lb}}{\cancel{in^2}} \times \frac{1\ ft^3}{60.79 \cancel{lb}} \times 144 \frac{\cancel{in^2}}{\cancel{ft^2}} = 14.19 \text{ ft}$$ (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. 0

ORIGINATOR G. KALINAUSKAS DATE NOV 08 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. 86

MODE G

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

TABLE G.1

NODE	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.

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

$h_f = 11.10$ 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

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

8856-M1-E21-30-1

REPORT OF PERFORMANCE TEST FOR PUMP S/N 107384

A performance test was conducted 8 September 1976 for a pump on order 006-36051 (AE 231). All necessary data associated with the hydraulic performance was obtained. The serial numbers for the impeller and casings are as follows:

Stage No.	Casings	Impellers
1	66044	57303
2	64953	68422
3	64946	68449
4	64957	55611
5	64703	69496
6	70976	68404

Vibration was found to be satisfactory as indicated by the data sheets. The NPSH points for a flow of 3004 GPM towards shut-off have been plotted on Curve N-831, Rev. 0 and fall on the head capacity curve. The NPSH data from 3625 GPM to runout is also plotted on N-831, Rev. 0.

FF128510

SUSQUEHANNA 1,2
MPL # E21-C001

TAG - 1P206 A, B, C & D

GENERAL ELECTRIC
NUCLEAR ENERGY DIVISION
☐ Disapproved per comments. Revise and resubmit for approval.
☐ Approved with Comments. Revise and resubmit IN FINAL FORM.
☐ Refer to EDS No.
☐ Approved. No further action req'd.
☐ Approved. Submit certified copy.
☒ Certified by Seller and Approved by Buyer.
Reviewed by
Date 25 Oct 1976
VPF No. 3308-149-1

CERTIFICATE OF COMPLAINCE

The performance test on Pump S/N 107384 on order 006-36051 (AE 231) was conducted in accordance with Procedure CQCP-1085, Rev. 4 except the test was conducted in the Cameron shell.

R. Lemp/

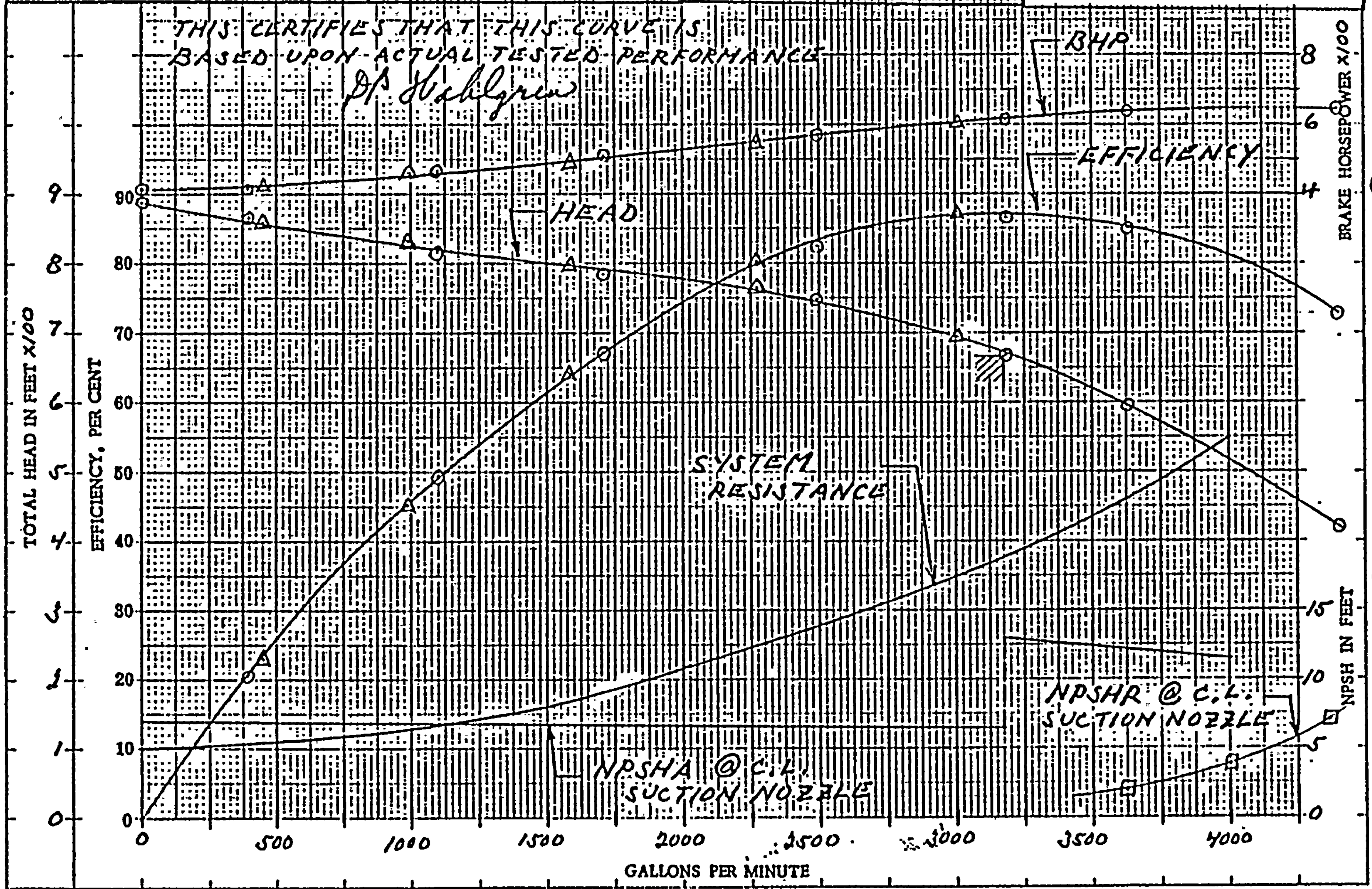
R. Lemp
Cameron Test Dept.

1

CUSTOMER G.E.A.P.E.D.	DESIGN CONDITIONS GPM 3175 EFF — T.H.(FT.) 668 BHP — SG. 1.0 RPM 1780 DRIVER HP 700 HP MOTOR WITH 1.0 S.F.	**Ingersoll-Rand**	CURVE N-831, REV.0.
PROPOSAL NO. 006-36061 ITEM 2			PUMP 25APHD-6
SPECIAL NOTES PUMP SN 107384 TESTED IN CAMERON SHELL		DRAWN BY D.P.W. 9-14-76 DATE	

THIS CERTIFIES THAT THIS CURVE IS BASED UPON ACTUAL TESTED PERFORMANCE

DP Wahlgren



PG. 2 OF 6

CURVE N-831, REV.0

9

PUMP SN 107384

PART OF PERFORMANCE CURVE N-831, REV. 0

NOTE:

⊙ PERFORMANCE DATA FOR HEAD, FLOW, EFFICIENCY & BHP

△ NPSH TEST BASIS NPSH HELD CONSTANT AT APPROXIMATELY 6.4 FT. REF. TO C.L. SUCTION NOZZLE (2.3 FT. CORRECTION INCLUDED).

⊡ NPSHR FROM 3625 GPM TOWARDS RUN-OUT, REF. TO C.L. SUCTION NOZZLE (2.3 FT. CORRECTION INCLUDED.

PG. 40

CAMERON PUMP DIVISION INGERSOLL-RAND COMPANY **TEST RECORD**

HEAD 3.56 @ 5000 GPM

HEAD	DISCHARGE HEAD — AS READ 0508	479	651	727	807	845	891	927	948		
	DISCHARGE HEAD — CORRECTED +2" ELEVATION	479	652	729	809	847	893	929	950		
	SUCTION LIFT FT. ZERO DEPRESSED 0120 FT.	61	61	62	62	62	63	63	63		
	CHANGE IN VELOCITY HEAD IN FEET 24x12	3	2	1	1	0	0	0	0		
	TOTAL HEAD	421	594	669	749	786	831	867	888		
CAPACITY	VENTURI TUBES SIZES AND READINGS — 18" TUBE	4380	0	0	0	0	0	0	0		
	CORRECTED	4411	0	0	0	0	0	0	0		
	10" TUBE	0	3647	3218	2581	1804	1084	375	0		
	CORRECTED	0	3632	3182	2491	1715	1098	395	0		
	TOTAL G.P.M.	4411	3632	3182	2491	1715	1098	395	0		
WATER H.P.		468.9	543.9	536.8	470.5	340.0	230.1	86.4	0		
POWER	WATTMETER T.R. 700/1 — AS READ	.732	.727	.702	.649	.570	.526	.479	.477		
	~~CORRECTED NON-ZERO~~ KW	512.4	508.9	491.4	454.3	399.0	368.2	335.3	333.9		
	TOP OF MOTOR VIB. = / ⊥	1.1 / .6		1.0 / .7				2.0 / 1.6			
	BRAKE H.P.	644	640	618	572	506	465	417	415		
SHAFT VIB. / H_2O °F		1.7 / 76	76	2.1 / 77	77	77	77	3.4 / 77	77		
SEAL LEAKAGE / Specific Gravity		NONE / .999	NONE / .999	NONE / .999	NONE / .999	NONE / .999	NONE / .999	NONE / .999	NONE / .999		
PUMP EFFICIENCY %		72.8	85.0	86.7	82.3	67.2	49.5	20.7	0		

DRIVER 700 HP MOTOR

FULL LOAD SPEED R.P.M.

PUMP NO. 107384

SIZE 25

TYPE APKD

STAGES 6

LIQUID H_2O

TEMP.

VISCOS.

GRAVITY 1.0

TEST STAND #16

TESTED BY R. LEMP

APP. BY

NOTES:—
T-R SHELL
SHUTDOWN TIME: 30 SEC.
WITNESSED BY: GWRPD-QC 311 9-8-76

G.P.M. 3175

TOTAL HEAD IN FT. 668

SUCT.

R.P.M. 1780

EFF. %

IMPELLER

DIA.

VANE DIA

DIFFUSOR

SUCTION CONNECTION TO C. L. PUMP

C. L. PUMP TO C. L. DISC. GAUGE

TEST PROCEDURE CQCP - 1085 REV. 4

CUSTOMER G.E.A.P.E.D.

ORDER NO. 006-36051

ITEM NO. 2

DATE SEPT. 8, 1976

TEST NO.

PG. 5 OF 6

UMP S/N 107384	SIZE 25	TYPE APKD-6	DATE SEPT. 8, 1976	TEST STAND #16
MPELLER	DIA	CUSTOMER G.E. A.P.E.D.		DATA BY R. LEMP
I-R SHELL		ORDER NO. 006-36051	ITEM NO. 2	WITNESSED BY GE 311 9-8-76

$NPSH=\left[\frac{(BARO-VP)1.133}{SP.\ GR.}\right]-\frac{SUC.+LIFT}{SP.\ GR.}+VEL.\ HD$

-2.2 SUBMERGENCE +2.3 CORRECTION

TOTAL HEAD=CORR.DISCH HD + VEL.HD+SUCT. HD

RUN NO.	DISCH. HEAD AS RUN	DISCH. HEAD CORRECTED TO C.L. OF SUCTION +15.8 FT. ELEV.	VELOCITY HEAD 24 to 12	VACUUM AT C.L. SUCTION (FT. OF H_2O)	TOTAL HEAD (FT. OF H_2O)	TEMP. AT PUMP SUCTION (°F)	10x18" TUBE GPM	CORRECTED GPM	WATT METER (AS READ)	KW	SPECIFIC GRAVITY	BAROMETER (INCHES HG)	SEAL LEAKAGE	VIBRATION (MILS)	SUCTION VELOCITY HEAD	VAPOR PRESSURE (INCHES HG)	RUNNING VACUUM (INCHES HG)	RUNNING VACUUM (FT. H_2O)	NPSH C.L. CUST. SUCTION	CORRECTED SUCTION HEAD	BRAKE HP	EFFICIENCY
1	822	837.8	0	21.5	860	80	430	450	485	340	999	27.83	NONE	3.6	0	1.03	28.80	32.63	6.4	21.4	424	23.0
2	795	810.8	.1	21.5	833	80	970	988	.520	364	↓	↓	↓	3.3	.01	1.03	28.80	32.63	6.4	21.4	460	45.1
3	760	775.8	.4	21.5	798	80	1665	1580	.557	390	↓	↓	↓	3.2	.02	1.03	28.80	32.63	6.4	21.4	495	61.3
4	726	741.8	.7	21.6	765	80	2350	2272	.619	433	↓	↓	↓	2.9	.05	1.03	28.80	32.63	6.3	21.5	547	80.1
5	657	671.8	1.3	21.7	695	81	3068	3004	.685	480	↓	↓	↓	2.8	.08	1.07	28.76	32.59	6.2	21.6	604	87.3
6	558	572.8	1.9	19.9	596	82	3585	3625	.722	505	.998	27.83	NONE	2.8	.12	1.10	28.73	32.55	8.1	19.7	635	85.7
	555	569.8	1.9	22.9	596	82	↓	↓	.722	505	↓	↓	↓	2.8	.12	1.10	28.73	32.55	5.0	22.8	635	85.7
	553	567.8	1.9	23.9	595	82	↓	↓	.722	505	↓	↓	↓	2.7	.12	1.10	28.73	32.55	4.0	23.8	635	85.6
	549	563.8	1.9	25.9	593	83	↓	↓	.725	508	↓	↓	↓	2.7	.12	1.14	28.69	32.51	1.9	25.9	638	84.9
	521	535.8	1.9	26.4	565	83	↓	↓	.719	503	↓	↓	↓	2.5	.12	1.14	28.69	32.51	1.4	26.4	633	81.6

8856-M1-E21-30-1

FE126510

BECHTEL COMMENT G

Comments –

1. Page 6 of 6 is missing.

DEC 06 1976

APED DRAWING REVIEW

COMMENTS AS CHECKED BELOW

E ☐ NO COMMENTS.
F ☐ COMMENTS AS INDICATED, FOR APED'S INFORMATION AND USE ONLY. NO REPLY REQUIRED.
G ☒ COMMENTS AS INDICATED, WHEN DIRECTLY AFFECTING BECHTEL RESPONSIBILITY. REPLY REQUIRED IF NOT INCORPORATED BY APED.

FORWARDED BY	DATE 1/24/77

REVIEWED	C	E	I	L	M

BECHTEL
SAN FRANCISCO

JOB NO. 8856

DISTRIBUTION	NO.	DATE
VENDOR	2P	
CLIENT	1T	
FIELD	2F	
Q.E.		
CIVIL		
ELECT.		JAN 28 1977
PLT. DES.		
MECH.	1	
CON. SYS.		
ARCH.		
PURCH.		
EXPED.		
INSPECT		
SCHED.		
START-UP		
RECORD	1F+0R	

BECHTEL
SAN FRANCISCO

S

DESCRIPTION–DRAWING

LOCATION

G

BECHTEL

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

9346

JOB NO. 8856

DISCIPLINE MECHANICAL/NUCLEAR

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

LE R.H.R. ΔP CALCULATIONS

SUSQUEHANNA STEAM
ELECTRIC STATION

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

AR 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-108-1 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, GBB-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-118-2 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
	12/11/79	G. KALINAUSKAS / G. Kalinauskas/us		1/25/80	B.M. Jackson	1/23/80
	6/20/79	G. KALINAUSKAS / G. Kalinauskas/us		8/20/79	B.M. Jackson	8/21/79
0	1/16/79	G. KALINAUSKAS / G. Kalinauskas/us	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)

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

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

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, DBB-207-2 Rev 2, DBB-215-1 Rev 5, DCA-208-1 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, GBB-205-1 Rev 4, GBB-205-2 Rev 4, GBB-206-1 Rev 5, GBB-206-2 Rev 4, GBB-207-1 Rev 6, GBB-207-2 Rev 4, GBB-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.
**Considers PSAR, codes and standards, redundancy and separation, operability and maintainability, technical adequacy, accuracy and clarity.

BECHTEL

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

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

JOB NO. 8856

DISCIPLINE MECHANICAL/NUCLEAR

TITLE R.H.R. ΔP 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 GBB-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.
**Considers PSAR, codes and standards, redundancy and separation, operability and maintainability, technical adequacy, accuracy and clarity.

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

B 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

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-M154-2-2
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.

**Considers PSAR, codes and standards, redundancy and separation, operability and maintainability, technical adeq

BECHTEL

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. 223

SECTION 3 - NPSH CALCULATIONS

MODE C-2

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

h_f

TABLE C-2.1

NODE	EQ. LENGTH or Cv	$\Delta P_{9260\,gpm}$ (psi)
2B-3B	$\Delta P = 2$ 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

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

$h_f = 6.70$ ft

$h_s = Z_2 - Z_1$ $Z_2 = 670'$ (min. water level - assumed 1' below normal - M-247 Rev 8) $\triangle 1$

$h_s = (670' - 648'0\tfrac{1}{2}")$ $Z_1 = 648'0\tfrac{1}{2}"$ (inlet level to pump - iso HBB-110-2 Rev 6) 5/15/7

$h_s = 21.96$ ft

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

$$h_{vpa}(200°F) = 11.53\ \text{psi}\left(\frac{1\ ft^3}{60.13\ lb}\right)\left(144\ \frac{in^2}{ft^2}\right) = 27.61\ ft \qquad (\text{ref } 1\ \text{pg } A\cdot6)$$

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

$= 20.81$ 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

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

h_f	NODE	TABLE G·1 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}

ΔP = 4.00 psi

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

$$h_f = 9.36\ ft$$

$h_s = z_2 - z_1$ $\qquad$ $z_2 = 670'$ (min. water level - assumed 1' below normal - M-247 Rev.8) 8/15/7: △1

$h_s = (670' - 648'0\tfrac{1}{2}")$ $\qquad$ $z_1 = 648'0\tfrac{1}{2}"$ (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)

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

$$\therefore NPSHA = h_s - h_f + h_a - h_{vpa} = 21.96 - 9.36 + 33.16 - 5.19$$
$$= 40.57\ ft$$

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

BECHTEL

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. ΔP 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)	NPSH A (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	3
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

8856-M1-E11-53-1

DISTRIBUTION

	NO.	DATE
VENDOR	NONE	
CLIENT	1T	
FIELD	2F	
Q.E.		
CIVIL		
ELECT.	1P	
PLT. DES.	1P	
MECH.	1P	
CON. SYS.		
ARCH.		
PURCH.		
EXPED.		
INSPECT		
SCHED.		
START-UP		
RECORD	1F+6219	

DEC. 8 - 1976

BECHTEL
SAN FRANCISCO

DESCRIPTION – DRAWING S

LOCATION G

OCT 4 1976

APED DRAWING REVIEW

COMMENTS AS CHECKED BELOW

E ☒ No comments.
F ☐ Comments as indicated, for APED's information and use only. No reply required.
G ☐ Comments as indicated, when directly affecting Bechtel responsibility. Reply required if not incorporated by APED.

FORWARDED BY	DATE
R. Mitzer	12-6-76

Reviewed	C	E	I	L	M

BECHTEL SAN FRANCISCO
JOB NO. 8856

FF724510

FF124510 8856-M1-E11-58-1

REPORT OF PERFORMANCE TEST FOR PUMP S/N 0573314

A performance test was conducted 26 July 1976 for a pump on order 006-36049 (AE 234). All necessary data associated with the hydraulic performance was obtained. The serial numbers for the impeller and casings are as follows:

Stage	Casings	Impellers
1	59910	66465
2	58664	66235
3	58665	68009
4	59882	65490

The vibration was found to be satisfactory as indicated by the Data Sheets. The NPSH points for a flow of 9898 GPM towards shut-off have been plotted on Curve N-810, Rev. 0 and fall on the head capacity curve. The NPSH data from 12081 GPM to runout is also plotted on N-810, Rev: 0.

GENERAL ELECTRIC A
NUCLEAR ENERGY DIVISION
☐ Disapproved per comments. Revise and resubmit for approval.
☐ Approved with Comments. Revise and resubmit IN FINAL FORM.
☐ Refer to EDS No.
☐ Approved. No further action req'd.
☐ Approved. Submit certified copy.
☒ Certified by Seller and Approved by Buyer.
Reviewed by
Date 12 Aug 1976
VPF No. 3307-73-1

CERTIFICATE OF COMPLIANCE

The performance test of pump S/N 0573314 on order 006-36049 (AE 234) was conducted in accordance with Procedure CQCP-1085, Rev. 4.

R. Lemp /

R. Lemp
Cameron Test Department

SUSQUEHANNA 1,2
MPL #E11C002

CUSTOMER G.E.A.P.E.D.

PROPOSAL NO. 006-36049 ITEM 2

SPECIAL NOTES
PUMP SN 0573314
PUMP TESTED IN
CAMERON SHELL

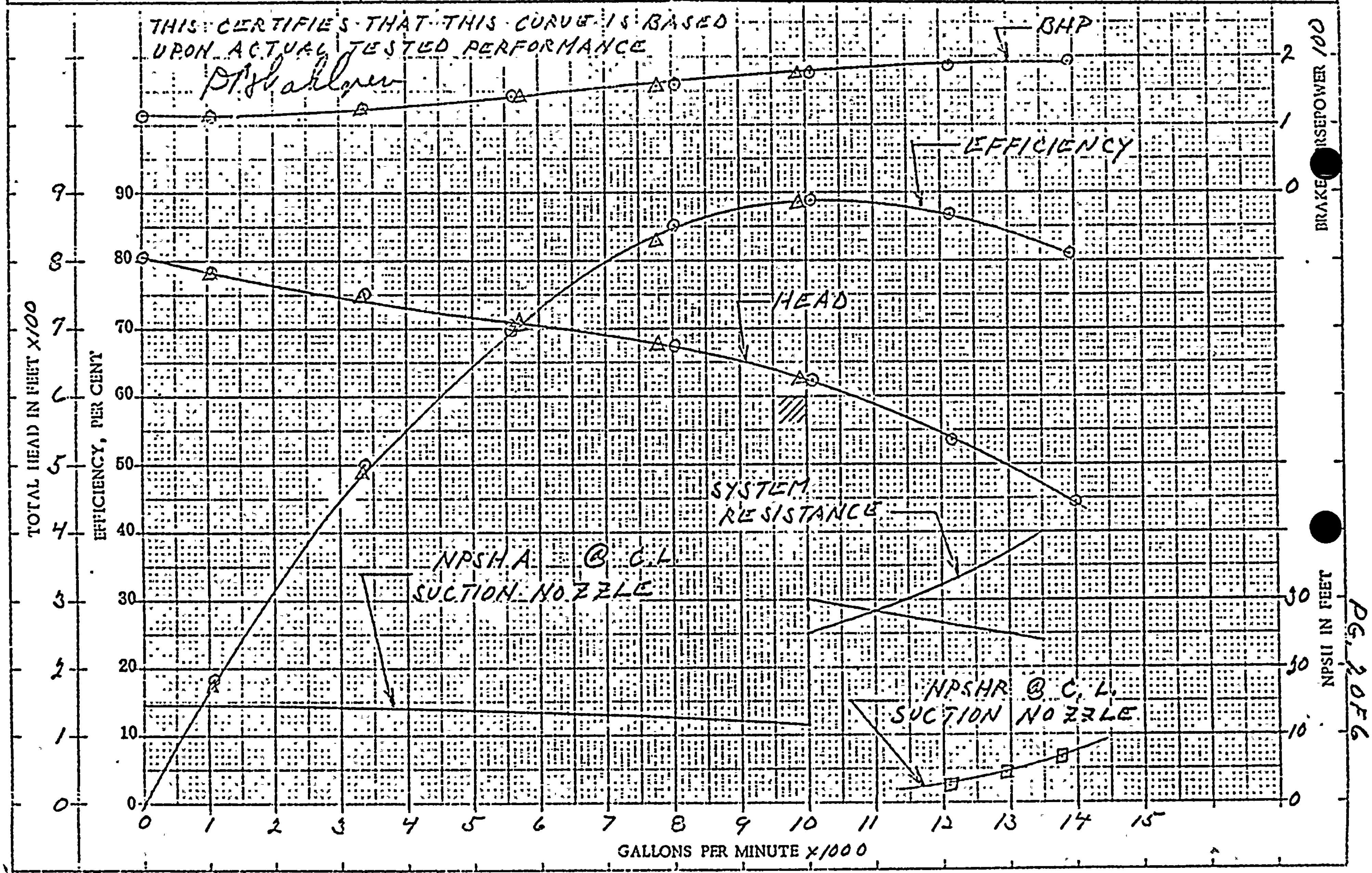
DESIGN CONDITIONS
GPM 10,000. EFF
T.H. (FT.) 600 BHP SG. 1.0
RPM 1180 DRIVER HP 2000 HP MOTOR WITH 1.0 S.F.

Ingersoll-Rand

DRAWN BY D.P.W. DATE 7-27-76

CURVE N-810, REV. 0

PUMP 34 APKD-4


THIS CERTIFIES THAT THIS CURVE IS BASED UPON ACTUAL TESTED PERFORMANCE

PG. 2 OF 6

CURVE N-810, REV. 0

PUMP SN 0573314

PART OF CURVE N-810, REV. 0

NOTE:

⊙ PERFORMANCE DATA FOR HEAD, FLOW, EFFICIENCY & BHP.

△ NPSH TEST BASIS NPSH HELD CONSTANT AT APPROXIMATELY 9.5 FT., REF. TO C.L. SUCTION NOZZLE (0.9 FT. CORRECTION INCLUDED)

⊡ NPSHR DATA FROM 12081 GPM TOWARDS RUNOUT, REF. TO C.L. SUCTION NOZZLE (0.9 FT. CORRECTION INCLUDED)

PG. 4 OF 6

C ON PUMP DIVISION **INGERSOLL-R D. COMPANY** TEST RECORD.

HEAD 1.67 @ 14,000	DISCHARGE HEAD	050% AS READ	506	598	683	739	770	816	852	875
		CORRECTED +2 ELEV.	507	599	686	742	774	820	854	878
	SUCTION LIFT FT. ZERO DEPRESSED ______ FT.		65	67	69	70	71	72	73	74
	CHANGE IN VELOCITY HEAD IN FEET 24"x18"		3	2	2	1	1	0	0	0
	TOTAL HEAD		446	536	621	676	707	751	784	807
CAPACITY	VENTURI TUBES SIZES AND READINGS	18" TUBE "Hg	12459	11049	8948	6973	5712	0	0	0
		GPM	12261	11033	8970	6915	5595	0	0	0
		10" TUBE "Hg	12.9	5.65	5.80	5.70	0	51.9	1082	0
		GPM	1681	1113	1127	1118	0	3372	1087	0
	TOTAL G.P.M.		13942	12146	10097	8033	5595	3372	1087	0
WATER H.P.			1567	1638	1578	1365	995	637	214	0
POWER	WATT METER T.R. 2800/1	AS READ	.562	.548	.518	.470	.419	.378	.348	.350
		KW	1574	1534	1450	1316	1173	1058	974	980
		R.P.M.								
	BRAKE H. P.		1935	1885	1775	1605	1424	1275	1170	1175
SHAFT VIB. MILS / H_2O °F			2.1 / 91	/ 93	3.1 / 94	/ 95	/ 96	/ 97	3.8 / 97	/ 97
SEAL LEAKAGE / SP. GR.			NONE / .997	NONE / .996	NONE / .996	NONE / .996	NONE / .996	NONE / .996	NONE / .996	NONE / .996
PUMP EFFICIENCY %			81.0	86.9	88.9	85.1	69.9	50.0	18.3	0

DRIVER 2000 HP MOTOR

FULL LOAD SPEED R.P.M.

PUMP NO. 0573374

SIZE 34

TYPE APKD

STAGES 4

G.P.M. 10,000

TOTAL HEAD IN FT. 600

SUCT.

R.P.M. 1180

EFF. %

LIQUID H_2O

NOTES:-

I-R SHELL

SHUTDOWN TIME: 70 SEC.

WITNESS BY:

QRC

7-26-76

TEMP.

VISCOS.

GRAVITY 1.0

TEST STAND #16

TESTED BY R. LEMP

APP. BY

IMPELLER

DIA.

VANE DIA

DIFFUSOR

SUCTION CONNECTION TO C. L. PUMP

C. L. PUMP TO C. L. DISC. GAUGE

TEST PROCEDURE CQCP-1085 REV. 4

CUSTOMER G.E.A.P.E.D.

ORDER NO. 006-36049

ITEM NO. 2

DATE JULY 26, 1976

TEST NO.

PG 5 OF 6

MP S/N 0573314

SIZE 34

TYPE APKD-4

DATE JULY 26, 1976

TEST STAND #16

MPELLER

DIA

CUSTOMER G.E.A.P.E.D.

DATA BY Ralph Lemp

I-R SHELL

ORDER NO. 006-36049

ITEM NO. 2

WITNESSED BY

NPSH = [(BARO−VP)1.133 / SP. GR.] − SUC. LIFT / SP. GR. + VEL. HD

−7.0 SUBMERGENCE + 19 CORRECTION

TOTAL HEAD = CORR. DISCH HD + VEL. HD + SUCT. HD

RUN NO.	DISCH. HEAD AS RUN	DISCH. HEAD CORRECTED TO C.L. OF SUCTION + 15.6 FT. ELEV.	VELOCITY HEAD 24 to 18	VACUUM AT C.L. SUCTION (FT. OF H_2O)	TOTAL HEAD (FT. OF H_2O)	TEMP. AT PUMP SUCTION (°F)	10"-18" TUBE GPM	CORRECTED GPM	WATT METER (AS READ)	KW	SPECIFIC GRAVITY	BAROMETER (INCHES HG)	SEAL LEAKAGE	VIBRATION (MILS)	SUCTION VELOCITY HEAD	VAPOR PRESSURE (INCHES HG)	RUNNING VACUUM (INCHES HG)	RUNNING VACUUM (FT. H_2O)	NPSH C.L. CUST. SUCTION	CORRECTED SUCTION HEAD	BRAKE HP	EFFICIENCY
1	743	760.1	0	16.0	781	106	1004	1016	.317	972	.994	29.91	None	3.9	0	2.31	27.59	31.26	9.4	15.9	1148	17.0
2	710	726.9	.2	16.0	748	108	49.8	3302	.377	1056	.993	↓	None	3.7	.1	2.45	27.45	31.10	9.4	15.9	1273	48.7
3	666	682.3	.5	16.0	704	109	[illegible]	5718	.417	1168	.993		None	3.6	.3	2.52	27.37	31.02	9.5	15.9	1418	71.2
4	[illegible]	655.8	1.0	16.0	678	110	[illegible]	7793	.467	1308	.993		None	3.6	.5	2.60	27.30	30.93	9.6	15.9	1597	82.9
5	[illegible]	602.9	1.6	16.1	626	112	[illegible]	10117	.512	1434	.992		None	3.3	.9	2.75	27.15	30.76	9.8	16.0	1759	88.2
6	[illegible]	519.6	2.4	15.0	541	113	33.0/131	12081	.543	1520	.992	29.91	None	2.8	1.3	2.82	27.07	30.67	11.2	13.9	1865	87.8
	503	516.6	2.4	17.0	540	114	↓	↓	.543	1520	.992	↓	↓	2.7	1.3	2.91	26.99	30.58	9.1	16.9	1865	87.7
	501	515.6	2.4	18.2	541	115			.543	1520	.992			2.8	1.3	3.00	26.90	30.49	7.7	18.2	[illegible]	87.7
	495	512.6	2.4	20.[illegible]	540	116			.543	1520	.992			2.6	1.3	3.08	26.83	30.37	5.5	20.3	[illegible]	87.5
	493	507.6	2.4	22.1	537	117			.543	1520	.991			2.8	1.3	3.17	26.73	30.29	3.5	22.3	1865	87.0
	[illegible]	503.6	2.4	22.9	534	118			.543	1520	.991			2.7	1.3	3.26	26.64	30.18	2.6	23.1	1865	86.5
	[illegible]	494.6	2.4	23.1	525	118			.541	1513	.991			2.8	1.3	3.26	26.64	30.18	2.4	23.3	1857	85.4
	411	425.1	2.4	23.5	456	119			.489	1365	.991			2.4	1.3	3.35	26.55	30.08	1.9	23.7	[illegible]	82.4

CRC

6 26 76

PG OF 6

UMP S/N 0573314	SIZE 34	TYPE APKD-4	DATE JULY 26, 1976
MPELLER	DIA	CUSTOMER G.E.A.P.E.D.	
I-R SHELL		ORDER NO. 006-36049	ITEM NO. 2

TEST STAND #16

DATA BY RALPH LEMP

WITNESSED BY

NPSH = [(BARO−VP)1.133 / SP. GR.] − SUC. LIFT / SP. GR. + VEL. HD

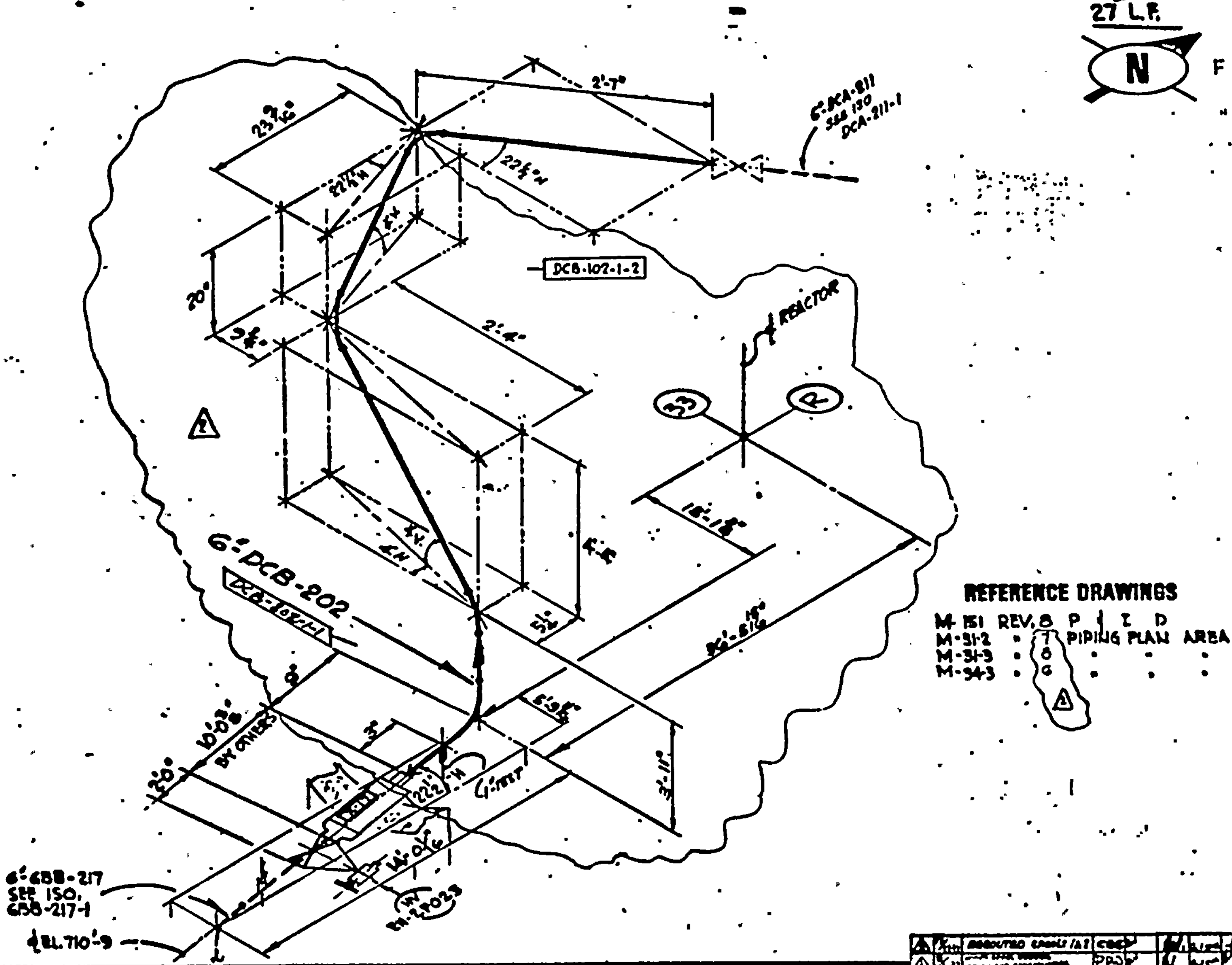
-7.0 SUBMERGENCE + .9 CORRECTION

TOTAL HEAD=CORR.DISCH HD + VEL.HD+SUCT. HD.

RUN NO.	DISCH. HEAD AS RUN	DISCH. HEAD CORRECTED TO C.L. OF SUCTION +15.6 FT. ELEV.	VELOCITY HEAD 24 to 18	VACUUM AT C.L. SUCTION (FT. OF H_2O)	TOTAL HEAD (FT. OF H_2O)	TEMP. AT PUMP SUCTION (°F)	12-1/8" TUBE GPM	CORRECTED GPM	WATT METER (AS READ)	KW	SPECIFIC GRAVITY	BAROMETER (INCHES HG)	SEAL LEAKAGE	VIBRATION (MILS)	SUCTION VELOCITY HEAD	VAPOR PRESSURE (INCHES HG)	RUNNING VACUUM (INCHES HG)	RUNNING VACUUM (FT. H_2O)	NPSH C.L. CUST. SUCTION	CORRECTED SUCTION HEAD	BRAKE HP	EFFICIENCY
7	415	477.6	2.8	15.9	503	120	[illegible]	1993	.551	1543	.990	[illegible]	NONE	2.7	1.5	3.45	26.45	29.97	7.8	15.9	1895	85.7
	414	478.6	2.8	18.0	504	121	↓	↓	.551	1543	.990	↓	↓	2.7	1.5	3.54	26.36	29.87	7.6	18.0	1895	85.9
	[illegible]	477.6	2.8	19.2	505	122			.551	1543	.990			2.6	1.5	3.64	26.26	29.75	6.2	19.3	1895	86.0
	457	471.6	2.8	20.4	500	123			.550	1541	.990			2.6	1.5	3.74	26.16	29.64	4.8	20.5	1892	85.3
	439	453.6	2.8	21.1	482	123			.547	1533	.990			2.7	1.5	3.74	26.16	29.64	4.1	21.2	1881	82.8
	409	423.6	2.8	21.3	452	124	↓	↓	.523	1464	.990	↓	↓	2.6	1.5	3.85	26.05	29.51	3.8	21.4	1795	81.3
8	415	429.6	3.2	15.4	453	125	350 / 1362	1376	.553	1548	.989	29.91	NONE	2.5	1.7	3.95	25.95	29.40	9.9	15.4	1900	82.0
	414	428.6	3.2	16.4	453	126	↓	↓	.553	1549	.989	↓	↓	2.6	1.7	4.06	25.84	29.28	8.8	16.4	1900	82.0
	410	424.6	3.2	17.7	450	127			.553	1541	.989			2.5	1.7	4.18	25.72	29.14	7.4	17.7	1895	81.6
	405	419.6	3.2	18.3	446	128			.551	1543	.988			2.5	1.7	4.29	25.61	29.02	6.7	18.3	1895	80.9
	374	388.6	3.2	18.5	415	128	↓	↓	.543	1520	.988	↓	↓	2.5	1.7	4.29	25.61	29.02	6.5	18.5	1866	76.4

303

CRC
7-26-76



REFERENCE DRAWINGS

M-151	REV. 8	P & I D			
M-31-2	"	7	PIPING PLAN	AREA	31
M-31-3	"	6	"	"	31
M-34-3	"	6	"	"	34

COMPONENTS ON THIS DWG. ARE Q-LISTED SPEC. 8856-G-9 APPLIES

Q

SS [illegible] JO REACTOR BLDG RHR

M

3		REROUTED CHANGE [illegible]	CBC						
2		[illegible]	PRJ						
1		ISSUED FOR FABRICATION	R-B						
NO.	DATE	REVISIONS	BY	CHK'D					APPD

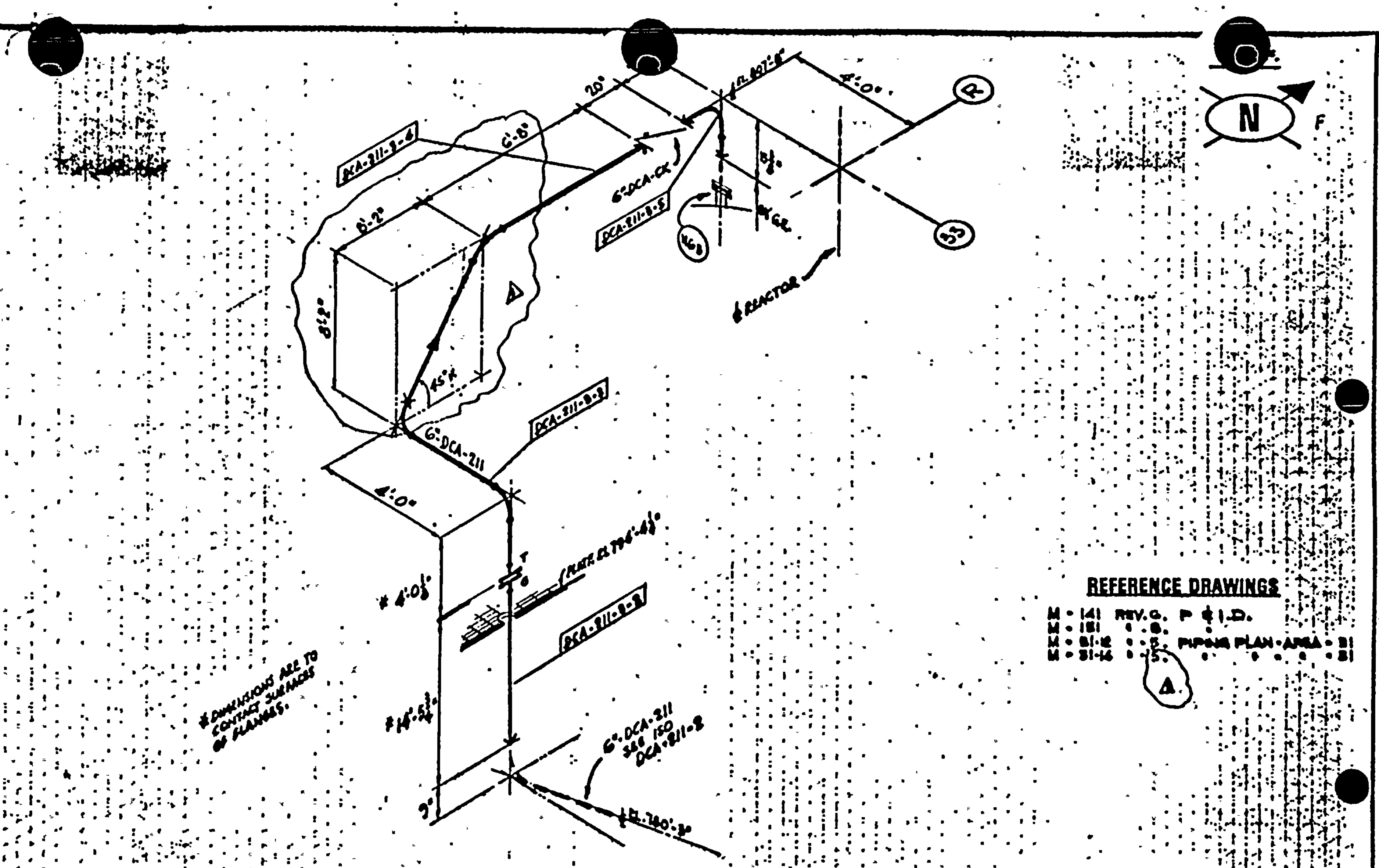
SCALE — DESIGNED DRAWN RMB.

PENNSYLVANIA POWER & LIGHT COMPANY
ALLENTOWN, PENNSYLVANIA
SUSQUEHANNA STEAM ELECTRIC STATION - UNIT 1, UNIT 2

BECHTEL - SAN FRANCISCO

ISOMETRIC - REACTOR BUILDING
RESIDUAL HEAT REMOVAL UNIT 2

JOB No. 51-28 DRAWING No. REV.
88[illegible] DCB-202-1 2



REFERENCE DRAWINGS

M-141 REV.G. P & I.D.
M-151 " .G. "
M-31-12 " .5. PIPING PLAN-AREA-31
M-31-14 " .5. " " " " -31

57

COMPONENTS ON
THIS DWG. ARE Q-LISTED
SPEC. 8856-G-9 APPLIES

Q

PENNSYLVANIA POWER & LIGHT COMPANY
ALLENTOWN, PENNSYLVANIA
SUSQUEHANNA STEAM ELECTRIC STATION - UNIT 1, UNIT 2

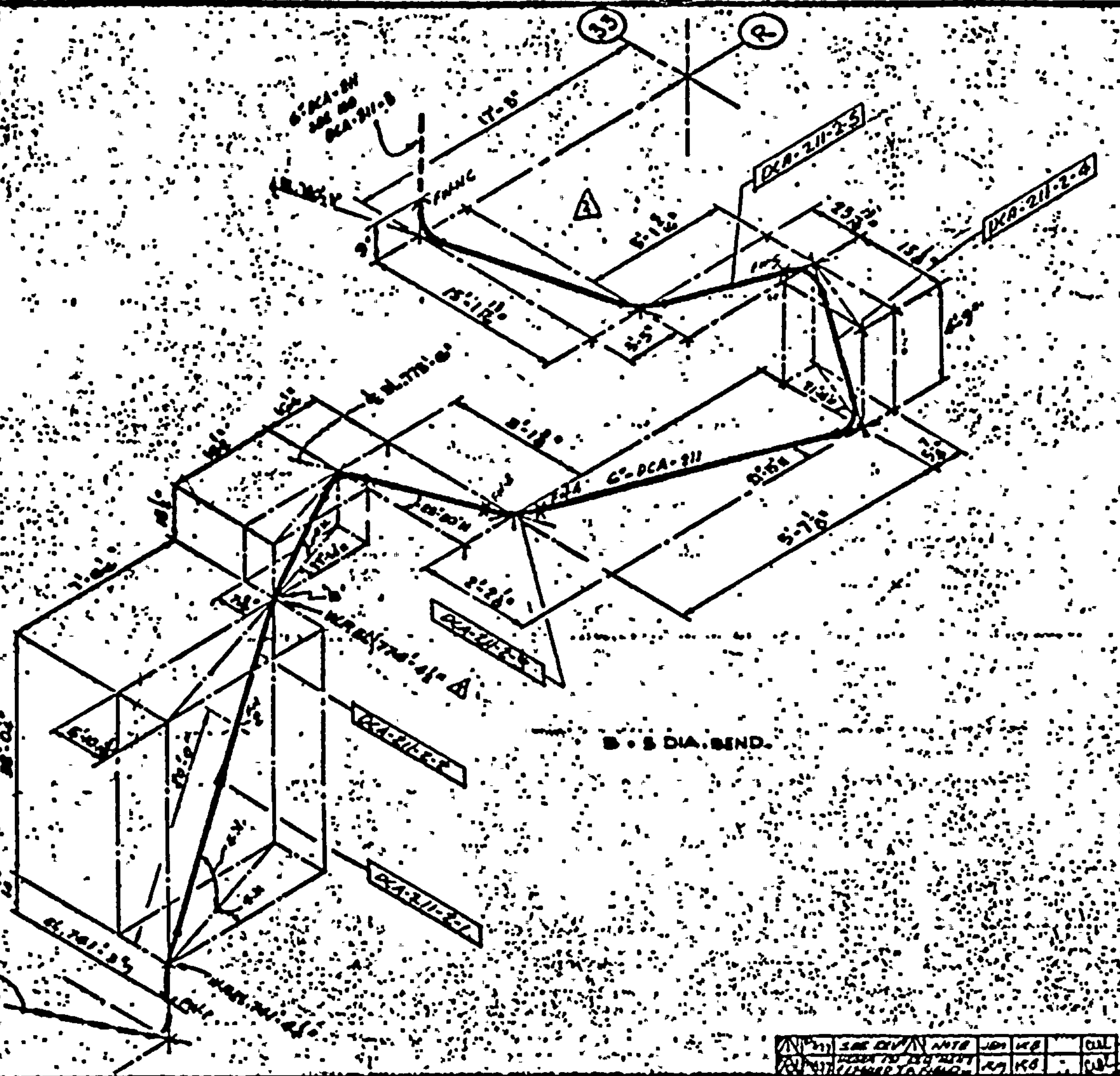
BECHTEL - SAN FRANCISCO

ISOMETRIC - REACTOR BLDG
RHR. UNIT - 2

JOB No.	41-13 DRAWING No.	REV.
8856	DCA-211-3	3

1150 REACTOR BLDG RHR

START UP SYSTEM
THIS ISO. 2-42A



78 L.F.

N

REV 1 /8 1 NOTE: REVISED TO ADD FIELD WELD NOS. AND WELDING REQUIREMENTS.

UNDER SFHD REV ⚠

REV ⚠ NOTE: UNDER SFHD REV ⚠: RE-ASSIGNED FW NO'S ISSUED DWG. TO GRINNELL FOR FAB OF SPOOLS AS SHOWN

REV ⚠ NOTE: ADDED PC NO'S 615 AS PER GRINNELL INFO: ADDED FW 615

REV ⚠ NOTE: RELOCATED FW'S 5 & 6 AS PER GRINNELL REQUEST

REFERENCE DRAWINGS

M-141 REV. G P & I.D.
M-151 " B "
M-31-4 " 5 PIPING PLAN - AREA - 31
M-31-12 " 5 " " " " -31

JAN 26 1983

⚠		SEE REV ⚠ NOTE	MH						
⚠		SEE REV ⚠ NOTE	MH						
⚠		REV'D ... REQUIREMENTS							
⚠		SEE REV ⚠ NOTE							
⚠		SEE REV ⚠ NOTE	RJ						
⚠		ISSUED FOR CONSTRUCTION							
⚠		ISSUED FOR FABRICATION	BL						

PENNSYLVANIA POWER & LIGHT COMPANY
ALLENTOWN, PENNSYLVANIA
SUSQUEHANNA STEAM ELECTRIC STATION - UNIT 1, UNIT 2
BECHTEL - SAN FRANCISCO

ISOMETRIC - REACTOR BLDG
R.H.R. UNIT - 2

8856 | 41-13 | DCA-211-2 | 2

WELD SURFACE PREPARATION IS TO BE APPLIED TO ALL WELDS ON THIS DWG. FOR IN SERVICE INSPECTION.

WELDING REQUIREMENTS Pipe Class DCA

☐ P1-A-C-Lh	☐ E-70S-2	■ Pre Heat - 60°F
☐ P1-AT-Lh	☐ E-6010	☐ Pre Heat - 200°F
☐ P8-A	☐ E-7018	☐ Pre Heat - 250°F
☐ P8-AT-Ag	■ ER-308-L	☐ Pre Heat - 275°F
■ P8-T-Ag	☐ ER-309	☐ Pre Heat - 450°F
☐ P1-T	☐ E-309-16	☐ Pre Heat -
☐ P1-A-Lh	☐ E-308L-16	■ Inlet Pass - SS&F
☐ P1A-AT-Lh	☐ E-8018-B2	☐ Backing Ring Req'd
☐ P4-AT	☐ ER-515	■ Argon Purge Req'd
☐ P8-P1-AT-Ag	☐	■ Pre Weld Insp. Req'd
☐	■ NDE - RT 16-2	RT-SA-1

Above Welding Requirements Are Certified Correct. [illegible]

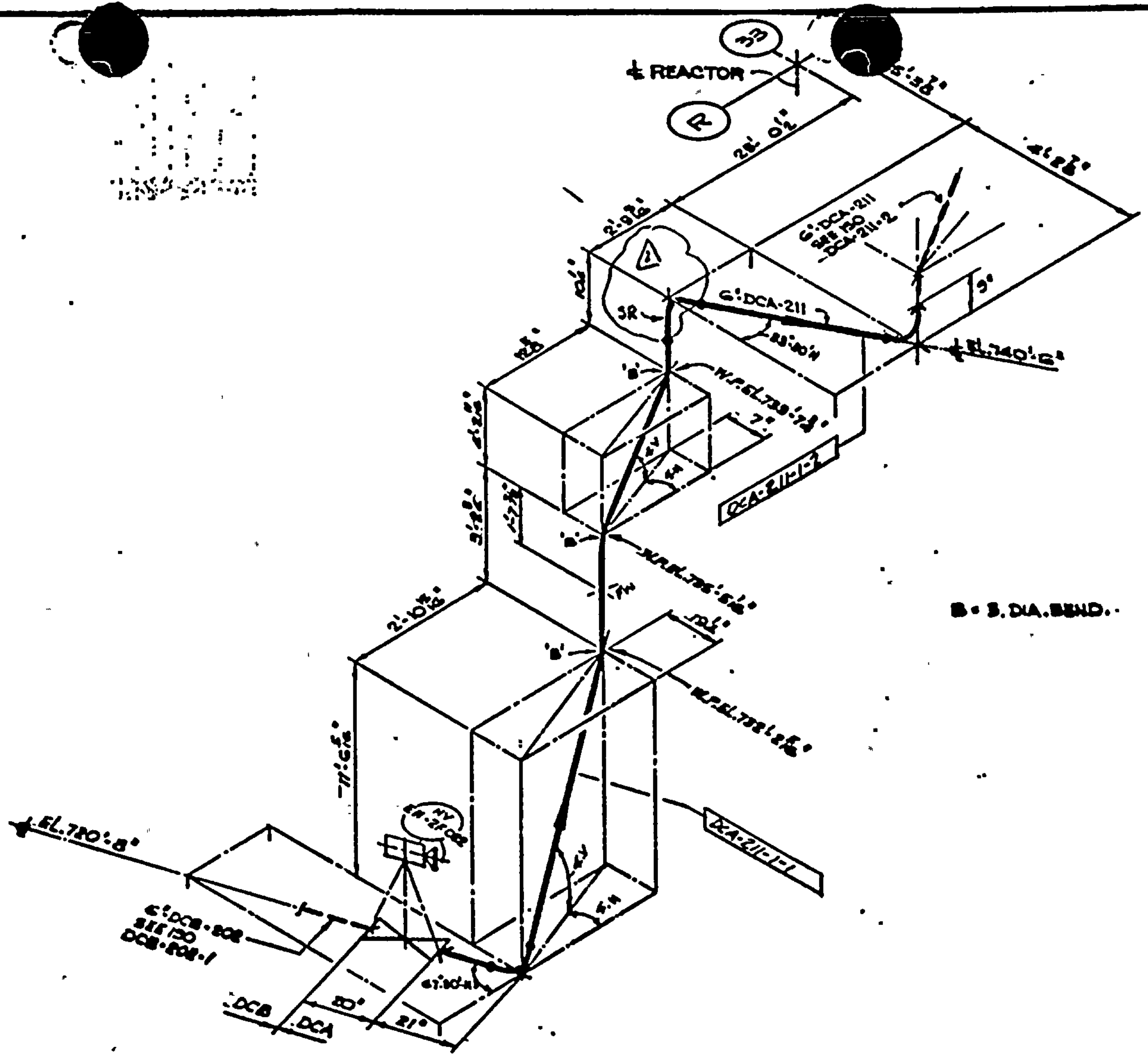
Q

COMPONENTS ON. THIS DWG. ARE Q-LISTED SPEC. 8856-G-9 APPLIES

WR-5/WR-6-REQ'D.

8121 | 1530 REACTOR BLDG. RHR

I certify that the image contained on this frame was made in the normal and regular course of business, on the date stated below and that it is an accurate reproduction of...



B = 3. DIA. BEND.

REFERENCE DRAWINGS

M-141	REV. 6.	P & I.D.
M-151	" 6.	"
M-B1-3	" 5.	PIPING PLAN - AREA - B1
M-B1-4	" 2.	" " - " -B1

51

COMPONENTS ON
THIS DWG. ARE Q-LISTED
SPEC. 8856-G-9 APPLIES

Q

⚠2	[illegible]	[illegible]	RJ	[illegible]	[illegible]	[illegible]	[illegible]		
⚠1	[illegible]	[illegible]	PDJ	[illegible]	[illegible]	[illegible]	[illegible]		
⚠0	[illegible]	ISSUED FOR FABRICATION	BL	[illegible]	[illegible]	[illegible]	[illegible]		
NO.	DATE	REVISIONS	BY	CHK	[illegible]	[illegible]	[illegible]	APPD	

SCALE [illegible] | [illegible] | DRAWN BL

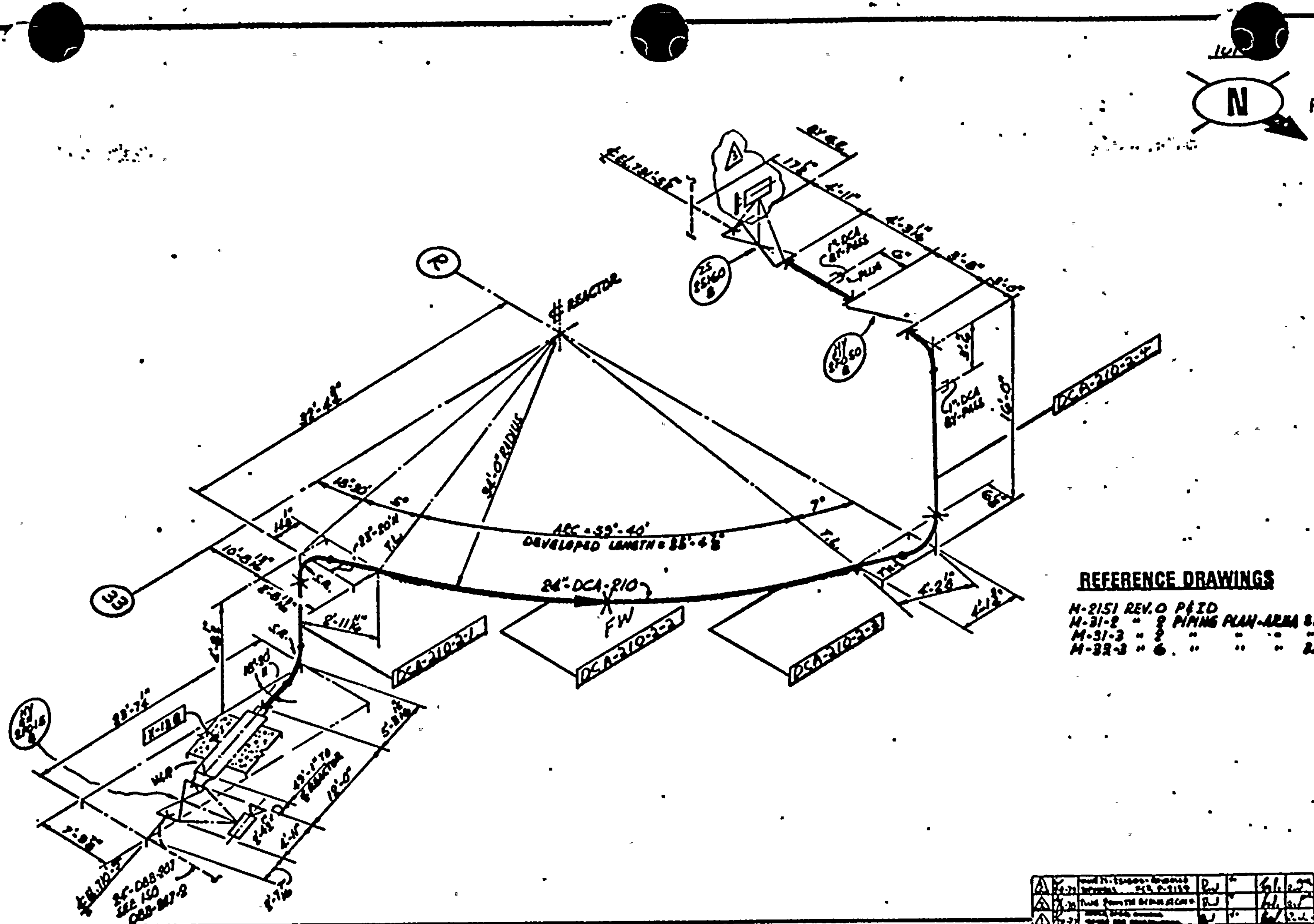
PENNSYLVANIA POWER & LIGHT COMPANY
ALLENTOWN, PENNSYLVANIA
SUSQUEHANNA STEAM ELECTRIC STATION - UNIT 1, UNIT 2

BECHTEL - SAN FRANCISCO

ISOMETRIC - REACTOR BLDG
R.H.R. - UNIT-2

JOB No.	41-1B DRAWING No.	REV.
8856	DCA-211-1	2

G2 ISO REACTOR BLDG RHR M



REFERENCE DRAWINGS

M-2151 REV. 0 P&ID
M-31-2 " 8 PIPING PLAN-AREA 31
M-31-3 " 8 " " " "
M-33-3 " 6 " " " 33

COMPONENTS ON
THIS DWG. ARE Q-LISTED
SPEC. 8856-G-9 APPLIES

Q

3		[illegible]						
2		[illegible]						
1		[illegible]						
0		ISSUED FOR FABRICATION	G					

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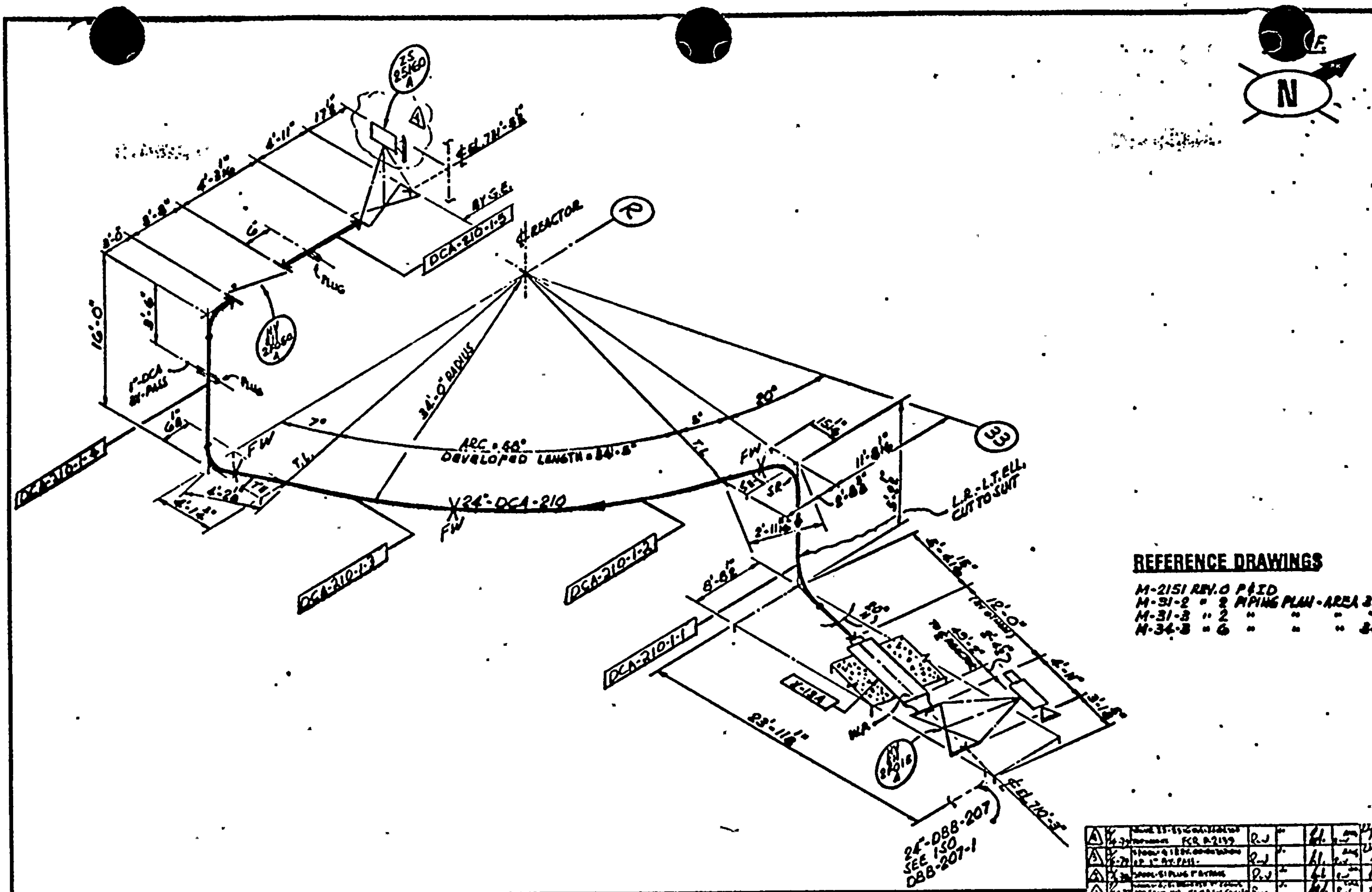
ISOMETRIC - REACTOR BLDG.
· R.H.R. - UNIT # 2

JOB No. 8856
DRAWING No. 51-85 DCA-210-2
REV. 3

G2 ISO REACTOR BLDG RHR



REFERENCE DRAWINGS

M-2151 REV.0 P&ID
M-31-2 " 2 PIPING PLAN - AREA 31
M-31-3 " 2 " " "
M-34-3 " 6 " " " 34.

COMPONENTS ON
THIS DWG. ARE Q-LISTED
SPEC. 8856-G-9 APPLIES

Q

4	[illegible]	[illegible] FCR P-2139	R.J	[illegible]	[illegible]	[illegible]	[illegible]	
3	[illegible]	[illegible] 1" BY-PASS	R.J	[illegible]	[illegible]	[illegible]	[illegible]	
2	[illegible]	[illegible] PLUG FITTING	R.J	[illegible]	[illegible]	[illegible]	[illegible]	
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
0	[illegible]	ISSUED FOR FABRICATION	G	[illegible]	[illegible]	[illegible]	[illegible]	
NO.	DATE	REVISIONS	BY	CHK'D	[illegible]	[illegible]	[illegible]	[illegible]

SCALE NONE | [illegible] | [illegible] G

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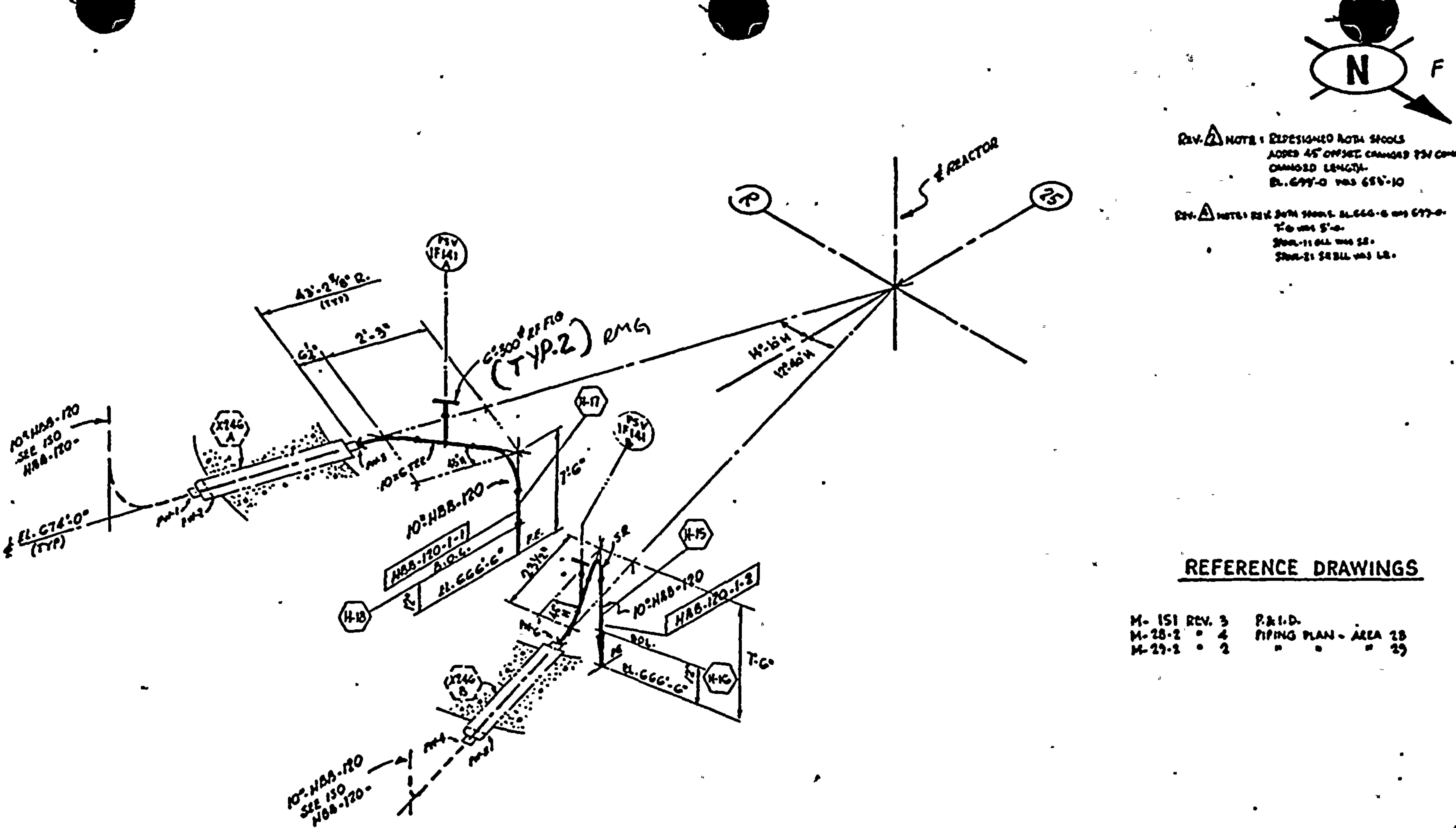
ISOMETRIC - REACTOR BLDG.
R.H.R. - UNIT # 2

JOB No. 8856 | 51-25 DRAWING No. DCA-210-1 | REV 4

G2 | ISO REACTOR BLDG RHR



REV. 2 NOTE: REDESIGNED BOTH SPOOLS
ADDED 45° OFFSET. CHANGED PSV CONN.
CHANGED LENGTH.
EL. 699'-0 WAS 655'-10

REV. 3 NOTE: REV. BOTH SPOOLS. EL.666'-6 WAS 699'-0.
7'-6 WAS 5'-0.
SPOOL-11 ELL WAS SR.
SPOOL-21 SR ELL WAS LR.

REFERENCE DRAWINGS

M- 151	REV. 3	P.& I.D.	
M- 28-2	" 4	PIPING PLAN - AREA	28
M- 29-2	" 2	" " "	29

COMPONENTS ON THIS DWG. ARE Q-LISTED SPEC. 8856-G-9 APPLIES

5	7-20-78	ADDED PIPE SUPPORTS	R.J	[illegible]	[illegible]		[illegible]
4	[illegible]	SEE REV 4 NOTE [illegible]	[illegible]	[illegible]	[illegible]		[illegible]
3	[illegible]-76	REV SPOOL-11 [illegible] PSV 1F141 WAS 1S130 A & B.	R.J	J.	[illegible]	R.J	[illegible]
2	[illegible]-76	SEE REV 3 NOTE	R.J	J.	[illegible]	R.J	[illegible]
1	9/19/7[illegible]	ADDED SPOOL & PW NO'S.	[illegible]	R.J	[illegible]	R.J	[illegible]
0	3/11/76	ISSUED FOR FABRICATION	R.J	RT	[illegible]	R.J	[illegible]

DRAWN R.J

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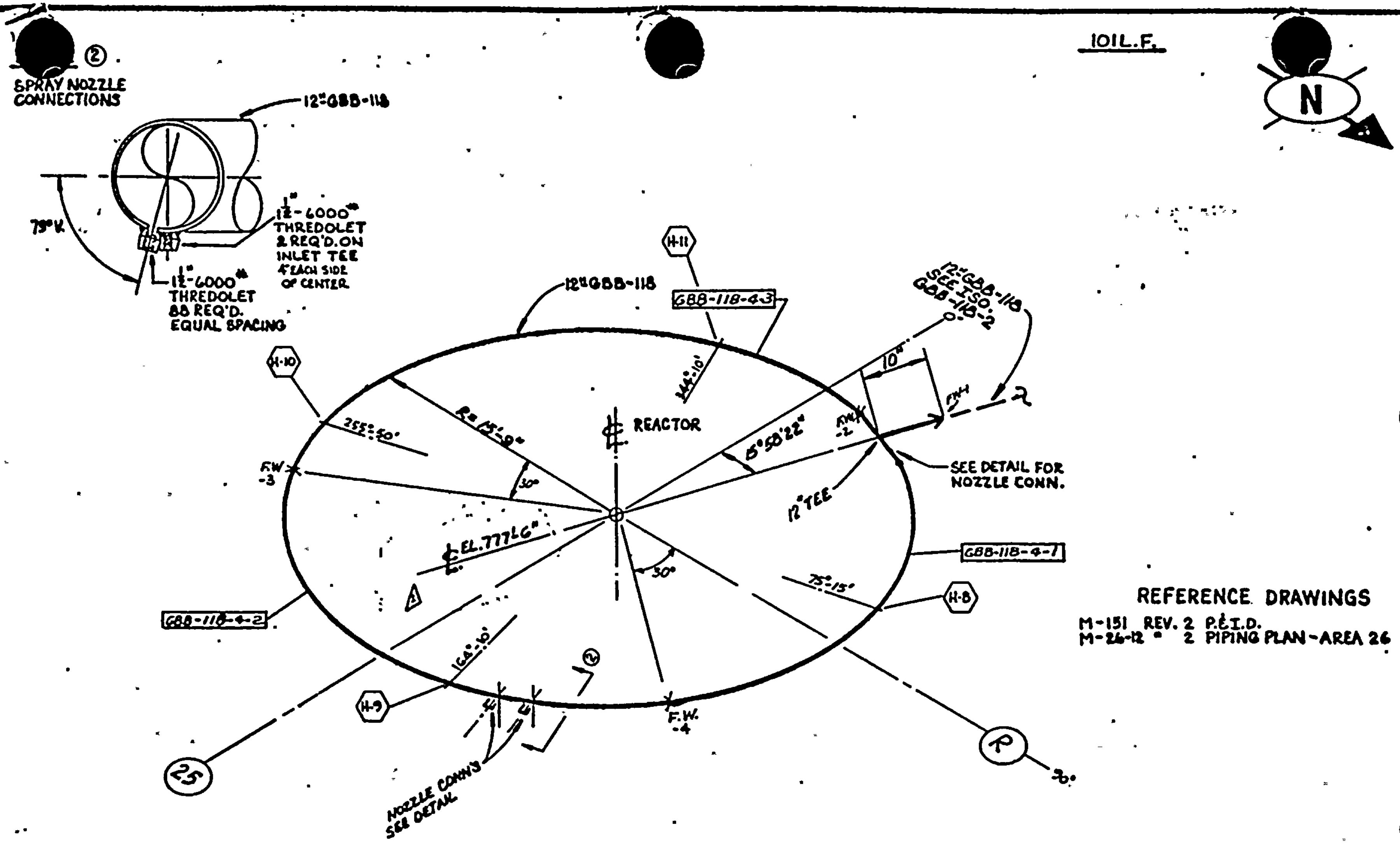
ISOMETRIC-REACTOR BLDG. R.H.R. - UNIT 1

JOB No.	51-21 DRAWING No.	REV.
8856	HBB-120-1	5

311 130 REACTOR BLDG RHR



REFERENCE DRAWINGS

M-151 REV. 2 P.&I.D.
M-26-12 " 2 PIPING PLAN-AREA 26

COMPONENTS ON
THIS DWG. ARE Q-LISTED
SPEC. 8856-G-8 APPLIES

△								
△								
△	[illegible]-76	[illegible] 111-6 [illegible] SUPPORTS. ISSUED FOR CONSTR.	RJ	[illegible]	[illegible]	RJ	[illegible]	
△	[illegible]	ADDED SPOOL & FW NOS. PER FIELD REQUEST	[illegible]	RJ	[illegible]	[illegible]	[illegible]	
△	[illegible]	ISSUED FOR FABRICATION	D.T.	RJ	[illegible]	RJ	[illegible]	

D.T.

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BECHTEL - SAN FRANCISCO

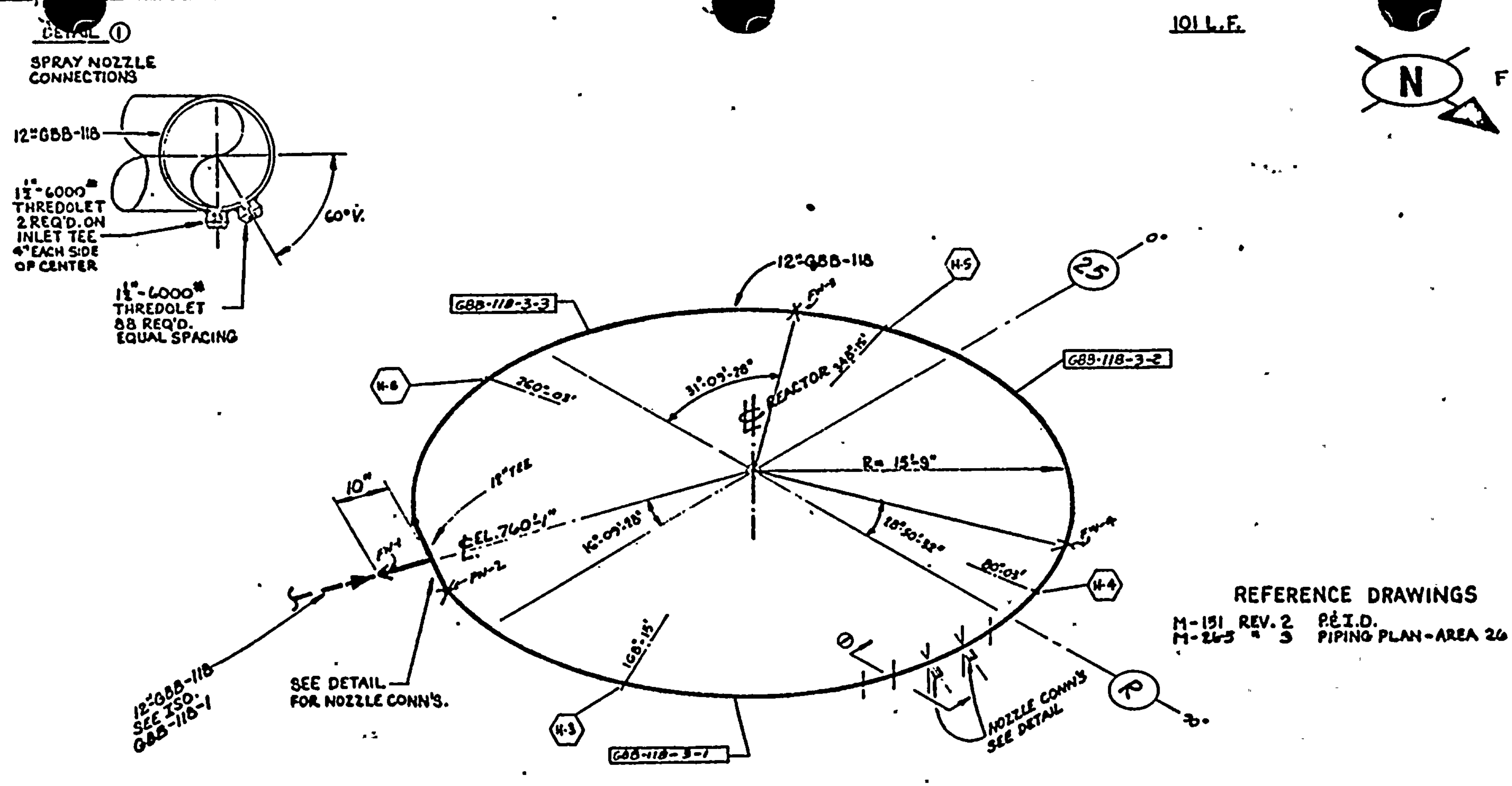
ISOMETRIC - REACTOR BLDG.
RHR - UNIT 1

BECHTEL

JOB No.	51-19 DRAWING No.	REV.
8856	GBB-118-4	2

Q

GI ISO REAC BLDG RHR M



REFERENCE DRAWINGS

M-151	REV. 2	P.&I.D.
M-265	" 3	PIPING PLAN-AREA 26

COMPONENTS ON THIS DWG: ARE Q-LISTED SPEC. 8856-G-9 APPLIES

△								
△								
△	[illegible]	[illegible]	RJ	[illegible]	[illegible]	[illegible]	[illegible]	
△	[illegible]	[illegible]	[illegible]	RJ	[illegible]	RJ	RC	
△	[illegible]	[illegible]	BT	RJ	[illegible]	[illegible]	[illegible]	

B.T.

PENNSYLVANIA POWER & LIGHT COMPANY

BECHTEL – SAN FRANCISCO

ISOMETRIC – REACTOR BLDG.
RHR – UNIT 1

JOB No.	DRAWING No.	REV
8856	51-19 GBB-118-3	2

Q

G 1 1 ISO REAC BLDG RHR 1 M

SUBJECT: Study on Torsional effect on the seismic response analysis of (1) ESSW Pumphouse (2) Diesel Generator Building

As requested by NRC analysis has been performed to study the effects of including torsion in the dynamic response analysis for (a) ESSW Pumphouse (b) Diesel Generator Building.

The Analytical Procedure used in this study consists of:

(i) The eccentricities of these structures were calculated.

(ii) The structures were represented by a fixed base 3-D stick models with structural masses properly lumped at the calculated eccentricities, as shown in Figure 1 and 2.

(iii) Modal frequency analyses of the 3-D stick models were performed to determine the structure frequencies.

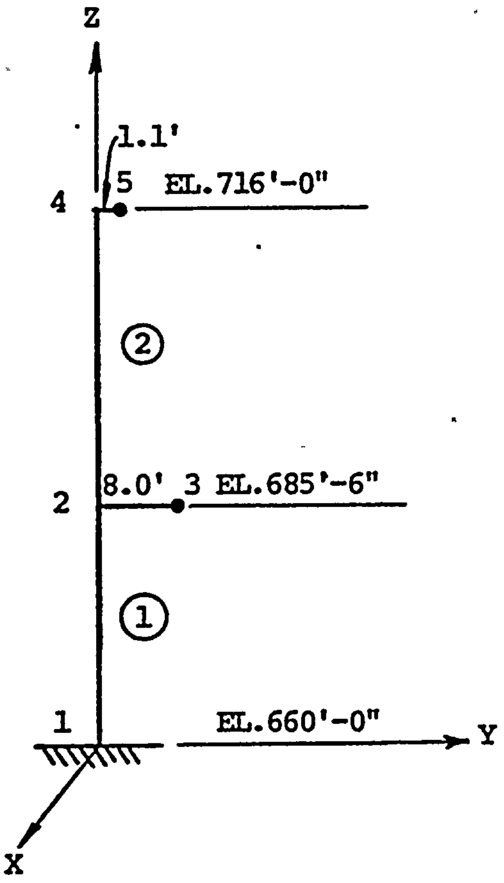
(iv) The frequencies determined are then compared with the corresponding frequencies associated with the fixed base models having zero eccentricities.

The results of comparison for the ESSW Pumphouse is shown on Table-1 and for the Diesel Generator building is shown on Table-2. These results indicate that there are insignificant shifts in the structural frequencies by including the eccentricities in the dynamic analysis.

From the results of this study, it is concluded that the structures modeled by lumped stick models without the inclusion of eccentricities in the dynamic analysis is adequate for the prediction of desired structural responses.

CONTROL# 8106120200

DATE- 6/10/81



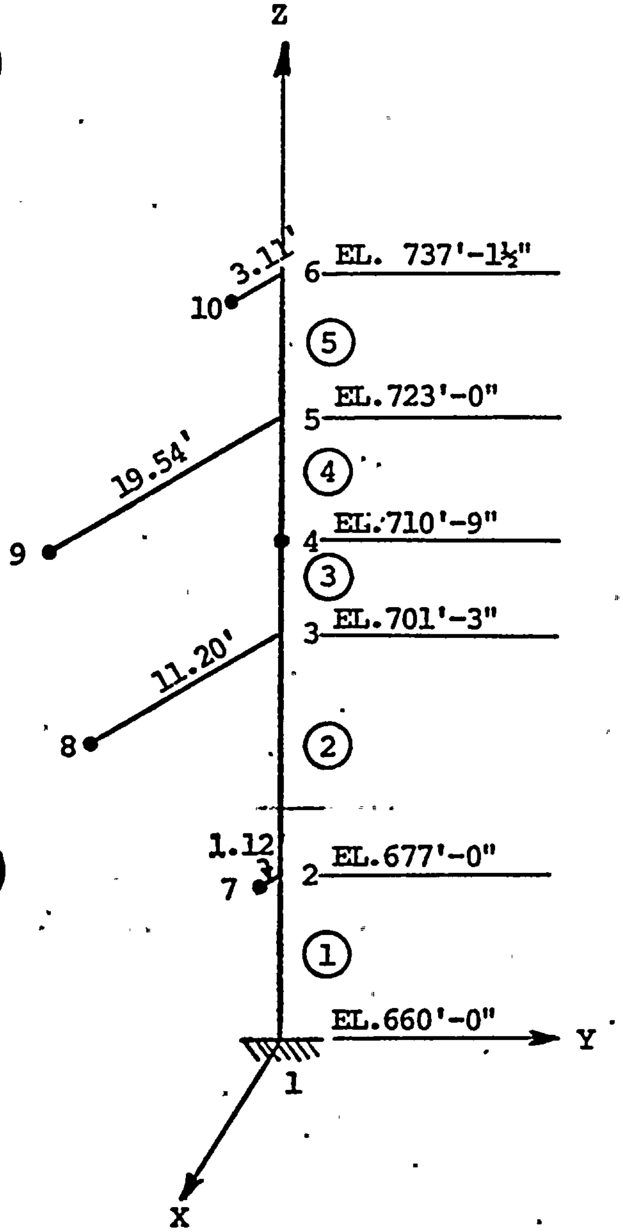
COORDINATES			
NODES	X	Y	Z
1	0.0	0.0	660.0
2	0.0	0.0	685.5
3	0.0	8.0	685.5
4	0.0	0.0	716.0
5	0.0	1.1	716.0

MASSES AT NODES 3 AND 5

FIGURE-1

ESSW PUMP HOUSE

3-D STICK MODEL



MASSES AT NODES 4,8,9,10

	COORDINATES		
NODES	X	Y	Z
1	0.0	0.0	660.0
2	0.0	0.0	677.0
3	0.0	0.0	701.3
4	0.0	0.0	710.8
5	0.0	0.0	723.0
6	0.0	0.0	737.1
7	0.5	-1.0	677.0
8	8.9	-6.8	701.3
9	19.5	-1.3	723.0
10	0.3	-3.1	737.1

FIGURE 2

DIESEL GENERATOR BUILDING

3-D STICK MODEL

Table-1: <u>ESSW PUMPHOUSE:</u>
Frequencies with and without
eccentricities
(See Figure-1)

Mode #	Frequencies (cps)	
	With Eccentricity	Without Eccentricity
1	13.93	13.94
2	18.05	18.06
3	28.94	28.97
4	38.83	40.01

Table-2: <u>DIESEL GENERATOR BUILDING:</u>
Frequencies with and without
eccentricities
(See Figure-2)

Mode #	Frequencies (cps)	
	With Eccentricity	Without Eccentricity
1	8.86	8.96
2	9.65	9.71
3	22.56	23.42
4	31.69	32.04
5	33.45	33.66

SUBJECT: Equivalence of Fixed Base and Flexible Base Models used for the analysis of Primary Containment for seismic loads.

In continuation of our response to the NRC question 130.20 as desired by NRC, a study has been made on the above subject. The object of this study is to demonstrate that as the shear wave velocity is increased, the results from the flexible base model converge to the results of the fixed base model.

The study considers the vertical seismic analysis for SSE for (a) a fixed base model (b) flexible base models for various foundation flexibililites defined by shear wave velocities V_S, $2V_S$, $5V_S$, $10V_S$ where V_S for the Susquehanna site is 6200 ft./sec. This corresponds to an equivalent vertical spring constant as shown in Table-1. A sketch of the flexible base vertical seismic model is shown in figure 3.7b-8 of FSAR (See Attachment #1).

A damping value of 5% of critical was used for all fixed base structural modes. The damping determination technique described in reference 3.7b-3 of FSAR [BC-Top-4A, Rev. 3, Appendix D] has been used to calculate the composite modal damping for the flexible base model.

The results for the fixed base and the flexible models are shown in Table-2 and Table-3, in terms of frequencies and modal damping values. The seismic (SSE) responses in terms of axial forces are presented in Table-4. The results indicate the following:

(a) Table-2: Frequencies values approach fixed base conditions for $5V_S$.

(b) Table-3: Modal damping values approach the fixed base condition for $5V_S$.

(c) Table-4: Seismic responses approach fixed base conditions for $2V_S$.

These results demonstrate that as the shear wave velocity is increased to 2 to 5 times the actual site shear wave velocity, the results from the flexible base model converge to the results of the fixed base model. Thus use of the flexible base model for the seismic analysis of the containment structure is more realistic.

Table-1: CONTAINMENT: Equivalent Vertical Spring Constants.

From FSAR Section 3.7b.5, Reference 3.7b-3
(BC-Top-4-A, Page 3-15)

Equivalent Vertical Spring Constant, $k_z = \frac{4GR}{(1-\nu)}$

Where ν = Poisson's ratio = 0.3

R = Radius of Circular base mat = 50 ft.

G = Shear Modulus = ρV_s^2

V_s = Shear Wave Velocity = 6200 ft./sec.

ρ = Mass density of foundation medium = 4.3478E-3 k.sec^2/ft^4 (γ = 140 lbs/cft.)

$V_s = V_s$ $\quad k_z$ = 4.78E07 k/ft.

$V_s = 2V_s$ $\quad k_z$ = 1.912E08 k/ft.

$V_s = 5V_s$ $\quad k_z$ = 1.195E09 k/ft.

$V_s = 10V_s$ $\quad k_z$ = 4.78E10 k/ft.

Table-2: CONTAINMENT: Vertical Seismic Model Flexible Base Vs. Fixed Base Frequencies. (Cps)

Frequencies (Cps)

Mode #	Flexible Base				Fixed Base
	V_s = 6200 ft/sec.	$2V_s$	5Vs	$10V_s$	
1	16.19	17.24	17.45	17.47	17.48
2	20.95	23.18	24.09	24.23	24.28
3	38.24	38.63	38.75	38.77	38.78

Table-3: CONTAINMENT: Vertical Seismic Model Flexible Base Vs. Fixed Base Modal Damping (% Critical)

Modal Damping (% Critical)

Mode #	Flexible Base				Fixed Base
	V_s = 6200 ft/sec.	$2V_s$	5Vs	$10V_s$	
1	9.3	5.3	5.0	5.0	5.0
2	9.1	6.1	5.0	5.0	5.0
3	5.0	5.1	5.0	5.0	5.0

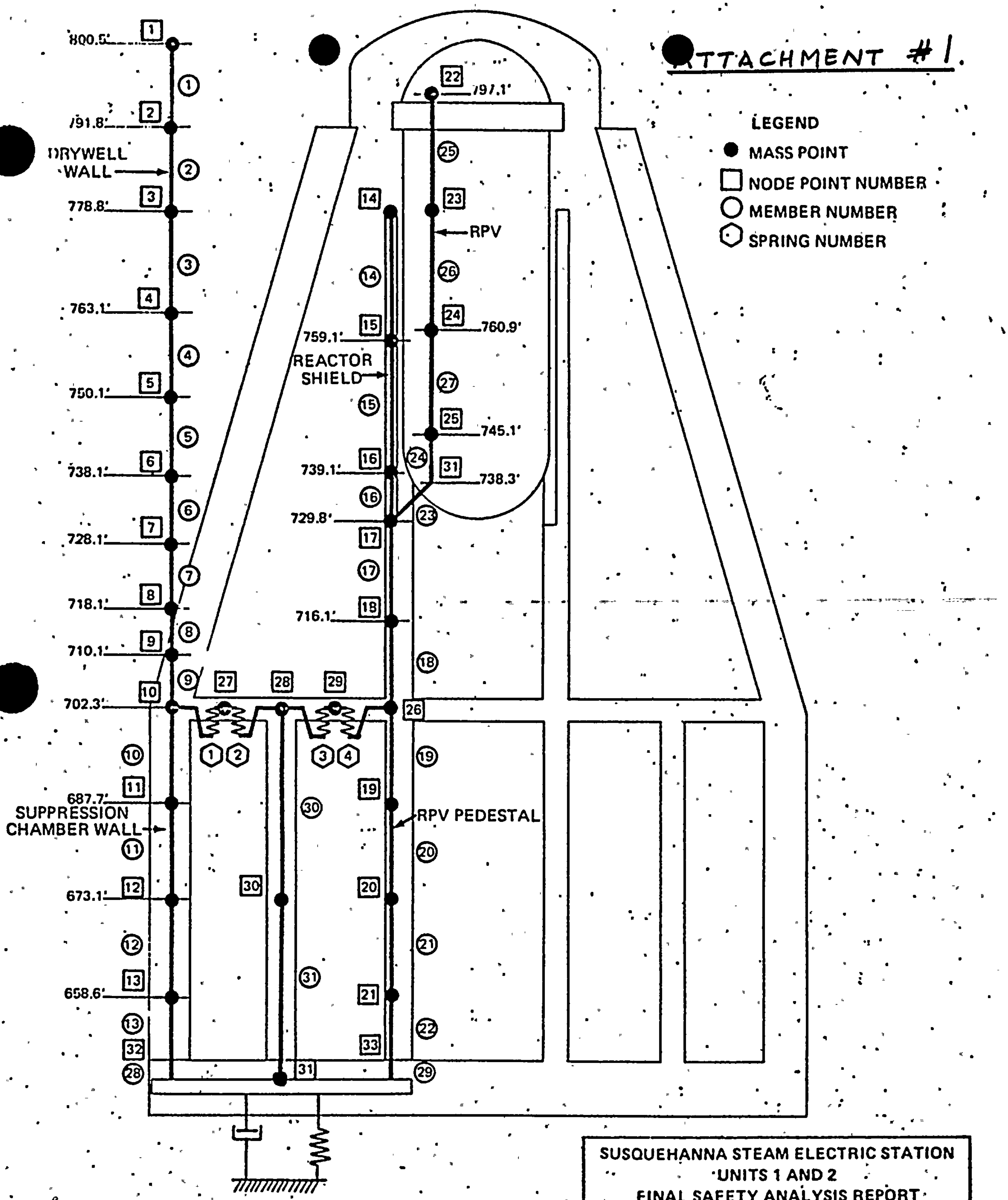
Table-4: CONTAINMENT: Axial Forces (SSE) (kips)
See Figure 3.7b-8 of FSAR, (Attachment #1)
for location of members.

Member #	Flexible Base				Fixed Base
	V_s = 6200 ft/sec.	$2V_s$	5Vs	$10V_s$	
1	14.5	21.8	22.2	21.9	21.9
2	84.7	127.5	130.0	127.7	127.8
3	239.9	360.7	367.7	360.8	361.1
4	412.2	617.9	629.1	617.0	617.6
5	576.5	860.7	874.9	857.7	858.4
6	734.5	1090.8	1106.6	1084.3	1085.1
7	866.9	1280.4	1296.1	1269.5	1270.3
8	991.5	1454.3	1468.5	1437.7	1438.4
9	1095.4	1595.9	1607.5	1573.1	1573.7
10	1319.0	1773.8	1774.7	1733.2	1733.2
11	1479.1	1968.3	1956.7	1909.4	1908.7
12	1611.6	2107.5	2078.2	2025.5	2024.0
13	1701.4	2177.3	2128.2	2071.5	2069.0
14	34.9	34.8	33.1	31.7	31.6
15	127.3	126.3	119.6	114.3	113.8
16	201.3	197.3	185.9	176.9	176.2
17	843.4	842.7	787.2	743.4	739.6
18	899.6	895.0	835.9	789.3	785.2
19	759.5	727.5	680.6	642.5	639.2
20	799.1	762.2	712.5	672.5	669.1

TABLE-4 (Cont'd)

Member #	Flexible Base				Fixed Base
	V_s = 6200 ft/sec.	$2V_s$	5Vs	$10V_s$	
21	829.5	786.9	734.8	693.5	689.9
22	845.3	797.2	743.3	701.5	697.8
23	602.9	611.5	571.5	540.0	537.3
24	602.9	611.5	571.5	540.0	537.3
25	76.9	78.2	73.2	69.3	68.9
26	234.2	238.4	223.1	211.0	209.9
27	418.5	426.1	398.4	376.6	374.7
28	1701.3	2177.3	2128.2	2071.5	2069.0
29	845.3	797.2	743.3	701.5	697.8
30	83.2	82.6	80.9	77.1	77.5

ATTACHMENT #1.



SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 AND 2
FINAL SAFETY ANALYSIS REPORT

VERTICAL SEISMIC
MODEL OF CONTAINMENT
WITH FLEXIBLE BASE

FIGURE 3.7b-8

SUSQUEHANNA SES UNIT 1 AND 2
DOCKET NUMBERS 50-387 AND 50-388
CATEGORY I MASONRY WALLS

PREAMBLE:.

Safety related masonry walls are interior partitions whose primary function is to provide shielding and fire protection. Masonry walls are not used as primary shear walls for seismic resistance of the structure. All category I masonry walls are reinforced with all cells fully grouted. The infill material of double wythe walls is either grout or concrete. The minimum specified compressive strength for grout, concrete, and mortar is 2500 psi. Mortar infill is not used on SSES masonry walls. Metal ties, between the wythes of double wythe walls, are provided at 24" spacing maximum in horizontal and vertical directions. Seismic design is in accordance with SSES FSAR Section 3.7. Allowable stresses are as noted in FSAR Section 3.8, Table 3.8-8 and Table 3.8-9. Safety related masonry walls are Q-listed and have been added to the FSAR Design Criteria Summary (Table 3.2-1), in response to NRC, Quality Assurance Branch, Question No. 260.1-b (34).

QUESTION NO. 1:

In your response to Question 2, you indicated that Sm is the allowable stress as specified in UBC. For extreme and/or abnormal loading combinations, you increase the allowable stress by a factor of 1.67, which is in conformance with the practice of SRP Sections 3.8.3 and 3.8.4, for reinforced concrete structures. However, concrete masonry walls are quite different from reinforced concrete walls, particularly the unreinforced ones, the use of such a practice may not result in an adequate design. Depending on the types of stress, that is, tensile, shearing or axial compressive, the factor may vary from 0 to 2.5 (see enclosure 2). Specify the masonry design strength f'_m used in Susquehanna masonry walls and the allowable values for all types of stresses.

RESPONSE:

Code allowable stresses for masonry tension, shear, compression, and bond are increased by a factor of 1.67 for load combinations involving abnormal and/or extreme environmental conditions which are credible but highly improbable. Since code allowable stresses are generally associated with a factor of safety of 3, the 1.67 increase provides a factor of safety against failure of 1.8 ($3 \div 1.67$) (see Table 4 for the increase allowed for each type of stress). There are no unreinforced masonry walls on SSES project. Susquehanna SES masonry walls are designed based on an ultimate compressive strength, f'_m, of 1500 psi as specified in UBC 1976, for solid grouted hollow masonry. Minimum compressive strength at 28 days for mortar, grout, and concrete is 2500 psi. Materials are in accordance with FSAR Appendix 3.8C. The allowable stresses are as listed in Table 1.

TABLE 1.

SSES ALLOWABLE STRESSES

Materials and Stress Type	Allowable Stress: UBC - 1976 (1) psi
1. **Masonry:**	$f'_m = 1500$ (see note 2)
Compression:	
Flexural	$.33f'_m = 500$
Axial	$.20f'_m \times (1-(h/40t)^3)$ h = clear height, in. t = wall thickness, in.
Flexural Shear	$1.1 \sqrt{f'_m} = 43$
Bond (deformed bars)	140
Bearing	$.25f'_m = 375$
Bed Joint tension	
Normal	(See note 3)
Parallel	25
Modulus of elasticity, E_m	$1000f'_m = 1,500,000$
Modulus of rigidity, E_v	$400f'_m = 600,000$
2. **Reinforcement:**	
Tension:	
Grade 40 Steel	20,000 (used for ties only)
Grade 60 Steel	24,000
Compression:	
Grade 40 Steel	16,000 (used for ties only)
Grade 60 Steel	24,000

Notes:
(1) For stress increase allowed for abnormal, or extreme environmental load combinations - See Table 4.

(2) Ultimate compressive strength as specified in UBC - 1976 for solid grouted hollow concrete units - Grade N.

(3) Zero tension normal to bed joint is used.

QUESTION NO. 2

In the note to your response to Question 2, you stated that the allowable shear or tension between masonry block and concrete or grout infill is considered to be equal to three percent of the compressive strength of the block. The allowable shear or tension as specified by you is in the staff's opinion too high. To specify the allowable shear or tension of the vertical joint between wythes in terms of the compression strength of the block is in the first place unconservative and the use of seemingly low percentage of 3% may actually result in an allowable shearing stress greater than its corresponding strength. Therefore, a revision of the stress criterion is required.

RESPONSE:

The specified shear and tension, for the interface of masonry block and concrete or grout infill, of three percent of compressive strength, f'_m, is based on the relationship $1.1\sqrt{f'_m}$ given in ACI-531-79. For $f'_m = 1500$ psi, this relationship yields a value of 43 psi compared to 45 psi (.03 x 1500) allowed for evaluation of project masonry walls. The difference of 2 psi is justified by the fact that the ultimate compressive strength of masonry f'_m, is generally higher than 1500 psi.

The values for shear and tension as specified above have been used only as a guide in evaluating double wythe walls, where infill thickness is greater than 8 inches (24" thick walls and larger). For walls having an infill thickness of less than 8 inches (total of four walls), zero tension/shear is assumed for evaluation purposes.

For SSES masonry walls, the actual shear stress, as determined by VQ/Ib for uncracked sections, and in the compression zone of cracked sections ranges from 5-10 psi; except for three walls. For these three walls shearing stress is in the range of 10-15 psi.

QUESTION NO. 3

In your response to Question 4: (1) It is indicated that response spectrum method is used for the dynamic analysis of the concrete masonry walls. However, there is no mention as to which of the response spectra is used, upper floor or lower floor response spectrum or the average of the two. It is required that an upper bound envelope of the individual floor is used. (2) Though the use of ACI 318 formula the cracking of concrete masonry wall is considered. The use of such a formula is questionable in view of the fact that in a concrete masonry wall the weakest section is the bed joint and the modulus of rupture is equal to that of neither the concrete block nor the mortar. Indicate how the modulus of rupture is established in your computation.

RESPONSE ITEM (1):

Response spectrum for the lower floor has been used for evaluation of cracked/uncracked behavior of masonry walls, as applicable, for vertical motion, and for walls cantilevered from the floor. For horizontal motion, the lower floor response spectrum has been used in the initial evaluation of cracked/uncracked behavior, as applicable, for walls spanning between two floors and walls having side connection at concrete walls. These walls have also been re-evaluated based on the average acceleration of the upper and lower floors. Where the upper floor acceleration is less than the lower floor acceleration, the lower floor acceleration is used. For justification of using average acceleration, see Enclosure 1.

RESPONSE ITEM (2):

Although ACI-318 formula is derived for cracked concrete sections, the use of the formula for masonry walls takes into consideration the difference in material strengths. The difference between masonry behavior and concrete behavior is recognized and allowances are provided in selection of seismic acceleration within a frequency variation of plus or minus fifteen percent of the natural frequency.

The modulus of rupture (f_r) for masonry is approximated by increasing the UBC allowable flexural tensile stress by a factor of safety of 3 and then applying a 33% reduction to arrive at a lower bound value. This value is used only for stiffness and frequency calculations of the cracked section and not for strength. Allowance for uncertainties in the modulus of rupture is accounted for in the frequency variation of ± 15% of the natural frequency.

QUESTION NO. 4:

In response to Question 5, it is stated that when the design stresses of masonry walls exceed the allowable stresses, fixes are designed such that the criteria is satisfied. Indicate the number of walls where such fixes are needed and provide examples.

RESPONSE:

The number of masonry walls requiring fixes for cracked section criteria is 36. Wall location, thickness, and elevation are as shown in Table 2. Typical fixes are shown in details type 1, type 2, type 3, and type 4 (see Enclosure 2).

TABLE 2

SSES - MASONRY WALLS
WALLS WHICH REQUIRED FIXES FOR CRACKED SECTION CRITERIA

BLDG.	FLOOR ELEVATION	WALL THICKNESS	NO. OF WALLS	REF. DWG.
Control	656'-0	8"	2	C-1301
Control	741'-0	6"	2	C-1304
Control	741'-0	8"	3	C-1304
Control	753'-0	8"	1	C-1304
Control	771'-0	8"	16	C-1304
Control	783'-0	1'-0"	3	C-1307
Control	806'-0	8"	3	C-1308
Control	806'-0	1'-0"	1	C-1308
Reactor	728'-0	8"	1	C-1202
Reactor	799'-0	8"	4	C-1205

QUESTION NO. 5:

Provide justification for any deviation from the attached staff's interim criteria in your design and analysis of the masonry walls.

RESPONSE:

Deviations and justification for differences between SSES criteria and SEB interim criteria are as noted in the following paragraphs.

Items which are not specifically addressed are in accordance with the criteria or not applicable to the project.

ITEM NO. 1: General Requirments

The materials, testing, analysis, design, construction and inspection related to the design and construction of safety-related concrete masonry walls shall conform to the applicable requirements contained in Uniform Building Code - 1979, unless specified otherwise, by the provisions in this criteria.

RESPONSE:

Uniform Building Code, 1976 edition, has been used for design and evaluation of Susquehanna masonry walls. A comparison of 1976 and 1979 editions of UBC shows no significant difference in criteria applicable to SSES masonry walls. In addition, ACI-531-79 is used to supplement UBC allowable stresses, and ACI-318 1977 in stiffness calculations.

ITEM NO. 2: Loads and Load Combinations

The loads and load combinations shall include consideration of normal loads, severe environmental load, extreme environmental load, and abnormal loads. Specifically, for operating plants, the load combinations provided in plant's FSAR shall govern. For operating license applications, the following load combinations shall apply for definition of load terms, (see SRP Section 3.8.4.11-3).

RESPONSE:

For comparison of SEB interim load combinations and load combinations used for masonry walls evaluation see Table 3. Definition of terms is as shown below.

Notation

D = Dead load of structure plus any other permanent loads contributing stress.

L = Live loads expected to be present when the plant is operating, including movable equipment, piping, cables.

P = Design basis accident pressure loads.

R = Steam/water jet forces or reactions resulting from rupture of process piping.

T_o = Thermal effects during normal operating conditions including temperature gradient and equipment and pipe reactions.

H_o = Force on structure due to thermal expansion of pipes under operating conditions.

T_a = Added thermal effects (over and above operating thermal effects) which occur during a design accident.

H_a = Force on structure due to thermal expansion of pipes under accident conditions.

E = Load due to Operating Basis Earthquake.

E' = Load due to Design Basis Earthquake.

W = Wind load.

W' = Tornado wind load.

D_s = Force on blockwall due to story drift under Operating Basis Earthquake Loading.

D'_s = Force on blockwall due to story drift under Safe Shutdown Earthquake Loading.

TABLE 3. - LOAD COMBINATION COMPARISON

LOAD COMBINATION	SEB INTERIM CRITERIA	SSES FSAR CRITERIA	COMMENTS
Service Load Condition	1. $D + L$ 2. $D + L + E$ 3. $D + L + W$	1. $D + L$ 2. $D + L + E + D_s$ 3. Not Applicable	 No wind pressure
	1a. $D + L + T_o + R_o$ 2a. $D + L + T_o + R_o + E$ 3a. $D + L + T_o + R_o + W$	1a. $D + L + T_o + H_o$ 2a. $D + L + T_o + H_o + E$ 3a. Not Applicable	 No wind pressure
Extreme environmental	4. $D + L + T_o + R_o + E'$ 5. $D + L + T_o + R_o + W_t$	4. $D + L + T_o + H_o + E' + D'_s$ 5. $D + L + T_o + H_o + W'$	 See note 2
abnormal	6. $D + L + T_a + R_a + 1.5\ P_a$	6. $D + L + (T_o + T_a) + R + 1.25\ P_a + H_a$	See note 1
abnormal/severe environmental	7. $D + L + T_a + 1.25\ P_a + 1.0\ (Y_r + Y_j + Y_m) + 1.25E + R_a$	7. $D + L + (T_o + T_a) + 1.25\ P_a + R + 1.25\ E + D_s$	
abnormal/ extreme environmental conditions	8. $D + L + T_a + R_a + 1.0\ P + 1.0\ (Y_r + Y_j + Y_m) + 1.0E'$	8. $D + L + (T_o + T_a) + R + 1.0\ P + 1.0\ E' + D'_s$	

Notes: (1) Abnormal load combination in SSES-FSAR Table 3.8-9. Part C will be revised to read $D + L + (T_o + T_a) + R + 1.5\ P_a + H_o$. All other load combinations will remain unchanged.

(2) W' does not include W_m, tornado missile. Masonry walls are not used for protection of safety related equipment against tornado missiles.

ITEM NO. 3: Allowable Stresses

Allowable stresses provided in chapter 24 of UBC-79, as supplemented by the following modifications/exceptions shall apply.

(a) When wind or seismic loads (OBE) are considered in the loading combinations, no increase in the allowable stresses are permitted.

RESPONSE:

Design and evaluation of masonry walls is based on a 33% increase in the allowable stress. This increase is permissible per UBC, 1979 and per ACI-531-79. The factor is also compatible with the 25% increase in stress noted in SSES FSAR for Working Stress Design Method.

ITEM NO. 3: (b) Use of allowable stresses corresponding to special inspection category shall be substantiated by demonstration of compliance with the inspection requirements of the NRC criteria.

RESPONSE:

Stresses corresponding to special inspection have been used in the design and evaluation of SSES masonry walls. Inspection required to assure that masonry construction is in accordance with Appendix "D" and amendments to the PSAR, and to assure that materials are in accordance with FSAR Appendix 3.8C is implemented. Documentation of this inspection is in project jobsite files.

ITEM NO. 3: (c) For load conditions, which represent extreme environmental, abnormal, abnormal/severe environmental, and abnormal/ extreme environmental conditions the allowable working stresses may be multiplied by the factors shown in the following table: (See table 4).

TABLE 4.

STRESS INCREASE FACTOR COMPARISON

	SEB	SSES	
	FACTOR	FACTOR	JUSTIFICATION/COMMENT
Axial or flexural compression	2.5	1.67	See Response Question #1
Bearing	2.5	1.67	"
Reinforcement stress except shear	2.0	1.67	See note 1
Shear Reinforcement and/or bolts	1.5	1.5	Anchor bolts are not used in safety related masonry walls
Masonry tension Parallel to bed joint	1.5	1.5	
Shear carried by masonry	1.0	1.67	See note 2
Masonry tension perpendicular to bed joint			
For reinforced masonry	0	0	
For unreinforced masonry	1.0	N/A	No unreinforced masonry walls

(1) Shall not exceed .90 fy

(2) The actual shear stress carried by masonry is within the allowable shear stress given in UBC Table 24-H with no increase factor applied.

RESPONSE:

See table above.

QUESTION NO. 5: Design and Analysis Considerations

ITEM 4g:

In new construction, no unreinforced masonry wall is permitted, also all grout in concrete masonry walls shall be compacted by vibration.

RESPONSE:

a. There are no unreinforced masonry walls in SSES project.

b. Cell grout and/or infill grout or concrete is compacted by either mechanical vibrators or by rodding.

ITEM 4i:

Special constructions (e.g., multiwythe, composite) or other items not covered by the code shall be reviewed on a case by case basis for their acceptance.

RESPONSE:

Double wythe walls are designed as composite sections, except as noted in response to Question No. 2. Allowable stresses are per ACI-531-79.

ITEM 4j:

Licensees or applicants shall submit QA/QC information, if available, for staff's review.

RESPONSE:

Applicable QA/QC information is available at SSES jobsite and will be submitted upon request.

ENCLOSURE 1.

JUSTIFICATION FOR THE USE OF AVERAGE RESPONSE SPECTRA

(13 PAGES)

WP26/23-1

JUSTIFICATION OF USING APPROXIMATION METHOD TO DETERMINE MAXIMUM WALL PANEL RESPONSES TO SEISMIC MOTION

The evaluations herein demonstrate that: (1) The use of the average floor acceleration response spectra to calculate the response of the wall panel is appropriate, and (2) The use of uniform inertia load with magnitude equal to the average spectral acceleration for the fundamental mode, in calculating the maximum seismic responses is a good approximation, even considering the higher mode effect.

For the purposes of this evaluation, the seismic response of a simply-supported, uniform beam simulating a strip of the wall panel with unit width is considered, as shown in Figure 1.

(1) Use of Average Spectra

The equation of motion of an undamped, simply-supported beam can be written in terms of the total displacement with respect to some fixed reference axis as:

$$m \frac{\partial^2 u}{\partial t^2} + EI \frac{\partial^4 u}{\partial x^4} = 0 \qquad (1)$$

Where m and EI are the mass density and flexural rigidity of the beam. Denote the seismic excitations at the ends of the

the beam as U_a and U_b. Then the total displacement $u(x,t)$ can be expressed in terms of the two seismic motions and the relative displacement to the seismic motions as:

$$u(x,t) = (x/L) \; U_b + (1 - x/L) \; U_a + r(x,t) \tag{2}$$

Where L is the length of the beam. The relation expressed by the above equation is shown in Figure 2. The relative displacement $r(x,t)$ needs to satisfy the following simply-supported conditions:

$$r(o,t) = r(L,t) = 0 \tag{3}$$

$$\left.\frac{\partial^2 r}{\partial x^2}\right|_{x=o} = \left.\frac{\partial^2 r}{\partial x^2}\right|_{x=L} = 0 \tag{4}$$

Substitute Equation 2 into Equation 1, the equation of motion in terms of relative displacement $r(x,t)$ can be expressed as:

$$m\frac{\partial^2 r}{\partial t^2} + EI\frac{\partial^4 r}{\partial x^4} = - m(x/L) \ddot{U}_b - m(1 - x/L)\ddot{U}_a \tag{5}$$

The eigen-function solutions for the homogeneous equation associated with Equation 5 that satisfy the boundary conditions specified by Equations 3 and 4 are:

$$\sin \frac{n\pi x}{L}, \quad n = 1, 2, 3, \ldots ,$$

and the corresponding frequencies of vibration are:

$$\omega_n = n^2 \pi^2 \sqrt{\frac{EI}{mL^4}} \qquad n = 1, 2, 3, \ldots \tag{6}$$

So, the solution of Equation 5 can be expressed as:

$$r(x,t) = \sum_{n=1}^{\infty} a_n(t) \sin \frac{n\pi x}{L} \tag{7}$$

Substitute Equation 7 into Equation 5, and multiply the latter by $\sin \frac{n\pi x}{L}$, and then integrate it with respect to x over the full length of the beam, the equation of motion can be transformed into modal equations of motion as:

$$\ddot{a}_n + \omega_n^2 a_n = \Gamma_n\left(\frac{\ddot{U}_a + \ddot{U}_b}{2}\right) \qquad n = 1, 3, 5, \cdots \tag{8a}$$

and

$$\ddot{a}_n + \omega_n^2 a_n = \Gamma_n\left(\frac{\ddot{U}_a - \ddot{U}_b}{2}\right) \qquad n = 2, 4, 6, \cdots \tag{8b}$$

where Γ_n = participation factor

$$= \frac{4}{n\pi} \tag{9}$$

If damping in the form of modal damping ratio is included, Equations 8a and 8b becomes:

$$\ddot{a}_n + 2\xi_n\omega_n\dot{a}_n + \omega_n^2 a_n = \Gamma_n\left(\frac{\ddot{U}_a + \ddot{U}_b}{2}\right) \qquad n = 1,3,5,... \tag{10a}$$

and

$$\ddot{a}_n + 2\xi_n\omega_n\dot{a}_n + \omega_n^2 a_n = \Gamma_n\left(\frac{\ddot{U}_a - \ddot{U}_b}{2}\right) \qquad n = 2,4,6,... \tag{10b}$$

Where ξ_n is the damping ratio of the nth mode.

Equation 10a means that the odd-number modes which are symmetrical about the mid-span of the beam will be excited by the average of the two seismic excitations; while equation 10b means that the even-number modes which are antisymmetrical about the mid-span of the beam will be excited by half of the difference between the two seismic excitations.

Expressing the maximum modal displacement response in equations 10a and 10b in terms of absolute acceleration response spectra gives:

$$|a_n|_{max} \leqslant |\Gamma_n| \left[\frac{S_a(\xi_n,\omega_n)}{2\omega_n^2} + \frac{S_b(\xi_n,\omega_n)}{2\omega_n^2} \right]$$

$$< \frac{4mL^4}{n^5 \pi^5 EI} \left[\frac{S_a(\xi_n,\omega_n) + S_b(\xi_n,\omega_n)}{2} \right] \qquad (11)$$

$$n = 1,2,3,\ldots$$

This illustrates that the use of the average of two floor acceleration response spectra to calculate the modal response of a wall panel is appropriate.

(2) Contribution of Higher Modes

From Equation 11, the relative importance of modes can be evaluated by examining the frequency ratios, modal participation ratios, and maximum modal response ratios for constant acceleration which can be shown as:

$$\omega_1 : \omega_2 : \omega_3 : . . . . = 1 : 4 : 9 : . . . \qquad (12)$$

$$\Gamma_1 : \Gamma_2 : \Gamma_3 : . . . . = 1 : -1/2 : 1/3 : . . . \qquad (13)$$

$$\frac{\Gamma_1}{\omega^2_1} : \frac{\Gamma_2}{\omega^2_2} : \frac{\Gamma_3}{\omega^2_3} : . . . . = 1 : -\frac{1}{32} : \frac{1}{243} : . . . . \qquad (14)$$

For an SRSS method of combining maximum response, the contribution of higher modes is clearly negligible.

If for example, the fundamental frequency ω_1 is above 8 H_z, the second frequency is above 32 H_z which is already in the rigid range, i.e., in the range of no amplification. Thus the S_a and S_b values associated with modes other than the fundamental will be the Zero-Period-Acceleration (ZPA) values of the two seismic motions U_a and U_b. Using the absolute sum (ABS) method of combining the modal maximum responses, In this case, the contribution of higher modes is not more than 4% of the fundamental mode.

The relative importance of modes can also be evaluated by examining the moment and shear responses in the beam for each mode, as shown in the following.

The moment in the beam due to the n^th mode can be evaluated by:

$$M_n(X) = EI \frac{\partial^2}{\partial X^2} \left[a_n \sin \left(\frac{n\pi X}{L} \right) \right]$$

$$< \frac{4mL^2}{n^3 \pi^3} \left[\frac{S_a(\xi_n, \omega_n) + S_b(\xi_n, \omega_n)}{2} \right] \sin \left(\frac{n\pi X}{L} \right) \qquad (15)$$

$$n = 1,2,3, \ldots$$

The moment at the mid-span of the beam is contributed only by the symetrical modes and can be expressed as follows:

$$M_n\left(\frac{L}{2}\right) < \frac{4mL^2}{n^3 \pi^3} \left[\frac{S_a(\xi_n, \omega_n) + S_b(\xi_n, \omega_n)}{2} \right] \qquad (16)$$

$$n = 1,3,5, \ldots$$

For a constant spectral acceleration, the contibution to the mid-span moment of the beam from each mode can be expressed in the following ratio:

$$M_1\left(\frac{L}{2}\right) \;:\; M_3\left(\frac{L}{2}\right) \;:\; M_5\left(\frac{L}{2}\right) \;:\; \cdots \;=\; 1 : \frac{1}{27} : \frac{1}{125} : \cdots \qquad (17)$$

Using the SRSS Method of combining modal responses, the contribution of the higher modes to the mid-span moment is less than 1% of that from the fundamental modes. Using the ABS method of combining modal responses, the contribution of higher modes is less than about 5%.

The shear force in the beam due to the nth mode can be evaluated as:

$$Q_n(X) = EI \frac{\partial^3}{\partial X^3} \left[a_n \sin\left(\frac{n\pi X}{L}\right)\right]$$

$$< \frac{4mL}{n^2\pi^2} \left[\frac{S_a(\xi_n, \omega_n) + S_b(\xi_n, \omega_n)}{2} \right] \cos\left(\frac{n\pi X}{L}\right) \qquad (18)$$

$$n = 1,2,3,4,\ldots$$

The maximum shear occurs at the support of the beam and can be expressed as:

$$Q_n(0) < \frac{4mL}{n^2\pi^2} \left[\frac{S_a(\xi_n,\omega_n) + S_b(\xi_n,\omega_n)}{2} \right] \quad (19)$$

$$n = 1,2,3,4,...$$

The contribution of the higher modes to the maximum shear at the beam support relative to that of the fundamental mode can be evaluated by comparing the modal effective masses (MEM) associated with the fundamental mode and the higher modes. The modal effective mass of the fundamental mode is

$$MEM_1 = \frac{8mL}{\pi^2} = 0.81\ mL \quad (20a)$$

The modal effective mass associated with modes higher than the fundamental mode can be calculated as

$$MEM_1' = (1 - 0.81)mL = 0.19\ mL \quad (20b)$$

The ratio of MEM_1' TO MEM_1 is 0.19/0.81 = 23%. That is the contribution of higher modes to the maximum shear is at most 23% of the contribution due to the fundamental mode. This ratio does not take into account the ratio of the spectral acceleration for the fundamental mode to the ZPA value for the higher modes. When the difference in spectral accelerations is accounted for, the contribution of higher modes to the maximum shear would be less than 23%. For example, if the spectral acceleration for the fundamental mode is 1.5 ZPA, then the ratio of higher mode contribution would be 0.19/(0.81 x 1.5) = 16%.

(3) Uniform Inertia Load Approximation

Using the modal responses, the maximum moment and shear of the beam can be calculated. This moment and shear can then be compared to the moment and shear based on a uniform inertia load using the average of the two floor spectral accelerations at the fundamental mode of the beam.

The maximum moment occured at the mid-span of the beam induced by a uniform load with the following magnitude:

$$f(X) = m\left[\frac{S_a\ (\xi_1,\omega_1) + S_b\ (\xi_1,\omega_1)}{2}\right] \qquad (21)$$

can be expressed as:

$$M^*\left(\frac{L}{2}\right) = \frac{mL^2}{8}\left[\frac{S_a\ (\xi_1,\omega_1) + S_b\ (\xi_1,\omega_1)}{2}\right] \qquad (22)$$

From Equation 16, the moment at the mid-span of the beam due to the fundamental mode is:

$$M_1\left(\frac{L}{2}\right) < \frac{4mL^2}{\pi^3} \left[\frac{S_a\ (\xi_1,\omega_1) + S_b\ (\xi_1,\omega_1)}{2}\right] \qquad (23)$$

The maximum difference between the moments from Equations 22 and 23 is about 3%.

The maximum shear occurred at the support of the beam induced by the uniform load expressed in Equation 21, can be written as:

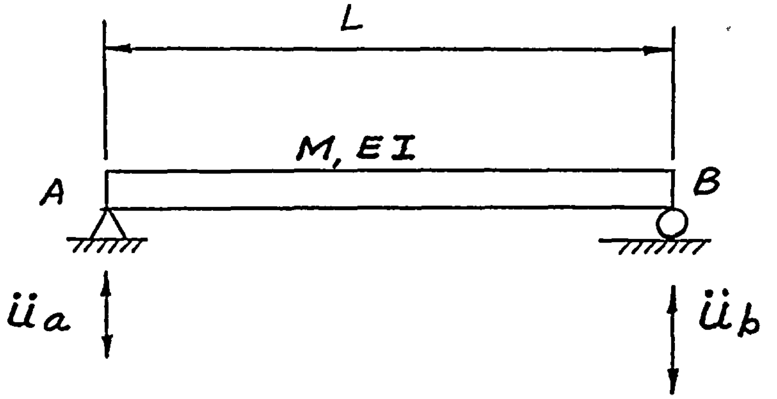
$$Q^*(0) = \frac{mL}{2} \left[\frac{S_a\ (\xi_1,\omega_1) + S_b\ (\xi_1,\omega_1)}{2}\right] \qquad (24)$$

From Equation 19, the shear at the support of the beam due to the fundamental mode is:

$$Q_1(0) < \frac{4mL}{\pi^2} \left[\frac{S_a\ (\xi_1,\omega_1) + S_b\ (\xi_1,\omega_1)}{2}\right] \qquad (25)$$

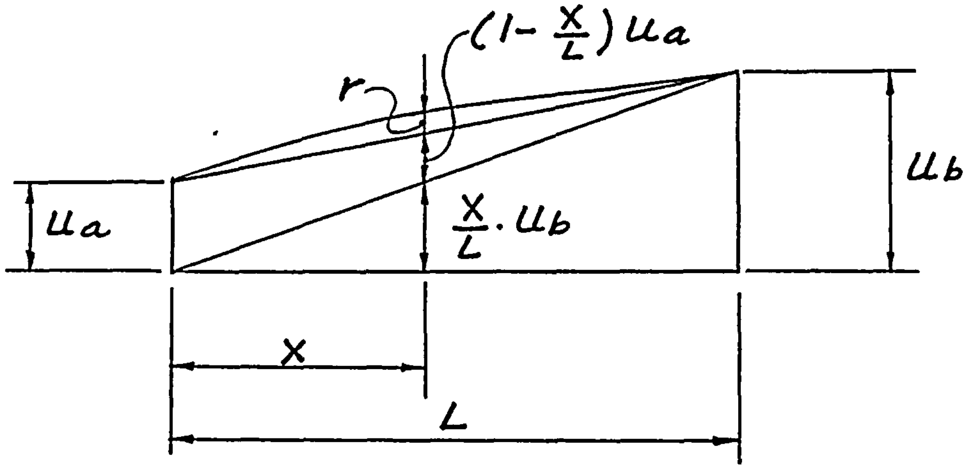
The shear from Equation 24 is greater than the shear from Equation 25 by about 25%. This margin can well cover the contribution to the shear due to the higher mode effect, as discussed previously.

From the above comparison, it can be concluded that the use of a uniform inertia load with the magnitude of the averaged floor spectral acceleration at the fundamental mode, provides a good approximation for calculating the seismic response in the wall panel.



IDEALIZED SIMPLY-SUPPORTED UNIFORM BEAM

FIGURE № 1



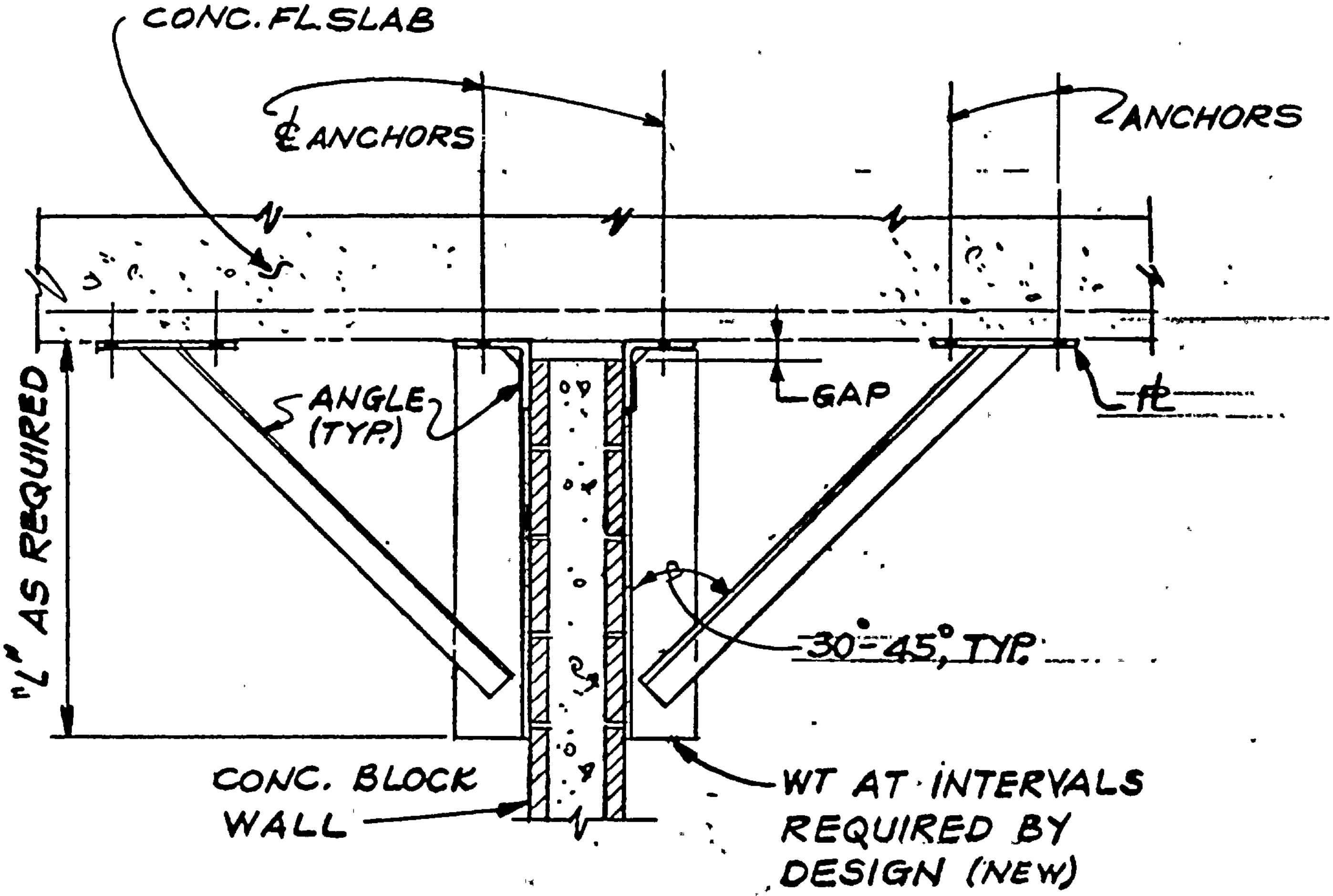
RELATION BETWEEN SEISMIC EXCITATION AND RELATIVE DISPLACEMENT

FIGURE № 2

ENCLOSURE 2

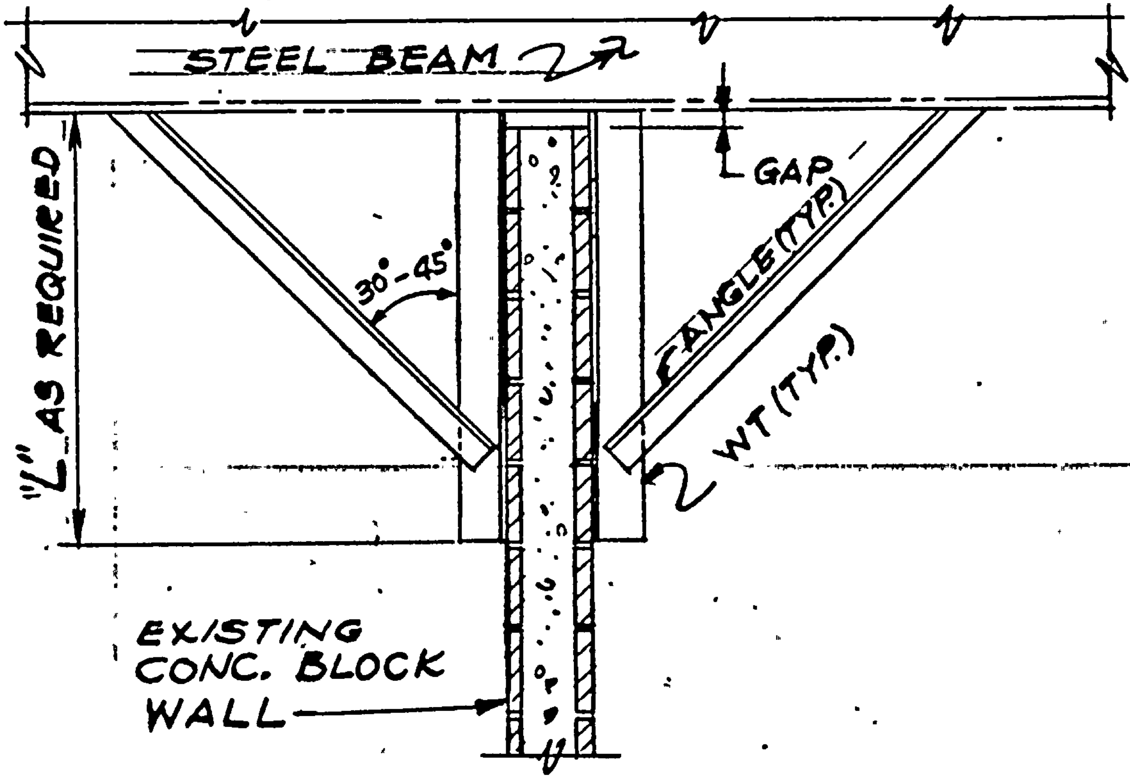
TYPICAL WALL FIXES

TYPE 1
TYPE 2
TYPE 3
TYPE 4



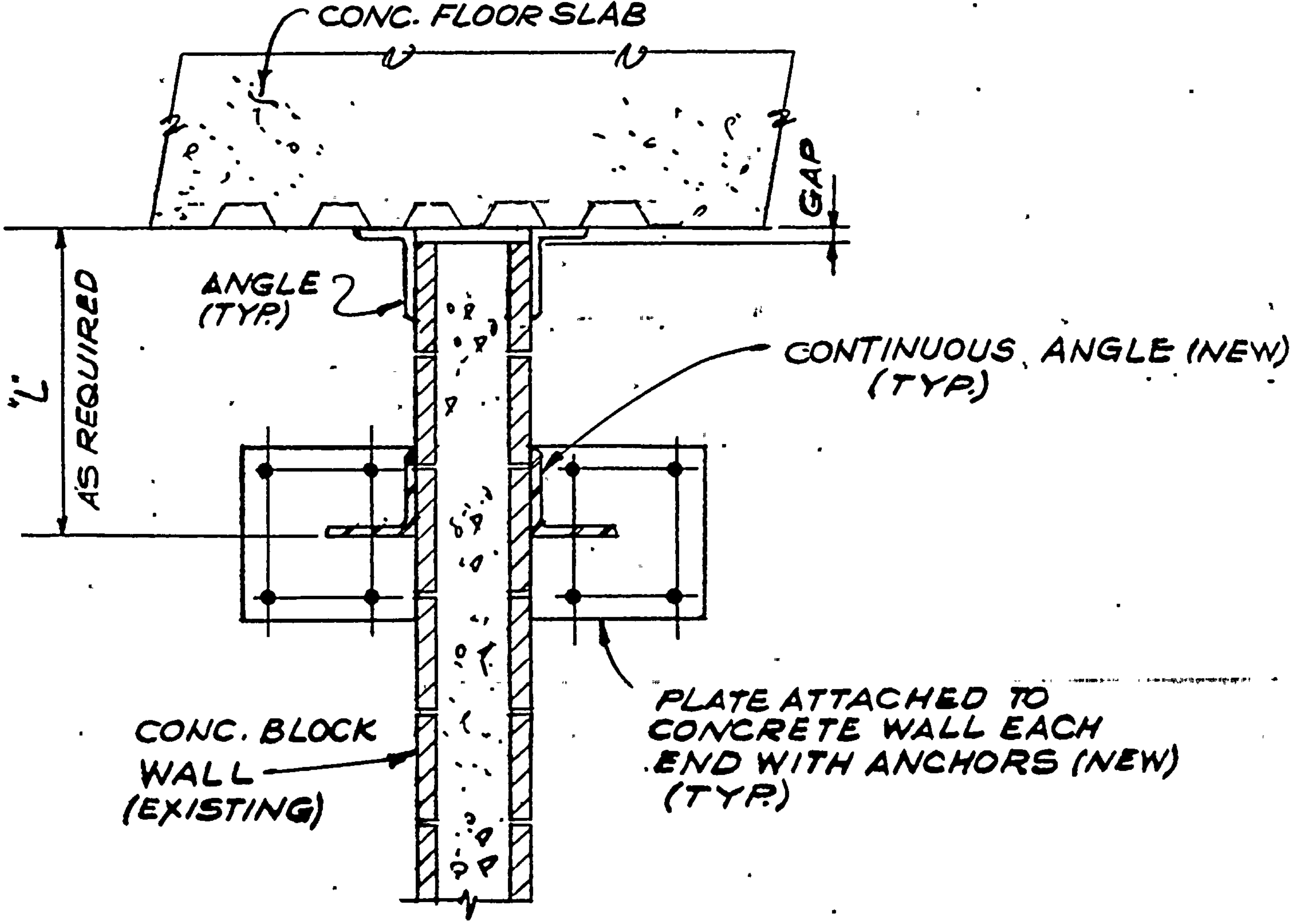
TYPE 1

ANGLE BRACING TO CONCRETE



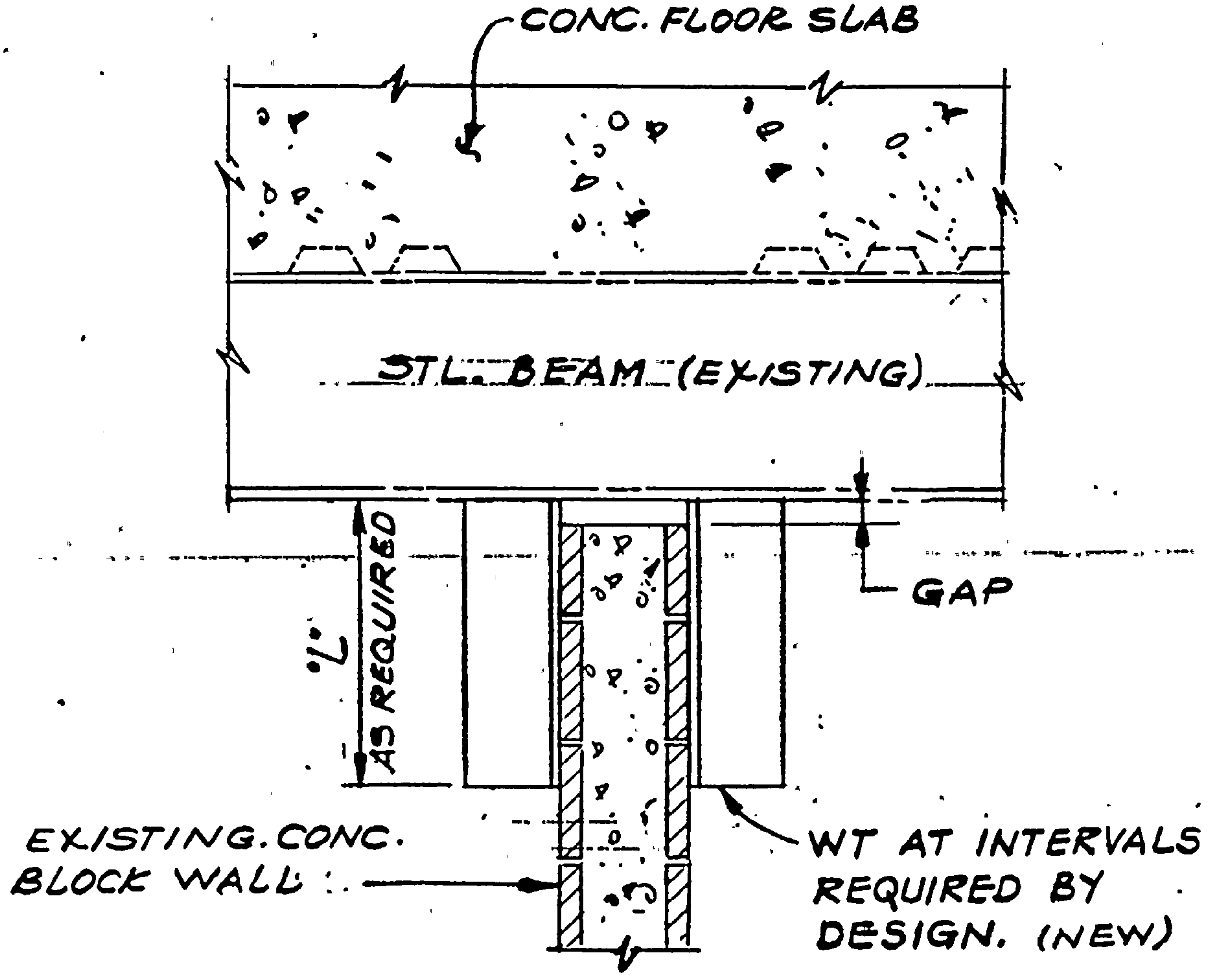
TYPE 2

ANGLE BRACING TO STEEL



TYPE 3

CONTINUOUS ANGLE



TYPE 4

INTERMITTENT SUPPORTS

ELECTRIC STATION, UNITS 1 AND 2

CALCULATION COVER SHEET

OB NO. 8856

DISCIPLINE MECHANICAL

COVER SH. A OF A
CALC. NO. M152-7.
NO. OF SHEETS 10
Q NO. 5LD

TITLE ALTERNATE SHUTDOWN COOLING

CALC. SHEET CONTROL:

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 ☐

[illegible]URCES OF DATA ISOMETRICS: HBB-104-1, REV. 8, GBB-101-2, REV. 3 DBB-113-1 REV3, DCA-109-1 REV.5, DCA-107-1, REV. 11.

SOURCES OF FORMULAE & REFERENCES
1) CORE SPRAY PUMP CALCS M 152-6, REV. 1
2) CRANE TECHNICAL PAPER No. 410, 1979 EDITION
3) CORE SPRAY PUMP PERFORMANCE CURVE 8856-M1-E21-30-1
4) GE CORE SPRAY PROCESS DIAGRAM 8856-M1-E21-15-2
5) CROSBY VALVE ENGINEERING AND CAPACITY DATA, CAT. #302, SUP. 1
6) PSV OUTLINE DWG. 8856-M1-B21-64-2

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

REV. NO.	DATE	CALCULATION BY	**CHECKED BY	DATE	APPROVED BY	DATE
	4/23/81	J. J. Brunner / J. Brunner	David Yang	5/4/81	E Connell Jr	5/4/81

*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

CALCULATION SHEET

CALC. NO. M162-7 REV. NO. 0

ORIGINATOR J. J. Brummer DATE 4/23/81 CHECKED Q. Yang DATE 5-4-81

PROJECT SUSQUEHANNA JOB NO. 8856

SUBJECT CORE SPRAY PUMPS IN ALTERNATE SHUTDOWN COOLING MODE 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 negleted because of large line diameter (12").

3. Friction losses in main steam piping are negligeable 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.

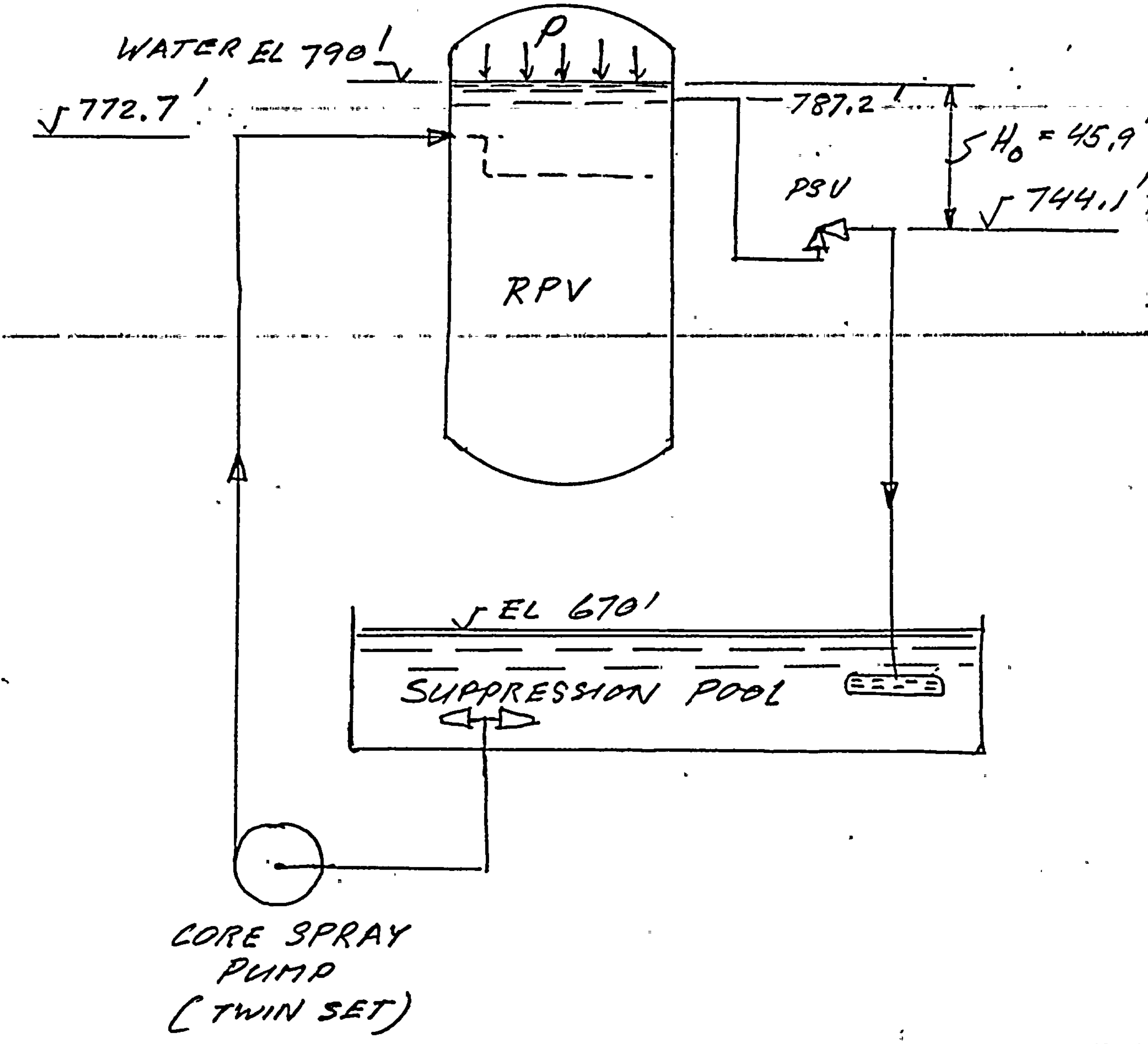
b). Calculations show (see page 9) that with 4 PSV open, runout flow of 7900 gpm will be reached with a valve C_V of 500.

CALCULATION SHEET

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

Use Core Spray Mode D

P_{RPV} = 105 psig (use 98 psig for shutdown cool'g. initiation)
T_{RPV} = 332 °F
T_{pool} = 170 °F
P_{pool} = 14.7 psia } (Ref. 4)
Assume water level ~3 ft above M.S. nozzle ℄



CALCULATION SHEET

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

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 ℄

$$H_S = 790' - 670' = 120'$$

Pressure Head

$$H_P = \frac{144}{\rho} \cdot P_{PSV} - H_0$$

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 = stat. head at PSV ℄ = 45.9' (see page 9)

Friction Head

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

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

Q_c (2 pumps) = 6350 gpm
H_{fc} = 277.3 ft

$$\boxed{H_T = H_S + \frac{144}{62.4}\left(\frac{Q}{C_V}\right)^2 - H_0 + \left(\frac{Q}{Q_c}\right)^2 \cdot H_{fc}}$$

RPV Pressure $= P_{PSV} - \frac{\rho}{144} \cdot H_0$

CALCULATION SHEET

BECHTEL

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

ORIGINATOR J. J. Brunner DATE 4/23/81 CHECKED DWJ DATE 5-4-81

PROJECT SUSQUEHANNA JOB NO. 8856

SUBJECT Core Spray Pumps in Alternate Shutdown Mode SHEET NO. 4 of 10

ONE PSV IS OPEN

$C_V = 400.$

Q	2000	4000	6000	8000
H_s	120	120	120	120
$H_p = \frac{144}{62.4}\left(\frac{Q}{400}\right)^2 - 45.9$	11.8	184.9	473.3	877
$H_f = \left(Q/6350\right)^2 \times 277.3$	27.5	110	247.5	440
H_{tot}	159.3	414.9	840.8	1437

$C_V = 500$

H_s	120	120	120	120
$H_p = \frac{144}{62.4}\left(\frac{Q}{500}\right)^2 - 45.9$	$-.9$	101.8	286.	545
H_f	27.5	110	247.5	440
H_{tot}	N/A	331.8	653.5	1105

P_{RPV} with 1 PSV @ $C_V = 400$ $Q = 5{,}450$ gpm

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

P_{RPV} with 1 PSV @ $C_V = 500$ $Q = 6{,}130$ gpm

$$P = \frac{56.2}{144} \left[\frac{144}{62.4}\left(\frac{6{,}130}{500}\right)^2 - 45.9\right] = 117.4 \text{ psig}$$

BECHTEL

CALCULATION SHEET

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

TWO PSV OPEN

$C_V = 400$

Q_{TOTAL}	2000	4000	6000	8000
Q_{PSV}	1000	2000	3000	4000
H_S	120	120	120	120
$H_P = \frac{144}{62.4}\left(\frac{Q_V}{400}\right)^2 - 45.9$	−31.5	11.8	83.9	184.9
$H_f = (Q_T/6350)^2 \cdot 277.3$	27.5	110	247.5	440
H_{tot}	N/A	241.8	451.4	744.9

$C_V = 500$

H_S	120	120	120	120
$H_P = \frac{144}{62.4}\left(\frac{Q_V}{500}\right)^2 - 45.9$	−36.7	−9	37.2	101.8
$H_f = (Q_T/6350)^2 \cdot 277.3$	27.5	110	247.5	440
	N/A	N/A	404.7	661.8

P_{RPV} @ $C_V = 400$ $\quad Q_{PSV} = 7,150/2 = 3,575$ gpm

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

P_{RPV} @ $C_V = 500$ $\quad Q_{PSV} = 7420/2 = 3,710$ gpm

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

BECHTEL

CALCULATION SHEET

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

ORIGINATOR J. J. Brunner DATE 4/23/81 CHECKED Guy DATE 5-4-81

PROJECT Susquehanna JOB NO. 8856

SUBJECT Core Spray Pumps in Alternate Shutdown Cooling Mode SHEET NO. 6 of 10

THREE PSV OPEN

$C_V = 400$

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	83.9
$H_f = (Q_T/6350)^2 \cdot 277.3$	61.9	247.5	557.0
H_{tot}	N/A	379.3	760.9

$C_V = 500$

H_S		120	120
$H_P = \frac{144}{62.4}\left(\frac{Q_V}{500}\right)^2 - 45.9$		-9	37.2
$H_f = (Q_T/6350)^2 \cdot 277.3$		247.8	557.
H_{tot}		N/A	714.2

P_{RPV} @ $C_V = 400$ $\qquad Q_{PSV} = 7600/3 = 2{,}533$ gpm

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

P_{RPV} @ $C_V = 500$ $\qquad Q_{PSV} = 7720/3 = 2{,}590$ 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

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

ORIGINATOR J. J. Brunner DATE 4/23/81 CHECKED DATE 5-4-81

PROJECT Susquehanna JOB NO. 8856

SUBJECT Core Spray Pumps in Alternate Shutdown Cooling Mode SHEET NO. 7 of 10

FOUR PSV OPEN

$C_V = 400$

Q_{TOT}	6000	8000	9000
Q_V	1500	2000	2250
H_S	120	120	120
$H_P = \frac{144}{62.4}\left(\frac{Q}{400}\right)^2 - 45.9$	−13.4	11.8	27.1
$H_F = (Q_T/6350)^2 \cdot 277.3$	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	0.8
$H_F = (Q_T/6350)^2 \cdot 277.3$		440	557
H_{tot}		N/A	677.8

P_{RPV} @ $C_V = 400$ $Q_{PSV} = 7780/4 = 1945$ gpm

$$P_{RPV} = \frac{59.6}{144}\left[\frac{144}{62.4}\left(\frac{1945}{400}\right)^2 - 45.9\right] = 3.5 \text{ psig}$$

P_{RPV} @ $C_V = 500$ $Q_{PSV} = 7900/4 = 1975$ gpm

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

(NEG)

BECHTEL

CALCULATION SHEET

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

ORIGINATOR J. J. Brunner DATE 4/23/81 CHECKED DATE 5-4-81

PROJECT SUSQUEHANNA JOB NO. 8856

SUBJECT CORE SPRAY PUMPS IN ALTERNATE SHUTDOWN COOLING MODE SHEET NO. 8 of 10

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

With 0 back pressure:

$$P_{PSV} = P_{RPV} + \frac{\rho H_0}{144} = 98 + \frac{56.2 \cdot 45.9}{144} = 115.9 \text{ psig}$$

Flow through PSV

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

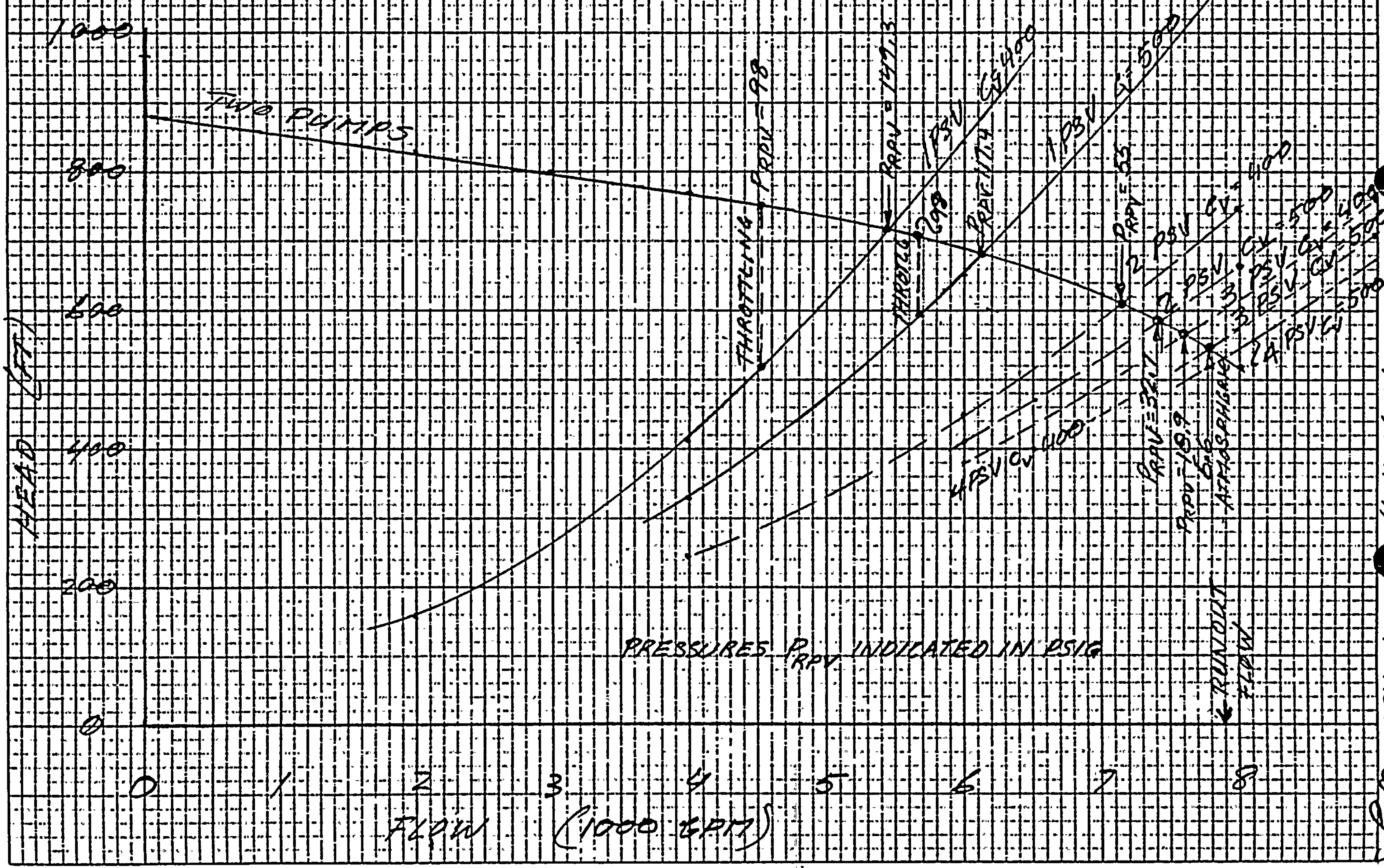
$$\therefore \quad Q = \left(P_{PSV}\frac{62.4}{\rho}\cdot C_V^2\right)^{0.5} = C_V\cdot\left(P_{PSV}\cdot\frac{62.4}{\rho}\right)^{0.5}$$

For $C_V = 400$: $Q = 400\cdot\left(115.9\cdot\frac{62.4}{56.2}\right)^{.5} = 4,528$

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

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

CORE SPRAY PUMP OPERATION IN ALTERNATE SHUTDOWN COOLING MODE



CALCS M152-7, REV 0

BY: [illegible] 4/2?/81 CHCKD: [illegible] E-4-81

SHEET 9 OF 10

CALCULATION SHEET

CALC. NO. M152-7 REV. NO. 0
ORIGINATOR J. J. Brunner DATE 4/30/81 CHECKED DATE 5-4-81
PROJECT SUSQUEHANNA JOB NO. 8856
SUBJECT CORE SPRAY PUMPS IN ALTERNATE SHUTDOWN COOLING MODE SHEET NO. 10 OF 10

APPENDIX A

ESTIMATE OF VALVE FLOW COEFFICIENT C_V

Valve capacity (per Ref. 5 for liquid)

$$Q = 27.2\, C_A\, A\, K_{sg} \sqrt{\underbrace{P - P_b}_{\Delta p}}$$

(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 R10 HB-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:

$$435.2 \cancel{\sqrt{\Delta p}} = C_V \sqrt{\frac{62.4}{\rho}} \cancel{\sqrt{\Delta p}}$$

$$\therefore \quad \boxed{C_V = \frac{435.2}{\sqrt{\frac{62.4}{\rho}}}}$$

et; $\rho = 59.8\ \text{lb/ft}^3$

$P = 14.7$ psia

$T = 212\,°F$

$$C_V = \frac{435.2}{\sqrt{\frac{62.4}{59.8}}} = 427$$

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

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

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

OURCES 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-1:2 Rev 4, HCB-101-1 Rev 3, HCB-102-1 Rev 2, HCD-111-1 Rev 6, 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, BEKENY, "BASIC GUIDANCE TO AVOID CAVITATION OF ORIFICES & VALVES" JUNE 21, 1974.

*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
	6/21/79	G. KALINAUSKAS / G. Kalinauskas		8/20/79	B.M. Jackson	8/21/79
[illegible]	3/27/79	G. KALINAUSKAS / G. Kalinauskas	J C McCune	3-30-79	B.M. Jackson	4/6/79
A	11/8/78	G. KALINAUSKAS / G. Kalinauskas	E. Connell	12-2-78	B.M. Jackson	1/2/79

*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

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

JOB NO. 8856

DISCIPLINE MECHANICAL / NUCLEAR

TITLE CORE SPRAY CALCULATIONS

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

CALC. SHEET CONTROL:

SUBJECT

STATEMENT OF PROBLEM

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 4.

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.) G.E. DESIGN SPECIFICATION + DATA SHEETS - DOC. No. 22A3053 Rev 0
(13.) P.+I.D. - M-108 Rev 12

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

1	6/21/79	G. Kalinauskas				
0	3/27/79	G. Kalinauskas	J C McCague	3-30-79	B.M. Jackson	4/6/79
A	11/8/78	G. Kalinauskas	E. Connell	12-2-78	BM Jackson	1/2/79

02099

CALCULATION SHEET

BECHTEL

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

PENNSYLVANIA P & L JOB 8856

JOB NO. 8856

SUBJECT CORE SPRAY CALCULATIONS

SHEET NO. 79

8035929

SECTION 3

NPSH CALCULATIONS

MODE A

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

h_f (120°F)

TABLE A'1

NODE	EQ. LENGTH or Cv	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
	Cv = 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 - 3 B	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 F001B

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

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

$$\Delta P = 0.09 \text{ psi}$$

FOR PIPE + FITTINGS:

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

$$Re = 123.9\frac{d v \rho}{\mu} = 123.9\frac{(15.25)(11.14)(61.73)}{(0.51)} = 2.55\times10^6$$

$f = 0.013$ (from ref 1 pg A'25)

$$\Delta P = 0.000216\frac{f L \rho Q^2}{d^5} = 0.000216\frac{(0.013)(136)(61.73)(6350)^2}{8.25\times10^5}$$

$$\Delta P = 1.15 \text{ psi}$$

CALCULATION SHEET

BECHTEL

CALC. NO. 152-6 REV. NO. 1

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 PENNSYLVANIA JOB 8856 SHEET NO. 80

2.1 - 2.2

FOR PIPE + FITTINGS:

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

$\Delta P = 0.30$ psi

2.1 - 3B

FOR PIPE + FITTINGS:

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

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

$\Delta P = 0.28$ 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 5/9/79

$Z_1 = 646' 10\,5/8"$ (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)

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

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

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

CALCULATION SHEET

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

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

PROJECT SUSQUEHANNA STATION UNITS 1 & 2 JOB NO. 8856

PENNSYLVANIA P & L JOB 8856

SUBJECT CORE SPRAY CALCULATIONS SHEET NO. 81

MODE B

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

h_f

NODE	TABLE B·1 TABLE B·1 OR C_v	ΔP (psi)
ENTRANCE	62'	0.27
15-16	250'	1.10
	C_v = 18,470	0.21
	124'	1.72
	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

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

$h_f = 14.20$ ft

$h_s = z_2 - z_1$ $z_2 = 673' 9''$ (outlet level from tank - iso HCB-1-2 Rev4)

$h_s = (673'9'' - 646'10\frac{5}{8}'')$ $z_1 = 646' 10\frac{5}{8}''$ (inlet level to pump - iso HBB-104-1 Rev6)

$h_s = 26.86$ ft

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

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

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

$NPSHA = 26.86 - 14.20 + 33.16 - 0.84$

$NPSHA = 44.98$ ft.

$NPSHR = 19$ ft (ref 2).

SFP-20768 Rev. (6/76) ED-69 (5/76)

(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 PENNSYLVANIA P. & L. JOB 8856 JOB NO. 8856

SUBJECT CORE SPRAY CALCULATIONS 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	$\Delta P = 2$ 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

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

$h_f = 4.84$ ft

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

$h_s = 23.11$ ft $z_1 = 646' 10\,5/8''$ (as before)

$h_a (670') = 33.16$ ft

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

ORIGINATOR G. KALINAUSKAS DATE NOV 08 1978
CALC. NO. 152-6 REV. NO. 0
CHECKED ΣCC DATE 12-6-78
PROJECT SUSQUEHANNA STATION UNITS 1 & 2 PENNSYLVANIA P & L JOB 8856
JOB NO. 8856
SUBJECT CORE SPRAY CALCULATIONS
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 - 38	127'	0.27

TOTAL ΔP = 3.74 psi

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

$h_f = 8.86$ 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

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

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

$NPSHA = 23.11 - 8.86 + 33.16 - 14.19$

$NPSHA \cdot 33.22$ ft

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

SFP-20768 Rev. (6/76) ED-69 (5/76)

BECHTEL

CALCULATION SHEET

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

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

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

JOB NO. 8856

SUBJECT Core Spray Calculations

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	$\Delta P = 2$ 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

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

$$h_f = 8.88 \text{ ft}$$

$$h_s = Z_2 - Z_1 \qquad Z_2 = 670' \text{ (as before)}$$

$$h_s = 23.11 \text{ ft} \qquad Z_1 = 646' \, 10\tfrac{5}{8}'' \text{ (as before)}$$

$$h_a(670') = 33.16 \text{ ft}$$

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

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

$$NPSHA = 23.11 - 8.88 + 33.16 - 27.61$$

$$NPSHA = 19.78 \text{ ft}$$

$$NPSHR = 11 \text{ ft.}$$ (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
PENNSYLVANIA P & L JOB 8856

JOB NO. 8856

SUBJECT Core Spray Calculations 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

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

$$h_f = 10.38\ ft$$

$h_s = Z_2 - Z_1$ $\qquad$ $Z_2 = 670'$ (as before)

$h_s = 23.11\ ft$ $\qquad$ $Z_1 = 646'\ 10\frac{5}{8}''$ (as before)

$$h_a(670') = 33.16\ ft$$

$$h_{vpa}(170°F) = 5.99 \frac{\cancel{lb}}{\cancel{in^2}} \times \frac{1\ ft^3}{60.79 \cancel{lb}} \times 144 \frac{\cancel{in^2}}{\cancel{ft^2}} = 14.19\ ft$$ (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

BECHTEL

ORIGINATOR G. KALINAUSKAS DATE NOV 08 1978
CALC. NO. 152-6 REV. NO. 0
CHECKED ΣCC DATE 12-2-78
PROJECT SUSQUEHANNA STATION UNITS 1 & 2 PENNSYLVANIA P & L JOB 8856
JOB NO. 8856
SUBJECT CORE SPRAY CALCULATIONS
SHEET NO. 86

MODE G

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

TABLE G.1

NODE	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.

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

$h_f = 11.10$ ft

$h_s = Z_2 - Z_1$ $\qquad Z_2 = 670'$ (as before)

$h_s = 23.11$ ft $\qquad Z_1 = 646'\,10\,5/8''$ (as before)

$h_a(670') = 33.16$ ft

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

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

$NPSHA = 23.11 - 11.10 + 33.16 - 17.85$

$NPSHA = 27.32$ ft

$NPSHR = 16$ ft (ref 2)

8856-M1-E21-30-1

REPORT OF PERFORMANCE TEST FOR PUMP S/N 107384

A performance test was conducted 8 September 1976 for a pump on order 006-36051 (AE 231). All necessary data associated with the hydraulic performance was obtained. The serial numbers for the impeller and casings are as follows:

Stage No.	Casings	Impellers
1	66044	57303
2	64953	68422
3	64946	68449
4	64957	55611
5	64703	69496
6	70976	68404

Vibration was found to be satisfactory as indicated by the data sheets. The NPSH points for a flow of 3004 GPM towards shut-off have been plotted on Curve N-831, Rev. 0 and fall on the head capacity curve. The NPSH data from 3625 GPM to runout is also plotted on N-831, Rev. 0.

FF128510

SUSQUEHANNA 1,2
MPL # E21-C001

TAG - 1P206 A, B, C & D

GENERAL ELECTRIC
NUCLEAR ENERGY DIVISION
☐ Disapproved per comments. Revise and resubmit for approval.
☐ Approved with Comments. Revise and resubmit IN FINAL FORM.
☐ Refer to EDS No.
☐ Approved. No further action req'd.
☐ Approved. Submit certified copy.
☒ Certified by Seller and Approved by Buyer.
Reviewed by
Date 25 Oct 1976
VPF No. 3308-149-1

CERTIFICATE OF COMPLAINCE

The performance test on Pump S/N 107384 on order 006-36051 (AE 231) was conducted in accordance with Procedure CQCP-1085, Rev. 4 except the test was conducted in the Cameron shell.

R. Lemp/

R. Lemp
Cameron Test Dept.

1

CUSTOMER G.E.A.P.E.D.

PROPOSAL NO. 006-36061 ITEM 2

SPECIAL NOTES
PUMP SN 107384
TESTED IN CAMERON SHELL

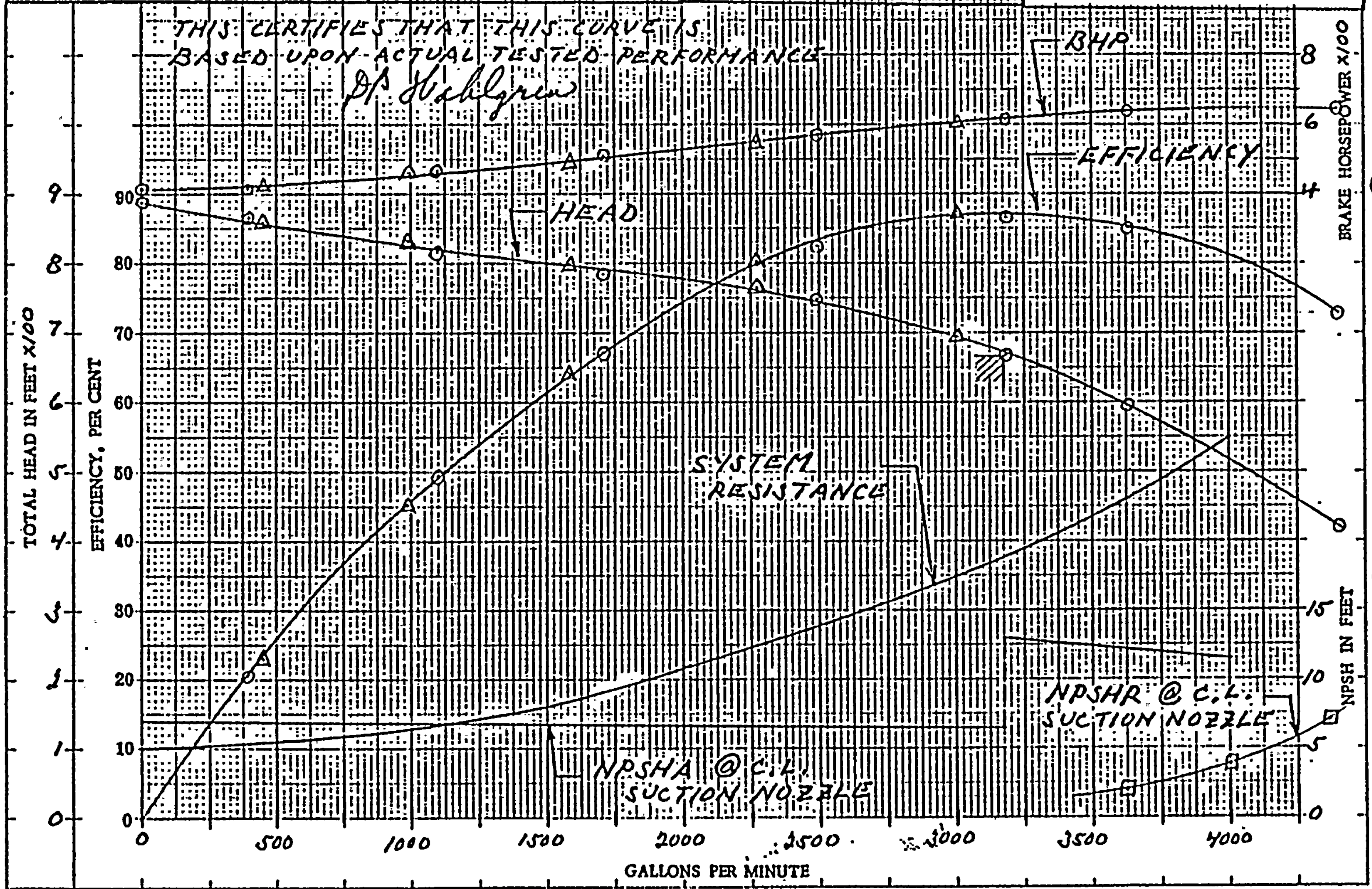
DESIGN CONDITIONS
GPM 3175 EFF —
T.H. (FT.) 668 BHP — SG. 1.0
RPM 1780 DRIVER HP
700 HP MOTOR
WITH 1.0 S.F.

Ingersoll-Rand

DRAWN BY D.P.W.
DATE 9-14-76

CURVE N-831, REV.O.

PUMP 25APHD-6



THIS CERTIFIES THAT THIS CURVE IS BASED UPON ACTUAL TESTED PERFORMANCE

DP Wahlgren

PG. 2 of 6

CURVE N-831, REV.O

PUMP SN 107384

PART OF PERFORMANCE CURVE N-831, REV. 0

NOTE:

⊙ PERFORMANCE DATA FOR HEAD, FLOW, EFFICIENCY & BHP

△ NPSH TEST BASIS NPSH HELD CONSTANT AT APPROXIMATELY 6.4 FT. REF. TO C.L. SUCTION NOZZLE (2.3 FT. CORRECTION INCLUDED).

⊡ NPSHR FROM 3625 GPM TOWARDS RUN-OUT, REF. TO C.L. SUCTION NOZZLE (2.3 FT. CORRECTION INCLUDED.

CAMERON PUMP DIVISION INGERSOLL-RAND COMPANY **TEST RECORD**

HEAD 3.56 @ 5000 GPM	DISCHARGE HEAD	AS READ 0508	479	651	727	807	845	891	927	948			
		CORRECTED +2" ELEVATION	479	652	729	809	847	893	929	950			
	SUCTION LIFT FT. ZERO DEPRESSED 0120 FT.		61	61	62	62	62	63	63	63			
	CHANGE IN VELOCITY HEAD IN FEET 24x12		3	2	1	1	0	0	0	0			
	TOTAL HEAD		421	594	669	749	786	831	867	888			
CAPACITY	VENTURI TUBES	18" TUBE	4380	0	0	0	0	0	0	0			
		CORRECTED	4411	0	0	0	0	0	0	0			
	SIZES AND READINGS	10" TUBE	0	3647	3218	2581	1804	1084	375	0			
		CORRECTED	0	3632	3182	2491	1715	1098	395	0			
	TOTAL G.P.M.		4411	3632	3182	2491	1715	1098	395	0			
WATER H.P.			468.9	543.9	536.8	470.5	340.0	230.1	86.4	0			
POWER	WATTMETER D- T.R. 700/1 O-	AS READ	.732	.727	.702	.649	.570	.526	.479	.477			
		KW	512.4	508.9	491.4	454.3	399.0	368.2	335.3	333.9			
		TOP OF MOTOR VIB. = / ⊥	1.1 / .6		1.0 / .7				2.0 / 1.6				
	BRAKE H.P.		644	640	618	572	506	465	417	415			
SHAFT VIB. / H2O °F			1.7 / 76	76	2.1 / 77	77	77	77	3.4 / 77	77			
SEAL LEAKAGE / Specific Gravity			NONE / .999	NONE / .999	NONE / .999	NONE / .999	NONE / .999	NONE / .999	NONE / .999	NONE / .999			
PUMP EFFICIENCY %			72.8	85.0	86.7	82.3	67.2	49.5	20.7	0			

DRIVER 700 HP MOTOR

FULL LOAD SPEED R.P.M.

LIQUID H2O

TEMP.

VISCOS.

GRAVITY 1.0

TEST STAND #16

TESTED BY R. LEMP

APP. BY

NOTES:—
T-R SHELL
SHUTDOWN TIME: 30 SEC.
WITNESSED BY: BWRPD-QC 311 9-8-76

PUMP NO. 107384

SIZE 25

TYPE APKD

STAGES 6

G.P.M. 3175

TOTAL HEAD IN FT. 668

SUCT.

R.P.M. 1780

EFF. %

IMPELLER

DIA.

VANE DIA

DIFFUSOR

SUCTION CONNECTION TO C.L. PUMP

C.L. PUMP TO C.L. DISC. GAUGE

TEST PROCEDURE CQCP - 1085 REV. 4

CUSTOMER G.E.A.P.E.D.

ORDER NO. 006-36051

ITEM NO. 2

DATE SEPT. 8, 1976

TEST NO.

PG. 5 OF 6

UMP S/N 107384	SIZE 25	TYPE APKD-6	DATE SEPT. 8, 1976	TEST STAND #16	NPSH+[(BARO-VP)1.133 / SP. GR.] - SUC.+LIFT / SP. GR. + VEL. HD
MPELLER	DIA	CUSTOMER G.E. A.P.E.D.		DATA BY R. LEMP	-2.2 SUBMERGENCE +2.3 CORRECTION
I-R SHELL		ORDER NO. 006-36051	ITEM NO. 2	WITNESSED BY 311 9-8-76	TOTAL HEAD=CORR.DISCH HD + VEL.HD+SUCT. HD.

RUN NO.	DISCH. HEAD AS RUN	DISCH. HEAD CORRECTED TO C.L. OF SUCTION +15.8 FT. ELEV.	VELOCITY HEAD 24 to 12	VACUUM AT C.L. SUCTION (FT. OF H_2O)	TOTAL HEAD (FT. OF H_2O)	TEMP. AT PUMP SUCTION (°F)	10+18" TUBE GPM	CORRECTED GPM	WATT METER (AS READ)	KW	SPECIFIC GRAVITY	BAROMETER (INCHES HG)	SEAL LEAKAGE	VIBRATION (MILS)	SUCTION VELOCITY HEAD	VAPOR PRESSURE (INCHES HG)	RUNNING VACUUM (INCHES HG)	RUNNING VACUUM (FT. H_2O)	NPSH C.L. CUST. SUCTION	CORRECTED SUCTION HEAD	BRAKE HP	EFFICIENCY
1	822	837.8	0	21.5	860	80	430	450	485	340	999	27.83	NONE	3.6	0	1.03	28.80	32.63	6.4	21.4	424	23.0
2	795	810.8	.1	21.5	833	80	970	988	.520	364	↓	↓	↓	3.3	.01	1.03	28.80	32.63	6.4	21.4	460	45.1
3	760	775.8	.4	21.5	798	80	1665	1580	.557	390	↓	↓	↓	3.2	.02	1.03	28.80	32.63	6.4	21.4	495	64.3
4	726	741.8	.7	21.6	765	80	2350	2272	.619	433	↓	↓	↓	2.9	.05	1.03	28.80	32.63	6.3	21.5	547	80.1
5	657	671.8	1.3	21.7	695	81	3068	3004	.685	480	↓	↓	↓	2.8	.08	1.07	28.76	32.59	6.2	21.6	604	87.3
6	558	572.8	1.9	19.9	596	82	3585	3625	.722	505	.998	27.83	NONE	2.8	.12	1.10	28.73	32.55	8.1	19.7	635	85.7
	555	569.8	1.9	22.9	596	82	↓	↓	.722	505	↓	↓	↓	2.8	.12	1.10	28.73	32.55	5.0	22.8	635	85.7
	553	567.8	1.9	23.9	595	82	↓	↓	.722	505	↓	↓	↓	2.7	.12	1.10	28.73	32.55	4.0	23.8	635	85.6
	549	563.8	1.9	25.9	593	83	↓	↓	.725	508	↓	↓	↓	2.7	.12	1.14	28.69	32.51	1.9	25.9	638	84.9
	521	535.8	1.9	26.4	565	83	↓	↓	.719	503	↓	↓	↓	2.5	.12	1.14	28.69	32.51	1.4	26.4	633	81.6

8856-M1-E21-30-1

FF126510

BECHTEL COMMENT G

Comments –

1. Page 6 of 6 is missing.

DEC 06 1976

APED DRAWING REVIEW

COMMENTS AS CHECKED BELOW

E ☐ NO COMMENTS.
F ☐ COMMENTS AS INDICATED, FOR APED'S INFORMATION AND USE ONLY. NO REPLY REQUIRED.
G ☒ COMMENTS AS INDICATED, WHEN DIRECTLY AFFECTING BECHTEL RESPONSIBILITY. REPLY REQUIRED IF NOT INCORPORATED BY APED.

FORWARDED BY
DATE 1/24/77

REVIEWED	C	E	I	L	M
					RH

BECHTEL
SAN FRANCISCO
JOB NO. 8856

DISTRIBUTION	NO.	DATE
VENDOR	2P	
CLIENT	1T	
FIELD	2F	
Q.E.		
CIVIL		
ELECT.		JAN 28 1977
PLT. DES.		
MECH.	1	
CON. SYS.		
ARCH.		
PURCH.		
EXPED.		
INSPECT		
SCHED.		
START-UP		
RECORD	1F+0B	G

BECHTEL
SAN FRANCISCO

S
DESCRIPTION–DRAWING
LOCATION
G

BECHTEL

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

9346

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

JOB NO. 8856

DISCIPLINE MECHANICAL / NUCLEAR

LE R.H.R. ΔP CALCULATIONS

SUSQUEHANNA STEAM
ELECTRIC STATION

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

AR 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-108-1 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, GBB-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-118-2 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
	12/11/79	G. KALINAUSKAS / G. Kalinauskas		1/25/80	B.M. Jackson	1/23/80
	6/20/79	G. KALINAUSKAS / G. Kalinauskas		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)

80101041

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

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, DBB-207-2 Rev 2, DBB-215-1 Rev 5, DCA-208-1 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, GBB-205-1 Rev 4, GBB-205-2 Rev 4, GBB-206-1 Rev 5, GBB-206-2 Rev 4, GBB-207-1 Rev 6, GBB-207-2 Rev 4, GBB-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.
**Considers PSAR, codes and standards, redundancy and separation, operability and maintainability, technical adequacy, accuracy and clarity.

0115 0002

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

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

NO. 8856

DISCIPLINE MECHANICAL/NUCLEAR

TITLE R.H.R. ΔP 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 GBB-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.
**Considers PSAR, codes and standards, redundancy and separation, operability and maintainability, technical adequacy, accuracy and clarity.

BECHTEL

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

B 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

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-M154-2-2
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.
**Considers PSAR, codes and standards, redundancy and separation, operability and maintainability, technical adeq

CALCULATION SHEET

BECHTEL

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. 223

SECTION 3 - NPSH CALCULATIONS

MODE C-2

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

ΔP = 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 8) △1

$h_s = (670' - 648'0\frac{1}{2}")$ $z_1 = 648'0\frac{1}{2}"$ (inlet level to pump - iso HBB-110-2 Rev 6) 5/15/79

$h_s = 21.96$ 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 (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

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

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}

ΔP = 4.00 psi

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

$$h_f = 9.36\ ft$$

$h_s = z_2 - z_1$ $\qquad$ $z_2 = 670'$ (min. water level - assumed 1' below normal - M-247 Rev.8) | 8/15/7 △1

$h_s = (670' - 648'0½")$ $\qquad$ $z_1 = 648'0½"$ (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)

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

$$\therefore NPSHA = h_s - h_f + h_a - h_{vpa} = 21.96 - 9.36 + 33.16 - 5.19$$
$$= 40.57\ ft$$

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

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. ΔP 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)	NPSH A (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	3
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

8856-M1-E11-53-1

DISTRIBUTION

	NO.	DATE
VENDOR	NONE	
CLIENT	1T	
FIELD	2F	
Q.E.		
CIVIL		
ELECT.	1P	DEC. 8 - 1976
PLT. DES.	1P	
MECH.	1P	
CON. SYS.		
ARCH.		
PURCH.		
EXPED.		
INSPECT		
SCHED.		
START-UP		
RECORD	1F+6219	

BECHTEL
SAN FRANCISCO

DESCRIPTION – DRAWING

LOCATION

S

G

OCT 4 1976

APED DRAWING REVIEW

COMMENTS AS CHECKED BELOW

E ☒ No comments.

E ☐ Comments as indicated, for APED's information and use only. No reply required.

G ☐ Comments as indicated, when directly affecting Bechtel responsibility. Reply required if not incorporated by APED.

FORWARDED BY	DATE
	12-6-76

Reviewed	C	E	I	L	M

BECHTEL
SAN FRANCISCO

JOB NO.
8856

FF/24510

FF12A510 8856-M1-E11-583-11

REPORT OF PERFORMANCE TEST FOR PUMP S/N 0573314

A performance test was conducted 26 July 1976 for a pump on order 006-36049 (AE 234). All necessary data associated with the hydraulic performance was obtained. The serial numbers for the impeller and casings are as follows:

Stage	Casings	Impellers
1	59910	66465
2	58664	66235
3	58665	68009
4	59882	65490

The vibration was found to be satisfactory as indicated by the Data Sheets. The NPSH points for a flow of 9898 GPM towards shut-off have been plotted on Curve N-810, Rev. 0 and fall on the head capacity curve. The NPSH data from 12081 GPM to runout is also plotted on N-810, Rev: 0.

GENERAL ELECTRIC A
NUCLEAR ENERGY DIVISION
☐ Disapproved per comments. Revise and resubmit for approval.
☐ Approved with Comments. Revise and resubmit IN FINAL FORM.
☐ Refer to EDS No.
☐ Approved. No further action req'd.
☐ Approved. Submit certified copy.
☒ Certified by Seller and Approved by Buyer.
Reviewed by
Date 12 Aug 1976
VPF No. 3307-73-1

CERTIFICATE OF COMPLIANCE

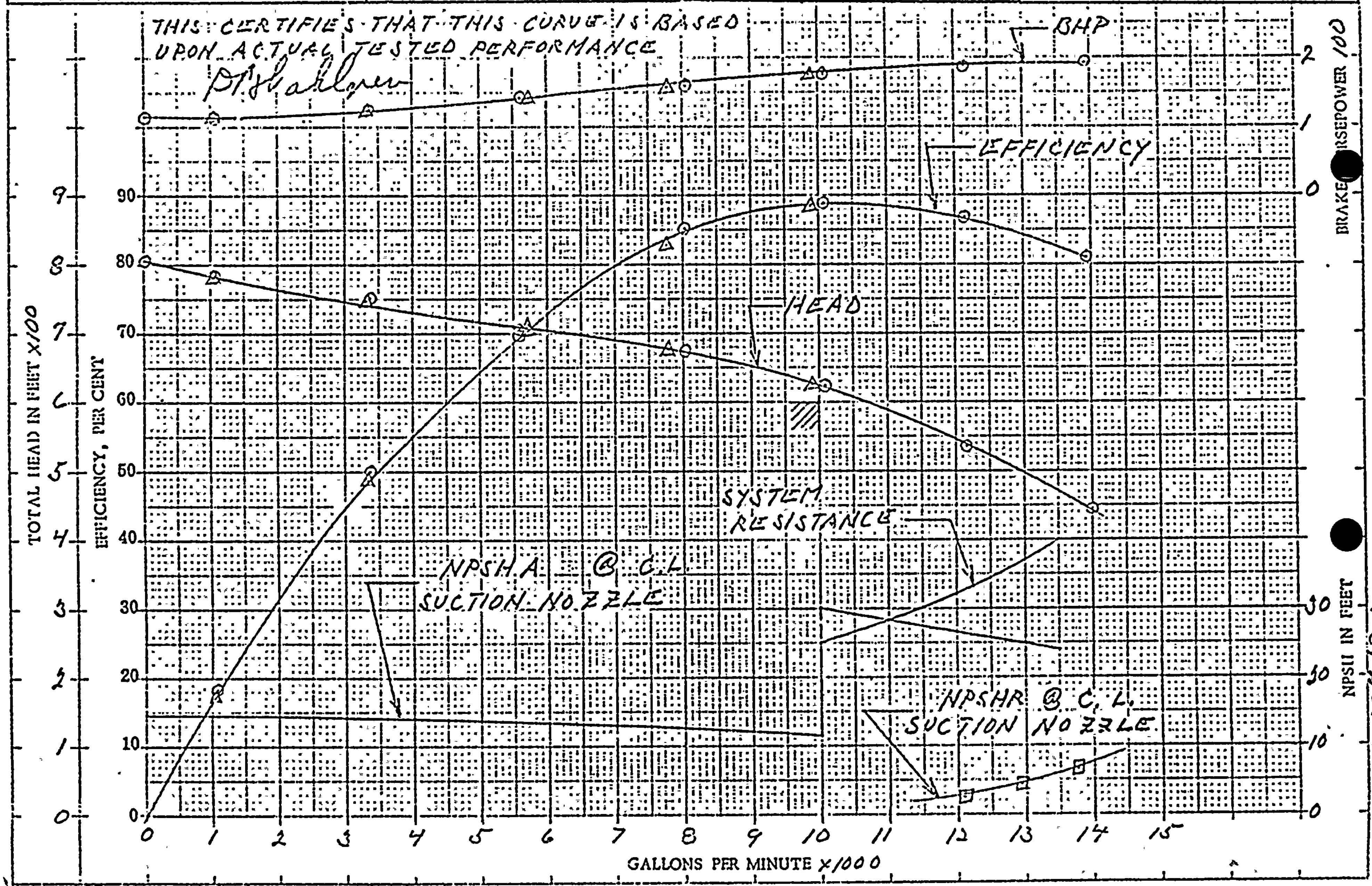
The performance test of pump S/N 0573314 on order 006-36049 (AE 234) was conducted in accordance with Procedure CQCP-1085, Rev. 4.

R. Lemp /

R. Lemp
Cameron Test Department

SUSQUEHANNA 1,2
MPL #E11C002

CUSTOMER G.E.A.P.E.D.	DESIGN CONDITIONS	**Ingersoll-Rand**	CURVE N-810, REV. 0
PROPOSAL NO. 006-36049 ITEM 2	GPM 10,000. EFF		PUMP 34 APKD-4
SPECIAL NOTES PUMP SN 0573314 PUMP TESTED IN CAMERON SHELL	T. H. (FT.) 600 BHP SG. 1.0 RPM 1180 DRIVER HP 2000 HP MOTOR WITH 1.0 S.F.	DRAWN BY D.P.W. DATE 7-27-76	



THIS CERTIFIES THAT THIS CURVE IS BASED UPON ACTUAL TESTED PERFORMANCE

PG. 2 OF 6

CURVE N-810, REV. 0

PUMP SN 0573314

PART OF CURVE N-810, REV. 0

NOTE:

⊙ PERFORMANCE DATA FOR HEAD, FLOW, EFFICIENCY & BHP.

◬ NPSH TEST BASIS NPSH HELD CONSTANT AT APPROXIMATELY 9.5 FT., REF. TO C.L. SUCTION NOZZLE (0.9 FT. CORRECTION INCLUDED)

⊡ NPSHR DATA FROM 12081 GPM TOWARDS RUNOUT, REF. TO C.L. SUCTION NOZZLE (0.9 FT. CORRECTION INCLUDED)

PG. 4 OF 6

C ON PUMP DIVISION INGERSOLL-RA D. COMPANY **TEST RECORD.**

HEAD 1.67 @ 14,000	DISCHARGE HEAD	050% AS READ	506	598	683	739	770	816	852	875			
		CORRECTED +2 ELEV.	507	599	686	742	774	820	854	878			
	SUCTION LIFT FT. ZERO DEPRESSED ______ FT.		65	67	69	70	71	72	73	74			
	CHANGE IN VELOCITY HEAD IN FEET	24"x18"	3	2	2	1	1	0	0	0			
	TOTAL HEAD		446	536	621	676	707	751	784	807			
CAPACITY	VENTURI TUBES SIZES AND READINGS	18" TUBE "Hg	12459	11049	8948	6973	5712	0	0	0			
		GPM	12261	11033	8970	6915	5595	0	0	0			
		10" TUBE "Hg	12.9	5.65	5.80	5.70	0	51.9	1082	0			
		GPM	1681	1113	1127	1118	0	3372	1087	0			
	TOTAL G.P.M.		13942	12146	10097	8033	5595	3372	1087	0			
WATER H.P.			1567	1638	1578	1365	995	637	214	0			
POWER	WATT METER T.R. 2800/1	AS READ	.562	.548	.518	.470	.419	.378	.348	.350			
		KW	1574	1534	1450	1316	1173	1058	974	980			
		R.P.M.											
	BRAKE H. P.		1935	1885	1775	1605	1424	1275	1170	1175			
SHAFT VIB. MILS / H_2O °F			2.1 / 91	93	3.1 / 94	95	96	97	3.8 / 97	97			
SEAL LEAKAGE / SP. GR.			NONE / .997	NONE / .996	NONE / .996	NONE / .996	NONE / .996	NONE / .996	NONE / .996	NONE / .996			
PUMP EFFICIENCY %			81.0	86.9	88.9	85.1	69.9	50.0	18.3	0			

DRIVER 2000 HP MOTOR

FULL LOAD SPEED R.P.M.

LIQUID H_2O

TEMP.

VISCOS.

GRAVITY 1.0

TEST STAND #16

TESTED BY R. LEMP

APP. BY

NOTES:-

I-R SHELL

SHUTDOWN TIME: 70 SEC.

WITNESS: BY:

CRC 7-26-76

205

PUMP NO. 0573374

SIZE 34

TYPE APKD

STAGES 4

G.P.M. 10,000

TOTAL HEAD IN FT. 600

SUCT.

R.P.M. 1180

EFF. %

IMPELLER

DIA.

VANE DIA

DIFFUSOR

SUCTION CONNECTION TO C. L. PUMP

C. L. PUMP TO C. L. DISC. GAUGE

TEST PROCEDURE CQCP-1085 REV. 4

CUSTOMER G.E.A.P.E.D.

ORDER NO. 006-36049

ITEM NO. 2

DATE JULY 26 1976

TEST NO.

PG 5 F6

PUMP S/N 0573314	SIZE 34	TYPE APKD-4	DATE JULY 26, 1976	TEST STAND #16	NPSH = [(BARO − VP)1.133 / SP. GR.] − SUC. LIFT / SP. GR. + VEL. HD
IMPELLER	DIA	CUSTOMER G.E.A.P.E.D.		DATA BY Ralph Lemp	−7.0 SUBMERGENCE + .9 CORRECTION
I-R SHELL		ORDER NO. 006-36049	ITEM NO. 2	WITNESSED BY	TOTAL HEAD = CORR. DISCH HD + VEL. HD + SUCT. HD

RUN NO.	DISCH. HEAD AS RUN	DISCH. HEAD CORRECTED TO C.L. OF SUCTION + 15.6 FT. ELEV.	VELOCITY HEAD 24 to 18	VACUUM AT C.L. SUCTION (FT. OF H_2O)	TOTAL HEAD (FT. OF H_2O)	TEMP. AT PUMP SUCTION (°F)	10"-18" TUBE GPM	CORRECTED GPM	WATT METER (AS READ)	KW	SPECIFIC GRAVITY	BAROMETER (INCHES HG)	SEAL LEAKAGE	VIBRATION (MILS)	SUCTION VELOCITY HEAD	VAPOR PRESSURE (INCHES HG)	RUNNING VACUUM (INCHES HG)	RUNNING VACUUM (FT. H_2O)	NPSH C.L. CUST. SUCTION	CORRECTED SUCTION HEAD	BRAKE HP	EFFICIENCY
1	743	760.1	0	16.0	781	106	1004	1016	.347	972	.994	29.91	None	3.9	0	2.31	27.59	31.26	9.4	15.9	1148	17.0
2	710	726.9	.2	16.0	748	108	49.8	3302	.377	1056	.993	↓	None	3.7	.1	2.45	27.45	31.10	9.4	15.9	1273	48.7
3	666	682.3	.5	16.0	704	109	[illegible]	5718	.417	1169	.993	↓	None	3.6	.3	2.52	27.37	31.02	9.5	15.9	1419	71.2
4	[illegible]	655.8	1.0	16.0	678	110	[illegible]	7793	.467	1308	.993	↓	None	3.6	.5	2.60	27.30	30.93	9.6	15.9	1597	82.9
5	[illegible]	602.9	1.6	16.1	626	112	[illegible]	10117	.512	1434	.992	↓	None	3.3	.9	2.75	27.15	30.76	9.8	16.0	1759	88.2
6	[illegible]	519.6	2.4	15.0	541	113	33.0/[illegible]	12081	.543	1520	.992	29.91	NONE	2.8	1.3	2.82	27.07	30.67	11.2	[illegible]	186.5	87.8
	503	516.6	2.4	17.0	540	114	↓	↓	.543	1520	.992	↓	↓	2.7	1.3	2.91	26.99	30.58	9.1	16.9	186.5	87.7
	501	515.6	2.4	18.2	541	115	↓	↓	.541	1520	.992	↓	↓	2.8	1.3	3.00	26.90	30.49	7.7	18.2	[illegible]	87.7
	495	512.6	2.4	20.2	540	116	↓	↓	.543	1520	.992	↓	↓	2.6	1.3	3.08	26.83	30.39	5.5	20.3	[illegible]	87.5
	493	507.6	2.4	22.1	537	117	↓	↓	.543	1520	.991	↓	↓	2.8	1.3	3.17	26.73	30.29	3.5	22.3	1865	87.0
	481	503.6	2.4	22.9	534	118	↓	↓	.542	1520	.991	↓	↓	2.7	1.3	3.26	26.64	30.18	2.6	23.1	1865	86.5
	[illegible]	494.6	2.4	23.1	525	118	↓	↓	.540	1512	.991	↓	↓	2.8	1.3	3.26	26.64	30.18	2.4	23.3	1857	85.4
	411	425.1	2.4	23.5	456	119	↓	↓	[illegible]	1365	.991	↓	↓	2.4	1.3	3.35	[illegible]	[illegible]	1.9	[illegible]	[illegible]	82.4
														CRC								
														6 26	76							

PG [illegible] OF 6

UMP S/N	SIZE	TYPE	DATE	TEST STAND	NPSH=[(BARO-VP)1.133 / SP. GR.] - SUC. LIFT / SP. GR. + VEL. HD
0573314	34	APKD-4	JULY 26, 1976	#16	-7.0 SUBMERGENCE + .9 CORRECTION
MPELLER	DIA	CUSTOMER		DATA BY	
		G.E.A.P.E.D.		RALPH LEMP	
I-R SHELL		ORDER NO. 006-36049	ITEM NO. 2	WITNESSED BY	TOTAL HEAD=CORR. DISCH HD + VEL. HD + SUCT. HD.

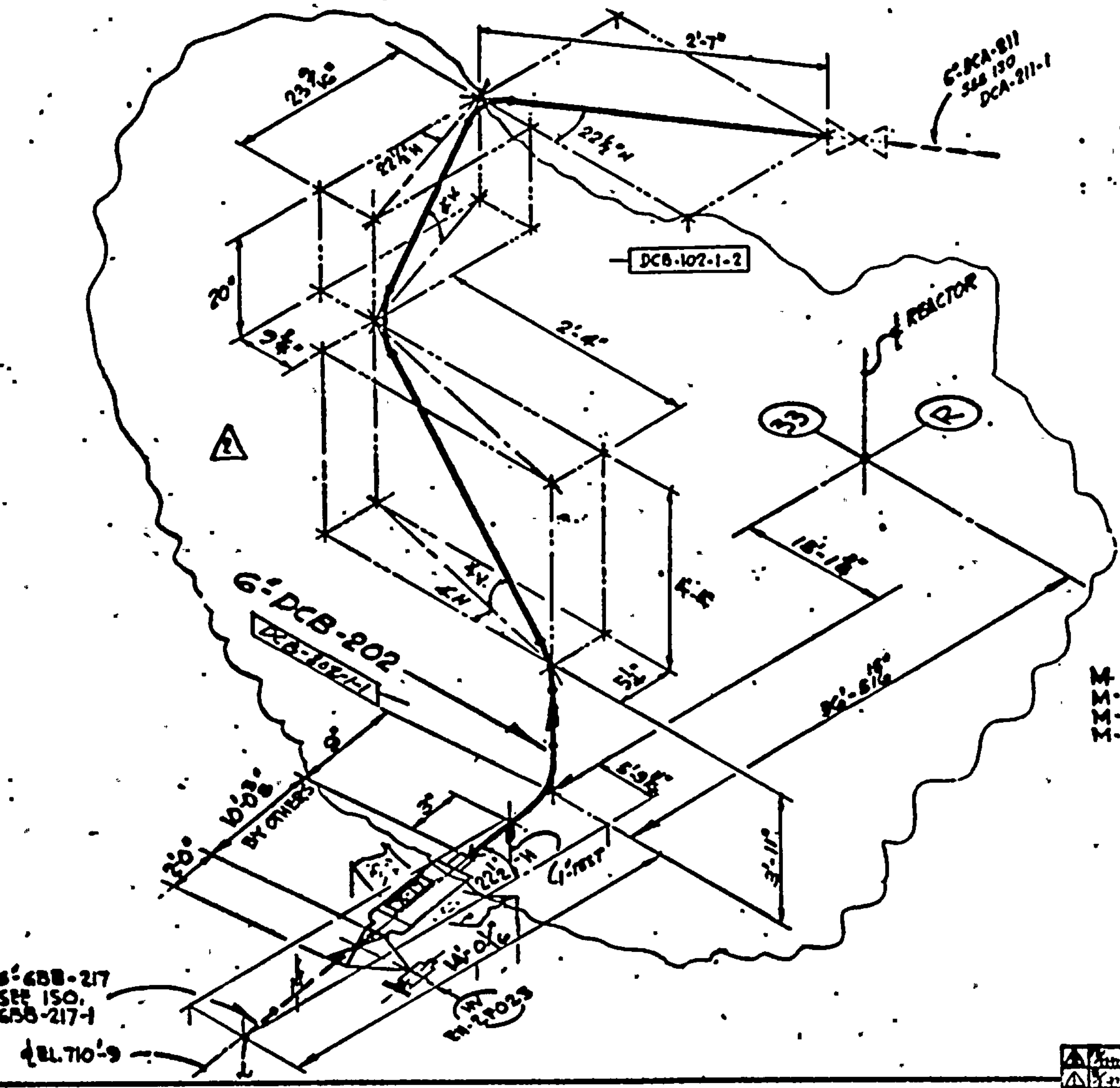
RUN NO.	DISCH. HEAD AS RUN	DISCH. HEAD CORRECTED TO C.L. OF SUCTION +15.6 FT. ELEV.	VELOCITY HEAD 24 to 18	VACUUM AT C.L. SUCTION (FT. OF H_2O)	TOTAL HEAD (FT. OF H_2O)	TEMP. AT PUMP SUCTION (°F)	12×18" TUBE GPM	CORRECTED GPM	WATT METER (AS READ)	KW	SPECIFIC GRAVITY	BAROMETER (INCHES HG)	SEAL LEAKAGE	VIBRATION (MILS)	SUCTION VELOCITY HEAD	VAPOR PRESSURE (INCHES HG)	RUNNING VACUUM (INCHES HG)	RUNNING VACUUM (FT. H_2O)	NPSH C.L. CUST. SUCTION	CORRECTED SUCTION HEAD	BRAKE HP	EFFICIENCY
7	[illegible]	477.6	2.8	15.9	503	[illegible]	[illegible]	1393	.551	1543	.990	[illegible]	[illegible]	2.7	1.5	3.45	26.45	29.97	7.8	15.9	1895	85.7
	414	478.6	2.8	18.0	504	121	↓	↓	.551	1543	.990	↓	↓	2.7	1.5	3.54	26.36	29.87	7.6	18.0	1895	85.9
	[illegible]	472.6	2.8	19.2	505	122			.551	1543	.990			2.6	1.5	3.64	26.26	29.75	6.2	19.3	1895	86.0
	457	471.6	2.8	20.4	500	123			.550	1541	.990			2.6	1.5	3.74	26.16	29.64	4.8	20.5	1892	85.3
	439	453.6	2.8	21.1	482	123			.547	1533	.990			2.7	1.5	3.74	26.16	29.64	4.1	21.2	1881	82.8
	409	423.6	2.8	21.3	452	124			.523	1161	.990			2.6	1.5	3.85	26.05	29.51	3.8	21.4	1795	81.3
8	415	429.6	3.2	15.4	453	125	350/1362	1376	.553	1548	.989	29.91	NONE	2.5	1.7	3.95	25.95	29.40	9.9	15.4	1900	82.0
	414	428.6	3.2	16.4	453	126	↓	↓	.553	1549	.989	↓	↓	2.6	1.7	4.06	25.84	29.28	8.8	16.4	1900	82.0
	410	424.6	3.2	17.7	450	127			.553	1541	.989			2.5	1.7	4.18	25.72	29.14	7.4	17.7	1899	81.6
	405	419.6	3.2	18.3	446	128			.551	1543	.988			2.5	1.7	4.29	25.61	29.02	6.7	18.3	1895	80.9
	374	388.6	3.2	18.5	415	128			.543	1522	.988			2.5	1.7	4.29	25.61	29.02	6.5	18.5	1866	76.4

CRC
7-26-76

27 L.F.

N

F



REFERENCE DRAWINGS

M-151	REV. 8	P & I D		
M-31-2	" 7	PIPING PLAN	AREA	31
M-31-3	" 6	"	"	31
M-34-3	" 6	"	"	34

COMPONENTS ON
THIS DWG. ARE Q-LISTED
SPEC. 8856-G-9 APPLIES

Q

3	[illegible]	REROUTED CABLE TRAY [illegible]	CBC						
2	[illegible]	[illegible]	PDJ						
1	[illegible]	ISSUED FOR FABRICATION	P.S.						
NO.	DATE	REVISIONS	BY	CHK'D					APPD

SCALE — DESIGNED DRAWN RMB.

PENNSYLVANIA POWER & LIGHT COMPANY
ALLENTOWN, PENNSYLVANIA
SUSQUEHANNA STEAM ELECTRIC STATION - UNIT 1, UNIT 2

BECHTEL - SAN FRANCISCO

ISOMETRIC - REACTOR BUILDING
RESIDUAL HEAT REMOVAL UNIT 2

JOB No. 8856 [illegible] 51-28 DRAWING No. [illegible] DCB-202-1 REV. 2

[illegible] REACTOR BLDG RHR

M

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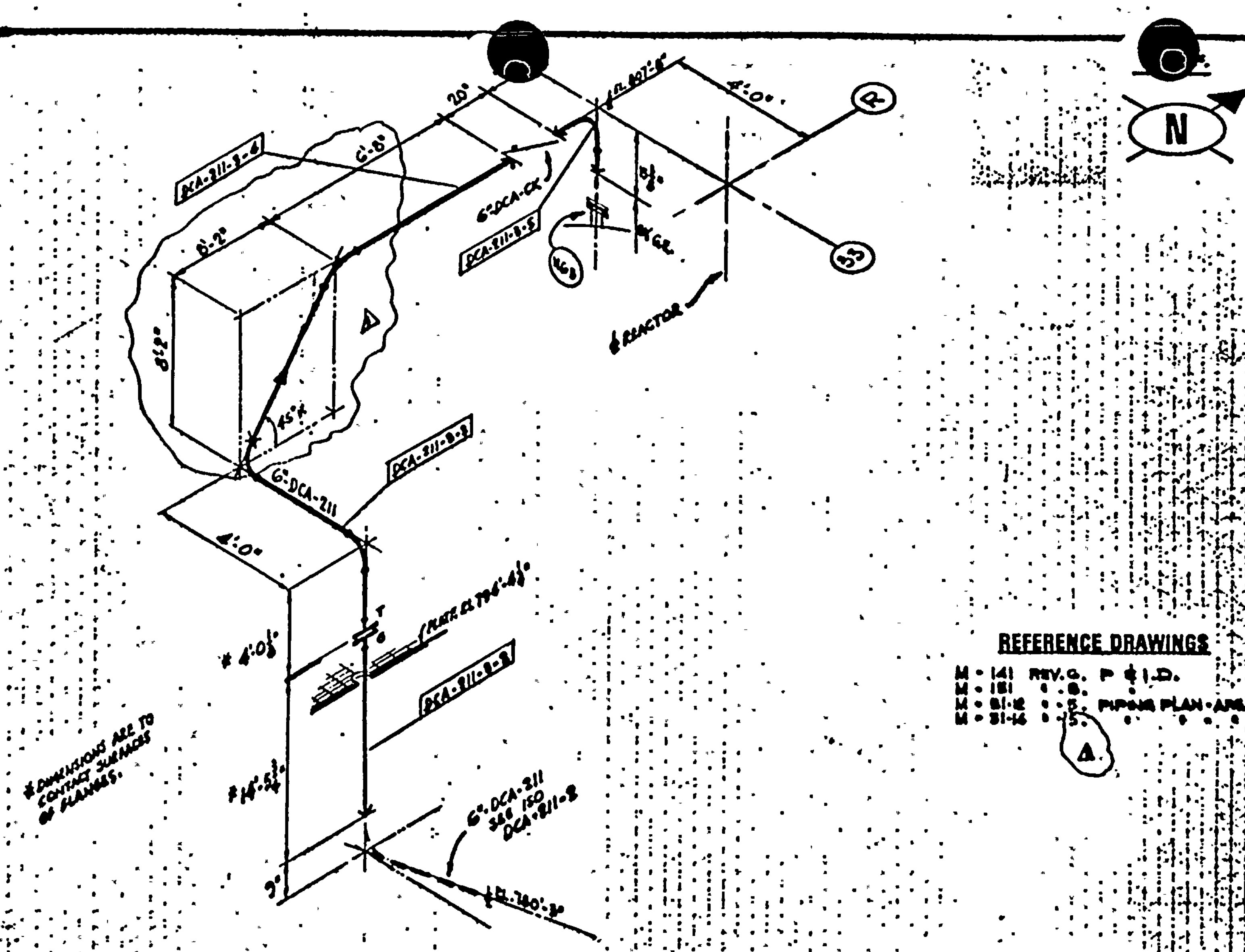


REFERENCE DRAWINGS

M-141 REV.G. P & I.D.
M-151 " .G. "
M-31-12 " .5. PIPING PLAN-AREA-31
M-31-14 " .5. " " " " -31

57

COMPONENTS ON
THIS DWG. ARE Q-LISTED
SPEC. 8856-G-9 APPLIES

Q

3	[illegible]	[illegible]	QJ						
2	[illegible]	[illegible]	QJ						
1	[illegible]	[illegible]							
0	[illegible]	ISSUED FOR FABRICATION	BL						

PENNSYLVANIA POWER & LIGHT COMPANY
ALLENTOWN, PENNSYLVANIA
SUSQUEHANNA STEAM ELECTRIC STATION - UNIT 1, UNIT 2

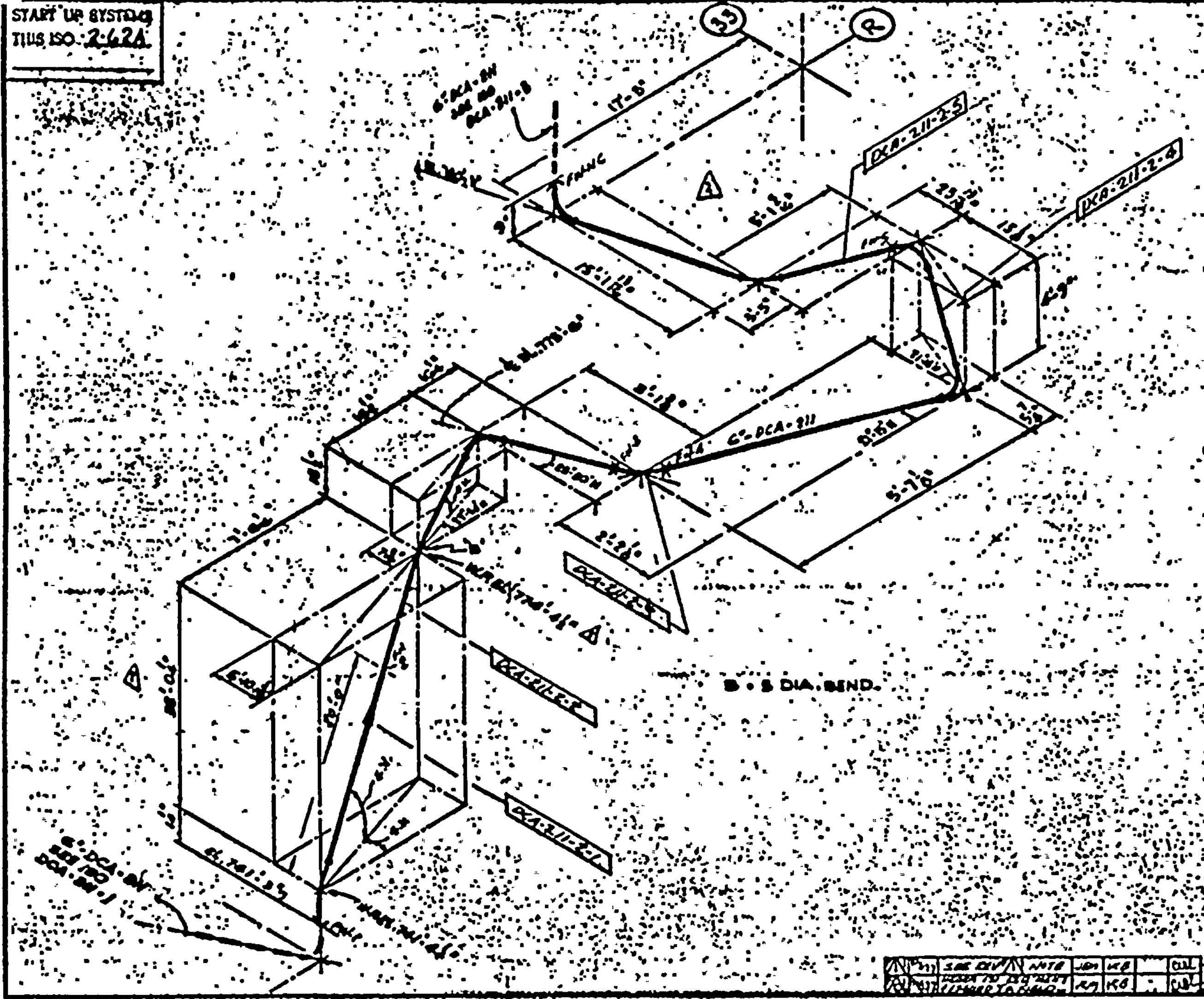
BECHTEL - SAN FRANCISCO

ISOMETRIC - REACTOR BLDG
RHR. UNIT - 2

8856
41-13
DCA-211-3
3

1150 REACTOR BLDG RHR

START UP SYSTEM
THIS ISO 2-42A



78 L.F.

N

F

REV 1 /R1 NOTE: REVISED TO
ADD FIELD WELD
NOS. AND WELDING
REQUIREMENTS.

UNDER SFND REV ⚠

REV ⚠ NOTE: UNDER SFND REV ⚠:
RE-ISSUED FW NO'S ISSUED
DWG TO GRINNELL FOR FAB OF
SPOOLS AS SHOWN

REV ⚠ NOTE: ADDED PC NO 615 AS PER
GRINNELL INFO: ADDED FW 615

REV ⚠ NOTE: RELOCATED FW 3 & 6 AS
PER GRINNELL REQUEST

REFERENCE DRAWINGS

M - 141 REV. G P & I.D.
M - 151 REV. B
M - 31-4 REV. 5 PIPING PLAN - AREA - 31
M - 31-12 REV. 5 PIPING PLAN - AREA - 31

JAN 26 1983

⚠		SEE REV ⚠ NOTE					
⚠		SEE REV ⚠ NOTE					
⚠		REVISED TO ADD REQUIREMENTS					
⚠		SEE REV ⚠ NOTE					
⚠		SEE REV ⚠ NOTE	RJ				
⚠		ISSUED FOR CONSTRUCTION					
⚠		ISSUED FOR FABRICATION					
⚠		SEE REV ⚠ NOTE					
⚠		ISSUED TO GRINNELL	RJ	KG			

WELD SURFACE PREPARATION IS TO BE APPLIED TO ALL WELDS ON THIS DWG. FOR IN SERVICE INSPECTION.

WELDING REQUIREMENTS Pipe Class DCA

☐ P1-A-C-Lt
☐ P1-AT-Lt
☐ P8-A
☐ P8-AT-Ag
■ P8-T-Ag
☐ P1-T
☐ P1-R-Lt
☐ P1A-AT-Lt
☐ P4-AT
☐ P8-P1-AT-Ag
☐

☐ E-70S-2
☐ E-6010
☐ E-7018
■ ER-308-L
☐ ER-309
☐ E-309-16
☐ E-308-16
☐ E-8018-B2
☐ ER-515
☐
■ NDE RT 16-2

☐ Pre Heat 60°F
☐ Pre Heat 200°F
☐ Pre Heat 250°F
☐ Pre Heat 275°F
☐ Pre Heat 400°F
☐ Pre Heat
■ Inlet Pass - SS
☐ Backing Ring Req'd
■ Argon Purge Req'd
■ Pre Weld Insp. Req'd
RT-SA-1

Above Welding Requirements Are Certified Correct

WR-5/WR-6 REQ'D.

COMPONENTS ON THIS DWG. ARE Q-LISTED SPEC. 8856-G-9 APPLIES

Q

121 115C REACTOR BLDG RHR

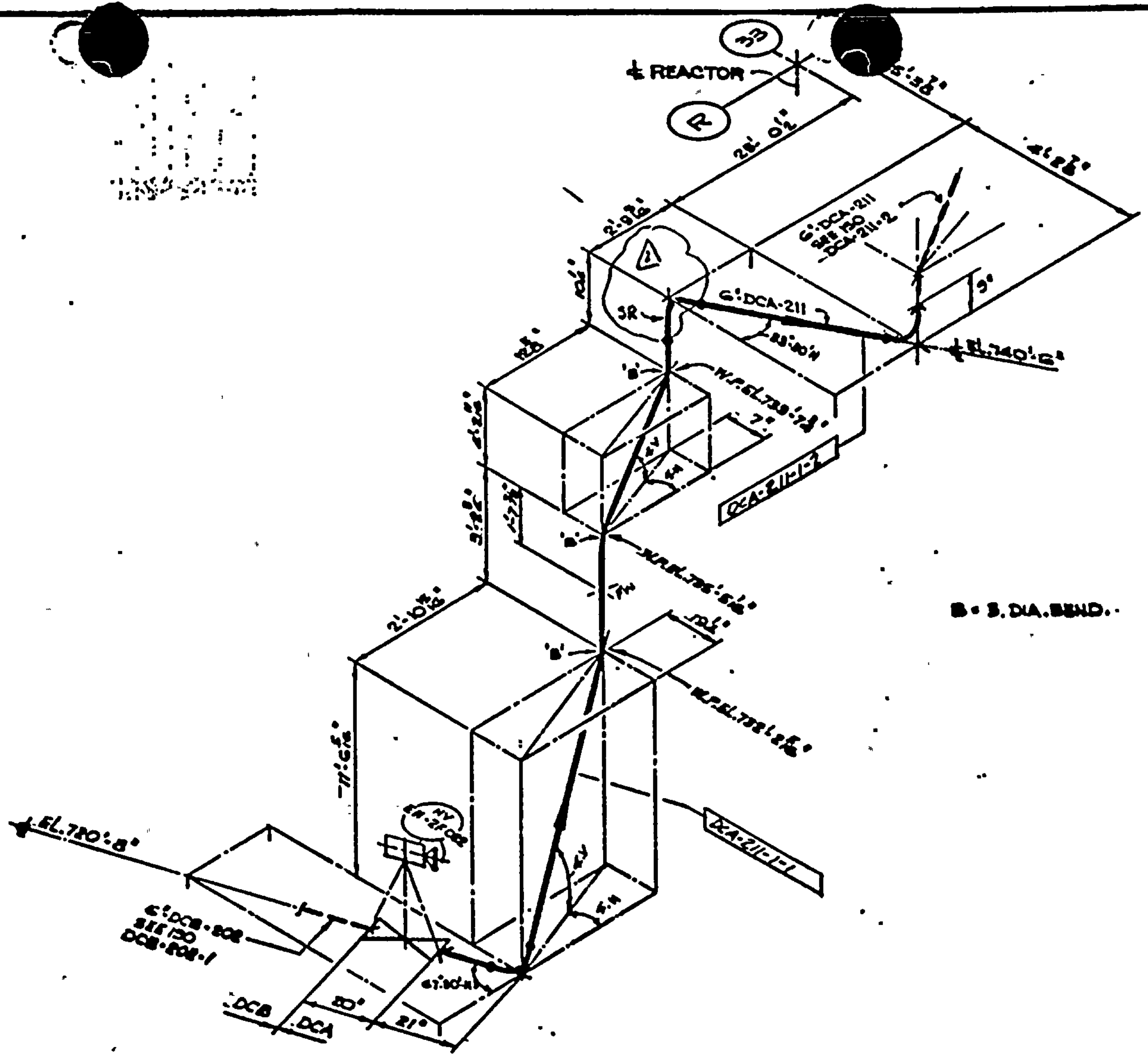
PENNSYLVANIA POWER & LIGHT COMPANY

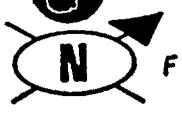
ALLENTOWN, PENNSYLVANIA
SUSQUEHANNA STEAM ELECTRIC STATION - UNIT 1, UNIT 2

BECHTEL - SAN FRANCISCO

ISOMETRIC - REACTOR BLDG
R.H.R. UNIT - 2

41-13
8856 DCA-211-2 2





B = 3. DIA. BEND.

REFERENCE DRAWINGS

M-141	REV. G.	P & I.D.
M-151	" 6.	"
M-31-3	" 5.	PIPING PLAN - AREA - 31
M-31-4	" 2.	" " - " - 31

51

COMPONENTS ON
THIS DWG. ARE Q-LISTED
SPEC. 8856-G-9 APPLIES

Q

3	[illegible]	[illegible]	RJ	[illegible]	[illegible]	[illegible]	[illegible]	
2	[illegible]	[illegible]	PDJ	[illegible]	[illegible]	[illegible]	[illegible]	
1	[illegible]	ISSUED FOR FABRICATION	BL	[illegible]	[illegible]	[illegible]	[illegible]	
NO.	DATE	REVISIONS	BY	CHK'D	[illegible]	[illegible]	[illegible]	APPD

SCALE N/A | CHECKED | DRAWN BL

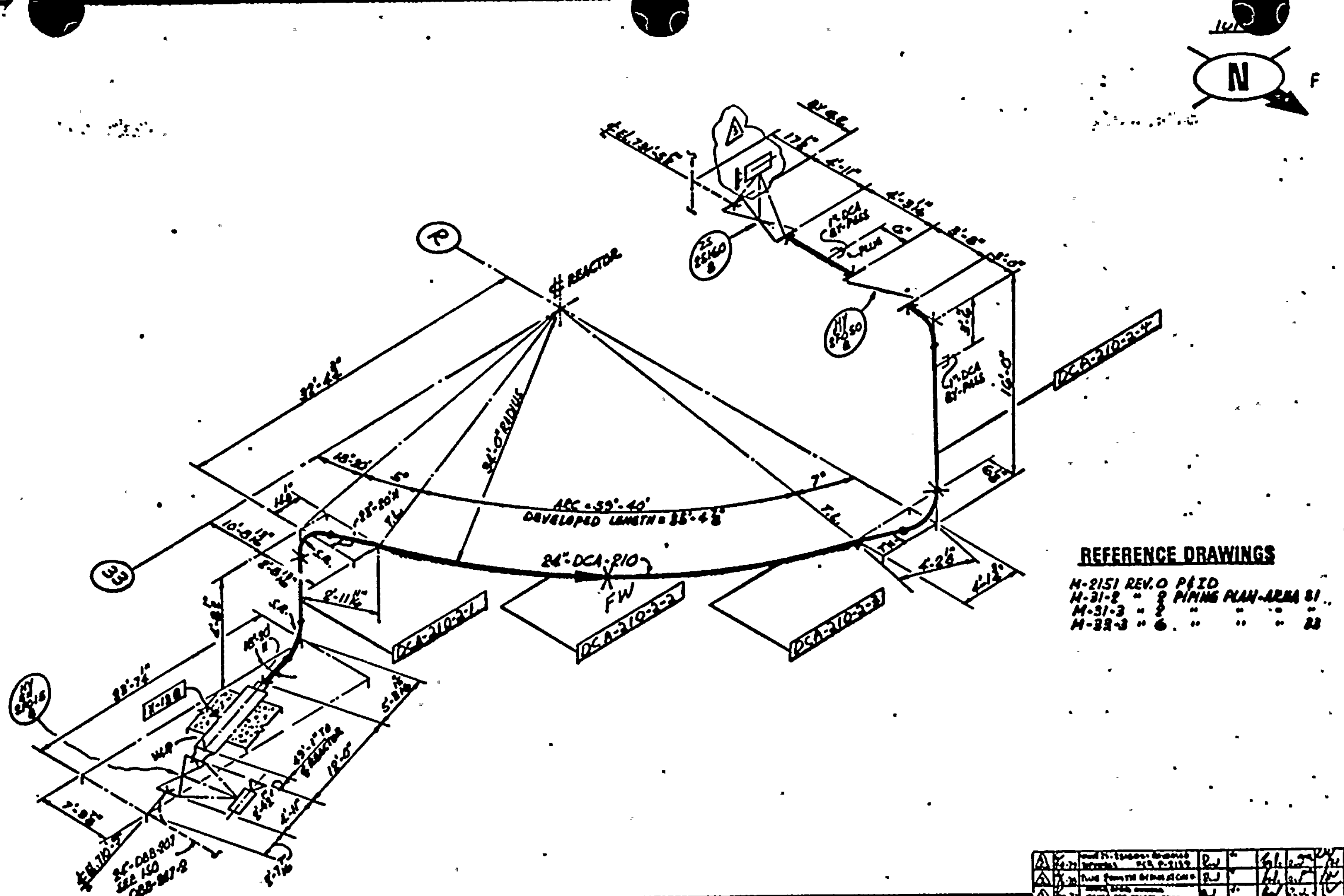
PENNSYLVANIA POWER & LIGHT COMPANY
ALLENTOWN, PENNSYLVANIA
SUSQUEHANNA STEAM ELECTRIC STATION - UNIT 1, UNIT 2

BECHTEL - SAN FRANCISCO

ISOMETRIC - REACTOR BLDG
R.H.R. - UNIT-2

JOB No.	41-13 DRAWING No.	REV.
8856	DCA-211-1	2

G2 ISO REACTOR BLDG RHR M



REFERENCE DRAWINGS

M-2151 REV. 0 P&ID
M-31-2 " 8 PIPING PLAN-AREA 31
M-31-3 " 8 " " " "
M-33-3 " 6 " " " 33

COMPONENTS ON THIS DWG. ARE Q-LISTED SPEC. 8856-G-9 APPLIES

Q

3	[illegible]	[illegible]	RJ					
2	[illegible]	[illegible]	RJ					
1	[illegible]	[illegible]	RJ					
0	[illegible]	ISSUED FOR FABRICATION	G		JEK			
NO.	DATE	REVISIONS	BY	CHK'D				APPD

DRAWN G

PENNSYLVANIA POWER & LIGHT COMPANY
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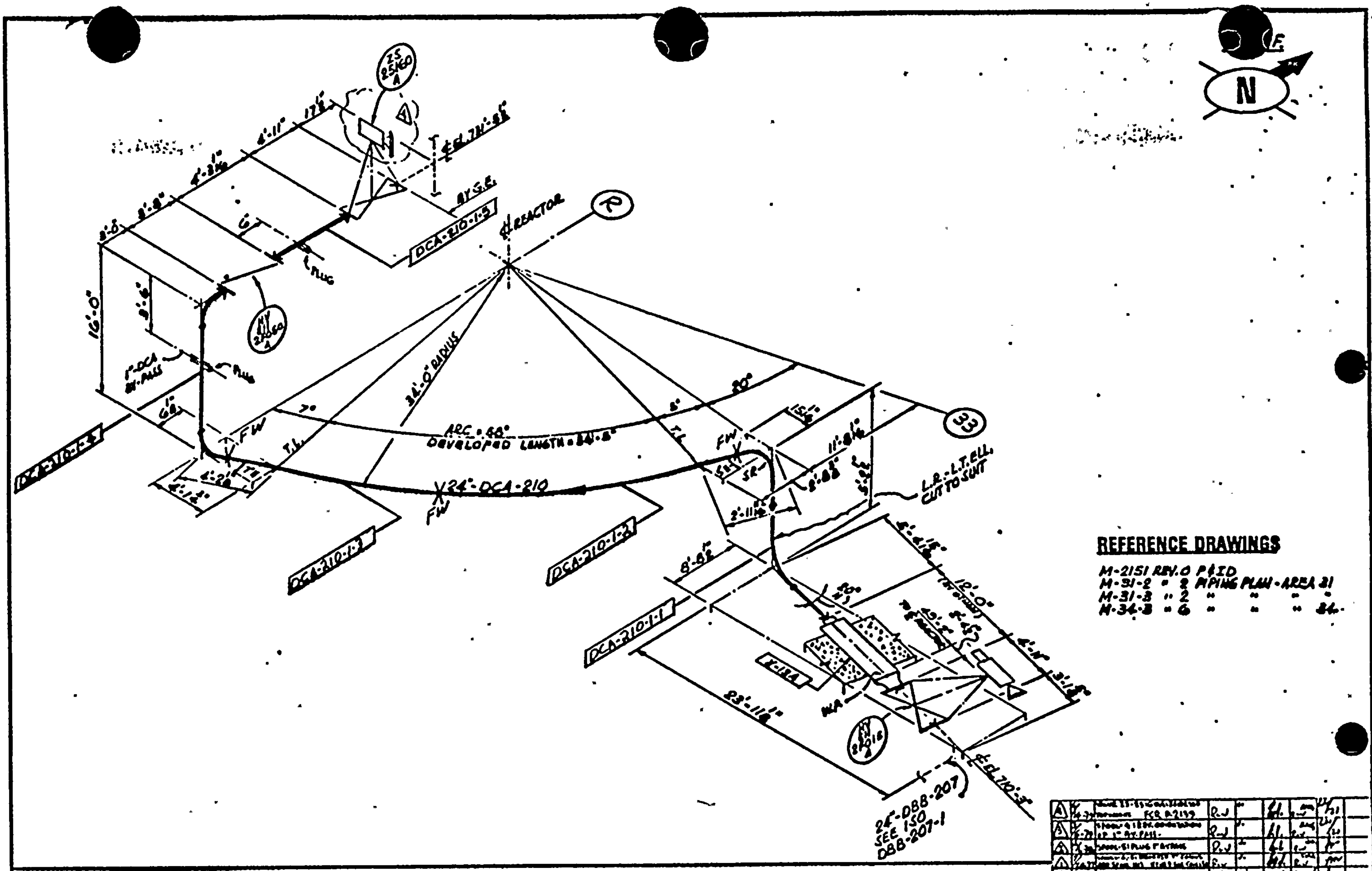
BECHTEL · SAN FRANCISCO

ISOMETRIC - REACTOR BLDG.
· R.H.R. · UNIT # 2

JOB No.	51-25 DRAWING No.	REV.
8856	DCA-210-2	3

G2 ISO REACTOR BLDG RHR



REFERENCE DRAWINGS

M-2151 REV.0 P&ID
M-31-2 " 2 PIPING PLAN - AREA 31
M-31-3 " 2 " " " "
M-34-3 " 6 " " " 34.

COMPONENTS ON
THIS DWG. ARE Q-LISTED
SPEC. 8856-G-9 APPLIES

Q

4	[illegible]	[illegible] FCR A2139	R.J	[illegible]	[illegible]	[illegible]	[illegible]	
3	[illegible]	[illegible] 1" BY-PASS	R.J	[illegible]	[illegible]	[illegible]	[illegible]	
2	[illegible]	[illegible] PLUG [illegible]	R.J	[illegible]	[illegible]	[illegible]	[illegible]	
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
0	[illegible]	ISSUED FOR FABRICATION	G	[illegible]	[illegible]	[illegible]	[illegible]	

G

PENNSYLVANIA POWER & LIGHT COMPANY
ALLENTOWN, PENNSYLVANIA
SUSQUEHANNA STEAM ELECTRIC STATION - UNIT 1, UNIT 2

BECHTEL - SAN FRANCISCO

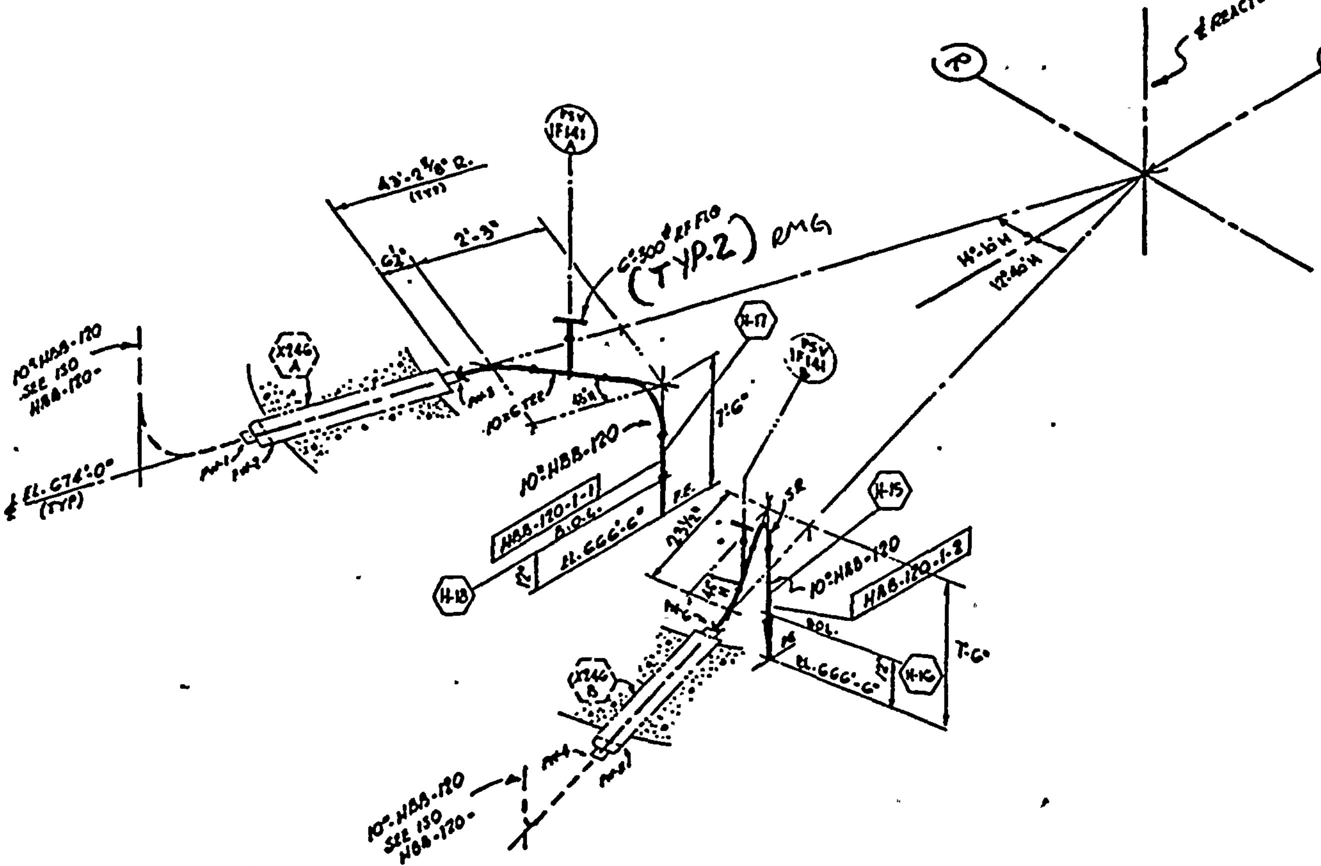
ISOMETRIC - REACTOR BLDG.
R.H.R. - UNIT # 2

51-25
8856
DCA-210-1
4

G2 ISO REACTOR BLDG RHR

Rev. ⚠2 NOTE: REDESIGNED BOTH SPOOLS
ADDED 45° OFFSET. CHANGED PSV CONN.
CHANGED LENGTH.
EL. 699'-0 WAS 658'-10

Rev. ⚠3 NOTE: REV. BOTH SPOOLS. EL. 666'-6 WAS 699'-0.
7'-6 WAS 5'-0.
SPOOL-11 ELL WAS SR.
SPOOL-21 SR ELL WAS LR.



REFERENCE DRAWINGS

M-151 REV. 3	P.&I.D.	
M-28-2 " 4	PIPING PLAN - AREA 28	
M-29-2 " 2	" "	" 29

COMPONENTS ON THIS DWG. ARE Q-LISTED SPEC. 8856-G-9 APPLIES

⚠5	7-20-78	ADDED PIPE SUPPORTS	RJ	[illegible]	[illegible]	[illegible]	[illegible]	
⚠4	[illegible]	SEE REV ⚠4 NOTE [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
⚠3	[illegible]-76	REV SPOOL-11 [illegible] PSV 1F141 AND 1S120 A & B.	RJ	J.	[illegible]	RJ	[illegible]	
⚠2	[illegible]-76	SEE REV ⚠2 NOTE	RJ	J.	[illegible]	R.	[illegible]	
⚠1	9/19/[illegible]	ADDED SPOOL & FW NO'S.	[illegible]	RJ	[illegible]	RJ	[illegible]	
⚠0	[illegible]	ISSUED FOR FABRICATION	RJ	RT	[illegible]	RJ	[illegible]	

DRAWN RJ

PENNSYLVANIA POWER & LIGHT COMPANY
ALLENTOWN, PENNSYLVANIA
SUSQUEHANNA STEAM ELECTRIC STATION - UNIT 1 & UNIT 2

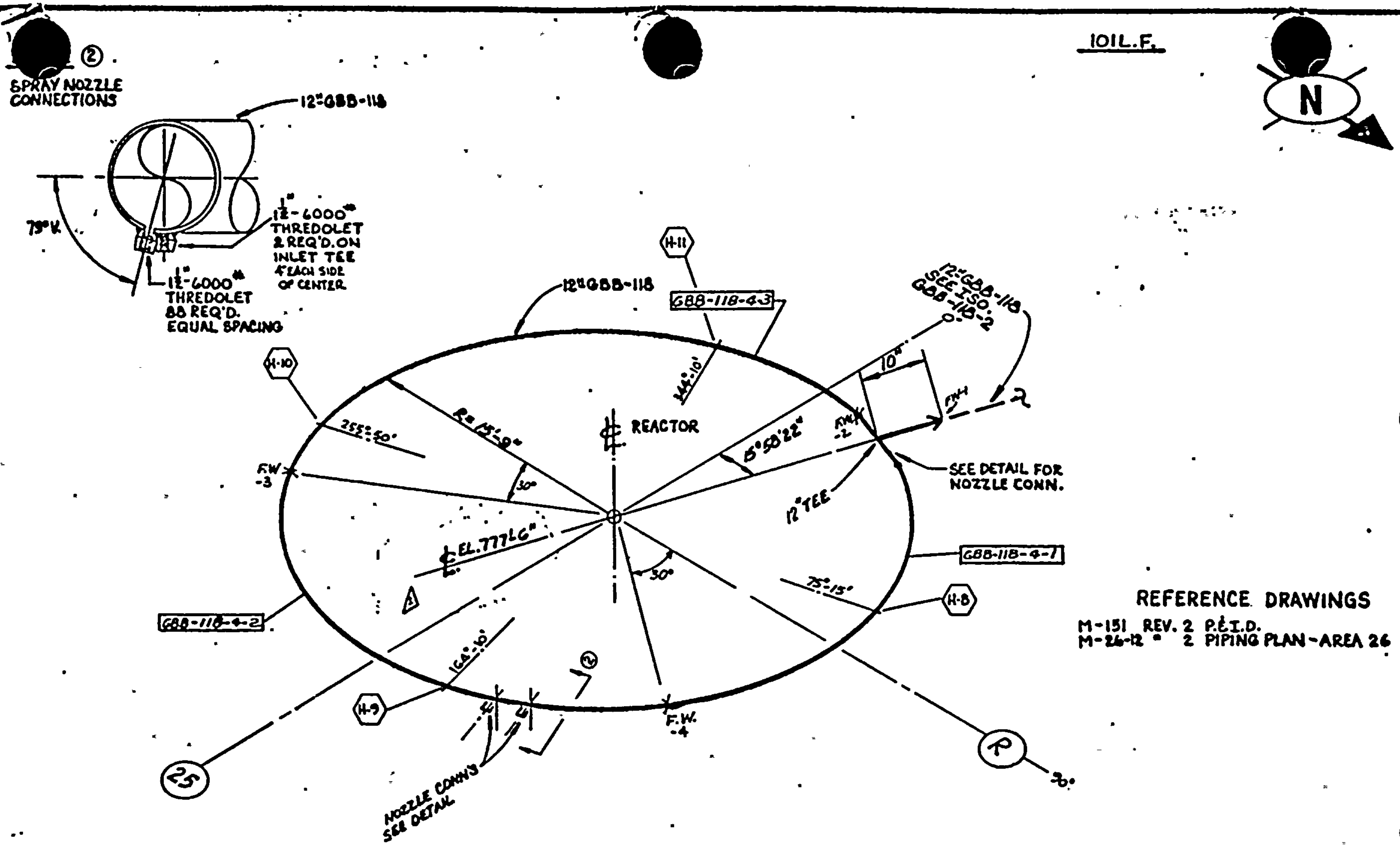
BECHTEL - SAN FRANCISCO

ISOMETRIC-REACTOR BLDG. R.H.R. - UNIT 1

JOB No.	51-21 DRAWING No.	REV.
8856	HBB-120-1	5

311 130 REACTOR BLDG RHR

101L.F.



REFERENCE DRAWINGS

M-151 REV. 2 P.&I.D.
M-26-12 " 2 PIPING PLAN-AREA 26

COMPONENTS ON
THIS DWG. ARE Q-LISTED
SPEC. 8856-G-8 APPLIES

△							
△							
4	1/7/76	[illegible] SUPPORTS. ISSUED FOR CONSTR.	RJ			RJ	
1	3/1/75	ADDED SPOOL & FW NOS. PER FIELD REQUEST		RJ			
0	3/26	ISSUED FOR FABRICATION	BT	RJ		RJ	

DRAWN D.T.

PENNSYLVANIA POWER & LIGHT COMPANY

ALLENTOWN, PENNSYLVANIA

SUSQUEHANNA STEAM ELECTRIC STATION - UNIT 1, UNIT 2

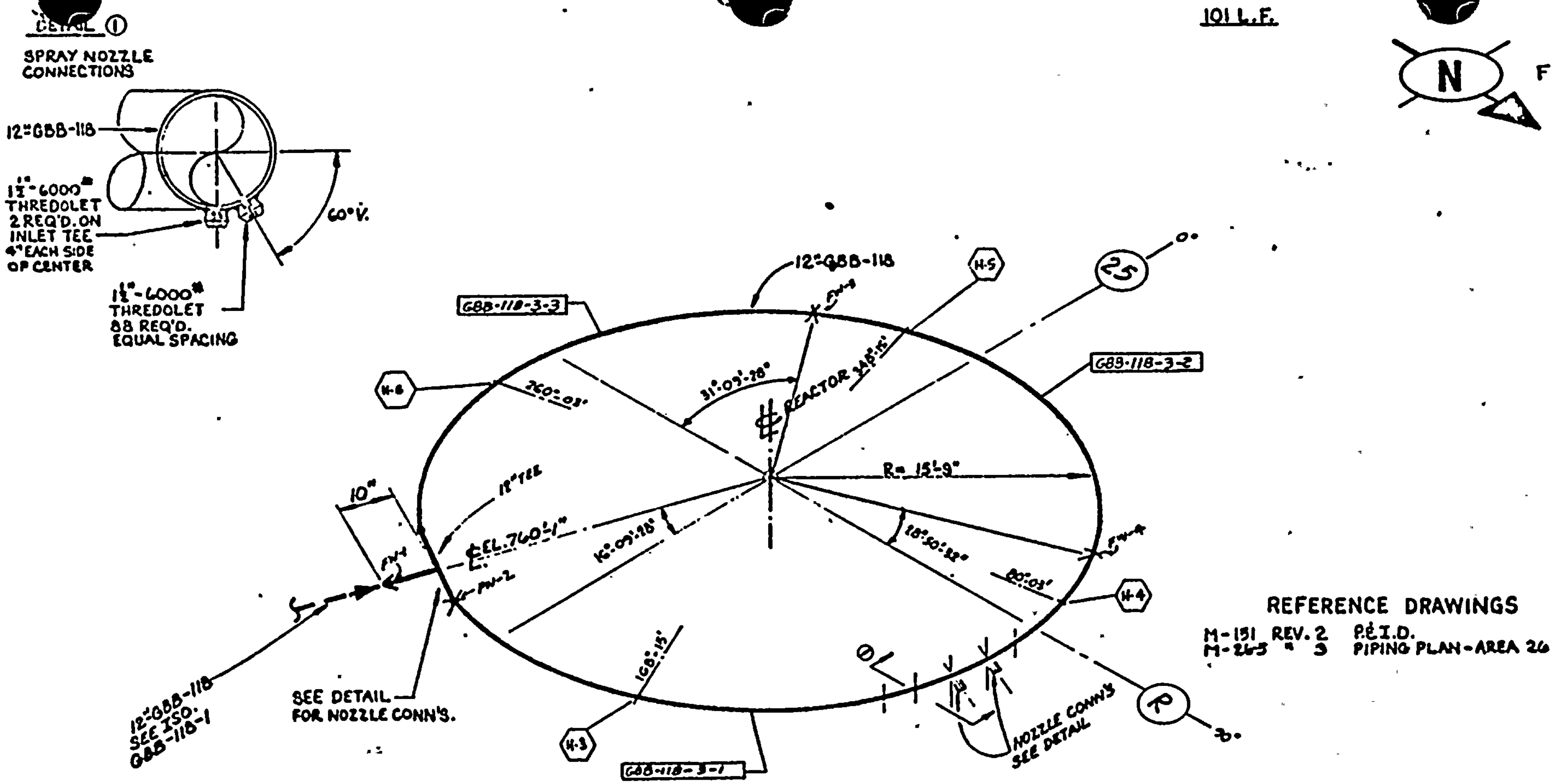
BECHTEL - SAN FRANCISCO

ISOMETRIC - REACTOR BLDG.
RHR - UNIT 1

JOB No.	51-19 DRAWING No.	REV.
8856	GBB-118-4	2

Q

GI ISO REAC BLDG RHR M



REFERENCE DRAWINGS

M-151 REV. 2 P.&I.D.
M-265 " 3 PIPING PLAN-AREA 26

COMPONENTS ON
THIS DWG: ARE Q-LISTED
SPEC. 8856-G-9 APPLIES

△								
△								
△	4/28	[illegible] SUPPORTS, ISSUED FOR CONSTR.	RJ	[illegible]	[illegible]	[illegible]	[illegible]	
△	[illegible]	ADDED [illegible]	[illegible]	RJ	[illegible]	BJ	RC	
△	[illegible]	[illegible]	BT	RJ	[illegible]	[illegible]	[illegible]	

B.T.

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SUSQUEHANNA STEAM ELECTRIC STATION - UNIT 1, UNIT 2
BECHTEL - SAN FRANCISCO

ISOMETRIC - REACTOR BLDG.
RHR - UNIT 1

JOB No. 8856
51-19 DRAWING No. GBB-118-3
REV 2

Q

G 1 1 1 1 5 0 R E A C B L D G R H R 1 M