# INDEPENDENT SEISMIC DESIGN VERIFICATION
# TURBINE DRIVEN SECTION
# EMERGENCY FEEDWATER SYSTEM

V.C. SUMMER NUCLEAR STATION

DRAFT FINAL REPORT: SEPTEMBER 30, 1982

prepared for

SOUTH CAROLINA
ELECTRIC & GAS COMPANY

J.O. 14236 September 30, 1982

CONTENTS

## LIST OF TABLES



## LIST OF ATTACHMENTS



## LIST OF FIGURES

## 1.0 INTRODUCTION

### 1.1 General Scope

Stone & Webster Engineering Corporation (SWEC) was engaged by South Carolina Electric & Gas Company (SCE&G) to perform an independent review of the seismic design for the flow path of the Turbine Driven Pump of the Emergency Feedwater System to Steam Generator at V.C. Summer Nuclear Station, Unit 1. The review consisted of three major tasks, specifically;

1) Field Walkdown: Verification of the as-built piping configuration
2) Stress Analysis and Evaluation: Analysis of the as-built piping system, review of stresses and support loads, and
3) Design Control Audit: Review of the design control procedures and implementation thereof by Gilbert Associates Incorporated (GAI), the designer of V.C. Summer Nuclear Station, Unit 1.

This report presents the final findings and recommendations. An earlier status report dated July 9, 1982 is enclosed as Appendix A.

### 1.2 Stone & Webster Qualifications and Independence

SWEC has extensive experience in the engineering, design, construction and startup operations for nuclear power plant projects as well as special expertise involving seismic design analysis, field verification efforts, and pipe stress and support reanalysis required by recent NRC I&E Bulletins. SWEC also has extensive experience in Quality Assurance aspects of the nuclear power industry and in auditing of large highly technical and complex projects. SWEC is justifiably proud of its record and large staff of capable and experienced personnel.

SWEC, its parent company Stone & Webster, Inc., its affiliated companies and all personnel assigned to this evaluation are independent of South Carolina Electric & Gas Co. Work performed by Stone & Webster and its affiliated companies for SCE&G represents only a miniscule portion of Stone & Webster's business. Stone & Webster, Inc. and its subsidiaries have no holdings of SCE&G securities. The Employee Savings Plan of Stone & Webster, Incorporated and participating subsidiaries is administered by the Chase Manhattan Bank, N.A. as trustee. Funds may be invested in the Employee Benefit Investment Funds, Equity Fund of the Chase Manhattan Bank which is a comingled fund. Stone & Webster exercises no direct control over the investment of such funds.

Table 1-1 lists personnel assigned to the various tasks. Dr. P. Dunlop, Project Manager, has overall responsibility for the project. Dr. K. Y. Chu is Project Engineer responsible for the technical evaluation (Tasks 1 and 2) and is independent of Mr. J. H. MacKinnon who is responsible for auditing the GAI design control program (Task 3). All key technical personnel assigned to the project signed disclosure statements (Attachment 1-1).

## 1.3 Evaluation Process

All work was performed in accordance with pro_ _ procedures (Table 1-2). Whenever a reviewer noticed anything outside the criteria, or had any question about the information or data, the reviewer identifed this. Specific procedures for identifying questions were different for each of the three major tasks and are explained in the task specific project procedures (Table 1-2).

### 1.3.1 Field Walkdown (as-built verification)

All field measurements were recorded directly on the piping isometrics. Whenever the measured values differed from the isometric values by more than the criteria presented in VCS-1, Field Walkdown Procedure, the recorded values were circled on the isometrics and also recorded on Difference List (DL) Forms. Copies of the marked-up isometrics and DI forms were provided to SCE&G at the end of the Field Verification Effort.

Section 3 presents complete details of this effort.

### 1.3.2 Stress Analysis and Evaluation

All analyses were performed in conformance with VCS-3, Analysis and Evaluation Procedure and VCS-4, Analysis and Evaluation Criteria. These provided the procedures and criteria for performing the piping reanalysis. Procedures for highlighting differences are defined in Procedure VCS-3. Questions raised by the stress analyst were formally recorded and resolved. A two step procedure was used. An Open Item Report (OIR) was initiated for all items requiring clarification or confirmation. The OIRs were formally transmitted to SCE&G for their review an evaluation. If a satisfactory resolution was received, the OIR was formally closed out. If a possible error or inconsistency was confirmed a Potential Discrepancy (PD) was written. Section 4 presents complete details of this effort.

### 1.3.3 Design Control Audit

Of the three tasks, the procedures and resolution of items for this task were more subjective. The personnel assigned to this effort were experienced certified auditors who performed the audit in conformance with general SWEC standards for such audits. Section 5 presents the complete audit report for this effort.

## TABLE 1-1 PROJECT PERSONNEL

Project Manager: Peter Dunlop

. Project Engineer: K. Y. Chu
. Assistant Project Engineer: J. F. Pam

. Design Control Audit Manager: J. H. MacKinnon

### TASK 1 FIELD WALKDOWN

N. Roth (Lead Field Verification Engineer)
K. Anderson
J. Y. Chen
D. Loffa
A. Moss
L. Peterson
V. Saleta

### TASK 3 DESIGN CONTROL AUDIT

D. Malone

R. Twigg

### TASK 2 STRESS ANALYSIS AND EVALUATION

T. Wei (Lead Engineering Mechanics Engineer)
J. Y. Chen
J. Chiang
Y. Chin
J. Chu
D. Loffa

## TABLE 1-2 PROJECT PROCEDURES

(A) TASK SPECIFIC PROCEDURES

FIELD WALKDOWN EFFORT

VCS-1 Field Walkdown Procedure

STRESS ANALYSIS AND EVALUATION

VCS-3 Analysis and Evaluation Procedure
VCS-4 Analysis and Evaluation Criteria

DESIGN CONTROL AUDIT

Design Control Verification Plan

(B) PROJECT GENERIC PLANS/PROCEDURES

Quality Assurance Plan
Document Control Procedure - VCS-2
Quality Assurance Records Procedure - VCS-5
Engineering Assurance Audit Program
E. A. Review Plan 1720 - Independent Seismic
Design Verification - Field Walkdown Effort

INDEPENDENT SEISMIC DESIGN VERIFICATION
V.C. SUMMER NUCLEAR STATION, UNIT NO. 1
SOUTH CAROLINA ELECTRIC & GAS CO.

Statement Regarding Potential or Apparent
Conflicts of Interest

To: Stone & Webster Engineering Corporation

Whereas, the undersigned employee ("Employee") understands that he or she is assigned as a participant to provide services to South Carolina Electric & Gas Company with respect to the Design Verification Program for the V.C. Summer Nuclear Station; and

Whereas, Employee understands that it is necessary that the participants be screened for any potential or apparent conflicts of interest with respect to this assignment;

Therefore, for the above stated purposes Employee makes the following representations to Stone & Webster Engineering Corporation:

1. Employee has not engaged in any work or business involved with or related to the engineering or design of the V.C. Summer Nuclear Station other than this Design Verification Program;

2. Neither Employee, nor any members of his or her immediate family, own any beneficial interest in the South Carolina Electric & Gas Company, including but not limited to common or preferred stock, bonds or other securities issued on behalf of the South Carolina Electric & Gas Company; and

3. None of the members of Employee's immediate family are employed by South Carolina Electric & Gas Company.

This statement is based upon the Employee's best information and belief and any exceptions to the representations contained herein have been described on the reverse side of this document.

Dated______________________________

Signature__________________________

___________________________________
Print Name

## 2.0 SUMMARY AND CONCLUSIONS

### 2.1 Conclusions

The following are the conclusions for each of the three tasks in this independent review of the seismic design of the turbine driven portion of the Emergency Feedwater System to Steam Generator C at the V.C. Summer Nuclear Station Unit 1.

1.) Field Walkdown - In general the field walkdown verified that the as-built condition of the piping subsystem reflected the design layout as presented on the isometric drawings. Where differences exceeded the stringent criteria they did not affect the stress results. One penetration, P-IB-1-041, had a very small clearance. SCE&G stated that this would be reviewed as part of their field sleeve clearance program which had not been completed at the time of SWEC's field investigations.

2.) Stress Analysis and Evaluation - The as-built piping was found to be within code allowable stresses throughout. Numerous differences in support loads were discovered. These were due to three causes; failure to include Diesel Generator Building seismic response spectra and movements in one piping subsystem, misorientation and mislocation of impingement jets, and modeling differences. Errors were subsequently corrected and are reported herein.

   Because of the significance of the omission of the seismic effects of the Diesel Generator Building and the finding in the design control audit related to response spectra it is recommended that piping systems be reviewed to ensure that all appropriate response spectra and seismic anchor movements are incorporated in the analysis of the as-built piping systems.

   Because of the inconsistencies in the jets, their orientation, location and combination with other loads it is recommended that these items be carefully reviewed. It is further recommended that GAI specification 1902 be updated to clearly reflect the design criteria applicable to jet impingement.

   Several inconsistencies in modeling and tranformations were found; however, these were not considered generic nor did they appear to have any impact on the results. There are, however, several generic factors which could possible affect the results. These relate to stiffnesses of skewed supports which are less than stiffnesses of global supports, location of mass points and flexibility of elbows. SWEC is currently reviewing TES computer input and modeling to better understand the differences. This review should be completed shortly and will be included in the final report. The differences observed for the final analyses are presented in Section 4.13.

3.) Design Control Audit - This task had three parts; review of GAI design control program, verification of program application, and confirmation of consistent labeling of response spectra. The conclusions are:

- GAI had an adequate Design Control Program meeting the requirements of 10CFR50 Appendix B relative to the specific areas investigated in this seismic design verification program.

- The implementation of the program was adequate except there were cases of inconsistencies in design inputs. These appear to be due to documentation problems. The complete audit results are presented in Section 5, with a recommendation to determine the extent of incomplete documentation and provide compilation of all appropriate design criteria so that a clear and traceable record is developed and maintained.

- The audit showed that response spectra were consistently labeled throughout the design process.

## 2.2 Field Verification Summary

In general the field walkdown verified that the as-built condition of this piping system reflected the design layout as presented on the isometric drawings. The followings is a brief description of all the differences identified.

1.) Gaps between piping and support steel larger than criteria -two occurrences. The largest of these was 9/32 inch whereas the criteria allowed only 5/32 inch. No effects from these were observed in the subsequent stress analysis.

2.) Clearances between piping and structural components - three occurrences. Two of these were small clearance between pipe and structural component - 0 and 7/64 inch. The 0 inch clearance was found at penetration P-IB-1-041 which had not yet been reviewed under SCE&G's sleeve clearance program when the field work was performed. The 7/64 inch clearance was found to be more than adequate based on the results of the subsequent stress analysis. The third occurrence was sleeve through a wall which was found to be partially grouted. This was subsequently determined to have been identifed by SCE&G (ECN 2316) and the grout had been removed when SWEC field personnel again visited the site on June 7, 1982.

3.) Struts at angles other than identified on the isometrics - three occurrences of struts more than 3 degrees from the values on the isometrics. The maximum difference was 11 degrees. No effects from these were observed in the stress analysis.

4.) Dimensional data outside the criteria specified for SWEC's field walkdown effort - 15 occurrences. The maximum difference was 5.3 inches for a span of 11.6 feet. All dimensional differences were within SWEC's standard criteria. No effects from these were observed in the stress analysis.

5.) Drafting Errors - five occurrences. These were confirmed by reviewing the support or piping drawings.

All differences were noted and included (except penetration P-IB-1-041) in the subsequent stress analyses. No significant impacts of these differences were observed in the stress analysis.

## 2.3 Analysis and Evaluation Summary

All piping stresses were found to be within code allowables and all thermal movements were within the criteria. Review of support, anchor, penetration and nozzle loads showed a number of cases where SWEC loads exceeded GAI loads. These were reviewed with GAI and TES and found to be due to three main causes.

(1) Seismic effects from the Diesel Generator Building were not included in the original GAI design analysis for subsystem EF-01 (SWEC stress package 101).

(2) Several jets were misoriented or mislocated in the original analyses.

(3) Differences in the capabilites of the two programs used and differences in modeling of stiffnesses, lumped mass locations, geometrical differences and engineering judgements.

GAI and TES subsequently corrected causes 1 and 2 as well as significant geometrical differences in cause 3. SWEC confirmed the engineering judgements leaving only possible differences in modeling of stiffnesses and lumped mass locations. These differences result possibly from two independent programs being used as well as different standard design procedures or techniques which have developed in the two organizations. SWEC is presently reviewing the TES computer input and modeling of the EF-01 subsystem. The conclusions of this review will be incorporated in the final report.

The results of these differences are presented in Table 4.13 and indicate that rather large variations in loads can result.

The final conclusion from the Stress Analysis and Evaluation is that the design criteria appear to be properly applied, the piping stresses are within allowables, thermal movements appear consistent but some variation between SWEC and GAI loads on supports is evident.

## 2.4 Audit of Design Control Summary

The three parts to this task were:

(1) Review of the GAI design control program

(2) Verification of program application

(3) Confirmation that the structural dynamic analysis output was consistent with response spectra provided to TES for analysis of the turbine driven portion of the Emergency Feedwater System.

The following are SWEC's conclusions based on the design control audit.

Procedural Program

An adequate Design Control Program, meeting the requirements of 10CFR50 Appendix B, was in place for the transmittal and utilization of input data for pipe strss analyses of subsystems EF-01, 02, 03 and 22 of the Emergency Feedwater Piping System (GAI and TES Subsystem numbering).

Only one instance was observed in the existing program where there was no formally approved procedure. Although formal procedures were available for indexing of design and procurement specifications, the maintenance and distribution of a mechanical specification index was performed using an updated, uncontrolled instruction with no evidence that the instruction had been approved. Although unapproved, the procedure was adequate and was being implemented.

Program Implementation

The procedures associated with the activities reviewed during the audit were adequately implemented except that the utilization of inputs to pipe stress analysis in some cases was not consistent with program requirements. The instances found in the audit are apparently documentation problems that would not affect the design. One case affecting the design was subsquently found during the Stress Analysis and Evaluation Task (2.3(1)). The following were found during the audit.

- o The pipe stress analysis package for subsystem EF-01 did not utilize Figure 64 response spectra as specified on the isometric. Although GAI had approved the deletion of Figure 64 in a request for information (RFI) there was no evidence that the isometric had been marked-up to indicate that Figure 64 should be deleted nor was there documentation in the pipe stress analysis package that justified the deletion of Figure 64 (such as by reference to the GAI approved RFI).

- o There was no documentation in the pipe stress analysis package for EF-22 that the differences between the thermal movements utilized in the analysis and the movements on the isometric had been evaluated. A letter to GAI from TES initiated as a result of this audit indicated that the differences had been evaluated when the analysis was performed and that reanalysis was not necessary.

- (The project scope was expanded to include SI-09 because of the difference noted in EF-22 above). The pipe stress analysis package for subsystem SI-09 apparently utilized anchor movement information from a Westinghouse letter rather than the movements identified on the isometric. There was no evidence that GAI had approved or transmitted this information for use. In addition, the pipe stress analysis package did not identify that the movements utilized were different than the isometric and the reasons for the differences. A letter submitted by TES to GAI as a result of the audit indicated that the Westinghouse anchor movement information had been used in the analysis.

- The nozzle loadings in pipe stress analysis packages were noted as acceptable by "trade-off". There was no documentation in the pipe stress analysis packages that identified the method or the acceptability of the method. There were approved RFI's in GAI files that addressed load trade-offs, but they were not referred to in the packages.

Another area that was not clearly documented was the application of damping factors. Although the application of damping factors complied with the FSAR, this could not be discerned unless reference was made collectively to the FSAR, Specification 702, pipe stress analysis packages, a GAI study, and minutes of a meeting. The underlying cause of this condition was apparently due to not updating Specification 702 to reflect the issuance of Amendment 26 to the FSAR.

Response Spectra Consistency

The response spectra utilized in the pipe stress analysis were consistent with the dynamic (structural) analysis output. In some cases additional spectra were utilized when it did not appear necessary. (The Stress analysis and evaluation portion of the seismic design verification effort subsequently identified one case in which a response spectra had been omitted from the analysis - see Section 2.2).

Recommendations

Procedures

A procedure governing the preparation and distribution of a specification index for mechanical specifications (and for other discipline specifications if necessary) should be formalized as part of the project program.

Implementation

The extent of incomplete documentation in pipe stress analysis packages should be determined and appropriate corrective action implemented.

To preclude future misunderstanding and provide clear traceability regarding application of damping factors, corrective action, in the form of either a revision to Specification 702, or a memorandum of explanation in the pipe stress analysis packages. or other appropriate equivalent, should be performed.

## 3.0 FIELD WALKDOWN

### 3.1 Scope

The as-built piping geometry of the Emergency Feedwater (EF) System for the flow path of the Turbine-Driven EF Pump to Steam Generator C, shown on Figure 3-1, was determined. The piping walkdown included identification of valve locations and orientation, support location, orientation, and function and other dimensions as necessary for the stress analysis. The walkdown continued beyond the identified flow path to equipment nozzles, terminal anchors or a series of constraints remote from the flow path for the purpose of terminating the mathematical model of the subsystem at a point where the boundary condition would have no practical effect on the structural response of this subsystem.

### 3.2 Walkdown Procedures and Criteria

#### 3.2.1 Walkdown Procedures

Prior to commencing any field work a project procedure, VCS-1, Field Walkdown Procedure, was prepared. A copy was submitted to SCE&G. This procedure provided all necessary steps, documentation and criteria required to proceed with the work in an orderly, consistent and efficient manner.

##### 3.2.1.1 Measuring Devices

The following devices were used for field measurements.

- 12 ft Engineers measurement tape, Lufkin, Ultralok, W312D
- 6 ft folding ruler, Lufkin Rugged Red End Engineers
- 6 inch stainless steel rulers, General Hardware Manufacturing Co., Inc., Nos. 300 and 616
- Protractor, General Hardware Manufacturing Co., Inc., No. 18
- Universal Protractor, by Sears Craftsman
- Feeler gauge, Starrett EDP 51170, Engineers gauge No. 245.

##### 3.2.1.2 Documents provided by SCE&G

All field measurements and observations were recorded on the following six GAI piping isometric drawings.

C-314-081, Sheet 27, Rev. 3
C-314-085, Sheet 1, Rev.2
C-314-085, Sheet 2, Rev. 2
C-314-085, Sheet 3, Rev. 3
C-314-085, Sheet 4, Rev. 2
C-314-085, Sheet 5, Rev. 2

Other drawings, such as concrete outline drawings, turbine driven EF pump drawing, Reactor Building penetration No. 213 drawing, and EF piping drawings, were also provided to SWEC for the purpose of providing orientation and dimensions which could not be measured.

3.2.1.3 Survey Teams

A Lead Field Verification Engineer was assigned responsibility for this task. He supervised three two-man survey teams. Each team was assigned a portion of the subsystem to survey.

3.2.1.4 Reference Points

There were basically three reference points used for this survey; the turbine driven EF pump, the Reactor Building penetration No. 213 and the steam generator nozzle. The locations and elevations of these three reference points were taken from the construction and fabrication drawings.

3.2.1.5 Survey and Documentation

The piping geometry was measured in segments to identify all locations of pipe supports, valves, flanges, tees, elbows, reducers, branch connections, penetrations and orifices. These measurements were recorded directly on the isometric drawings.

Pipe clearances at penetrations and pipe supports were also measured and recorded. Pipe support types (functions) and orientations were verified and noted on the drawings. Orientations and lengths of valve operators were also measured. Also, all valve numbers were checked.

Any dimensions found outside the tolerance criteria in Section 3.2.2 were circled on the isometric drawings and recorded on a Difference List (Form DL). All dimensions verified as being within the tolerance criteria were noted with a check mark (✓) on the isometric drawings. The DL forms and the isometric drawings were reviewed and approved by the Lead Field Verification Engineer after they had been completed, signed and dated by the two survey team members.

3.2.2 Tolerance Criteria

In order to compare the accuracy of the dimensions on the isometric drawings with SWEC's measurement, a set of tolerance criteria was established based on SCE&G's MF-14 Walkdown Procedure. All SWEC's dimensions deviating from the dimensions on the isometric drawings by more than the values listed below were entered onto a Difference List (Form DL).

1. 0.50 inch between an anchor or nozzle and the closest support
2. 2.0 inches between two adjacent supports
3. 2.0 inches for segment length up to 6 inches
   3.0 inches for segment length greater than 6 inches and up to 24 inches
   6.0 inches for segment length greater than 24 inches and up to 60 inches

10.0% for segment length greater than 60 inches

4. 3 degrees for angle measurements.
5. 5/32 inch for total gaps between piping and support steel.

### 3.3 Walkdown Results

Approximately 800 feet of piping and 116 supports were fieldwalked. The geometrical data, orientations and functions of pipe supports on the six isometric drawings were generally accurate. There were some minor differences found which exceeded the stringent tolerance criteria. These differences are summarized as follows:

#### 3.3.1 Difference in span lengths between an anchor/nozzle and the closest support.

There were eight (8) occurrences of differences exceeding the one half inch (0.5 inch) criterion. The maximum difference was 2.5 inches in a length of 5.5 feet, which represents a difference of only 3.8%. The complete list of these differences is as follows:

| Difference (in.) | Span length (ft) | Percentage (%) |
|---|---|---|
| 2.50 | 5.45 | 3.80 |
| 1.39 | 3.93 | 2.95 |
| 0.82 | 2.60 | 2.62 |
| 1.45 | 5.37 | 2.25 |
| 0.65 | 4.40 | 1.23 |
| 1.80 | 16.40 | 0.90 |
| 0.84 | 9.20 | 0.76 |
| 0.91 | 11.80 | 0.64 |

#### 3.3.2 Differences in span lengths between two adjacent supports

There were six (6) occurrences of differences exceeding the two (2.0) inch criterion as listed below:

| Difference (in.) | Span Length (ft) | Percentage (%) |
|---|---|---|
| 4.43 | 5.12 | 7.21 |
| 3.94 | 6.22 | 5.27 |
| 5.29 | 11.60 | 3.80 |
| 3.43 | 9.62 | 2.97 |
| 2.95 | 8.34 | 2.95 |
| 2.65 | 18.95 | 1.17 |

#### 3.3.3 Differences in segment lengths

Only one (1) difference exceeded the criterion. This difference was 3.4 inches, which was measured from the center line of a support to the nearest elbow. This difference was a portion of the total cumulative difference between two adjacent supports, which was listed in item 3.3.2.

3.3.4 Support orientations

Three occurrences had angles different from the values on the isometric drawings by more than 3 degrees. These were 11, 11 and 9 degrees for Supports EFH-4024, 4028 and 103 respectively.

3.3.5 Gaps between piping and support steel larger than criteria

Two lateral supports (EFH-080 and EFH-099) had gaps between piping and support steel exceeding 5/32 inch. They were 9/32- and 1/4-inch.

3.3.6 Clearance to allow piping movements

Clearances were observed and measured to ensure that piping movements as designed were not obstructed by rigid elements, such as other pipes, support steel, penetration sleeves or sealants. Three instances were identified as follows:

- The lateral clearance of the vertical support EFH-4020 was only 7/64 inch. This is rather small. However, SWEC's pipe stress analysis verified that the total pipe movement due to thermal and seismic effects would amount to only 1/32 inch. Thus, this clearance is acceptable.

- Although penetration P-IB-1-041 was at least 2 inches larger in diameter than the pipe, there was hardly any clearance at one point. As indicated by SCE&G, the penetration program to identify sleeve clearance and QC surveillance requirements was not complete at the time of this field measurement.

- Penetration P-AB-4-049 was partially grouted for a depth of about 1 1/2 inches. This was subsequently determined to have been identified by SCE&G (ECN 2316) and the grout had been removed when SWEC fieldwalk personnel again visited the site on June 7, 1982.

3.3.7 Drafting errors on isometric drawings

The functions of four supports were labeled incorrectly. Th conclusion was confirmed by the agreement between the as-built supports and the original pipe support drawings. Also, one elbow radius was written as 5R, which should have read 0.5R, a standard long radius elbow for the 4 inch pipe.

3.4 Conclusions

All data verified by the field walkdown were recorded on the isometric drawings and used for the independent seismic design verification analysis. All differences exceeding the tolerance criteria were addressed. Although the tolerance criteria were very stringent, only a few differences were found and most of these were minor. No significant impacts of these were observed in the stress analysis. Overall, the fieldwalk verified that the as-built condition of this piping subsystem reflected the design layout as presented on the isometric drawings.

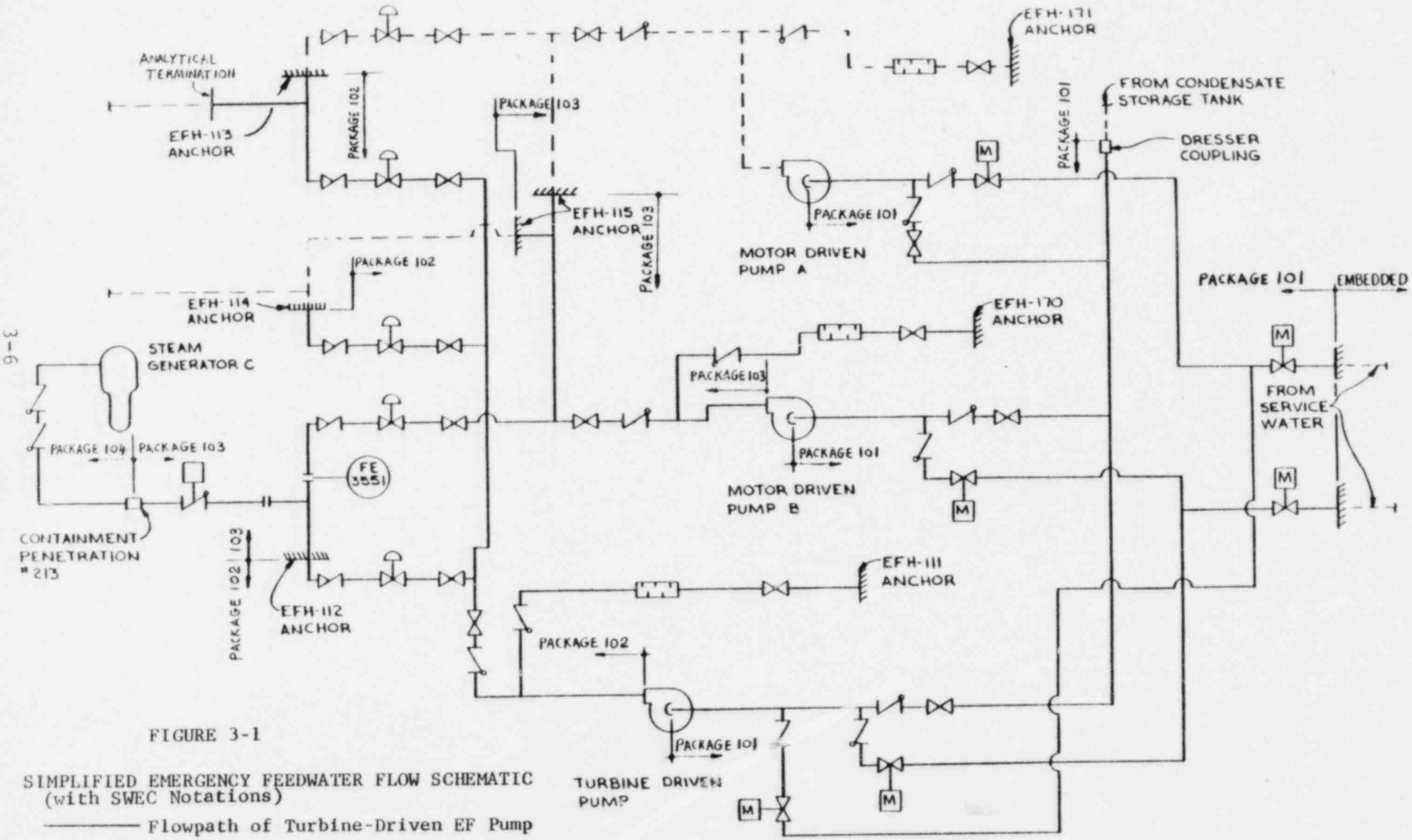


FIGURE 3-1

SIMPLIFIED EMERGENCY FEEDWATER FLOW SCHEMATIC
(with SWEC Notations)

——— Flowpath of Turbine-Driven EF Pump to Steam Generator C

## 4.0 STRESS ANALYSIS AND EVALUATION

### 4.1 Scope

The flow path of the Turbine-Driven Emergency Feedwater Pump to Steam Generator C was independently analyzed and results evaluated. This verification analysis was based on SWEC's field walkdown data and design criteria provided to SWEC by SCE&G and GAI. This task did not include a review of original licensing commitments nor of construction quality assurance. The evaluation included comparison of pipe stress with allowables, load comparison of pipe supports and anchors with design loads, and load comparison of equipment nozzles and Reactor Building penetration with allowable loads as provided by various design documents. Individual load cases were dead load, design pressure, thermal, seismic and jet impingement loads.

### 4.2 As-Built Data

SWEC's field walkdown data as recorded on the GAI isometric drawings were reviewed by the stress analysts. This review identified a need for additional information and clarification. The stress analysts issued a Field Information Request (FIR) for each item to be verified. A field verification team was then assigned to make an additional survey in order to respond to the FIRs. The FIR responses were incorporated in the stress analysis.

### 4.3 Stress Analysis Procedures

Two project procedures, VCS-3, Analysis and Evaluation Procedure, and VCS-4, Analysis and Evaluation Criteria, were developed to provide design input information, load combinations, reference documents, guidelines for calculation preparation, evaluation criteria, and other documentation and procedural requirements in order to ensure a uniform analysis approach.

Initially, all requests for design criteria from SWEC were addressed to SCE&G. SCE&G either responded directly or requested GAI to provide information to SWEC. Occassionally, telecopy or phone calls were utilized to expedite the effort. All telecopies were filed on the project and all phone calls transmitting data or decisions were recorded and filed.

On July 7, 1982, a meeting among GAI, TES and SWEC was held at TES, in Waltham, Ma. The purpose of the meeting was to ensure that SWEC understood the design criteria and their application to the analysis. All items discussed were documented officially as meeting notes, copies of which were distributed to SCE&G, GAI and TES. Based on the information provided in this meeting and other criteria provided previously, the "Initial Analysis" was performed. Results of this analysis were reviewed and compared with the GAI design loads. Differences between SWEC's and GAI's support loads, penetration and equipment nozzle allowables were identified as Open Item Reports

(OIRs). Copies were sent to SCE&G and GAI for review and clarification.

SCE&G called a meeting with GAI, TES and SWEC on July 28, 1982 at GAI offices in Reading, Pa. The purpose of the meeting was to review the OIRs issued as a result of the Initial Analysis. GAI advised that some of the design criteria provided to SWEC were erroneous. Therefore, all the OIRs were voided and a new analysis was required. The new corrected data and criteria were documented in a GAI letter addressed to SCE&G. The new analysis, called "Comparison Analysis" was performed in order to incorporate the new information. Section 4.4, Evaluation Criteria, identifies all applicable criteria for this Comparison Analysis.

Review of pipe stress, support load, equipment nozzle load, penetration load and thermal movement is presented in Section 4.5 to 4.9 based on the result of the "Comparison Analysis". Open Item Reports were written to document differences between SWEC's results and GAI's design loads or allowables. Copies of OIR's were sent to SCE&G, GAI and TES for review and clarification.

On August 13, 1982, a meeting among SCE&G, GAI, TES and SWEC was held at TES offices in Waltham, Ma. for the purpose of reviewing the OIRs issued as a result of the Comparison Analysis. GAI advised in the meeting that some of the jet forces were redefined and TES was in the process of revising their analysis to include these revised jet forces and the effects of seismic response spectra and movement from the Diesel Generator Building which were omitted originally. After receipt of the official transmittals from GAI documenting the revised jet forces, and new support and nozzle load summary sheets, SWEC performed a "Final Analysis," which is presented in Section 4.12.

4.3.1 Design Documents provided by SCE&G and GAI

Reference documents from SCE&G or GAI are listed as follows:

1. Design Specification, DSP-544C-044461-000, "Emergency Feedwater System Piping and Pipe Supports", Rev. 5, 4-30-82, V.C. Summer Nuclear Station, Unit No. 1.

2. Pipe Line Specifications for Nuclear Safety Class Piping, SP-545-044461-000, Rev. 7, 11-25-80, V.C. Summer Nuclear Station, Unit No. 1.

3. Pipe Line Specifications for Conventional Piping, SP-337-4461-00, Rev. 8, 9-29-77, V.C. Summer Nuclear Station, Unit No. 1.

4. Design Specification for Reactor Building Piping Penetrations, ASME B&PV Code, Section III, Division 1, Class 2, DSP-606-044461-000, Rev. 9, 2-1-82, V.C. Summer Nuclear Station, Unit No. 1.

5. Specification, Seismic Analysis, Testing and Documentation, SP-702-4461-00, Rev. 4, 2-11-77, V.C. Summer Nuclear Station, Unit No. 1.

6. Design Specification, Motor Driven Emergency Feedwater Pumps, ASME III, Class 3, DSP-508A-4461-00, Rev. 2, 7-8-77, V.C. Summer Nuclear Station, Unit No. 1.

7. Design Specification, Turbine Driven Emergency Feedwater Pumps, ASME III, Class 3, DSP-508B-4461-00, Rev. 2, 4-2-76, V.C. Summer Nuclear Station, Unit No. 1.

8. Steam Generator Design Loads, Auxiliary Feedwater Nozzle, Model D (51-D) Steam Generator, Design Specification 679060, Rev. 6, 11-3-80, Westinghouse Electric Corporation.

9. Letter from G.J. Braddick, Gilbert/Commonwealth, to C.A. Price, SCE&G, CGGS-27683, dated May 27, 1982.

10. "Jet Loadings on ASME Section III Piping," Gilbert Associates, Inc., Report No. 1902.

11. SWEC Letter to C.A. Price, SCE&G, dated June 1, 1982.

12. Memorandum from K.R. Gabel, GAI, to K.Y. Chu, SWEC, dated June 4, 1982.

13. Letter from G.J. Braddick, GAI, to C.A. Price, SCE&G, CGGS-27890, dated June 15, 1982, with Attachment: Memorandum from K.R. Gabel to J.R. Helwig, dated June 11, 1982.

14. Record of telephone conversation, from K.Y. Chu, SWEC, to K.R. Gabel, GAI, dated June 29, 1982.

15. Letter from SWEC to C.A. Price, SCE&G, dated June 11, 1982.

16. Memorandum from K.R. Gabel to J.R. Helwig, both GAI, dated June 28, 1982.

17. Letter from Teledyne Engineering Services (TES) to GAI, 4813-9, dated Nov. 24, 1980, with Attachment: Minutes of Meeting.

18. Record of telephone conversation among GAI, TES and SWEC, July 16, 1982.

19. Letter from G. J. Braddick, GAI, to C. A. Price, SCE&G, CGGS-28392, dated July 29, 1982, with Attachments.

20. Letter from G.J. Braddick, GAI, to C.A. Price, SCE&G, CGGS-28528, dated August 16, 1982, with Attachments.

21. Letter from G.J. Braddick, GAI, to C.A. Price, SCE&G, CGGS-28587, dated August 24, 1982, with Attachments.

22. Letter from G.J. Braddick, GAI, to C.A. Price, SCE&G, CGGS-28697, dated September 13, 1982, with Attachments.

23. Letter from G.J. Braddick, GAI, to C.A. Price, SCE&G, CGGS-28744, dated September 20, 1982, with Attachments.

4.3.2 Stress Packages

Upon, receipt of the field verified isometric drawings, the Lead Engineering Mechanics Engineer reviewed, logged in and divided the subsystem into four stress packages for mathematical modeling. Each of these stress packages was terminated at six-way restraints (anchors, equipment nozzles, Reactor Building penetration), except for package 102, in which the subsystem was extended and terminated after several restraints at a point where the boundary conditions would not affect the flow path piping being analyzed. These four packages are as shown on Figure 3-1.

Package 101: Supply line from Dresser coupling to turbine-driven EF pump XPP-8-EF.

Package 102: Discharge line from turbine-driven pump XPP-8-EF to inline anchor EFH-112.

Package 103: From inline anchor EFH-112 to Reactor Building penetration No. 213.

Package 104: From Reactor Building penetration No. 213 to Steam Generator C.

Appendage vent, drain, and instrument piping up to 1½" were not included in the mathematical models because the moments of inertia of these are much smaller than the moments of inertia for the main runs, and their coupling effects are therefore negligible. These small pipe lines were not a part of the scope. However, when considered necessary, a concentrated weight was added at the branch point to account for the contributing weight.

The Lead Engineering Mechanics Engineer assigned stress analysts to work on these packages. Concurrently, he assigned an engineer to develop for each package a set of digitized response spectra to envelope the floor response spectra for the locations and elevations where the pipe supports are attached.

| Package | Building | Highest elevation of support attachment | Figures to be enveloped |
|---|---|---|---|
| 101 | Intermediate Bldg. | 433'-6" | 62 (El. 436')<br>61 (El. 412') |
| | Diesel Generator Bldg. | 425'-0" | 30 (EL. 427') |
| 102 | Intermediate Bldg. | 432'-0" | 62 (El. 436')<br>61 (El. 412') |

| | | | |
|---|---|---|---|
| 103 | Intermediate Bldg. | 436'-0" | 62 (El. 436')<br>61 (El. 412') |
| | Reactor Building | 443'-1" | 8 (El. 462')<br>7 (El. 435') |
| 104 | Reactor Building | 441'-1" | 8 (El. 462')<br>7 (El. 435') |
| | Interior Concrete | 477'-3" | 21 (El. 475')<br>20 (El. 462')<br>19 (El. 445') |

4.3.3 Field Information Requests

Additional field information or clarification was requested by completing a Field Information Request (FIR). Twenty-two FIRs were submitted to the Project Engineer, who ensured that they were logged in and indexed. Responses to the FIRs were documented on FIR Response Forms by the field verification team. These FIR responses were provided to the stress analysts and incorporated into the analysis.

Copies of all FIRs and FIR responses were transmitted to SCE&G.

4.3.4 Analysis Input Criteria

4.3.4.1 Deadweight

In addition to the weight of the run pipe, water, valve, flanges and other fittings, the weights of pipe support attachments and most of the vent, drain and instrument lines were included in the analysis as concentrated weights. In a few cases the weight of support attachments was represented by a distributed weight along the pipe length with a limitation of not being longer than one pipe diameter on each side of the support.

4.3.4.2 Thermal Conditions

Two thermal conditions were considered which included the maximum and minimum temperatures specified for various design, operating and environmental conditions. They were as follows:

- Thermal Condition 1
  - Entire subsystem — 32°F
- Thermal Condition 2
  - Line from check valve 1038C-EF to steam generator nozzle — 600°F
  - Line from Reactor Building Penetration to the check valve — 120°F

The rest of the line 110°F

Thermal displacements at the steam generator nozzle were also considered.

#### 4.3.4.3 Internal Pressure

The values of pressure used for the analysis were selected from the maximum of various plant and system operating conditions as follows:

| Stress Package | Internal Pressure (psig) |
|---|---|
| 101 | 27 - Supply lines from condensate storage tank<br>60 - Supply lines from Service Water System |
| 102 | 2250 - Discharge line from turbine driven EF pump to stop-check valves 1020A-EF, 1020B-EF, and 1020C-EF. Recirculation line up to orifice.<br>55 - Recirculation line downstream of orifice.<br>1360 - All other portions. |
| 103 | 1715 - Discharge lines from motor driven EF pumps to stop-check valves 1019A-EF, 1019B-EF, and 1019C-EF. Recirculatoin line up to orifice.<br>55 - Recirculation line downstream of orifice.<br>1360 - All other portions. |
| 104 | 1360 |

#### 4.3.4.4 Seismic Response Spectra

Both Operating Basis Earthquake (OBE) and Design Basis Earthquake (DBE) were analyzed by means of the response spectrum approach. The contribution of closely spaced modes was considered by the grouping method as addressed in NRC Regulatory Guide 1.92.

The dynamic analysis considered all significant modes up to and including the first frequency exceeding 33 Hz.

The individual spectra used for enveloping were taken directly from the GAI Seismic Analysis Specification for OBE with a 1% damping factor. The DBE response spectra were obtained by scaling the OBE response spectra for a 2% damping factor with the following factors as defined in the GAI specification:

Reactor Building 1.50

| | |
|---|---|
| Intermediate Building | 1.55 |
| Diesel Generator Building | 1.62 |

In addition, depending on the location of pipe supports, GAI applied a different type of scaling factor (Gamma) to the vertical components of the response spectra. The factor throughout all four piping packages was 1.0.

4.3.4.5 Seismic Anchor Movement

All components of the seismic anchor movements were taken from the GAI isometric drawings and referenced GAI correspondence. Another specific criterion provided to SWEC was that if all three directions of relative seismic anchor movement between two adjacent supports were equal to or less than 1/8 inch, the differential movement was not considered in the analysis.

4.3.4.6 Jet Impingement Load

Break point, jet orientation and jet impingement forces were provided in GAI Report No. 1902, Jet Loading on ASME Section III Piping. There were seven break points to be considered, five from the 4" steam line to the turbine and two from the discharge side of this subsystem. The jet from one of these seven break points was not analyzed per GAI's direction that a shield installation negated this jet force.

The jet impingement forces given in the report did not include the dynamic load factor and shape factor. SWEC assumed a shape factor of 0.60 and a dynamic load factor of 2.0 for the initial stage of jet impingement. (see Section 4.12 for subsequent revision of these criteria for specific jets). During the initial stage of jet impingement all shock suppressors (snubbers) were considered effective. After the initial stage, the jet load becomes a stationary force. Therefore, a second analysis was performed for this condition, in which no dynamic load factor was included and the shock suppressors were considered deactivated.

4.3.5 Calculation Preparation

Stress analyses were performed using the NUPIPE-SW (ME 110) computer program.

Work sketches representing the mathematical models of the stress packages were prepared (Figures 4-1, 4-2, 4-3 and 4-4). The data in the work sketches included dimensions, pipe support types and orientations, node and mass points, valve and operators, elbows and other fittings. All work sketches were checked by a stress analyst other than the preparer for completeness and accuracy.

During the process of preparing work sketches the stress analysts identified seven items requiring clarification. Each item was documented in an Open Item Report (OIR) and resolved as discussed in Section 4.10.1.

The stress calculations were prepared and reviewed in accordance with SWEC Engineering Assurance Procedure (EAP) 5.3, Preparation and Control of Manual and Computerized Calculations (Nuclear Projects). In addition to the normal standard presentation of a calculation, the stress package included comparison of pipe support loads, anchor loads and thermal movements with the data received from GAI, and comparison of penetration and equipment nozzle loads with the given allowables.

### 4.4 Evaluation Criteria

#### 4.4.1 Piping Allowable Stresses

The piping is to meet the requirements of 1971 ASME Boiler and Pressure Vessel Code, Section III (ASME III), Division 1, Class 2 and 3, with addenda up to and including the Summer 1973 issue and Code Case N-240. Loading combinations together with their design criteria are as follows:

1) System Normal/Upset I Operating Condition

| NC 3600 Equations | Combination | Allowable Stress |
|---|---|---|
| 8 | DL + LP | $S_h$ |
| 9 | DL + LP + OBEI | 1.2 $S_h$ |
| 11 | DL + LP + TH + OBEA | $S_A + S_h$ |

2) System Upset II Operating Condition (Plant Emergency)

| NC 3600 Equations | Combination | Allowable Stress |
|---|---|---|
| 9 | DL + LP + JI | 1.5 $S_h$ |

3) System Emergency Condition (Plant Faulted)

| NC 3600 Equations | Combination | Allowable Stress |
|---|---|---|
| 9 | DL + LP + DBEI | 1.8 $S_h$ |

where

$S_h$ = allowable stress at maximum (hot) temperature

$S_c$ = allowable stress at minimum (cold) temperature

$S_A$ = f(1.25 Sc + 0.25 $S_h$), f=1.0 the stress range reduction factor

DL = Deadweight

LP = Longitudinal Pressure Stress

OBEI/DBEI = Inertia effects of OBE/DBE.

| | |
|---|---|
| OBEA = | OBE anchor movements |
| TH = | Thermal load |
| JI = | Jet impingement load |

4.4.2 Pipe Support and Anchor Load Combinations

The pipe support and anchor loads from the following load combinations were compared with the loadings from GAI pipe support drawings and TES documents. If the loads exceeded the original design values by 15% or more, and if they also exceeded them by 100 lbs or 100 ft-lbs, an Open Item Report (OIR) was generated and submitted to the Lead Engineering Mechanics Engineer, Project Engineer and Project Manager for review and resolution.

| System Operation | Loading Combination |
|---|---|
| Normal | DL + TH |
| Upset I | $DL + TH + (OBEI^2 + OBEA^2)^{\frac{1}{2}}$ |
| Upset II | DL + JI |
| Emergency | DL + DBEI |

4.4.3 Equipment Nozzle Loads

4.4.3.1 Steam Generator Nozzle

Forces and moments from individual load cases were compared with the allowables given in Design Specification 679060, Rev. 6, 11-3-80, Westinghouse Electric Corporation.

4.4.3.2 Pump Nozzles

Forces and moments derived from the same load combinations as for pipe supports were compared with the allowables given in the design specifications for motor and turbine driven EF pumps.

4.4.4 Reactor Building Penetration No. 213

The forces and moments from each individual load case were first transformed to axial and shear forces, and torsion and bending moments, which were then compared with the allowables given in the GAI Design Specification, DSP-606-044461-000, Rev. 9, 2-1-82. Load comparisons were made at both ends of the penetration.

4.4.5 Comparison of Thermal Movements

Thermal movements from the two thermal conditions at pipe supports were compared with those presented in GAI pipe support drawings. If the movements exceeded the original values by 15% or more, and if they also exceeded them by 0.02 inch, an OIR was generated and sent to the Lead Engineering Mechanics Engineer, Project Engineer and Project Manager for review and resolution.

4.5 Pipe Stress Review

All piping stresses were found to be within allowables for all analyses performed. Maximum stresses from each stress packages are presented in Table 4-1.

4.6 Support Load Review

All four load combinations for all supports were tabulated and compared with the design loads from GAI pipe support drawings and supplements provided by GAI. For terminal anchors, the loadings from SWEC's analysis were combined with the loadings from the interfacing side which was not analyzed by SWEC. These loadings were provided to SWEC by GAI and TES.

The load comparisons proceeded in two steps. The first step was to calculate the difference between SWEC's values and the original design values. The second step was to calculate the ratio of the difference to the original design value.

Based on the information provided in the pipe support load comparison tables, a summary table for each package was prepared to indicate differences in values and in percentages. Unless noted otherwise, SWEC's load in the summary tables is for an Upset Condition, generally the controlling design case. The GAI load is for the same load combination. The value in the column "Difference" is SWEC's load minus the corresponding GAI load. This value divided by the corresponding GAI load is recorded in the column "Percentage". The last column, "Dominant Factor", indicates the load case contributing most to this difference. There are probably four major factors that contributed to differences. One is the effect of seismic response spectra (seismic inertial). The second is the effect of differential seismic support movement, noted in the tables as "Seismic Movement". The third is the jet impingement effect, which could have been caused by misinterpretation of the impingement target area. The fourth is modeling differences due to program differences and engineering judgment.

4.6.1 Comparison Review - Package 101

This package contains 32 supports and two anchors. The load comparison indicates that 20 supports and both anchors have load differences and ratios exceeding 100 (lbs, ft-lbs) and 15%. The primary contributor for all these differences appears to be the seismic response spectra and movement of the Diesel Generator Building, which were not considered in the original analysis. Table 4-2 identifies all differences.

4.6.2 Comparison Review - Package 102

This package contains 23 supports and 4 anchors. The load comparison indicates that 5 supports and 3 anchors have load differences and ratios exceeding 100 (lbs, ft-lbs) and 15%. Four of these are probably caused by the difference in the effects of the seismic response spectra. One anchor (EFH-113) has a large discrepancy in My. This seems to be caused by the difference in the mathematical models. SWEC's model represents the physical location of the anchor, i.e., one foot away from a vertical riser, while the GAI's model assumed the anchor located at the intersection where the vertical riser joins the horizontal run. One support, EFH-048, is near the jet impingement target from break number 32. The GAI load did not include this effect due to misorientation of this jet. For anchor EFH-111 all force and moment components except Mx are within the comparison criteria. The difference of Mx appears to be caused by deadweight. SWEC's analysis shows that Mx due to deadweight is almost entirely caused by a valve located only few inches away and having its center of gravity 8.5 inches off the pipe axis. The difference for the remaining support EFH-057 seems to be from thermal effects. Table 4-3 identifies all differences.

#### 4.6.3 Comparison Review - Package 103

This package contains 32 supports and 4 anchors. The load comparison indicates that 6 supports and one anchor have load differences and ratios exceeding 100 lbs and 15%. Three of these are caused by the effect of jet impingement from break no. 33. This jet was misoriented in the original TES analysis. The higher total loads in the anchor and two other supports were probably caused by higher thermal load. The difference for the remaining support EFH-4029 load is primarily due to relative seismic movement. This is the vertical and lateral support closest to the Reactor Building penetration.

Table 4-4 identifies all differences.

#### 4.6.4 Comparison Review - Package 104

This package contains 12 supports. None of SWEC's support loads exceeded the comparison criteria.

### 4.7 Equipment Nozzle Load Review

#### 4.7.1 Steam Generator Nozzle

All forces and moments from each individual load case were substantially smaller than the allowables specified for this nozzle.

#### 4.7.2 Pump Nozzles

The forces and moments from all required load combinations at the motor driven pump nozzles and at the discharge nozzle of the turbine driven pump are smaller than the specified allowables. However, at the suction nozzle of the turbine driven pump the X-force component and the force resultant from Upset II Condition are greater than the allowables. Also, the moment resultant from Upset I Condition is greater than the specified allowable.

## 4.8 Reactor Building Penetration Load Review

The shear forces of SWEC's analysis for deadweight and seismic load cases at the outside interface exceed the specified allowables, but fall within the values from the TES' analysis. Since GAI had concluded previously that the penetration was good for the TES' forces, it should be acceptable for SWEC's forces.

At the inside interface of penetration SWEC's analysis indicated that all forces and moments are within the specified allowables.

## 4.9 Thermal Movement Review

### 4.9.1 Thermal Movement at Support Locations

Thermal displacements in unrestrained directions at all support locations were reviewed and compared with the values on the GAI pipe support drawings. No significant difference was found between these two analyses. In two instances the difference exceeded 0.01 inch, but, did not exceed 0.02 inch.

### 4.9.2 Thermal Movement at Supports with Excessive Gaps

The field verification effort identified two supports with excessive gaps. These were EFH-099 and EFH-080.

EFH-099 (Stress Package 101) was originally designed as a North-South restraint. During field walkdown the clearance was found to exceed the criteria, therefore, this support was assumed ineffective in the stress analysis. The result of the analysis verified that this assumption was correct. The maximum thermal displacement is 0.019 inch at this point. The total displacement including the effects of deadweight, thermal and seismic will amount to 0.030 inch, much less than the existing clearance.

EFH-080 (Stress Package 103) was originally designed as a vertical and East-West restraint. Since the horizontal gap exceeded the criteria, the East-West restraint was considered ineffective in the analysis. The result of the analysis indicates that thermal movement is 0.019 inch, and total displacement including the effects of thermal, seismic and deadweight is 0.032 inch, much less than the existing clearance. Therefore, the assumption is verified to be correct.

### 4.9.3 Thermal Movement at Supports with Small Clearance

EFH-4020 is a box-type vertical support with very little lateral clearance, 7/64 inch. Normally, a clearance of at least 1 inch would be expected. However, the analysis verified that the pipe lateral movement is expected to be very small- 0.019 inch for thermal case, and 0.022 inch for maximum load combination.

4.10 Open Item Reports

4.10.1 Open Item Reports for Interpreting Field Walkdown Data

During the stage of preparing work sketches, seven OIRs requesting clarification of field walkdown data were filed by the stress analysts. These were reviewed by the Lead Engineer Mechanics Engineer, Project Engineer and Project Manager. These OIRs were then resolved based on the responses to FIRs.

4.10.2 Open Item Reports for Analysis Review

4.10.2.1 Initial Analysis

The initial analysis was completed based on the design criteria provided by SCE&G and GAI. Review of the results indicated many supports, some equipment nozzles and the Reactor Building penetration exceeded the original design values or allowables by the amount specified in the comparison criteria. Each of these items was documented on an OIR and submitted to the Lead Engineering Mechanics Engineer, Project Engineer and Project Manager for review and resolution.

These OIRs were forwarded to SCE&G and GAI for their review to be certain that the input criteria provided to SWEC were complete and correct. A meeting was held in GAI's office and attended by representatives of SCE&G, GAI, TES and SWEC. During review of each OIR, it became evident that some of the data transmitted to SWEC were inconsistent and required corrections. These were:

1. Seismic anchor movement for Diesel Generator Building.

2. Jet impingement effect should not be considered positive and negative (±).

3. Seismic effects due to response spectra and anchor movement should be combined as square-root-of-the-sum-of-the-squares (SRSS) instead of absolute summation.

As a result of these corrections new analysis was performed. This was called "Comparison Analysis" and represents the basis for SWEC's evaluations.

4.10.2.2 Comparison Analysis

A comparison analysis was made to incoporate the changes of criteria plus other minor adjustments, such as distribution of deadweight and consideration of pipe support attachment points offset from the pipe axis. The following OIRs were written and submitted for further review and resolution as a result of this analysis. Copies of OIRs were forwarded to SCE&G, GAI and TES for their review and action.

| Package No. | Total Number of OIR | Review Category |
|---|---|---|
| 101 | 20 | Support Load, Section 4.6 |
| | 2 | Anchor Load, Section 4.6 |
| | 1 | Nozzle Load, Section 4.7 |
| 102 | 5 | Support Load, Section 4.6 |
| | 3 | Anchor Load, Section 4.6 |
| 103 | 6 | Support Load, Section 4.6 |
| | 1 | Anchor Load, Section 4.6 |
| | 1 | Penetration Load, Section 4.8 |
| 104 | None | |

### 4.11 Potential Discrepanies

The OIRs were scrutinized and those reaching the following conditions were classified as Potential Discrepancy (PD) items for which further evaluation should be made and corrective action should be considered.

1. Difference between SWEC's and GAI's design loads is substantial.

2. SWEC's maximum load is significant in respect to support capacity.

3. Adequacy can only be justified with additional calculation.

The majority of the OIRs stemmed from three generic Potential Discrepancies which are:

1. Diesel Generator Building

   Seismic effects, including response spectra and support movement, from Diesel Generator Building were not included in the original GAI design data for Subsystem EF-01 (SWEC Stress Package 101).

2. Jet Impingement

   Two jets were misoriented. In one instance the target area of a jet impringement in the design document (1902) appeared to be inappropriate. Subsequent communication indicates that the jet need not be included in the analyses because shield installation negates this break load.

3. Mathematical Modeling Techniques

   These could include inconsistent pipe support stiffnesses, lumped mass locations, geometrical differences and differences in engineering judgments. Two differences identifed which could contribute to frequency shift and load differences are the following.

A. SWEC's analyses used a consistent stiffness value of $1 \times 10^{12}$ (lbs/in, in-lbs/rad) for all supports to simulate the TES criteria which basically used rigid supports. TES's analyses however actually used several stiffness values, i.e. infinite stiffness for supports oriented in global axes, $1 \times 10^{6}$ lbs/in for supports not oriented in global axes because of modeling techniques, and $3.5 \times 10^{4}$ lbs/in for the horizontal direction of support EFH-4029 to represent the actual stiffness. This latter support modeling is considered acceptable as discussed in Section 4.13.3, however, the lower stiffnesses for skewed supports could influence the loads on these and adjacent supports.

B. SWEC's model did not have any mass points at support locations, while TES's did have mass points at support locations. Also, one of the elbows in EF-01 was not modeled with reduced rigidity in TES's analysis. These could influence the natural frequency of the subsystems and cause different inertial loads. (Section 4.11.1 Package 101).

4.11.1 Package 101

All 23 OIRs (Section 4.10.2.2) were primarily due to the effects of Diesel Generator Building seismic response spectra and support movement, which were not included in the original design (Potential Discrepancy No. 1).

A jet impingement force caused the suction nozzle of the turbine driven pump to exceed the specified allowables (Potential Discrepancy No. 2).

Comparison of the first mode frequency indicated a minor difference between these two analyses. SWEC's mathematical model has a natural frequency of 11.04 Hz in the first mode versus 11.9 Hz for TES's analysis. (This was subsequently reduced to 11.7 Hz in the TES revised analysis). This lower frequency will cause greater seismic inertial response in SWEC's analysis of the piping subsystem. There could be numerous reasons contributing to this difference, such as number and location of lumped mass points, magnitude of masses, geometrical difference, and stiffness of pipe supports (Potential Discrepancy No. 3).

4.11.2 Package 102

Three of the eight OIRs (Section 4.10.2.2) were classified as PDs. These are for support EFH-048 (Potential Discrepancy No. 2), and for anchors EFH-113 and 114 (Potential Discrepancy No. 3). The other five OIRs were judged to be satisfactory without further evaluation or corrective action. The bases for the judgments are:

1. The difference does not occur in the controlling design condition (supports EFH-051 and 4005, anchor EFH-111),

2. Difference appears to be insignificant for the as-built support structure (support EFH-057),

3. Maximum design load appears to be substantially smaller than any commercially available support component (support EFH-182).

### 4.11.3 Package 103

Five of the seven OIRs (Section 4.10.2.2) were classified as PDs. Three of them for supports EFH-060, 61 and 62 were caused by an erroneous jet impingement target (Potential Discrepancy No. 2). Two others are linear type supports not oriented in global axes of the model. These two supports (EFH-083 and 4029) were represented in TES's analysis by a stiffness value smaller than others (Potential Discrepancy No. 3). Consequently, TES's analysis indicated a smaller load for these two supports than the case of consistent stiffness for all supports.

Two OIRs for supports EFH-082 and 115 were judged to be satisfactory without further evaluation or corrective action. The basis for this judgment is that the difference exists in Normal Condition only, which is not the controlling design condition. The OIR for Reactor Building penetration No. 213 was resolved satisfactorily based on additional information provided by GAI and TES. According to GAI, during original design stage they recognized that TES's loads exceeded the specified allowables. Further evaluation was made and it was concluded that the penetration was designed adequately for those loads. SWEC's loads are similar or smaller than TES's loads, and therefore the same conclusion is valid.

## 4.12 Final Analysis

On August 13, 1982, a meeting among SCE&G, GAI, TES and SWEC was held at TES offices in Waltham, Ma. The purpose of the meeting was to review the OIRs issued as a result of the Comparison Analysis. In the meeting, GAI advised that TES was to rerun the computer analysis for EF-01 (SWEC Stress Package 101) to include the seismic input from Diesel Generator Building. Also, three jet forces would be redefined. GAI confirmed this information by a copy of a letter to SCE&G, dated August 16, 1982 (Ref. 20, Section 4.3.1), in which three jet forces, one each for subsystems EF-01, EF-02 and EF-03, were reduced significantly. In addition, these forces were to be multiplied by a factor of 0.75 representing the combined effect of the dynamic and shape factors.

SWEC performed a Final Analysis using these new jet forces and factors. Results of this analysis were reviewed and compared with the new support load summary sheets which were transmitted to SWEC by GAI as attachments to a letter to SCE&G dated August 24, 1982 (Ref. 21, Section 4.3.1). The support load summary sheets include all supports except spring hangers and anchors for Subsystem EF-01, one support (EFH-113) for Subsystem EF-02 and one support (EFH-062) for Subsystem EF-03. TES subsequently telecopied additional information regarding load summary sheets for the two anchors in EF-01 and for the suction nozzle of the Turbine Driven EF Pump.

4.13 Resolution of Open Item Reports and Potential Discrepancies

The Open Item Reports and Potential Discrepancies issued as a result of the Comparison Analysis were reviewed again with the latest knowledge of the new load summary sheets. Section 4.11 identified three Potential Discrepancies for which corrective actions might be required. Potential Discrepancies Nos. 1 and 2 were subsequently corrected in TES's reanalysis. The remaining Potential Discrepancy No. 3, Mathematical Modeling Techniques, is presently being reviewed. SWEC is reviewing the TES computer input/output modeling of subsystem EF-01. The results of this review will be incorporated in the final report.

4.13.1 Package 101

Comparison between the result of SWEC's Final Analysis and TES's new load summary sheets indicates the following:

1. Eight OIRs for supports EFH-094, 095, 096, 098, 4019, 4022, 4031 and 4034 are closed, since TES loads from the reanalysis with Diesel Generator Building seismic response are now within the evaluation criteria.

2. OIR for support EFH-4023: SWEC's loads in Upset and Emergency Conditions are within the evaluation criteria. SWEC's load in Normal Condition is 141 lbs larger than TES's load; however, this load is not a controlling design case, it amounts to only 64% of the load in Upset Condition. Therefore, this OIR is closed.

3. OIR for support EFH-4026: SWEC's loads in Upset Condition are 2487 lbs compression and 5251 lbs tension. The tensile force is within the evaluation criteria, while the compressive force exceeds the TES's load by 344 lbs and 16%. Since the support is a short rigid strut, pin to pin 13 5/8 inches, the controlling design load should be the larger tensile force. This OIR is considered closed.

4. OIR for support EFH-4046: SWEC's load in Emergency Condition is 881 lbs, 19% over the TES's load. However, this is not a controlling design case. Both SWEC's and TES's loads in Upset Condition are approximately 8400 lbs. Therefore, this OIR is considered closed.

5. Anchor at Node No. 441: This is an anchor embedded in concrete. Only the negative Mx moment in the Normal Condition exceeds the evaluation criteria. However, this

value is only about one half of the positive Mx value. Therefore, this OIR is considered closed.

6. Suction Nozzle of the Turbine Drive EF Pump: The moment resultant is still higher than the specified allowable, however, it is lower than TES's value. Since GAI considered TES's value acceptable, SWEC's value must also be acceptable. This OIR is therefore closed.

7. Unresolved OIRs: Ten remaining OIRs for nine supports and one concrete anchor have not been resolved due to Potential Discrepancy No. 3, Mathematical Modeling Techniques. The supports and anchor are listed in Table 4.13, where the major design loads from SWEC's and TES's analyses are also tabulated for clarity.

### 4.13.2 Package 102

Five OIRs were resolved satisfactorily in Section 4.11.2. The remaining three OIRs are discussed in the following:

1. OIR for Support EFH-048: SWEC's Final Analysis with the revised jet force indicates that the support loads fall within the evaluation criteria. This OIR is therefore closed.

2. OIR for anchor EFH-113: The new load summary sheet from TES indicates a My moment much larger than SWEC's value. Therefore, the concern expressed before is resolved satisfactorily. This OIR is therefore closed.

3. OIR for anchor EFH-114: This OIR cannot be resolved. The cause of potential discrepancy has been identified before as Mathematical Modeling Techniques. This anchor along with its major design load is also listed in Table 4.13.

### 4.13.3 Package 103

Two OIRs were resolved satisfactorily in Section 4.11.3. The remaining five OIRs are discussed in the following:

1. Three OIRs for supports EFH-060, 61 and 62: SWEC's Final Analysis with the revised jet force indicates that the support loads are within the evaluation criteria. The Potential Discrepancy No. 2, Jet Impingement, was corrected. Therefore, these OIRs are considered closed.

2. OIR for support EFH-4029: SWEC's Final Analysis indicate a much higher horizontal load than TES's. SWEC has made an analysis using a horizontal support stiffness value approximately equal to the actual stiffness of this support. This had been done by TES to more accurately model the distribution of Load between EFH-4029 and the containment

penetration which is only 1.7 feet away. The result of this analysis indicates that the support load is reduced to less than the TES's valve. When the representative stiffness is used. Therefore TES's design value is considered to be acceptable. This OIR is therefore considered closed.

3. OIR for support EFH-083: This OIR cannot be resolved. The potential discrepancy due to mathematical modeling techniques requires further evaluation. This support is included in Table 4-5, Supports with Potential Discrepancy.

4.13.4 Package 104

No Open Item Reports (OIRs) and no Potential Discrepancies (PDs).

## 4.14 CONCLUSIONS

The independent seismic design verification analysis confirmed that all piping stresses in the flow path of the Turbine Driven EF Pump of the Emergency Feedwater System to Steam Generator C were within the ASME Code allowables. Review of the piping thermal movement, Reactor Building penetration No. 213, and all pump nozzles but the suction nozzle of the turbine driven pump led to the conclusion that adequate design data were properly used by GAI. However, SWEC's Comparison Analysis showed that loads for 26 supports, four anchors, and the suction nozzle of the Turbine Driven EF Pump were substantially higher than design loads. These differences appeared to be caused by three Potential Discrepancies. Two of these discrepancies, i.e. Diesel Generator Building seismic input and jet impingement locations and orientations, were subsequently corrected by GAI and TES. Results of TES's reanalysis were compared with SWEC's Final Analysis with revised jet forces. This comparison indicated that ten supports and two anchors still have differences exceeding SWEC's evaluation criteria. These differences are probably due to differences in mathematical modeling. (Potential Discrepancy No. 3). SWEC is presently reviewing the computer input and modeling of subsystem EF-01. The results of this review should be available shortly and will be incorporated into the final report.

Table 4-1: Maximum Piping Stresses from the Comparison Analysis

| Package No. | System Condition | Equation | Node No. | Max. Stress (psi) | Allowable Stress (psi) |
|---|---|---|---|---|---|
| 101 | Normal | 8 | 323 | 2,097 | 15,000 |
| | Upset I | 9 | 197 | 4,991 | 18,000 |
| | | 11 | 1 | 20,188 | 37,500 |
| | Upset II | 9 | 227 | 2,251 | 22,500 |
| | Emergency | 9 | 197 | 5,833 | 27,000 |
| 102 | Normal | 8 | 950 | [illegible],374 | 15,000 |
| | Upset I | 9 | 950 | 10,593 | 18,000 |
| | | 11 | 524 | 30,356 | 37,500 |
| | Upset II | 9 | 950 | 8,378 | 22,500 |
| | Emergency | 9 | 950 | 10,648 | 27,000 |
| 103 | Normal | 8 | 1008 | 9,428 | 15,000 |
| | Upset I | 9 | 1008 | 12,801 | 18,000 |
| | | 11 | 14 | 28,104 | 37,500 |
| | Upset II | 9 | 1008 | 9,429 | 22,500 |
| | Emergency | 9 | 1008 | 13,331 | 27,000 |
| 104 | Normal | 8 | 94 | 7,336 | 15,000 |
| | Upset I | 9 | 123 | 17,391 | 18,000 |
| | | 11 | 123 | 30,069 | 37,500 |
| | Upset II | 9 | | No Jet Impingement | |
| | Emergency | 9 | 123 | 17,923 | 27,000 |

## TABLE 4-2: SUPPORT LOAD REVIEW OF PACKAGE 101

| Support No. EFH- | SWEC's Node No. | SWEC's Load | Corresp. GAI Load | Difference | Percentage (%) | Dominant Factor | Support Type |
|---|---|---|---|---|---|---|---|
| 094 | 95 | 1352 | 783 | 569 | 73 | Seismic Movement | U-Bolt |
| 095 | 85 | 1424 | 1230 | 194 | 16 | Seismic Movement | U-Bolt |
| 096 | 83 | 321 | 210 | 111 | 53 | Seismic Movement | Clamp |
| 097 | 71 | 891 | 577 | 314 | 54 | Seismic Movement | Clamp |
| 098 | 63 | 527 | 399 | 128 | 32 | Seismic Incertial | U-Bolt |
| 101 | 145 | 2727 | 1034 | 1693 | 166 | Seismic Inertial | Snubber |
| 102 | 153 | 1342 | 1039 | 303 | 29 | Seismic Inertial | Framing |
| 103 | 165 | 3410 | 2307 | 1103 | 48 | Seismic Inertial | Strut |
| 104 | 175 | 2173 | 1637 | 536 | 33 | Seismic Inertial | Rod |
| 106 | 197 | 2478 | 1153 | 1325 | 115 | Seismic Inertial | Framing |
| 4019 | 235 | 549 | 22 | 527 | 2396 | Seismic Movement | Snubber |
| 4021 | 213 | 1277 | 672 | 605 | [illegible] | Seismic Inertial | Snubber |
| 4022 | 245 | 2292 | 1083 | 1209 | 112 | Seismic Movement | Strut |
| 4023 | 343 | 1282 | 966 | 316 | 33 | Seismic Inertial | Strut |
| 4026 | 257 | 5251 | 2692 | 2559 | 95 | Seismic Movement | Strut |
| 4028 | 163 | 4171 | 2307 | 1864 | 81 | Seismic Inertial | Strut |
| 4031 | 213 | 5050 | 2302 | 2748 | 119 | Seismic Movement | Framing |
| 4034 | 275 | 1613 | 110 | 1503 | 1366 | Seismic Movement | Strut |
| 4035 | 273 | 2110 | 1216 | 894 | 74 | Seismic Movement | Strut |
| 4036 | 41 | 881* | 683 | 198 | 29 | Seismic Movement | Strut |
| Anchor | 1 | 1426 | 1057 | 369 | 35 | Seismic Inertial | Concrete |
| Anchor | 441 | 922 | 785 | 137 | 18 | Seismic Inertial | Concrete |

NOTE: Load are forces in lbs.
*Emergency Condition

TABLE 4-3: SUPPORT LOAD REVIEW OF PACKAGE 102

| Support No. EFH- | SWEC's Node No. | SWEC's Load | Corresp. GAI Load | Difference | Percentage (%) | Dominant Factor | Support Type |
|---|---|---|---|---|---|---|---|
| 048 | 600 | 1227 | 280 | 947 | 338 | Jet Impingement | Strut |
| 051 | 754 | 188 | 59 | 129 | 219 | Seismic Inertial | Snubber |
| 057 | 508 | 341 | 239 | 102 | 43 | Thermal | Framing |
| 111**** | 710 | 1416 | 200 | 1216 | 608 | Dead Weight | Trunnion |
| 113* | 824 | 11176 | 2732 | 8444 | 309 | Model | Trunnion |
| 114** | 970 | 477 | 336 | 141 | 42 | Seismic Inertial | Trunnion |
| 182 | 544 | 162*** | 19 | 143 | 753 | Seismic Inertial | Snubber |
| 4005 | 532 | 355*** | 117 | 238 | 203 | Seismic Inertial | Strap |

NOTE: Unless otherwise noted Loads are forces in lbs.
*EFH-113 is an anchor, the indicated loads are Moment My in in-lbs.
**EFH-114 is an anchor, the indicated loads are Forces Fx.
***Loads indicated are from Emergency Condition.
****EFH-111 is an anchor, the indicated loads are Moment Mx (in-lbs) in Normal Condition, all others are within the criteria.

TABLE 4-4: SUPPORT LOAD REVIEW OF PACKAGE 103

| Support No. EFH- | SWEC's Node No. | SWEC's Load | Corresp. GAI Load | Difference | Percentage (%) | Dominant Factor | Support Type |
|---|---|---|---|---|---|---|---|
| 060 | 1019 | 995 | 757 | 238 | 31 | Jet Impingement | Strut |
| 061 | 1020 | 925 | 412 | 513 | 125 | Jet Impingement | Strut |
| 062 | 1018 | 678 | 166 | 512 | 308 | Jet Impingement | Strap |
| 082 | 1029 | 365*** | 189 | 176 | 93 | Thermal | Framing |
| 083* | 1500 | 2012 | 1160 | 852 | 73 | Thermal | Skewed Strut |
| 115** | 1400 | 4420 | 3509 | 911 | 26 | Thermal | Trunnion |
| 4029* | 1001 | 2148 | 914 | 1234 | 135 | Seismic Movement | Framing |

NOTE: *Orientation of support not in global coordinate system.
**Anchor, the indicated loads are Forces Fz in Normal Condition.
***Loads in Normal Condition.
Loads are forces in lbs.

## TABLE 4-5: SUPPORTS WITH POTENTIAL DISCREPANCY

| Stress Package | Support No. EFH- | SWEC's Node No. | SWEC's Load | TES's Load | Difference | Percentage (%) |
|---|---|---|---|---|---|---|
| 101 | 0[illegible]7 | 71 | 403 | 173 | 230 | 133 |
| 101 | 101 | 145 | 2727 | 1168 | 1559 | 134 |
| 101 | 102 | 153 | 1342 | 1056 | 286 | 27 |
| 101 | 103 | 165 | 3410 | 2439 | 971 | 40 |
| 101 | 104 | 175 | 2173 | 1821 | 352 | 19 |
| 101 | 106 | 197 | 2478 | 1469 | 1009 | 69 |
| 101 | 4021 | 213 | 1277 | 962 | 315 | 33 |
| 101 | 4028 | 163 | 4171 | 2296 | 1875 | 82 |
| 101 | 4035 | 273 | 903 | 633 | 270 | 43 |
| 101 | Anchor | 1 | 1426 | 1098 | 328 | 30 |
| 102 | 114* | 970 | 477 | 336 | 141 | 42 |
| 103 | 083 | 1500 | 2012 | 1160 | 852 | 73 |

Note: All loads are in lbs.
*An anchor, the loads are Forces Fx.

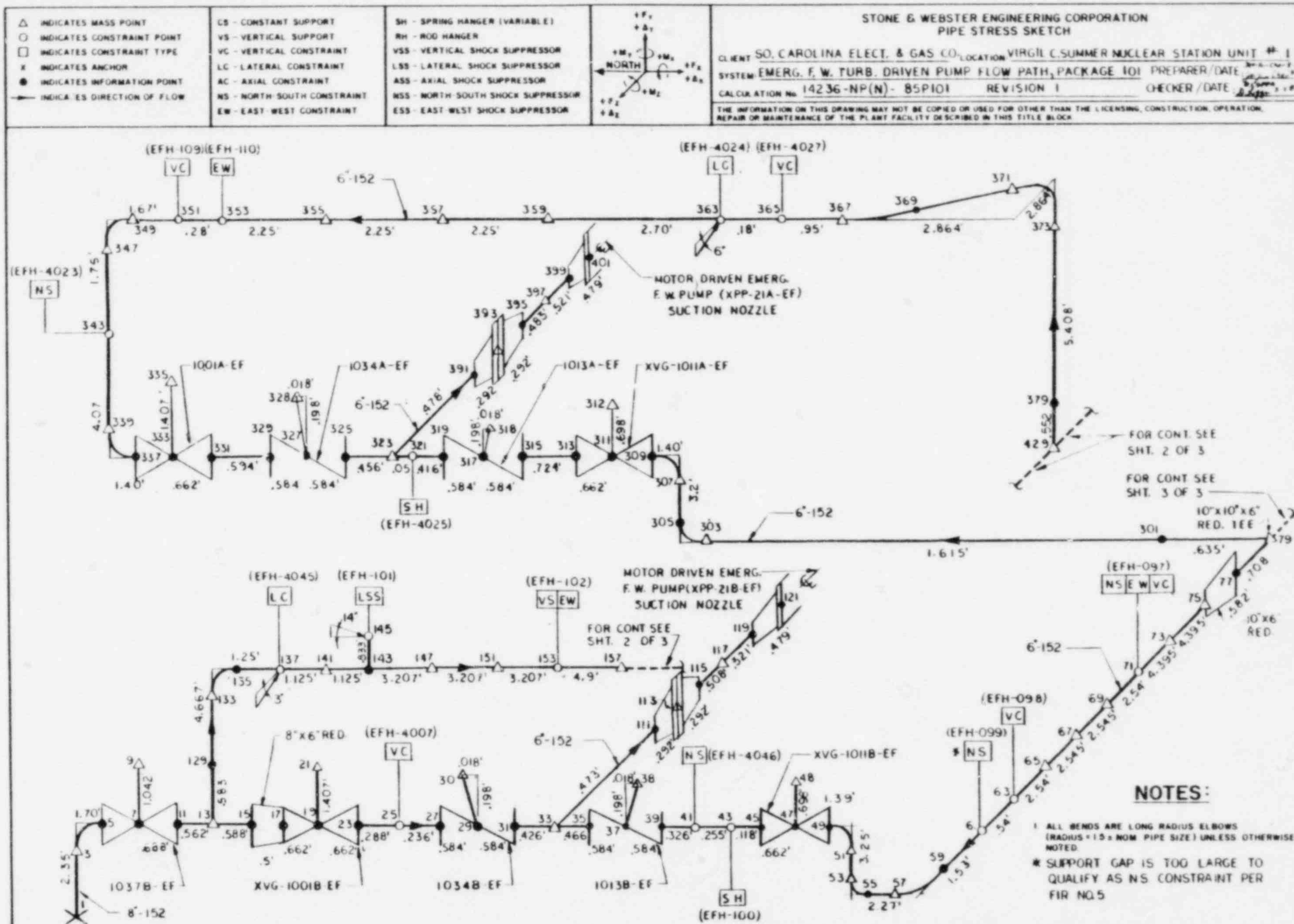


FIGURE 4-1
WORK SKETCH FOR PACKAGE 101

| | | | |
|---|---|---|---|
| △ INDICATES MASS POINT | CS - CONSTANT SUPPORT | SH - SPRING HANGER (VARIABLE) | |
| ○ INDICATES CONSTRAINT POINT | VS - VERTICAL SUPPORT | RH - ROD HANGER | |
| □ INDICATES CONSTRAINT TYPE | VC - VERTICAL CONSTRAINT | VSS - VERTICAL SHOCK SUPPRESSOR | |
| x INDICATES ANCHOR | LC - LATERAL CONSTRAINT | LSS - LATERAL SHOCK SUPPRESSOR | |
| ● INDICATES INFORMATION POINT | AC - AXIAL CONSTRAINT | ASS - AXIAL SHOCK SUPPRESSOR | |
| ⟶ INDICATES DIRECTION OF FLOW | NS - NORTH SOUTH CONSTRAINT | NSS - NORTH SOUTH SHOCK SUPPRESSOR | |
| | EW - EAST-WEST CONSTRAINT | ESS - EAST-WEST SHOCK SUPPRESSOR | |

+F_Y +Δ_Y +M_Y +M_X NORTH +F_X +Δ_X +M_Z +F_Z +Δ_Z

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SYSTEM EMERG. F.W. TURB. DRIVEN PUMP FLOW PATH, PACKAGE 101 PREPARER/DATE:

CALCULATION No. 14236-NP(N)- 85P101 REVISION 1 CHECKER/DATE:

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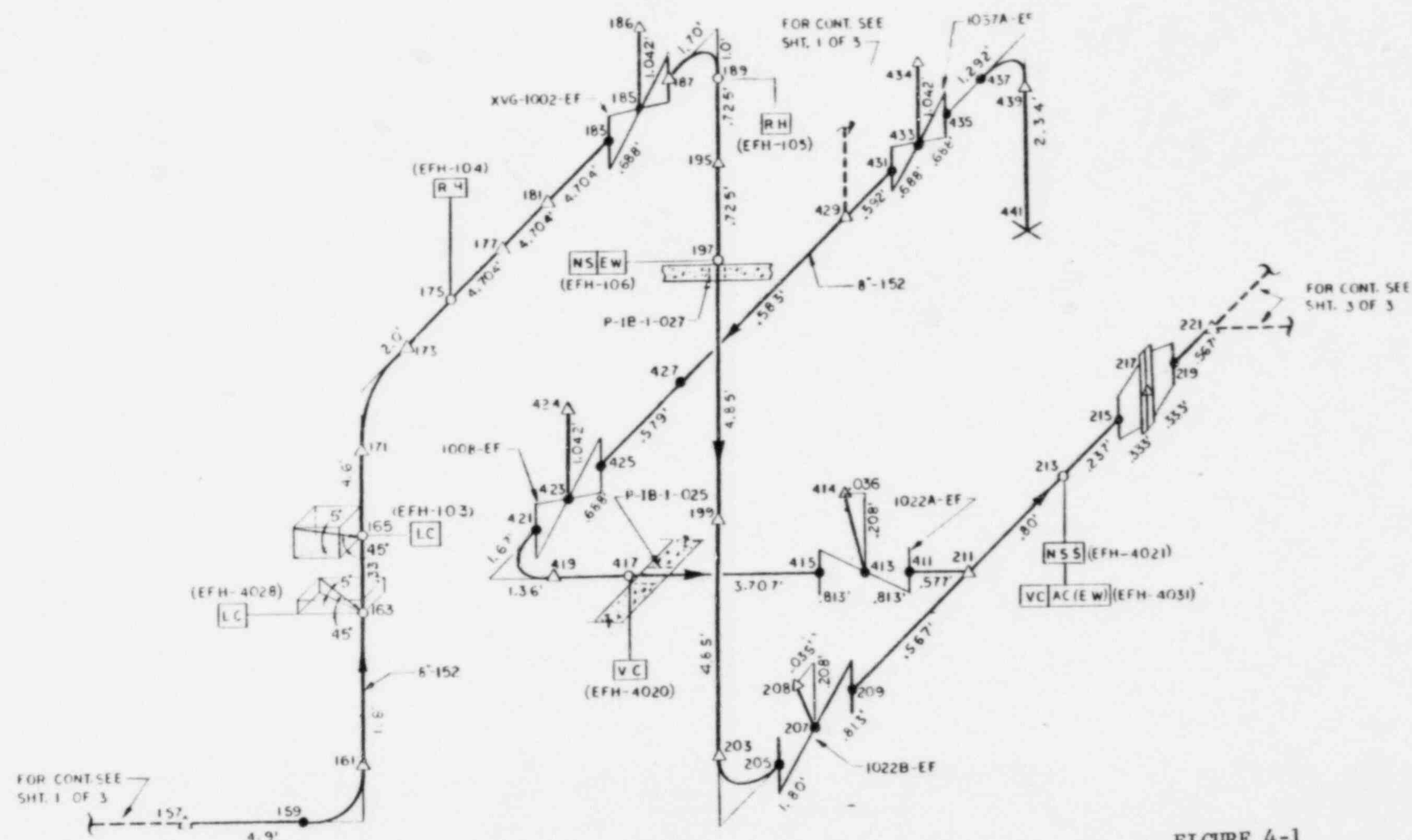


FIGURE 4-1
WORK SKETCH FOR PACKAGE 101

SHT. 2 OF 3

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## PIPE STRESS SKETCH

| | | |
|---|---|---|
| △ INDICATES MASS POINT | CS - CONSTANT SUPPORT | SH - SPRING HANGER (VARIABLE) |
| ○ INDICATES CONSTRAINT POINT | VS - VERTICAL SUPPORT | RH - ROD HANGER |
| □ INDICATES CONSTRAINT TYPE | VC - VERTICAL CONSTRAINT | VSS - VERTICAL SHOCK SUPPRESSOR |
| x INDICATES ANCHOR | LC - LATERAL CONSTRAINT | LSS - LATERAL SHOCK SUPPRESSOR |
| ● INDICATES INFORMATION POINT | AC - AXIAL CONSTRAINT | ASS - AXIAL SHOCK SUPPRESSOR |
| → INDICATES DIRECTION OF FLOW | NS - NORTH SOUTH CONSTRAINT | NSS - NORTH SOUTH SHOCK SUPPRESSOR |
| | EW - EAST WEST CONSTRAINT | ESS - EAST WEST SHOCK SUPPRESSOR |

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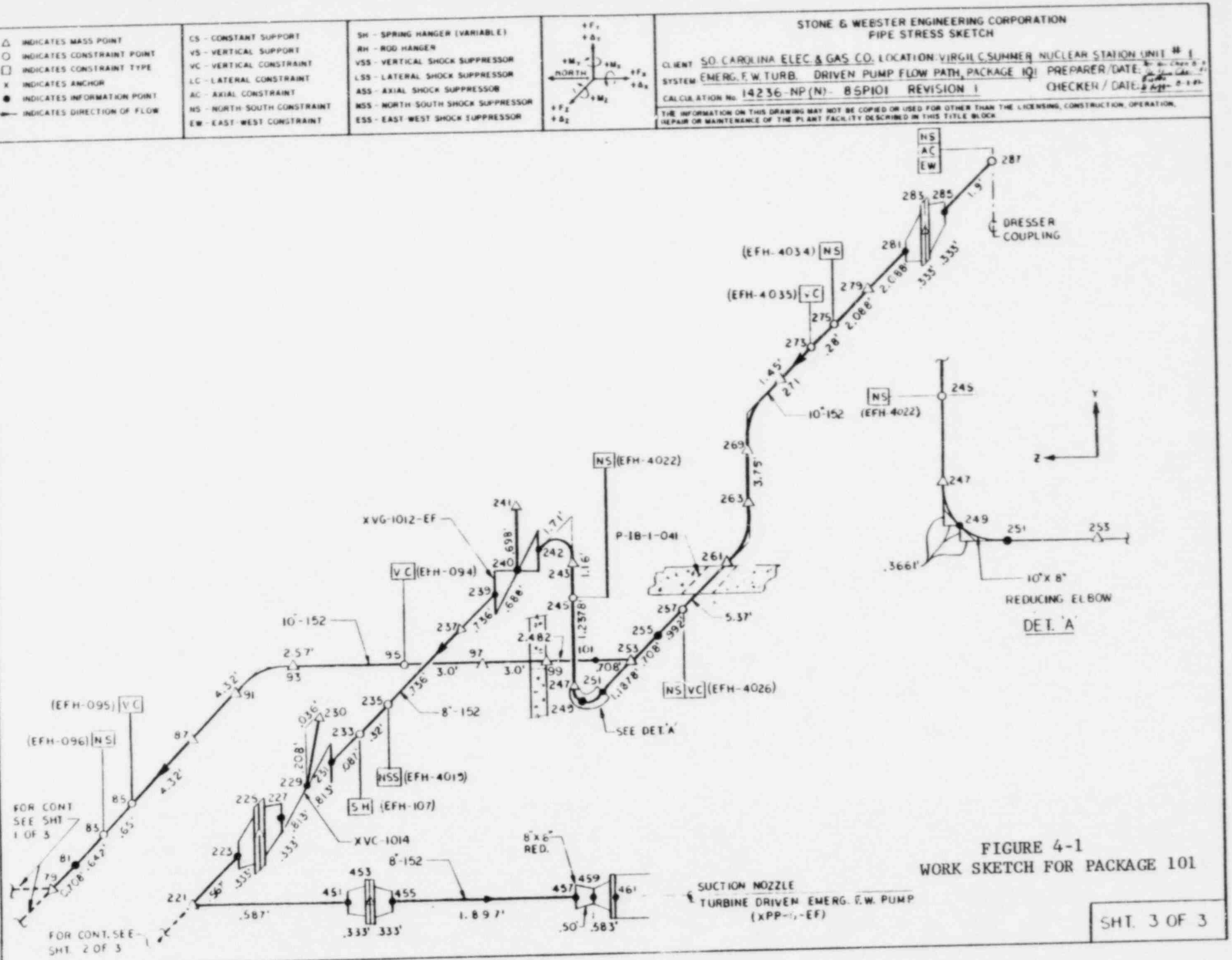


FIGURE 4-1
WORK SKETCH FOR PACKAGE 101

| | | | |
|---|---|---|---|
| △ INDICATES MASS POINT | CS - CONSTANT SUPPORT | SH - SPRING HANGER (VARIABLE) | +F_Y +Δ_Y |
| ○ INDICATES CONSTRAINT POINT | VS - VERTICAL SUPPORT | RH - ROD HANGER | +M_Y +M_X NORTH +F_X +Δ_X |
| □ INDICATES CONSTRAINT TYPE | VC - VERTICAL CONSTRAINT | VSS - VERTICAL SHOCK SUPPRESSOR | +M_Z |
| × INDICATES ANCHOR | LC - LATERAL CONSTRAINT | LSS - LATERAL SHOCK SUPPRESSOR | +F_Z +Δ_Z |
| ● INDICATES INFORMATION POINT | AC - AXIAL CONSTRAINT | ASS - AXIAL SHOCK SUPPRESSOR | |
| ← INDICATES DIRECTION OF FLOW | NS - NORTH SOUTH CONSTRAINT | NSS - NORTH-SOUTH SHOCK SUPPRESSOR | |
| | EW - EAST-WEST CONSTRAINT | ESS - EAST-WEST SHOCK SUPPRESSOR | |

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## NOTES:

1. ALL BENDS ARE LONG RADIUS ELBOWS (RADIUS = 1.5 x NOM. PIPE SIZE) UNLESS OTHERWISE NOTED.
2. THE PIPE SECTION FROM NODES 2826 TO 2858 IS INCLUDED ONLY FOR THE PURPOSE OF PROVIDING AN ANALYTICAL TERMINAL POINT FOR THIS SUBSYSTEM.

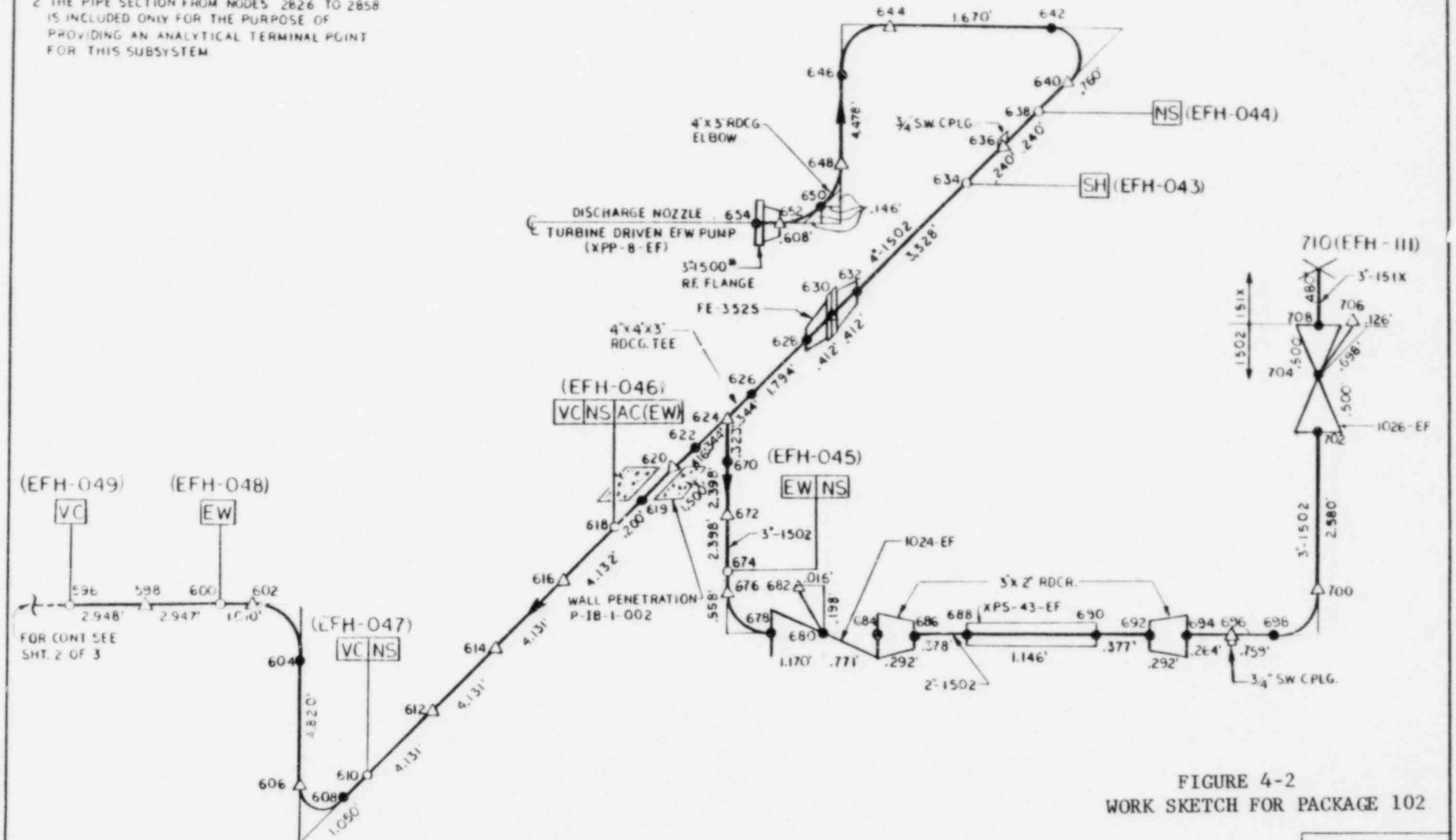


FIGURE 4-2
WORK SKETCH FOR PACKAGE 102

SHT. 1 OF 3

| | | | |
|---|---|---|---|
| △ INDICATES MASS POINT | CS - CONSTANT SUPPORT | SH - SPRING HANGER (VARIABLE) | |
| ○ INDICATES CONSTRAINT POINT | VS - VERTICAL SUPPORT | RH - ROD HANGER | |
| □ INDICATES CONSTRAINT TYPE | VC - VERTICAL CONSTRAINT | VSS - VERTICAL SHOCK SUPPRESSOR | |
| x INDICATES ANCHOR | LC - LATERAL CONSTRAINT | LSS - LATERAL SHOCK SUPPRESSOR | |
| ● INDICATES INFORMATION POINT | AC - AXIAL CONSTRAINT | ASS - AXIAL SHOCK SUPPRESSOR | |
| ← INDICATES DIRECTION OF FLOW | NS - NORTH SOUTH CONSTRAINT | NSS - NORTH SOUTH SHOCK SUPPRESSOR | |
| | EW - EAST-WEST CONSTRAINT | ESS - EAST-WEST SHOCK SUPPRESSOR | |

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FOR GENERAL NOTES SEE SHT 1 OF 3

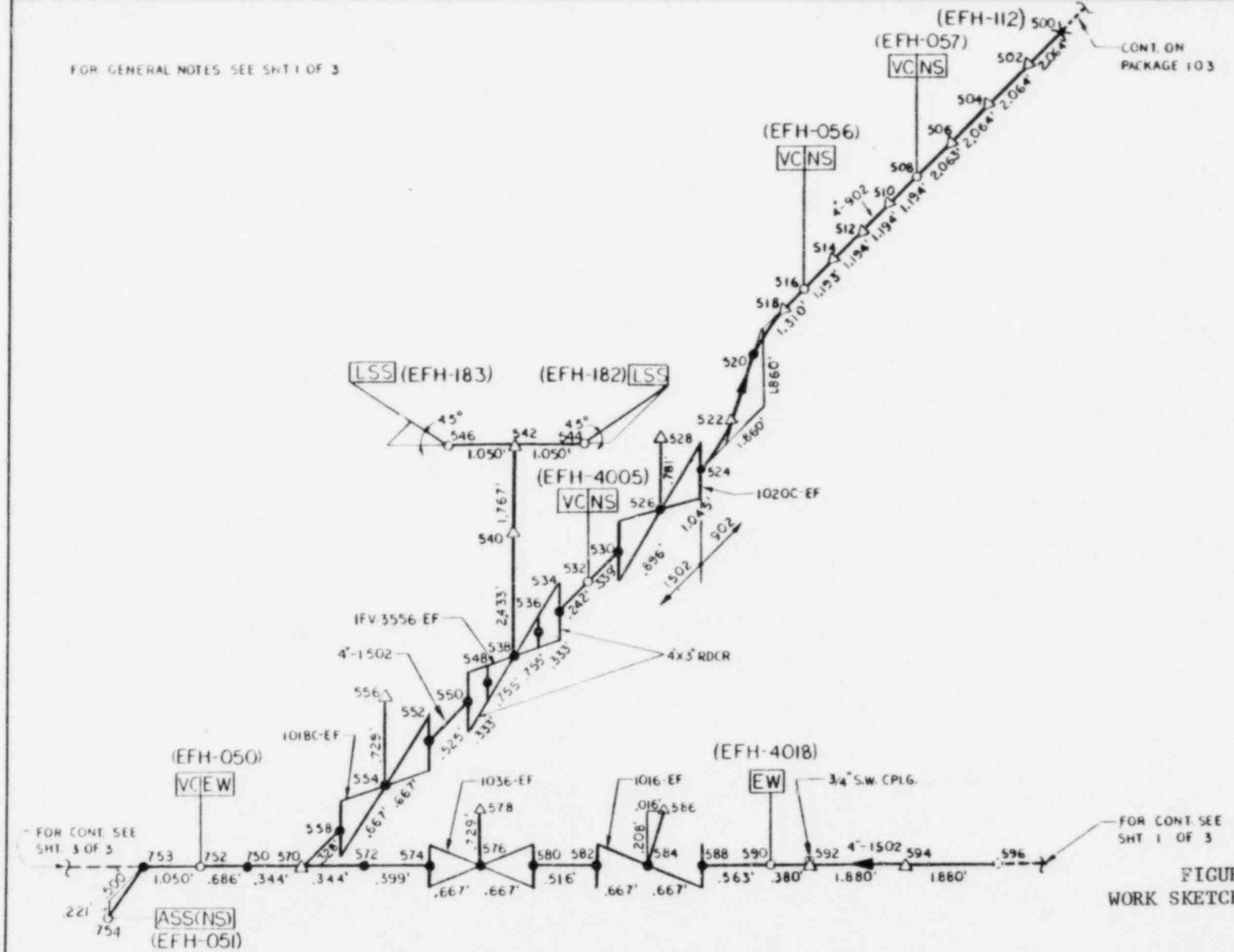


FIGURE 4-2
WORK SKETCH FOR PACKAGE 102

SHT. 2 OF 3

| | | |
|---|---|---|
| △ INDICATES MASS POINT | CS - CONSTANT SUPPORT | SH - SPRING HANGER (VARIABLE) |
| ○ INDICATES CONSTRAINT POINT | VS - VERTICAL SUPPORT | RH - ROD HANGER |
| □ INDICATES CONSTRAINT TYPE | VC - VERTICAL CONSTRAINT | VSS - VERTICAL SHOCK SUPPRESSOR |
| x INDICATES ANCHOR | LC - LATERAL CONSTRAINT | LSS - LATERAL SHOCK SUPPRESSOR |
| ● INDICATES INFORMATION POINT | AC - AXIAL CONSTRAINT | ASS - AXIAL SHOCK SUPPRESSOR |
| → INDICATES DIRECTION OF FLOW | NS - NORTH SOUTH CONSTRAINT | NSS - NORTH SOUTH SHOCK SUPPRESSOR |
| | EW - EAST-WEST CONSTRAINT | ESS - EAST WEST SHOCK SUPPRESSOR |

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CALCULATION NO. 14236-NP(N)-65P102 REVISION 1 CHECKER/DATE [illegible]

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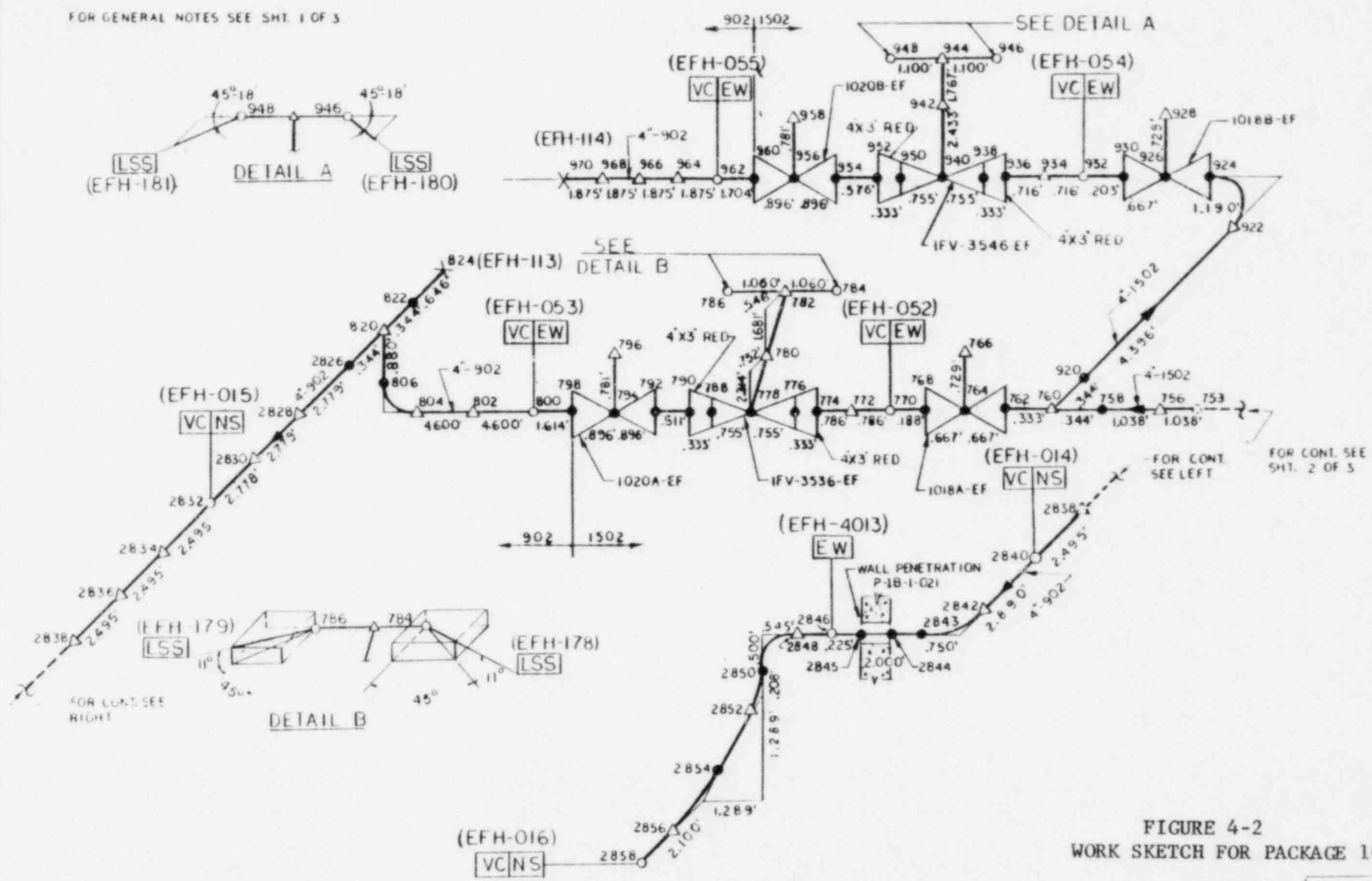


FIGURE 4-2
WORK SKETCH FOR PACKAGE 102

SHT. 3 OF 3

| | | | |
|---|---|---|---|
| △ INDICATES MASS POINT | CS - CONSTANT SUPPORT | SH - SPRING HANGER (VARIABLE) | |
| ○ INDICATES CONSTRAINT POINT | VS - VERTICAL SUPPORT | RH - ROD HANGER | |
| □ INDICATES CONSTRAINT TYPE | VC - VERTICAL CONSTRAINT | VSS - VERTICAL SHOCK SUPPRESSOR | |
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| —→ INDICATES DIRECTION OF FLOW | NS - NORTH-SOUTH CONSTRAINT | NSS - NORTH-SOUTH SHOCK SUPPRESSOR | |
| | EW - EAST-WEST CONSTRAINT | ESS - EAST WEST SHOCK SUPPRESSOR | |

+Fy +θy, +Mx, NORTH, +My, +Fx +θx, +Fz +θz, +Mz

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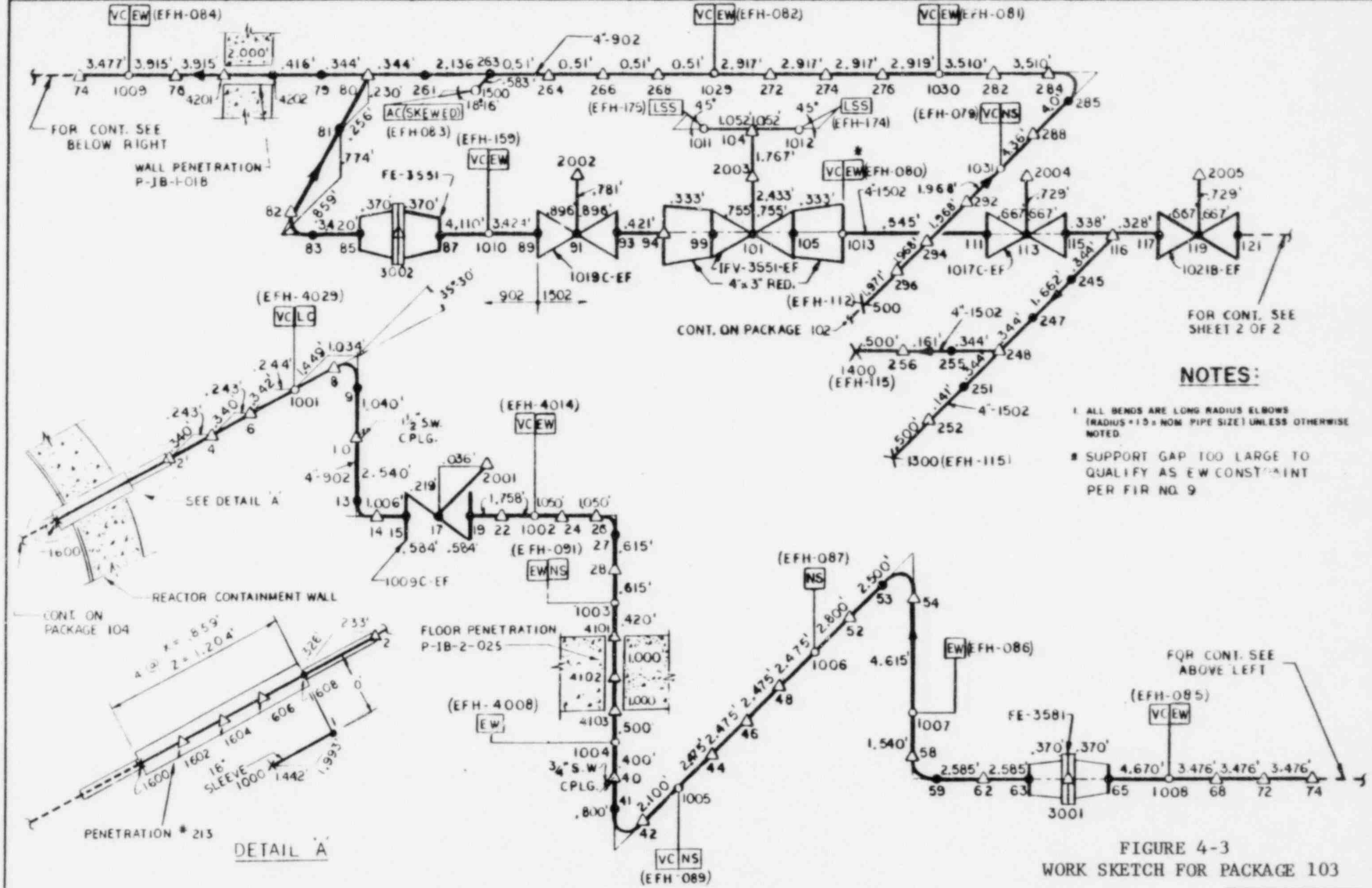


**NOTES:**

1. ALL BENDS ARE LONG RADIUS ELBOWS (RADIUS = 1.5 x NOM. PIPE SIZE) UNLESS OTHERWISE NOTED.

* SUPPORT GAP TOO LARGE TO QUALIFY AS EW CONSTRAINT PER FIR NO. 9

FIGURE 4-3
WORK SKETCH FOR PACKAGE 103

SHT. 1 OF 2

| | | |
|---|---|---|
| △ INDICATES MASS POINT | CS - CONSTANT SUPPORT | SH - SPRING HANGER (VARIABLE) |
| ○ INDICATES CONSTRAINT POINT | VS - VERTICAL SUPPORT | RH - ROD HANGER |
| □ INDICATES CONSTRAINT TYPE | VC - VERTICAL CONSTRAINT | VSS - VERTICAL SHOCK SUPPRESSOR |
| x INDICATES ANCHOR | LC - LATERAL CONSTRAINT | LSS - LATERAL SHOCK SUPPRESSOR |
| ● INDICATES INFORMATION POINT | AC - AXIAL CONSTRAINT | ASS - AXIAL SHOCK SUPPRESSOR |
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| | EW - EAST-WEST CONSTRAINT | ESS - EAST-WEST SHOCK SUPPRESSOR |

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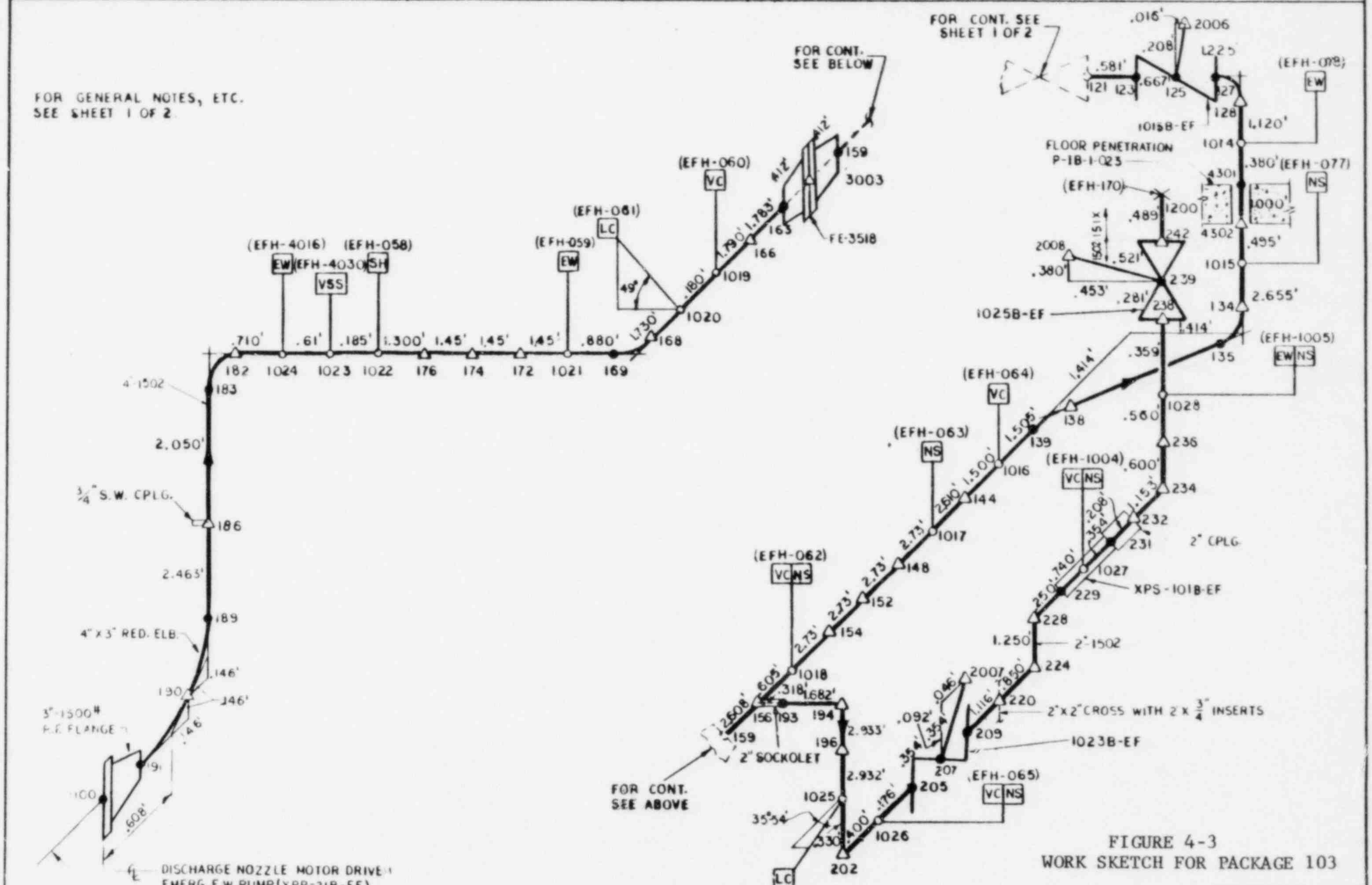


FIGURE 4-3
WORK SKETCH FOR PACKAGE 103

SHT. 2 OF 2

| | | | |
|---|---|---|---|
| △ INDICATES MASS POINT | CS - CONSTANT SUPPORT | SH - SPRING HANGER (VARIABLE) | |
| ○ INDICATES CONSTRAINT POINT | VS - VERTICAL SUPPORT | RH - ROD HANGER | |
| □ INDICATES CONSTRAINT TYPE | VC - VERTICAL CONSTRAINT | VSS - VERTICAL SHOCK SUPPRESSOR | |
| x INDICATES ANCHOR | LC - LATERAL CONSTRAINT | LSS - LATERAL SHOCK SUPPRESSOR | |
| ● INDICATES INFORMATION POINT | AC - AXIAL CONSTRAINT | ASS - AXIAL SHOCK SUPPRESSOR | |
| → INDICATES DIRECTION OF FLOW | NS - NORTH-SOUTH CONSTRAINT | NSS - NORTH-SOUTH SHOCK SUPPRESSOR | |
| | EW - EAST-WEST CONSTRAINT | ESS - EAST-WEST SHOCK SUPPRESSOR | |

**STONE & WEBSTER ENGINEERING CORPORATION**
**PIPE STRESS SKETCH**

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## NOTES:

1. ALL BENDS ARE LONG RADIUS ELBOWS (RADIUS = 1.5 x NOM. PIPE SIZE) UNLESS OTHERWISE NOTED

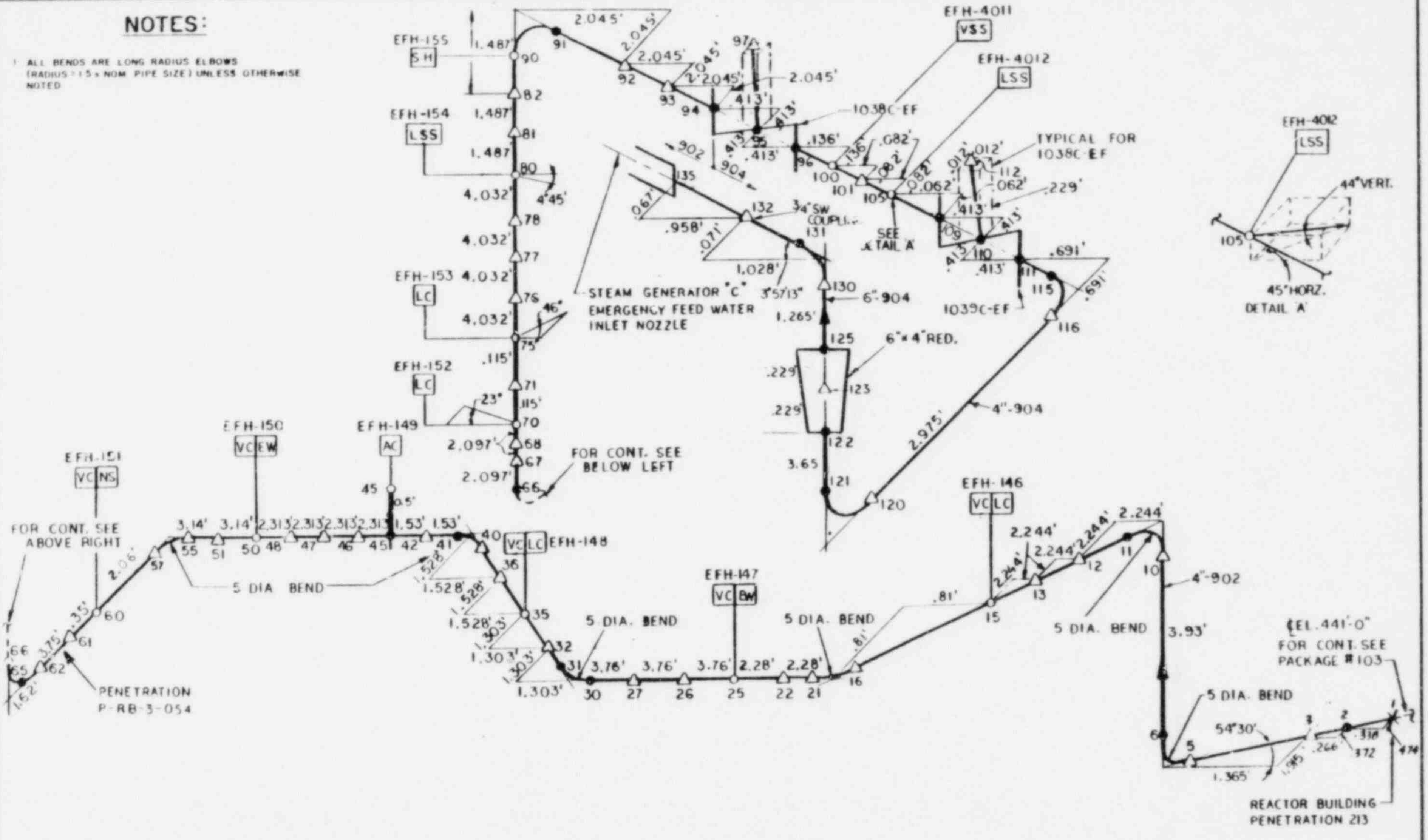


FIGURE 4-4
WORK SKETCH FOR PACKAGE 104

## 5.0 AUDIT REPORT, DESIGN CONTROL PROGRAM

PREPARED BY: D. L. Malone
Audit Team Leader

REVIEWED BY: J. H. MacKinnon
Design Control Audit Manager

APPROVED BY: D. C. Shelton
Division Chief, Engineering Assurance

CONTENTS

## 5.1 PURPOSE

The purpose of this audit was to independently verify that an adequate design control program, meeting the requirements of 10CFR50 Appendix B, was in place and implemented for transmittal and utilization of input data for activities associated with the seismic analysis of the Emergency Feedwater Piping System for the flow path of the turbine driven Emergency Feedwater Pump of the V.C. Summer Nuclear Station, Unit No. 1.

## 5.2 SCOPE

The audit included the inputs used to perform the seismic analysis (pipe stress analysis) of that portion of the Emergency Feedwater System identified as subsystems EF-01, EF-02, EF-03 and EF-22 on Figure 5-1. It also included a review of the procedures for controlling design inputs generated by Gilbert Associates, Incorporated (GAI) or provided to GAI by manufacturers, through transmittal to the input user, Teledyne Engineering Services (TES). Control of inputs such as the following were included:

- Response Spectra
- Design Specifications/Requirements/Conditions
- Manufacturer's Data

Control of inputs to pipe stress analyses for other piping systems was examined when necessary to provide sufficient basis to justify conclusions.

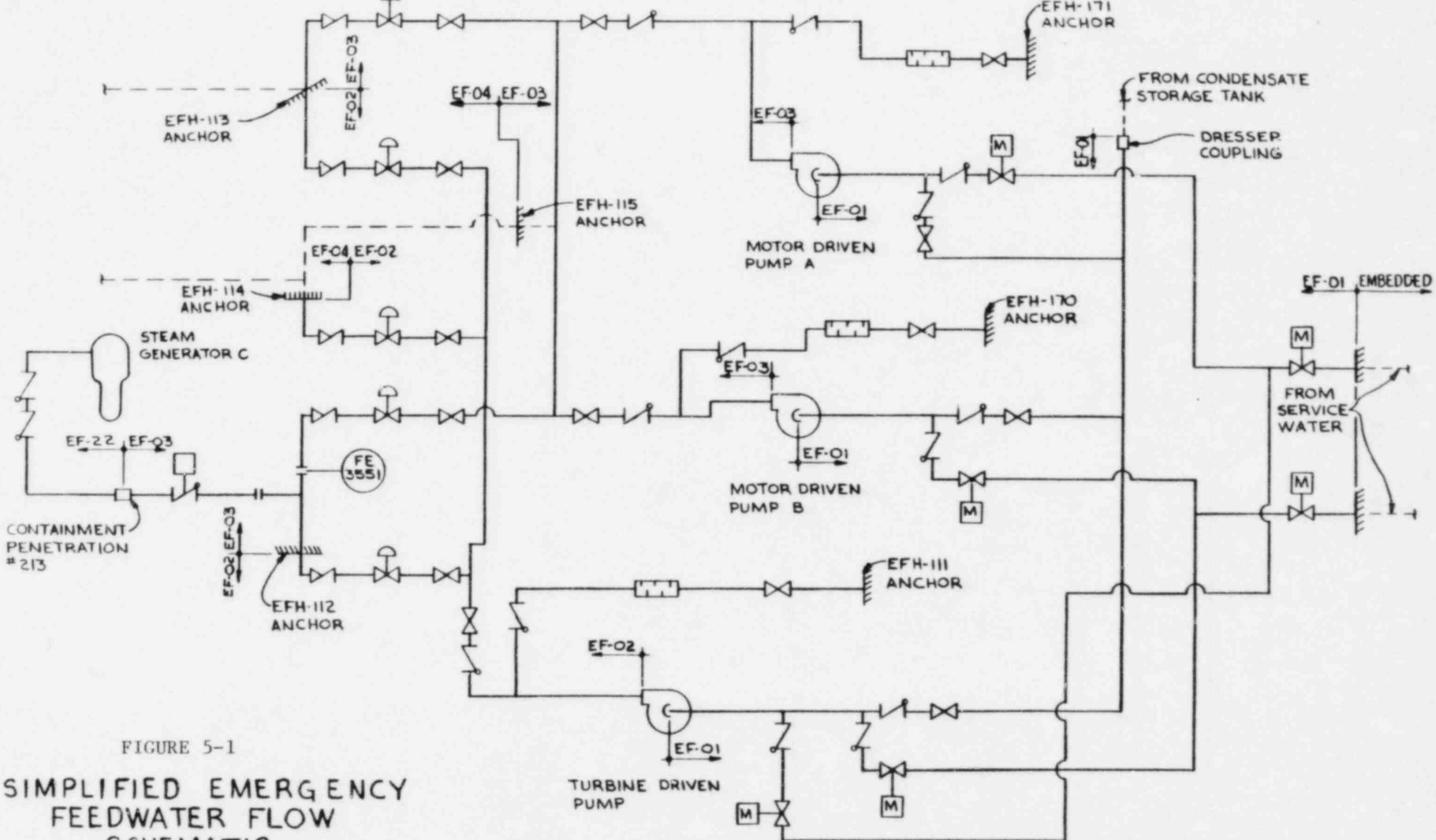


FIGURE 5-1

SIMPLIFIED EMERGENCY FEEDWATER FLOW SCHEMATIC

## 5.3 APPROACH

### 5.3.1 General

The first stage of the audit was a pre-audit conference with GAI. (GAI is the Architect/Engineer (A/E) for the V.C. Summer Nuclear Station). The pre-audit conference was held May 19, 20 and 21. In addition to presenting the purpose and scope of the audit, the conference was used to gain understanding of the GAI organization and procedural program.

The flow of design information relating to pipe stress analysis was discussed in detail. Based on this discussion and a review of applicable procedures, a preliminary flow chart depicting the basic flow of pipe stress analysis input was prepared during this period. This flow chart was used as a reference document during the course of the audit and was modified to reflect observed information flow. (See Figure 5-2, Sheet 1).

Sheet 2 of Figure 5-2, which is based on discussions with GAI and procedure review, is included for information only. The scope of the audit did not directly include pipe support design for, or field walkdown of, piping systems. Figure 5-2, Sheets 1 and 2, are simplified for clarity. Not all documents, procedures and feedback loops are shown.

The GAI quality assurance program document hierarchy is shown on Figure 5-3. The procedures most directly applicable to the audit were contained in the Project Management Manual (PMM) and Design Control Procedures (DCPs).

The Reference PMM and the DCPs underwent major restructuring in 1977. The restructured program was invoked on the V.C. Summer Project in November 1981. As explained by GAI, many of the changes in the program dealt mainly with format. The significant difference in the program was the increased requirements for controlling design verification (e.g., design verification status reports). The present program requires that designs be verified prior to installation except piping design (pipe stress analysis and pipe support design). Verification of these designs may be performed after installation, but prior to fuel load. This exception is provided for in the PMM.

Discussion at the pre-audit conference included clarification of the interface between GAI and TES. South Carolina Electric and Gas Company contracted with TES to perform pipe stress analyses using inputs supplied by GAI. The interface between GAI and TES is controlled by an interface procedure (an appendix to the Project Management Manual for the V.C. Summer Project).

Following the pre-audit conference, an audit checklist was developed. The checklist questions developed were basically of two categories:

1. Questions that related to tracking a specific pipe stress analysis input from its source (e.g., a GAI calculation or a vendor drawing) to its use in pipe stress analysis.

2. General questions that dealt with a specific control aspect (e.g., control of specifications or control of vendor drawings).

Initial examination of evidence began at GAI on May 24, 1982 and continued until May 28, 1982. On May 28, 1982, a status meeting was held with GAI. The purpose of the meeting was to advise GAI that the major part of the audit was complete but the audit would resume in approximately one week after SWEC had time to evaluate audit results to date. After this evaluation was completed it was determined that additional documentation should be examined. This was accomplished on June 9, 1982.

On June 10, 1982 a post audit conference was held to present the audit results.

Audit Participants, including attendees at the pre-audit conference, status meeting and post-audit conference, are identified on Attachment 1.

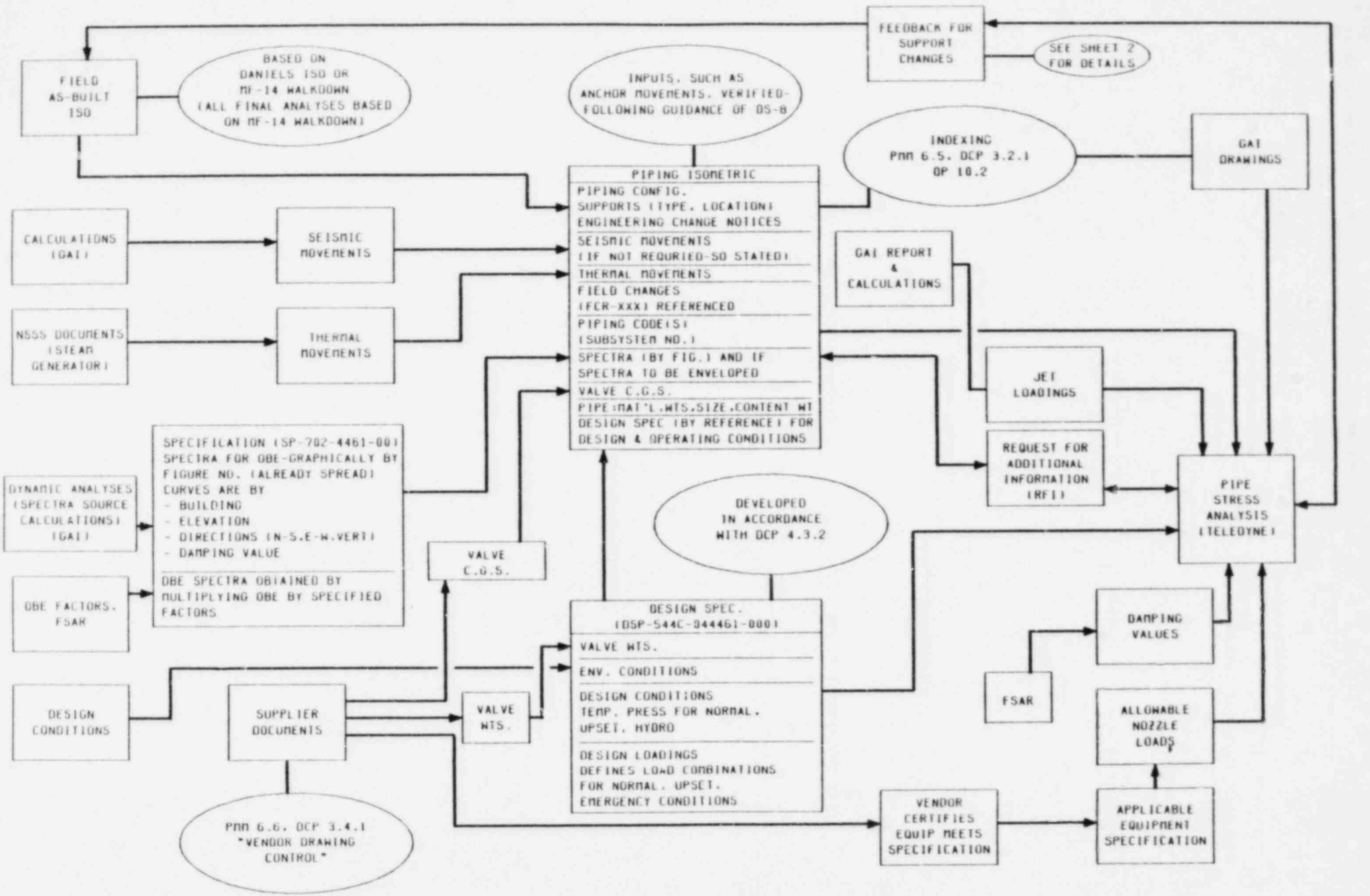


FIGURE 5-2, Sheet 1

Design Input Flow Chart

# DOCUMENT/ PAGE PULLED

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NO. OF PAGES 1

REASON

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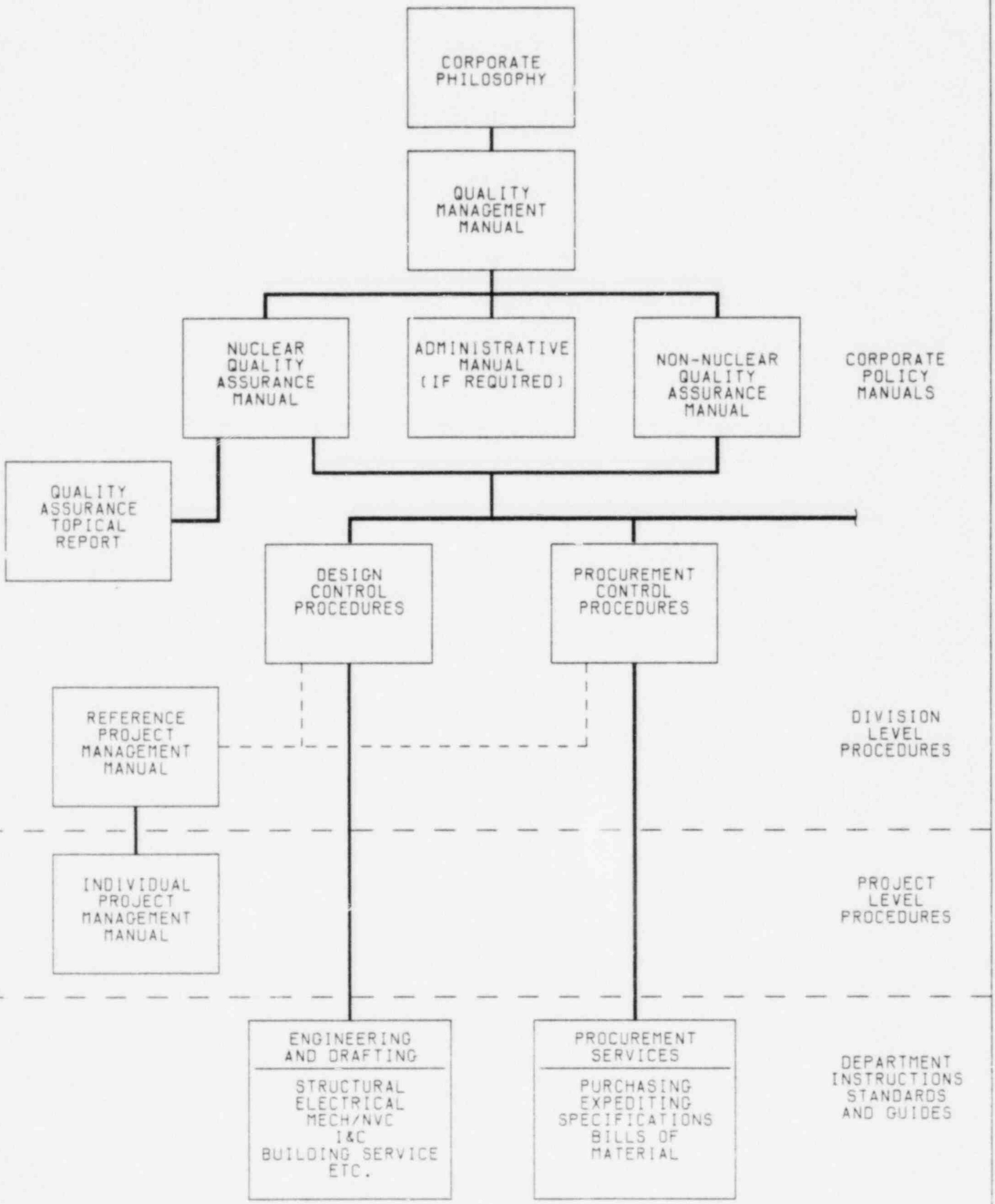
FIGURE 5-3 QUALITY MANAGEMENT PROGRAM DOCUMENT HIERARCHY



### 5.3.2 Examination of Evidence

#### 5.3.2.1 Inputs to Pipe Stress Analysis

The initial planned approach and sampling are discussed below. In some cases it was necessary to select additional items; these cases are discussed in Sectic i 5.5, Results.

Response Spectra (OBE) - The piping isometric drawings (isometrics) identify the response spectra to be utilized by reference to a Figure Number in GAI Specification SP-702-4461-00 (Specification 702). The figures contained in Specification 702 were compared to the results of the dynamic analysis (computer printout section of GAI calculation). This was accomplished by comparing one or more points (at a peak or peaks) on the curve in the specification against the dynamic analysis results.

It was then determined if the spectra (Figure Nos.) called out on the isometrics were appropriate, considering piping location (building, elevation).

The TES pipe stress analysis packages (EF-01,02,03 and 22) were then reviewed to determine if the spectra identified on the isometrics were utilized in the analysis. This was determined by comparing the spectra listed on the input section of the stress analysis packages against the isometrics.

All response spectra identified as applicable to the turbine driven pump portion of the Emergency Feed Water System (subsystems EF-01, 02, 03 and 22) were compared in this manner.

DBE Factors - DBE response spectra are obtained by factoring the OBE spectra by a value that is dependent on the piping location (building). The DBE factors are contained in Specification 702.

The DBE factors in Specification 702 (for the buildings of interest) were compared to the factors in the FSAR for the same buildings. The factors utilized in the pipe stress analysis (as evidenced in the input section of the analysis) were then reviewed to determine if they were appropriate for the location of the piping analyzed.

All DBE factors associated with subsystems EF-01,02,03 and 22 were tracked in this manner.

Damping Factors - The response spectrum for a particular building elevation, and direction is represented by several curves, each corresponding to a damping factor.

The damping factors utilized in the pipe stress analysis packages (as evidenced in the input section of the analyses) were compared to those provided by GAI. The damping factors provided were also compared to the FSAR.

This methodology was applied to all subsystems within the scope of the audit.

Design Conditions - A sample of design conditions (one temperature and three pressures) was selected from GAI Design Specification DSP-544C-044461-000 (Specification 544C) and compared against the source document (e.g., GAI calculation or Westinghouse Design Specification). The input section of the two pipe stress analysis packages that would utilize these inputs were reviewed to determine if these design conditions were evaluated.

Anchor Movements - Anchor movements (thermal and seismic) are identified on the isometrics. A sample of three sets of seismic movements and one set of thermal movements were selected from the isometrics and compared to the results of GAI calculations. These movements were also compared to the values utilized in the pipe stress analysis. Since the input section of the pipe stress analysis package did not list anchor movements, it was necessary to review the echo print from the computer run to determine values used.

Jet Loadings - A sample of jet loadings (five load cases) transmitted by GAI to TES, were selected and compared to the results of GAI calculations. The echo print of the computer run associated with the pipe stress analysis was reviewed to determine if the transmitted loadings were utilized.

Pipe Materials - A sample of pipe materials was selected from the isometrics consisting of material sizes and schedules in the run of piping between the turbine driven Emergency Feedwater Pump to the Steam Generator. Comparisons were made between the isometric, design specification and piping drawing to determine if the materials and sizes were consistent. Since the pipe stress analysis did not define materials but material properties, the modulus and allowables in the pipe stress analysis packages were compared to those specified in ASME Boiler and Pressure Vessel Code.

Valve Weights - A sample of ten valves was selected from flow diagrams. The weights of the valves, as determined from the suppliers' drawings, was compared against the valve weights listed in the system design specification. The weights were also compared to the values used in the pipe stress analysis by reviewing the echo print of the computer printout associated with the pipe stress analysis.

Valve Center of Gravity (CGs) - Valve CGs are shown on the isometrics. The same sample of valves used to compare valve weights was used in comparing valve CGs.

The CG locating dimensions shown on the isometric were compared against the supplier drawing for each valve. By reviewing the echo print of the computer printout associated with the pipe stress analysis, the locating dimensions shown on the isometric were compared to the dimensions utilized in the pipe stress analysis.

Nozzle Loadings - A sample of components was selected (steam generator, containment penetration, and two pumps). The allowable loads on a nozzle or nozzles of the components were determined from the procurement specifications for the component. These values were compared against the calculations contained in the nozzle load summary section of the pipe stress analysis packages.

5.3.2.2 Control Methods

Certain aspects associated with control of pipe stress analysis inputs through transmittal and utilization were evaluated. The first step was to determine if procedures were available to cover these aspects. Secondly, the procedures were reviewed to determine if basic elements were addressed. In addition, documentation was examined to determine if specific areas of the procedures were consistently implemented.

Vendor Drawing Control - Applicable procedures were reviewed to determine if the following were addressed:

- o Receipt control (logging/indexing)
- o Review and approval by appropriate personnel
- o Distribution to appropriate personnel
- o Retention/filing

The index of vendor drawings was reviewed to determine if it is maintained up-to-date and that the listed drawings were clearly identified.

Specification Control - Applicable procedures were reviewed to determine if the following were addressed and evidence was examined to determine implementation:

- o Distribution of specifications (including revisions) to appropriate personnel
- o Maintenance and distribution of indexes

In addition, the specification issues identified on the index were compared against those issues identified on isometrics and against those issues transmitted for use in the pipe stress analysis.

Drawing Control - Procedures were reviewed to determine if the following were addressed and evidence was examined to determine implementation:

- o Distribution of drawings (including revisions) to appropriate personnel
- o Maintenance and distribution of indexes

In addition, the isometric revisions, identified on the index, were compared against the isometric revisions referred to in the pipe stress analysis packages.

Change Mechanisms - GAI utilizes several advance change mechanisms. However, only one, the Engineering Change Notice (ECN) system was evaluated since only ECNs were used to make changes to isometrics.

The procedure was reviewed to determine if the following were addressed and evidence was examined to determine implementation:

- o Identification on the ECN of affected documents.

- A method of identifying ECN status and tracking the change through incorporation into the affected documents.

Interface Control (GAI/TES) - The procedure establishing the interface requirements between GAI and TES was reviewed to determine if methods for transmitting information were provided and implemented, including subsequent changes to previously transmitted information.

One of the interface communication mechanisms is the use of a form called "Request for Information" (RFI). Methods for identifying and logging RFIs were examined.

Computer Programs - Procedures were reviewed to determine if the following were addressed and evidence was examined to determine implementation:

- Requirements for utilization of verified/certified computer programs.

- Methods for identifying/tracking the use of computer programs that are not verified/certified to ensure later verification/certification.

Design Verification - Procedures were reviewed to determine methods utilized in performing and documenting design verification. Evidence was examined to determine implementation.

5.4 EVIDENCE EXAMINED

The following is a list of the major documents examined during the audit:

PROCEDURES

Project Management Manual (October 1971 - November 1981):

| | |
|---|---|
| 6.6 | Manufacturer's Drawings |
| 7.3 | Design Review and Verification |
| 8.1 | Drafting Interface Information |
| 10 | Design Changes |
| 13 | Schedules |
| Appendix 5A | As-built Piping Verification - GAI and Subcontractor Interface Control Document |

Project Management Manual (Effective November 1981):

| | |
|---|---|
| 6.07 | Vendor's Drawings |
| 7.19 | Design Verification |
| 7.20 | Vendor's Drawings and other Documents |
| 8.0 | Document and Record Control |
| 9.0 | Design Changes |
| Appendix 7A | As-built Piping Verification - GAI and Subcontractor Interface Control Document |

Design Control Manual (DCPs) (Old):

| | |
|---|---|
| 1.5 | Design Control Program |
| 3.2.1 | Identification of GAI Drawings |
| 3.4.1 | Vendor's Drawing Control |
| 3.6.1 | Design Verification |
| 3.12.1 | Computer Program Development and Maintenance |
| 3.12.2 | Computer Program Verification/Certification |
| 4.2.1 | Design Analyses/Calculations |
| 4.3.2 | Design Specifications |

Design Control Manual (DCPs) (Effective November 1981) (New):

| | |
|---|---|
| 2.05 | Design Verification |
| 3.05 | Vendor Drawings |
| 4.15 | Procurement Documents |

Office Procedures:

| | |
|---|---|
| 10.1 | Correspondence Action Control |
| 10.2 | Distribution of Project Documents |

Specifications and Bills of Materials Department Instructions:

Instruction 1.4 - Setting Up the Specification Program
Instruction 1.5 - Developing and Maintaining the Engineering and Purchasing Schedule

Other:

Piping Engineering Standard DS-8, General Procedure for Design Verification
Computer Applications Manual (CAM)
SCE&G Quality Control Procedure MF-14

## ANALYSES/CALCULATIONS/REPORTS

TES Technical Reports (Pipe Stress Analysis Packages):

Technical Report TR-4813-8, Rev.1, Stress Analysis and Support Load Summary of Emergency Feedwater Subsystem EF-01 Piping for Virgil C. Summer Nuclear Power Plant April 22, 1982.

Technical Report TR-4813-9, Rev. 2, Stress Analysis and Support Load Summary of Emergency Feedwater Subsystem EF-02 Piping for Virgil C.Summer Nuclear Power Plant, April 23, 1982.

Technical Report TR-4813-10, Rev. 1, Stress Analysis and Support Load Summary of Emergency Feedwater Subsystem EF-03 Piping for Virgil C. Summer Nuclear Power Plant, April 23, 1982.

Technical Report TR-4813-15, Rev. 1, Stress Analysis and Support Load Summary of Emergency Feedwater Subsystem EF-22 Piping for Virgil C. Summer Nuclear Power Plant, April 22, 1982.

GAI Calculations:

File Code 2.9.2
File Code 2.4.3.13
File Code S-14:05
File Code S-14:01
File Code S-14:06
File Code EF-01
File Code EF-02
File Code EF-03
File Code EF-21
File Code EF-22
File Code EF-02 and 03

GAI Reports:

Report No. 1902, Jet Loadings on ASME Section III Piping, dated 1/77
Report W.O. Number 04-4461-000 dated 9/10/81

VENDOR DRAWINGS

| | |
|---|---|
| IMS-50181-3 | Fischer 54A 7509-D |
| IMS-50176-4 | Fischer 54A 7513-D |
| IMS-25-242-4 | Anchor Darling 3342-3-D |
| IMS-25-602-1 | Anchor Darling 93-14530-A |
| IMS-25-222-3 | Anchor Darling 3316-3-C |
| IMS-25-276-7 | Anchor Darling 3379-3-G |
| IMS-25-273-3 | Anchor Darling 3317-3 |
| IMS-25-224-3 | Anchor Darling 3318-3 |
| IMS-25-695-1 | Anchor Darling 93-15061-A |
| IMS-06-083-0 | Pathways Bellows D-50-1776 |

## SPECIFICATIONS

DSP-544C-044461-000 Rev. 5, Design Specification Emergency Feedwater System Piping and Pipe Supports (ASME III Division 1 Class 2 & 3)

DSP-508A-4461-00 Rev. 2, 7/8/77, Design Specification Motor Drive Emergency Feedwater Pumps (ASME III Class 3)

DSP-508B-4461-00 Rev. 2, 4/2/76, Turbine Driven Emergency Feedwater Pumps

DSP-606-044461-000 Rev. 9, 2/1/82, Design Specification for Reactor Building Piping Penetrations (ASME III Div. 1, Class 2)

SP-545-044461-000 Rev. 17 11/25/80 - Pipe Line Specification for Nuclear Safety Class Piping

SP-702-4461-00 Rev. 4 2/11/77 - Seismic Analysis, Testing and Documentation.

Westinghouse Steam Generator Specification, dated 11/3/80, Revision 6

## DRAWINGS/DIAGRAMS

Isometric Drawings:

| | | |
|---|---|---|
| C-314-085 | Sheet 1 | Revision 2 |
| C-314-085 | 3 | 2,3 |
| C-314-085 | 2 | 2 |
| C-314-085 | 4 | 2 |
| C-314-085 | 5 | 2 |
| C-314-085 | 27 | 3 |

Flow Diagrams:

D-302-083 Revision 17

D-302-085 Revision 13

Piping Drawings:

E-304-087 Revision 6

E-304-090 Revision 4

## MISCELLANEOUS

Engineering Change Notices(ECNs):

ECNs - 1891, 2134, 2143, 2202, 2206, 2219, 2230

Request for Information (RFIs):

RFIs - 1240, 1241, 1242, 1243, 1244, 0131, 0180, 0152, 0140, 0017, 0195, 0082, 0285

GAI Letters of Specification Transmittal:

CGGS - 10760 (2/23/77), 4815 (6/30/75), 1819 (1/21/74), Number not Recorded (5/17/72), 24079 (7/23/81), 22117 (12/8/80), 19996 (2/26/80), 16207 (8/2/78), 6936 (3/15/76), 5196 (8/15/78), 23248 (4/13/82, 20886 (7/3/80), 18654 (6/7/79), 13095 (8/23/77), 6509 (2/5/76)

Other:

ASME III Boiler and Pressure Vessel Code, Section III
(1971 Edition, Summer 1973 Addendum)

FSAR, V.C. Summer Nuclear Station

Certification of Compliance for Turbine Driven Pump

Manufacturers Print Index Activity List dated 4/14/82

Engineering Change Status Report dated 5/13/82

GAI letter CGGS-23411/CGGT-0048 of 4/27/81, transmittal of information to TES

GAI letter of October 10, 1980, transmittal of documents to TES

GAI letter CGGS-22092/CGGT-0014of 12/1/80, transmittal of information to TES

Request For Information Log

TES letter 4813-159 of 5/26/82, Confirmation of Specification revisions

Specification and Drawing Distribution Control Forms for specifications DSP-544C, SP220, and SP702

## 5.5 RESULTS

### 5.5.1 Inputs to Pipe Stress Analysis

Response Spectra - For all response spectra reviewed, the spectra figures contained in GAI Specification 702 agreed with the results of the GAI dynamic (structural) analysis.

The response spectra called out on the isometrics were appropriate for the piping location except that it did not appear necessary to utilize Figure 64 (elevation 463 of intermediate building) as specified on the isometric for subsystem EF-01 since the piping did not appear to extend to the elevation represented by this figure. This was confirmed as indicated below.

The response spectra utilized in the analyses were consistent with those specified on the isometrics with the following exceptions/comments:

1. The isometrics covering subsystem EF-01 specifies the enveloping of Figures 61, 62 and 64. The pipe stress analysis package indicates only Figures 61, and 62 were enveloped. There was no documentation in the package to indicate why Figure 64 had not been used. An RFI (TES-0082) from TES which addressed the deletion of Figure 64 was located in the GAI files. This RFI was approved by GAI. However, the package did not reference the RFI nor was there evidence that TES had marked up the ISO (as required by the interface procedure) to show the deletion of Figure 64.

2. The pipe stress analysis package for subsystem EF-02 indicates that Figures 7,8,61,62 and 64 are used in the analysis. Figures 7 and 8 are for the Reactor Building and Figure 64 is for elevation 463 of the Intermediate Building. Subsystem EF-02 terminates in the Intermediate Building and does not extend to elevation 463 of the Intermediate Building. Therefore, it appears that the use of Figures 7, 8 and 64 was not necessary.

3. The pipe stress analysis package for subsystem EF-03 indicates that Figure 64 (elevation 463 of the Intermediate Building) was used in the analysis (along with Figures 7, 8, 61 and 62). EF-03 piping does not extend to elevation 463. Therefore, it appears that the use of Figure 64 was not necessary.

   NOTE: When an isometric depicts more than one subsystem all applicable spectra figures are listed. The appropriate spectra for each subsystem is then selected from that list.

DBE Factors - The DBE factors contained in Specification 702 agree with the factors contained in the FSAR. The DBE factors utilized in the pipe stress analysis packages for subsystems EF-01, 02, 03 and 22 were appropriate for the locations of the piping.

Damping Factors - Amendment 26 to the FSAR specifies the following damping factors:

| | OBE | DBE |
|---|---|---|
| 12 inch or Smaller Piping | 1.0% | 2.0% |

Specification 702 presents damping factors as:

| | Working Stress No More Than About 1/2 Yield Point | At or Just Below Yield Point |
|---|---|---|
| Vital Piping Systems | 0.5% | 1.0% |

The FSAR damping factors were used as the basis for pipe stress analysis.

An additional factor, "gamma factor", is defined in Specification 702. The The gamma factor accounts for vertical flexure in certain slabs under seismic conditions. To obviate application of the gamma factor, GAI performed a study (W.O. No. 04-4461-000, dated 9/11/81) that demonstrated that the direct use of 0.5% vertical damping would account for the gamma factor and meet FSAR requirements of 1.0% damping. This information was supplied to TES and the other subcontractor performing pipe stress analysis.

Pipe Stress analysis packages for subsystems EF-01, 02, 03 and 22 all used damping factors of 0.5% vertical and 1.0% horizontal, which meets or exceeds FSAR requirements.

Design Conditions - The sample of design conditions selected from the design specification agreed with or were more conservative than the source documents and the pipe stress analysis packages used the design conditions.

Anchor Movements - Of the four sets of anchor movements initially selected, two sets as depicted on the isometrics did not exactly agree with the GAI calculation. The movements are very small and the differences were negligible (e.g., 0.0722 versus 0.07064). In one of the GAI calculations, the verifier had noted the differences as negligible. Since the movements were so small, TES (in the pipe stress analysis packages for EF-01 and 02) documented that anchor movements were not considered in the analysis.

In the other two cases (one thermal, one seismic) the movements specified on the isometric agreed with the GAI calculations. The seismic movements utilized in the pipe stress analysis package agreed with the isometric. However, the thermal movements utilized in the pipe stress analysis package (for EF-22) did not appear to agree with the isometric for x-direction (-0.718 on isometric,-0.9645 in analysis) and slightly different for z-direction (-1.679 on isometric,-1.698 in analysis).

Later correspondence initiated by the audit (TES letter dated June 23, 1982) indicates that TES had observed that the movements had been changed on Revision 1 of the isometric, had considered the changes insignificant and that reanalysis was not required. The fact that there were differences and that the differences were evaluated was not documented in the pipe stress analysis package.

Due to the above differences, an additional pipe stress analysis package from a different system was selected for review; subsystem SI-09. The anchor movements utilized in the pipe stress analysis package did not agree with the anchor movements called out on the isometric.

The above mentioned TES letter of 6/23/82 states,

> "The SAM displacements used in the analysis for the SI-09 subsystem were obtained via a copy of Westinghouse letter, number CGWG-2290, dated February 18, 1981 from Mr. James B. Cookinham of Westinghouse to Mr. H.E. Yocom of GAI. This letter defined the OBE Seismic Movements for a number of subsystems including SI-09. The copy was transmitted informally at the V.C. Summer Station during an informal meeting for which no record could be located. It was Teledyne's understanding, at the time, that the C-314 isometrics for SI-09 would be revised to include these movements. This was not done and the discrepancy still exists between the drawings and the analysis. It is Teledyne's understanding that the SAMs used in the analysis are correct and, therefore, the C-314 isometrics should be revised to incorporate them.".

There was no documentation in the pipe stress analysis package for SI-09 to indicate why the anchor movements utilized were different than the isometric values. In addition, there was no evidence that GAI had approved or transmitted the movements utilized.

Jet Loadings - In each of the five load cases selected, the loadings transmitted to TES agreed with the results of the GAI calculations and the loadings utilized in the pipe stress analysis packages were consistent with those transmitted. (The values utilized in the analysis were twice the values transmitted since a dynamic factor of 2.0 was utilized).

Pipe Materials and Sizes - The comparison of pipe materials, sizes and schedules between piping drawings, flow diagrams and design specifications revealed correlation between input documents. The allowable stresses and modulus identified within the pipe stress analysis were in agreement with those identified within ASME Section III 1971 Edition, including Summer 1973 Addenda for Class 2 piping.

Valve Weights - The comparison of valve weights contained on the latest issues of vendor drawings, design specifications and pipe stress analysis were in agreement.

The valve weights used in pipe stress analysis of subsystem EF-01 were 10% greater than certified weights since certified valve weights were not available when the analysis was originally performed. This 10% margin was consistent with the system design specification.

Valve Centers of Gravity (CG)s - The valve CGs shown on the latest issue of vendor drawings agreed with the piping isometric. The valve CGs utilized in the pipe stress analysis packages were consistent with the CGs shown on the isometrics, or if different were justified by GAI approved RFIs which were referenced within the pipe stress analysis packages.

Nozzle Loadings - Loadings on seven of the nine nozzles audited were less than the allowables loads established within the component design specifications.

Pipe stress analysis packages for subsystems EF-03 and EF-22 indicate that nozzle loads exceeded the established allowable loads for Reactor Containment Penetration No. 213 (inside and outside ends) and for Motor Driven Pump XPP-21A-EF. Notes on the pipe stress analysis packages indicate that the exceeded allowables are "ok by trade-off". However, the packages do not identify or reference what trade-off methods were used. An RFI (TES-0285) was located during the audit that discussed allowable load trade-offs. However, this RFI did not apply to subsystems EF-03 or EF-22.

The allowable loads evaluated for motor driven pump XPP-21A-EF were compared for the DBE event rather than OBE event as required by Specification 508A. When the allowable loads are compared to DBE load combinations the allowable loads are not exceeded. Therefore utilization of "trade-off" methods is not required for this case.

5.5.2 Control Methods

Vendor Drawings - PMM 6.6 (old), PMMs 6.07 and 7.20 (new), DCP 3.4.1 (old) and DCP 3.05 (new) establish the methods for control of vendor drawings. These procedures provide for receipt control, review and approval, distribution and retention.

The Manufacturers Print Index Activity List of 4/14/82 was reviewed. This index contained the GAI number, number of sheets, revision, description, vendor drawing number, date received, (purchase order number or system bill of material number). The index was consistent with all vendor drawings examined in conjunction with valve weight and center of gravity input comparisons.

Specification Control - PMM 13.0 established the requirements for maintenance of an Engineering-Purchase Schedule. This schedule functions as an index for procurement specifications. Specifications and Bills of Material Department (SBMD) Instructions 1.4 and 1.5 and Office Procedures (OP) 10.2 provide amplification such as distribution requirements. A procedure for maintaining a mechanical design specification index was in use but had not been formally promulgated.

Distribution of specifications and revisions was performed in accordance with procedures for a sample of three selected specifications, DSP 544C, SP 702 and SP 220.

Comparison of revisions from the specification indexes to that called out on the isometrics and that transmitted to TES was conducted. It was noted that Rev. 5 to DSP 544C dated 4/30/82 had not yet been formally transmitted to TES. The information contained in Rev. 5 was a reformatting of previously provided data which would not affect the analysis.

Drawing Control - PMM 8.1 (old), PMM 8.0 (new), DCP 3.2.1 (old), DCPs 1.30 and 3.20 (new), and OP 10.2 established the requirements for drawings and index distribution and maintenance.

Indexes were updated and distributed in accordance with procedures.

The revisions to the isometrics used in the pipe stress analysis packages were consistent with the isometric index with the exception that one sheet of an isometric series did agree with the index. The index had not been updated to reflect recent revisions of this sheet. The latest isometric revision had been used in the analysis. An additional sample of five controlled tracings was compared to the index. The issue numbers agreed.

Interface - The interface between GAI and the subcontractors was formally established by an interface procedure, PMM Appendix 5A (old) and 7A (new), which was contractually invoked by SCE&G.

The input information was formally transmitted to TES by GAI. However, the first transmittal of the input information did not clearly identify the revision of all documents forwarded to TES. Subsequent correspondence and discussions with TES confirmed that the latest revisions had been received.

The Request for Information (RFI) Log contained information such as RFI number, applicable subsystem, date reviewed, date answered, etc. The log was maintained in accordance with the interface procedure.

Computer Programs - The requirements for using verified/certified programs are addressed in the existing procedural program as are methods for tracking the use of programs that have not been verified/certified. Computer program verification/certification requirements are established in the Computer Applications Manual (CAM). A "Design Verification Record" form is required by DCP 2.05, for each analysis. If an unverified/uncertified computer program is utilized, the Design Verification Record is annotated to indicate an assumption requiring later confirmation. This information is also reflected on the Design Verification Status Report (DVSR). The DVSR is a listing of open design verification items and their current status.

GAI calculation, file code 2.9.2 (verified 8/11/81), was evidence of implementation of this tracking method. The verifier recorded the use of a program requiring verification/certification on the Design Verification Record form. The DVSR appropriately reflected that the calculation used an unverified/uncertified computer program.

As required by the CAM, a list of certified computer programs is issued semi-annually. The latest listing was dated 4/17/82. Distribution of the list includes all holders of the CAM.

During the course of tracking pipe stress analysis inputs, the use of one program for which there was no evidence of verification/certification and no direct evidence of tracking the program use was observed. (Three other computer programs used in analyses performed in 1974 and 1980 had been verified/certified.) The computer program was identified as S051 (GAI number) and was used in GAI Calculation S-14:01 for developing the response spectra for the Reactor Building. This calculation was performed in 1972 prior to any formal requirements for computer program verification/certification. DCP 4.2.1, issued October 1972 addressed the use of verified/certified computer programs in analyses and DCP 3.12.1, issued October 1973, addressed computer program development and maintenance.

According to GAI, this program (S051) had been tested but the material had not been compiled into a formal certification package. GAI was apparently aware that formal verification/certification was required as evidenced by a GAI memo dated 8/6/80. Verification/certification of this program was completed during the audit.

As a result of this one instance, additional investigation was performed. Fourteen additional computer programs were selected. All had been verified/certified. However, due to the difficulty in reconstructing the historical usage of computer programs, especially usage circa 1971, GAI performed a survey of all Departments to determine if any unverified/uncertified computer programs had been used in finalized safety related analyses for the V.C. Summer Plant. The results of the survey indicated no such usage.

Design Verification - PMM 7.3 (old), PMM 7.19 (new), DCP 3.6.1 ( old), DCP 2.05 (new), and Piping Engineering Standard DS-8 provided direction for controlling design verification activities.

The detailed implementing procedure for piping design (including pipe stress analysis) was DS-8. The stated purpose of the procedure was, "To review, conform or substantiate a design by one or more methods in order to provide assurance that system design meets the specified design inputs and that these inputs were selected in accordance with appropriate design criteria".

The implementation and documentation of the verification is by use of various forms and checklists. For example, form 2.3, Review of Analysis, includes:

2.3.1 Applicable Drawings

1. Have the latest revisions been used as a source of input for the analysis?

2.3.2 Modeling

1. Is the system configuration as analyzed representative of the layout depicted by the latest information?

2. Has acceptable modeling theory been utilized?

The form continues and asks similar questions regarding: design conditions; static analysis; dynamic analysis; output; supports and restraints.

Implementation of design verification was evident in all GAI calculations and TES pipe stress analysis packages reviewed during the audit.

A major tool in controlling design verification is the Design Verification Status Report (DVSR). The DVSR is a listing compiled from information supplied by all disciplines that identifies all items (e.g., calculations) requiring verification. The DVSR identifies, for example, if a particular item has been verified and if assumptions have been confirmed.

The DVSR is a computer based information system that is up-dated on a continuing basis. There is no specified frequency for issuing the DVSR but recent DVSRs were issued approximately quarterly.

## 5.6 CONCLUSIONS

### 5.6.1 Procedural Program

An adequate Design Control Program, meeting the requirements of 10CFR50 Appendix B, was in place for the transmittal and utilization of input data for pipe stress analyses of subsystems EF-01, 02, 03 and 22 of the Emergency Feedwater Piping System.

Only one instance was observed in the existing program where there was no formally approved procedure. Although formal procedures were available for indexing of design and procurement specifications,the maintenance and distribution of a mechanical specification index was performed using an undated, uncontrolled instruction with no evidence that the instruction had been approved. Although unapproved, the procedure was adequate and was being implemented.

In the early stages of the project there were no formal procedures governing the verification/certification of computer programs and their use. During the course of audit the use, in 1972, of one program for which there was no evidence of verification/certification was observed. (Three other programs used in analyses performed in 1974 and 1980 had been verified/certified). This led to additional investigation. A review of additional program usage, procedures and tracking mechanisms indicates that the existing program does address this area and controls the use of computer programs. In addition, GAI conducted a survey to determine if any other unidentified uses of unverified/uncertified programs had occurred; no other instances were revealed by this GAI survey.

5.6.2 Program Implementation

The procedures associated with the activities reviewed during the audit were adequately implemented except that the utilization of inputs to pipe stress analysis in some cases was not consistent with program requirements. The instances are apparently documentation problems that would not affect the design adequacy.

- o The pipe stress analysis package for subsystem EF-01 did not utilize Figure 64 response spectra as specified on the isometric. Although GAI had approved the deletion of Figure 64 in an RFI there was no evidence that the isometric had been marked-up to indicate that Figure 64 should be deleted nor was there documentation in the pipe stress analysis package that justified the deletion of Figure 64 (such as by reference to the GAI approved RFI).

- o There was no documentation in the pipe stress analysis package for EF-22 that the differences between the thermal movements utilized in the analysis and the movements on the isometric had been evaluated. A letter to GAI from TES initiated as a result of this audit indicated that the differences had been evaluated when the analysis was performed and that reanalysis was not necessary.

- o The pipe stress analysis package for subsystem SI-09 apparently utilized anchor movement information from a Westinghouse letter rather than the movements identified on the isometric. There was no evidence that GAI had approved or transmitted this information for use. In addition, the pipe stress analysis package did not identify that the movements utilized were different than the isometric and the reasons for the differences. A letter submitted by TES to GAI after the audit indicated that the Westinghouse anchor movement information had been used in the analysis.

- o The nozzle loadings in pipe stress analysis packages were noted as acceptable by "trade-off". There was no documentation in the pipe stress analysis packages that identified the method or the acceptability of the method. There were approved RFIs in GAI files that addressed load trade-offs, but they were not referred to in the packages.

Another area that was not clearly documented was the application of damping factors. Although the application of damping factors complied with the FSAR, this could not be discerned unless reference was made collectively to the FSAR, Specification 702, pipe stress analysis packages, a GAI study, and minutes of a meeting. The underlying cause of this condition was apparently due to not updating Specification 702 to reflect the issuance of Amendment 26 to the FSAR.

The response spectra utilized in the pipe stress analysis were consistent with the dynamic (structural) analysis output. In some cases additional spectra were utilized when it did not appear necessary. Utilization of these additional spectra adds to the conservatism of the design.

### 5.6.3 Recommendations

Procedures

A procedure governing the preparation and distribution of a specification index for mechanical specifications (and for other discipline specifications if necessary) should be formalized as part of the project program.

Implementation

The extent of incomplete documentation in pipe stress analysis packages should be determined and appropriate corrective action implemented.

To preclude future misunderstanding and provide clear traceability regarding application of damping factors, corrective action, in the form of either a revision to Specification 702, or a memorandum of explanation in the pipe stress analysis packages, or other appropriate equivalent, should be performed.

ATTACHMENT 1 TO SECTION 5.0

AUDIT PARTICIPANTS

PRE-AUDIT CONFERENCE ATTENDEES (MAY 19, 1982)

GAI

| | | |
|---|---|---|
| G.J. Braddick | - | Project Manager |
| K.R. Gabel | - | Project Engineer |
| J.R. Helwig | - | Project Control Engineer |
| D.R. Kershner | - | Piping Engineer (and Primary Contact during Audit) |
| H.A. Manning | - | Quality Assurance Program Manager |
| F.L. Moreadith | - | Manager of Engineering |
| J.B. Muldoon | - | Department Manager, Specialty Engineering |
| C.C. Paschall | - | Manager, Design Control |
| C.N. Rentschler | - | Piping As-Built Verification Task Manager |
| K.W. Sandman | - | Project Piping Support Designer |

SWEC

| | | |
|---|---|---|
| J. MacKinnon | - | Design Control Audit Manager |
| D.L. Malone | - | Audit Team Leader |
| R.W. Twigg | - | Auditor |

## GAI PERSONNEL CONTACTED DURING EXAMINATION OF EVIDENCE

R.S. Chang
R.F. Ely
J.R. Helwig
D.R. Kershner
G. Khurshudyan
J.E. Lisney
H.A. Manning
J.B. Muldoon
C.C. Paschall
J.W. Reitnauer
R.J. Sheldon

## STATUS MEETING ATTENDEES (MAY 28, 1982)

### GAI

| | | |
|---|---|---|
| N.R. Barker | - | Vice President & General Manager QA Division |
| F.G. Boutros | - | Manager, Nuclear Section |
| G.J. Braddick | - | Project Manager |
| C. Chen | - | Manager, Structural Department |
| E.C. Goodling | - | Section Manager, Piping Stress Analysis |
| J.R. Helwig | - | Project Control Engineer |
| D.R. Kershner | - | Piping Engineer |
| J.E. Lisney | - | Structural Project Engineer |
| H.A. Manning | - | QA Project Manager |
| W.E. Meck | - | Vice President, Projects |
| F.L. Moreadith | - | Manager of Engineering |
| J.B. Muldoon | - | Manager, Specialty Engineering |
| C.C. Paschall | - | Manager of Design Control |
| C.N. Rentschler | - | Section Manager, Pipe Support Design |
| R.J. Sheldon | - | Mechanical Engineer |

### SWEC

| | | |
|---|---|---|
| P. Dunlop | - | Project Manager |
| J.H. MacKinnon | - | Design Control Audit Manager |
| D.L. Malone | - | Audit Team Leader |
| R.W. Twigg | - | Auditor |

## POST-AUDIT CONFERENCE ATTENDEES (JUNE 10, 1982)

GAI

| | | |
|---|---|---|
| F.C. Boutros | - | Manager, Nuclear Section |
| G.J. Braddick | - | Project Manager |
| K.R. Gabel | - | Piping Project Engineer |
| J.R. Helwig | - | Project Control Engineer |
| E.K. Hess | - | Vice President |
| D.R. Kershner | - | Piping Engineer |
| J.E. Lisney | - | Structural Project Engineer |
| H.A. Manning | - | QA Project Manager |
| J.B. Muldoon | - | Manager, Specialty Engineering |
| C.C. Paschall | - | Manager of Design Control |
| W.F. Sailer | - | Manager, Program Management QAD Division |
| T.F. Sheehan, Sr. | - | Manager of Projects |
| R.J. Sheldon | - | Mechanical Engineer |

SWEC

| | | |
|---|---|---|
| J.H. MacKinnon | - | Design Control Audit Manager |
| D.L. Malone | - | Audit Team Leader |

# APPENDIX A: STATUS REPORT JULY 9, 1982

# INDEPENDENT SEISMIC DESIGN VERIFICATION
# TURBINE DRIVEN SECTION
# EMERGENCY FEEDWATER SYSTEM

V.C. SUMMER NUCLEAR STATION

STATUS REPORT: JULY 9, 1982

prepared for

SOUTH CAROLINA
ELECTRIC & GAS COMPANY

J.O. 14236 July 9, 1982

## 1. INTRODUCTION:

### 1.1 GENERAL SCOPE

Stone & Webster Engineering Corporation (SWEC) was engaged by South Carolina Electric & Gas Company (SCE&G) to perform an independent review of the seismic design for the Turbine Driven portion of the Emergency Feedwater System at V.C. Summer Nuclear Station, Unit No. 1. The review consisted of three major tasks, specifically;

1) Field Walkdown: Verification of the as-built piping configuration
2) Stress Analysis and Evaluation: reanalysis of the as-built piping system, review of stresses and support loads, and
3) Design Control Audit: review of the design control procedures and implementation thereof by Gilbert Associates Incorporated (GAI), the designer of V.C. Summer Nuclear Station, Unit 1.

### 1.2 STONE & WEBSTER QUALIFICATIONS AND INDEPENDENCE

SWEC has extensive experience in the engineering, design, construction and startup operations for nuclear power plant projects as well as special expertise involving seismic design analysis, field verification efforts, and pipe stress and support reanalysis required by recent NRC I&E Bulletins. SWEC also has extensive experience in Quality Assurance aspects of the nuclear power industry and in auditing of large highly technical and complex projects. Stone & Webster is justifiably proud of its record and large staff of capable and experienced personnel.

SWEC, its parent company Stone & Webster, Inc., its affiliated companies and all personnel assigned to this evaluation are independent of South Carolina Electric & Gas Co.

Work performed by Stone & Webster and its affiliated companies for SCE&G represents only a miniscule portion of Stone & Webster's business. All key technical personnel assigned to the project signed disclosures (Attachment 1-1). Table 1-1 lists personnel assigned to the various tasks. Dr. P. Dunlop, Project Manager, has overall responsibility for the project. Dr. K. Y. Chu is Project Engineer responsible for the technical evaluation (Tasks 1 and 2) and is independent of Mr. J. H. MacKinnon who is responsible for auditing the GAI design control program (Task 3).

## 1.3 EVALUATION PROCESS

All work was performed in accordance with project procedures (Table 1-2). Whenever a reviewer noticed anything outside the criteria, or had any question about the information or data, the reviewer highlighted this. Specific procedures for highlighting questions were different for each of the three major tasks and are explained in the task specific project procedures (Table 1-2).

### 1.3.1 Field Walkdown (as-built verification)

All field measurements were recorded directly on piping isometrics. Whenever the measured values differed from the isometric values by more than the criteria presented in VCS-1 Field Walkdown Procedure, the recorded values were circled on the isometrics and also recorded on Difference List (DL) Forms. Copies of the marked-up isometrics and DL forms were provided to SCE&G at the end of the Field Verification Effort.

### 1.3.2 Stress Analysis and Evaluation

All analyses are to be performed in conformance with VCS-3, Analysis and Evaluation Procedure and VCS-4, Analysis and Evaluation Criteria. These provide the procedures and criteria for performing the piping reanalysis. Procedures for highlighting differences are defined in Procedure VCS-3. Questions raised by the stress analysts are formally recorded and resolved. A two step procedure is used. An Open Item Report (OIR) is initiated for all items requiring clarification or confirmation. If a satisfactory resolution is received, the OIR is formally closed out. If a possible error or inconsistency is confirmed a Potential Discrepancy (PD) is written. These PD's will be formally transmitted to SCE&G for their review and evaluation.

### 1.3.3 Design Control Audit

Of the three tasks the procedures and resolution of items for this task are more subjective. The personnel assigned to this effort were certified auditors and performed the audit in conformance with general Stone & Webster standards for such audits.

## 2.0 PROGRAM STATUS

As of July 9, 1982, SWEC has completed Tasks 1 and 3. Task 2 is currently in progress. To date nothing has been found which would require the initiation of a 10CFR21 review. The detailed status of each task is given below.

Task 1: Field Walkdown - verification of the as-built piping geometry. This task has been completed and all Difference List (DL) items have been forwarded to SCE&G for their review and information. The following is a brief description of the differences identified.

(1) Gaps between piping and support steel larger than criteria - two occurrences. The largest of these was 9/32 inch whereas the criteria allowed only 5/32 inch.

(2) Clearances between piping and structural components - three occurrences. Two instances of small clearance between pipe and structural component (0 and 7/64 inch) to be reviewed during stress analysis. A sleeve through a wall was also found to be partially grouted. This was subsequently determined to have been identified by SCE&G (ECN 2316) and the grout had been removed when SWEC field personnel again visited the site on June 7, 1982.

(3) Struts at angles other than identified on the isometrics - three occurrences of struts more than 3 degrees from the values on the isometrics. The maximum difference was 11 degrees.

(4) Dimensional data outside the criteria specified for SWEC's field walkdown effort - 15 occurrences. The maximum difference was 5.3 inches for a span of 11.6 feet. All dimensional differences were within SWEC's standard criteria.

(5) Drafting Errors - five occurrences. These were confirmed by reviewing the support or piping drawings.

All field measured dimensions will be input to the stress analysis in Task 2. Any impact of the above on the stress analysis will therefore be obtained.

Task 2: Stress Analysis and Evaluation - reanalysis of the piping system with as-built geometry, comparison of pipe stress with allowables and support loads. This task which consists of coding piping/support geometry and design criteria into the NUPIPE program is currently in progress. No detailed results have yet been obtained to compare with the piping allowable stress or with the original design loads for supports. Three inconsistencies were identified during correspondence with GAI relative to design criteria. These are:

(1) During the field walkdown and subsequent data review it was found that several supports on subsystem EF-01 were in the Diesel Generator Building. This subsystem therefore should be analyzed considering seismic response spectra from the Diesel Generator Building. The piping isometric does not indicate this requirement.

(2) During reivew of data received an inconsistency in jet orientation and jet location was identified.

(3) In one instance the target area of a jet impingement in the design document (1902) appeared to be inappropriate. Subsequent communication indicates that the jet need not be included in the analysis because shield installation negates this break load.

It is not known what impact these inconsistencies might have on the detailed stresses and support loads in the piping reanalysis. This task is expected to be complete by July 27, 1982.

Task 3: Design Control Audit - This task consists of three parts. These are:

(1) Review of the GAI design control program

(2) Verification of program application

(3) Confirmation that the structural dynamic analysis output was consistent with response spectra provided to Teledyne Engineering Service (TES) for analysis of the turbine driven portion of the Emergency Feedwater System.

The above three parts of this task have been completed. The following are SWEC's conclusions based on the design control audit.

Procedural Program

An adequate Design Control Program, meeting the requirements of 10CFR50 Appendix B, was in place for the transmittal and utilization of input data for pipe stress analyses of subsystems EF-01, 02, 03 and 22 of the Emergency Feedwater Piping System.

Only one instance was observed in the existing program where there was no formally approved procedure. Although formal procedures were available for indexing of design and procurement specifications, the maintenance and distribution of a mechanical specification index was performed using an undated, uncontrolled instruction with no evidence that the instruction had been approved. Although unapproved, the procedure was adequate and was being implemented.

Program Implementation

The procedures associated with the activities reviewed during the audit were adequately implemented except that the utilization of inputs to pipe stress analysis in some cases was not consistent with program requirements. The instances are apparently documentation problems that would not affect the design.

° The pipe stress analysis package for subsystem EF-01 did not utilize Figure 64 response spectra as specified on the isometric. Although GAI had approved the deletion of Figure 64 in a request for information (RFI) there was no evidence that the isometric had been marked-up to indicate that Figure 64 should be deleted nor was there documentation in the pipe stress analysis package that justified the deletion of Figure 64 (such as by reference to the GAI approved RFI).

- o There was no documentation in the pipe stress analysis package for EF-22 that the differences between the thermal movements utilized in the analysis and the movements on the isometric had been evaluated. A letter to GAI from TES initiated as a result of this audit indicated that the differences had been evaluated when the analysis was performed and that reanalysis was not necessary.

- o (The project scope was expanded to include SI-09 because of the difference noted in EF-22 above). The pipe stress analysis package for subsystem SI-09 apparently utilized anchor movement information from a Westinghouse letter rather than the movements identified on the isometric. There was no evidence that GAI had approved or transmitted this information for use. In addition, the pipe stress analysis package did not identify that the movements utilized were different than the isometric and the reasons for the differences. A letter submitted by TES to GAI as a result of the audit indicated that the Westinghouse anchor movement information had been used in the analysis.

- o The nozzle loadings in pipe stress analysis packages were noted as acceptable by "trade-off". There was no documentation in the pipe stress analysis packages that identified the method or the acceptability of the method. There were approved RFI's in GAI files that addressed load trade-offs, but they were not referred to in the packages.

Another area that was not clearly documented was the application of damping factors. Although the application of damping factors complied with the FSAR, this could not be discerned unless reference was made collectively to the FSAR, Specification 702, pipe stress analysis packages, a GAI study, and minutes of a meeting. The underlying cause of this condition was apparently due to not updating Specification 702 to reflect the issuance of Amendment 26 to the FSAR.

Response Spectra Consistency

The response spectra utilized in the pipe stress analysis was consistent with the dynamic (structural) analysis output. In some cases additional spectra were utilized when it did not appear necessary. Utilization of these additional spectra adds to the conservatism of the design.

INDEPENDENT SEISMIC DESIGN VERIFICATION
V.C. SUMMER NUCLEAR STATION, UNIT NO. 1
SOUTH CAROLINA ELECTRIC & GAS CO.

Statement Regarding Potential or Apparent
Conflicts of Interest

To: Stone & Webster Engineering Corporation

Whereas, the undersigned employee ("Employee") understands that he or she is assigned as a participant to provide services to South Carolina Electric & Gas Company with respect to the Design Verification Program for the V.C. Summer Nuclear Station; and

Whereas, Employee understands that it is necessary that the participants be screened for any potential or apparent conflicts of interest with respect to this assignment;

Therefore, for the above stated purposes Employee makes the following representations to Stone & Webster Engineering Corporation:

1. Employee has not engaged in any work or business involved with or related to the engineering or design of the V.C. Summer Nuclear Station other than this Design Verification Program;

2. Neither Employee, nor any members of his or her immediate family, own any beneficial interest in the South Carolina Electric & Gas Company, including but not limited to common or preferred stock, bonds or other securities issued on behalf of the South Carolina Electric & Gas Company; and

3. None of the members of Employee's immediate family are employed by South Carolina Electric & Gas Company.

This statement is based upon the Employee's best information and belief and any exceptions to the representations contained herein have been described on the reverse side of this document.

Dated______________________________

Signature__________________________

___________________________________

Print Name

## TABLE 1-1 PROJECT PERSONNEL

Project Manager: Peter Dunlop

- Project Engineer: K. Y. Chu
- Assistant Project Engineer: J. F. Pam

TASK 1 FIELD WALKDOWN

N. Roth
K. Anderson
J. Y. Chen
D. Loffa
A. Moss
L. Peterson
V. Saleta

TASK 2 STRESS ANALYSIS AND EVALUATION

T. Wei
D. Loffa
J. Y. Chen
J. Chiang
Y. Chin
J. Chu

- Design Control Audit Manager: J. H. MacKinnon

TASK 3 DESIGN CONTROL AUDIT

D. Malone
R. Twigg

## TABLE 1-2 PROJECT PROCEDURES

(A) TASK SPECIFIC PROCEDURES

FIELD WALKDOWN EFFORT

VCS-1 Field Walkdown Procedure

STRESS ANALYSIS AND EVALUATION

VCS-3 Analysis and Evaluation Procedure
VCS-4 Analysis and Evaluation Criteria

DESIGN CONTROL AUDIT

Design Control Verification Plan

(B) PROJECT GENERIC PLANS/PROCEDURES

Quality Assurance Plan
Document Control Procedure - VCS-2
Quality Assurance Records Procedure - VCS-5
Engineering Assurance Audit Program