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AUTH.NAME AUTHOR AFFILIATION
VAN BRUNT,E.E. Arizona Nuclear Power Project (formerly Arizona Public Serv
RECIP.NAME RECIPIENT AFFILIATION
KNIGHTON,G.W. Office of Nuclear Reactor Regulation, Director (pre-851125)

SUBJECT: Forwards clarification of Section 4.1, "Structural Analysis of Spray Pond Piping Sys" in response to 851003 request. Clarification addresses weld corrosion evaluation & provides supporting calculations.

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Arizona Nuclear Power Project
P.O. BOX 52034 • PHOENIX, ARIZONA 85072-2034

November 6, 1985
ANPP-33943 EEVB/PGN

Director of Nuclear Reactor Regulation
Attention: Mr. George W. Knighton, Project Director
PWR Project Directorate #7
Division of Pressurized Water Reactor Licensing - B
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: Palo Verde Nuclear Generating Station (PVNGS)
Units 1, 2, and 3
Docket Nos. STN-50-528 (License NPF-41)/529/530
Clarification of Structural Analysis for Spray Pond Piping
File: 85-056-026; G.1.01.10

References: (1) Letter from E. E. Van Brunt, Jr. (APS) to G. W. Knighton (NRC) dated April 3, 1985, ANPP-32303, Subject: Essential Spray Pond Corrosion.

(2) Telecon between Manny Licitra (NRC), Peggy Nelson (PAS), and Doug Freeland (Bechtel) dated October 3, 1985, Subject: Structural Analysis for Spray Pond Piping.

Dear Mr. Knighton:

The reference 1 letter transmitted an evaluation of spray pond weld corrosion at PVNGS. The reference 2 telecon requested clarification for section 4.1 of the evaluation, which addressed the structural analysis of the (spray pond) piping system.

Attached please find the requested clarification to section 4.1 of the spray pond weld corrosion evaluation, as well as the supporting calculations.

If you have any questions or require additional information, please contact Mr. W. F. Quinn of my staff.

Very truly yours,

E E Van Brunt /DBK

E. E. Van Brunt, Jr.
Executive Vice President
Project Director

EEVB/WFQ/PGN/bg
Attachment

cc: E. A. Licitra
M. C. Ley
R. P. Zimmerman
A. C. Gehr

A001
1/1

STRUCTURAL ANALYSIS OF THE SPRAY POND PIPING SYSTEM

Evaluation for corrosion of submerged essential spray pond piping required development of an analytical model. The approach taken was to determine what minimum cross sectional pipe weld area is required to meet the design requirements. Two conditions were considered. One was uniform degradation (thinning) of the pipe weld to establish what uniform circumferential weld thickness is required. The other was total penetration of the pipe weld by through wall pits. For this, a conservative model of four equally spaced pipe weld segments of minimum fabricated pipe wall thickness was assumed to determine the circumferential length of integral weld required. For both cases, the highest total piping loads (including those for a seismic event) were taken from the original system design calculation for each size of pipe and were applied to the reduced pipe weld cross section. ASME Code Section III equations, including appropriate stress intensification factors, were used to work backwards from the allowable stresses to obtain the required pipe weld sections.

The results are shown in the attached calculation section. The most critical case is for the 14 inch diameter pipe where a uniform weld thickness of 0.206 inch is required, or a conservative intermittent weld length (total of four segments) of 35.12 inches is required. This represents a 34% reduction from nominal wall thickness or a 20% reduction of total circumferential weld length, respectively. The reference 1 letter recorded a 40% allowable reduction from the nominal wall thickness based on preliminary calculations.

Subsequently, radiographic weld examinations revealed 108 indications for a 14 inch diameter pipe weld. For evaluation purposes, it was conservatively assumed that all indications became 1/8 inch diameter through wall pits. This 30% loss of circumferential weld length was greater than that allowed from the initial conservative analysis. Thus, the pipe was reevaluated for the assumed reduced section. This time the resulting stress was determined for the highest combined loads from the original design analysis. For the purposes of analysis, stress concentration factors around the holes were excluded because (1) the conservative assumptions used for establishing the reduced sections were considered compensating, (2) the evaluation already included component stress intensification factors, and (3) the material in the assumed section was symetrically distributed around the circumference. The resulting stress is less than that allowed by ASME Code. The 24 inch diameter pipe was similarly evaluated for its maximum number of radiographic indications and was found to be less critical. The remaining pipe sizes were judged acceptable by comparison.

The existing pipe condition is a combination of intermittent pipe wall thickness deteriorations and through wall pitting. The majority of the radiographic indications showed negligible deterioration of the pipe wall. The limited number of through wall pits were mostly pinhole type (1/32 inch or smaller). The pipe is not expected to ever achieve a condition equal to any of the conditions evaluated above. It is concluded, therefore, that the essential spray pond piping is structurally capable of performing its intended function.

SUPPORT DWG. NO. — REV.

NCR # WY-1262

NCR # PY-10373

PROBLEM

Spray pond trunk lines and spray nozzle piping have possible deficient welds (pinholes / pitting potentally due to microbiologically induced corrosion).

WANTED

Calculate the required welding which is needed to maintain structural piping integrity under all plant operating conditions.

SOLUTION

This calculation will derrive the equations & give the resulting weld requirements to structurally keep the pipe connected for two different welding conditions: 1) The size of weld required assuming a continuous weld around the circumference of the pipe & 2) The amount of weld length required assuming an intermittant stitch weld with a weld size equal to the minimum wall thickness allowed by standard fabrication procedures.

INFORMATION ONLY

NOTICE

BECHTEL

CALCULATION SHEET

PROB. NO. ZZ-584

SIGNATURE Kevin B. [signature] DATE 3/16/85 CHECKED [signature] DATE 3/19/85

PROJECT PALO VERDE NUCLEAR GENERATING STATION JOB NO. 10407-002

SUBJECT ESP PIPE ~~SUPPORTS~~ SHEET 2 OF 15 SHEET

NCR'S WY-1262, PY-10373

~~SUPPORT DWG. NO.~~ REV.

Derrivation of formulas used

Basic Assumptions

A. Calculating minimum weld size

1. The weld size will be calculated assuming a full circumferential weld
2. Weld properties calculated treating the weld as a line (standard) and assuming the weld is made at the inside circumference of the pipe.

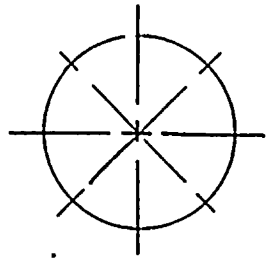

FIG. 1

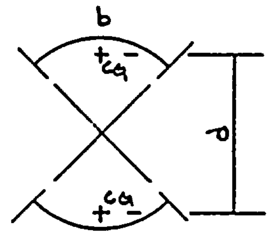

FIG 2

B. Calculating minimum weld length.

1. All weld properties will be as stated in note A2 above
2. Weld properties will be calculated using 4 segments of weld equally spaced around the pipe
3. Only 2 segments (ref. note B2) will be used to calculate section modulus and all 4 segments will be used to calculate pressure requirements.
4. Since 'd' will reduce as the segment lengths increase, "d" will be based on a segment of weld length equal to .25 times the pipe circumference. (ref. Fig. 2)
5. The dimension "b" will then be assumed to be a straight line acting through the "c.g." of the weld.

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CALCULATION SHEET

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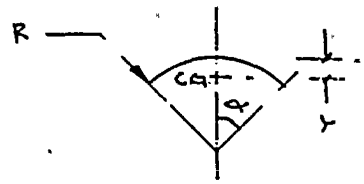
PROJECT PALO VERDE NUCLEAR GENERATING STATION JOB NO. 10407-002

SUBJECT ESP PIPE ~~SUPPORTS~~ SHEET 3 OF 15 SHEET

NCR's WY-1262, PY-10373 ~~SUPPORT DWG. NO.~~ REV.

Derrivations of formulas used (cont'd)



Find proportion of d for .25 × circumference

$$Y = R\left(1 - \frac{\sin\alpha}{\alpha}\right)$$

$$Y = R\left(1 - \frac{\sin \pi/4\,(\text{rad})}{\pi/4}\right) = .1R$$

$$d = 2(R - .1R) = 1.8R$$

INFORMATION ONLY

Find Z

std. equation $Z = b\,d\,t$.* where t = weld thickness

std. equation $Z = \pi R^2 t$**

Formulas. (ref. sht. 7 in volume 1 of pipe stress calculation 13-MC-ZY-S

A. Calculating min weld size, t_m

① $$\frac{PD_o}{4t_m} + \frac{.75\,i\,M_A}{\pi R^2 t_m} \le 1.0\,S_h$$

* 2 segment weld - consv. since side segments are ignored.

② $$\frac{PD_o}{4t_m} + \frac{.75\,i\,(M_A + M_B)}{\pi R^2 t_m} \le 1.2\,S_h$$

** full circumferential weld

③ $$\frac{PD_o}{4t_m} + \frac{.75\,i\,M_A}{\pi R^2 t_m} + \frac{i\,M_c}{\pi R^2 t_m} \le (S_h + S_A)$$

where t_m = min weld thickness

$i(.75) \ge 1$

P = 100 psi (consv. since line list specifies 50 psi design)

CALCULATION SHEET

PROB. NO. ZZ-584

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PROJECT PALO VERDE NUCLEAR GENERATING STATION JOB NO. 10407-002

SUBJECT ESP PIPE ~~SUPPORTS~~ SHEET 4 OF 15 SHEETS

NCR's WY-1262, PY-10373

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Formulas (cont'd)

B. Calculating min weld length, $t_M = 0.875\,t_n$

(4) $$\frac{PD_o\,(2\pi R)}{4t_m\,(4b)} + \frac{.75\,i\,M_A}{1.8R(b)(t_M)} \le 1.0\ S_h$$

(5) $$\frac{PD_o\,(2\pi R)}{4t_M\,(4b)} + \frac{.75\,i\,(M_A + M_B)}{1.8R(b)(t_M)} \le 1.2\ S_h$$

(6) $$\frac{PD_o\,(2\pi R)}{4t_M\,(4b)} + \frac{.75\,i\,M_A + i\,M_C}{1.8R(b)(t_m)} \le (S_h + S_a)$$

Material & allowable stress values

- Material SA-312 Gr TP 316L

Allowable stress values - S_h = 15.7 ksi S_c = 15.7 ksi S_a = 23.6 ksi

Loads

Loads were obtained from calculation 13-MC-ZY-533B and calculation shown on the following sheet. Thermal loads on 4" ϕ risers were not included in calc 13-MC-ZY-533B since they are not controling.

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CALCULATION SHEET

PROB. NO. ZZ-584

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PROJECT PALO VERDE NUCLEAR GENERATING STATION JOB NO. 10407-002

SUBJECT ESP PIPE ~~SUPPORTS~~ SHEET 5 OF 15 SHEETS

NCR WY-1262, PY-10373

~~SUPPORT DWG. NO.~~ REV.

THERMAL LOAD ON 4"ϕ RISERS

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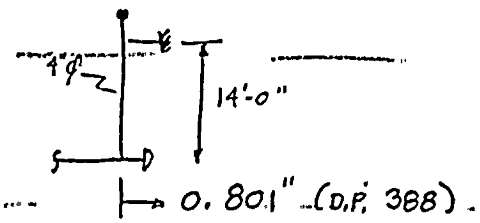

ASSUME GUIDED CANTILEVER

$$M = \frac{EI\delta}{288L^2}$$

$E = 28.3 \times 10^6$

$I = 7.23\ in^4$

$\delta = 0.801$

$L = 14\ ft$

$$M_{4"\phi} = \frac{28.3 \times 10^6 (7.23)(0.801)}{288(14)^2} = 2903\ ft\text{-}lb$$

ALSO USE $M_{6"\phi} = 2903\ ft\text{-}lb$ FOR 6"ϕ HEADER

FOR 8"ϕ HEADER δ @ 4"ϕ = 0.638"

$$\therefore M_{8"\phi} = \frac{0.638}{0.801}(2903) = 2312\ ft\text{-}lb$$

For 14"ϕ HEADER - calc. 13-MC-ZY-533B have a greater load at the intersection of 24"ϕ pipe than whats induced by 4"ϕ pipe

CALCULATION SHEET

BECHTEL

PROB. NO. ZZ-5E6

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PROJECT PALO VERDE NUCLEAR GENERATING STATION JOB NO. 10407-002

SUBJECT ESP PIPE SUPPORTS SHEET 6 OF 15 SHEETS

NCR's WP-1262, PY-10373

SUPPORT DWG. NO. ______ REV. ______

INFORMATION ONLY

CALCULATING MINIMUM WELD SIZE

NOMINAL PIPE DIA. (IN.)	Do (IN.)	i *	R (IN.)	MA (IN·K)	MB (IN·K)	MC (IN·K)	EQUATION #	STR. ALLOW.	ALLOWABLE STR. VALUE (KSI)	Tm (IN.)
4	4.5	1	2.01	—	6.4	34.8	1	Sh	15.7	.007
							2	1.2 Sh	18.8	.033
							3	SH + SA	39.3	.073
6	6.63	1	3.03	9.1	5.5	34.8	1	Sh	15.7	.031
							2	1.2 Sh	18.8	.036
							3	SH + SA	39.3	.043
		1.69					1	SH	15.7	.036
							2	1.2 SH	18.8	.043
							3	SH + SA	39.3	.066
		2.0					1	SH	15.7	.041
							2	1.2 SH	18.8	.049
							3	SH + SA	39.3	.078
8	8.63	1	4.06	12.2	7.8	27.7	1	SH	15.7	.029
							2	1.2 SH	18.8	.032
							3	SA + SH	39.3	.025
		2.0					1	SH	15.7	.036
							2	1.2 SH	18.8	.042
							3	SA+SH	39.3	.042
14	14.0	1.0	6.69	41.1	125.6	295.5	1	SH	15.7	.041
							2	1.2 SH	18.8	.082
							3	SA + SH	39.3	.070

INFORMATION ONLY

CALCULATING MINIMUM WELD SIZE (CONT'D.)

NOMINAL PIPE DIA (IN.)	Do (IN.)	i [A]	R (IN.)	MA (IN·K)	MB (IN·K)	MC (IN·K)	EQUATION #	STR. ALLOW	ALLOWABLE STR VALUE (KSI)	TM (IN.)
14	14.0	2.0	6.69	41.1	125.6	295.5	1	SH	15.7	.050
							2	1.2SH	18.8	.113
							3	SA+SH	39.3	.127
		3.34					1	SH	15.7	.069
							2	1.2SH	18.8	.177
							3	SA+SH	39.3	.206
24	24.0	1.0	11.63	178.5	67	224	1	SH	15.7	.065
							2	1.2SH	18.8	.063
							3	SA+SH	39.3	.039
		3.34					1	SH	15.7	.105
							2	1.2 SH	18.8	.109
							3	SA+SH	39.3	.087

A INTENSIFICATION FACTORS FOR VARIOUS COMPONENTS IN SPECIFIED LINE SIZE

INFORMATION ONLY

Calculating Minimum Weld Length

Nominal Pipe Dia (in.)	Do (in.)	i *	R (in.)	tm (in.)	MA (in·k)	MB (in·k)	MC (in·k)	Equation #	Str. Allow.	Allowable Str. Value (ksi)	b (in.)
4	4.5	1.0	2.01	.207	—	6.4	34.8	4	Sh	15.7	.11
								5	1.2 Sh	18.8	.55
								6	Sh + Sa	39.3	1.23
6	6.63	1.0	3.03	.245	9.1	5.5	34.8	4	Sh	15.7	.64
								5	1.2 Sh	18.8	.75
								6	Sh + Sa	39.3	.92
		1.69						4	Sh	15.7	.75
								5	1.2 Sh	18.8	.91
								6	Sh + Sa	39.3	1.42
		2.0						4	Sh	15.7	.86
								5	1.2 Sh	18.8	1.04
								6	Sh + Sa	39.3	1.67
8	8.63	1.0	4.06	.219	12.2	7.8	27.7	4	Sh	15.7	.89
								5	1.2 Sh	18.8	1.00
								6	Sh + Sa	39.3	.79
		2.0						4	Sh	15.7	1.13
								5	1.2 Sh	18.8	1.33
								6	Sh + Sa	39.3	1.33
14	14.0	1.0	6.69	.273	41.1	125.6	295.5	4	Sh	15.7	1.65
								5	1.2 Sh	18.8	3.41
								6	Sh + Sa	39.3	2.95

INFORMATION ONLY

CALCULATING MINIMUM WELD LENGTH (CONT'D)

NOMINAL PIPE DIA (IN.)	Do (IN.)	i *	R (IN.)	tm. (IN.)	MA (IN.-K)	MB (IN.-K)	MC (IN.-K)	EQUATION #	STR. ALLOW.	ALLOWABLE STR. VALUE (KSI)	b (IN.)
14	14.0	2.0	6.69	.273	41.1	125.6	295.5	4	Sh	15.7	2.05
								5	1.2 Sh	18.8	4.76
								6	Sh + Sa	39.3	5.39
		3.34						4	Sh	15.7	2.85
								5	1.2Sh	18.8	7.74
								6	Sh+Sa	39.3	8.78
24	24.0	1.0	11.63	.328	178.5	67	224	4	Sh	15.7	3.78
								5	1.2 Sh	18.8	3.68
								6	Sh+ Sa	39.3	2.34
		3.34						4	Sh	15.7	6.28
								5	1.2 Sh	18.8	6.54
								6	Sh+ Sa	39.3	5.28

* INTENSIFICATION FACTORS FOR VARIOUS COMPONENTS IN SPECIFIED LINE SIZE.

CALCULATION SHEET

SIGNATURE [signature] DATE ____ CHECKED [signature] DATE 3/19/85 PROB. NO. ZZ.5-4

PROJECT PALO VERDE NUCLEAR GENERATING STATION JOB NO. 10407-002

SUBJECT ESP PIPE ~~SUPPORTS~~ SHEET 10 OF 15 SHEETS

NCRS WP-1262, PY-10373 ~~SUPPORT DWG NO.~~ REV. ____

INFORMATION ONLY

SPRAY POND PIPING - WELD REQUIREMENT SUMMARY*

NOMINAL PIPE DIA.	WELD POINT	PIPE PROPERTIES: NOMINAL WALL	PIPE PROPERTIES: MINIMUM WALL	PIPE PROPERTIES: PIPE CIRCUM.	WELD REQUIREMENTS ③: MINIMUM THICKNESS ①	WELD REQUIREMENTS ③: STITCH LENGTH ②	WELD REQUIREMENTS ③: TOT. LENGTH INTER. WELD
24	STRAIGHT	.375 in.	.328 in.	73.1 in.	.07 in	4.00 in	16.00 in
	TEE				.11 in	6.75 in	27.00 in
14	STRAIGHT	.312 in.	.273 in.	42.0 in	.08 in	3.50 in	14.00 in
	REDUCER				.13 in	5.5 in	22.00 in
	TEE				.21 in	9.0 in	36.00 in
8	STRAIGHT	.250 in	.219 in	25.5 in.	.03 in	1.25 in	5.00 in.
	REDUCER				.04 in.	1.50 in.	6.00 in.
6	STRAIGHT	.280 in	.245 in.	19.0 in	.04 in.	1.00 in	4.00 in.
	TEE				.07 in	1.50 in.	6.00 in.
	REDUCER				.08 in.	1.75 in	7.00 in.
4	STRAIGHT	.237 in	.207 in	12.6 in	.07 in	1.50 in.	6.00 in.

NOTES:

① ASSUMING A COMPLETE WELD AROUND THE PIPE

② ASSUMING AN INTERMITTANT WELD SPACED EQUALLY 4 PLACES AROUND THE PIPE

③ ROUNDED UP

* SEE ADDITIONAL RESULTS, SHEETS 11-15

CALCULATION SHEET

PROB. NO. ZZ-584

SIGNATURE: Dreeland DATE: 3/25/85 CHECKED: [initials] DATE: 4/13/85

PROJECT: PALO VERDE NUCLEAR GENERATING STATION JOB NO. 10407-002

SUBJECT: ESP PIPING ~~PIPE SUPPORTS~~ SHEET 11 OF 15 SHEETS

NCR'S WY-1262, PY-10373 ~~SUPPORT DWG. NO.~~ REV.

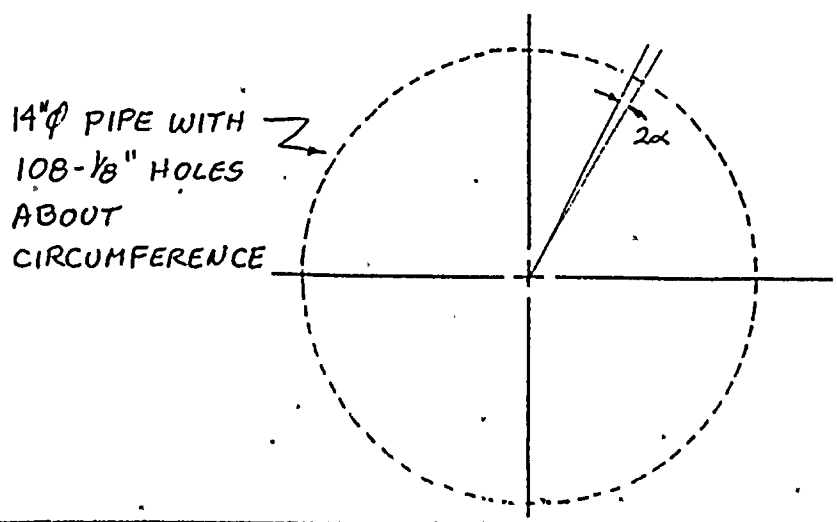
INFORMATION ONLY

SUBSEQUENT TO THE PRECEDING EVALUATION, THE NUMBER OF INDICATIONS WERE QUANTIFIED FOR THE VARIOUS PIPE SIZES. ~~THE MAXIMUM NUMBER OF~~ INDICATIONS ARE AS FOLLOWS:

PIPE SIZE	INDICATIONS
24	147
14	108
8	34
6	14
4	14

MOST INDICATIONS ARE INSIGNIFICANT IN SIZE AND NONE ARE LARGER THAN 1/16" DIAMETER. THUS, IT IS CONSERVATIVELY ASSUMED THAT ALL INDICATIONS ARE 1/8" DIAMETER HOLES.

FOR THE MOST CRITICAL 14"φ PIPE, 108 - 1/8"φ HOLES WILL RESULT IN A WELD REDUCTION OF APPROXIMATELY 30%, WHICH IS GREATER THAN THAT PREVIOUSLY CALCULATED. THE PIPE INTEGRITY WILL BE RECALCULATED (BASED ON MINIMUM WALL THICKNESS BUT EXCLUDING OTHER PREVIOUS CONSERVATIVE ASSUMPTIONS).



INFORMATION ONLY

SEGMENT INCLUDED ANGLE $(2\alpha) = \frac{360}{108} - 360\left(\frac{0.125}{\pi D}\right)$

$= \frac{360}{108} - 360\frac{(0.125)}{\pi(14.0)} = 2.310° = 4.032\times10^{-2}$ RAD

SEGMENT ORIENTATION ANGLES $(\theta_m) = m\frac{360}{108} = m\,(3.333°)$

MOMENTS OF INERTIA ABOUT PRINCIPLE AXES

$$I_1 = R^3 t\left(\alpha + \sin\alpha\cos\alpha - \frac{2\sin^2\alpha}{\alpha}\right)$$

$$= \left(\frac{14}{2}\right)^3(0.273)\left[2.016\times10^{-2} + \sin 1.155°\cos 1.155° - \frac{2\sin^2 1.155°}{2.016\times10^{-2}}\right]$$

$$= 4.065\times10^{-4}\ \text{IN}^4$$

$$I_2 = R^3 t\,(\alpha - \sin\alpha\cos\alpha)$$

$$= \left(\frac{14}{2}\right)^3(0.273)\left(2.016\times10^{-2} - \sin 1.155°\cos 1.155°\right)$$

$$= 6.469\times10^{-4}\ \text{IN}^4$$

$$y_1 = R\left(1 - \frac{\sin\alpha}{\alpha}\right) = \left(\frac{14}{2}\right)\left(1 - \frac{\sin 1.155°}{2.016\times10^{-2}}\right) = 9.764\times10^{-4}\ \text{IN}$$

SEGMENT AREA, $A = \frac{2\alpha}{360}\pi D t = \frac{2.310}{360}\pi(14)(0.273) = 7.705\times10^{-2}\ \text{IN}^2$

CALCULATION SHEET

PROB. NO. ZZ-584

SIGNATURE: D. Sheeland DATE: 3/25/85 CHECKED: [initials] DATE: 4/13/85

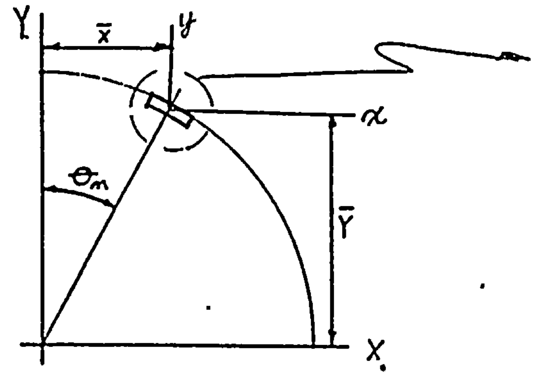
PROJECT: PALO VERDE NUCLEAR GENERATING STATION JOB NO. 10407-002

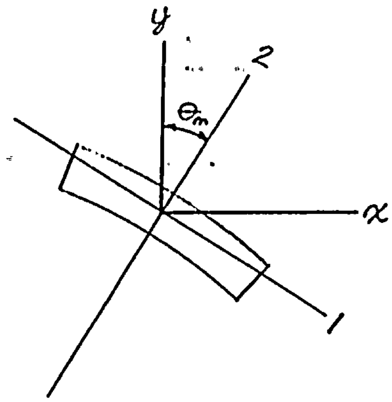
SUBJECT: ESP PIPING ~~PIPE SUPPORTS~~ SHEET 13 OF 15 SHEETS

~~SUPPORT DWG. NO.~~ NCR'S WY-1262, PY-10373 REV.

INFORMATION ONLY

FOR SKEWED SEGMENT:





$$I_{Xm} = I_1 \cos^2\theta_m + I_2 \sin^2\theta_m + A\bar{Y}^2$$

$$= I_1 \cos^2\theta_m + I_2 \sin^2\theta_m + A(R\cos\theta_m)^2$$

$$= (I_1 + A\bar{R}^2)\cos^2\theta_m + I_2 \sin^2\theta_m$$

$$= 3.776 \cos^2\theta_m + 6.469 \times 10^{-4} \sin^2\theta_m$$

TOTAL MOMENT OF INERTIA,

$$I_X = \sum_{m=1}^{108} 3.776 \cos^2\left(\frac{10m}{3}\right) + 6.469 \times 10^{-4} \sin^2\left(\frac{10m}{3}\right)$$

$$I_X = 204 \text{ IN}^4$$

USING MAXIMUM MOMENTS FOR 14"Ø LINE,

$$\sigma = \frac{PD_o}{4t_m} \cdot \frac{\pi D}{(\pi D - 108/8)} + \frac{0.75 i M_A + i M_C}{2 I_X / D}$$

CALCULATION SHEET

PROB. NO. ZZ-5E4

SIGNATURE [signature] DATE 3/25/85 CHECKED [initials] DATE 4/13/85

PROJECT PALO VERDE NUCLEAR GENERATING STATION JOB NO. 10407-002

SUBJECT ESP PIPING ~~PIPE SUPPORTS~~ SHEET 14 OF 15 SHEET

NCRs WY-1262, PY-10373 ~~SUPPORT DWG. NO.~~ REV.

INFORMATION ONLY

$$\sigma_{14''\phi} = \frac{50\,(14)\,\pi\,(14)/1000}{4(0.273)\,[\pi(14) - 108/8]} + \frac{0.75(3.34)(41.1) + (3.34)(295.5)}{2(204)/14}$$

$$\sigma_{14\phi} = 0.93 + 37.4 = 38.3 \text{ ksi} < 39.3 \quad (S_h + S_A) \; \therefore O.K.$$

FOR 24"ϕ LINE 147 INDICATIONS WERE IDENTIFIED. USING THE SAME APPROACH AS ABOVE,

$$\theta_m = \frac{360}{147} m$$

$$2\alpha = \frac{360}{147} - 360\frac{(0.125)}{\pi(24.0)} = 1.852^\circ \doteq 3.233 \times 10^{-2} \text{ RAD}$$

$$I_1 = \left(\frac{24}{2}\right)^3 (.328)\left[1.616\times10^{-2} + \sin 0.926^\circ \cos 0.926^\circ - \frac{2\sin^2 0.926^\circ}{1.616\times10^{-2}}\right]$$

$$I_1 = 566.8\,(1.616\times10^{-2} + 1.616\times10^{-2} - 3.232\times10^{-2}) = 2.201\times10^{-3} \text{ IN}^4$$

$$I_2 = \left(\frac{24}{2}\right)^3 (0.328)\left[1.616\times10^{-2} - \sin 0.926 \cos 0.926\right] = 2.329\times10^{-3} \text{ IN}^4$$

$$y_1 = \left(\frac{24}{2}\right)\left(1 - \frac{\sin 0.926}{1.616\times10^{-2}}\right) = 1.483\times10^{-3} \text{ IN}$$

$$A = \frac{2\alpha}{360}\pi D t = \frac{1.852}{360}\pi(24)(0.328) = 0.127 \text{ IN}^2$$

$$I_{X_m} = (18.29)\cos^2\theta_m + 2.329\times10^{-3}\sin^2\theta_m$$

$$I_X = \sum_{m=1}^{147} I_{X_m} = 1344$$

CALCULATION SHEET

PROB. NO. ZZ-584

SIGNATURE Freeland DATE 3/25/85 CHECKED [illegible] DATE 4/13/85

PROJECT PALO VERDE NUCLEAR GENERATING STATION JOB NO. 10407-002

SUBJECT ESP PIPING ~~PIPE SUPPORTS~~ SHEET 15 OF 15 SHEETS

NCRs WY-1262, PY-10373 ~~SUPPORT DWG. NO.~~ REV.

INFORMATION ONLY

$$\sigma_{24''\phi} = \frac{PD_o}{4t_m}\frac{(\pi D)}{(\pi D - 147/8)} + \frac{0.75i\,(M_A + M_B)}{2I/D}$$

$$\sigma_{24''\phi} = \frac{50(24)\pi(24)/1000}{4(.328)[\pi(24) - 147/8]} + \frac{0.75(3.34)(178.5+67)}{2(1344)/24}$$

$$\sigma_{24''\phi} = 1.21 + 5.49 = 6.7\ \text{ksi} < 18.8\ (1.2\,S_h)\ \therefore\ \text{O.K.}$$

THE REMAINING PIPE SIZES HAVE RELATIVELY FEWER INDICATIONS (34, 14, AND 14 FOR 8"ϕ, 6"ϕ AND 4"ϕ RESPECTIVELY) AND ARE CONSIDERED ACCEPTABLE BY COMPARISON WITH THE 14"ϕ PIPE.