FLORIDA POWER & LIGHT CO.

STEAM GENERATOR

CHEMICAL CLEANING PROGRAM

FOR

ST. LUCIE PLANT

UNIT NO. I

SAFETY EVALUATION REPORT

NOVEMBER 24, 1978

INDEX

INTRODUCTION

This document contains the Florida Power and Light Company Steam Generator Secondary Side Chemical Cleaning Program Description and Safety Evaluation for the St. Lucie Plant Unit #1 Steam Generators. It is the intent of this program to "capture" the denting progression at St. Lucie in its early stages to allow future unrestricted operation and avoid costly repairs that can occur in advanced stages of this problem.

To accomplish this program, the capabilities of four (4) Companies have been brought together and directed towards a common goal....the chemical cleaning of the St. Lucie Plant Steam Generators.

The Companies and their responsibilities are:

1) Florida Power and Light Company--overall program co-ordination and responsibility.
2) Combustion Engineering--NSSS Vendor--Solvent Process Qualification; Engineering-Testing and Support; Corrosion Testing; Technical Review; License Assistance; Vibration Testing and Analysis.

3) Dow Chemical Company--Solvent Vendor--Solvent Process development and testing; Engineering Review; Technical direction for process use; Analytical Services; Environmental and Waste Disposal Assistance.

4) Ebasco Services--Architectural Engineers for St. Lucie Plant--Detailed design package; materials procurement assistance; System Construction; removal of system after cleaning; Engineering and Technical review.

It is the hope of Florida Power and Light Company that the successful culmination of this effort will result in a viable treatment for this problem at St. Lucie Plant and throughout the Nuclear Pressurized Water Reactor Industry.

Respectfully,

Charles A. Moore

Charles A. Moore
Project Manager
Steam Generator Chemical Cleaning
Florida Power and Light Company

SECTION I

THE PROBLEM

The St. Lucie Unit #1 Steam Generators have two (2) sets of drilled carbon steel partial support plates in the upper part of the tube bundle (See Fig. I-1). Approximately 2224 of the 8519 tubes pass thru one or both of these partial support plates (See Fig. I-2 and I-3). The remainder of the tubes at these elevations and all other tube-to-support intersections are of the Combustion Engineering "Egg-Crate" design. No problems are indicated in the "Egg-Crate" support arrangements of the St. Lucie Plant Steam Generators. (See Fig. I-4.)

The partial plates are one (1) inch thick and drilled such that an approximate 8 mil radial annulus exists when the Inconel tube is inserted (See Fig. I-5). During plant operations these annuli become fouled with corrosion products from the secondary systems via normal Steam Generator make-up. While this condition, in itself, might not be of major concern, the result of this fouling is that effectively a "mini-concentrator" is created in the crevices which allows contaminants in the Steam Generator bulk water to concentrate to high levels in the annuli.

Concentration factors of greater than 10,000 have been observed in testing performed by PWR NSSS Vendors (See Fig. I-6 and I-7).

Specifically, from condenser inleakage, chlorides concentrate in the fouled crevices forming an acid chloride that causes accelerated (Non-protective magnetite) corrosion to occur continuously on the carbon steel support plates. In the reaction of the iron (Fe) with oxygen (O_2) to form Fe_3O_4 (magnetite), the product formed occupies approximately twice the space as the original reactants. This causes a compacting of the material in the crevice eventually resulting in a coupling between the tube and the tube support plate. As the corrosion continues, since the magnetite cannot exit from the deep (1") crevice, pressure is exerted on the tubes and likewise on the tube support plate.

This is the beginning of the phenomenon known as "denting", in that the steam generator tube actually starts to 'hourglass' or 'neck down' in the tube support plate, due to the increasing pressure. Concurrent with the tube denting, pressures are also being exerted on the tube support plate.

The denting, in advanced stages, leads to two (2) problems:

(1) The tube is reduced in inside diameter (ID) to a point of cracking inwardly, causing primary to secondary leakage.

(2) The stress on the tube support plate causes deformation and cracking which can lead to loss of tube support and tube failures due to the shearing action from plate movement.

It can be clearly seen that advanced stages of denting are undesireable. At this time, St. Lucie Plant is well removed from the effects described above and effective remedial action should prevent such a condition from developing.

The following pages contain summaries of the St. Lucie Plant Steam Generator inspections, as found at the April, 1978 refueling outage and the November, 1978 shutdown for Steam Generator Inspection.

ST. LUCIE - I

STEAM GENERATOR A

SUMMARY OF EDDY CURRENT TEST RESULTS

APRIL, 1978 REFUELING

<u>TUBES EXAMINED</u>

	#	% OF TOTAL	
HOT SIDE DEFECT DETECTION	580	6.9	NO REPORTABLE TUBE WALL DEGRADATION
COLD SIDE DEFECT DETECTION	100	1.2	NO REPORTABLE TUBE WALL DEGRADATION
HOT SIDE SLUDGE	60	0.7	4 INCH MAXIMUM
COLD SIDE SLUDGE	60	0.7	3½ INCH MAXIMUM

ST. LUCIE I

STEAM GENERATOR A

SUMMARY OF DENT INDICATIONS

APRIL, 1978 REFUELING

INSPECTED TUBE/SUPPORT PLATE INTERSECTIONS	NUMBER	% OF TOTAL	NUMBER WITH CENTER DENTS	% OF INTERSECTIONS INSPECTED WITH DENTS
#10 HOT SIDE	275	35.7%	55	20%
#9 HOT SIDE	545	24.5%	23	4.2%
#10 COLD SIDE	275	35.7%	18	6.5%
#9 COLD SIDE	510	22.9%	5	1%

% OF SUPPORT PLATE INTERSECTIONS TESTED WITH DENTS	6.3%
% OF TUBES INSPECTED WITH DENTS	14.6%
INDICATIONS AT SUPPORT PLATE EDGES	52 (PREDOMINANTLY AT #10 HOT)

FLORIDA POWER AND LIGHT

ST. LUCIE I

NUCLEAR POWER PLANT

EXCERPTS FROM

STEAM GENERATOR

SECONDARY SIDE

VISUAL INSPECTION

APRIL, 1978

Florida Power and Light
St. Lucie 1 Nuclear Power Plant
Steam Generator Secondary Side Visual Inspection

INTRODUCTION

This report covers the visual inspection of the secondary side of steam generators at the Florida Power and Light St. Lucie 1 Nuclear Power Plant, performed by Combustion Engineering, Inc. (C-E) during April 1978. The inspection was accomplished during a scheduled refueling outage to determine the overall condition of the steam generators.

Initial criticality occurred in April 1976 with an accumulated power history of approximately 370 effective full-power days prior to this visual inspection.

Special equipment provided by C-E for the visual inspection included a specially adapted close-up camera, boroscope, fiber optics equipment, a 35 mm camera, sample collecting equipment, and other miscellaneous items used in the inspection.

INSPECTION

The actual visual inspection of the "A" steam generator began April 2, 1978 in the dryer/separator region. This region was found to be in good general condition with dryer chevrons and supports free from heavy deposits. A light layer of loose powdery magnetite, which was easily removed by wiping, was observed on the top and sides of the separator cans. The separator wall perforations were free of any appreciable buildup of magnetite. The can deck was clean with only minor accumulations of magnetite.

The examination of the feedwater ring area revealed that the feedwater ring was coated with a moderate layer of magnetite. The feedwater discharge elbows were examined and no evidence of erosion was discovered.

The inspection team then proceeded to the tube bundle area below the can deck. In general, there was a moderate to heavy coating of magnetite on all surfaces particulatly the baffle walk and the I beam supports. The tube bundle and vertical support strips, however, were noticeabily free from heavy deposits.. The light film of loose powdery magnetite which coated the tubes was easily removed to reveal bare metal.

A close examination of the outer periphery of the drilled tube support plates, supports number 9 and 10, revealed no apparent distortion in the plates. The support plate/baffle clearance were measured at both elevations. The one-fourth inch ($\frac{1}{4}$") diameter flow holes were open and free from noticeable buildup. The tube/support plate annuli were inspected around the periphery of the upper support plate on both the hot and cold leg sides and each annulus appeared to be completely plugged. An attempt was made to insert a feeler gauge into the annulus at several locations. This attempt failed, as each location checked would not accept the tip of a 0.002" gauge. The nominal installed radial gap for these annuli is 0.007". Several attempts were made to remove the material from the annuli without success.

Several of the vertical support strips were measured before and after wire brushing to remove oxides and deposits. There was no difference in the before and after measurements with the average thickness being 0.094". The nominal installed thickness of the vertical strips was 0.090 $\pm$0.005". The inspection of the areas accessible from the secondary manway was concluded at this point.

The inspection then proceeded to the hand hole region. Access to the 90° hand hole was barred by the ECT apparatus; therefore, the inspectors could examine only the hand hole located on the 0° axis. The tubes adjacent to this hand hole were coated with a moderate layer of loose powdery magnetite. This layer was easily removed by wiping with a gloved hand. A light buildup of magnetite was in evidence on the surface of the tubesheet. At this point the inspection was concluded for the day.

The inspection of the "B" steam generator began the afternoon of April 3, 1978 with the examination of the hand hole region. The tubes adjacent to the hand hole located on the 90^{o} axis were observed to be coated with a light to moderate layer of loose powdery magnetite. This layer, as in the "A" steam generator, was easily removed by wiping with a gloved hand. Approximately one-half inch ($\frac{1}{2}$") of water was covering the tube sheet surface. This layer prevented the determination of the sludge thickness on the tube sheet. The first egg crate could be seen from the hand hole and appeared to be free from deposits in the crevices between the tubes and egg crate bars. An examination of the egg crate was conducted with fiber optics equipment. No abnormalities were seen.

The inspection was then moved to the dryer/separator region. There was no basic difference in the conditions observed in this region from those previously described for the unit "A" generator.

The inspection of the tube bundle area also revealed the same basic conditions as seen in the "A" steam generator. The drilled tube support plates were closely examined and no visual evidence of distortion was seen. The support plate/baffle annulus measurements showed that in general

the support plates in this generator are closer to the baffle than those in generator "A". Of particular note is the one-eighth inch (1/8") annulus measured at the center of the lower plate, support number 9, on the cold leg side.

Special effort was taken in this generator to insert a feeler gauge into the tube/support plate annuli. The tip of a 0.002" gauge could not be forced into any of the locations checked. A second attempt was made with a straight wire filed down to approximately 0.002". Again the inspectors had no success.

CONCLUSIONS

Both steam generators were relatively clean and in good condition. However, in both steam generators the tube/tube support plate annuli (where visible) were completely plugged. Attempts to insert a feeler gauge into the annuli to measure the annular gaps proved fruitless as even a 2 mil. thick gauge failed to go in.

In samples of steam generator crud from other plants iron (as magnetite) has usually been the major sample component with copper as the minor component. In the St. Lucie I steam generator samples the situation was reversed. As indicated by sample results (Attachment B) a high content of elemental copper was present in all samples. Other metals such as nickel and zinc were also noted.

ATTACHMENT (B)

STEAM GENERATOR SAMPLES CHEMICAL ANALYSIS

NOTE: (F.P. - Flame Photometry)
(A.A. - Atomic Absorption)
(N/D - None Detectable)

Semi-Quantitive X-Ray Fluorescence Results

Values Reported as % Found

St. Lucie "A" Steam Generator Samples

Element	Water Level Indication Nozzle	I Beam Flange	Surface of Steam Separator Can (Small Holes Area)	Top of the I Beam	Can Deck Floor	Top of Feedwater Ring	Top of Tube Bundle
Sodium (F.P.)	<0.1	<0.1	0.074	<0.1	<0.1	<0.1	N/D
Magnesium (A.A.)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	N/D
Aluminum	0.19	0.20	0.24	0.33	0.29	0.15	0.21
Silicon	0.066	0.066	0.042	0.067	0.066	0.092	0.10
Phosphorous	0.037	0.045	0.060	0.050	0.052	0.063	0.058
Sulfur	0.0075	0.0031	0.0046	0.0057	0.0047	0.008	0.010
Chlorine	N/D	N/D	N/D	0.013	N/D	N/D	N/D
Potassium	0.0025	N/D	N/D	0.0019	N/D	0.001	0.0012
Calcium	0.013	0.036	0.021	0.020	0.033	N/D	0.008
Titanium	0.54	0.43	0.41	0.31	0.45	0.48	0.50
Vanodium	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Cromium	0.45	0.12	0.18	0.099	0.14	0.12	0.12
Manganese	0.51	0.13	0.26	0.33	0.21	0.13	0.16
Iron	38.0	24.7	22.6	31.9	24.7	23.1	22.9
Cobolt	N/D	N/D	0.061	0.055	0.036	N/D	N/D
Nickel	2.9	5.4	4.2	4.5	5.4	5.2	6.9
Copper	35.6	51.4	55.2	42.5	50.7	54.0	50.9
Zinc	2.7	3.5	3.4	2.8	3.3	3.0	3.6
Zirconium	0.015	N/D	0.0086	N/D	N/D	N/D	N/D
Molybdenum	N/D	0.0094	0.024	0.016	0.0079	N/D	0.014
Tin	0.095	0.17	0.14	0.12	0.17	0.20	0.24
Lead	0.013	0.0089	0.0069	0.013	0.011	0.01	0.013
Silver	N/D	0.015	N/D	N/D	N/D	N/D	N/D

NOTE: (F.P. - Flame Photometry)
(A.A. - Atomic Absorption)
(N/D - None Detectable)

Semi-Quantitive X-Ray Fluorescence Results

Values Reported as % Found

St. Lucie "B" Steam Generator Samples

Element	Water Level Indication Nozzle	I Beam Flange	Surface of Steam Separator Can (Small Holes Area)	Top of the I Beam	Can Deck Floor	Top of Feedwater Ring	Top of Tube Bundle
Sodium (F.P.)	<0.1	0.074	0.074	0.074	<0.1	N/D	<0.1
Magnesium (A.A.)	<0.1	<0.1	<0.1	<0.1	<0.1	N/D	≤0.1
Aluminum	0.21	0.34	0.25	0.28	0.22	0.30	0.17
Silicon	0.061	0.072	0.032	0.069	0.042	0.23	0.10
Phosphorous	0.022	0.058	0.047	0.051	0.047	0.067	0.060
Sulfur	N/D	N/D	0.0074	0.006	0.003	0.019	0.0061
Chlorine	0.0051	0.014	N/D	N/D	N/D	N/D	N/D
Potassium	N/D	N/D	N/D	0.0013	N/D	N/D	0.001
Calcium	0.0091	0.020	0.023	0.019	0.030	N/D	N/D
Titanium	0.44	0.50	0.41	0.37	0.37	0.48	0.43
Vanadium	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Chromium	0.34	0.21	0.19	0.12	0.14	0.089	0.11
Manganese	0.41	0.38	0.26	0.32	0.19	0.11	0.14
Iron	50.3	32.1	24.6	33.2	26.5	19.1	24.3
Cobolt	0.067	0.067	0.062	0.045	0.035	N/D	N/D
Nickel	1.9	4.2	4.8	4.5	5.0	7.4	5.4
Copper	21.5	41.7	51.2	40.4	49.8	55.6	51.9
Zinc	2.1	3.0	3.7	3.4	3.1	3.3	3.1
Zirconium	0.027	N/D	0.010	N/D	0.012	N/D	0.008
Molybdenum	N/D	N/D	N/D	0.014	N/D	N/D	N/D
Tin	0.067	0.097	0.13	0.11	0.16	0.10	0.21
Lead	0.0067	0.023	0.0071	0.011	0.013	0.032	0.01
Silver	0.019	N/D	0.0099	N/D	0.017	N/D	N/D

X-Ray Diffraction Results
St. Lucie "A" Steam Generator Samples

Sample Location	Major	Minor	Trace
Water Level Indication Nozzle	Fe_3O_4 Cu	---	Fe_2O_3
I Beam Flange	Cu Fe_3O_4	---	CuO
Surface of Steam Separator Can (Small Holes Area)	Cu Fe_3O_4	---	---
Top of the I Beam	Cu Fe_3O_4	---	CuO
Can Deck Floor	Cu Fe_3O_4	---	CuO
Top of Feedwater Ring	Cu Fe_3O_4	CuO Cu_2O	---
Top of Tube Bundle	Cu Fe_3O_4	CuO	---

X-Ray Diffraction Results

St. Lucie "B" Steam Generator Samples

Sample Location	Major	Minor	Trace
Water Level Indication Nozzle	Fe_3O_4 Cu	Fe_2O_3	---
I Beam Flange	Cu Fe_3O_4	---	CuO
Surface of Steam Separator Can (Small Holes Area)	Cu Fe_3O_4	---	---
Top of the I Beam	Cu Fe_3O_4	---	CuO
Can Deck Floor	Cu Fe_3O_4	---	CuO
Top of Feedwater Ring	Cu Fe_3O_4	CuO	---
Top of Tube Bundle	Cu Fe_3O_4	CuO Cu_2O	---

ST. LUCIE I

NOVEMBER, 1978 SHUTDOWN

SUMMARY OF EDDY CURRENT TEST RESULTS

STEAM GENERATOR 1A HOT SIDE

TUBE SUPP ELEV	NUMBER OF TESTS	FREQ OF INDICAT OCCURRING	% INDICATION	AVG DENT (MLS)
9	697	91	13.0	.19
10	324	127	39.2	.90

STEAM GENERATOR 1A COLD SIDE

TUBE SUPP ELEV	NUMBER OF TESTS	FREQ OF INDICAT OCCURRING	% INDICATION	AVG DENT (MLS)
9	697	63	9.0	.14
10	324	52	16.0	.45

ST. LUCIE I

NOVEMBER, 1978 SHUTDOWN

SUMMARY OF EDDY CURRENT TEST RESULTS

STEAM GENERATOR 1B HOT SIDE

TUBE SUPP ELEV	NUMBER OF TESTS	FREQ OF INDICAT OCCURRING	% INDICATION	AVG DENT (MLS)
9	540	36	6.7	.27
10	230	101	43.9	1.23

STEAM GENERATOR 1B COLD SIDE

TUBE SUPP ELEV	NUMBER OF TESTS	FREQ OF INDICAT OCCURRING	% INDICATION	AVG DENT (MLS)
9	539	74	13.7	.21
10	229	95	41.5	1.00

STEAM GENERATOR CONDITION

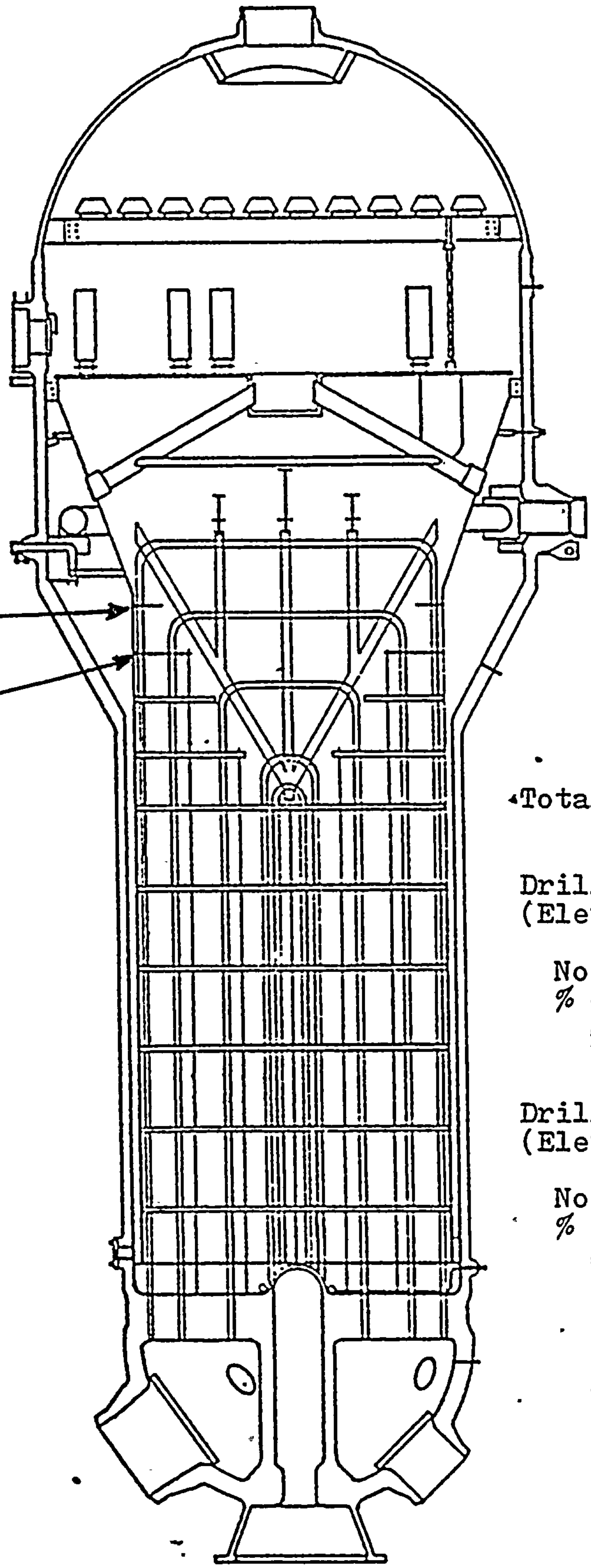
Both steam generators were inspected by ECT and visual techniques during the November, 1978 outage to determine the condition of the support plates and to check for any other circumstances which would complicate cleaning. There was no evidence of support plate cracking in either generator, nor was there evidence of yielding within the support plate. Indeed, except for the fact that most (but not all) support plate annuli were closed, the support plates appeared to be in completely nominal condition. The ECT examination showed that the level of denting had increased slightly (less than one mil) from the previous examination. While more detailed calculations are still under way, the general level of denting found was determined to be less than that required for plate yielding, which is consistent with the visual status.

The support plates will be re-checked for evidence of cracking before the start of any cleaning operations.

Fig. I-1

Drilled Plate
(Elev. 10)

Drilled Plate
(Elev. 9)



Total No. of Tubes
8519

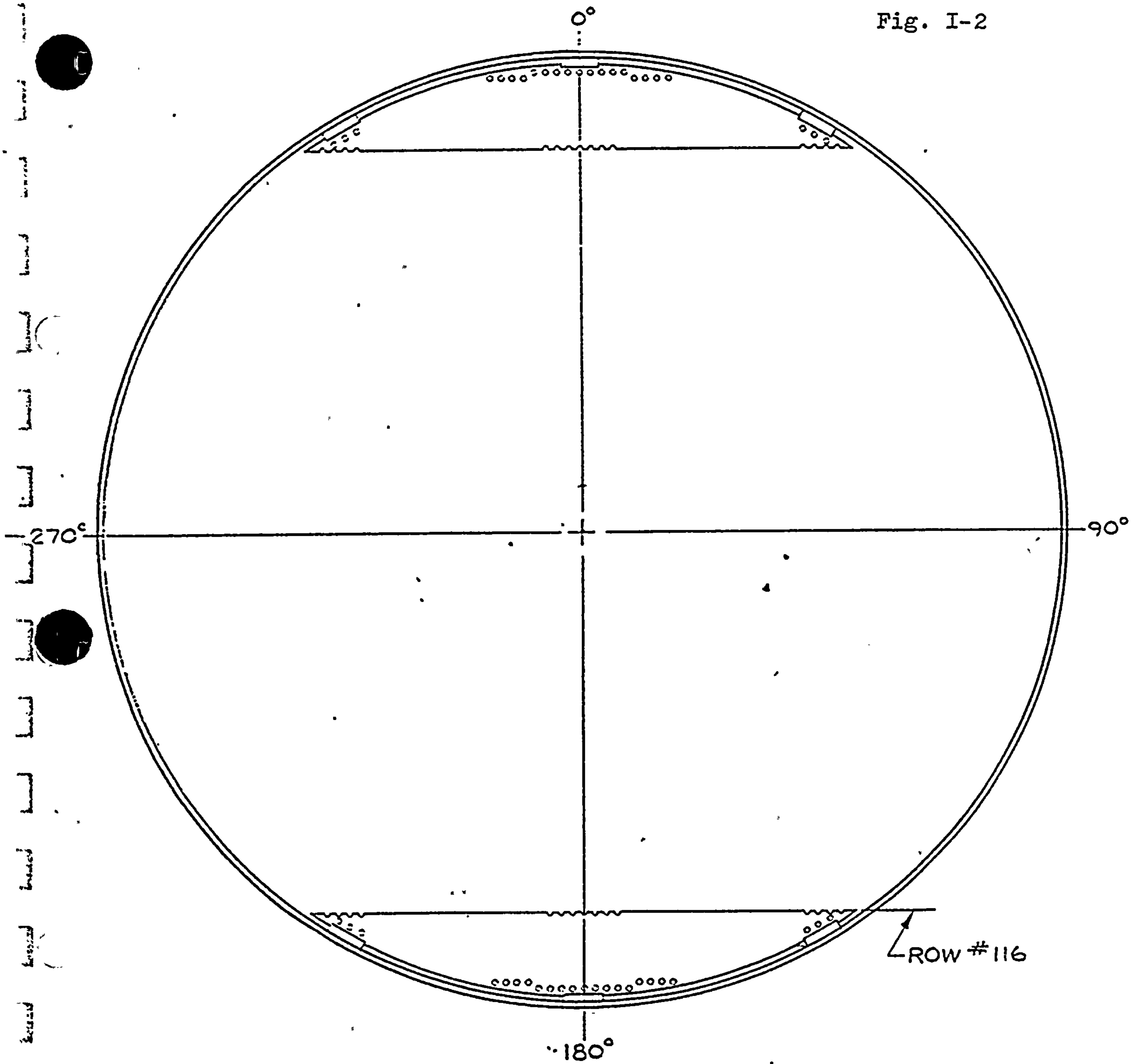
Drilled Plate
(Elev. 9)

No. of Tubes-2224
% of Total Heated Surface - 31.4%

Drilled Plate
(Elev. 10)

No. of Tubes-772
% of Total Heated Surface - 11.7%

Fig. I-2

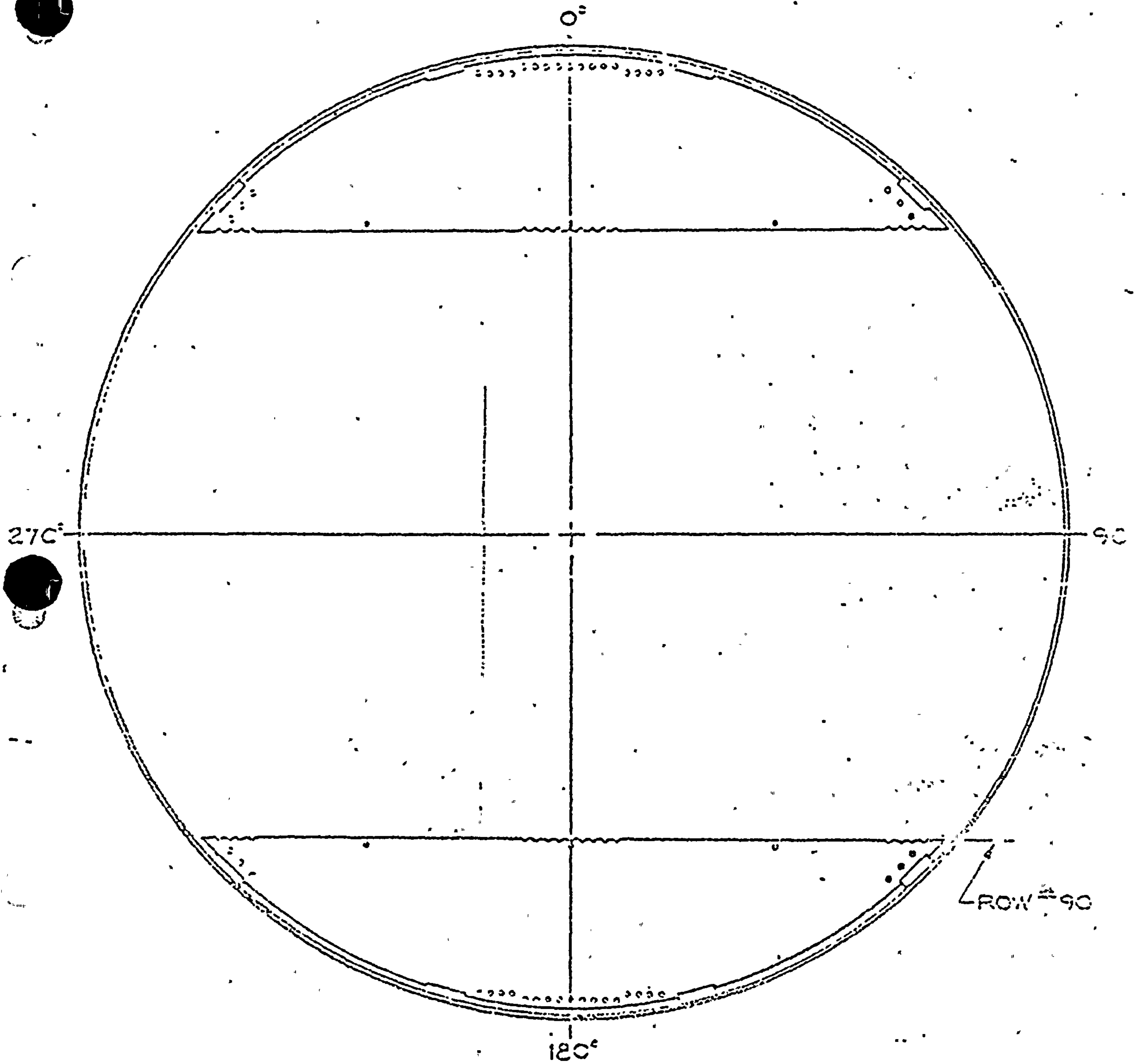


ST. LUCIE I

DRILLED PLATE (ELEV. 10)

No. of Tubes--772
% of Total Heated Surface - 11.7%

Fig. I-3

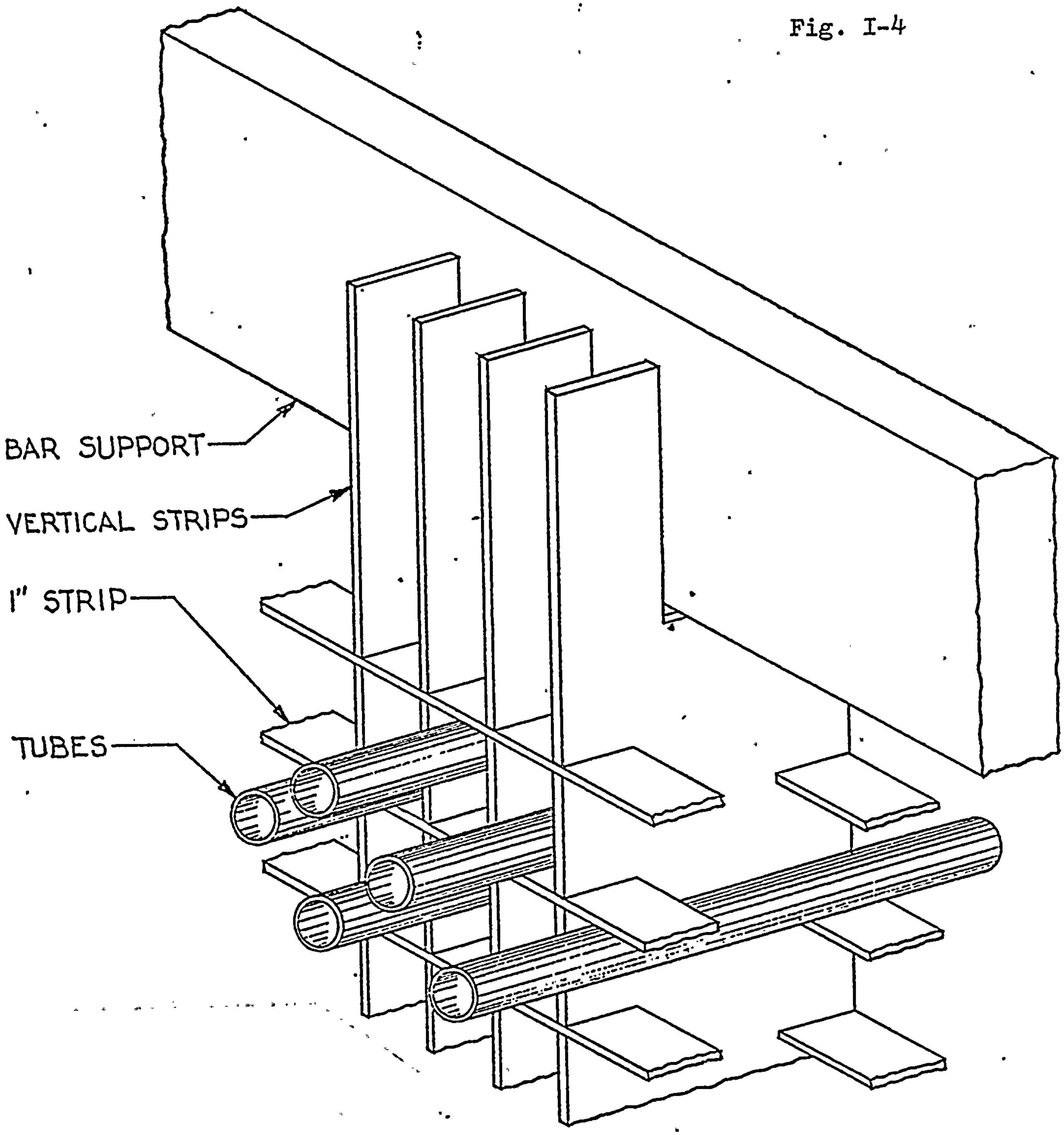


ST. LUCIE I

DRILLED PLATE (ELEV. 9)

No. of Tubes--2224
% of Total Heated Surface-31.4%

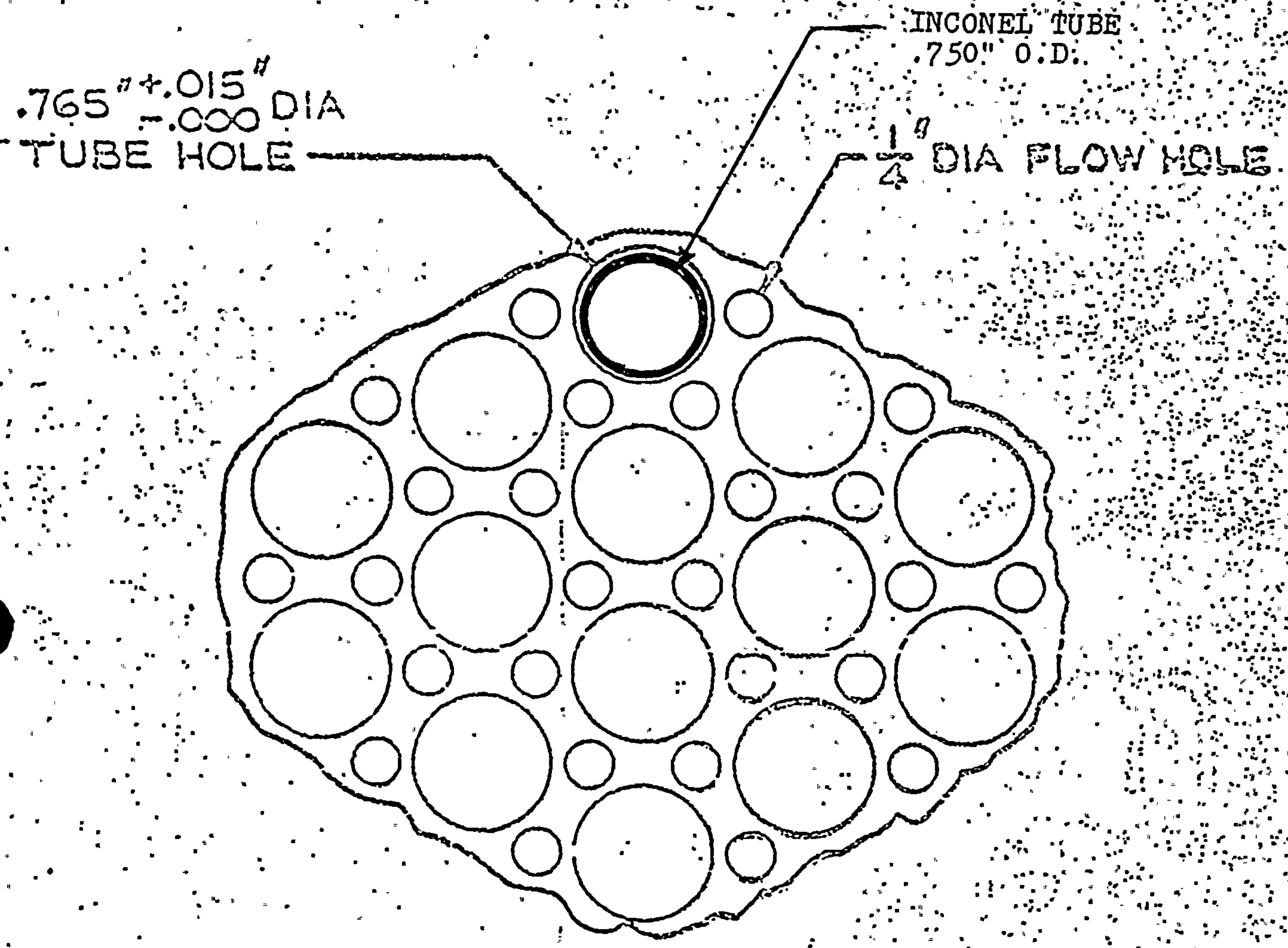
Fig. I-4



ST. LUCIE I

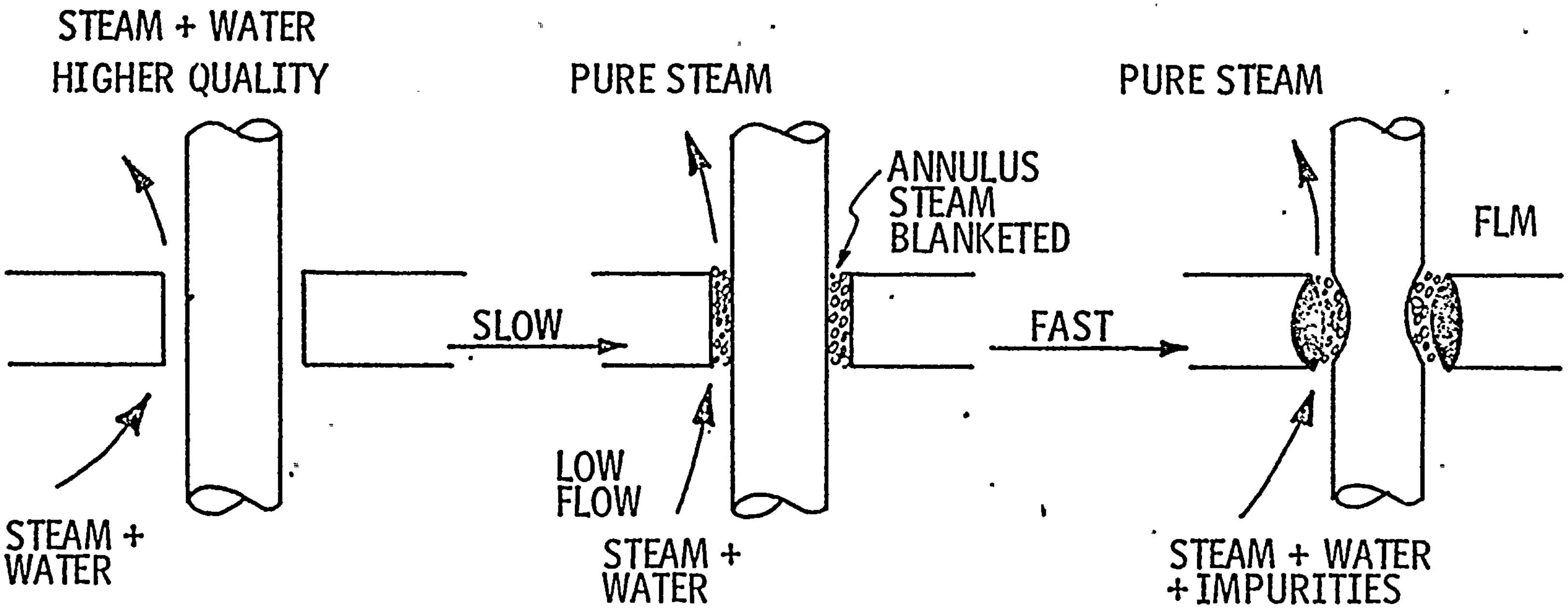
TUBE SUPPORT

Fig. I-5



TYPICAL TUBE SUPPORT
PLATE PATTERN

OVERVIEW OF DENTING PROCESS



CLEAN ANNULUS

- FLUSHED BY HIGH VELOCITY STEAM-WATER MIXTURE
- LITTLE OR NO SUPERHEAT IN ANNULUS
- NO CONCENTRATION OF SOLUBLE IMPURITIES

CONCENTRATING ANNULUS

- PLUGGED WITH SUSPENDED CORROSION PRODUCTS, LOW SOLUBILITY MATL, etc.
- SIGNIFICANT SUPERHEAT
- LOW VELOCITY

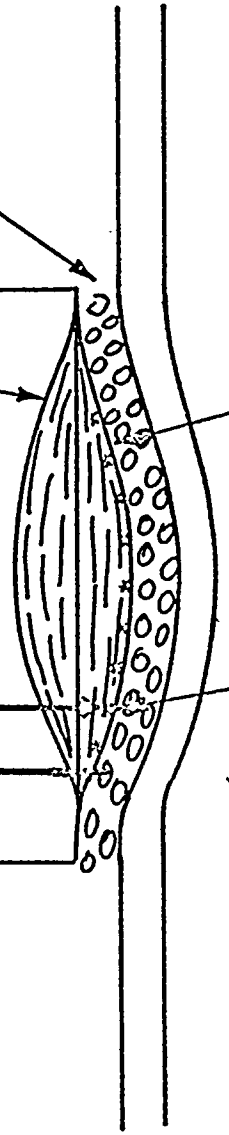
DENTED TUBE

- CONDENSER INLEAKAGE
- CONCENTRATION OF ACID SALTS IN ANNULUS

  $H_2O + Mg\,Cl_2 \rightarrow Mg\,O\downarrow + 2HCl$
- INITIATION OF "FAST LINEAR MAGNETITE" GROWTH ON CARBON STEEL

Fig. I-6

CLOSEUP OF DENTING PROCESS



HIGH CONC Fe^{+2} IN SOLUTION ($Fe\,Cl_2$)
pH ~ 5 - 7 (?)
Cl ~ 7000 - 60 (?) PPM

AT INNER SURFACE

$Fe \rightarrow Fe^{+2} + 2e^-$

$Fe^{+2} + \left\{ \begin{matrix} OH^- \\ O^{-2} \end{matrix} \right. \rightarrow Fe_3O_4$

e^-

OH^- OR O^{-2}

COPPER DEPOSITION IN VICINITY

$Cu^{+2} + 2e^- \rightarrow Cu$

- FAST LINEAR MAGNETITE

  NO BARRIER TO ANION TRANSFER

  MICRO-CRACKED, LAMINATED

AT OUTER SURFACE OF FLM

CONTROLLING REACTION

$2H_3O^+ + 2e^- \rightarrow 2H_2O + H_2 \uparrow$

Ni, Co, Cu METALLIC DEPOSITS

- REACTION CONTROLLED (LIMITED) BY RATE OF REDUCTION

  - $[H_3O^+]$ OR pH
  - AVAILABILITY OF CATHODIC SURFACES (Ni, Co, Cu?)
  - POSS. OTHER REDUCING REACTIONS

Fig. I-7

SECTION II

THE PROGRAM

Recognizing the need for expeditious handling of this problem, Florida Power and Light initiated a program to develop and implement a Steam Generator Chemical Cleaning Program geared towards the April, 1979 Refueling Outage.

Such a process is chemically feasible because dissolving sludge and crevice magnetite is an acid-base reaction, while corrosion of the carbon steel base metal is an oxidation-reduction reaction. By adding agents to inhibit the oxidation-reduction reaction, the magnetite can then be dissolved with relatively low levels of base metal corrosion.

The program has four (4) parallel paths of action, summarized below:

Path 1. Solvent Development

Since a viable process did not exist at the start of this program, there are allowances for developmental work during the course of testing.

Phase I

This involved competitive evaluation of two (2) possible vendors of a cleaning process by comparing the results of respective "Pot" boiler cleaning efforts at the Combustion Engineering Test Facility in Windsor, Connecticut. The participating vendors were Dow Chemical and Halliburton Services. In both "Pot" boiler units numerous test specimens were included for evaluating solvent action on dented tube crevices and corrosion effects on the various metals of the St. Lucie Plant Steam Generators. Additionally, an actual sample of support plate from the Millstone Unit #2 (a similar C-E Unit) was included in each run.

After careful evaluation of the results, Dow Chemical was selected to continue the program. While both Dow and Halliburton processes had achieved some success and showed strong potential, the Dow process was determined to be more viable, considering the limited amount of time to complete development of the program (approximately six (6) months).

Intermediate Phase

The period between Phase I and Phase II testing is being used to allow additional process improvement work and consists of a series of "Pot" boiler tests in Dow Chemical's Larkin Labs in Midland, Michigan. Basically, in each successive run a single parameter is varied to determine the most effective process combination. The objective is to raise the Dow process to its highest possible level of efficiency prior to the Phase II testing in January, 1979.

Phase II

This phase consists of performing a test cleaning on a Combustion Engineering "Model" Boiler in the Chattanooga Test Facility. The "Model" Boilers are larger than the Windsor Pot Boilers and in terms of design, more closely represent an actual steam generator.

The model boiler to be cleaned is being operated to dent with fault chemistry intended to duplicate the St. Lucie Steam Generator situation in a short period of time.

The results of this phase will be strongly considered in a final determination to proceed towards chemical cleaning the St. Lucie Unit #1 Steam Generators.

Path II. Vibration Analysis

The vibration analysis test program is intended to acquire base line vibration data representative of St. Lucie Plant Steam Generators before cleaning and data on

what is considered to be the post-cleaned geometry. A comparison can then be made to determine if increased vibration characteristics have occurred as a result of the chemical cleaning. Several runs are being performed to conservatively bound the actual cleaning operation.

This testing is being performed in the Combustion Engineering Windsor Vibration Test Facility. The data analysis is being directed and conducted by Combustion Engineering Steam Generator design engineers at the Chattanooga Facility.

The base line run and the first post cleaned run have been completed and preliminary results are favorable. A second post cleaned vibration run at a more conservative level is being conducted at this time and provisions have been made for a third run. The intent of this additional testing is to make allowances for a possible second cleaning of the St. Lucie Steam Generators at some time in the future and also to "profile" the vibration characteristics of C-E Steam Generators of this design.

Path III. Engineering and System Installation

(1) Design

The system design has been developed using the C-E Engineering Group for initial design work utilizing input from Dow Chemical. The final design and construction package is being developed by the Ebasco Onsite Unit #1

Backfit Group. Input and review are continuously being provided by C-E, Dow Chemical and FP&L to Ebasco as the final design package is being assembled. A formal acceptance review will be conducted by Ebasco, C-E, and Dow to ensure all capabilities and considerations have been incorporated before system construction is authorized by Florida Power and Light.

(2) System Installation

The system to apply the cleaning process will be constructed by the onsite Backfit organization consisting of labor and field supervision by Ebasco under the direction of Florida Power and Light Construction Department. Portions of the system outside containment will be built prior to refueling shutdown. The remainder of the system (inside containment) will be installed during the early part of the outage. Final scheduling and work sequencing have not been completed at this time.

The entire system for performing chemical cleaning is temporary and all portions of the system inside containment and/or having any effects on plant operation will be removed after cleaning. No permanent plant changes are required to perform this cleaning.

Path IV. Program Review

The purpose of this document is to compile the program into a single package to allow Florida Power and Light to conduct the appropriate reviews and to provide the Nuclear Regulatory Commission with the information on which Florida Power and Light has based its review.

It should be recognized that portions of the test program have not been completed at this time and of necessity, this information will be provided later, when available.

(A) Florida Power and Light

The program is being developed in such a manner as to receive appropriate reviews by the following groups:

1. Florida Power and Light Company Environmental Review Group (Non-Rad. Effluents and Waste Disposal)
2. Florida Power and Light Quality Assurance Department.
3. St. Lucie Plant Quality Control Department.
4. Florida Power and Light Engineering Department.

5. FP&L Power Resources Department.

6. St. Lucie Plant Facility Review Group.

7. Florida Power and Light Company Nuclear Review Board

(B) Nuclear Regulatory Commission

1. A meeting was held on August 31, 1978 with representatives of the Nuclear Regulatory Commission to inform them of Florida Power and Light's intent to develop a Steam Generator Chemical Cleaning Program for the St. Lucie Plant.

2. A second meeting was held with representatives of the Nuclear Regulatory Commission on October 26, 1978. For this meeting more detail was provided on the program, schedule and progress. Nuclear Regulatory Commission was also informed of Florida Power and Light's selection of Dow Chemical for continuation of the program.

3. This submittal is intended to provide additional material for the information of the Nuclear Regulatory Commission.

4. Additional meetings and correspondence will be utilized as necessary to ensure proper communication between Florida Power and Light and the Nuclear Regulatory Commission.

SECTION III

SOLVENTS

FORMULATION

The chemical formulations of the various solvent systems proposed for use at St. Lucie are proprietary at The Dow Chemical Company. A description of the solvent systems will be disclosed under provision 10 CFR 2.790 for review by the Nuclear Regulatory Commission (NRC). This disclosure is separated from this submittal and copies of the description of the solvent system are requested to be returned to The Dow Chemical Company when no longer needed for NRC review.

SECTION III

SOLVENTS

SOLVENT HANDLING

The chemicals used to formulate the proposed solvent systems for use at St. Lucie are basically common industrial chemicals. Industrial procedures and practices exist so that the personnel handling these chemicals and the environment in which they are used can be protected from excessive exposure. As formulated for use the chemicals are greatly diluted with water, thus further minimizing exposure. Furthermore, specific toxicological and environmental data will be generated for the formulations where deemed necessary.

Both toxicological and environmental data regarding these chemicals will be incorporated into the planning for and actual operations employed for the St. Lucie Steam Generator Cleaning.

SOLVENT FLAMMABILITY

The solvents proposed for use in the St. Lucie cleaning are all water based and as a result not spontaneously flammable at conditions anticipated during use or in disposal.

SECTION III

SOLVENT THERMAL DECOMPOSITION

Both theoretical and laboratory tests indicate that the types of solvents proposed for use at St. Lucie thermally decompose at elevated temperatures as follows:

Vapor

Major -- ammonia and carbon dioxide

Minor -- acetaldehyde, ethane, ethylene, propane, propylene and methane.

Liquid

Major -- carboxylic acid salts and inorganic sulfate salts.

Minor -- mixture of single amines such as dimethylamines, trimethylamines, etc.

Prolonged heating will cause decomposition to carbon dioxide and ammonia.

Because of the rinsing operation planned after the cleaning process only minor traces of residual solvent will be expected in the generators.

SOLVENT QUALIFICATION

POT AND MODEL BOILER TESTING PROGRAM

The Combustion Engineering Windsor, Connecticut, Pot Boiler Facility was used for solvent screening. Those tests have been completed, and the resulting test specimens are currently in analysis. The Combustion Engineering Chattanooga, Tennessee, Model Boiler Facility will be used for the principal confirmatory solvent test. That facility is now being prepared for the test by operation under faulted chemistry conditions intended to generate support-plate denting similar to that observed at St. Lucie. It is expected that the model boiler test will take place early in 1979.

This report section summarizes the "Pot Boiler" results available to date, and describes the test planned for the model boiler.

The Windsor "Pot Boiler" Facility is a highly flexible test loop capable of heating (among other tests) four (4) tube "pot boilers" which can be used to simulate the effects of faulted chemistry operation. Two such "pot boilers" were selected for the screening tests in this program. The two "pots" had been operated on faulted (i.e., high chloride, pre-packed crevice conditions) volatile chemistry. These "pots" displayed several dent indications each, as determined by ECT measurement. The "pots" were modified for the test by adding a loose sludge in order to better simulate the sludge composition found at the preceeding St. Lucie inspection; however, about one half of the sludge in the "pots" was baked on during the course of the preceeding high-temperature operation. In addition, sufficient Inconel surface was added to simulate the overall Inconel surface area to volume ratio of St. Lucie, since it was believed that this parameter might be significant to the performance of the solvent inhibitors.

An attached photograph shows the "pot" internals as prepared for cleaning. It can be seen that a variety of metallurgical specimens, including reverse dents, were hung in the "pot" to measure corrosion rates on representative materials. A piece of the Millstone II support plate was also included to allow comparison of field-grown magnetite denting deposits to the laboratory-grown reverse dents and the dents grown during "pot" operation.

The "pots" were then cleaned by the solvent vendor personnel using their prescribed solvent formulations and procedures. Combustion Engineering personnel were present at all times to monitor test procedures and operate equipment where necessary. Florida Power and Light personnel were present for all operations judged to be important to test or field success.

Following cleaning, the "pots" were opened and examined by all parties. Thereafter, they were returned to the loop for operation at high temperature (simulating St. Lucie steam conditions) to check for possible solvent hangover effects. At the conclusion of hangover testing, the pots were opened and disassembled for complete examination. Based on these tests and other experimental results made available to it, Florida Power and Light selected Dow Chemical for further testing. Therefore, although the results were promising on both vendors, the balance of this discussion will address only the Dow results.

The principal results available to date on the Dow "pot" can be summarized as follows:

1. The corrosion rates were acceptable, and in particular were within the criterion for carbon steel corrosion being tested by the vibration program.
2. The sludge removal was good, with only a small fraction of an inch of material left on the bottom of the "pot".
3. There was no observable degradation of the Inconel tubes, either by visual or ECT indications.
4. The Millstone specimen was completely cleaned.
5. The reverse dents and "pot boiler" U-tube dents were all cleaned to some extent, ranging from complete cleaning to roughly half cleaned.

6. There were no observable hangover effects.

Within the limits of the program status, these are considered to be acceptable results in all cases. The limited cleaning of some dents is attributed to the relatively poor solvent circulation of the "pot boilers"; good solvent circulation is an important contributor to deep crevice penetration by the solvent package. This conclusion will be tested in the Chattanooga model boiler, where fluid circulation is much closer to that expected in a typical Steam Generator.

The Chattanooga model boiler test is now scheduled for January, 1979, although preparations have been under way since September, 1978. In particular, a model boiler was fabricated having 16 heated tubes in a geometry simulating St. Lucie (see attached Figure XII-1). A support plate simulating St. Lucie was included, with the intention of generating several dents for cleaning (see attached photo). Denting is being achieved by injection of actual St. Lucie seawater and sludge simulating the St. Lucie sludge composition. All volatile treatment is being maintained using Amerzine (catalized hydrazine), which is the St. Lucie volatile additive.

It is intended that the Chattanooga test simulate the St. Lucie field operations as closely as practical. The solvent circulation equipment, therefore, will be scaled and used in a manner calculated to closely simulate the conditions expected in the generators.

The results of the model boiler test will be reported when the test has been completed.

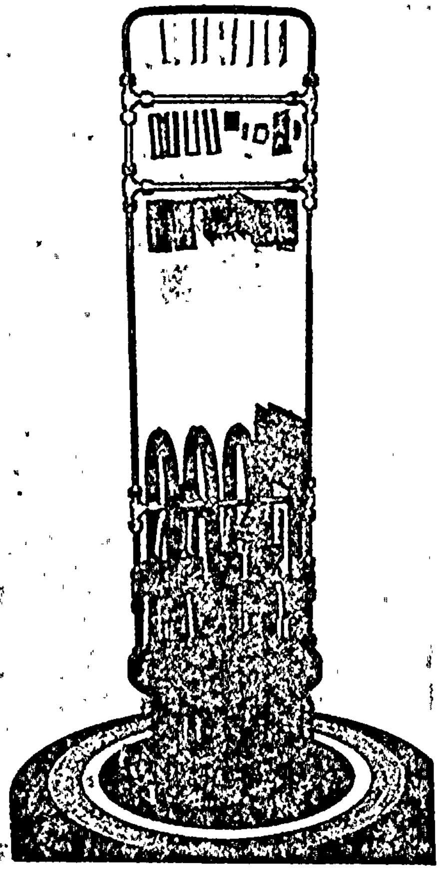
COMBUSTION ENGINEERING, INC.

WINDSOR TEST FACILITY

POT BOILER

This unit was one of two used for Florida Power and Light Company Solvent Vendor Selection Runs.

Photo taken prior to cleaning.



Unit was operated with AVT Fault Chemistry to foul and dent for Solvent Cleaning Test. Note numerous corrosion specimens to evaluate solvent effects on Steam Generator materials.

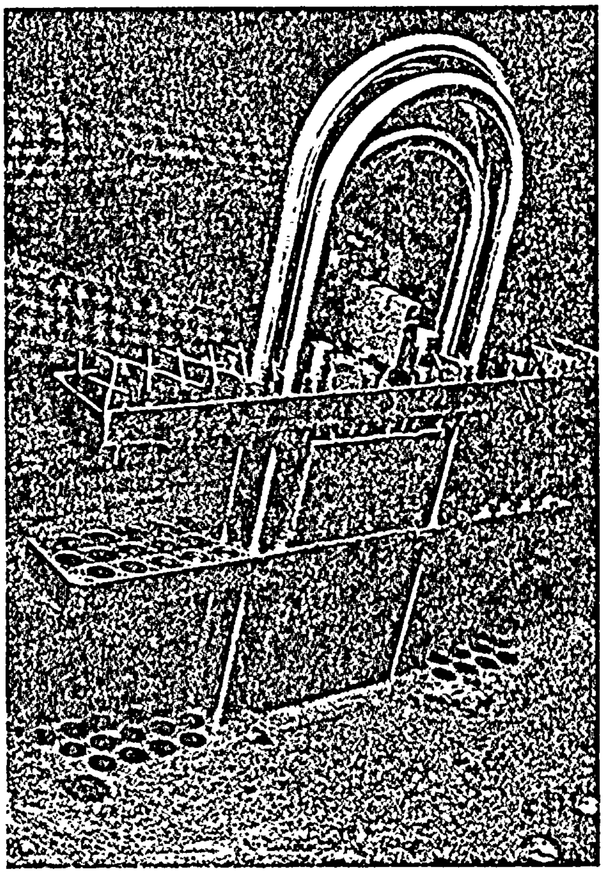
COMBUSTION ENGINEERING, INC.

CHATTANOOGA TEST FACILITY

MODEL BOILER

This unit will be used for Phase II Solvent Qualification Testing.

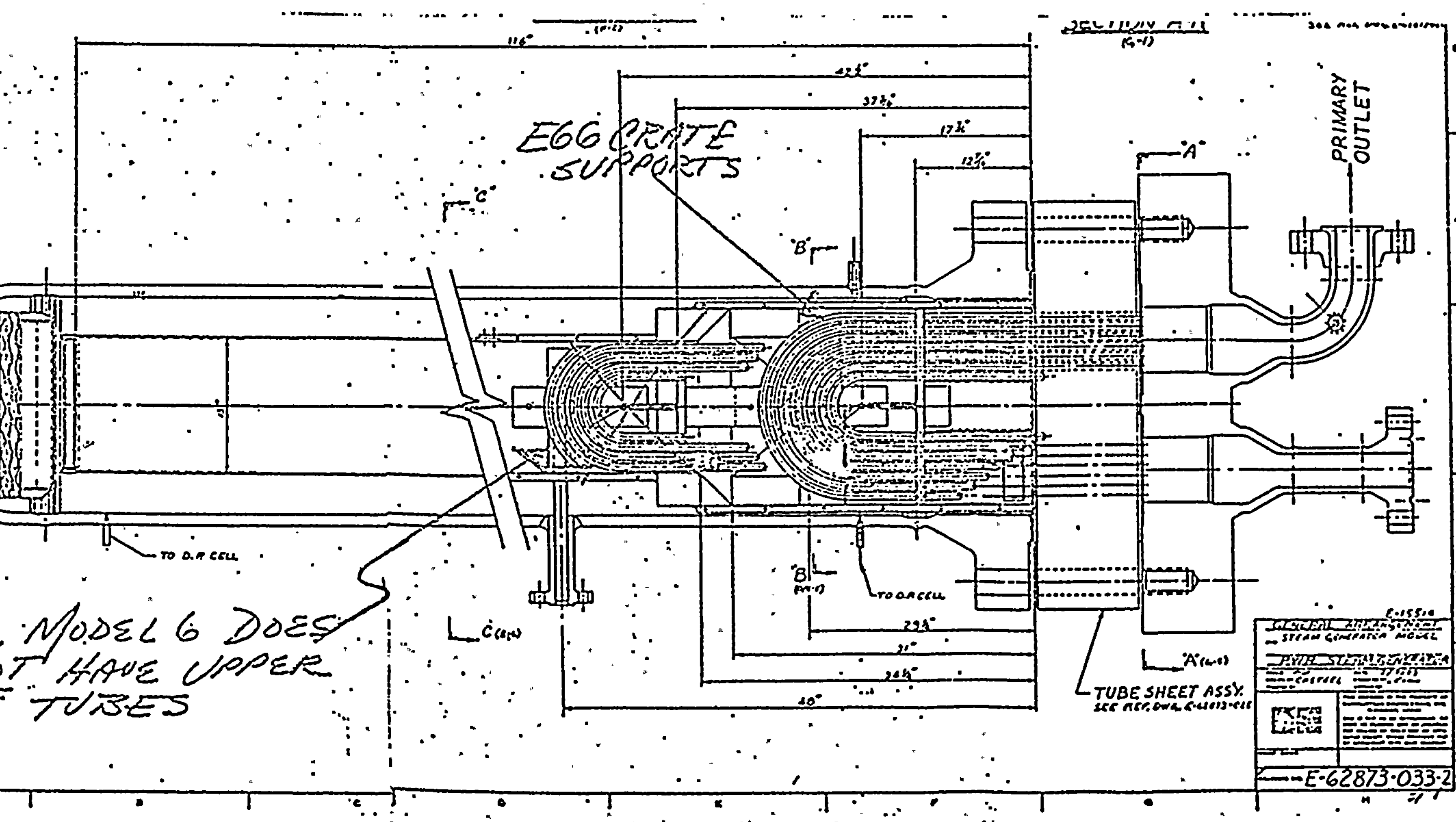
Photo taken during fabrication.



NOTE "Egg-Crate" support and drilled solid support plate.

SECTION III

Fig. III-1
C-E Model Boiler
Chattanooga
Test Facility



CHEMICAL CLEANING PROCESS DESCRIPTION

1.0 Copper Removal (NC-300)

This solvent will be mixed at the St. Lucie Plant site prior to use. This entails acquisition of demineralized water and addition of chemicals. The mixing should take 8-10 hours for completion.

1.1 Injection of NC-300 --- 2 hours.

1.2 Bulk circulation at ambient temperature about 10 hours.

1.3 Analysis of copper will be used to monitor the process.

1.4 Drain solvent -- 2 hours.

2.0 Water Rinse

2.1 Accumulate 70,000 gallons of demineralized water and inject into the Steam Generator --- 2 hours.

2.2 Circulate rinse water and drain --- 2½ hours.

NOTE: Times noted are estimates used for planning purposes.

3.0 Sludge Solvent (NS-5)

The bulk of this solvent will arrive on site in a liquid concentrated form. The concentrate will be added to water. A liquid chemical will be added with mixing to comply with NS-5 specifications. This mixing can be done during the NC-300 stage.

3.1 Inject NS-5 into the Steam Generators --- 2 hours.

3.2 Begin bulk circulation of the Steam Generators and heating to 190°F. The heating should take 4 hours. This stage will run approximately 24 hours after reaching temperature.

3.3 Iron analysis hourly by atomic absorption.

3.4 More than one iron sludge step may be needed. Additional stages would follow the same procedure.

3.5 Begin cooling solvent for next stage --- 3 hours.

3.6 Drain system with nitrogen --- 2 hours.

4.0 Chemical Rinse (NR-100)

This stage can be mixed during the NS-5 stage. Water mixed with chemicals.

4.1 Inject NR-100 --- 2 hours.

4.2 Circulate NR-100 --- 1 hour and drain --- 2 hours.

4.3 Analysis required is iron concentration by atomic absorption of the drain sample.

5.0 Copper Removal Stage (NC-300)

5.1 Mix chemicals in about 10 hours.

5.2 Inject NC-300 --- 2 hours.

5.3 Bulk circulate at ambient temperature for 10 hours and drain --- 2 hours.

5.4 Analysis of copper will be used to monitor the process.

5.5 An additional copper stage depends on analysis.

6.0 Dent Solvent *

6.1 Repeat step 3.0 (sludge solvent NS-5).

6.2 Inject NS-5 -- 2 hours.

6.3 Heat solvent to 220°F. --- 6 hours.

6.4 This stage will remain in the Steam Generators for 180 hours during which time the mechanical agitation via intermittent bulk circulation and oscillation will be incorporated.

*This stage may be subject to change pending Dow and Combustion Engineering "pot boiler" test results.

6.5 Analysis of iron by atomic absorption.

6.6 Cool NS-5 --- 6 hours and drain --- 2 hours.

7.0 NR-100

7.1 Repeat steps 4.0 thru 4.2.

8.0 NC-300

8.1 Mix half strength solution.

8.2 Inject NC-300 -- 2 hours.

8.3 Bulk circulation for approximately 5 hours. (Pending copper analysis.)

8.4 Drain -- 2 hours.

9.0 NR-100

9.1 Repeat steps 4.0 thru 4.2.

9.2 Monitor pH of solution.

10.0 Passivation

10.1 Dry chemicals are added to demineralized water and mixed.

10.2 Inject passivation -- 2 hours with slight heating. ($<120^{\circ}F$)

10.3 Bulk circulate -- ½ hour and drain 2 hours.

11.0 Water Rinse

11.1 Fill Steam Generators completely full with water (144,000 gallons) in approximately 4 hours.

11.2 Circulate for 2 hours.

11.3 Check drain sample conductivity.

*12.0 Water Rinse

* May need second water rinse pending criteria established for effluent of Step 11.0.

SECTION IV

CORRONSION CONSIDERATIONS

A) The chemical solvents proposed for use in the St. Lucie cleaning will be batch mixed according to specific procedures prior to injection into the Steam Generator as a primary control to assure proper concentration is attained. A second level assurance will be attained through chemical analysis of the solvents after the mixing but prior to injection into the St. Lucie Steam Generator.

B) During the actual cleaning operation the chemical parameters of concern for that specific solvent (strength, temperature, dissolved species, pH, etc.) will be monitored to follow the progress of the cleaning operation and thus control the operation. A significant data base has been generated during the developmental testing of the proposed cleaning process which indicates that the chemistry is predictable during use. Furthermore, the solvents employed are buffered so upsets in chemistry are not expected as they interact with the anticipated Steam Generator deposits.

C) The physical system that will be employed to apply the solvents to the St. Lucie Steam Generators will be designed so that fluid velocities in the temporary system and the Steam Generators will be below those rates acceptable based on the corrosion results attained for similar materials tested in a dynamic corrosion test system simulating the cleaning process.

D) The cleaning process proposed for use at St. Lucie incorporates the use of an external heating and cooling system which places the solvent's temperature under the positive control of the operators. Furthermore, the heating and cooling system is designed for gradual temperature changes, thus limiting to possibility of upsets leading to rapid overall temperature changes during those phases of the cleaning process where heating and/or cooling are required.

E) The nature of the cleaning operation aimed at crevice cleaning dictates that time is the factor which will be used to determine the end point of the operation. The specific time for this operation will be based on rates found to be sufficient for the satisfactory cleaning of laboratory crevice deposits. This predetermined

time limit for solvent contract will control the end point of this phase of the cleaning operation.

F) By nature chemical solutions containing iron and/or copper can be corrosive to metals during storage. The design of waste handling systems for the spent solvents resulting from the proposed St. Lucie cleaning will take these corrosive mechanisms into account.

RESIDUAL EFFECTS

One potential concern in a chemical cleaning is that small amounts of the solvents will be left behind in crevices, and that during the return to power operation, this material will be converted by high temperature into aggressive compounds. Such effects are called residual effects, or hangover effects.

There are at least two reasons that hangover effects are unlikely in the process proposed at St. Lucie:

1) There are several circulated rinse steps of various types following the presence of any compounds which might be subject to hangover behavior. Thus, the concentration of such compounds in crevices will be very low.

2) Extensive Dow testing indicates that the thermal decomposition products of the presently proposed solvents are not, in fact, aggressive.

Nevertheless, since hangover effects cannot be completely ruled out on theoretical grounds, it was decided to test specifically the proposed solvents for hangover effects. This testing was principally achieved in the Windsor pot boiler runs. There, at the conclusion of the cleaning run,

the pot boiler was re-assembled and returned to full-pressure operation, thus simulating the actual return to power operation at St. Lucie following cleaning.

After several weeks of simulated power operation, the pot was disassembled and checked carefully for any sign of hangover effects. A variety of examination techniques were used to detect any such effects:

1) Detailed visual examination of all surfaces by personnel familiar with various corrosion evaluation techniques.
2) Macrophotography with comparision to pre-hangover photographs.
3) Eddy-current examination of the heated U-tubes.
4) Destructive metallographic examination of representative samples of Inconel and other important materials.

Possible hangover effects specifically addressed in these examinations were:

1) Changes in characterized pits in pre-pitted Inconel samples (i.e., changes indicating transition from passive to active corrosion status).
2) Inconel cracking or inter-granular attack.
3) Hydrogen embrittlement.

4) Cracking, inter-granular attack, or localized corrosion of carbon or low alloy steels, especially in heat-affected zones or weld areas.

The visual and ECT examinations have been completed, and show no hangover effects. The metallographic examinations are still in process, but to date, show no evidence of hang-over effects.

If such effects are found in subsequent testing, they will be considered in the continuing evaluation of the cleaning program. For the present, however, it is concluded that hangover effects are not a concern in the process proposed for St. Lucie.

CORROSION DATA

The following Table IV-1 contains a listing of the corrosion samples and their corrosion rates included in the Dow Chemical Windsor Phase I Solvent Testing Run. The table also shows the relative location of each during the cleaning operation.

The corrosion rates are very low for all materials of concern. The highest corrosion rates observed were on A508 carbon steel. By referring to Figure IV-1a, it can be seen that this alloy is used for the tube sheets and certain penetrations, none of which represent critical tolerances and are quite capable of accommodating such corrosion rates.

Primarily because of vibration considerations, the alloy 1010 carbon steel used for the "Egg-Crate" strips is of special interest. The corrosion rates shown in the table for this alloy are being conservatively bounded by the vibration test program.

Corrosion rates will be measured in the Model Boiler Phase II Test Run in Chattanooga in January, 1979 and again during the actual cleaning operation.

TABLE IV-1

DOW SPECIMENS AND WEIGHT LOSSES

CORROSION SPECIMENS

MATERIAL	MILS CORROSION DURING CLEANING VAPOR PHASE	BULK SOLUTION	SLUDGE AREA
409 Stainless Steel	0.004	0.041	0.034
405 Stainless Steel	0.005	0.005	0.005
A 508 Steel	1.546	12.163	6.734
A 533 Steel	0.231	1.686	0.628
1010 Carbon Steel	0.201	2.671	1.978
Inconel (annealed)	<0.001	0.001	0.001
Inconel (sensitized)	<0.001	0.002	0.003

CLEANING EFFECTS SPECIMENS

SPECIMEN	VAPOR PHASE	BULK SOLUTION	SLUDGE AREA
CAPSULE GROWN REVERSE DENTS		X	X
MILLSTONE II SUPPORT PLATE SEGMENT		X	
STEAM DRYER SEGMENTS	X		
SEPARATOR CLAMP SEGMENTS	X		
INCONEL/CARBON STEEL U-BEND COUPLES			X
PRE-PITTED INCONEL TUBING	X	X	X
NUT AND BOLT COUPONS	X		
SUPPORT CASTINGS (SA 216, GRADE WCB)	X		
STRESSED WELD SAMPLE			X
HEAT AFFECTED ZONE SAMPLE			X

STEAM GENERATOR MATERIALS

As can be seen from Figure IV-1a, the Steam Generator is constructed from a variety of carbon and low alloy steels, together with the Inconel 600 tubing. For the purposes of cleaning corrosion loss, the critical components are the "Egg-Crate" supports and the support plates, both of which are fabricated of material equivalent to 1010 carbon steel. Therefore, while a wide variety of other specimens have been checked for corrosion effects, the principal focus of testing has been the 1010 carbon steel. By limiting the corrosion loss of this material to a value qualified by the vibration testing program, acceptable post-cleaning performance is assured.

ST. LUCIE PLANT UNIT #1

STEAM GENERATOR MATERIALS OF CONSTRUCTION

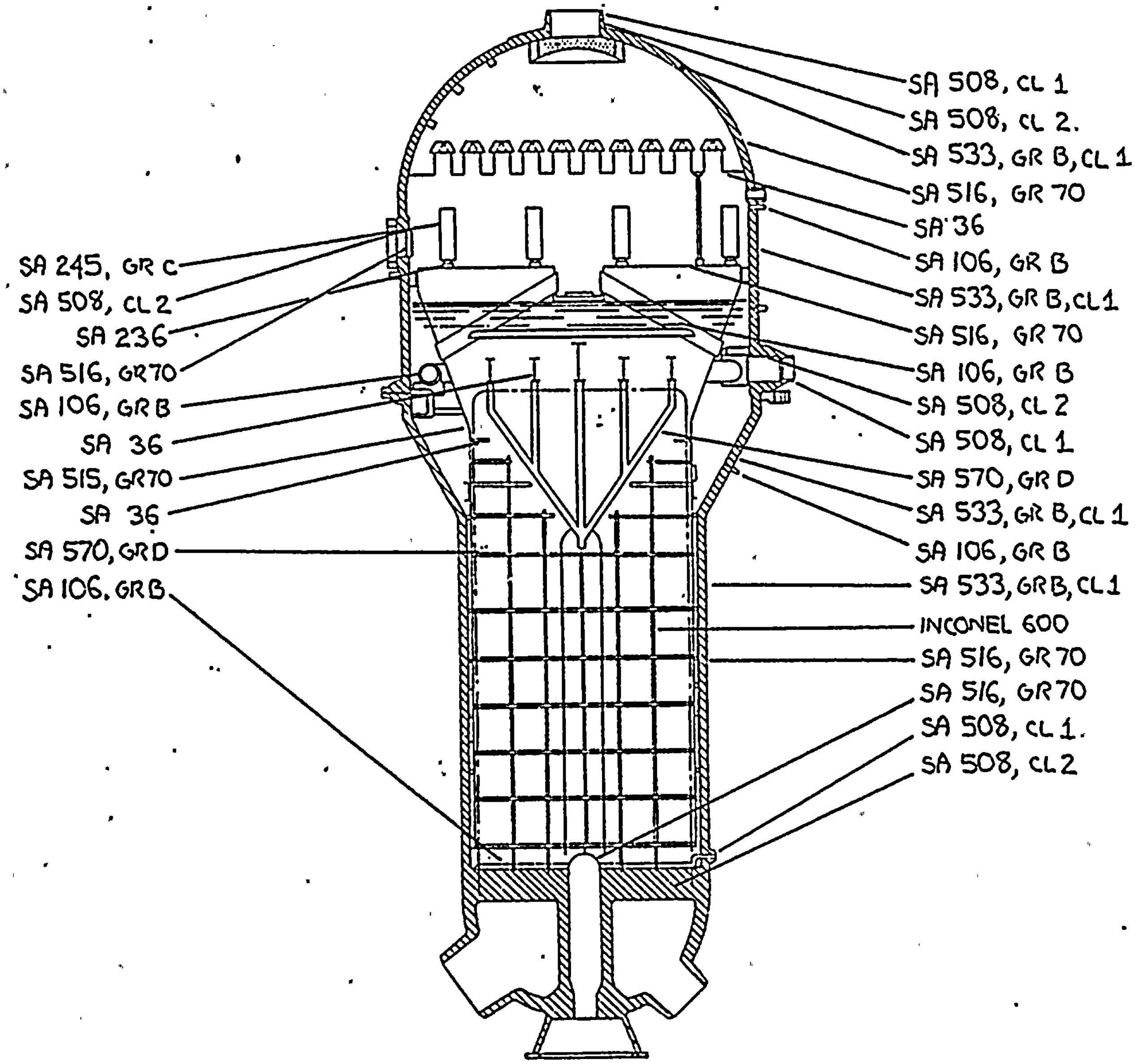


FIGURE IV-1a

SECTION V

ENGINEERING

SECTION V

ST. LUCIE I SECONDARY SIDE STEAM GENERATOR CHEMICAL CLEANING

USAGE DESCRIPTION

1.0 CHEMICAL CLEANING FACILITY DESIGN

1.1 The chemical cleaning facility consists of three principal sub-systems as follows:

1. The major system includes temporary piping and components required to inject, heat, recirculate, oscillate, monitor, drain and flush solvent(s) in the Steam Generators.
2. The second system includes temporary piping, components and 15 storage tanks, with a combined capacity of 300,000 gallons, and is required for mixing and storage of solvents.
3. The third system includes the existing Steam Generator Blowdown System (SGBS) process stream. The Copper solvent waste will be stored in the available SGBTF tankage (3-180,000 gallon tanks) and processed through the existing Blowdown Demineralization System.

2.0 CLEANING FACILITY

2.1 The major system is designed for a maximum flow capacity of 3500 gallons per minute; the actual flow rate will be determined by tests now in progress.

Suction will be from the two hand holes of each Steam Generator, through a strainer and then to the suction side of the pump. The discharge of the pump goes, with a 6" sidestream, through a set of temporary heat exchangers (designed for steam heating and sea water cooling). Two (2) 100% pumps and heat exchangers are designed into the system for reliability. Associated instrumentation and sub loops near the pumps and heat exchangers will be as follows:

1. Pressure indicator
2. Temperature
3. Sample cooler for monitoring system chemistry
4. Coupon sample vessel (corrosion specimens)

The discharge line out of the heat exchangers will tee into 2 lines, one to each Steam Generator with

inline strainers. The discharge line to the Steam Generator will tee into two (2)-8" lines with isolation valves. The 8" lines will enter through a special manway plate on the upper portion of the Steam Generator. One 8" line will go to the can deck manway and feed the existing downcomers placing solvent on the outside of the inner shroud near the feedwater ring header. The other 8" line will tee into several smaller lines that will feed down through to an area around the drilled support plates. Flow through this path will be called bulk circulation and flow through the other 8" line will establish the oscillation of this process.

Liquid level in the secondary side Steam Generator will be monitored by a level transmitter with remote readout at the control station. The main steam lines will be pinned and flooded and the water level monitored to prevent solvent vapor entry. A method for back flushing stagnant lines off the Steam Generators following the chemical cleaning will be incorporated to prevent unmonitored solvent action. The primary side coolant lines into the Steam Generators will be dammed, with the manways open, for periodic checks to verify no solvent leakage is occurring.

The feedwater lines, ring headers and annulus flow area will be flushed between chemical steps with demineralized water supplied by the auxiliary feed pumps.

A nitrogen blanket in the upper portion of the Steam Generator will minimize solvent vapor condensation on upper portion metal and assist the draining as well as supplement the required NPSH of the pumps.

Amalgamated into the design will be a method to flush the temporary piping for removal of deleterious material and to test the integrity of the temporary system.

2.2 The mixing and storage tank system is being designed for a flow of 1000 gpm. Specifications for the pump will meet the criteria established for maximum mixing and minimum injection time. Additional equipment being considered to enhance mixing and minimize time are (1) educator units on the mixing pumps, (2) hopper/conveyor, and (3) a temporary tent to protect the chemicals and solvents from the environmental elements. Tanks will be arranged and isolated to prevent the possibility of combining solvent systems. Mixing facility areas and the containment will have adequate safety showers, etc. for personnel protection.

STEAM GENERATOR CHEMICAL CLEANING PROCESS SYSTEM DESCRIPTION

DESIGN BASIS

The Steam Generator Chemical Cleaning Process System is designed to:

a) Provide a means of safely mixing the bulk quantities of chemicals required for the cleaning operation and injecting the mixed solution into the Steam Generators.

b) Provide a means of circulating the chemical solvent solutions through the Steam Generators at sufficient velocities to enhance chemical solvent reaction and to maintain the required chemical concentrations and temperatures.

c) Provide a means of heating and cooling both the cleaning solution volumes, approximately 70,000 gallons per step, and the mass of both Steam Generators.

d) Provide two (2) independent motive means of removing a chemical solvent solution volume from the generators and storing such a volume of solvent in holding tanks.

SYSTEM DESCRIPTION

The major active components of the system consists of two (2) 100% capacity circulation pumps, three (3) chemical mix-transfer pumps and mechanized bulk chemical handling equipment. The remainder of the system consists of two (2) 100% capacity heat exchangers, chemical mixing tanks, spent chemical holding tanks, pneumatic operated control valves and the piping system. Refer to the system flow diagram for additional insight into the system.

The circulation pumps are electrically driven high volume, low head, single stage, centrifugal pumps rated at 3500 gpm at 190 foot head. The pumps are constructed such that all wetted parts are stainless steel; ie, cast stainless ASTM A296, Gr CF-8M and wrought stainless ASTM A276, Type 316. The pumps are equipped with mechanical seals. As shown by the attached flow diagram the pumps are installed in parallel so as to provide two (2) 100% in-line capacity pump capability. The pumps are supplied with 480V three phase electrical power from the site construction sub-station #2 which is connected through a step-down transformer from Florida Power and Light's local 13.2 KV distribution lines. A local stop/start control station will be provided for pump operation.

The system heat exchangers are each 100% capacity units of the shell and tube design. It is intended to use one heat exchanger for heating and the other for cooling. For the heating mode of operation, 200 psi saturated steam supplied by the site auxiliary boiler will be used. Condensate build-up in the shell of the heat exchanger will be controlled manually by throttling the shell drain valve. For the cooling mode of operation low pressure salt water will be used. This water will be supplied by a temporary line connected to the plant intake cooling water system's salt water strainer blow-down line. Under this method, the only alteration to the intake cooling water system will be a continuous blow-down of the strainers.

The system provides two (2) basic flow paths for circulation of the solvent solutions. These are closed circulation through each generator simultaneously and a cyclic flow path from one generator to the other, hereafter referred to as the "yo-yo" mode. Each of the two (2) flow paths can be used to enhance fluid movement in the generators. Changes in the flow paths are accomplished using the pneumatic operated control valves.

Basically, the "yo-yo" mode of operation transfers solvent solution alternately from one Steam Generator to the

other. Fluid flow will exit one Steam Generator via the lower hand holes and enter the second Steam Generator thru the upper manway with flow directed thru the normal feed-water flow path outside the wrapper. During this operation, the tube bundles in both Steam Generators remain flooded at all times. That is only a "slosh" volume (approximately 10,000 gallons) will be transferred. Hence, the cycle times will be on the order of 2½ to 5 minutes depending upon the flowrate. Under this method, fluid movement by the support plates to be cleaned will be in both the up and down direction.

Under the circulation mode of operation, both Steam Generators are circulated simultaneously with fluid exiting from both lower hand hole connections and returning through the upper manway connections. The discharge flow is directed to the area of the support plates inside the feed wrapper. With a circulation rate of 3,500 gpm for each generator, the turnover of the solvent solution will be approximately every ten minutes. This circulation mode provides the same fluid movement velocity as the "yo-yo" mode, but only in one direction.

The chemical mixing tanks and the spent chemical holding tanks are rectangular, skid mounted, unlined, carbon steel constructed, portable tanks, each rated at 20,000 gallons capacity. Each tank is equipped with nozzle connections for filling, circulating and emptying the tanks. Level indication in each tank will be done by manual gauging.

The chemical mix/transfer pumps are electrically driven, single stage, centrifugal pumps rated at 1000 gpm at 170 foot head. The pumps are of similar construction as the main circulation pumps; that is, all wetted parts are stainless steel and equipped with mechanical seals. These pumps will also be supplied with power from the site construction sub-station #2. A local stop/start control station will be provided for each pump. The control valves are pneumatically operated butterfly valves. The valves will primarily be used in the full open or full closed mode of operation with limited throttling. These valves are constructed of stainless steel with teflon stem seals and teflon seats. For the chemical mixing and transfer tanks, manually operated butterfly valves will be used with all the wetted parts teflon coated. Each generator has a temporary 2-inch line for both venting and pressurization. Nitrogen will be used to pressurize the generators during the chemical cleaning steps to provide an inert cover gas and to satisfy NPSH requirements of the circulation pumps. This nitrogen source of energy can also be used to provide the motive force to drain the generators by gravity. The source of nitrogen will be from the plant bulk nitrogen storage system.

Material and Solvent Compatability

Piping material will be primarily standard weight carbon steel with stainless steel sleeves or target plates in high velocity areas. Dow will review selected construction materials for use with their proprietary solvents. The butterfly control valves will have all wetted parts constructed of stainless steel with teflon seats and seals.

SECTION VI

SYSTEM INSTALLATION

The temporary system to apply the cleaning process will be constructed by the Florida Power and Light/Ebasco Backfit Construction Group. Construction is intended to start about March 1, 1979 on the portions to be built outside the Reactor Containment Building. Installation of the remaining parts of the system inside the Reactor Containment Building will be completed after Reactor Shutdown for Refueling shortly after April 1, 1979.

The construction effort will consist of activities such as:

1) Installation of approximately 3000 feet of schedule 40 carbon steel pipe ranging in size from the 12" main header down to 4" lines connecting the temporary storage tanks.
2) Fitting and welding of all the elbows, valves, and fittings associated with the piping in Item 1.
3) Setting 15-20,000 gallon temporary storage and batching tanks in place.

4) Setting two (2) 3500 gpm and three (3) 1000 gpm pumps in place and providing temporary electrical power.

5) Setting two (2) 4' x 15' heat exchangers in place, piping up steam heating from the auxiliary boiler and cooling water from the Intake Cooling Water System.

6) Instrumentation for flows, pressures, levels, etc.

7) Pneumatic control system for approximately twelve (12) 10" control valves.

8) Fabricating and installing special fittings for the Steam Generator Manways for supply and return lines.

9) Drip pans, spill protection, splash guards, safety showers, eye wash, etc.

10) Pipe insulation and thermal guards.

11) Removal of the entire system after completion of the cleaning.

Precautions will be taken to ensure that the system is capable of the proper levels of protection for both personnel and equipment. Prevention of personnel injury and equipment damage will be a paramount consideration throughout the system construction and operation.

Radiation Exposure Estimates

The following figure (VI-2) shows the radiation levels found at the April, 1978 Refueling. During the November, 1978 Shutdown similar radiation levels were seen. Based on this and other Radiation Survey information, the radiation exposures expected to be incurred during the construction and operation of the cleaning system were estimated.

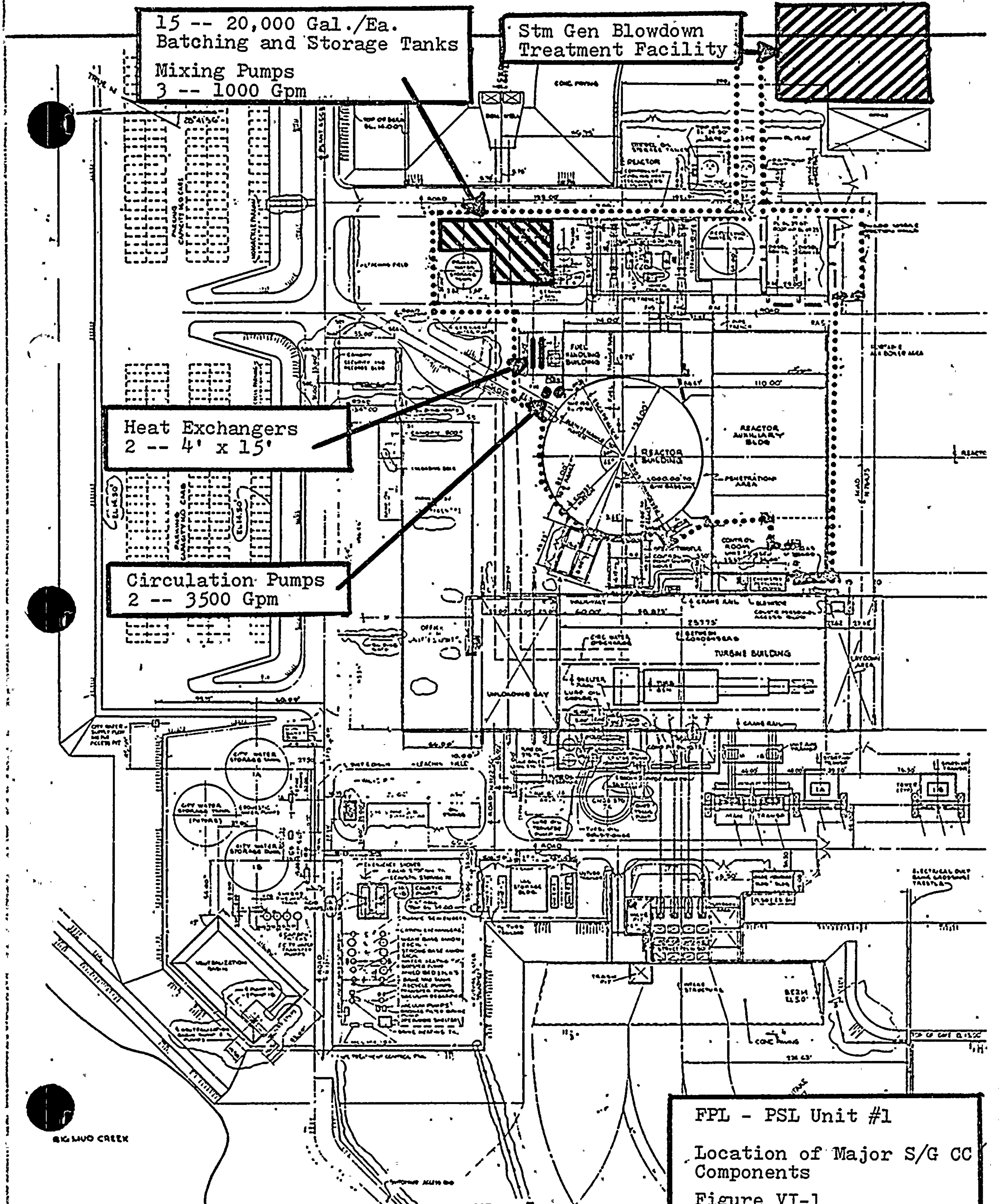
An evaluation of the activities planned and the necessity for proximity to various radiation levels has shown that the majority of the personnel exposure will be in conjunction with the construction of the temporary system inside containment.

Radiation Exposure Analysis -- Assumptions

1) The general area around the Steam Generator averages approximately 50 mrem/hr.
2) The general area in the upper (Separator) section of the Steam Generator is approximately 250 mrem/hr.
3) Twenty-five (25) men spend an 8 hour shift each working inside containment for 15 days and 50% of their time is in the general area of the Steam Generators.
4) Six (6) men work 6 hours each for four (4) days in the upper part of the Steam Generators.

A)	$\frac{25 \text{ men} \times 8 \text{ hrs/day} \times 15 \text{ days} \times 50 \text{ mr/hr}}{2}$	= 75 Man-rem
B)	6 men x 6 hrs. each x 4 days x 250 mr/hr.	= 36 Man-rem
C)	Steam Generator Inspections (Pre and Post) Based on Historical Data 5 men x 400 mrem/inspection x 2 Inspections	= 4 Man-rem
D)	Estimated Exposure from Operations and Misc. Activities	= 5 Man-rem
	Total Estimate	= 120 Man-rem

In Florida Power and Light's continuing commitment to ALARA, maximum efforts will be expended to reduce the personnel exposure to the lowest possible levels and still accomplish the cleaning task.



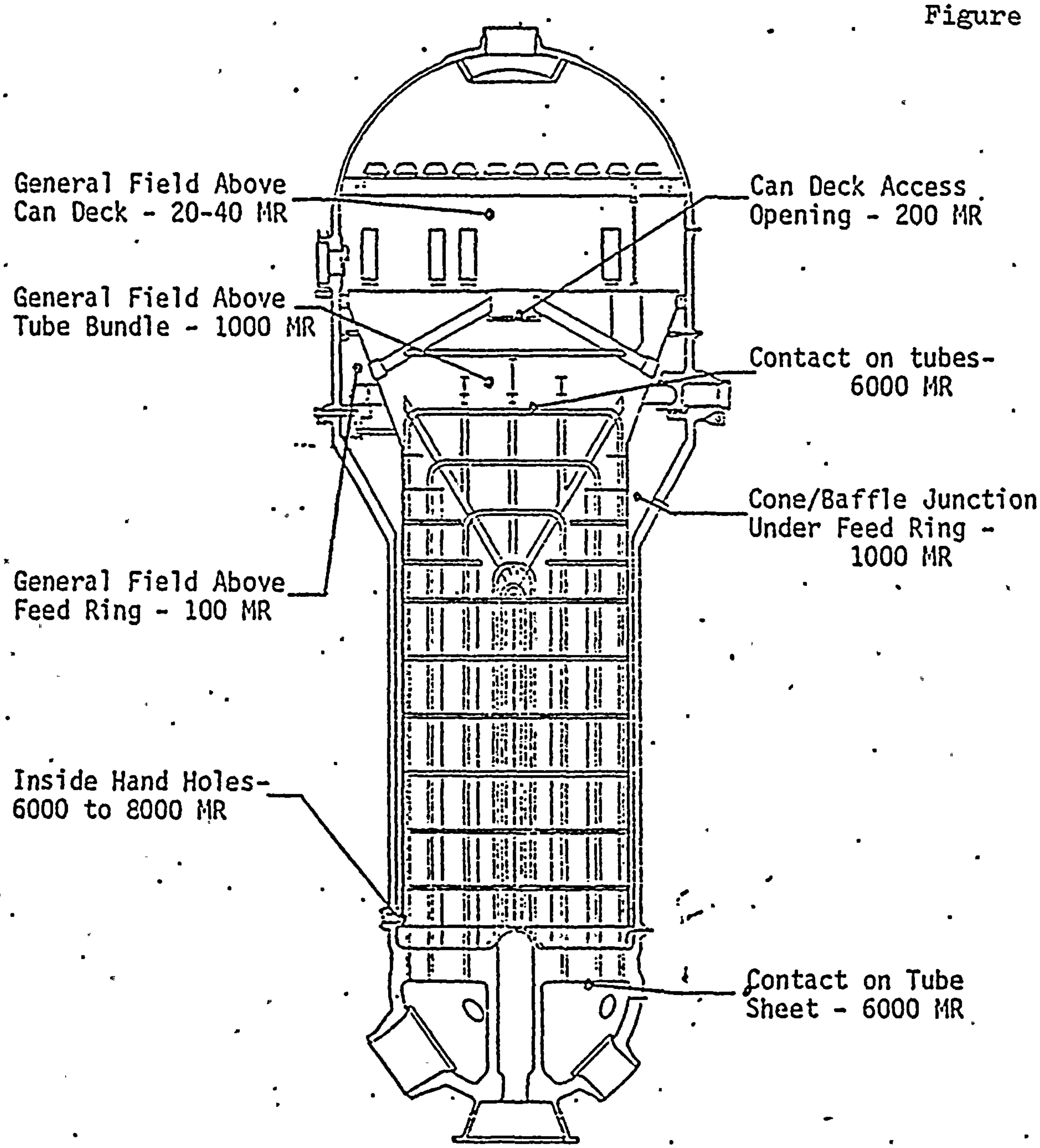
FPL - PSL Unit #1

Location of Major S/G CC Components

Figure VI-1

FP&L - St. Lucie I
Radiation Survey Data
For Steam Generators A&B

Figure VI-2



SECTION VII

SYSTEM OPERATION

I. PRE-OPERATIONAL TESTING

A) The Steam Generator Chemical Cleaning System will be thoroughly flushed in accordance with site procedures to ensure that the cleanliness requirements of the Steam Generators are maintained.

B) The system will be hydrostatically tested to $1\frac{1}{2}$ times the maximum operating pressure to demonstrate the structural integrity and leak tightness of the system and its components.

C) An initial inservice inspection will be conducted to detect sources of leakage or potential leakage.

D) Prior to starting the chemical cleaning of the Steam Generators, an operational test of the system will be performed using demineralized water to demonstrate the operational reliability of the system and its components.

II. OPERATION

A) The operation of the Steam Generator Chemical Cleaning System will be co-ordinated by Backfit Start-up Engineers/Supervisors familiar with start-up activities. The individuals selected for the Shift Co-ordinator positions are participating in the development of the cleaning program and the procedure for operation. This involvement will ensure that these individuals are thoroughly familiar with the cleaning process.

B) The Steam Generator Chemical Cleaning System will be operated by Florida Power and Light Unit #1 trained shift operators. These shift operators are considered to be best qualified for this job since their normal duties routinely involve large scale pumping operations such as this.

C) Mixing, Batching, and Chemistry Control will be performed under the direction of the Dow Chemical Project Consultants. Actual supervision of the process system operation will be by Florida Power and Light personnel in accordance with specific procedures.

D) Construction labor will be provided for handling and bulk mixing of dry chemicals.

E) All personnel involved in this project will be instructed in the hazards, proper handling, safety equipment and safety precautions necessary to ensure that safe operating conditions are maintained at all times. This instruction will include operation, location and proper usage of safety equipment.

F) During operation, the system will be monitored by Dow Chemical Engineers and Chemists to follow the progress of the cleaning and thus control the operation. The system will be monitored physically during operation by periodic inspections of all piping and components to ensure that system integrity and safety is maintained.

G) The operating procedure will be developed by Florida Power and Light Start-up Engineers/Supervisors using the guide lines of the "Chemical Cleaning Process Description" in Section III of this Safety Evaluation and input from Dow, Combustion Engineering, Ebasco and Florida Power and Light.

SECTION VIII

STEAM GENERATOR CHEMICAL CLEANING WASTE CONSIDERATIONS

I. Estimated Volumes for Waste Handling

The anticipated chemical cleaning sequence of events and generated liquid waste volumes are as follows: (Estimates include the volume associated with both steam generators and associated fluid handling system.)

1)	Copper Removal	75,000 gallons of Spent NC-300
2)	Pure Water Rinse	75,000 gallons of rinse solution
3)	Iron Removal	75,000 gallons of Spent NS-5
4)	Chemical Rinse	75,000 gallons of NR-100 rinse solution
5)	Copper Removal	75,000 gallons of Spent NC-300
6)	Pure Water Rinse	147,000 gallons of rinse solution
7)	Iron (Dent Cleaning Stage)	75,000 gallons of Spent NS-5
8)	Chemical Rinse	75,000 gallons of NR-100 rinse solution
9)	Copper Removal	75,000 gallons of Spent NC-300

10)	Pure Water Rinse	147,000 gallons of rinse solution
11)	Iron (Dent Cleaning) Stage	75,000 gallons of Spent NS-5
12)	Pure Water Rinse	75,000 gallons of rinse solution
13)	Chemical Rinse	147,000 gallons of NR-100 rinse solution
14)	Passivation	147,000 gallons of NP-100 solution
15)	Pure Water Rinse	147,000 gallons of rinse solution
16)	Final Pure Water Rinse	147,000 gallons of rinse solution

A) Total Volume Considerations

225,000 gallons of Spent NC-300 Solvent
225,000 gallons of Spent NS-5 Solvent
297,000 gallons of NR-100 Chemical Rinse Solution
147,000 gallons of NP-100 Passivation Solution
738,000 gallons of Pure Water Rinse
1,632,000 gallons of Total liquid volume waste

II. Planned Disposal Scheme

A. NC-300

1) The quantity of copper picked up by the copper solvent will be a function of the amount of copper which has been deposited within the steam generator. During the Dow Windsor Pot Boiler Test, concentrations of copper up to approximately 2500 ppm were observed.

2) The planned method for the disposal of the Spent NC-300 solution will be processing via demineralizers located in the Steam Generator Blowdown Treatment Facility. After demineralization, which should significantly reduce the concentration of copper, discharge of the demineralized effluent to the east storm basin is planned. The Spent NC-300 can be described as being similar to a liquid fertilizer.

B. NS-5

1) The quantity of iron picked up in the iron removal stages will be a function of the quantity of iron sludge deposited within the steam generators, plus the degree of component corrosion by the solvent. During the Dow Windsor Pot Boiler Test, concentrations of iron up to about 7500 ppm were observed.

2) The planned method for disposal of the Spent NS-5 solvent will be processing using caustic treatment for pH neutralization and partial precipitation. The neutralized effluent will be discharged to the east storm basin.

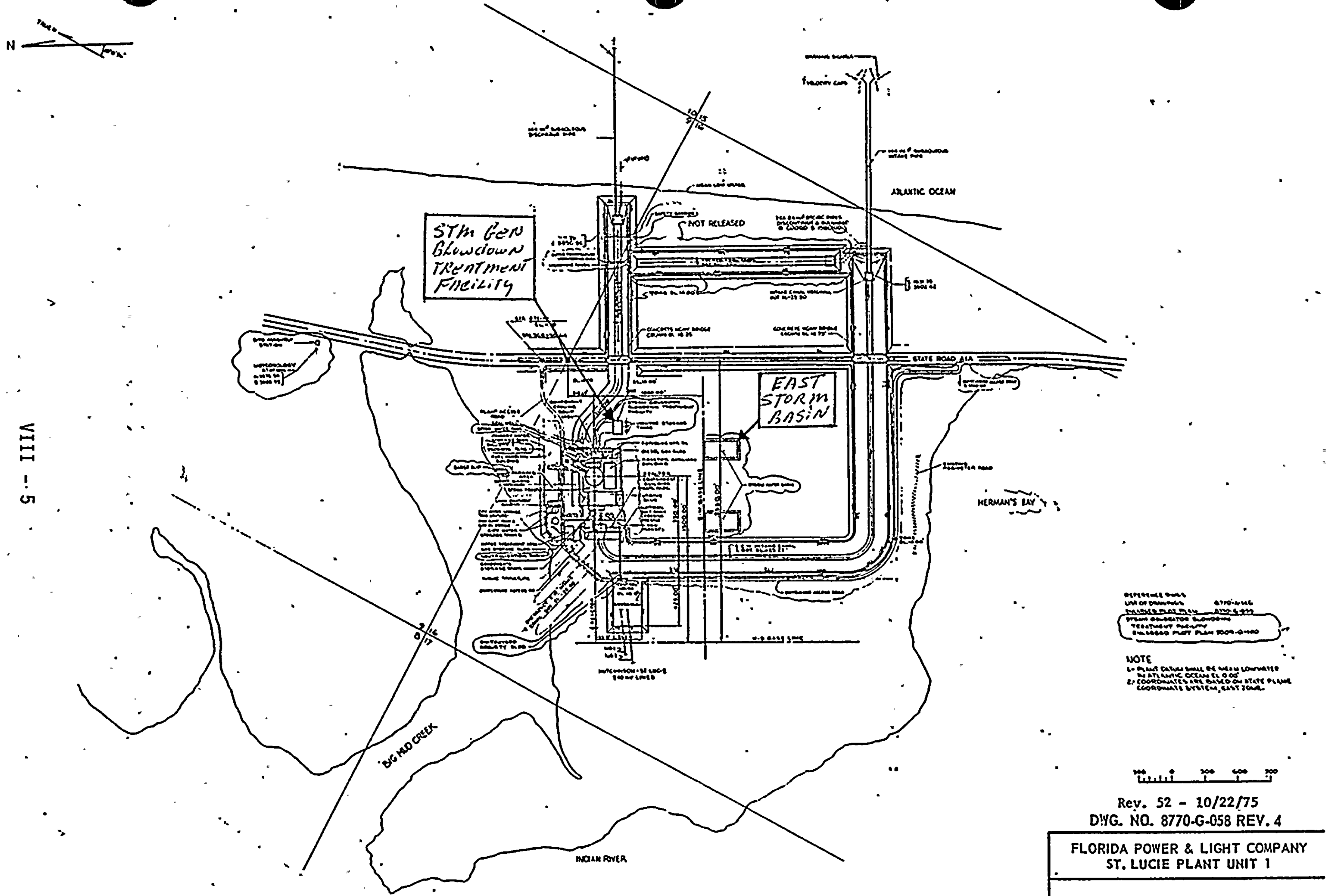
C) NP-100, NR-100, Pure Water Rinses

1) Relatively low concentrations of iron and copper are expected to be in these solutions.

2) The planned method of disposal for the passivation solution and all rinse solutions is discharge to the east storm basin.

The proposed scheme is still under review by the Florida Power and Light Company Environmental Department. Final plans will include provisions for compliance to applicable EPA and State of Florida regulations covering effluent limits, surveillances, etc. pertaining to this type of waste disposal program.

The wastes from this program will be very similar to those generated during Fossil Unit Chemical Cleanings, for which acceptable waste disposal processes already exist.



Rev. 52 - 10/22/75
DWG. NO. 8770-G-058 REV. 4

FLORIDA POWER & LIGHT COMPANY
ST. LUCIE PLANT UNIT 1

SITE PLAN
FIGURE 1.2-1

EBASCO SERVICES INCORPORATED
NEW YORK

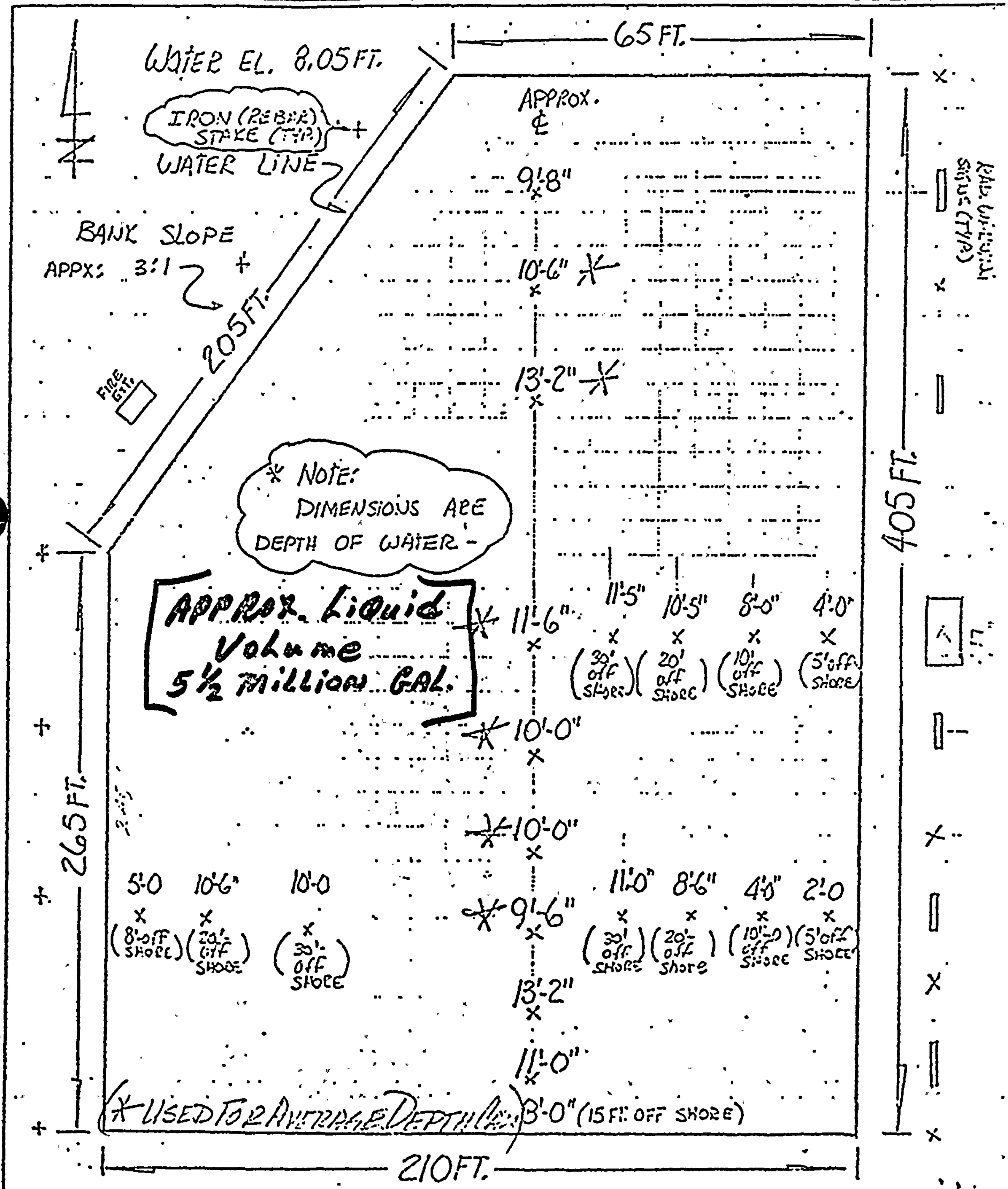
DATE 9-12-77 SHEET 1 OF 1

DATE OFS NO. DEPT. NO.

FP&L EAST STORM BASIN

PROJECT ST. LUCIE #1

SUBJECT DEPTH PROFILE OF HOLDING POND (ACTUAL MEASURE



SECTION IX

PRE & POST INSPECTION PROGRAM

SECTION IX

PRE-CLEANING INSPECTIONS

a) An eddy current examination will be conducted on both Steam Generators covering, as a minimum, the requirements of the Plant Technical Specifications and Regulatory Guide 1.83.

b) A comprehensive secondary side visual inspection will be performed on both Steam Generators including measurements to determine the clearance between the partial supports and the wrapper to verify plate stability.

c) Cognizant Dow, Combustion Engineering, Ebasco, and Florida Power and Light personnel of the cleaning effort will perform visual inspections of the Steam Generators prior to the cleaning process in order to be able to assess the effectiveness of the cleaning.

d) Radioactivity analyses of secondary side samples will be performed prior to primary side depressurization to verify no primary to secondary leakage exists.

POST CLEANING INSPECTIONS

A comprehensive secondary side inspection will be conducted including:

1) Visual inspection by knowledgeable Combustion Engineering and Florida Power and Light personnel for physical and mechanical characteristics.

2) Visual inspections by Dow Chemical personnel for effects of cleaning with particular attention to corrosion of Steam Generator internals.

3) Detailed analyses of corrosion specimens subjected to the cleaning process.

4) Samples of the final rinse water will be analyzed for contaminants etc. to verify the effectiveness of the rinses.

5) A wire gauge will be inserted into accessible intersections of the upper and lower support plates to determine if the annuli have been cleaned.

6) Eddy current examinations conducted at subsequent refuelings will determine whether or not denting has effectively been arrested.

NOTE: During the November, 1978 shutdown and again during the Spring, 1979 Refueling Shutdown, cognizant Dow Combustion Engineering, Ebasco and Florida Power and Light personnel will have become thoroughly familiar with the pre-cleaned Steam Generators in order to compare with the post-cleaned condition.

SECTION X

CONTINGENCY PLAN FOR ACTIVITY IN SOLVENT WASTE

A) Periodic analyses will be performed to determine if the solvent has become contaminated with radioactivity. Since the St. Lucie Plant has experienced no primary to secondary leakage, it is expected that the solvent and rinse wastes will be disposed of as non-radioactive waste.

B) At this time, the most likely process application will be with external heating and cooling. This method has the Reactor Coolant System at mid nozzle with the primary side of the Steam Generators drained. The likelihood of process contamination from the reactor coolant system is low using this scheme.

C) In the unlikely event that any of the solvent or rinse waste does become contaminated, the following plan will be used:

1) Each step of the process will be analyzed for radioactivity. The largest amount of contaminated waste that can occur at one time, will be one system volume (approximately 147,000 gallons).

2) The waste will be collected in the Steam Generator Blowdown Treatment Facility (SGBTF) Monitor Tanks (3-180,000 gallon tanks) and processed through

the Demineralizer System of the SGBTF. This system was designed and constructed to process radioactivity in Steam Generator Blowdown using ion exchange resins and has all provisions for activity reduction, monitoring, collecting, and discharge of processed effluent. (See attached FSAR Description.)

D) The potential for significant process waste contamination is very remote as demonstrated by the following example:

<u>Assumptions:</u>

1) Ten (10) gallons of reactor coolant are inadvertently mixed with a cleaning step.
2) The gross activity is $1x10^{-1}$ uc/ml approximately two weeks after reactor shutdown.

$$\frac{\text{10 gallons (Rx coolant)}}{\text{147,000 gallons (fill volume)}} \times 1x10^{-1} \text{ uc/ml} = 6.8 \times 10^{-6} \text{ uc/ml}$$

Processing waste of this activity does not represent a problem, particularly with the large storage capacity and high processing capability (300 GPM) of the SGBTF. Ample spare ion exchange resins will be on hand to handle contaminated waste should it occur.

Any waste needing treatment and not readily deminer-alizable would be processed thru the rad waste evaporator.

10.4.7 STEAM GENERATOR BLOWDOWN SYSTEM (SGBS)

Steam generator blowdown is utilized to maintain the total dissolved
solids (TDS) content of steam generator secondary side coolant within
normal operating limits. Primary to secondary leakage would result in
some activity accumulation within the steam generator secondary. Thus,
under these circumstances the blowdown stream would have an activity level
associated with it. Should this activity level exceed a specified limit
the blowdown stream would be processed prior to its release via the dis-
charge canal. Three blowdown process streams provide this capability.
Each stream can process the total combined blowdown (40 gpm or greater)
from both units 1 and 2. The facility is being provided on a backfit 42
basis and is expected to become operational in calendar year 1977.

During the period prior to the operation of the new blowdown treatment
facility, steam generator blowdown will be sent to the blowdown flash tank.
A blowdown sample stream is continuously monitored by a process radiation
monitor. If the monitor indicates that the radionuclide concentrations are
acceptable the blowdown will be discharged to the circulating water dis- 50
charge. If not, the blowdown is automatically terminated and can be routed
to the equipment drain tank in the reactor auxiliary building for process-
ing in the liquid radwaste treatment system. The gaseous emissions from
the blowdown flash tank vent will be continuously discharged via the blow-
down flash tank vent. Figure 10.4-2 provides the P&ID for interim system
operation.

10.4.7.1 Design Bases

The SGBS design bases are:

a) to control steam generator secondary side coolant chemistry within normal operating limits.

b) to ensure that any activity levels associated with the blowdown effluent when combined with other liquid effluents will comply with limitations governing these releases as set forth in the Technical Specifications.

c) to provide blowdown system containment isolation capability in accordance with General Design Criterion 57 (GDC57).

The SGBS is required to support normal operations. It is not required to achieve a safe shutdown, or mitigate the consequences of an accident. Based on the guidance set forth in Regulatory Guides 1.26 and 1.29 it is a Quality Group D system that need not be seismically designed. Since the SGBS is not safety related, it is housed in a structure designed to standards appropriate for non-safety related structures.

10.4.7.2 System Description

A SGBS process and instrumentation diagram is provided as Figure 10.4-1. Normally the blowdown from the steam generators is cooled in a closed blowdown heat exchanger. These heat exchangers eliminate the need for a blowdown storage tank and its atmospheric vent. Blowdown pressure is then

reduced by a pressure reducing valve. The cooled, low pressure blowdown is then routed directly to the discharge canal. Continuous monitoring of this blowdown stream is provided. Should the activity level in the blowdown stream exceed a specified value, the stream is automatically diverted to one of the three process streams. Diversion of the blowdown stream would annunciate the SGBS alarm in the control room.

Each of the three blowdown process streams is capable of processing the blowdown from both units 1 and 2 (40 gpm or greater). The three 100 percent streams and the associated valving and piping interconnections (see Figure 10.4-1) provide considerable operational flexibility. One operating mode would have one process stream aligned to receive unit 1 blowdown and one process stream aligned to receive unit 2 blowdown. Should either stream be required, it would be automatically placed in service. The remaining spare process stream would be available to reprocess liquids recirculated from a monitor tank should reprocessing be required.

Blowdown sent to a process stream passes through a blowdown filter where suspended solids are removed. It then enters the blowdown demineralizer system where the concentration of exchangeable ions in the coolant is reduced significantly. The processed blowdown stream passes through a resin trap enroute to a monitor tank. Since the decontamination factor of the process stream is more than sufficient to achieve activity levels acceptable for release, the monitor tanks may be pumped directly to the discharge canal. The activity of this discharge stream is monitored and the capability for automatic isolation is provided. Provisions are also provided to allow the monitor tank contents to be recycled to the plant for use as makeup. Low water level in a monitor tank will automatically terminate discharge from that tank.

The blowdown demineralization system consists of a cation bed demineralizer and a mixed-bed demineralizer connected in series. The cation resin used in the cation and mixed-bed demineralizers is a high capacity, strong acid exchange resin in the H^+ form. The mixed-bed anion resin is a high capacity, Type I, strong-base exchange resin of the OH^- form. Spent ion exchange resins are gravity fed to a spent resin storage tank for temporary storage prior to disposal as a solid waste.

Since the blowdown lines penetrate containment and are connected to a closed Class I system (steam generator secondary) within containment, one isolation valve is provided inside and one outside on each blowdown line. The isolation valve is located outside containment and is automatically closed on a containment isolation signal (CIS). 32

Table 10.4-1 provides a listing of design data for SGBS components.

10.4.7.3 Process Sampling and Monitoring

Process radiation monitoring is provided at two points, downstream of the pressure reducing valve and in the monitor tank line to the discharge canal upstream of the point of discharge. In addition, sampling capability is provided at several locations to allow for periodic monitoring of system performances. The sampling locations are:

a) blowdown filter influent and effluent.

b) demineralizer influent and effluent.

c) monitor storage tank contents

Capability is provided to recirculate the monitor tank contents prior to sampling to insure a representative sample.

10.4.7.4 System Evaluation

Radiological evaluations of normal gaseous and liquid are provided in Sections 11.2 and 11.3. The process streams are required if a coincidence of failed fuel level, primary to secondary leakage and blowdown rate are such that activity levels in the blowdown stream reach a level exceeding that allowable for direct release to the discharge canal. Should this occur three 100 percent separate process streams (40 gpm or greater/stream) are available. Thus, sufficient redundancy is provided to ensure the availability of the process stream as required to support normal plant operations. There are no safety related functional considerations associated with this system.

10.4.7.5 Instrumentation

Instruments are provided as required to monitor system operation. The number, type and location are shown on Figure 10.4-1. The sampling capability discussed in Section 10.4.7.3 is available to supplement process instrumentation data.

10.4.7.6 Testing and Inspection

Correct installation of the system will be verified prior to preoperational testing which will verify system functional capability. The process streams will be required from time to time during plant operation thereby providing an opportunity to periodically monitor process stream performance.

TABLE 10.4-1

DESIGN PARAMETERS FOR THE STEAM GENERATOR BLOWDOWN SYSTEM

1. FILTERS

Quantity	3
Type of elements	Replaceable Cartridge
Particle retention, micron	5
Design pressure, psig	250
Design temperature, F	200
Design flow, gpm	300
Material	Stainless Steel
Code	ASME VIII, Division I

2. DEMINERALIZERS

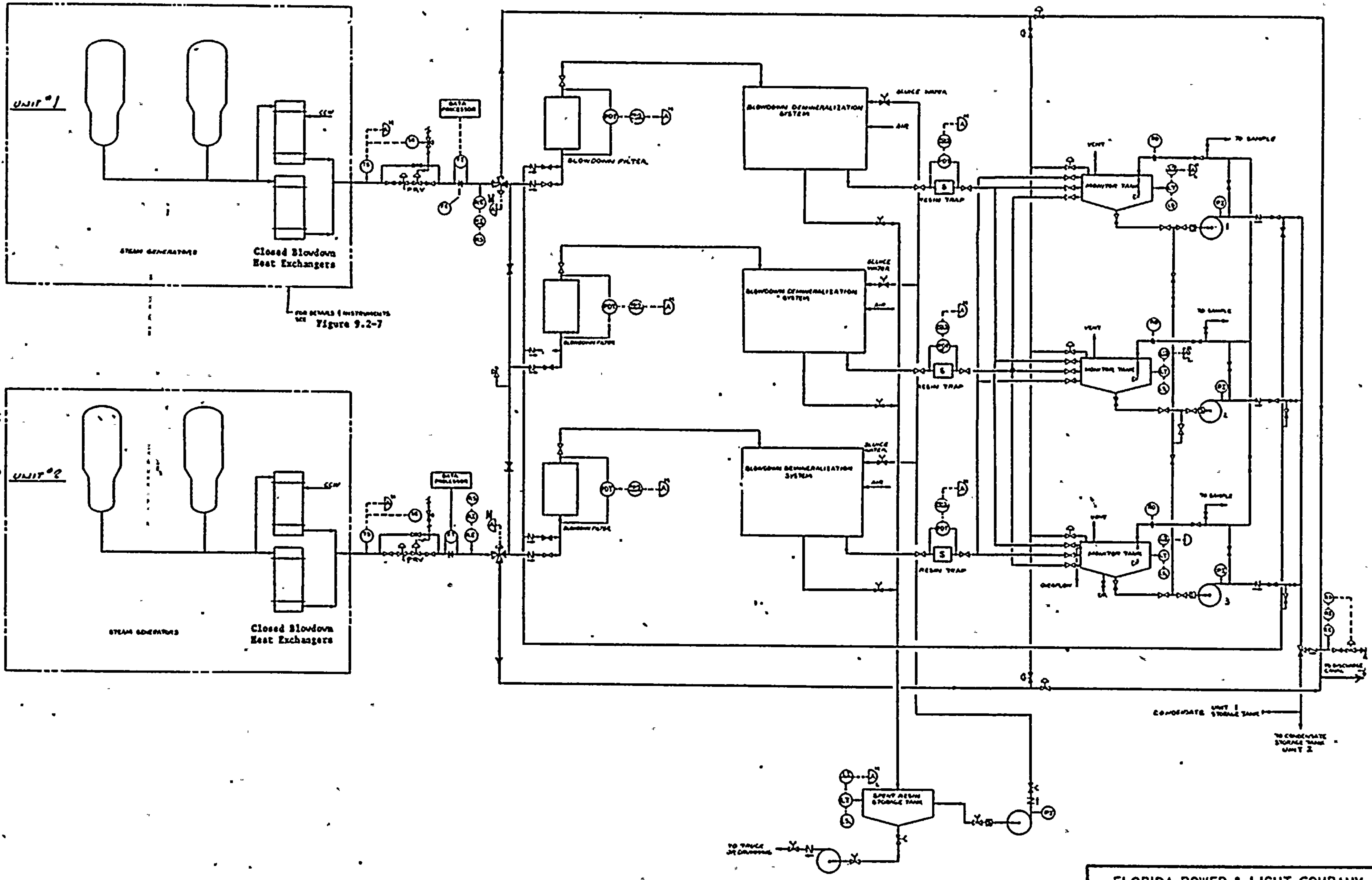
	Cation	Mixed-Bed
Quantity	3	3
Design pressure, psig	250	250
Design temperature, F	200	200
Resin volume, ft^3	150	250
Design flow, gpm	300	300
Material	Stainless Steel	Stainless Steel
Code	ASME VIII, DIV I	ASME VIII, DIV I

3. TANKS

	Monitor-Storage	Spent Resin Storage
Quantity	3	1
Internal volume, gal	180,000	8000
Design pressure, psig	Atmospheric	Atmospheric
Design temperature, F	200	150
Material	CARbon Steel (Epoxy Lined)	Stainless Steel
Code	ANSI, AWWA, or API	ASME VIII, Div. I

4. PUMPS

	Monitor Tank Discharge	Sluice Water	Resin Transfer
Quantity	3	1	2
Type	Centrifugal	Centrifugal	Centrifugal
Design pressure, psig	150	150	150
Design temperature, F	150	150	150
Capacity, gpm	400	200	10
Design head, ft	150	150	50
Wetted material	Stainless Steel	Stainless Steel	Stainless Steel
Horsepower	50	20	1
Code	N.A.	N.A.	N.A.



FLORIDA POWER & LIGHT COMPANY
ST. LUCIE PLANT UNITS 1 & 2

STEAM GENERATOR BLOWDOWN PROCESS SYSTEM [illegible] DIAGRAM

FIG[illegible] 10.4-1

SECTION XI

STEAM GENERATOR TUBE VIBRATION TESTING

SECTION XI

TUBE BUNDLE DYNAMIC RESPONSE TEST FOR CHEMICALLY CLEANED STEAM GENERATOR INTERIM SUMMARY OF RESULTS

For the St. Lucie Unit 1 Steam Generators chemical cleaning has been proposed to remove corrosion products from the tube/tube support plate crevice. Some degree of "tube denting" has been experienced, effectively increasing the tube/tube support plate clearance once chemical cleaning has been performed. There exists concern that, following the removal of corrosion products by chemical cleaning, the enlarged support clearances may induce higher tube vibration levels. This summary reviews a program for investigating the effects of enlarged tube clearances on the dynamic characteristics of a representative St. Lucie Unit 1 Steam Generator Tube Bundle. The test results provide experimental data in support of the necessary computations which will assess the effects of chemical cleaning on tube vibration.

The test model geometry is depicted in Figure XI-1, as well as its correspondence to the actual Steam Generator. The dynamic tube parameters in response to a constant

input acceleration, induced at the simulated tube sheet, are identified. A frequency sweep technique and a movable, internally mounted accelerometer are employed to map the dynamic responses along the tube height. The data is analyzed and comparisons made between the "as-built" and "chemically cleaned" conditions. Parameters of significant interest for these comparisons are:

a. natural frequencies;

b. mode shapes;

c. critical damping ratios; and

d. dynamic responses.

Testing is conducted for a water environment only.

A resonance dwell test, in excess of 10^7 cycles, at the end of the program will investigate if extended resonant vibration causes tube wear due to fretting.

In addition an analytical model was constructed (see Figure XI-2) so that a model analysis could be performed. The results were of considerable help in evaluating the data.

PHASE I RESULTS:

The test was initially run for as-built geometry. Support spacings are shown in Figure XI-1. The nominal plate hole size is 0.780 inch. The nominal "Egg-Crate" strip thickness is 0.090 inch.

For the "after cleaned" condition a radial dent magnitude of 0.020 inch was conservatively assumed for the plates. Thus the enlarged plate hole size is 0.836 inch which includes chemical action on base material. The thinned "Egg-Crate" strip thickness (due to chemical action) is 0.084 inch.

A comparative increase in harmonic tube response at the support plate levels of from two to four was observed. Little change was observed at the "Egg-Crate" levels. The structural effects of this increase is being evaluated.

PHASE II PLANS:

It is planned to further increase the clearances in both the plates and "Egg-Crates" by 0.014 inch on the diameter. Also additional instrumentation will be used to assess the effects of impacting between the tubes and supports and gain information on the increase in random tube response.

Provisions have been made to perform an additional vibration run at an even higher level of metal removal if other factors indicate a need exists.

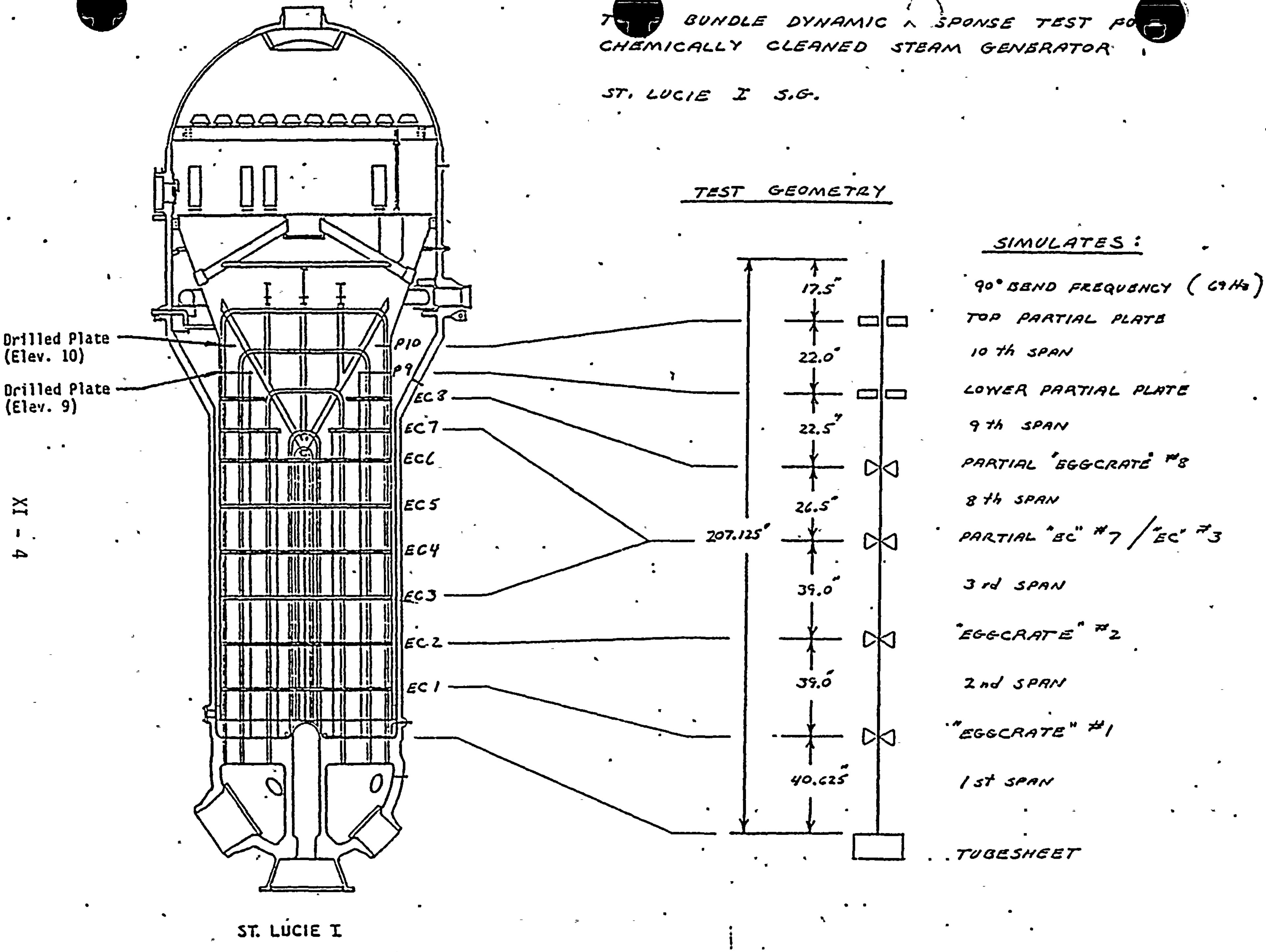
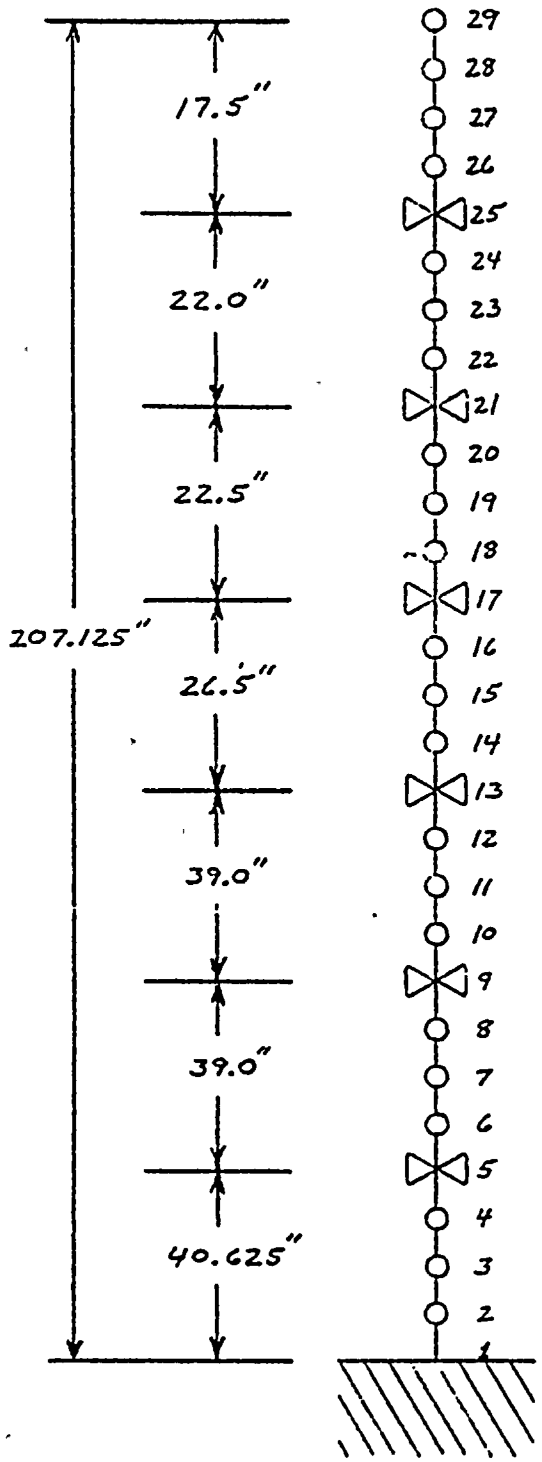

T[?] BUNDLE DYNAMIC [?]SPONSE TEST FO[?]
CHEMICALLY CLEANED STEAM GENERATOR
ST. LUCIE I S.G.
TEST GEOMETRY
SIMULATES:
90° BEND FREQUENCY (69 Hz)
TOP PARTIAL PLATE
10 th SPAN
LOWER PARTIAL PLATE
9 th SPAN
PARTIAL "EGGCRATE" #8
8 th SPAN
PARTIAL "EC" #7 / "EC" #3
3 rd SPAN
"EGGCRATE" #2
2 nd SPAN
"EGGCRATE" #1
1 st SPAN
TUBESHEET
17.5"
22.0"
22.5"
26.5"
207.125"
39.0"
39.0"
40.625"
Drilled Plate (Elev. 10)
Drilled Plate (Elev. 9)
P10
P9
EC 8
EC 7
EC 6
EC 5
EC 4
EC 3
EC 2
EC 1
ST. LUCIE I

FIGURE XI-1

EIGENVALUE ANALYTICAL MODEL



$O.D. = 0.75$ IN

$t_{WALL} = 0.048$ IN

$R_o = 0.375$ IN

$R_i = 0.327$ IN

$A_i = \pi R_i^2 = 0.336$ IN^2

$A_o = \pi R_o^2 = 0.442$ IN^2

$A_t = \pi(R_o^2 - R_i^2) = 0.106$ IN^2

$I_t = \frac{\pi}{4}(R_o^4 - R_i^4) = 0.00655$ IN^4

$\rho_t = 0.305$ lb/IN^3

$\rho_w = 0.0361$ lb/IN^3

$E = 31.7 \times 10^6$ PSI @ 70°F

$w_{VM} = 1.52 A_o = 0.672$ IN^2

$$\bar{w} = A_t \rho_t + w_{VM} \rho_w$$
$$= (.106)(.305) + (.672)(.0361)$$
$$= .0323 + .0243$$
$$= .0566 \text{ lb/IN}$$

FIGURE XI-2

SEISMIC AND DYNAMIC TEST CAPABILITIES AT COMBUSTION ENGINEERING

KARL H. HASLINGER, Supervisor
Dynamic Testing
Engineering Development & Services

Nuclear Power Systems
Combustion Engineering, Inc.
Windsor, Connecticut

Presented at
SYMPOSIUM ON SIMULATION OF SEISMIC ENVIRONMENT
at the
94th MEETING OF THE ACOUSTICAL SOCIETY
December 13-17, 1977
Miami Beach, Florida

POWER SYSTEMS

TIS-5730

SEISMIC AND DYNAMIC TEST CAPABILITIES

AT COMBUSTION ENGINEERING, INC.

The purpose of this presentation is to describe the equipment and capabilities of Combustion Engineering's Nuclear Laboratories for solving specific technical and engineering problems related to dynamic and seismic qualification testing of nuclear components and equipment.

To meet increasing demands for verification by testing of the structural integrity of reactor components (fuel elements, control rod drive mechanisms, steam generator tubes and others), together with the demand for more complete experimental data, the C-E Engineering Development Department has acquired additional test equipment and built up a dynamic test group of skilled manpower. Although this growth in capability was generated primarily to support C-E's own reactor component projects, C-E's dynamic test facility is also now rendering parametric type of vibration and seismic qualification testing services to utilities and various equipment vendors and users. This presentation is divided into five categories:

1) The staffing of the Dynamic Test Group.
2) The existing analytical capabilities.
3) The test machine capabilities (the main emphasis of the presentation).
4) The environmental test capabilities.
5) An outline of a combined analytical-experimental qualification program for a Class 1E electrical component.

STAFFING

The dynamic test group is composed of a team of four senior engineers (PHDs and MSs), a strain gauge specialist, plus experienced engineering specialists and senior technicians, experienced with vibration transducers and test equipment. This team has conducted all of C-E's extensive test programs on fuel assemblies, as well as the seismic qualification test of CEDMs (combined analytical and experimental) and several electronic packages. They are directly involved in the planning of proposed and conducted test programs. Other areas of this team's involvement include:

1) Acquisition of a digital vibration control system.
2) Dynamic testing of steam generator tubes.
3) Combined analytical and experimental seismic qualification of plant protective cabinets.
4) Field testing of reactor components.
5) Modal analysis studies and use of FFT type data acquisition system for determination of natural frequencies and damping parameters of lightly dampened, fluid-elastically coupled tubular arrays.

The staff engineers also provide consulting services to other C-E departments and to customers. Some of their projects are described in Refs. 1-4.

ANALYTICAL CAPABILITIES

The Component and the Dynamic Test Groups of the C-E Nuclear Laboratories design as well as perform analysis for the verification of structural integrity of control rod drive mechanisms under postulated mechanical excitation and seismic disturbance conditions. The STRUDL, ANSYS, MRI/STARDYNE and SAP-4* computer programs are used to perform dynamic analysis of the CEDM structures (and also of other structures including cabinets, test fixtures, etc.) and to compute their response characteristics to seismic disturbance conditions. Consequently, the dynamic test group engineers are intimately familiar with applied response spectra techniques, random vibration analysis, and time history methods. They have experience with the mathematical modeling of non-linear structures, too. This analytical expertise is complemented by extensive exposure to experimental testing.

High-speed digital computation and information processing has been employed to analyze dynamic response data from tests. The existing in-house computer programming capacity has recently been expanded by the acquisition of a digital vibration control system with modal analysis capabilities. This system provides all advanced data analysis functions such as statistical analysis, Fourier analysis, PSDs, transfer functions, auto and cross correlation analysis, coherence functions, zoom capabilities, shock spectrum analysis, etc. Fast digital plotting routines are available for all generated functions.

DYNAMIC TEST MACHINE CAPABILITIES

The nuclear laboratories have a series of electrodynamic shakers, one mechanical shaker, and two hydraulic actuators. Most important of these units are the 50-lb electrodynamic shaker, which has been successfully employed for resonance and damping surveys in the field, the 1200-lb and the 1500-lb electrodynamic shakers, and the 22,000-lb force capability hydraulic actuator, which drives the seismic simulation fixture. A second hydraulic actuator (on order with 11,000

* All computer codes are subject to C-E's quality assurance requirements.

lbs force, 6-inch double amplitude stroke and velocity capability in excess of 40 in/sec) will allow envelopment of generic type of required response spectra for C-E electronic packages and devices that are part of the plant protective systems.

Both the 1200-lb and 1500-lb electrodynamic shakers are equipped with analog type, dual-channel tracking filter vibration control and data acquisition systems. These installations allow continuous sine (resonance dwell) tests, and sine sweep tests with closed feedback loop controlled input motions. The electrodynamic shakers can also be hooked up to the digital vibration control system for more complex input motion tests, such as random or sine beat tests. One of the Spectral Dynamics, Inc. analog vibration control systems is shown in Fig. 1 with the Unholtz Dickie electrodynamic shaker, which is set up to excite a cluster of straight steam generator tubes. A tank enclosure is used to simulate the actual water operating environment for the tubes, which are supported off the building wall. Vertical support of the tubes is provided by an M/Rad Corp slip table.

Figures 2 and 3 show the biaxial, seismic simulation fixture, which has been used for sine sweep, resonance dwell, and shock response spectra tests. For the latter test mode, the analog shock spectrum synthesizer and analyzer units used initially are now replaced by the new Time Data Digital Vibration Control System which has demonstrated superior control of the shaker table motion compared with the analog equipment.

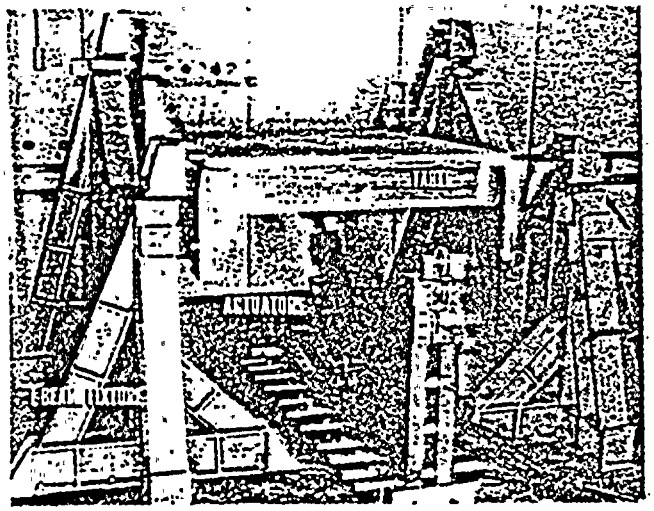


Fig. 2: Seismic simulation system

The seismic simulation system consists of an MTS electro-hydraulic actuator and an M/Rad test table. The hydraulic actuator that drives the table has a nominal dynamic force rating of $\pm$ 22,000 lbs with a maximum stroke of $\pm$ 3 inches.

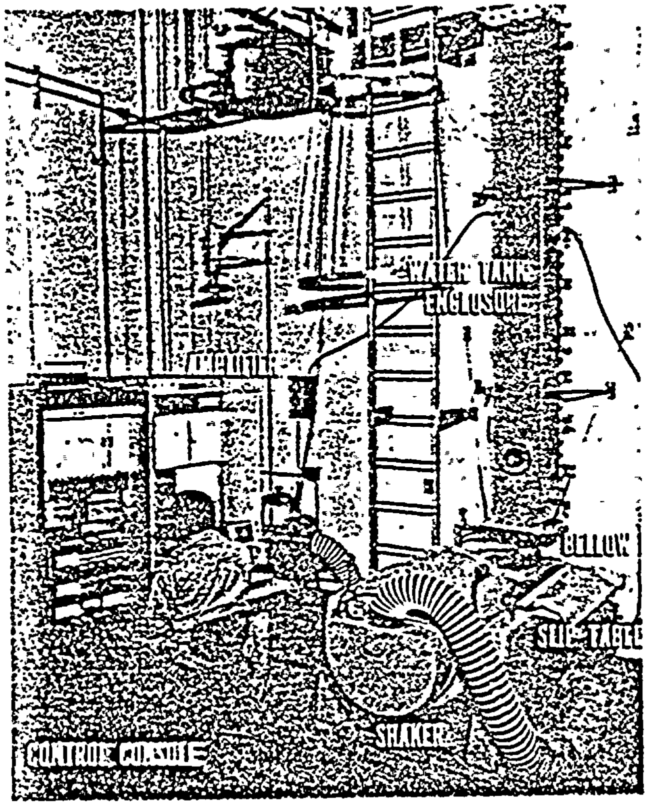


Fig. 1: Steam generator tube vibration test stand

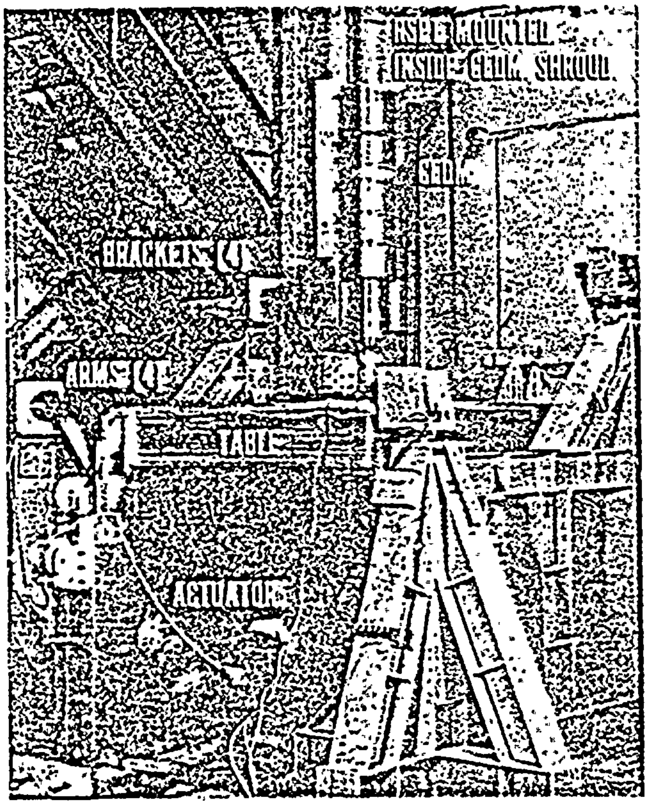


Fig. 3: Side view of seismic simulation system with mounted CEDM

The dual, high performance servo-valves provide 15 gpm fluid flow with a flat frequency response to 100 Hz. The pumping capacity of the hydraulic power supply is 20 gpm. The actuator is equipped with a swivel base and swivel head for ease in installation and use of the test table fixture.

The table is constructed of aluminum with a structural steel support frame. The top surface of the table affords a 5 ft x 5 ft test area. The 1300-lb table is supported off the frame by four two-inch-square arms, pinned at each corner of the table and to the support frame. The arms rotate on steel pins with lubricated bronze bearings.

The actuator is connected to the center underside of the test table and anchored to the floor through a vector base. The vector base permits adjusting the direction of input from horizontal to vertical. As the table is restrained by its arms, a single vectored input is converted to both horizontal and vertical motions. The relationship of the horizontal and vertical forces is adjusted by varying the input angle to the actuator with respect to the table. This angle is adjustable in five-degree increments from vertical to horizontal. The horizontal and vertical components are described as phase-locked since they are always acting together in the same vector direction.

The entire test fixture is secured to a large concrete mass by means of concrete anchors.*

The new digital vibration control system that drives the seismic simulation fixture is shown in Fig. 4 along with peripheral type of signal conditioning and recording equipment. The Time Data Corporation control system consists of a 28k memory PDP-11 computer, a hardwired processing unit and a dual cartridge disk unit. The hardware also includes the CRT display unit, as well as hard copier. The peripheral equipment shown consists of charge and voltage amplifiers for acceleration and for strain signal conditioning, an 8-channel CRT type oscillograph, a Rockland filter, and an oscilloscope. The software and front panel options purchased with the vibration control system provide for the following test and analysis capabilities:

1) Sine sweep testing (four channels).

2) Continuous random testing.

3) Response spectrum synthesis (single channel) and analysis (four channels) of 30 second (minimum) duration shock waveforms. Damping and frequency resolution variable over a wide range.

4) Synthesis of a single axis of excitation of (up to) 80 second duration time history events.

* Additional information about the sytem can be obtained from Reference 1.

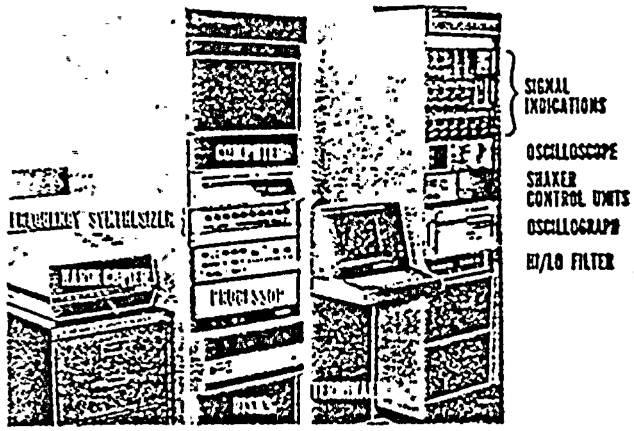


Fig. 4: Digital vibration control system

5) Modal analysis.

6) Zoom analysis and standard signal processing functions such as Fourier transfer, Auto/Cross power spectral density, coherence functions, etc.

The dynamic test facility has in excess of 50 piezoelectric accelerometers, and an accelerometer calibrator, a variety of quartz and strain gauge type of load cells, 25 LVDT type displacement transducers and a series of velocity transducers. In addition to the data acquisition channels of the various vibration control systems, the dynamic test facility is equipped with two 8-channel light-trace visicorders and three 8-channel strip chart recorders. The existing FM tape recorder with multiplexing feature adds an additional 40 channels of permanent data recording capability. The signals can be directly processed from tape by the nuclear laboratory's digital data reduction installation.

ENVIRONMENTAL TEST EQUIPMENT

Three ovens are available in the nuclear laboratories for temperature aging in an uncontrolled air environment. They are controllable up to 500 F with calibrated temperature recording devices available. In addition, there are a total of 18 autoclaves of various sizes ranging from 1-inch diameter by 18 inches long to a 12-inch diameter by 144 inches long. All are of stainless steel construction with ratings up to 3200 psi at 800 F.

Environmental testing under temperature and humidity controlled conditions is performed in a 2x2x2-ft environmental test chamber. Special test chambers have been built to accommodate long tubular types of test specimens for controlled temperature and humidity exposures.

OUTLINE FOR SEISMIC QUALIFICATION APPROACH OF CLASS 1E COMPONENTS

Figures 3 and 5 show a free-standing control rod drive mechanism (CRDM) on the seismic simulation fixture. This set-up was for a test to qualify a reed switch position transmitter (RSPT) for commercial service at two reactor installations in conformance with the requirements of IEEE 344-1975. (See Ref. 1 for details). The RSPT is a transducer element that senses the position of the control element assembly within a reactor core and provides a voltage signal analogous to it. The RSPT is mounted (inside the shroud) on a control element drive mechanism, a large number of which are in turn mounted on top of the reactor vessel head.

C-E's plants have the capability of being sited in areas where the stipulated seismic environment at the fundamental natural frequency of the CEDM may be so high that an additional seismic support would be required. Figure 6 shows a schematic of such a reactor head configuration. The design calls for 91 CEDMs with varying nozzle length. These are tied together by a series of mechanical shock arresters in a criss-cross pattern and are supported through a seismic support plate off the reactor head lift structure (Figs. 7 and 8). As for the seismic qualification requirements for the reactor head area, the reactor head lift structure, the CEDMs and the RSPTs

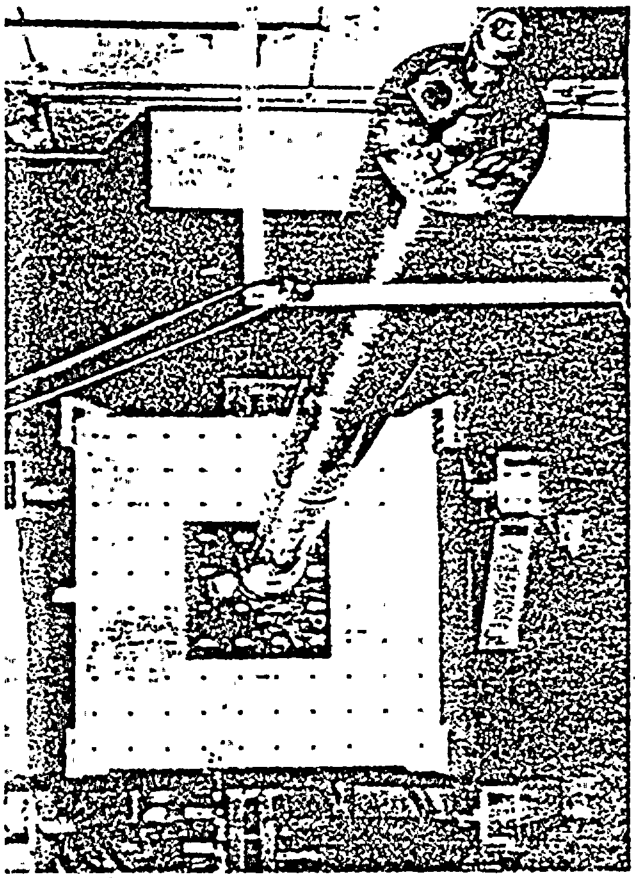


Fig. 5: Test set up CEDM on seismic table-free stand

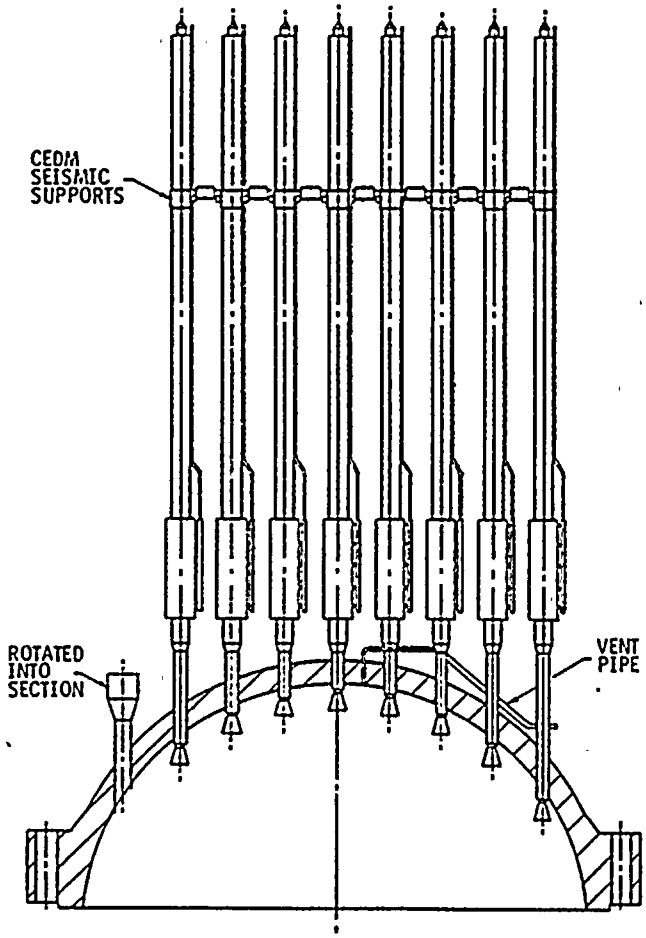


Fig. 6: Schematic of reactor head area

housed inside the CEDM shroud are of concern. Whereas the first two items are qualified primarily by analytical means (backed up by test data), the verification of the adequacy of the RSPT design is subject to a test.

As to the reactor head lift structure, the large beamplate type finite element model of Fig. 9 is used for determination of the stresses. The loading coming from the CEDMs into the head lift rig structure is considered in the analysis.

As to the qualification of the CEDMs, a representative dynamic finite element model is available (Fig. 10). The validity of the model, in terms of natural frequencies, mode shapes, and critical damping parameters, can be investigated by a series of transient excitation and forced vibration tests on prototypical free-standing or supported, single CEDMs. Since the dynamic effects of the head lift structure cannot be neglected, its fine mesh stress model representation is reduced to a simple beam type model which retained the dynamic stiffness and mass characteristics of the actual structure. The 91 CEDMs are lumped into one large CEDM type, assuming tuned frequency characteristics for all CEDMs, and then connected by a representative line snubber connection to the reactor head lift structure. For this

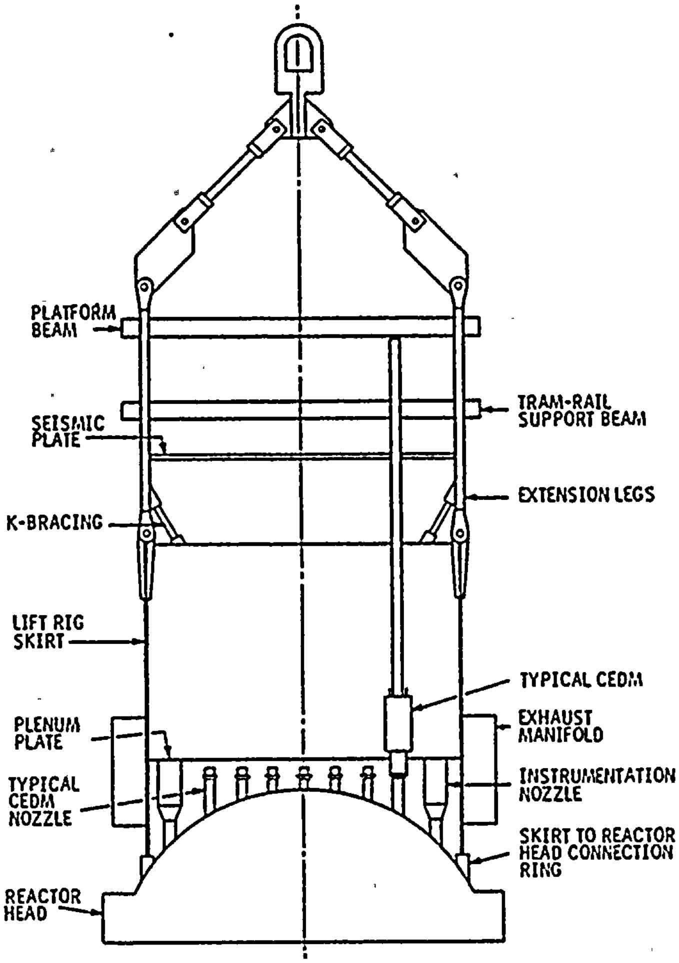


Fig. 7: Head lift rig with CEDMs

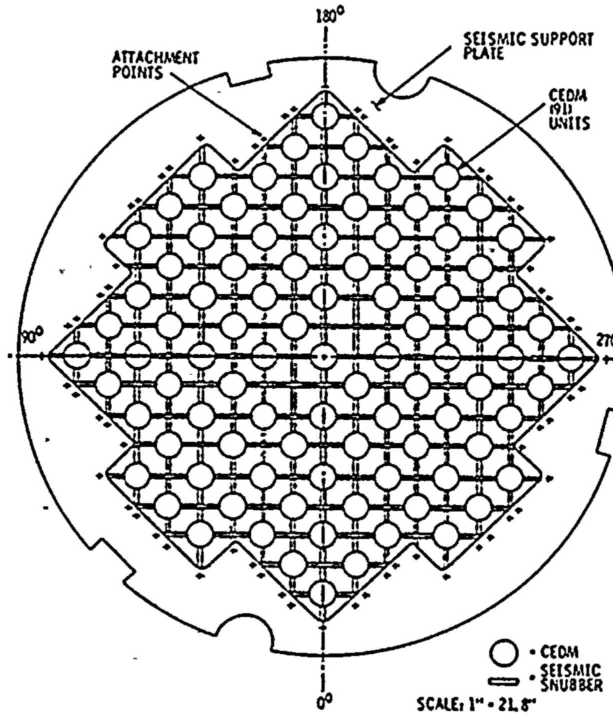


Fig. 8: CEDM seismic support attachment points

coupled configuration, a response spectrum analysis is performed with the loading input specified for the reactor vessel head elevation. Since the CEDM frequencies are highly influenced by the CEDM nozzle height, the nozzle length of the model is varied over the entire range and results from all these computations are enveloped. The stress levels determined by this conservative qualification approach were found acceptable in all cases studied.

To increase realism for plants with higher seismic requirements, parallel to this effort an analysis program has been initiated in which the individuality of all 91 CEDMs (with different nozzle lengths), snubbers, or the head lift rig structure components can be considered over a wide frequency range. From the fine mesh/stress model representations of components, such as the seismic plate or the head lift rig support barrel, super-element type mass and stiffness matrices were developed and tied together in a large computer model. Early results of this sophisticated analysis approach support the simplified method.

For the seismic qualification testing of the RSPT, our test setup is capable of simulating its

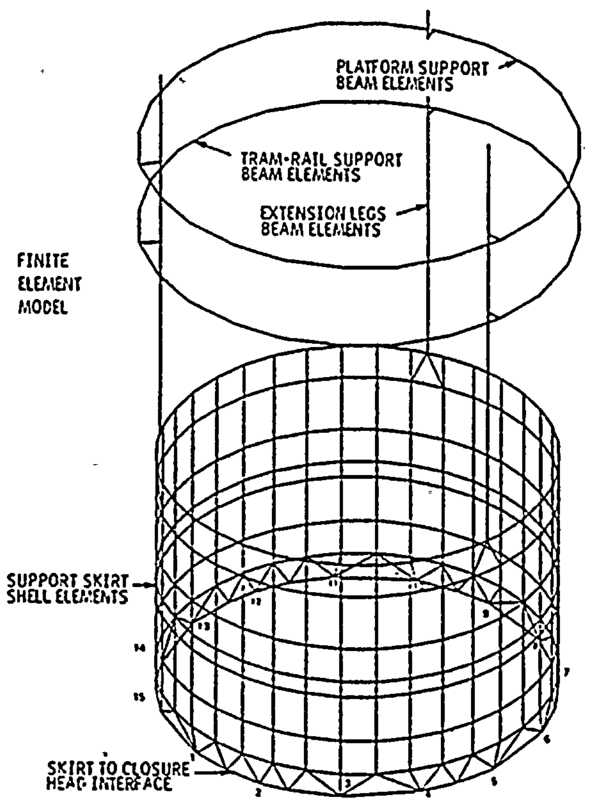


Fig. 9: Reactor head lift rig structure stress model

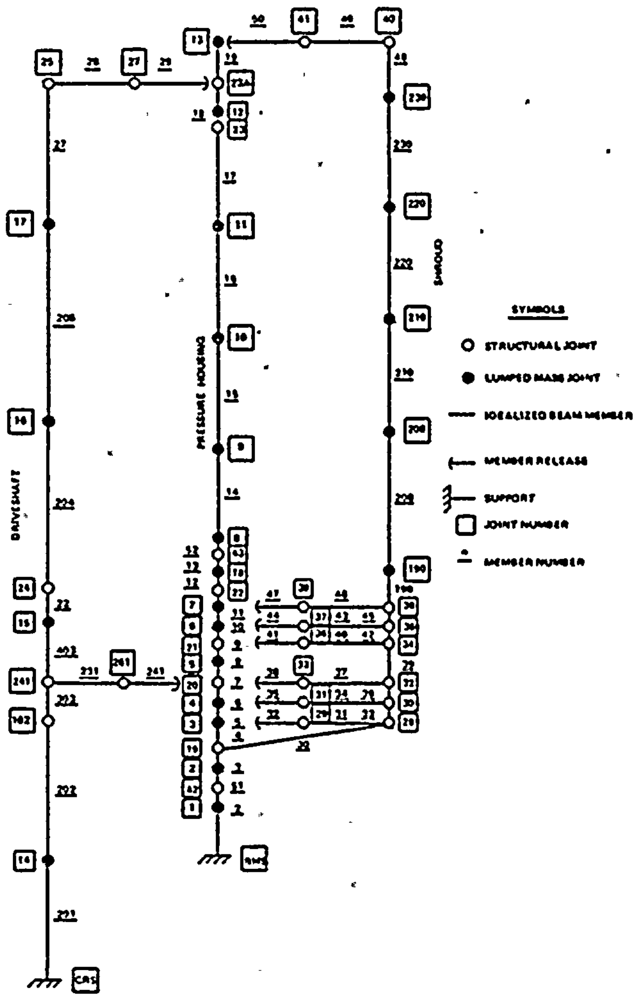


Fig. 10: Schematic representation of the theoretically modeled 150-inch CEDM

in-service mounting conditions. A full sized CEDM can be assembled on the seismic shaker table. The reed switch assembly is inserted in the shroud and clamped into place. The effects of the seismic support configuration then can be simulated in a conservative fashion by means of a mast type test fixture mounted on the shaker table. Actual shock arresters can be used to tie the CEDM to the support test fixture. Both the CEDM and its support structure will be subjected to the same excitation specified in terms of response spectra for the OBE and DBE events.

To guarantee the adequacy of this approach, the test configuration has been modeled and analyzed for its representativeness of the reactor environment. The criteria employed for the evaluation are similar frequency characteristics of the CEDM, as well as, sufficiently high root-of-the-squares displacement excursions at the RSPT mounting locations. Initially low level sine sweep tests can be conducted to demonstrate agreement of the empirical dynamic characteristics (model verification -- natural frequencies damping) of the test configuration with the characteristics predicted by the analytical modeling techniques. During the qualification test, the entire structure will be exposed to simultaneous, phase-locked vertical and horizontal excitations of equal magnitudes. The random multi-frequency input motions will be synthesized over the seismic range. Analysis of the input response spectra will be performed beyond the ZPA level. The electrical performance of the RSPT will be monitored for any transients or failure modes.

CONCLUSION

The acquisition of modern test equipment combined with test experience gained over several years in structural testing, seismic qualification testing, fluid-structure interaction patterns, and analytical modeling and computation techniques forms the basis for a strong and aggressive dynamic test group at the C-E Nuclear Laboratories. The large financial investments made during the past not only allow us to meet our in-house requirements, but allow us to provide commerical services to outside organizations.

REFERENCES

1. HASLINGER, K. H. and HORLACHER, W. R., "A Biaxial Seismic Simulation Test System," TEST Magazine, June/July 1977; Combustion Engineering Reprint TIS-5173.

2. HASLINGER, K. H., "Forced Vibration Testing of a Nuclear Fuel Assembly," Paper presented at ASME Vibrations Conference, Chicago, Illinois, September 26-28, 1977; ASME Paper 77-DET-141; Combustion Engineering Publication TIS-5139.

3. HORLACHER, W. R., "Analytical Generation of Response Spectra for Equipment Mounted in Large Cabinets," Paper presented at the 17th ICES Users Group Worldwide Conference, Cambridge, Massachusetts, September 15-17, 1976; Combustion Engineering Publication TIS-4940.

4. LUBIN, B.T., HASLINGER, K.H., PURI, A., and GOLDBERG, J., "Experimental Data on the Natural Frequency of a Tubular Array," Paper presented at Joint Applied Mechanics, Fluids Engineering & Bioengineering Conference, New Haven, Connecticut, June 15-17, 1977; ASME Paper 77-FE-10.

SECTION XII

FP&L CO. OPINION OF THE PROGRAM

SECTION XII

FLORIDA POWER AND LIGHT COMPANY OPINION

1) The application of the cleaning process will be accomplished with a system that is completely temporary. All portions of the system inside containment and/or having any effects on plant operation will be removed upon completion of the cleaning.

2) No permanent plant changes are required to perform this cleaning operation.

3) No technical specification changes are necessary in order to perform the cleaning.

4) Throughout laboratory and "pot" boiler testing, including residual hang over testing, no adverse effects have been identified. Model Boiler Tests planned for January, 1979 are expected to further confirm this.

5) A viable process exists-additional developmental work being done is oriented towards having the highest possible level of confidence that the process will clear the fouled annuli.

6) A comprehensive tube vibration test and analyses program is demonstrating that the post cleaned Steam Generator will perform mechanically as well as the pre-cleaned Steam Generator.

7) Corrosion testing has repeatedly demonstrated that the corrosion rates are acceptably low and, in fact,

may have allowances for multiple cleanings. No unexpected or exotic types of corrosion have occurred throughout testing by Dow or Combustion Engineering. In particular the Inconel Tubes show rates of corrosion very close to zero.

8) This is considered to be a maintenance evolution of a preventative nature.

Considering the preceding and that:

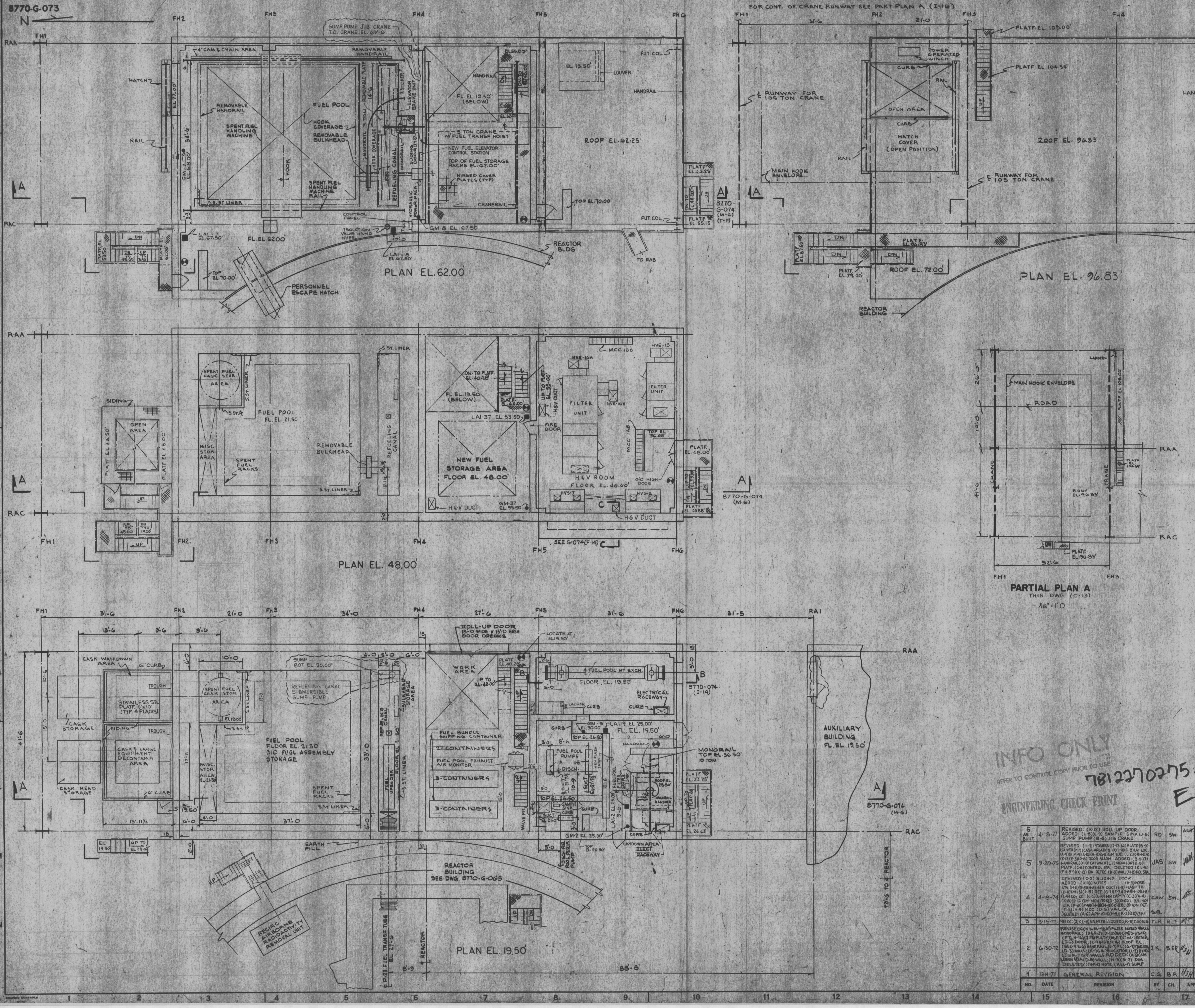
1. The probability of occurrence or the consequences of an accident or malfunction of equipment important to safety previously evaluated in the Safety Analysis Report is not increased.
2. The possibility for an accident or malfunction of a different type than any evaluated previously in the Safety Analysis Report is not created.
3. The margin of safety as defined in the bases for any Plant Technical Specification is not reduced.

IT IS CONCLUDED THAT THE PROPOSED STEAM GENERATOR CHEMICAL CLEANING PROGRAM DOES NOT INVOLVE AN UNREVIEWED SAFETY QUESTION*

* This opinion is based on information about the Steam Generator Chemical Cleaning Program as it presently exists.

Certain developmental and process testing work is ongoing at this time and may result in changes to the program. It is intended to subject any changes that may occur, when finalized, to the same review process as is conducted on this Evaluation Report. A determination will be made that these changes, if any, do not affect the Florida Power and Light opinion of this cleaning operation prior to commencement of cleaning activities on the St. Lucie Plant Steam Generators.

8770-G-073



REFERENCE DRAWINGS

LIST OF DRAWINGS	8770-A-146
SITE PLAN	8770-G-058
ENLARGED PLOT PLAN	8770-G-059
GEN. ARR. - REACTOR AUX. BLDG.	8770-G-071
GEN. ARR. - REACTOR BLDG	8770-G-068
GEN ARR. FUEL HANDLING BLDG. SECT.	8770-G-074

NOTES

PLANT DATUM SHALL BE MEAN LOW WATER IN ATLANTIC OCEAN EL. 0.00

● GM - GEIGER - MUELLER MONITOR

APM - AIR PARTICLE MONITOR

■ LAI - LOCAL/ALARM INDICATOR

⊗ CO_2 FIRE EXTINGUISHER

10 5 10 15 20 25 30 FT

1/8" = 1'-0

INFO ONLY
REFER TO CONTROL COPY PRIOR TO USE

7812270275-01
E

ENGINEERING CHECK PRINT

RECEIVED
AUG 9 1977
EBASCO SERVICES
ST. LUCIE PLANT

TERA APERTURE CARD

ARTHUR JOHN ROSSI
REGISTERED PROFESSIONAL ENGINEER
13797
STATE OF FLORIDA

NO.	DATE	REVISION	BY	CH.	APPROVED		
6 AS BUILT	4-18-77	REVISED: (K-12) ROLL-UP DOOR ADDED: (L-8)(L-9) SAMPLE SINK (J-6) SUMP PUMP (B-6) JIB CRANE	RD	SW			
5	9-20-75	REVISED: (H-2) STAIRS (D-13,14) PLATF (B-9) LOUVER (K-2) CASK AREA (K-9,10)(L-9)(G-8) LAI LOC. (A-4)(K,M-9)(L-10)(H-8)(G-6) GM LOC. (L-2,10)(H-2,9)(K-12)(E-3)(D-8) DOOR ALARM ADDED: (B-9,17) HANDRAIL (D-10) CATWALK (L-7) MONITOR (D-5) PLATF. (C-6) CONTROL STA. DELETED: (K,L-8)(F,H-8,9)(K-18) ION. DETEC. (K-8) WALL (H-8) HO. STA.	JAS	SW			
4	4-19-74	REVISED: (C-6) SLIDING DOOR ADDED: (K-18) NOTES (H-9) HOSE STA. (H-6)(G-8)(H-8) H&V DUCT (L-9) FLASH TK. (D-11)(M-13)(J-15) REF. (G-7)(E-3)(D-8)(H-10)(J-8)(L-9) CO_2 EXT. (C-5)(L-10) MR CAP'TY (C-3)(A-4)(K-8)(L-10) GM MONITOR (D-3)(D-6)(L-9)(L-10) LIA (F-8)(F-9)(H-8)(H-9)(K-8)(L-8) ION DET. (F-9)(H-9) MCC (D-6) VA LOC. DELETED: (A-6) APM (C-4)(H-8)(K-2)(L-2) GM	CAW S.B.	SW			
3	8-15-72	RELOC. (J,K,L-8) VA. PITS. ADDED: (K-9) DOORS	FLP.	RJT			
2	6-30-72	REVISED: (K TO M-9 & 10) FILTER SHIELD WALLS MONORAIL; (D & H-2)(D-10)(B & C-14)(D-11 TO 14)(F TO H-16)(I-15) PLATF; (B & F-7)(J TO L-7) STAIRS (J-6) DOOR; (C-9 & 16)(H-16) ROOF EL. (B & C-3 TO 6) HANDRAIL; (C-7) FL.; (G-7) STOR AREA (D-3) WALL; (K-1) GM-28 LOCATION; (L-2) DIM'S (J TO M-7 TO 9) WALLS ADDED: (A-3) CAM & CHAIN AREA (D-8) WALL; (H-5)(M-2) DIM DELETED: (J & K-2) NOTE; (K & L-1) SUMP	J.K.	B.F.R.			
1	12-14-71	GENERAL REVISION	C.G.	B.R.			

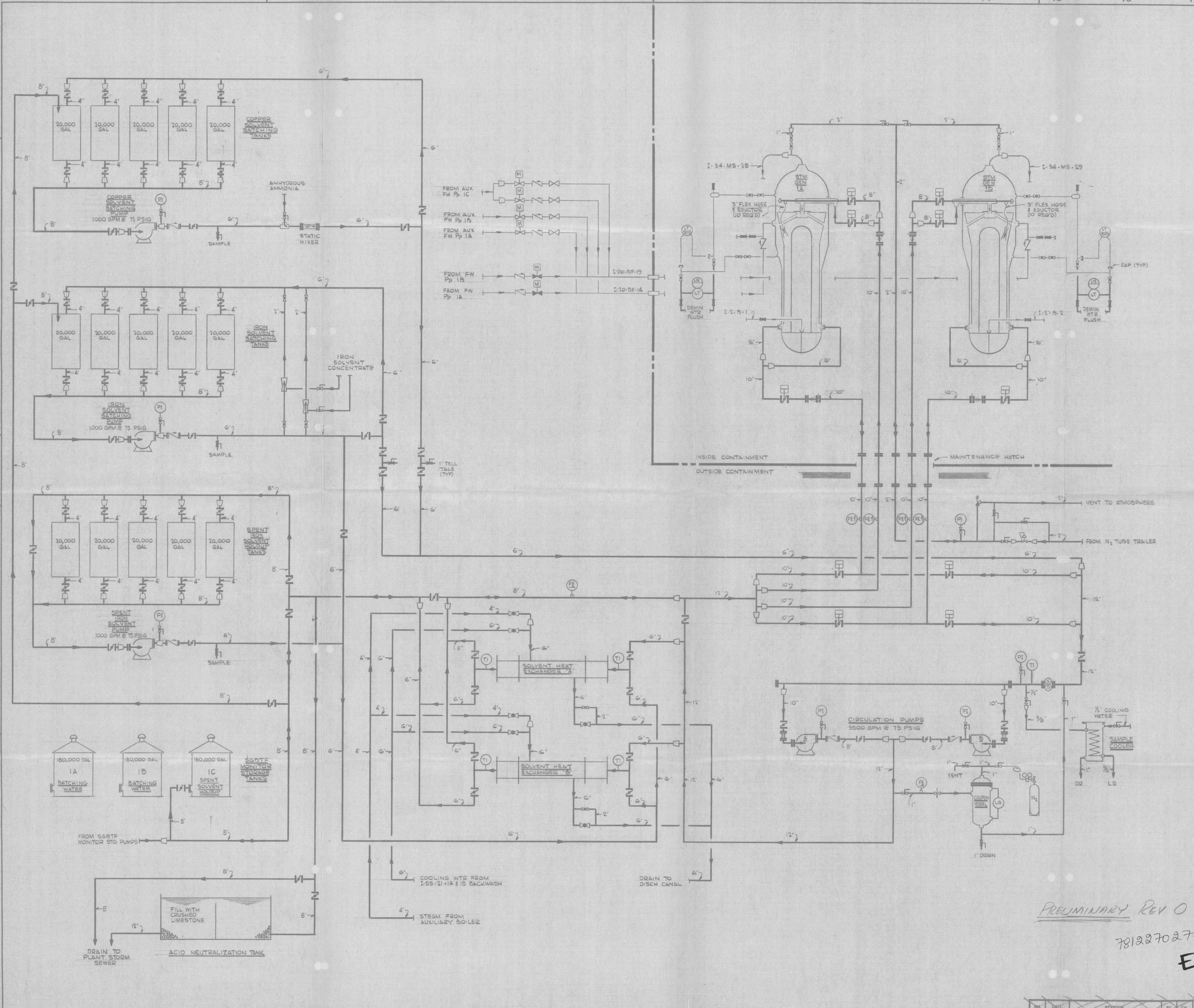
FLORIDA POWER & LIGHT COMPANY
HUTCHINSON ISLAND PLANT
1973 – 890,000 KW INSTALLATION – UNIT NO. 1

GENERAL ARRANGEMENT
FUEL HANDLING BUILDING—PLANS

EBASCO SERVICES INCORPORATED NEW YORK

SCALE 1/8" = 1'-0
APPROVED
DATE 11/17/65
DIV. MECH
DR. C. GOURGUE
CH. V. AMICO

8770-G-073



NOTES:
1. NO VENTS & DRAINS SHOWN — SUBJECT TO FINAL PIPING DESIGN
2. P&ID SUBJECT TO CHANGE TO MATCH VENDOR SUPPLIED ITEMS
3. FLUSHING CONNECTIONS TO BE ADDED SUBJECT TO FINAL PIPING DESIGN.

TERA APERTURE CARD

PRELIMINARY REV 0 11/14/78

7812270275

E

No	DATE	BY	CH	APPROVALS
2				
1				

DESCRIPTION

REVISIONS

FLORIDA POWER & LIGHT CO.
ST. LUCIE PLANT
1976 - 890 MWe INSTALLATION - UNIT 1

STEAM GENERATOR CHEMICAL CLEANING SYSTEM P&ID

C-E PROPRIETARY STATEMENT

CE POWER SYSTEMS
COMBUSTION ENGINEERING, INC
NUCLEAR POWER SYSTEMS

APPROVALS | DATE

DWG NO SE-19367-300-001

EBASCO PROPRIETARY STATEMENT

EBASCO SERVICES INCORPORATED

SCALE NONE | APPROVED | DATE

DIV.
DR. PELPHREY
CH.

BCS-125-54
.300

NO.	DATE	REVISION	BY	CH.	APPROVED