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APPENDICES: 0 Pages
OTHER ATTACHMENTS: 0 Pages

DESIGN REPORT

FOR

SOUTHERN CALIFORNIA EDISON - SAN ONOFRE STEAM GENERATOR

MANWAY AND HANDHOLE STUD/STUDHOLE REPAIR EVALUATION UNITS 2 AND 3

CR-9448-CSE92-1106, REV. 2

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The Safety-Related design information contained in this document has been verified to be correct by means of Design Review using Checklist(s) 9 of QAM-101.

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1.0 INTRODUCTION

The required stud thread engagement is determined for the SCE San Onofre Units 2 and 3 steam generator manway and handhole closures. The application of helicoil inserts for stud hole thread repair is established for these closures. Design conditions are evaluated in accordance with the requirements of the ASME Boiler and Pressure Vessel Code, Section III.

2.0 SUMMARY OF RESULTS

The stud minimum required thread engagement is 1.5" or 12 full threads for the primary manway, 1.25" or 10 full threads for the secondary manway and 1.25" or 10 full threads for the secondary handhole. When the helicoil inserts are installed, the stud minimum required thread engagement is greater than the above values

Application of the following helicoil inserts requires a larger diameter hole which meets the reinforcement requirements of the ASME Code.

> 1.5"-8 Pitch x 2.5" Nominal Length Helicoil Insert for Primary and Secondary Manways.
>
> 1.0"-8 Pitch x 1.5" Nominal Length Helicoil Insert for Secondary Handhole.

The shear stress in the threaded insert is less than the allowable stress for the maximum design stud load. It is concluded that the helicoil insert meets the ASME Code requirements and may be installed in any of the closure stud holes. Also, there is no limit on the number of helicoil inserts that can be installed in each enclosure.

No compatibility problems are known to exist with the use of a stainless steel helicoil insert installed with a low alloy steel stud and studhole for the manways and handhole. This statement applies to both corrosion and thermal expansion points of consideration.

3.0 REFERENCES

1. "Analytical Report for Southern California Edison San Onofre Unit No. 2 Steam Generator", CENC-1272, dated September, 1976.

2. "Analytical Report for Southern California Edison San Onofre Unit No. 3 Steam Generator", CENC-1298, dated September, 1977.

3. ASME Boiler and Pressure Vessel Code, Section III for Nuclear Vessels, 1971 Edition, and Addenda through Summer 1971.

4. Bulletin 913B, "Heli-coil 8-pitch Insert", Heli-Coil Products, A Black & Decker Company, Danbury, CT 06810.

5. Bulletin 1000, "Heli-Coil Screw Thread Inserts Inch Series Design and Production Manual", Heli-Coil Products, A Black & Decker Company, Danbury, CT 06810.

6. "Machine Design", by Shigley, J.E., McGraw-Hill Book Co., Inc., 1956.

4.0 ANALYSIS

From References 1 and 2, the following table summarizes the specifics for each closure opening using the worst case design conditions from Units 2 and 3 steam generators.

TABLE 4.1

Manway and Handhole Stud Details

Description	Primary Manway	Secondary Manway	Secondary Handhole
No. of Studs	20	16	10
Threads Specification	1 1/2-8N-2A	1 1/2-8N-2A	1-8UNC-2A
Stud Material	SA-540 B-24 CL.3	SA-540 B-24 CL.3	SA-193 B-7
S_m (stud) KSI	34.8	36.6	28.1
Base Material	SA-533 Gr.B CL.1	SA-508 CL.2	SA-508 CL.1
S_m (base) KSI	26.7	26.7	17.9
d (pitch dia.) in.	1.4188	1.4188	0.9188
F (preload/stud) kips	48.75	36.5	18.5
Design Temp. °F	650	560	560

4.1 Stud Thread Engagement

The average thread shear stress for the stud screw is given by the following formula:

$$\tau = \frac{2F}{\pi\, dh} \qquad \textit{Equation 1}$$

Rearranging this equation results in a formula for minimum length of thread engagement or:

$$h = \frac{2F}{\pi \, d\tau} \qquad \textit{Equation 2}$$

Where,

d = *Pitch Diameter, in.*

F = *Preload/Stud, kips*

$\tau = .6\ S_m$ *(Paragraph NB-3227.2 of References 3 for Pure Shear)*

S_m = *Design Stress Intensity for*

Internal Thread Material, KSI, i.e. Base Material in Table 4.1

Equation 1 or 2 is more conservative than the one in Reference 6, page 185, for average thread shearing stress of the internal thread material. This is due to the pitch diameter in equations 1 and 2 being less than the major diameter of the thread in the equation from Reference 6.

Substituting into equation 2 results in the following minimum thread length engagements for each closure opening using the design conditions in Table 4.1.

4.1.1 Primary Manway

$$h = \frac{2(48.75)}{\pi\ (1.4188)\ (.6 \times 26.7)} = 1.37\ in.$$

For primary manway stud use 1.5" minimum or 12 full threads.

4.1.2 Secondary Manway

$$h = \frac{2\ (36.5)}{\pi\ (1.4188)\ (.6 \times 26.7)} = 1.02\ in.$$

For secondary manway stud use 1.25" minimum or 10 full threads.

4.1.3 Secondary Handhole

$$h = \frac{2\ (18.5)}{\pi (0.9188)\ (.6 \times 17.9)} = 1.19\ in.$$

For secondary handhole stud use 1.25" minimum or 10 full threads.

4.2 Reinforcement with Helicoil Inserts

The manway and handhole reinforcement areas are calculated for the helicoil inserts in both Units 2 and 3 per Paragraph NB-3334 of Reference 3. Using the worst case closure openings from Units 2 and 3 steam generators, results in the following reinforcement areas.

4.2.1 Primary Manway

From page A-41 of Reference 2.

$$A_1 = 39.764 \ in.^2$$

$$A_2 = 8.327 \ in.^2$$

$$A_{STUDHOLE} = 3.125 \ (1.625) = 5.078 \ in.^2 \ (w/helicoilinsert)$$

$$A_{AVAILABLE} = A_1 + A_2 - A_{STUDHOLE}$$

$$= 39.764 + 8.327 - 5.078$$

$$= 43.013 \ in.^2 > A_{REQUIRED} = 31.906 \ in.^2$$

The reinforcement area requirement is met based on using a 1 1/2" helicoil insert with a tapped hole diameter of 1.625".

4.2.2 Secondary Manway

From page A-48 of Reference 2,

$$A_1 = 1.596 \ in.^2$$

$$A_2 = 31.562 \ in.^2 + Old \ Studhole \ (i.e. \ 4.5 \ in.^2) = 36.062 \ in.^2$$

$$A_3 = 10.370 \ in.^2$$

$$A_4 = 4.346 \ in.^2$$

$$A_{STUDHOLE} = 3.0 \ (1.625) = 4.875 \ in.^2 \ (w/helicoil \ insert)$$

$$A_{AVAILABLE} = A_1 + A_2 + A_3 + A_4 - A_{STUDHOLE}$$

$$= 1.596 + 36.062 + 10.370 + 4.346 - 4.875$$

$$= 47.499\ in.^2 > A_{REQUIRED} = 43.452\ in.^2$$

The reinforcement area requirement is met based on using a 1 1/2" helicoil insert with a tapped hole diameter of 1.625".

4.2.3 Secondary Handhole

From page A-55 of Reference 2,

$$A_1 = 0.0171\ in.^2$$

$$A_2 = 12.831\ in.^2 + Old\ Studhole\ (i.e.\ 2.25\ in.^2) = 15.081\ in.^2$$

$$A_3 = 2.641\ in.^2$$

$$A_4 = 1.551\ in.^2$$

$$A_{STUDHOLE} = 2.25\ (1.125) = 2.531\ in.^2$$

$$A_{AVAILABLE} = A_1 + A_2 + A_3 + A_4 - A_{STUDHOLE}$$

$$= 0.0171 + 15.081 + 2.641 + 1.551 - 2.531$$

$$= 16.759\ in.^2 > A_{REQUIRED} = 15.328\ in.^2$$

The reinforcement area requirement is met based on using a 1" helicoil insert with a tapped hole diameter of 1.125".

4.3 Shear Strength of Helicoil/Stud Arrangement

The helicoil specifications are as follows:

Material: SA-479, Type 304 or 302 (Reference 5)

S_m: 16.8 ksi @ 560 °F (Table I-1.2 of Reference 3)
16.2 ksi @ 650 °F (Table I-1.2 of Reference 3)

Size: 1 1/2"-8N x 2 1/2" engagement (Reference 4)
1"-8N x 1 1/2" engagement (Reference 5)

The tensile stress area of the stud design, A, is based on the thread root or section of least diameter, d_m, and is given by the following formula:

$$A = \frac{\pi\ d_m^2}{4} \qquad Equation\ 3$$

The maximum design stud load, F, is:

$$F = A \times S_m\ (for\ stud\ material) \qquad Equation\ 4$$

The shear stress in the helicoil, τ, is:

$$\tau = \frac{2F}{\pi\ dh_m} \qquad Equation\ 5$$

Where,

d = Pitch Diameter of Threads

h_m = Minimum Thread Engagement of Helicoil

Equation 5 is the same as Equation 1 and is also more conservative than the one in Reference 6, page 185, for reasons previously mentioned.

Substituting into Equations 3, 4 and 5, results in the following helicoil shear stresses for the respective closure opening.

4.3.1 Primary Manway

Tensile Stress Area

$$A = \frac{\pi\ (1.31)^2}{4} = 1.348\ in.^2$$

Maximum Design Stud Load at 650 °F

$$F = (1.348)(34.8) = 46.91 \text{ kips}$$

Shear Stress in Helicoil

$$\tau = \frac{2(46.91)}{\pi\ (1.4188)\ (2.25)}$$

Where:

$d = 1.4188"$
$h_m = 2.25"$ (Reference 5 for 1 1/2" Helicoil Insert)

Use 1 1/2-8 x 2.25" long insert with 18 minimum free* coils.

*Free coils are counted 90° from the tang in the uninstalled (free) condition (Reference 4).

$$\tau = 9.35\ ksi < .6S_m^* \text{ or } .6\ (16.2) = 9.72\ ksi$$

*Per paragraph NB-3227.2 of Reference 3 for Pure Shear

The shear stress allowable is satisfied for the Maximum Design Stud Load.

4.3.2 Secondary Manway

Tensile Stress Area

$$A = \frac{\pi\ (1.31)^2}{4} = 1.348\ in.^2$$

Maximum Design Stud Load at 560 °F

$$F = (1.348)\ (36.6) = 49.34\ kips$$

Shear Stress in Helicoil

$$\tau = \frac{2(49.34)}{\pi\ (1.4188)\ (2.25)}$$

Where;

$d = 1.4188"$

$h_m = 2.25"$ (Reference 5 for 1 1/2" Helicoil Insert)

Use 1 1/2-8 x 2.5" long insert with 18 minimum free* coils

*Free coils are counted 90° from the tang in the uninstalled (free) condition (Reference 4).

$$\tau = 9.84\ ksi < .6\ S_m\ or\ .6(16.8) = 10.08\ ksi$$

The shear stress allowable is satisfied for the Maximum Design Stud Load.

4.3.3 Secondary Handhole

Tensile Stress Area

$$A = \frac{\pi\ (.8375)^2}{4} = 0.551\ in.^2$$

Maximum Design Stud Load at 560 °F

$$F = (0.551)\ (28.1) = 15.48\ kips$$

Shear Stress in Helicoil

$$\tau = \frac{2(15.48)}{\pi(0.9188)\ (1.5)}$$

Where;

d = 0.9188"

h_m = 1.50" (Reference 5 for 1" Helicoil Insert)

Use 1"-8 x 1.5" long insert with 10.2 minimum free* coil

> *Free coils are counted 90° from the tang in the uninstalled (free) condition (Reference 5).

$$\tau = 7.15\ ksi < .6S_m\ or\ .6\ (16.8) = 10.08\ ksi$$

The shear stress allowable is satisfied for the Maximum Design Stud Load.

4.4 Compatibility of Stud/Helicoil/Manway/Handhole Materials

The helicoil material is stainless steel, type 304 or 302 with an ASME designation of SA-479. The stud is a high strength low alloy steel bolting material either in SA-540, B-24, CL-3 or SA-193, B-7 designation. The manway/handhole studhole is also low alloy steel material in either SA-533, Gr B, CL-1; SA-508, CL-2; or SA-508, CL-1 designation.

The heli-coil insert is manufactured from a corrosion resistant alloy (stainless steel). This alloy will not degrade from corrosion in the reactor containment environment as long as the material does not come in contact with known chemicals (chlorides, etc.) that can potentially initiate a corrosion mechanism.

The presence of stainless steel installed in a bolted joint with low alloy steel will not increase the propensity for corrosion of low alloy in this particular environment.

From a thermal expansion standpoint, only the primary manway opening was examined, since the application of the nominal coefficients of thermal expansion to its respective dimensions would give the most conservative results.

From Table I-5.0 of Reference 3, Table 4.2 lists the properties for the respective primary manway materials.

TABLE 4.2

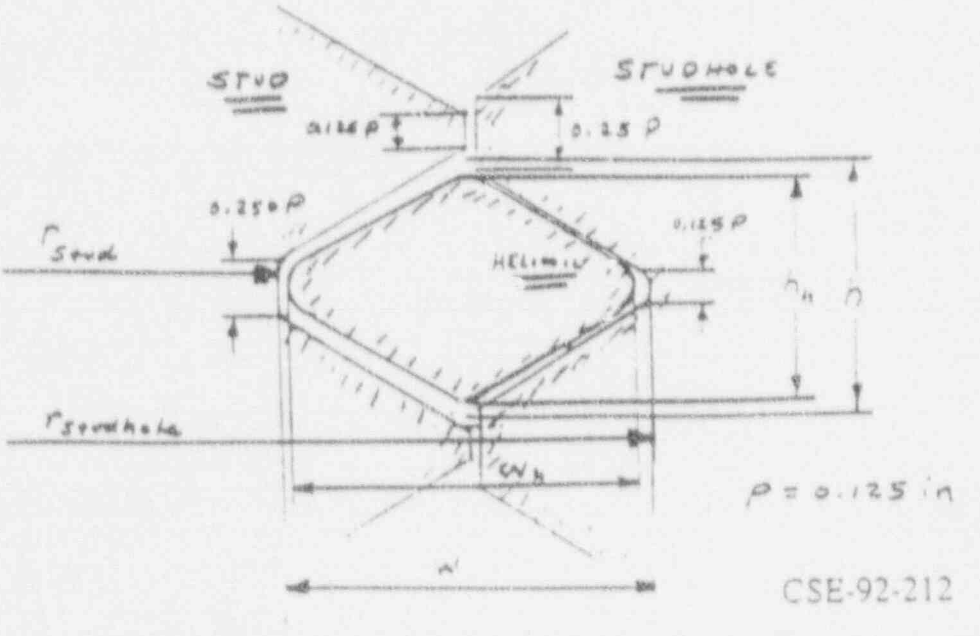
Thermal Expansion Coefficients for Primary Manway

Description	Material	Mean Coefficient of Thermal Expansion α (10^{-6} in/in/°F)	Expansion Rate @ 650°F (in/in) ($\alpha \times (650-70)$)
Stud	SA-540, B-24, CL-3	7.41	0.004298
Helicoil Insert	SA-479, Type 302 or 304	9.61	0.005574
Studhole	SA-533, Gr B, CL-1	7.90	0.004582

Figure 4.1 shows a cross-section view of the stud/helicoil insert/studhole material arrangement with the applicable "worst case" dimensions.

FIGURE 4.1

Cross-Sectional View



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From the above figure, the following dimensions at room temperature, 70 °F, are:

$r_{stud} = 0.6733$ in. (max.)
$r_{base} = 0.8125$ in. (min.)
$w = r_{base} - r_{stud} = 0.1392$ in. (min.)
$h_{min} = .750\ p = .750(.125) = 0.0938$ in. (min.)
$w_h = 0.115$ in.*
$h_h = 0.092$ in.*

Since the dimensions on the cross-sectional view of the helicoil insert are 0.092 in. by 0.115 in., there is clearance between the helicoil insert and the stud and studhole thread surfaces at room temperature, 70 °F. When the arrangement in Figure 4.1 is increased in temperature to 650 °F, all the surfaces expand. The new dimensions at 650 °F are:

$$r'_{stud} = 0.6733\ (1.004298) = 0.6762\ in.\ \text{(max.)}$$

$$r'_{base} = 0.8125\ (1-.004582) = 0.8088\ in.\ \text{(min.)}$$

$$w' = r'_{base} - r'_{stud} = 0.1326\ in.\ \text{(min.)}$$

$$h'_{min} = 0.0938(1 - \frac{.004582 + .004298}{2}) = 0.0934\ in.\ \text{(min.)}$$

$$w_h = 0.115(1.005574) = 0.1156\ in. < 0.1326\ in = w'_{min}$$

$$h_h = 0.092(1.005574) = 0.0925\ in. < 0.0934\ in = h'_{min}$$

At 650 °F, there is still clearance between the helicoil insert and the stud and studhole thread surfaces. Therefore, no structural problem is present with the thermal expansion of the different materials.

*Actual as-measured values from a typical helicoil (1.5" size).