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

DESIGN DOCUMENT COVER SHEET

DOCUMENT ID NUMBER: ST-257 REVISION NUMBER: 0

PROJECT NUMBER: 46621

SECURITY STATUS: PROPRIETARY ____ NON-PROPRIETARY x

PERIOD: Life of the Project + 1 year

TITLE: Structural Evaluation of the St. Lucie S.G. Package (Non-Proprietary)

PREPARED BY: [signature] DATE: 6/10/97

TITLE: Principal Engineer

REVIEWED BY: [signature] DATE: 6/10/97

TITLE: Senior Project Engineer

REVISION NOTES:

DOCUMENT CONTROL

Received By: [signature] Date: 6/10/97

Document Dated From: 6-10-97 To: 6-10-97

Verification to Index By: [signature] (10 pages) Date: 6-11-97

Storage Shelf Location: 4-A

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

DESIGN DOCUMENT REVIEW CHECKLIST

Design Package Identification No ST- 257

Date 6/10/97 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 - This design package will be submitted to obtain exemption for the Saint Lucie Steam Generator Package as it provides equivalent safety to that of DOT IP-2 Packages.

2, 5 Through 8, 10,11 - Details are part of the Proprietary Document and are included in the Design Package ST-255.

12 - No design review meeting is needed.

Independent Reviewer [signature]

Introduction

Florida Power & Light (FP&L) Company will be replacing the steam generators at their St. Lucie Unit 1 facility. The old steam generators (OSGs) will be transported to Barnwell South Carolina for disposal. The steam generators will be transported under DOT exemption as alternatively packaged radioactive material that provide equivalent safety to that of DOT IP-2 packages. These IP-2 packages are required by 49 CFR 173.411 to meet the general requirements of 49 CFR 173.410 and must prevent loss or dispersal of radioactive contents or significant increases in the external radiation dose rates when subjected to the tests prescribed in 49 CFR 173.465 (c) and (d), namely, 1-foot drop and compression tests. The 1-foot drop test requires that the package be dropped in the most vulnerable orientation so that the maximum damage is caused. The special procedures used to handle the steam generators during transportation provide significant increases in safety over uncontrolled shipments, and provide controls to prevent the steam generators from being dropped in an arbitrary orientation.

From the time the packages are ready for shipment to the time they arrive in the burial trench they are permanently tied to a pair of saddles. Each saddle is bolted to a massive frame which, in turn, is secured to a self propelled modular transporter (see Figure 1 for a schematic of the tie-down). The steam generators are raised and lowered on the cribbing using these frames. During this operation the assembly is raised by only a few inches above the support points. Therefore, the only probable drop that could occur is a drop of the assembly by a few inches over the cribbing-pile. Because of the flexibility of the support-frame and the cribbing pile involved in this drop, such a drop will have a minor effect on the steam generator. A much more severe drop has been postulated for analyzing the steam generator for the compliance with the regulatory requirement. In this scenario, the steam generator is dropped on a rigid surface from a height of 1-foot in the orientation it is transported. Since the diameter of the primary side of the steam generators is smaller than that of the secondary-side, such a drop would result in an initial impact on the secondary side and a second impact (slap-down) on the primary side of these generators.

It should be noted that for the transportation, the steam generators are rotated in such a way that all their protrusions are well above an imaginary horizontal plane drawn at the bottom of the steam generator (Figures 2 and 3). Table 1 lists all the protrusions and their circumferential orientation from a vertical plane pointing downwards. Thus, for the postulated 1-foot drop, none of the protrusions on the steam generator would impact the rigid surface. The protrusion closest to the impact point are, (1) the secondary manway, and, (2) the primary inlet nozzle. The lowest point of the secondary manway is 4.52" above the horizontal plane (see Figure 4) and that of the primary inlet nozzle is 2.68" above the horizontal plane (see Figure 5). The analysis performed to comply the regulatory requirement of 1-foot drop of the package on an unyielding surface shows that due to such a drop,

(1) The stresses in the package do not exceed the allowable stresses. The allowable stresses are established based on NRC Regulatory Guide 7.6. Accordingly, the extreme fiber stress on the shell does not exceed the ultimate strength of the material and the average stress over the cross-section does not exceed 70% of the Ultimate strength of the material.

(2) Due to the deceleration experienced by the package during the drop, all the caps and plugs of the nozzles maintain their sealing. The stresses in the caps and plug welds are limited to the AISC allowable values.

(3) The deformation of the package would not be sufficient to cause any of the protrusions to impact the unyielding surface.

The compression test, which is required to simulate the loding on the package when they are stacked on top of another, is not applicable for the shipment of the steam generators because the generators would be shipped separately and no other component is stacked on top of these generators during the shipment.

Analysis Methodology

Figure 6 shows the scenario used in the drop analysis of the steam generator package. The lowest point of the package, i.e., the secondary shell, is located 1 foot above the unyielding surface. The package is assumed to be horizontal in order that the primary shell is located farthest from the surface (conservative). The package is dropped from this orientation. The first impact takes place on the secondary shell. Subsequently, because of the location of the center of gravity in the primary end of the steam generator, the primary side rotates about the transition cone edge and a slap-down takes place. The analyses cover both the primary and secondary impacts.

The analysis is performed using ANSYS finite element computer program. The steam generator is modeled by two-dimensional beam elements that appropriately represent the area and the moment of inertia of the steam generator along its length. The unyielding surface is modeled by rigid surfaces that are capable of reacting only the compressive load. The local flexibility of the steam generator shell is included in the model and 5% structural damping is used in the analyses.

The model is analyzed using the linear transient (time-history) option of ANSYS program. The displacement, velocity, acceleration and reaction force time-history at each node of the model are obtained for the initial and secondary impact of the steam generator with the rigid surface. The maximum acceleration is established from the largest acceleration of these time-histories. The largest deformation at an appropriate node is used to establish whether the protrusions nearest to the rigid surface would come in contact with it or not. The largest reaction forces in the in the primary and secondary shells are used in separate linear finite element models to obtain the stresses in the steam generator. The largest acceleration value is used with the mass of the caps and plugs to evaluate the weld stresses.

Although it is shown that none of the protrusions would make a contact with the rigid surface, the protrusions closest to the rigid surface (primary outlet nozzle and secondary manway) are analyzed for the stresses under the maximum reaction force obtained from the beam finite element model, described in the above paragraph.

Results

The results of the analysis show that the stresses in the steam generator under 1-foot drop on a rigid unyielding surface, are within the allowable values, the cap and plug welds maintain their integrity, and the deformation at the point of impacts is such that none of the protrusions make a contact with the rigid surface.

Table 1 - Location of the Protrusions on the St. Lucie Steam Generators

Protrusion	Circumferntial Location from the Bottom (Degrees)
Primary Inlet Nozzle	-52
Primary Outlet Nozzle No.1	83
Primary Outlet Nozzle No.2	173
Handhole No.1	128
Handhole No.2	-142
Primary Manway No.1	128
Primary Manway No.2	-119.5
Feedwater Nozzle	128
Secondary Manway No.1	38
Secondary Manway No.2	-142
Steam Outlet Nozzle	90
Support Skirt	90
Bottom Blow-Down Nozzle	-142

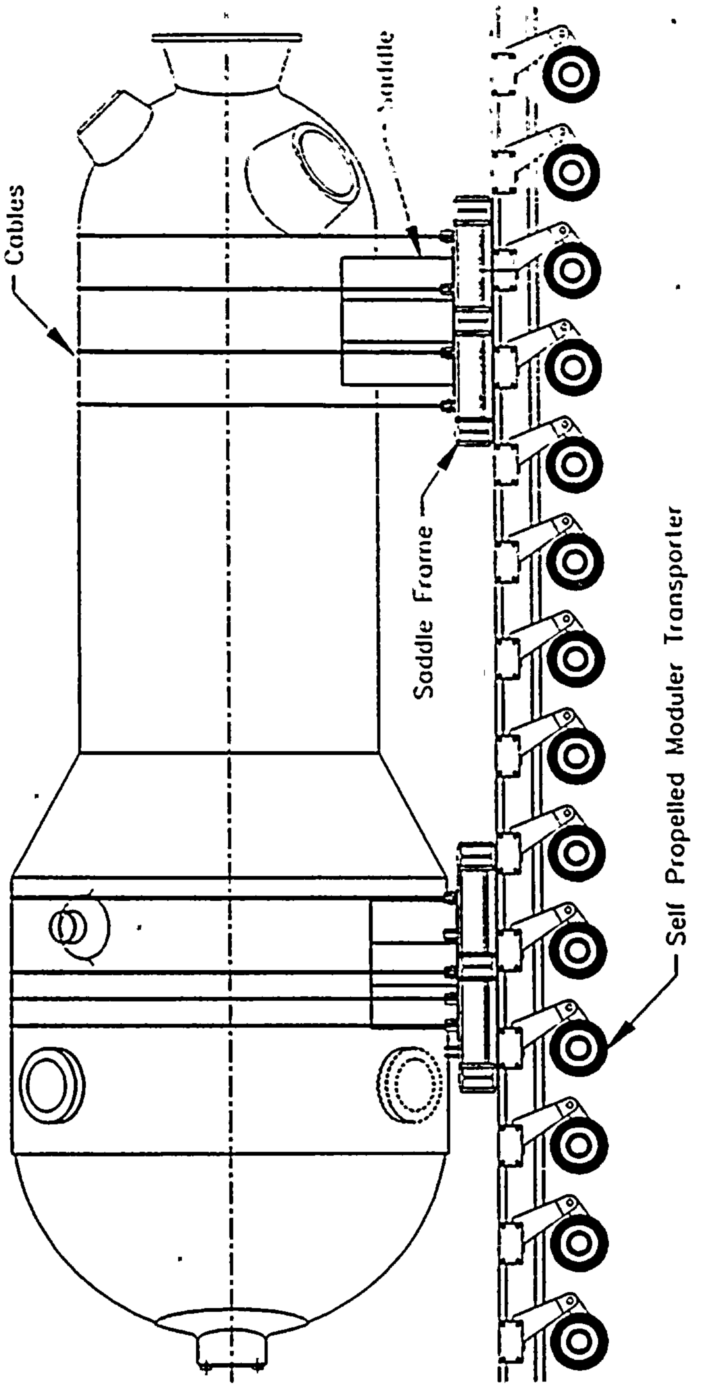


Figure 1 - St. Lucie Steam Generators - Tie-Down Schematic Diagram

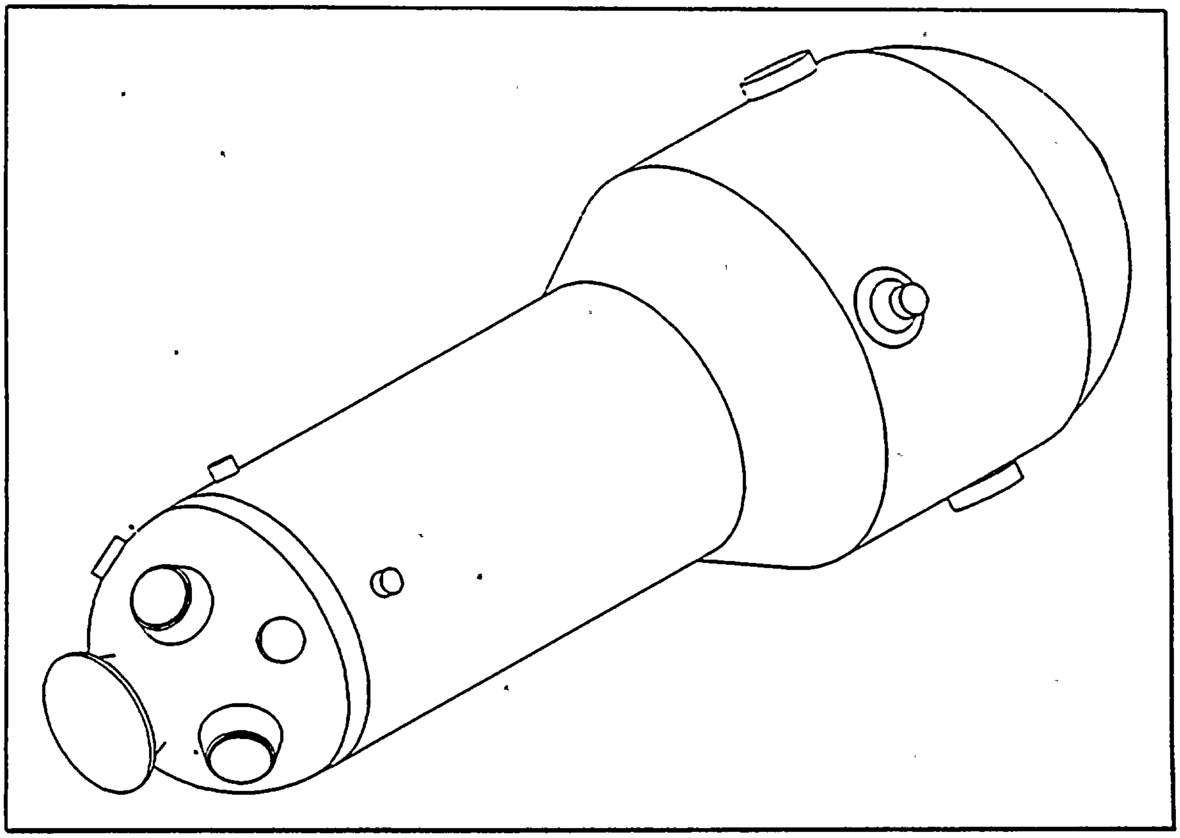


Figure 2 - St. Lucie Steam Generators - Isometric View

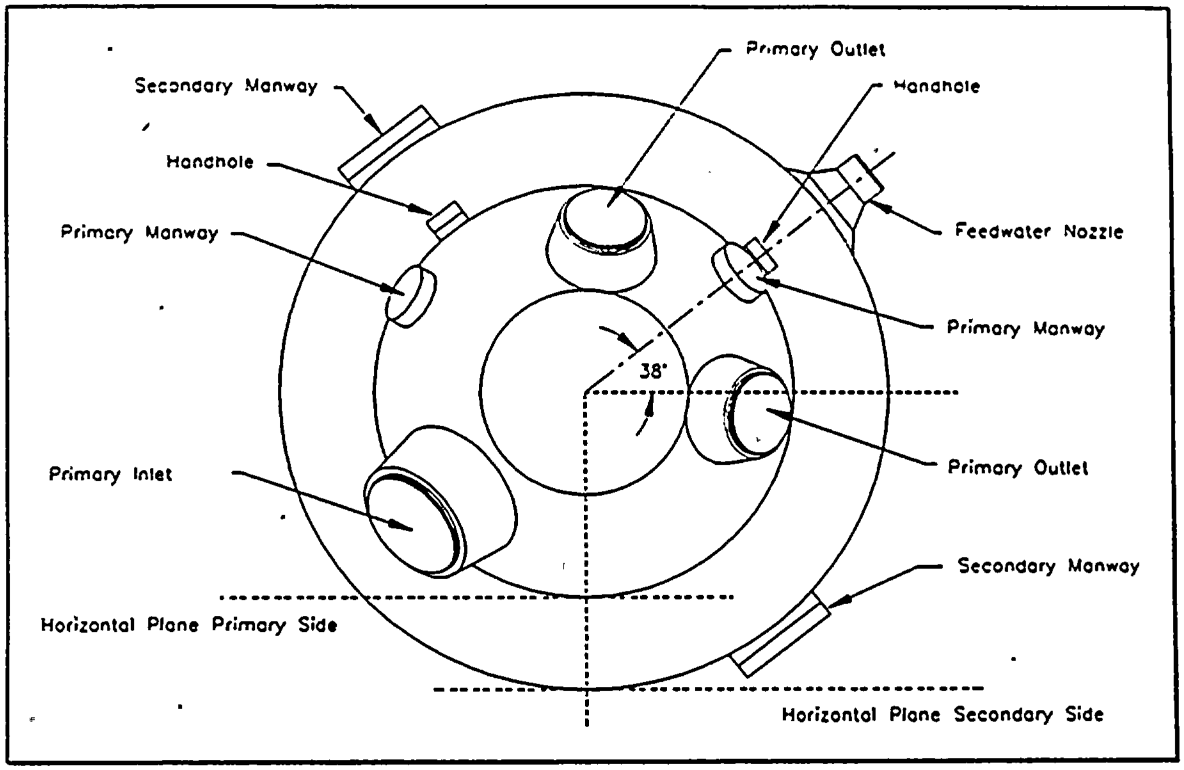


Figure 3 - Orientation of Steam Generator Protrusions

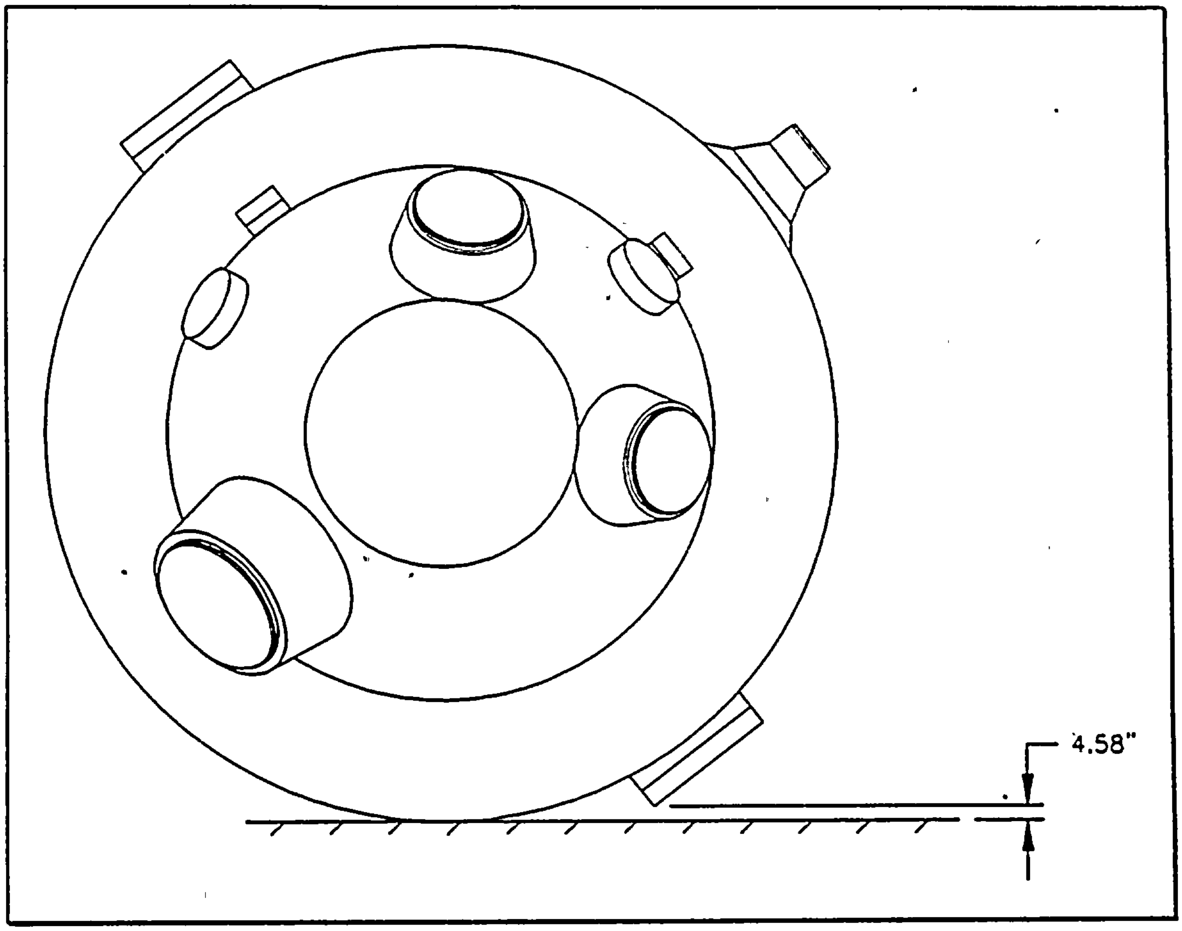


Figure 4 - Lowest Protrusion on the Secondary Side

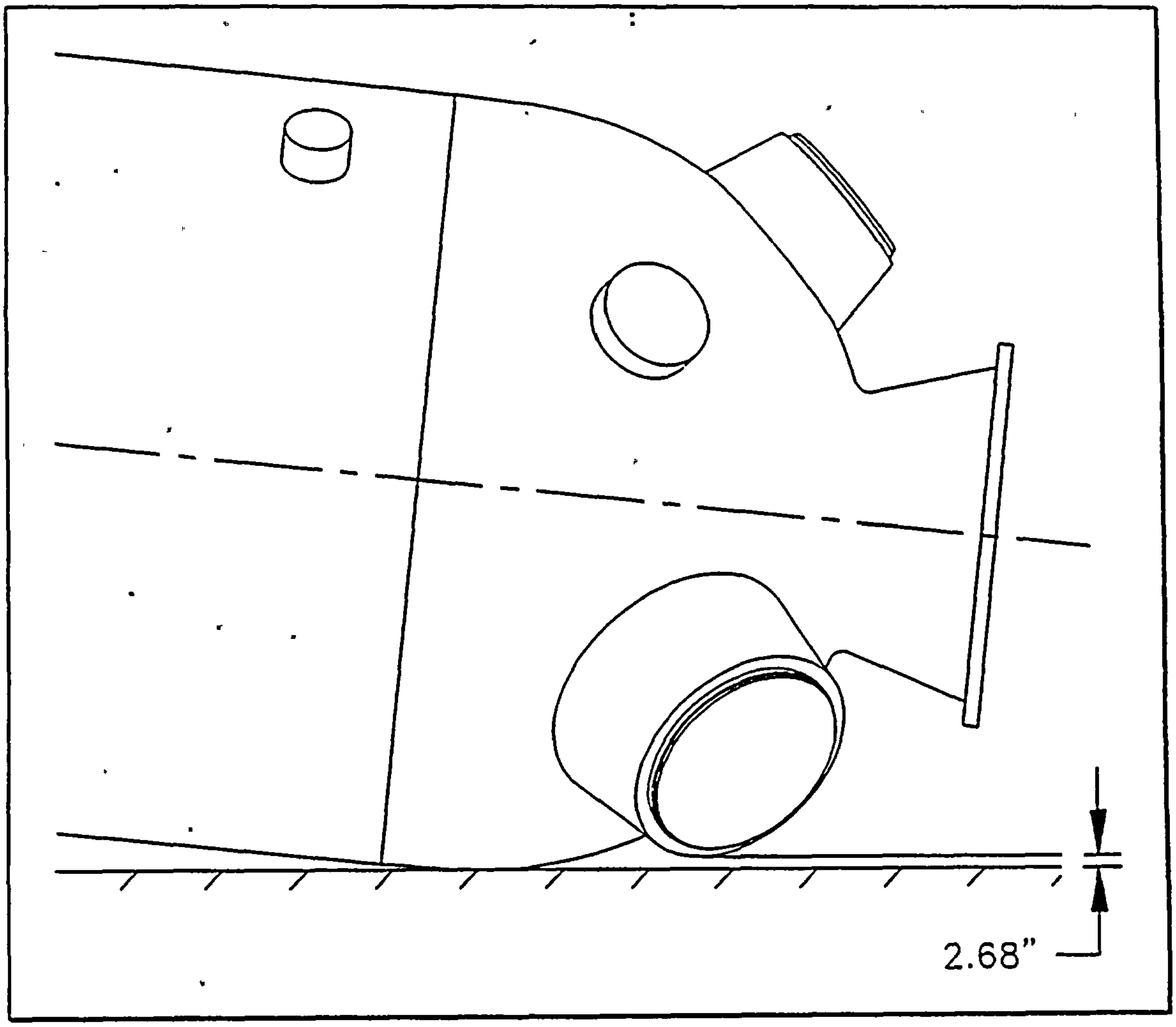


Figure 5 - Location of the Primary Inlet Nozzle above the Rigid Surface

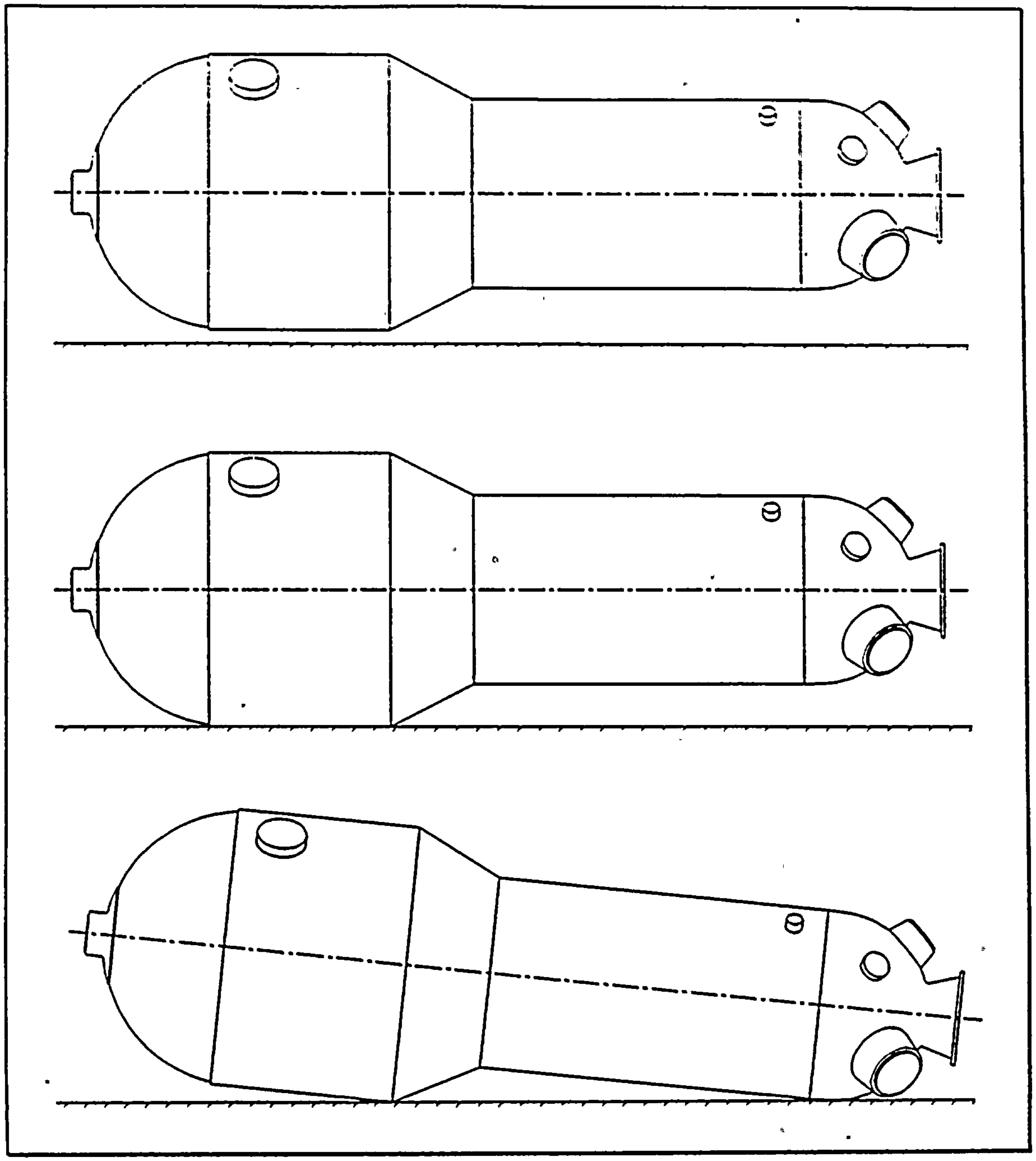


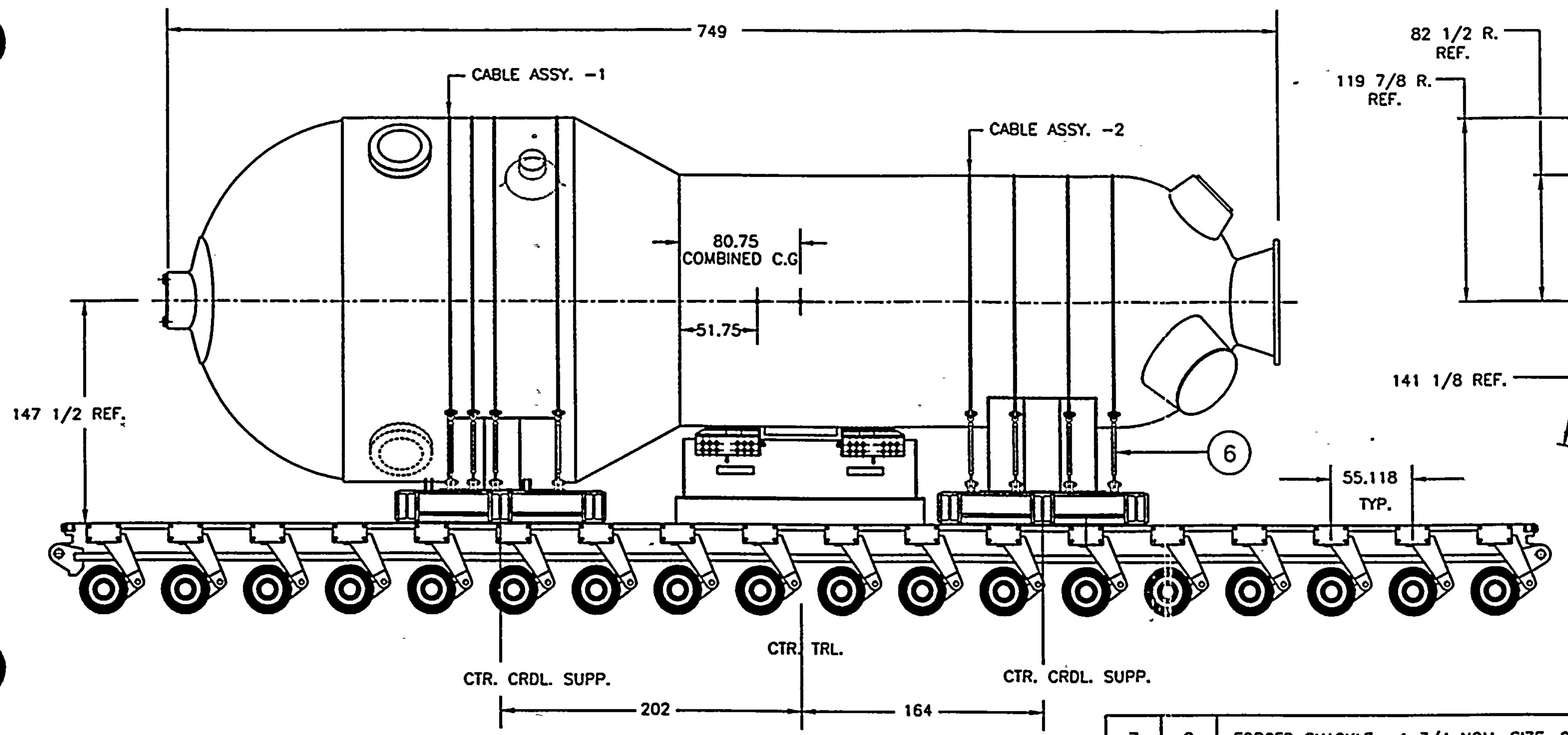
Figure 6 - Steam Generator 1-Foot Drop Scenarios

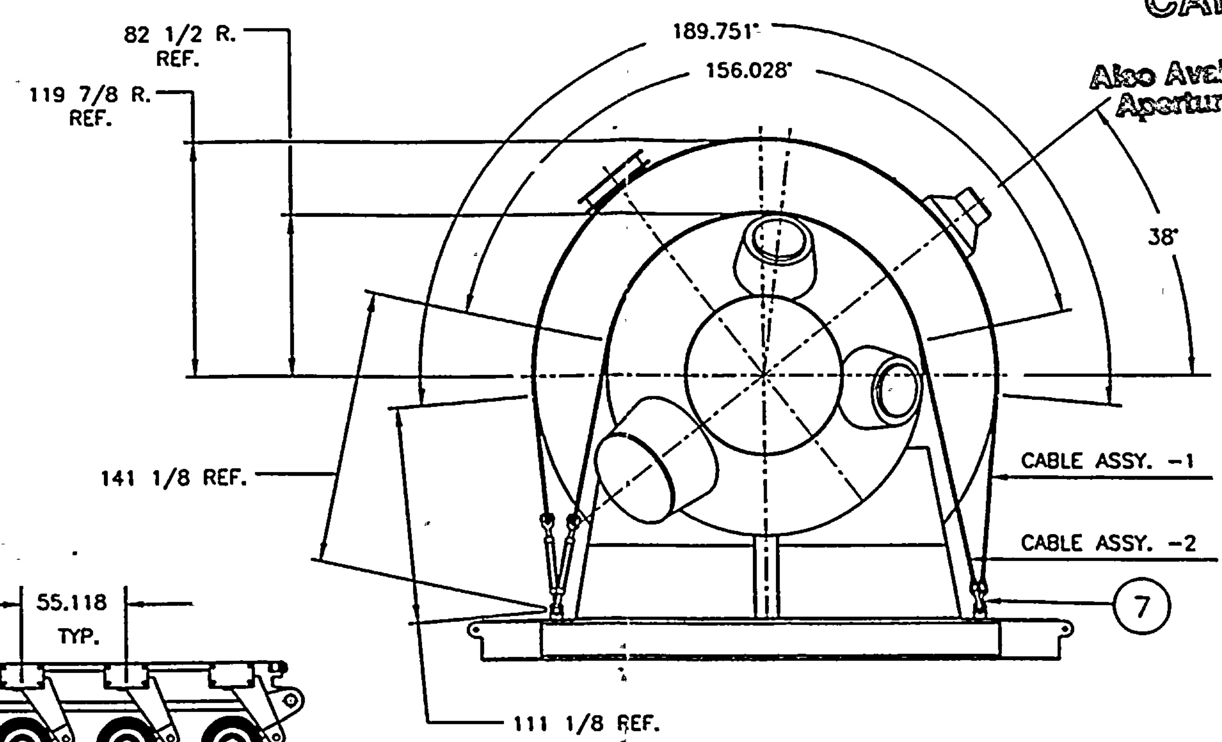
Attachment 5

Steam Generator Transportation General Arrangement Drawings

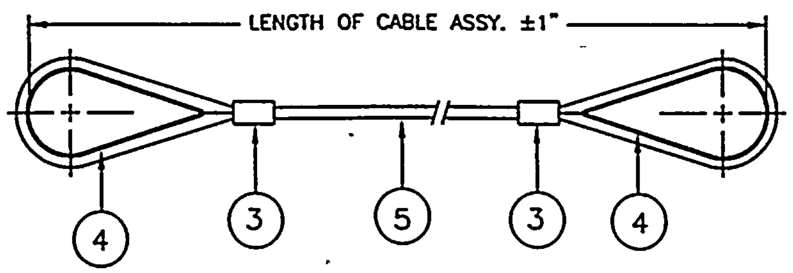
C-110-B-4662-003 Sheet 1; "St. Lucie Unit 1 Steam Generator Cable Tie-Down," Chem-Nuclear Systems, Inc.

C-110-B-4662-004 Sheets 1 to 3; "St. Lucie Unit 1 Steam Generator General Assembly," Chem-Nuclear Systems, Inc.





LAYOUT CABLE LENGTH



CABLE ASSEMBLY -1 & -2

LENGTH OF CABLE ASSY. REQ'D.

ASSY.-1: 619 7/8" - (16" + 53 7/8") = 550" (45'-10")
ASSY.-2: 491 7/8" - (16" + 53 7/8") = 422" (35'-2")

GENERAL NOTES:

USE 2 1/2 X 24, JAW & EYE TURNBUCKLE, ONE (1) EACH END OF CABLE ASSY.
LENGTH FULLY EXTENDED: 75.8"
LENGTH FULLY CLOSED: 51.8"
MAX. LENGTH OF TRAVEL: 24"
FIELD ADJUSTMENT: 16"

ITEM	QTY	DESCRIPTION	SPEC. AND / OR PART No.
7	8	FORGED SHACKLE, 1 3/4 NOM. SIZE, 25 TON WLL - #S-213	CROSBY OR EQ.
6	8	TURNBUCKLE, 2 1/2 X 24 JAW & EYE, HG-227- #1032457	CROSBY OR EQ.
5	8	WIRE ROPE, 1 3/8" DIA. IWRC, EIPS X LENGTH AS REQ'D	B30.9
4	16	THIMBLE FOR 1 3/8" DIA. WIRE ROPE	CROSBY OR EQ.
3	16	SWAGE FITTING FOR 1 3/8" DIA. WIRE ROPE	CROSBY OR EQ.
2	4	CABLE ASSEMBLY	———
1	4	CABLE ASSEMBLY	———

BILL OF MATERIALS

☐ PROPRIETARY
☒ NON-PROPRIETARY

FSCM No. 54643

DO NOT SCALE PRINT
DIMENSIONS ARE IN INCHES UNLESS NOTED

PROJECT No. 57906 | FILE ID. 08900100

REVIEWERS OF ORIGINAL (REV. 0)

DRAWN BY R. BREHEN 5/6/97
CHECKED BY [signature] 6/6/97
ENGINEER [signature] 6/6/97

CHEM-NUCLEAR SYSTEMS

ST. LUCIE UNIT 1 STEAM GENERATOR CABLE TIE-DOWN

SIZE B | DRAWING NUMBER C-110-B-46621-003 | REV. 0
SCALE 1/100 | WT N / A | SHEET 1 OF 1

9706270134-01

5 4 3 2 1

ANSTEC APERTURE CARD

Also Available on Aperture Card

ITEM	QTY	DESCRIPTION	SPEC. AND / OR PART No.
19	8	HX. NUT, 1 3/4"-5 UNC., FLAT AND SPLIT WASHER	COMML
18	8	HX. HD BOLT, 1 3/4"-5 UNC X 3" LG.	A325
17	A/R	HX. NUT, 1/2"-13 UNC., FLAT AND SPLIT WASHER	COMML
16	A/R	HX. HD. BOLT, 1/2"-13 UNC X 3" LG.	A325
15	A/R	CLAMP PLATE.	DWG. C-110-D-46976-100
14	1	SHEAR KEY BLOCKING BEAM ASSEMBLY	DWG. C-110-D-46621-015
13	A/R	SHIELD PLATES (LOWER FRAME)	DWG. C-110-D-46621-014
12	A/R	SHIELD PLATES (UPPER FRAME)	DWG. C-110-D-46976-100
11	24	LUG PLATES	DWG. C-110-D-46976-500
10	48	SHACKLE, 1 3/4" DIA. STOCK, 25 TON WLL - G-213-1018277	CROSBY OR EQ.
9	24	JAW AND JAW TURN BUCKLE, 2 X 24 #1033054	CROSBY OR EQ.
8	8	CABLE TIE DOWN	DWG. C-110-D-46621-003
7	1	PRIMARY CRADLE ASSEMBLY	DWG. C-110-D-46621-013
6	1	SECONDARY CRADLE ASSEMBLY	DWG. C-110-D-46621-012
5	1	PERSONNAL BARRIER MAIN SUPPORT FRAME (BASE SECTION)	DWG. C-110-D-46621-009
4	2	CRADLE SUPPORT BEAM	DWG. C-110-D-46621-009
3	1	PERSONNAL BARRIER END SUPPORT FRAME (BASE SECTION)	DWG. C-110-D-46621-006
2	1	PERSONNAL BARRIER FRAME (MID. SECTION)	DWG. C-110-D-46621-007
1	1	PERSONNAL BARRIER FRAME (UPPER) SECTION)	DWG. C-110-D-46621-005

BILL OF MATERIALS

☐ PROPRIETARY
☒ NON-PROPRIETARY

FSCM No. 54643

DO NOT SCALE PRINT
DIMENSIONS ARE IN INCHES UNLESS NOTED

PROJECT No. 57906 | FILE ID. 08910100

REVIEWERS OF ORIGINAL (REV. 0)

DRAWN BY R. BREHEN 5/6/97
CHECKED BY [signature] 6/6/97
ENGINEER [signature] 6/6/97

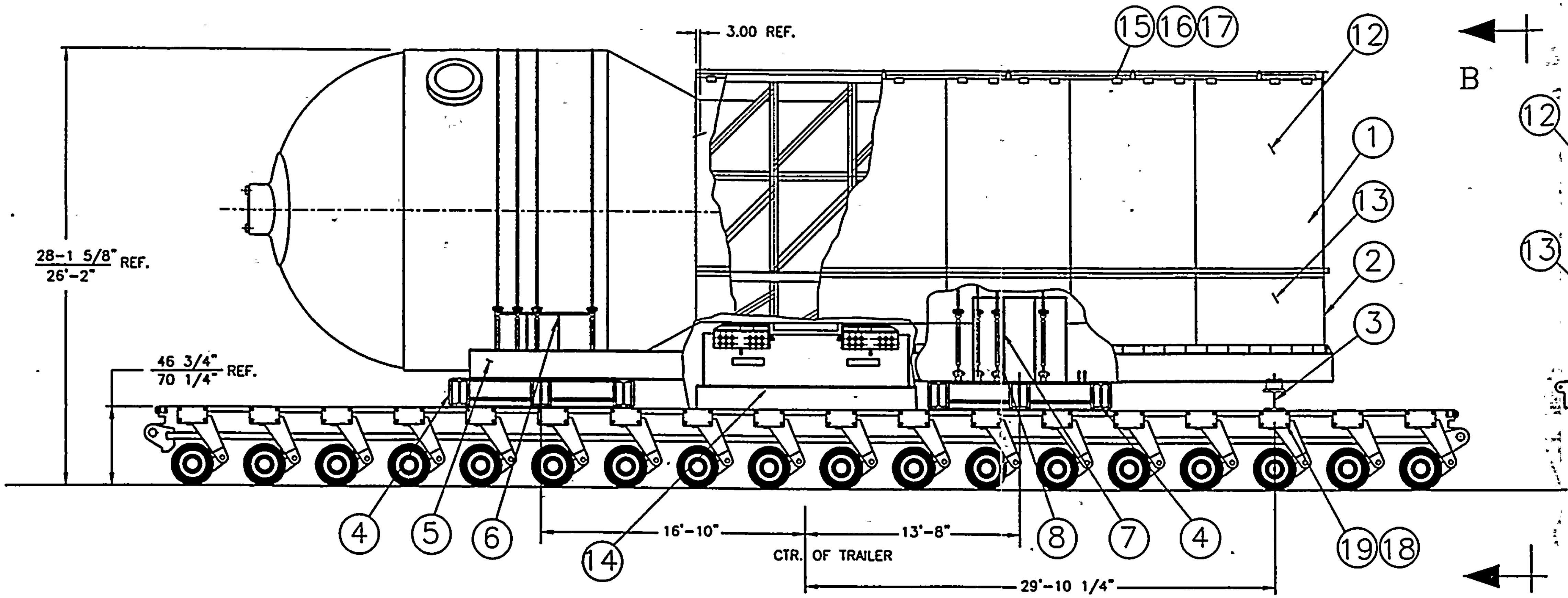
CHEM-NUCLEAR SYSTEMS

ST. LUCIE UNIT 1
STEAM GENERATOR
GENERAL ASSEMBLY

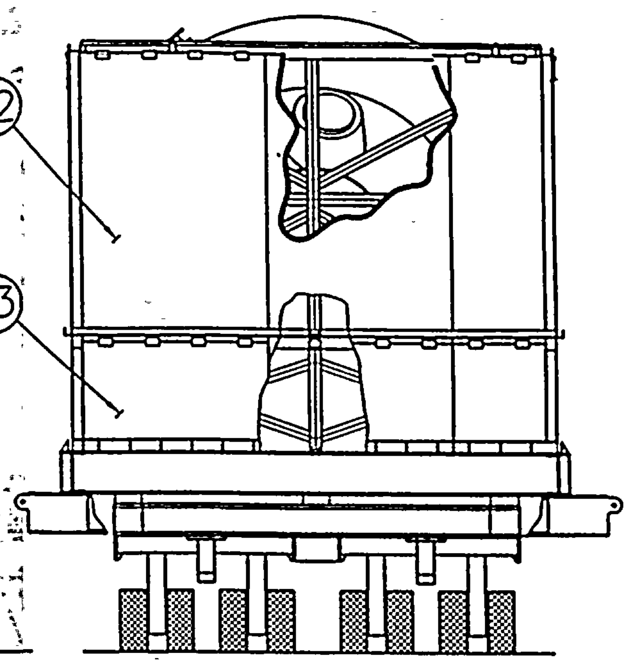
SIZE B | DRAWING NUMBER C-110-B-46621-004 | REV 0

SCALE 1/100 | WT N / A | SHEET 1 OF 3

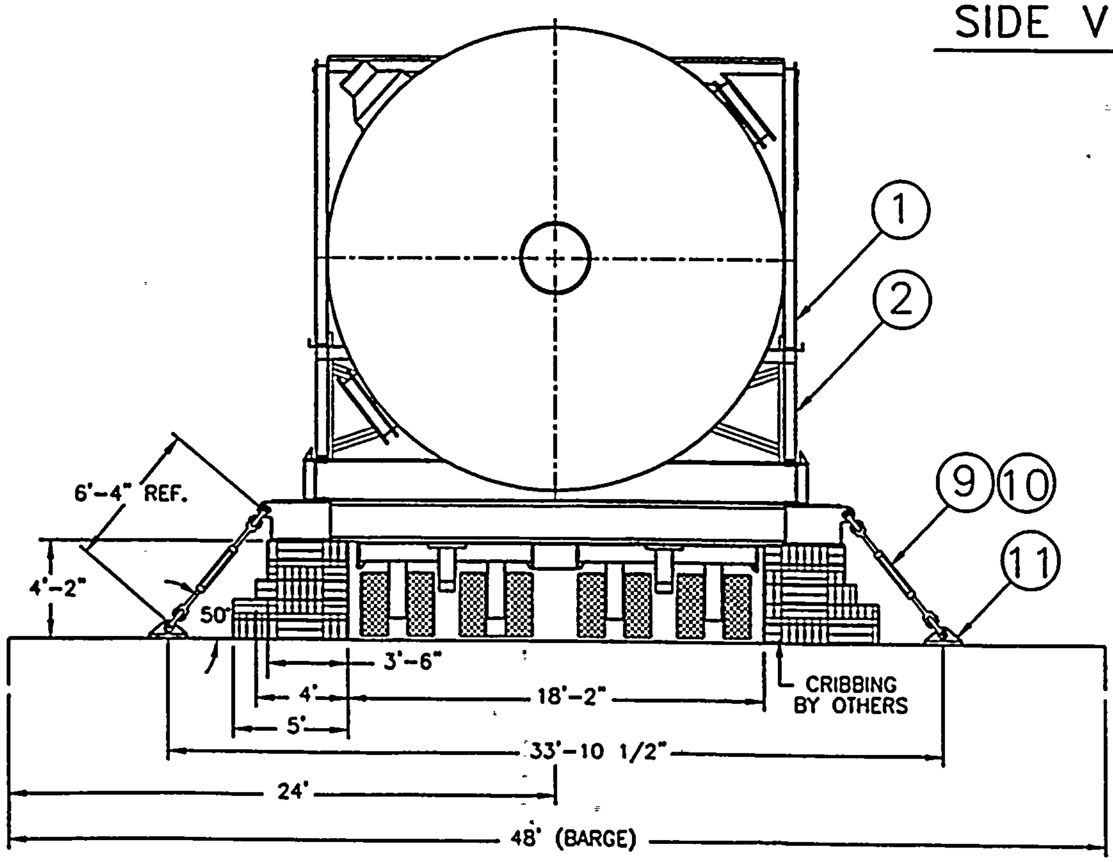
9706270134-02



SIDE VIEW



VIEW B-B



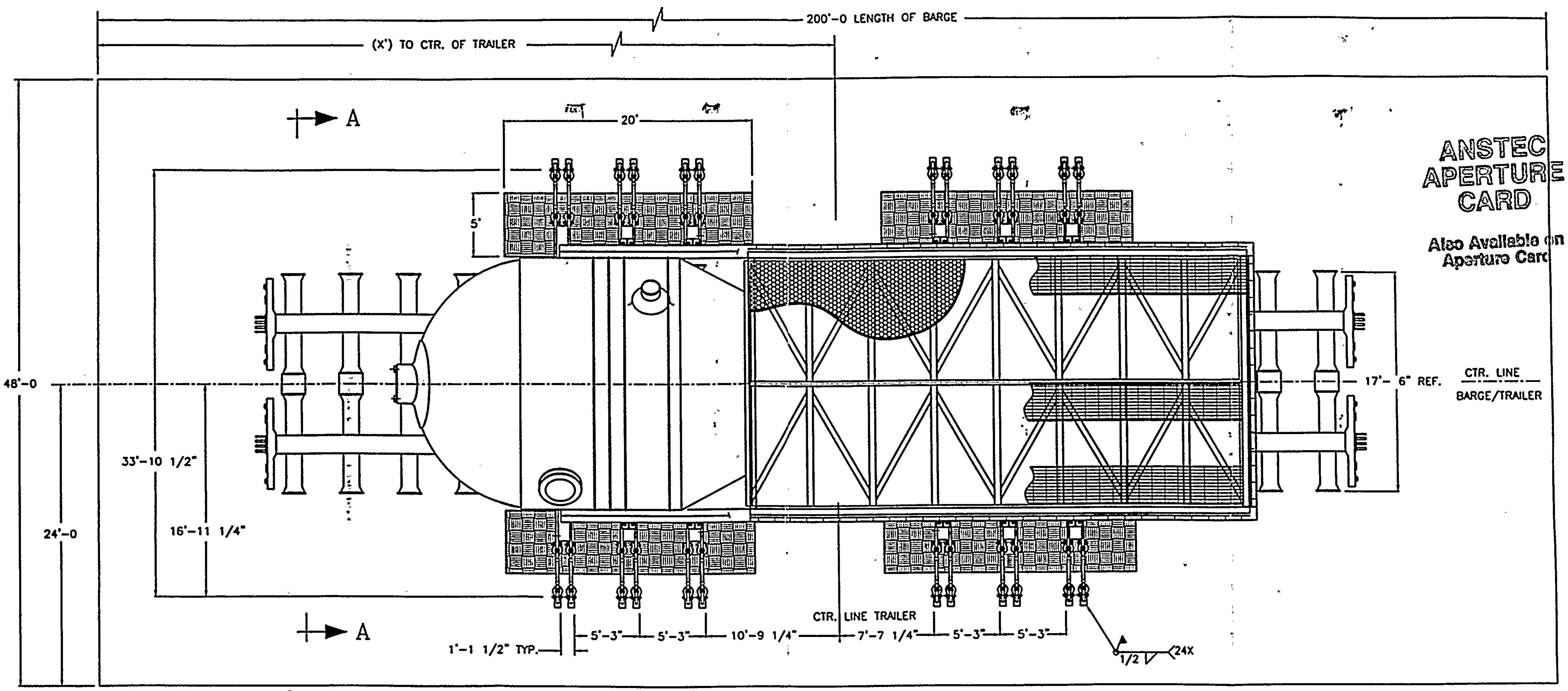
VIEW A-A (SHT. 3 OF 3)

ANSTEC APERTURE CARD

Also Available on Aperture Card

☐ PROPRIETARY ☒ NON-PROPRIETARY	DO NOT SCALE PRINT DIMENSIONS ARE IN INCHES UNLESS NOTED	CHEM-NUCLEAR SYSTEMS
FSCM No. 54643	PROJECT No. 57906 FILE ID. 08910200 REVIEWERS OF ORIGINAL (REV. 0)	ST. LUCIE UNIT 1 STEAM GENERATOR GENERAL ASSEMBLY
THIS DRAWING IS THE PROPERTY OF CHEM-NUCLEAR SYSTEMS IT IS LOANED UPON THE CONDITION THAT IT IS NOT TO BE REPRODUCED, COPIED OR LOANED TO OTHERS WITHOUT WRITTEN PERMISSION OF CHEM-NUCLEAR SYSTEMS AND IS TO BE RETURNED UPON REQUEST.	DRAWN BY R. BREHEN 5/12/97 CHECKED BY [signature] 6/6/97 ENGINEER [signature] 6/6/97	SIZE B · DRAWING NUMBER C-110-B-46621-004 · REV 0 SCALE 1/100 · WT N / A · SHEET 2 OF 3

9706270134-03



BARGE DECK – PLAN VIEW

☐ PROPRIETARY ☒ NON-PROPRIETARY	DO NOT SCALE PRINT DIMENSIONS ARE IN INCHES UNLESS NOTED	CHEM-NUCLEAR SYSTEMS
FSCM No. 54643	PROJECT No. 57906 FILE ID. 08910300 REVIEWERS OF ORIGINAL (REV. 0)	ST. LUCIE UNIT 1 STEAM GENERATOR GENERAL ASSEMBLY
THIS DRAWING IS THE PROPERTY OF CHEM-NUCLEAR SYSTEMS IT IS LOANED UPON THE CONDITION THAT IT IS NOT TO BE REPRODUCED, COPIED OR LOANED TO OTHERS WITHOUT WRITTEN PERMISSION OF CHEM-NUCLEAR SYSTEMS AND IS TO BE RETURNED UPON REQUEST.	DRAWN BY R. BREHEN 5/14/97 CHECKED BY [signature] 6/6/97 ENGINEER [signature] 6/6/97	SIZE B DRAWING NUMBER C-110-B-46621-004 REV 0 SCALE 1/100 WT N/A SHEET 3 OF 3

9706270134-04

Attachment 6

Preliminary Waste Characterization