ATTACHMENT (4)

Non-Proprietary -- Vendor Report S-PENG-CALC-008,

"Nozzle Loads for which SONGS Bottom Mounted

PRZ MNSA was Qualified"

Design Analysis Title Page

WESTINGHOUSE NON-PROPRIETARY CLASS 3

Title: **Nozzle Loads for which SONGS Bottom Mounted PZR MNSA was Qualified**

Document Number: S-PENG-CALC-008 Revision Number: **01**

Quality Class:

☒ QC-1 (Safety-Related) ☐ QC-2 (Not Safety-Related) ☐ QC-3 (Not Safety-Related)

1. **Approval of Completed Analysis**

This Design Analysis is complete and verified. Management authorizes the use of its results.

	Printed Name	Signature	Date
Cognizant Engineer(s)	K. H. Haslinger	Karl H. Haslinger	3/5/98
Mentor ☒ **None**			
Independent Reviewer(s)	D. J. Ayres	David J. Ayres	3/5/98
Management Approval	R. O. Doney	RO Doney	3/5/98

2. **Package Contents** (this section may be completed after Management approval):

Total page count, including body, appendices, attachments, etc. ______
List associated CD-ROM disk Volume Numbers and path names: ☒ None

Note: CD-ROM are stored as separate Quality Records

CD-ROM Volume Numbers	Path Names (to lowest directory which uniquely applies to this document)

Total number of sheets of microfiche: ☒ None Number of sheets: ______

Other attachments (specify): QA Forms (8 pages)

3. **Distribution**:

QA(2)

Contingencies and Assumptions

Title: **Nozzle Loads for which SONGS Bottom Mounted PZR MNSA was Qualified**

Document Number: **S-PENG-CALC-008** Revision Number: **01**

Instructions: List below all contingencies and assumptions on this Design Analysis that must be cleared before structures, systems or components to which they apply are put into service. Types of contingencies and assumptions:

Internal contingencies/assumptions are those which are CENO's responsibility to clear.

External contingencies/assumptions are those which are the customer's responsibility to clear.

Contingencies/assumptions which are CENO's responsibility shall be cleared by the Cognizant Engineer using one of two mechanisms described in paragraph 3.8 of QP 3.4. A copy of this form is to be given to the Project Manager who is responsible for assuring that all contingencies and assumption on a project which are CENO's responsibility to clear are cleared, and those which are the customer's are transmitted to them.

If there are no Internal or External Contingencies/Assumptions, then this form need not be included in the Design Analysis.

Type of Contingency/Assumption	Contingency/Assumption
☐ Internal ☐ External	
☐ Internal ☐ External	
☐ Internal ☐ External	
☐ Internal ☐ External	
☐ Internal ☐ External	

RECORD OF REVISIONS

Revision Number	Issue Date	Author	Independent Reviewer	Management Approver	Revised Pages		
					Replaced	Added	Deleted
00	02/03/98	K. H. Haslinger	D. J. Ayres	R. O. Doney	n/a	n/a	n/a
01	3/05/98	K. H. Haslinger	D. J. Ayres	R. O. Doney	all	n/a	n/a

TABLE OF CONTENTS

1.0 INTRODUCTION

Mechanical Nozzle Seal Assemblies (MNSA) will be installed at various instrument nozzle locations at Southern California Edison (SCE), San Onofre Units 2 and 3.

The MNSA is a mechanical device that acts as a complete replacement of the "J" weld between the Inconel 600 instrument nozzles and either the Hot Leg pipe, the Pressurizer vessel, or Steam Generator shell. The function of the MNSA is to prevent leakage and restrain the nozzle from ejecting in the event of a through-wall crack or weld failure of a nozzle. The potential for these events exists due to primary water stress corrosion cracking.

2.0 SIGNIFICANT RESULTS

3.0 DETAILED ANALYSIS

DETERMINATION OF NOZZLE LOADS FOR WHICH SONGS PRESSURIZER BOTTOM MOUNTED MNSAs WERE SHOWN "ACCEPTABLE" DURING ABB-CE SEISMIC TEST

[ ]

4.0 REFERENCES

4.1 Design Report No. S-PENG-DR-005, Rev. 00, "Addendum to CENC-1365 and CENC-1507 Analytical Report for Southern California Edison San Onofre Units 2 and 3 Piping".

4.2 TR-PENG-033, Rev. 00, "Seismic Qualification of the San Onofre Units 2 & 3 MNSA Clamps for Pressurizer Instrument Nozzles and RTD Hot Leg Nozzles".

4.3 TR-PENG-042, "Test Report for MNSA Hydrostatic Test and Thermal Cycle Test," July 3, 1997.

4.4 ABB-CE Drawing E-MNSA-228-008, Rev. 02, MNSA Seismic Test Fixtures.

4.5 Roark's Formulas for Stress and Strain, Sixth Edition.

4.6 Dubbels Taschenbuch für den Maschinenbau, Zwölfe Auflage, 1966.

4.7 TR-PENG-050, "Test Report for MNSA Hydrostatic Test," January 22, 1998.

4.8 ASME Boiler and Pressure Vessel Code, Section III, 1989 Edition (no Addenda).

APPENDIX A

3 Pages

REFERENCE MATERIAL

(Beam Deflection and Rotation Formulae)

Wegen der Symmetrie der Belastungsfläche ist

$$A' = B' = \frac{1}{2}\,\frac{l}{2}\,\frac{Pl}{4} = \frac{Pl^2}{16}, \qquad F_x = A\,x \cdot x/2 = P\,x^2/4,$$

also folgt $$EJy = \frac{Pl^2}{16}x - \frac{Px^2}{4}\,\frac{x}{3} = \frac{Pl^2}{16}\left(x - \frac{4}{3}\,\frac{x^3}{l^2}\right) = \frac{Pl^3}{16}\left(\frac{x}{l} - \frac{4}{3}\,\frac{x^3}{l^3}\right),$$

$$y = \frac{Pl^3}{16EJ}\left(\frac{x}{l} - \frac{4}{3}\,\frac{x^3}{l^3}\right)$$

die Gleichung der elastischen Linie; für $x = \frac{l}{2}$ wird $\max y = f = \frac{Pl^3}{48EJ}$ (Bild 63c).

Die Neigung der elastischen Linie in den Auflagern kann aus $EJ\hat{\alpha} = EJ\,\mathrm{tg}\,\alpha = A' = Pl^2/16$ ermittelt werden. (Fortsetzung s. S. 363 oben)

3. Es sind die Neigungen an den Auflagern des durch ein Moment M im Auflager A beanspruchten Trägers (Bild 64, S. 361) zu bestimmen. Die Momentenfläche ist ein Dreieck; für die Auflagerkräfte des mit der Momentenfläche belasteten Trägers folgt

$$A'l = \frac{Ml}{2}\cdot\frac{2}{3}l, \quad A' = \frac{1}{3}Ml \quad \text{und} \quad B' = \frac{1}{2}Ml - A' = \frac{1}{6}Ml;$$

$$\hat{\alpha} = \frac{Ml}{3EJ} \quad \text{und} \quad \hat{\beta} = \frac{Ml}{6EJ}.$$

Für die Gleichung der Biegelinie folgt $y = \frac{Ml^2}{6EJ}\,\frac{x}{l}\left(1 - \frac{x}{l}\right)\cdot\left(2 - \frac{x}{l}\right)$.

d) Formänderungsarbeit. Es war (S. 333) $A^\circ = \frac{1}{2}M\,d\varphi$. Mit M als Biegemoment, $y' = \mathrm{tg}\,\alpha = \hat{\alpha}$, also $d\varphi = d\hat{\alpha} = dy' = y''\,dx$ als Drehung des Stabelementes von der Länge dx folgt $dA^\circ = \frac{1}{2}My''\,dx$ oder für den ganzen Stab $A^\circ = \int_0^l dA^\circ$. Mit $M = EJy''$ (Differentialgleichung der elastischen Linie) wird auch $A^\circ = \frac{1}{2}\int_0^l EJy''^2\,dx = \frac{1}{2}\int_0^l M^2\,dx/EJ$.

e) Tafel: Momente und Durchbiegungen für Träger mit gleichbleibendem Querschnitt

Es bedeuten: l = Länge zwischen den Stützpunkten oder Stablänge in cm;

x, y = Koordinaten eines Punktes der Biegelinie (in cm); ← Bei den Belastungsfällen 6, 13, 15 und 16 ist im Interesse einfacherer Gleichungen der Bezugspunkt für x von der üblichen Lage abweichend gewählt.

f = Durchbiegung in cm unter der Einzellast P;

f_m = maximale Durchbiegung in cm;

α = spitzer Winkel der Tangente mit der x-Achse;

P = äußere Kräfte in kg;

q = Belastung in kg/cm;

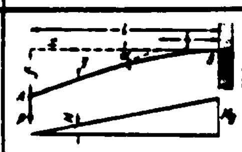
M = Biegemoment in kgcm; im Wendepunkt der Biegelinie ist $M = 0$;

J = Trägheitsmoment des Querschnittes in cm⁴;

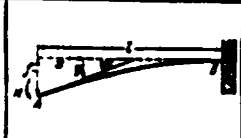
W = Widerstandsmoment des Querschnittes in cm³; $W erf = \frac{\max M}{\sigma_{zul}}$;

σ_{zul} = zulässige Biegespannung in kg/cm²;

$\max M$ = maximales Biegemoment, von der Form $\max M = P\,l\,\lambda$, also Tragkraft $P = W\,\sigma_{zul}/l\,\lambda$.

Nr.	Belastungsfall	Bemerkungen	Auflagerdrücke A, B / Biegemomente M	Gleichung der Biegelinie	Durchbiegungen f und f_m
1		Freiträger. Gefährdeter Querschnitt bei B	$B = P$; $M = -Pl\cdot x/l$; $\max M = Pl$	$y = \frac{Pl^3}{3EJ}\left(1 - \frac{3}{2}\,\frac{x}{l} + \frac{1}{2}\,\frac{x^3}{l^3}\right)$; $\mathrm{tg}\,\alpha_{(x=0)} = Pl^2/2EJ = 3f/2l$	$f = f_m = \frac{Pl^3}{3EJ}$

Dubbels, Reference 6

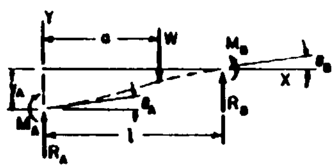
Nr.	Belastungsfall	Bemerkungen	Auflagerdrücke A, B / Biegemomente M	Gleichung der Biegelinie	Durchbiegungen f und f_m
8		Freiträger, Moment am freien Ende	$B = 0$; $M = \text{const.}$	Kreisbogen vom Radius $\varrho = EJ/M$ ersetzt durch $y = \frac{Ml^2}{2EJ}\left(1 - \frac{x}{l}\right)^2$; $\mathrm{tg}\,\alpha_{(x=0)} = Ml/EJ = 2f/l$	$f = \frac{Ml^2}{2EJ}$

From Reference 6

TABLE 3 Shear, moment, slope, and deflection formulas for elastic straight beams

NOTATION: W = load (force); w = unit load (force per unit length); M_o = applied couple (force-length); θ_o = externally created concentrated angular displacement (radians); Δ_o = externally created concentrated lateral displacement; T_1 and T_2 = temperatures on the top and bottom surfaces, respectively (degrees). R_A and R_B are the vertical end reactions at the left and right, respectively, and are positive upward. M_A and M_B are the reaction end moments at the left and right, respectively. All moments are positive when producing compression on the upper portion of the beam cross section. The transverse shear force V is positive when acting upward on the left end of a portion of the beam. All applied loads, couples, and displacements are positive as shown. All deflections are positive upward, and all slopes are positive when up and to the right. E is the modulus of elasticity of the beam material, and I is the area moment of inertia about the centroidal axis of the beam cross section. γ is the temperature coefficient of expansion (unit strain per degree)

1. Concentrated intermediate load



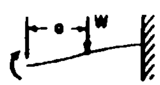
Transverse shear $= V = R_A - W\langle x - a\rangle^0$

Bending moment $= M = M_A + R_A x - W\langle x - a\rangle$

Slope $= \theta = \theta_A + \frac{M_A x}{EI} + \frac{R_A x^2}{2EI} - \frac{W}{2EI}\langle x - a\rangle^2$

Deflection $= y = y_A + \theta_A x + \frac{M_A x^2}{2EI} + \frac{R_A x^3}{6EI} - \frac{W}{6EI}\langle x - a\rangle^3$

(Note: see page 98 for a definition of the term $\langle x - a\rangle^n$)

End restraints, reference no.	Boundary values	Selected maximum values of moments and deformations
1a. Left end free, right end fixed (cantilever) 	$R_A = 0$ $M_A = 0$ $\theta_A = \frac{W(l-a)^2}{2EI}$ $y_A = \frac{-W}{6EI}(2l^3 - 3l^2 a + a^3)$ $R_B = W$ $M_B = -W(l-a)$ $\theta_B = 0$ $y_B = 0$	Max $M = M_B$; max possible value $= -Wl$ when $a = 0$ Max $\theta = \theta_A$; max possible value $= \frac{Wl^2}{2EI}$ when $a = 0$ Max $y = y_A$; max possible value $= \frac{-Wl^3}{3EI}$ when $a = 0$
1b. Left end guided, right end fixed 	$R_A = 0$ $M_A = \frac{W(l-a)^2}{2l}$ $\theta_A = 0$ $y_A = \frac{-W}{12EI}(l-a)^2(l+2a)$ $R_B = W$ $M_B = \frac{-W(l^2 - a^2)}{2l}$ $\theta_B = 0$ $y_B = 0$	Max $+M = M_A$; max possible value $= \frac{Wl}{2}$ when $a = 0$ Max $-M = M_B$; max possible value $= \frac{-Wl}{2}$ when $a = 0$ Max $y = y_A$; max possible value $= \frac{-Wl^3}{12EI}$ when $a = 0$

APPENDIX B

QUALITY ASSURANCE FORMS

8 Pages

Design Analysis In-Process Approvals

Verification Plan

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Design Analysis Verification Checklist

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Design Analysis Verification Checklist

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Reviewer's Comment Form

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Title: **Nozzle Loads for which SONGS Bottom Mounted PZR MNSA was Qualified**

Document Number: **Nozzle Loads for which SONGS MNSAs are Qualified** Revision Number: 01

Comment Number	Reviewer's Comment	Response Required?	Author's Response	Response Accepted?
	None			