ATTACHMENT 2
STRUCTURAL PACKAGE EVALUATION

(1) ST-452, Structural Evaluation of the D.C. Cook Unit 1 SGLA Closures

PROPERTY OF DURATEK INC. AND ITS SUBSIDIARIES

DESIGN DOCUMENT COVER SHEET

DOCUMENT ID NUMBER: ST-452 REVISION NUMBER: 0

PROJECT NUMBER: 163033.0000.50

SECURITY STATUS: PROPRIETARY: ____ NON-PROPRIETARY: X

RETENTION PERIOD: Life of the Project + 1 Year

TITLE: **Structural Evaluation of the D.C. Cook Unit 1 SGLA Closures**

PREPARED BY: Paul Donha DATE: 11-17-2003

TITLE: Principal Engineer

REVIEWED BY: M Hambley DATE: 11/20/03

TITLE: Chief Engineer

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DESIGN DOCUMENT REVIEW CHECKLIST

Document ID No.: ST-452 Revision No.: 0

Date: 11/20/03

	ITEM	YES	N/A*
1.	The purpose or objective is clear and consistent with the analysis.	√	
2.	Design Inputs such as design bases, regulatory requirements, codes, and standards are identified and documented.	√	
3.	Effect of design package on compliance with the Safety Analysis Report or Certificate of Compliance identified and documented.		√
4.	References are complete and accurate.	√	
5.	Latest version of the drawings is used, and the revision numbers are correct on the list of drawings.	√	
6.	Assumptions are reasonable, and the list of assumptions is complete and appropriate.		√
7.	Assumptions that must be verified as the design proceeds have appropriately identified.		√
8.	Analysis methodology is appropriate, and correct analysis method used.	√	
9.	Correct values used from drawings?	√	
10.	Answers and units correct?	√	
11.	Summary of results matches calculations?	√	
12.	Material properties properly taken from credible references?	√	
13.	Figures match design drawings?	√	
14.	Computer input complete and properly identified?		√
15.	Conclusions are consistent with the analysis results.	√	
16.	Documentation of all hand calculations attached?	√	
17.	Meeting minutes of the Design Review?		√

* Not Applicable, Explain

3. There is no Safety Analysis Report or Certificate of Compliance for this equipment.
6. No major assumptions that needed verification were made.
7. This document presents the evaluation of the final design.
14. No computer code is used.
17. No design review meeting is needed for this equipment.

Independent Reviewer

PROPERTY OF DURATEK INC. AND ITS SUBSIDIARIES

DESIGN DOCUMENT REVIEW METHOD CHECKLIST

Document ID No.: ST-452 Revision No.: 0

Date: 11/20/03

	ITEM	
1.	Alternate or simplified computational method.	
2.	Comparison of results to other calculations of a similar nature.	
3.	Numerical repetition of the calculations.	√
4.	Comparison of calculations with experimental results.	
5.	Other (specify)	
6.	Comments:	

Independent Reviewer Hasan Baig

Title	Structural Evaluation of the D.C. Cook Unit 1 SGLA Closures		
Calc. No. ST-452	Rev. 0	Sheet 1	of 12

OBJECTIVE

Structural evaluation of the D.C. Cook Unit 1 steam generator lower assembly (SGLA) closure to demonstrate that they will maintain their integrity during transportation.

INTRODUCTION

American Electric Power (AEP) Company has replaced the Donald C. Cook Nuclear Plant (CNP) Unit 1 four steam generators (Reference 1) in the year 2000. The steam dome portions of the old steam generators have been cut (Figure 1). The steam generator lower assembly (SGLA) packages are currently stored on site and will be transported to Barnwell South Carolina for disposal. These packages have been classified as SCO-II under 49 CFR Part 173 (Reference 2). Per 49 CFR 173.427, the SCO-II class materials are required to be shipped using IP-2 packages. Because of the unique size and shape of the SGLA, and controlled handling process during the transportation, an exemption from packaging requirement is requested from the DOT (Reference 3). A detailed handling and shipment plan is developed and will be adhered to during the transportation of these assemblies. The ability of this plan to provide an equivalent safety as that of an SCO-II object shipped in an IP-2 package forms the basis of this exemption request.

The SGLAs have several openings that will be welded shut for the transportation. These openings and their circumferential locations are listed in Table 1. The details of the closure of these openings are shown in Reference 4, and Figures 2 to 4 of this document. The cut end of the steam generator will be closed using a 3" thick end plate that will be welded to the body using welds shown in Figure 4. Figure 1 of this document shows the location of openings that were listed in Table 1 as well as the openings that are closed with their original covers (manways and handholes).

Evaluations are provided in this document that show that all the closures of the SGLAs have sufficient structural strength to maintain their integrity under the loading expected during the road and railroad transportation of the SGLAs per References 5 and 6.

REFERENCES

(1) Westinghouse Electric Corporation Drawing No. 1097J74, Rev.4, "51 Series Steam Generator General."

(2) Code of Federal Regulations, Title 49, Part 173.

(3) U.S. DOT exemption issued to Indiana Michigan Power for the transportation of the D.C. Cook Unit 1 SGLAs from D.C. Cook to the Chem-Nuclear disposal site (pending).

(4) Bechtel Drawing No. 23733-M-003, Rev.1, "Steam Generator Lower Assembly Cover Plates and Seal Plugs."

(5) Code of Federal Regulations, Title 49, Part 393.100.

(6) AAR Manual, Rev.9, Section No.1, General Rules, 1993.

(7) AISC, *Steel Construction Manual*, Ninth Edition.

(8) Duratek drawing C-068-163033-001, Rev 0, "D.C. Cook Unit 1 SGLA General Arrangement."

MATERIAL PROPERTIES

Shells

Specification: ASME SA-533 Type A, Class 1

Minimum Yield Strength, S_y = 50,000 psi

Minimum Ultimate Strength, S_u = 80,000 psi

Caps and Plugs

Specification: ASTM A-36

Minimum Yield Strength, S_y = 36,000 psi

Minimum Ultimate Strength, S_u = 58,000 psi

Welds

Rod Specification: E-70xx Electrodes

Minimum Ultimate Strength, S_u = 70,000 psi

ALLOWABLE STRESSES

Stresses in the caps and plugs and the welds are conservatively based on the AISC (Reference 7) allowable values for A-36 material.

Caps and Plugs

Allowable bending stress	= 0.66 S_y	= 24,000 psi
Allowable shear stress	= 0.4 S_y	= 14,400 psi

Welds

Allowable shear stress in fillet welds	= 0.3 S_u	= 21,000 psi

EVALUATION OF THE CLOSURES

The closures of the SGLAs are evaluated for the largest acceleration that they may experience during the road and rail transportation per References 5 and 6. Of the two modes of transportation, the largest acceleration on the SGLAs occurs during the rail transportation. According to the requirements of the AAR Manual (Reference 6) the largest acceleration experienced by the SGLAs is 3g in the longitudinal direction. Conservatively, 3g acceleration is assumed to occur in all directions and the closures are analyzed for this loading.

Primary (Main) Inlet & Outlet Nozzle Closures (Reference 4, Detail 2)

The primary (main) inlet and outlet nozzle closures are shown in Figure 2. The closure plates are 3" thick and have a diameter of 35 inch. The weight of the closure plate is:

$W = \pi/4 \times 35^2 \times 3 \times 0.283 = 817$ lbs

The maximum bending moment in the closure plate is:

$M_c = q \times a^2 \times (3+\nu)/16$

Where,

q = uniformly distributed load intensity for 3g acceleration

$q = 3 \times 817/(\pi/4 \times 35^2) = 2.55$ psi

a = radius of the plate = 35/2 = 17.5 in

Therefore,

$M_c = 2.55 \times 17.5^2 \times 3.3/16 = 161$ in-lb/in

The maximum bending stress in the plate is:

$\sigma_b = 6 \times M_c/t^2$

Where,

t = plate thickness = 3"

Therefore,

$\sigma_b = 6 \times 161/3^2 = 107$ psi $<<$ 24,000 psi O.K.

The closure plates are held by four 5/16" fillet welds 2" long (Reference 4). The remainder of the circumference of the plate is seal welded. Taking no credit for the seal weld, the shear stress in the fillet weld is:

$\tau_v = 3\times817/(4\times2\times0.707\times5/16) = 1{,}387$ psi

Considering the inertia load to act at the C.G. of the plate, the bending moment on the weld group is:

$M = 3\times817\times1.5 = 3{,}677$ in-lb

Conservatively consider only two of the four welds to calculate the section modulus of the weld group. Also assume these welds to be located at location diametrically opposite each other. The section modulus for the weld group consisting of two 5/16" fillet welds, 2" long and 35" apart about the axis parallel to the weld length is:

$S = 2\times35\times0.707\times0.3125 = 15.47$ in^3

Therefore, the shear stress in the weld group due to bending moment,

$\tau_b = 3{,}677/15.47 = 238$ psi

Total shear stress, $\tau = 1{,}387 + 238 = 1{,}625$ psi $<< 21{,}000$ psi O.K.

Manway Closures

The primary manways are closed with the original covers. These manways have a 16-inch inside diameter; the covers are 4.60 inches thick and are 26.75 inches in diameter (Per the Figure 1-1 outline drawing listed in Reference 8). Then, the manway cover weight (W_m) is:

$W_m = (\pi/4)\times26.75^2\times4.60\times(1/12)^3\times490 = 733$ lbs, say 1,000 lbs to account for the insert

Under 3g load the manway cover will be loaded by a uniform pressure of,

$q = (3\times1{,}000)/[(\pi/4)\times16^2] = 14.9$ psi

The primary side of these steam generators is designed for 2,485-psig internal pressure and is hydro tested to 3,106-psig (Per the Figure 1-1 outline drawing listed in Reference 8). Under these pressures the manways remain closed and sealed. Therefore, under the small 14.9 psi transport loading the manways will remain intact.

Handhole Closures

The secondary handholes are closed with the original covers. These covers are fitted over 6" diameter nozzles, each cover is 11.62 inches in diameter and is 1.60 inches thick (Per the Figure 1-1 outline drawing listed in Reference 8).

Then, the handhole cover weight (W_h) is:

$W_h = (\pi/4)\times11.62^2\times1.60\times(1/12)^3\times490 = 48$ lbs, say 80 lbs

Under 3g load they will be loaded by a uniform pressure of,

$q = 3\times80/(\pi/4\times6^2) = 8.5$ psi

This pressure is even smaller than that of the manways shown above and therefore by the same justification the handholes will remain intact during transportation.

Bottom Blow-Down, Shell Drain and Wide Range Water Level Tap Nozzle Closures (Reference 4, Detail 3)

The bottom blow-down, shell drain and wide range water level tap nozzle closures are closed using plugs, as shown in Reference 4. The schedule of the plugs used for the closure of these openings is also given in Figure 3 of this document.

Per Reference 4 drawing, all plugs are welded in place using continuous seal weld all around the plug. For the evaluation purposes, this document considers a 1/8" continuous fillet weld all around. Conservatively using the largest plug diameter (1.6875") and a plug length of 3 ¼" to calculate the maximum plug weight. The maximum plug weight (W) is:

$W = (\pi/4) \times 1.6875^2 \times 3.25 \times 0.284 = 2.1$ lbs say 5 lbs

Calculating the weld shear stress using the smallest plug diameter, the weld shear stress (τ) is:

$\tau = 3\times5/(\pi\times0.57375\times0.707\times0.125) = 94.2$ psi $<<$ 21,000 psi O.K.

End Closure (Reference 4, Detail 1)

The end closure of the SGLA is made from a 3" thick by 167.75" diameter cover plate. The closure assembly is shown in Figure 4. The weight of the cover plate is:

$W = (\pi/4)\times167.75^2\times3\times0.284 = 18{,}830$ lbs

The maximum bending moment in the closure plate is:

$M_c = q\times a^2\times(3+\nu)/16$

Where,

q = uniformly distributed load intensity for 3g acceleration

$q = (3\times18{,}830)/[(\pi/4)\times167.75^2] = 2.56$ psi

a = radius of the plate = 167.75/2 = 83.875 in

Therefore,

$M_c = 2.56\times83.875^2\times3.3/16 = 3{,}715$ in-lb/in

The maximum bending stress (σ_b) in the plate is:

$\sigma_b = 6 \times M_c / t^2$

Where,

t = plate thickness = 3"

Therefore,

$\sigma_b = 6 \times 3{,}715 / 3^2 = 2{,}477$ psi $<< 24{,}000$ psi O.K.

As shown in Figure 4, the maximum steam generator diameter (outside diameter at the transition cone) is 171.75 inches that exceeds the desired 168 inches (14'-0"). To allow for a 14'-0" maximum width, the transition cone will have to be trimmed. The 3" cover plate is held in place by six segments of ½" fillet welds, 4" long each, and the remainder of the circumference of the plate is seal welded (Reference 4). The worst-case orientation for the load carrying ½" intermittent fillet welds is shown in Figure 4. At this particular orientation, the two 4" long segments of the ½" fillet weld located at 90° and 270° (as shown in Figure 4) may also be removed with portions of the transition cone shell. The weld evaluation presented herein ignores any contribution from these two weld segments and assumes credit only for the other four segments to withstand the transportation loading. Taking no credit for the seal weld, the shear stress (τ_v) in the fillet weld due to the shear load is:

$\tau_v = 3 \times 18{,}830 / (4 \times 4 \times 0.707 \times 0.5) = 9{,}988$ psi

Considering the inertia load to act at the C.G. of the plate, the bending moment on the weld group is:

$M = 3 \times 18{,}830 \times 1.5 = 84{,}735$ in-lb

Consider only four of the six welds to calculate the section modulus of the weld group. Also assume these welds to be located at 60° from the horizontal axis as shown in Figure 4. The minimum section modulus of the weld group is about the vertical, 0°-180°, axis of Figure 4, and it is:

$S = 4 \times 4 \times 0.707 \times 0.5 \times (83.875 \times \text{Cos } 60°)^2 / (2 \times 83.875 \times \text{Cos } 60°) = 118.60$ in^3

Therefore, the shear stress (τ_b) in the weld group due to bending moment,

$\tau_b = 84{,}735 / 118.60 = 715$ psi

Total shear stress, $\tau = \tau_v + \tau_b = 9{,}988 + 715 = 10{,}703$ psi $< 21{,}000$ psi O.K

CONCLUSIONS

It has been shown in this report that all the closures of the SGLA have adequate strength to react to the load normally expected during its transportation by road or rail (per References 5 and 6). The stress allowables based on the AISC criteria are satisfied by all the components of the closure assembly with an acceptable margin of safety. The SGLAs will, therefore, remain completely sealed and behave like a unitized body during transportation. An exemption from packaging the SGLAs during transportation has, therefore, been requested from the DOT.

Table 1: Location of the Welded Shut Protrusions on the D.C. Cook Unit 1 SGLA

Protrusion	Circumferential Location from the Top (Degrees), Figure 1
Primary Nozzle (Main) - Inlet	36.5
Primary Nozzle (Main) - Outlet	143.5
Bottom Blow-Down (Nozzle No.1)	90
Bottom Blow-Down (Nozzle No.2)	270
Shell Drain	206.5
Wide Range Water Level Tap	126.5
End Plate (Transition Cone Cover Plate)	- (1)

Note:

(1) 3" End-plate is used to close the cut end of the SGLA.

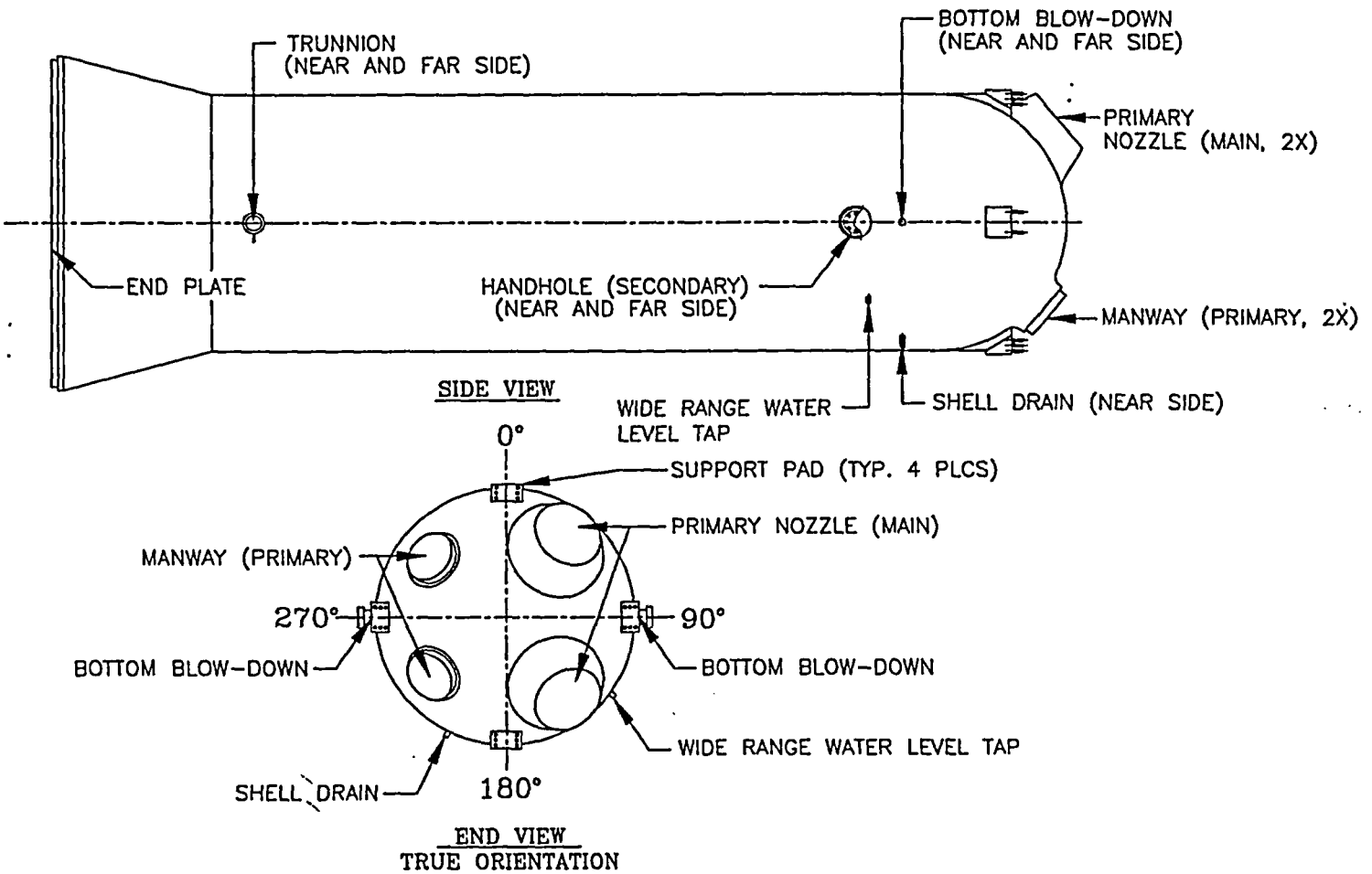


Figure 1: DC Cook Unit 1 SGLA Protrusion Location

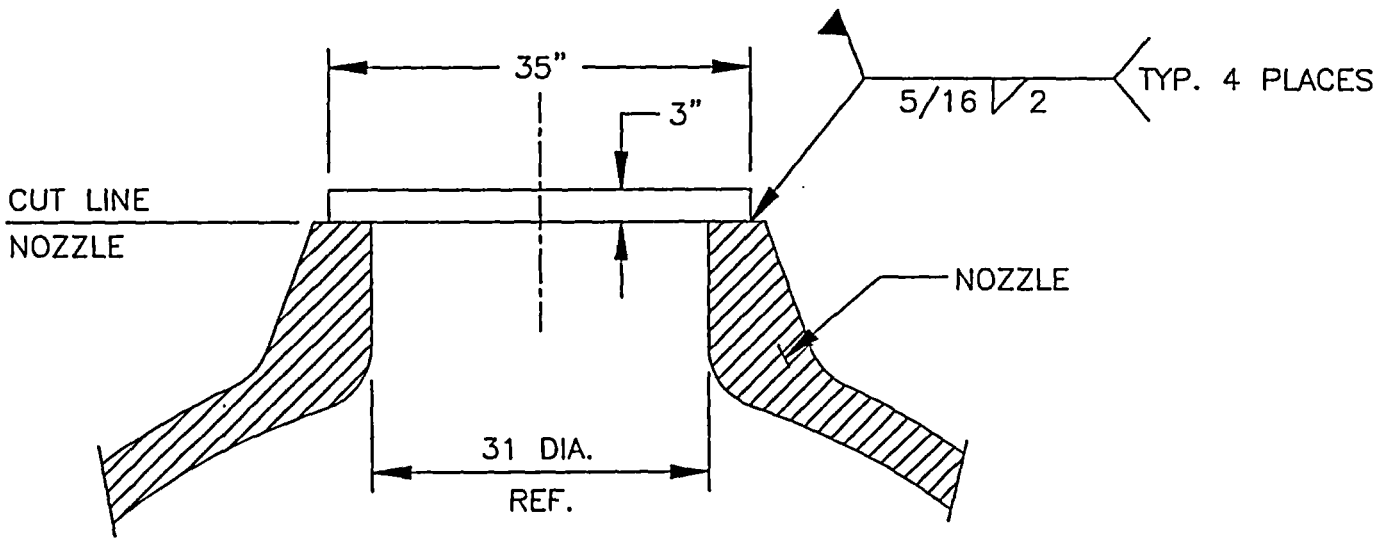
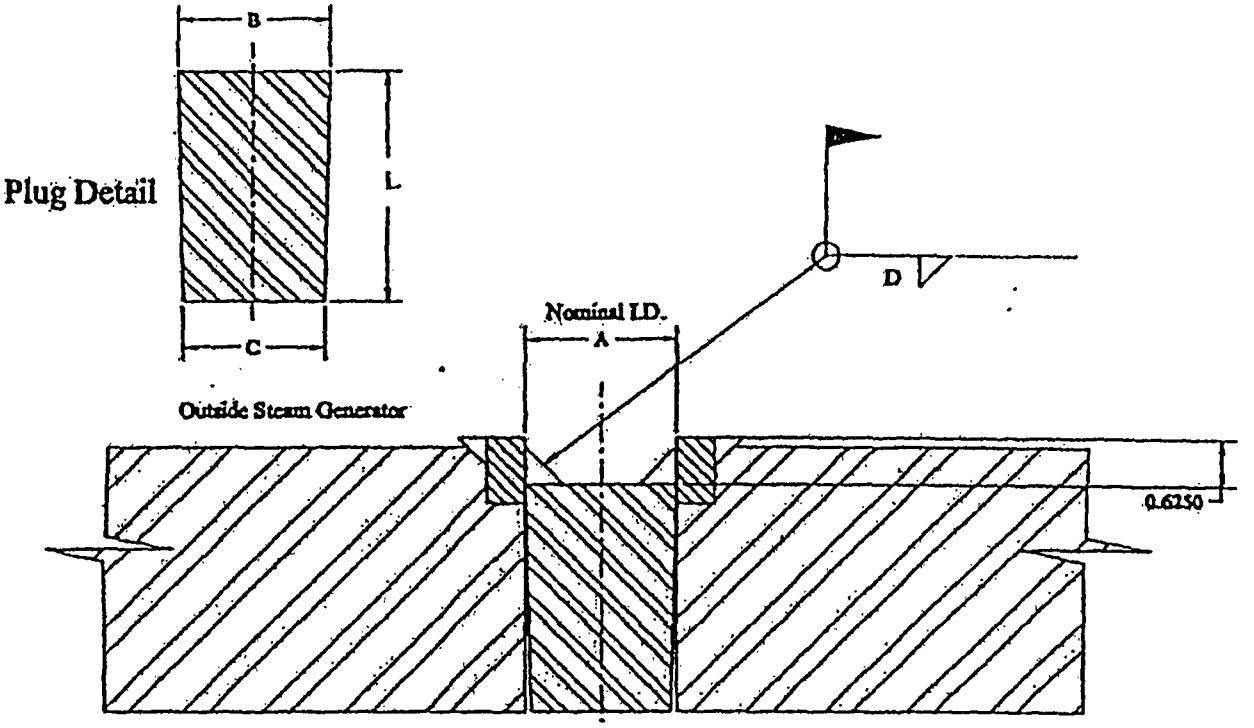


Figure 2: Primary Nozzle (Main) - Inlet/Outlet Closure Details



PLUG SCHEDULE						
Closure Description	Qty Per S.G.	"A" Nominal I.D.	Plug Dimension			Weld
			Maximum Plug Dia.	Minimum Plug Dia.	Maximum Plug Length	
			"B"	"C"	"L"	"D"
Bottom Blow-Down Nozzle	2	1 23/32"	1.6875"	1.6675"	3 ¼"	1/8"
Shell Drain	1	1"	0.8125"	0.7925"	3 ¼"	1/8"
Wide Range Water Level Tap	1	¾"	0.59375"	0.57375"	3 ¼"	1/8"

Figure 3: Small Nozzle Closure Using Plugs

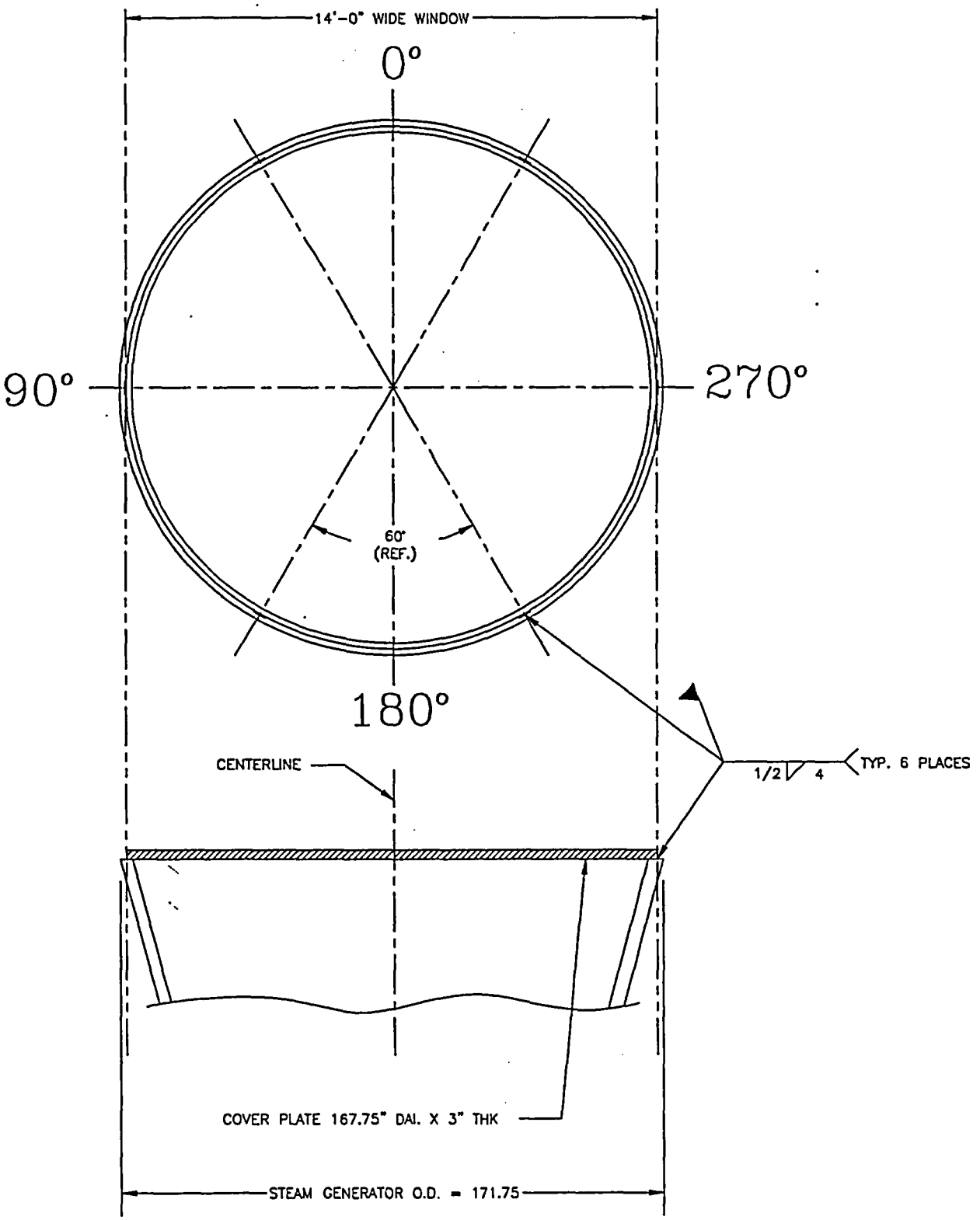


Figure 4: SGLA End Closure Details

ATTACHMENT 3
SGLA GENERAL ARRANGEMENT
AND
CLOSURE DRAWINGS

(1) Westinghouse Drawing, (1097J74) "General Arrangement"

(2) "Figure 1-1 Outline from Westinghouse Electric Co Steam Generator Manual for D.C. Cook" – 2 Pages

(3) Bechtel Drawing, 23733-M-003 Rev 1 – "Steam Generator Lower Assembly Cover Plates and Seal Plugs"

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ATTACHMENT 4
TRANSPORTATION SYSTEM GENERAL ARRANGEMENTS DRAWINGS

(1) Duratek Drawing, C-068-163033-001 Rev 0, "D. C. Cook Unit 1 SGLA General Arrangement"

(2) Duratek Drawing, C-068-163033-010 Rev 0, "D.C. Cook Unit 1 SGLA Road Transportation General Arrangement"

(3) Duratek Drawing, C-068-163033-020 Rev 0, "D.C. Cook Unit 1 SGLA Rail Transportation General Arrangement"