CHEM-NUCLEAR SYSTEMS, LLC.
140 STONERIDGE DRIVE
COLUMBIA, S.C. 29210

DESIGN DOCUMENT COVER SHEET

DOCUMENT ID NUMBER: ST-307 REVISION NUMBER: 0

PROJECT NUMBER: 46628

SECURITY STATUS: PROPRIETARY____ NON-PROPRIETARY x

PERIOD: Life of the Project + 1 year

TITLE: Structural Evaluation of the D.C. Cook Unit 2 SGLA Package

PREPARED BY: [signature] DATE: 8/19/98

TITLE: Principal Engineer

REVIEWED BY: Paul Dandler [signature] DATE: 8/20/98

TITLE: Senior Project Engineer

REVISION NOTES: CONTROLLED COPY NO. 3242

INFORMATION ONLY

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DESIGN DOCUMENT REVIEW CHECKLIST

Design Package Identification No ST-307

Date 8/19/98 Revision No. 0

ITEM	YES	N/A*
1.A Design Inputs such as design bases, regulatory requirements, codes, and standards are identified and documented.	✓	
1.B Effect of design package on compliance with the Safety Analysis Report or Certificate of Compliance identified and documented.		✓
2. Revision numbers correct on the list of drawings?	✓	
3. Assumptions reasonable?	✓	
4. Appropriate analysis method used?	✓	
5. Correct values used from drawings?	✓	
6. Answers and units correct?	✓	
7. Summary of results matches calculations?		✓
8. Material properties properly taken from credible references?	✓	
9. Figures match design drawings?	✓	
10. Computer input complete and properly identified?		✓
11. Documentation of all hand calculations attached?	✓	
12. Meeting minutes of the Design Review?		✓

* Not Applicable, Explain

1.B There is no SAR or Certificate of Compliance for this equipment.

7. Results are not summarized.

10. No computer analysis performed.

12. No design review meeting needed.

Independent Reviewer [signature]

OBJECTIVE

Structural evaluation of the D.C. Cook steam generator lower assembly (SGLA) package to demonstrate that its closures provide sufficient strength to maintain their integrity during the transportation.

INTRODUCTION

American Electric Power (AEP) company has replaced the steam generators at their D.C. Cook Unit 2 facility. The steam dome portions of the old steam generators (OSGs) (Reference 1) have been cut. The steam generator lower assembly (SGLA) packages 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. 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 and IP-2 package forms the basis of this exemption request.

The SGLAs have several openings that have been welded shut for the transportation. These openings and their circumferential locations are listed in Table 1 and are shown in Figure 1. The details of the closure of these openings are shown in Reference 3. The cut end of the steam generators were closed using 3" thick end-plates that are welded to the body using 3/8" fillet welds. These welds were made according to AEP work plan but lack the quality assurance documentation. Therefore, additional attachment is provided by specially designed clips that are welded to the steam generator body and the endplate. Details of these clips are provided in Reference 4.

Evaluations are provided in this document that show that all the closures of the SGLA have sufficient structural strength to maintain their integrity under the loading expected during the transportation.

REFERENCES

(1) CNS Drawing No. C-110-B-46628-001, Rev.1, *D.C. Cook Unit 2, Steam Generator General Layout.*

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

(3) CNS Drawing No. C-110-B-46628-004, Rev.1, *D.C. Cook Unit 2, Steam Generator Containment Details.*

(4) CNS Drawing No. C-110-B-46628-003, Rev.1, *D.C. Cook Unit 2, Steam Generator Shear Key and Shield Plate Tie-Bar.*

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

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

MATERIAL PROPERTIES

Shells

Specification: ASME SA-516 Gr 70

Minimum Yield Strength, S_y = 38,000 psi

Minimum Ultimate Strength, S_u = 70,000 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 5) allowable values.

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 steam generator package are evaluated for the largest acceleration the package may experience during the transportation. The largest acceleration that the SGLA would experience during the entire process of shipping and handling is during the rail transportation. According to the general rules of AAR (Reference 6), these accelerations are 3g in the longitudinal direction, 2g in the lateral direction, and 2g in the vertical direction. Conservatively,

3g acceleration is assumed to occur in all directions and the closures are analyzed for this loading. It is also assumed that the mass of the components used for closing the opening during storage - plates, manways, handholes lid, etc. - apply the inertia loading to the closures.

Primary Inlet & Outlet Nozzle Closures

The primary inlet and outlet nozzle closures (Figure2) are made of two items:

Item - 1: 50.5 in Dia × ¼ in thick plate. Its weight is,

$$W_a = (\pi/4)\times 50.5^2\times 0.25\times (1/12)^3\times 490 = 142 \text{ lbs}$$

Item - 2: 50.5 in Dia × ¼ in thick × 26 in long shell. It weight is,

$$W_b = \pi\times 50.5\times 0.25\times 26\times (1/12)^3\times 490 = 293 \text{ lbs}$$

Total closure weight = 142 + 293 = 435 say 450 lbs

Conservatively assume that the coverplate has a dia of 50.5 in and thickness of 2.5 in. Then, the coverplate weight,

$$W_c = (\pi/4)\times 50.5^2\times 2.5\times (1/12)^3\times 490 = 1{,}420 \text{ lbs, say } 1{,}500 \text{ lbs}$$

The inertia load in a direction normal to the ¼ in plate will be reacted by the edge shear. The shear stress in the plate is:

$$\tau = 3\times(450+1{,}500)/(\pi\times 50.5\times 0.25) = 148 \text{ psi} \ll 14{,}400 \text{ psi}$$

The plate is welded to the shell with a full penetration weld which will have strength equal to or larger than the base metal. The welds between the shell and the nozzle are 3/16" fillet which will develop a shear stress,

$$\tau_{weld} = 3\times(450+1{,}500)/(\pi\times 50.5\times 0.707\times 3/16) = 278 \text{ psi} \ll 21{,}000 \text{ psi}$$

The inertia load in the plane of the coverplate, will cause bending and shear load at the base of the shell. Conservatively assuming that the entire mass is located at the end of the shell, the bending moment at the base of the shell is:

$$M = 3\times(450+1{,}500)\times 26 = 152{,}100 \text{ in-lb}$$

Bending stress in the shell,

$$\sigma_{bending} = 152{,}100/[\pi\times(50.5/2)^2\times 0.25] = 304 \text{ psi} \ll 24{,}000 \text{ psi}$$

Shear stress in the shell,

$$\tau = 3\times(450+1{,}500)/(\pi\times 50.5\times 0.25) = 147 \text{ psi} \ll 14{,}400 \text{ psi}$$

Shear stress in the weld caused by bending moment,

$$\tau_{bending} = 152,100/[\pi\times(50.5/2)^2\times0.707\times3/16] = 573 \text{ psi}$$

Shear stress in the caused by the shear force,

$$\tau_{shear} = 3\times(450+1,500)/(\pi\times50.5\times0.707\times3/16) = 278 \text{ psi}$$

Combined shear stress,

$$\tau = 573 + 278 = 851 \text{ psi} < 21,000 \text{ psi}$$

Manway Closures

The manway closures (Figure 3) are made of two items:

Item - 1: 28 in Dia × ¼ in thick plate. Its weight is,

$$W_a = (\pi/4)\times28^2\times0.25\times(1/12)^3\times490 = 44 \text{ lbs}$$

Item - 2: 28 in Dia × ¼ in thick × 6.5 in long shell. It weight is,

$$W_b = \pi\times28\times0.25\times6.5\times(1/12)^3\times490 = 41 \text{ lbs}$$

Total closure weight = 44 + 41 = 85 say 100 lbs

Conservatively assume that the manway has a dia of 28 in and thickness of 6.5 in. Then, the manway weight,

$$W_m = (\pi/4)\times28^2\times6.5\times(1/12)^3\times490 = 1,135 \text{ lbs, say } 1,200 \text{ lbs}$$

The inertia load in a direction normal to the ¼ in plate will be reacted by the edge shear. The shear stress in the plate is:

$$\tau = 3\times(100+1,200)/(\pi\times28\times0.25) = 177 \text{ psi} \ll 14,400 \text{ psi}$$

The plate is welded to the shell with a full penetration weld which will have strength equal to or larger than the base metal. The welds between the shell and the nozzle are ¼ in fillet which will develop a shear stress,

$$\tau_{weld} = 3\times(100+1,200)/(\pi\times28\times0.707\times1/4) = 251 \text{ psi} \ll 21,000 \text{ psi}$$

The inertia load in the plane of the coverplate, will cause bending and shear load at the base of the shell. Conservatively assuming that the entire mass is located at the end of the shell, the bending moment at the base of the shell is:

$$M = 3\times(100+1,200)\times6.5 = 25,350 \text{ in-lb}$$

Bending stress in the shell,

$$\sigma_{bending} = 25{,}350/[\pi\times(28/2)^2\times0.25] = 165 \text{ psi} \ll 24{,}000 \text{ psi}$$

Shear stress in the shell,

$$\tau = 3\times(100+1{,}200)/(\pi\times28\times0.25) = 177 \text{ psi} \ll 14{,}400 \text{ psi}$$

Shear stress in the weld caused by the bending moment,

$$\tau_{bending} = 25{,}350/[\pi\times(28/2)^2\times0.707\times1/4] = 233 \text{ psi}$$

Shear stress in the weld caused by the shear force.

$$\tau_{shear} = 3\times(100+1{,}200)/(\pi\times28\times0.707\times1/4) = 251 \text{ psi}$$

Combined shear stress,

$$\tau = 233 + 251 = 484 \text{ psi} < 21{,}000 \text{ psi}$$

Handhole, Blowdown, Shell Drain and Water Level Nozzle Closures

These closures have the same design details as the manway closures. Since they are much smaller in size than the manway closure, the stresses calculated for the manway closure envelop the stresses in these closures.

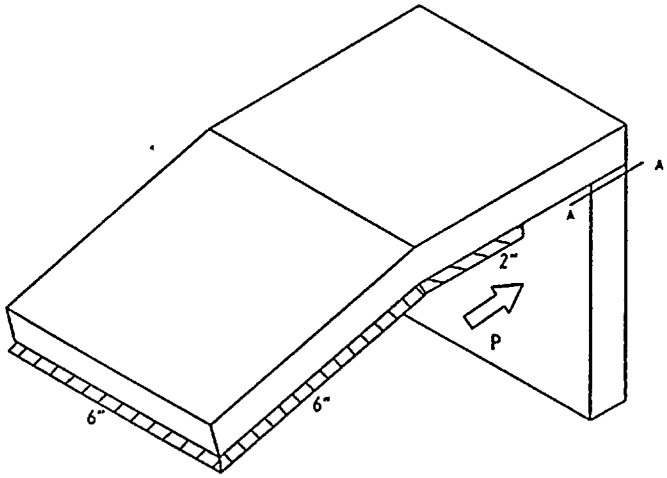
Endplate Clips

Eight clips (Figure 4), in addition to the 3/8" fillet weld around the circumference hold the endplates of the SGLAs. These clips are designed to provide restraint to the endplate against 3g acceleration in all directions without relying on the endplate to steam generator weld. The endplates are 176 in diameter, 3 in thick that weigh,

$$W_p = \pi/4\times176^2\times3\times490/12^3 = 20{,}696 \text{ lbs say } 21{,}000 \text{ lbs}$$

The eight clips share the inertia load normal to the plate surface equally. Therefore, load on each clip is:

$$P = 3\times21{,}000/8 = 7{,}875 \text{ lbs}$$



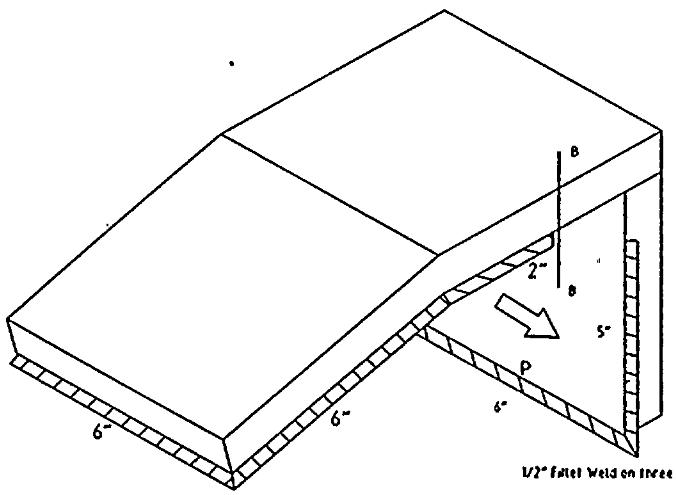
This load causes the shear of section AA. The average shear stress over this section is:

$$\tau = 7{,}875/(6\times1) = 1{,}313 \text{ psi} \ll 14{,}400 \text{ psi}$$

The welds on the horizontal end react to this load. Assuming that only the weld legs parallel to the load react to it, the shear stress in the weld is:

$$\tau_{weld} = 7{,}875/(2\times8\times0.5\times0.707) = 1{,}392 \text{ psi} \ll 21{,}000 \text{ psi}$$

The inertia load parallel to the plane of the endplate is assumed to be reacted by only two clips that are parallel to the direction of the load. In this case the loading on the clips are as follows:



The loading on each clip is:

$$P = 3\times21{,}000/2 = 31{,}500 \text{ lbs}$$

Shear stress on section BB is:

$$\tau = 31{,}500/(6\times1) = 5{,}250 \text{ psi} \ll 14{,}400 \text{ psi}$$

Bending stress on section BB is:

$$\sigma_{bending} = 31{,}500\times3\times6/(1\times6^2) = 15{,}750 \text{ psi} < 24{,}000 \text{ psi}$$

To calculate the maximum stress in the weld group on the steam generator, the entire group of weld is assumed to react the 31,500 load and the two 8 in legs only are assumed to react to the bending moment. The stresses due to these two effects are added to obtain the maximum weld stress. Shear stress due to 31,500 lbs force.

$$\tau_{force} = 31{,}500/(22\times0.5\times0.707) = 4{,}050 \text{ psi}$$

Shear stress in the weld due to bending moment,

$$\tau_{moment} = 31{,}500\times8/(6\times8\times0.5\times0.707) = 14{,}851 \text{ psi}$$

Combined shear stress,

$$\tau = 4{,}050 + 14{,}851 = 18{,}901 \text{ psi} < 21{,}000 \text{ psi}$$

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 handling and transportation. The stress allowables based on the AISC criteria are satisfied by all the components of the closure assembly with a large margin of safety. SGLAs will be, therefore, completely sealed and behave like a unitized body for which exemption from packaging may be requested from DOT.

[illegible]

Table 1 - Location of the Protrusions on the D.C. Cook SGLA

Protrusion	Circumferential Location from the Top (Degrees)
Primary Inlet Nozzle	36.3
Primary Outlet Nozzle	143.7
Handhole No.1	90
Handhole No.2	270
Primary Manway No.1	308.7
Primary Manway No.2	241.7
Blow-Down Nozzle No.1	90
Blow-Down Nozzle No.2	270
Shell Drain	206.3
Water Level Tap	126.7
End Plate	- (1)

Notes:

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

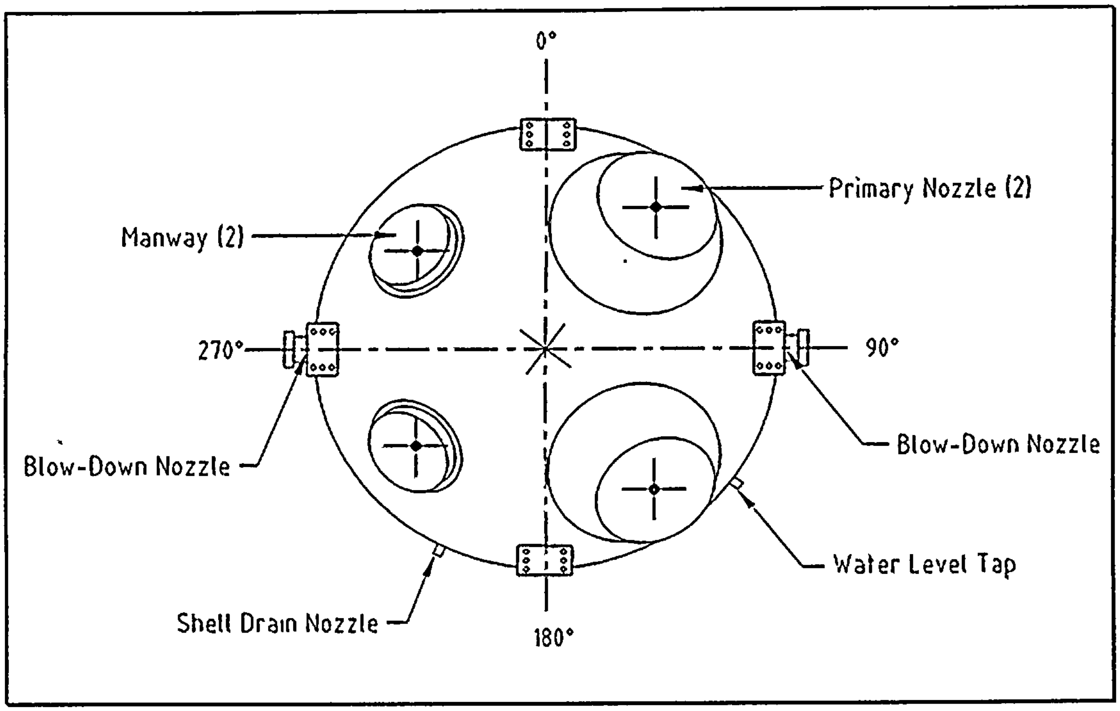


Figure-1 D.C. Cook SGLA Protrusion Location

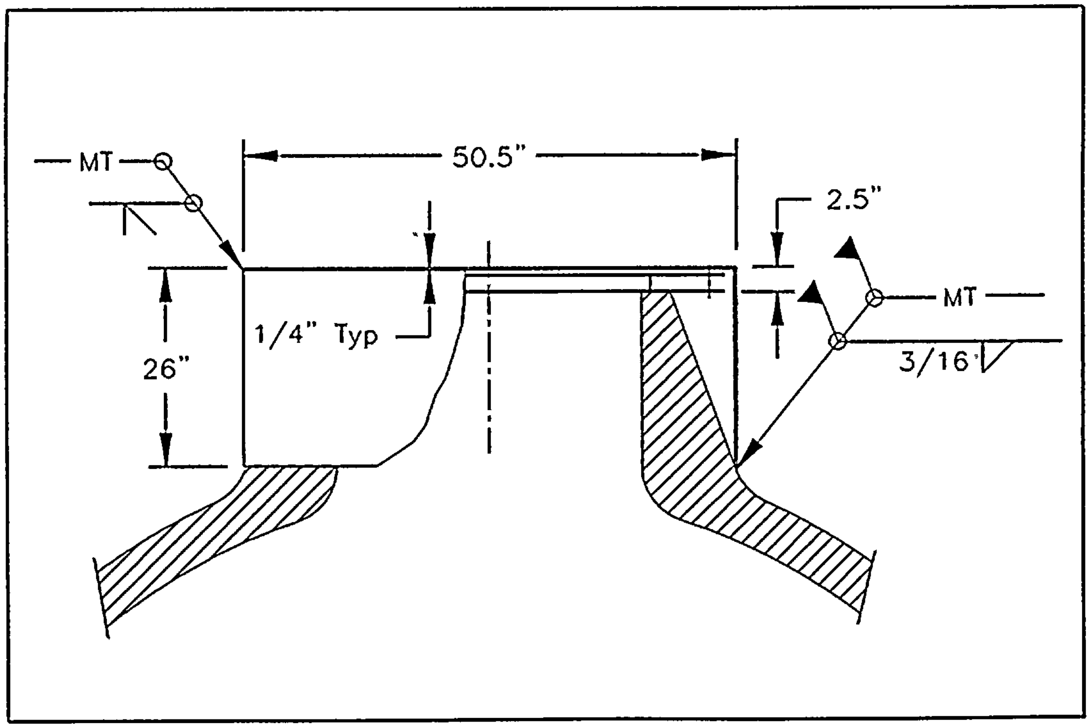


Figure-2 Primary Nozzle Cover Details

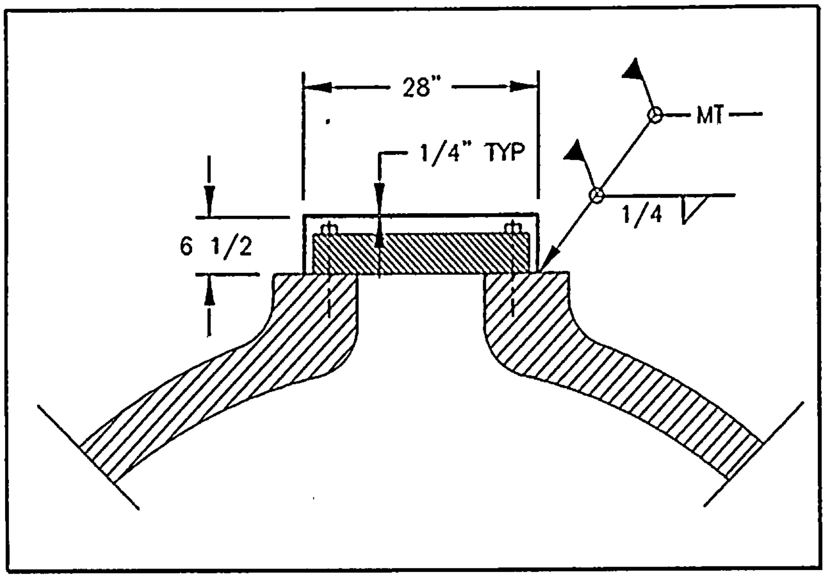


Figure-3 Manway Cover Details

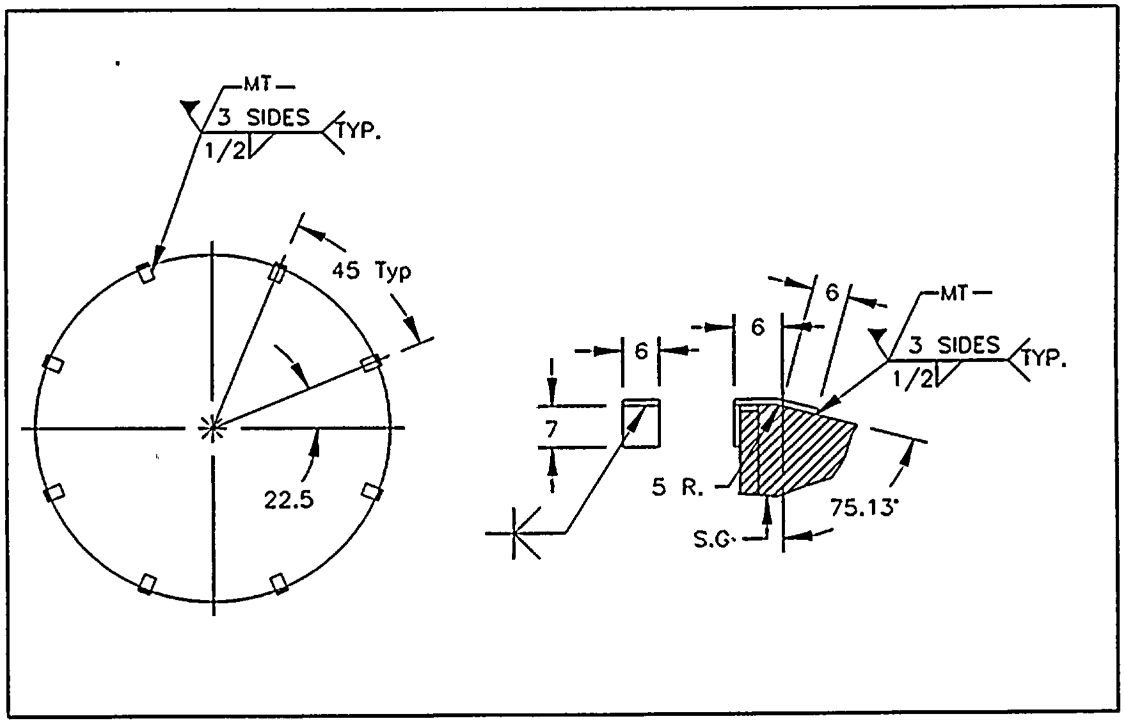


Figure-4 End-Plate Attachment Details