GE MK I

MARK 1 CONTAINMENT PROGRAM

Program Action Plan

GENERAL ELECTRIC

A-18

MARK I CONTAINMENT PROGRAM

PROGRAM ACTION PLAN

Copy No. 64

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EW 7610.09
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SAN JOSE, CALIFORNIA 95125

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1. INTRODUCTION

The Mark I Containment Program Action Plan provides a detailed description of project management information in an integrated format. The Program Action Plan defines the objective of the Mark I Containment Program, gives program task descriptions and shows how the integration of activities will lead to a definition of loads for final re-evaluation of the containment structure by the individual licensees. Included in this report, for reference purposes, is a brief summary of the historical background related to the reevaluation program for Mark I Containments.

The technical approach followed in the Mark I Containment Program, as well as the "key decision making" milestones, are summarized. The pressure suppression loads are described and the technical tasks which establish load magnitudes are explained in the context of their interrelationship and how they support final load determination. The many test activities contained in this program and how they integrate with analytical activities are also summarized. Included is a discussion of the expected followup activities which individual Mark I owners may enter into upon completion of load definitions for the Mark I Containment Program.

Since the Mark I Containment Program is expected to be continually modified on the basis of newly acquired test data and analyses and the key decisions that will follow from this additional information, the Program Action Plan has been constructed in a flexible format which will permit an update of the information as required.

It should be noted that a fundamental objective of this program is to quantify more precisely and to confirm the various loads for the present containment geometry.

Load mitigation tasks are included in the program as a parallel effort. Small-scale screening tests, already in progress, are included to provide a basis for a more complete program, including larger scale tests, should that be found necessary.

2. BACKGROUND

2.1 MARK I CONTAINMENT - GENERAL SYSTEM DESCRIPTION

The Mark I containment is a vapor suppression system which houses the BWR vessel, the reactor coolant recirculating loops and other branch connections of the Nuclear Steam Supply System (NSSS). It consists of a drywell, a vapor suppression chamber which contains a large volume of water, a connecting vent system between the drywell and the water pool, isolation valves containment cooling systems, and other service equipment. For most Mark I plants, the vapor suppression chamber is a steel pressure vessel in the shape of a torus, and is located below and encircling the drywell. The suppression chamber is held on supports which transmit vertical and seismic loading to the reinforced concrete foundation slab of the reactor building. The drywell to wetwell vents are connected to a vent header which is contained within the airspace of the suppression chamber. Projecting downward from the vent header are the downcomer pipes, which are nominally 24 in. in diameter and terminate approximately 4 ft. below the water surface of the pool. The pressure suppression chamber in relation to the steel drywell is shown in Figure 2-1. Figure 2-2 shows a cross-section through the suppression chamber.

In the highly unlikely event of an NSSS piping failure within the drywell, reactor water and steam are released into the drywell atmosphere. As a result of increased drywell pressure a mixture of drywell atmosphere, steam, and water is forced through the vent system into the pool of water which is stored in the suppression chamber. The steam vapor condenses in the suppression pool. The drywell atmosphere is initially transferred to the suppression chamber and pressurizes the chamber. At the end of the blowdown the chamber is vented to the drywell to equalize the pressures between the two vessels. Cooling systems are provided to remove heat from the reactor core, the drywell, and from the water in the suppression chamber, thus providing continuous cooling of the primary containment under accident conditions.

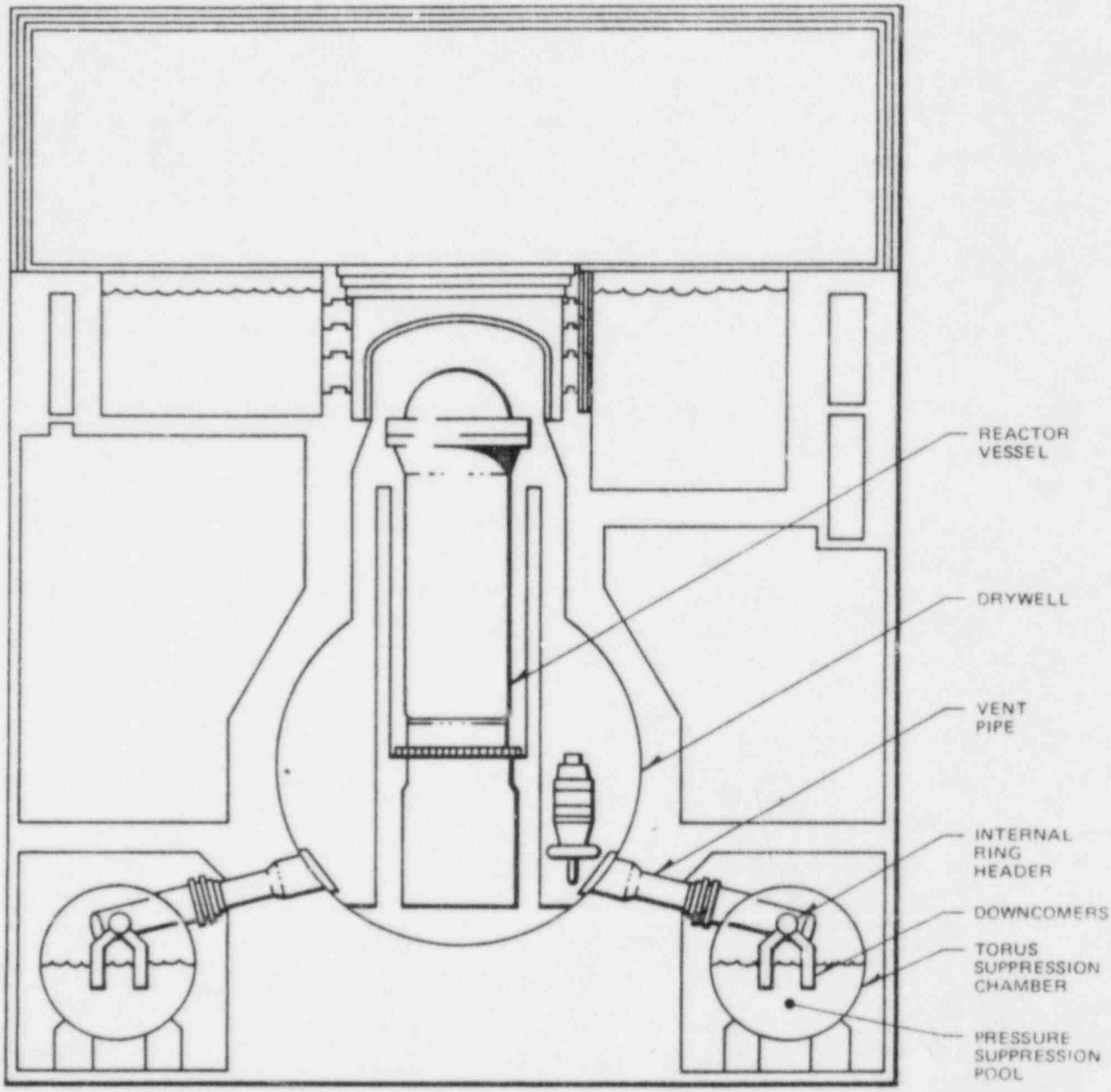

Figure 2-1. Mark I Containment

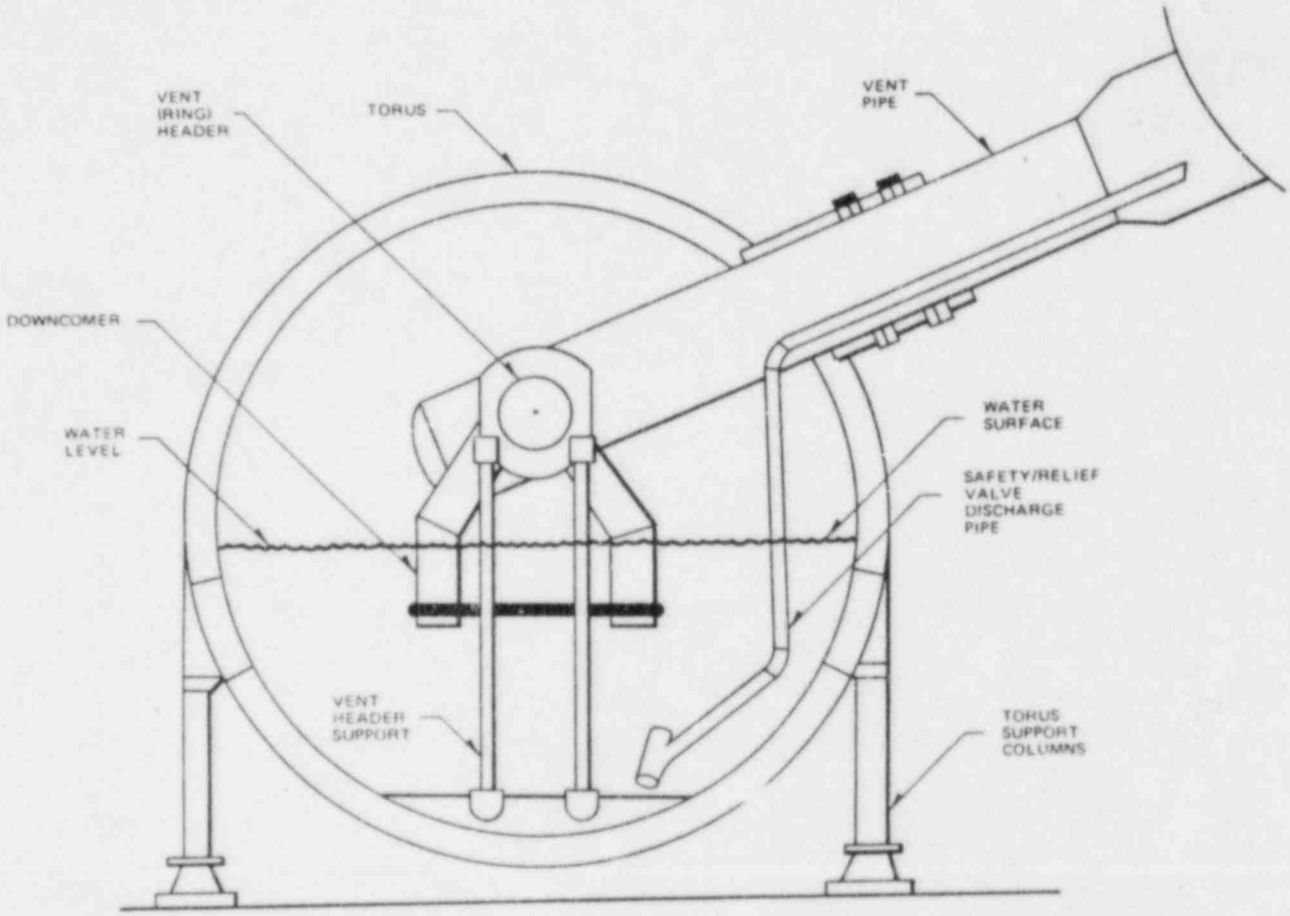

Figure 2-2. Composite Section Through Suppression Chamber

2.2 HISTORICAL DEVELOPMENT OF MARK I CONTAINMENT PROGRAM

In February and April 1975, the NRC transmitted letters to each utility with a Mark I containment requesting addtional information on the capability of its structure. The February 1975 letters reflected concerns about the dynamic nature of safety relief valve (SRV) discharge while the April 1975 letters indicated the need to evaluate the containment structure for newly identified dynamic loads associated with the loss-of-coolant accident (LOCA). On April 23, 1975, the domestic Mark I containment owners met and formed an ad-hoc Owners Group to respond to these NRC requests for additional information. Recognizing that the additional evaluation work would be very similar for all plants, this organization was formed to pool the available talents, ideas, and experience so that a uniform and technically sound program could be established to respond to the NRC requests in the shortest time possible.

A two-phase program was established and identified to the NRC in letters submitted during the week of May 5, 1975. The Phase I effort, called the Short-Term Program (STP), would provide a rapid confirmation of the adequacy of the containment to maintain its integrity under the most probable course of the LOCA event considering the latest available information on the key suppression pool dynamic loads. The first phase would thus demonstrate the acceptability of continued operation during the performance of Phase II, called the Long-Term Program (LTP), where detailed testing and analytical work would be performed to define the specific design loads to which the containment will be assessed to establish conformance to agreed-to acceptance criteria.

The initial portion of the Phase I task of evaluating the integrity of the containment vent system and vent system supports is documented in a five-volume report which was submitted to the NRC in September 1975 (Short-Term Program Report NEDC-20989). Addendum 1 to this report, which was submitted to the NRC in December 1975, documented an evaluation of LOCA-related hydrodynamic loads on SRV discharge piping and testing performed on a representative vent bellows assembly. Additional information was provided in response to NRC questions on this report. Responses were transmitted by GE for the Mark I Owners Group in a letter dated September 9, 1976.

In addition to the generic reference plant evaluation presented in the Short-Term Program Report, a plant unique analysis of the external support system for the toroidal pressure suppression chamber and the externally attached piping has also been performed by each utility with an operating Mark I plant and submitted on their licensing docket. The loading information used for these evaluations is presented in Addenda 2 and 3 to the Short-Term Program Report (submitted to the NRC in June 1976 and August 1976, respectively).

This additional plant-unique analysis was performed in accordance with the approach described in NUTECH Report No. MKI-02-012, Rev. 2, which was transmitted to the NRC in July 1976. This NUTECH report also identified the acceptance criteria that each plant's support system and external piping was to be assessed against. Additionally, each utility has indicated that they will maintain the water volume in the torus to as near the minimum as practical and has committed to control the normal pressure in the drywell to at least 1.0 psi greater than the air space pressure in the torus for interim operating conditions. Scaled sensitivity tests showed that this action would result in the reduced net loading on the torus support system. Several utilities have also increased the capability of key structural members to provide additional margin of safety.

Throughout the performance of the Short-Term Program work, periodic meetings were held with the NRC staff and status reports were submitted to appraise them of the program results. The documentation of all Short-Term Program results is now essentially complete. The results show that there is no undue risk to the health and safety of the public and the Long-Term Program can proceed. The remainder of this report describes the details of that Mark I Containment Program.

3 MARK I CONTAINMENT PROGRAM SUMMARY

3.1 GENERAL STRUCTURE

The basic objective of the Mark I Containment Program is to ensure that all Mark I containments are structurally adequate for their full life based on criteria acceptable to the NRC. This Program consists of testing and analysis for a combination of hydrodynamic phenomenological and structural tasks. It includes the establishment of agreed upon Structural Acceptance Criteria against which the results of structural evaluations can be assessed. Also included in the program is the evaluation of the need for structural modifications and/or load mitigation devices, to assure adequate Mark I containment structural safety margin. Key parts of the program are:

(1) A Load Definition Report (LRD), which will contain design basis hydrodynamic pressure suppression loads and their possible combinations, and proper procedures as how to apply them for structural evaluation;

(2) Structural Acceptance Criteria - acceptance criteria for assessing the results will be established considering current requirements and increased knowledge gained since original design.

(3) Plant Unique Analyses - Each utility will perform a unique structural evaluation of their plant by using the loads defined in the LDR in conjunction with the agreed to Acceptance Criteria ("Plant-Unique Analyses Reports" will be submitted by each utility to NRC for their review and approval.); and

(4) Final NRC Approval - A final approval of plant-unique analyses reports and any required structural modifications by NRC followed by Safety Evaluation Reports will bring the program to its completion.

Periodically during the progress of the program, the Mark I Owner's Group will have discussions with NRC to appraise them of progress and of key program decisions. In order to promote an orderly program, five key decision points have been identified:

(1) Decisions on the need for modifications and/or load mitigation devices that may be made early in the program on the basis of information available at that time.

(2) Confirm the need for the modifications, information available at time of **decision 1 does not indicate this clearly.**

(3) Select two or more load mitigation devices for further development, if load mitigation is determined to be required (based on decisions 1 and 2).

(4) Select structural modifications for plant-unique implementation if structural modifications are required (decisions 1 and 2).

(5) Specify technical configuration for load mitigation devices for plant-unique implementation.

A detailed description of these decision points and their relative timing is given in Section 3.5.

3.2 PRESSURE SUPPRESSION HYDRODYNAMIC LOADS

Hydrodynamic loads to which the suppression system can be subjected are due primarily to the following phenomena: (1) safety/relief valve (SRV) discharge, and (2) loss-of-coolant accident (LOCA).

3.2.1 Safety/Relief Valve Discharge

Actuation of safety/relief valves (SRV's) produces dynamic loadings on components and structures in the suppression pool region.

4. FOLLOWUP ACTIVITIES

Some additional program activities will follow after the issuance of the final LDR. These followup activities will bring the Mark I containment Program to a final conclusion. Utilities will have the prime responsibility of executing these activities, and GE will provide support for the LDR loads and load combinations.

Specific activities will include:

4.1 PLANT UNIQUE ANALYSIS

Based upon the hydrodynamic loads defined in the final LDR, each utility will perform the structural evaluation of this plant to show that Structural Acceptance Criteria is met.

4.2 DECIDE ON STRUCTURAL MODIFICATIONS

If the Structural Acceptance Criteria is violated, each utility will decide the type of structural modifications to be implemented. If a decision is made by utilities to incorporate load mitigation devices, the final LDR will be revised to incorporate the effect of mitigation devices on the loads for use by the utilities for reevaluation.

Figure 4-1, which follows, summarizes these events graphically.

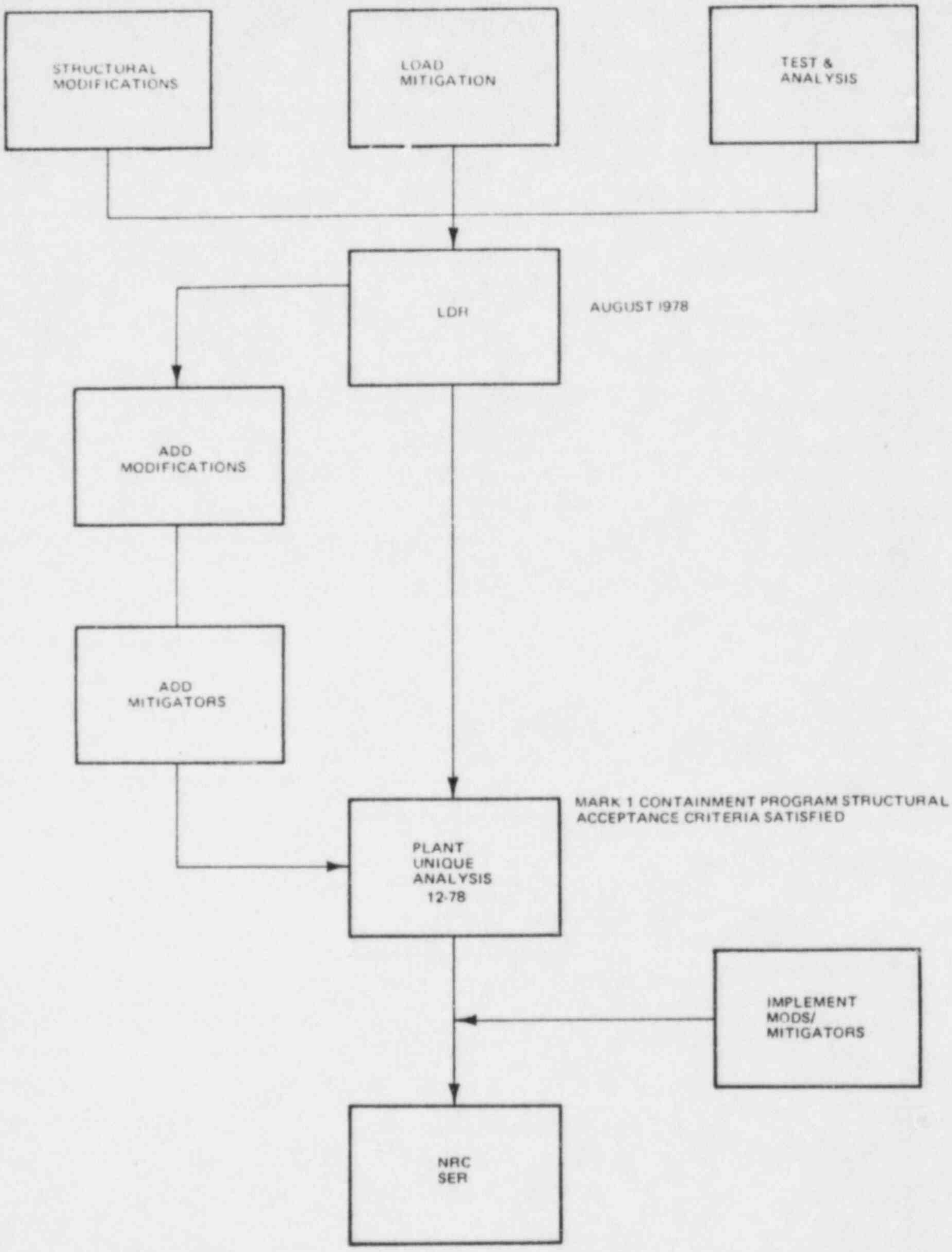

Figure 4-1. Followup Activities

When a relief valve lifts, the effluent reactor steam causes a rapid pressure buildup in the discharge pipe due to compression of the column of air initially occupying the pipe and a subsequent accleration of the water slug in the submerged portion of the pipe. During this process, the pressure in the pipe builds to a peak as the last of the water is expelled. At this point, the compressed air between the water slug and the effluent vapor begins to leave the pipe. As the compressed air exits the discharge line, it immediately begins to expand, displacing the water and propagating a pressure disturbance throughout the suppression pool. The dynamics of an expanding compressed bubble of air are manifested in pressure oscillations (similar to that of a spring-mass system) arising from the bubble expansion coupled with inertial effects of the moving water mass. The magnitude of the pressure disturbance in the suppression pool decreases with increasing distance from the point of discharge, resulting in a damped oscillatory load at every point on the torus wall below the water surface. This load produces oscillatory stress in the torus shell.

The above description is for a single SRV action. There are several SRV's in the plant, each having different discharge line characteristics.

The following SRV actions may impose loads upon the suppression chamber region:

(1) Single Actuation

(2) Consecutive Actuation

(3) Multiple actuation (two valves or more actuating simultaneously)

3.2.2 Loss-of-Coolant Accident

The various phenomena that can occur during the course of a postulated loss-of-coolant accident in Mark I pressure suppression containment system can impose significant dynamic loads upon the torus and associated structures.

With an instantaneous rupture of a steam or recirculation line, the escaping steam/water mixture causes a very rapid increase in drywell pressure and temperature. With the drywell pressure increase, the water initially standing in the downcomers accelerates into the pool and the downcomers clear of water. During this water clearing process, a water jet forms in the suppression pool which may cause water jet impingement load on the structures within the suppression pool and on the torus.

Immediately following downcomer clearing, a bubble of air starts to form at the exit of the downcomers. Since initially the bubble pressure is essentially equal to the drywell pressure at the time of clearing, the bubble pressure is transmitted through the suppression pool water and results in a downward load on the torus.

When the air-steam flow from the drywell becomes established in the vent system, the initial bubble expands and decompresses. Some of the steam portion of the flow is condensed but continued injection of drywell air and expansion of the air bubble results in a non-uniform rise of the suppression pool surface. Structures close to the pool surface may experience loads as the rising pool surface impacts the lower surface of the structure. As the suppression pool surface rises, the air in the upper half of the torus is compressed and causes a net upward load on the torus.

After the pool surface rises, there is a breakup of the slug of water and the subsequent pool swell evolves into a two phase "froth" of air and water. The pool swell transient associated with drywell air venting to the pool typically lasts for 3 to 5 seconds. Following air carryover, there will be a fairly long period of high steam flow rate through the vent system. Data indicate that this steam will be entirely condensed in a region right at the downcomer exit.

During steam condensation, the downcomers experience a lateral loading caused by random movements of the steam-water interface. The magnitude of these loads varies with steam mass flux and suppression pool temperature and are greatly reduced if there is any air entrained in the steam flow. The maximum lateral loads in a design basis LOCA will occur toward the end of blowdown when conditions of low mass flux, high pool temperature, and steam flow may exist. With a decrease in the blowdown flow rate to a very low value, the water may intermittently re-enter the downcomers in an oscillatory manner. This behavior is referred to as "chugging." The chugging phenomenon may also result in pressure loadings on the containment walls.

Shortly after an LOCA, the Emergency Core Cooling Systems (ECCS) pump would automatically startup to pump condensate water and/or suppression pool water into the reactor pressure vessel. This water floods the reactor core and subsequently cascades into the drywell from the break. Because the drywell will be full of steam when the vessel floods, the introduction of water causes steam condensation and drywell depressurization.

Following vessel flooding, suppression pool water is continuously recirculated through the core by the ECCS pumps. The energy associated with the core decay heat will result in a slow heatup of the suppression pool. To control suppression pool temperature, operators activate the RHR heat exchangers. After several hours, the heat exchangers terminate the suppression pool temperature increase.

The following is a listing of the various loads and effects which may be experienced by the containment system due to SRV discharge and LOCA phenomena:

<u>SRV</u>

- Water jet loads
- Air clearing loads
- High steam flow condensation loads
- Submerged structure drag loads

- Thrust loads on SRV discharge lines (DL)

- SRV DL internal pressure

LOCA

- Vent system thrust and pressurization loading

- Water jet loads

- Downward air bubble pressure load

- Pool swell liquid impact and drag loads

- Upward air compression load

- Submerged drag loads

- Froth impingement loads

- Pool fallback loads

- Post-swell wave loads

- High steam flow condensation loads

- Chugging (low steam flow condensation) loads on downcomers (lateral)

- Chugging on torus wall

- Containment design pressure loads

- Drywell depressurization

- Asymmetrical effects

- Pool stratification effects

3.3 LOADS CLASSIFICATION AND QUANTIFICATION

3.3.1 Load Classification

All the pressure suppression loads given in the above section were .evieved by General Electric during the Short-Term Program to establish their relative significance. The loads were classified with respect to severity of impact on the structure and the level of confidence in the quality of the loads (aided by STP test results). The emphasis of the Mark I Containment Program is to perform the tests and analyses which are considered necessary to provide a strong technical basis for the loads that could most significantly effect structural capability. The loads which are to receive primary attention in this Mark I Containment Program include:

A. Pool swell loads

Upward air compression loads

Pool swell impact and drag loads

"Downward" bubble pressure

B. Chugging Loads

Lateral vent loads

Wall loads

C. Safety relief valve loads on internals and walls

D. Seismic slosh

E. Asymmetric torus loads

F. Pool thermal stratification during relief valve discharge

3.3.2 Load Quantification

For each major load listed in Subsection 3.3.1, the current bases and tasks planned in the Program to supplement the current bases are indicated as follows:

A. Pool Swell Loads

Components Affected:

(1) Torus shell and piping, external supports and welds.

(2) Vent header, vacuum breaker, catwalks, bellows, RV lines, vent header columns.

Current Base:

(1) Bodega tests and 1/12 Scale 2D GE tests.

(2) 1/10 Scale 2D (EPRI), 1/12 Scale 2D GE tests, PSTF tests.

Program Tasks:

(1) 2.5*
Review current data and establish bounding values for pool swell loads.

(2) 5.5, 5.8
Use 1/4 Scale pool swell 2-D test results to verify scaling methods.

(3) 5.6
Pool swell tests to account for 3-D effects.

*Refers to Mark I Containment Program Task Number (See Appendix A).

(4) 5.9

Develop 3-D pool swell models to simulate pool swell phenomena.

(5) 5.3

Flexible cylinder tests to account for fluid-structure interaction.

(6) 5.9

Fluid-structure interaction modeling.

B. Chugging Loads

Components Affected:

(1) Downcomers

(2) Torus shell

(3) External supports

(4) Internal structures

Current Bases:

(1) Foreign data

(2) 4T Mark II test data

Program Tasks:

(1) 2.6

Evaluate chugging loads based on existing data.

(2) 5.2

Use 4T Mark II test data to develop an understanding of the basic chugging phenomena and determine the effect of temperature on chugging.

(3) 5.10

Monitor pressure suppression efforts going on in other organizations' facilities.

(4) 5.11

Full Scale 2-D tests to quantify single cell chugging loads. (Preliminary design)

(5) 5.12

Multivent scaled test to obtain data basis for superposition of chugging loads. (Preliminary design)

(6) 5.13

Analytical Chugging Evaluation

C. Safety/Relief Valve Loads

Components Affected: (1) Torus shell

(2) SRV lines

(3) Submerged structures

(4) External supports

Current Bases: (1) Quad Cities in-plant test data

(2) Models in NEDE-20942-P

Program Tasks: (1) 2.1

Review the current data and determine bounding value.

(2) 5.1

Evaluate Monticello Test data for:

a) Direct measurement of torus shell stresses

b) Direct measurement of external support structures

c) Direct measurement of S/RV loads

D. Seismic Slosh Loading

Component Affected: (1) Downcomers and submerged structures. Uncovering of downcomers is the primary concern. (Seimic loading upon the torus shell)

(2) Torus shell and external supports

Current Bases: (1) Analytical methods.

(2) Mark III seismic slosh tests

Program Tasks: (1) 5.4

Conduct scaled test for Mark I geometry. Confirm that uncovering of downcomers is of no concern.

E. Asymmetric Loading

Component Affected: (1) Potentially all to various degrees.

Current Bases: (1) Scoping calculations presented in NEDC-20989

(2) Judgment

Program Tasks: (1) 2.6

Using engineering judgment, establish bounding values and determine resulting structural margin for loads.

(2) 5.6

Evaluate test results of 1/12 scale 3-D tests.

(3) 5.9

Use pool swell models to perform sensitivity studies and predict plant-unique loads.

F. Pool Stratification During SRV Discharge

Component Affected: None. Concern is pool temperature monitoring.

Current Bases: (1) Quad Cities in-plant test data.

LTP Tasks: (1) 2.1

Review existing data and establish bounding results.

(2) 5.1

Evaluate pool temperature measurements from Monticello data.

(3) 7.5

Redefine analytical models.

3.4 MARK I CONTAINMENT PROGRAM TASKS

3.4.1 General

The objective of the Mark I Containment Program is to verify that all Mark I containments are structurally adequate for their plant life based on criteria acceptable to the NRC. This will be accomplished through the multiple approach of definition of hydrodynamic phenomena and comprehensive structural evaluation, together with development of a load mitigation program, as required.

From the analytical and experimental investigation of Mark I containment phenomena, a complete set of design basis loads will be established. The twin objectives of the phenomena investigation are to: (1) provide a definition of Mark I LOCA and S/RV related phenomena and aided by testing and analytical activities, establish with a high level of confidence that all pressure suppression loads have been properly accounted for; and (2) provide realistic but yet conservative, design basis loads for the individual Mark I plants.

Supporting structural evaluations will consider: (1) fluid-structure interaction effects, (2) composite plant evaluation; and (3) structural acceptance criteria.

Table 3-1 lists the total Mark I Containment Program tasks as currently structured. Detailed task descriptions are provided in Appendix A; a summary of the major work packages follows.

3.4.2 Task Description

Task 1.0 - Program Action Plan (See introduction to this report)

Task 2.0 - Initial Load Evaluation Activity

This activity will contain a preliminary assessment of all key hydrodynamic loads associated with LOCA and SRV phenomena for initial structural

Table 3-1
MARK I CONTAINMENT PROGRAM TASK LIST

1.0	Program Action Plan
2.0	Initial Load Evaluation Activities
2.1	S/RV Loads - Methodology
2.2	S/RV Loads - Plant Data & Grouping
2.3	S/RV Loads - Calculations
2.4	LOCA Loads - Plant Grouping
2.5	LOCA Loads - Calculations
2.6	Misc. Loads - Calculations
2.7	Load Combination Criteria
2.8	Report Preparation
3.0	Structural Acceptance Criteria
4.0	Composite Plant Evaluation
5.0	Testing and Data Correlation
5.1	Monticello Test
5.2	4T High Temperature Test
5.3	Flexible Cylinder Tests (GE & EPRI)
5.4	Seismic Slosh Test
5.5	1/4 Scale 2-D Test
5.6	1/12 Scale 3-D Test (EPRI)
5.8	1/12 Scale 2-D Tests
5.9	Pool Swell Model
5.10	Misc. Monitoring & Scoping Activities
5.11	Full Scale 2D Chugging Tests - Preliminary Design
5.12	Scaled Multivent chugging tests - Preliminary Design
5.13	Chugging Analytical evaluations
6.0	Load Mitigation Testing
6.1	Chugging
6.2	S/RV Discharge
6.3	Pool Swell
7.0	Load Definition Report
7.1	S/RV Loads - Model
7.2	S/RV Loads - Calculations
7.3	LOCA Loads - Calculations
7.4	Load Combination Criteria
7.5	Steam Mixing Model
7.6	Report Preparation

evaluation activities. Loads defined in this document will be based upon best available test data/correlations and analytical methods at the time. Best engineering judgment, wherever necessary, will be used to define reasonably conservative load magnitude. The results of this activity will assist the utilities in performing preliminary structural evaluation of their torus and make an assessment for potential structural modification.

Task 3.0 - Structural Acceptance Criteria

The Code rules used at the time of the design of these Mark I plants did not account for many of the newly-identified types of loads. Acceptance criteria for application to this Mark I Containment Program plant-unique analyses will be needed. Short-Term Program results (loads and structural evaluation reports), feedback from composite plant evaluation, and load evaluation activities will play a part in the development of criteria. Interpretations of current Code rules, specific development tasks, and the incorporation of additional Code rules may be required to complete a comprehensive structural criteria for the loads to be applied in the Mark I Containment Program evaluation.

Task 4.0 - Composite Plant Evaluation

The primary objective of this task is to establish the structural response to the defined loads for the most critical components from the Mark I plants. Weaker structural elements, identified from the review of STP plant unique analyses reports, plus structural evaluation for chugging and SRV loads, will be incorporated in this evaluation. If the loads result in stress levels in excess of defined allowables, then one or both of the following corrections will be made: (1) justifying reduction of loads via additional testing or by mitigation process; or (2) modifying the component structurally so that it is acceptable, would be investigated. Combinations of both of the above alternatives may be the optimum solution in some cases.

Task 5.0 - Testing and Data Correlation

Several separate tests are in progress or scheduled to further empirically clarify the loads created from hydrodynamic effects of LOCA pool swell and chugging, and SRV discharge. Table 3-2 summarizes the current test program.

Task 6.0 - Load Mitigation (Small Scale)

The primary objective of this activity is to provide quantitative evaluation of different mitigating devices for pool swell, SRV and chugging loads by performing screening tests in small-scale test facilities.

Task 7.0 - Load Definition Report (LDR)

The LDR will contain the design basis loads. All Mark I activities will contribute directly or indirectly toward the establishment of design basis magnitude for all pressure suppression pool loads.

Figure 3-1, a time-scaled program activities network, shows interrelationship among various activities. Key program decision points are shown on the figure and discussed in detail in Section 3.5. It is to be noted that some completion dates indicated in this network are considered tentative until detailed planning, which is in progress, is completed.

3.5 KEY DECISION POINTS

Based upon STP results, it is possible that structural modifications may be needed on several plants in order to meet the anticipated acceptance criteria to be set for the long term. Early decisions on plant modifications are clearly advantageous. After a careful review of the Program's objectives, five key decision points were identified and are described below. A flow network showing the interplay between these key decision points is shown in Figure 3-2.

Table 3-2

LOAD EVALUATION TEST PROGRAMS SUMMARY TABLE

TASK NUMBER		Performing Agency/Facility	Scale	Phenomena Being Tested	Testing Fluid	Date for Completion of Testing	Comments
5.1	Monticello	GE/NSP	Full	S/RV Discharge Loads	Air/Steam	June 1976	--
5.2	4T High Temperature Tests	GE/GE	Full	Chugging Wall and Vent Loads	Steam	July 1976	Mark II Configuration
5.3	Flexible Cylinder Tests	EPRI/DSI	1/6 and 1/3	Fluid/Structure Interaction-Vent Header	Water	March 1977	--
		GE/(1)	Large (>1/3)	--	Water	April 1977	--
5.4	Seismic Slosh	GE/(1)	1/20 to 1/30	Seismic Loads/ Vent Uncovering	Air	July 1977	Completion date under review
5.5	1/4-Scale 2-D Test	GE/NSC	1/4	Pool Swell Loads	Air	November 1976	
5.6	1/12-Scale 3-D Test	EPRI/SRI	1/12	Pool Swell Loads	Air	January 1977	--
5.8	1/12-Scale 2-D Test	GE/GE	1/12	Pool Swell	Air	September 1976	Check on Dec. 1975/ January 1976 tests
5.11	Full-Scale 2-D Test	GE/(1)	Full	Chugging	Steam	(1)	Preliminary design
5.12	Scaled Multi-Vent	GE/(1)	1/6 & 1/12	Chugging	Steam	(1)	Preliminary design

(1) To be established.

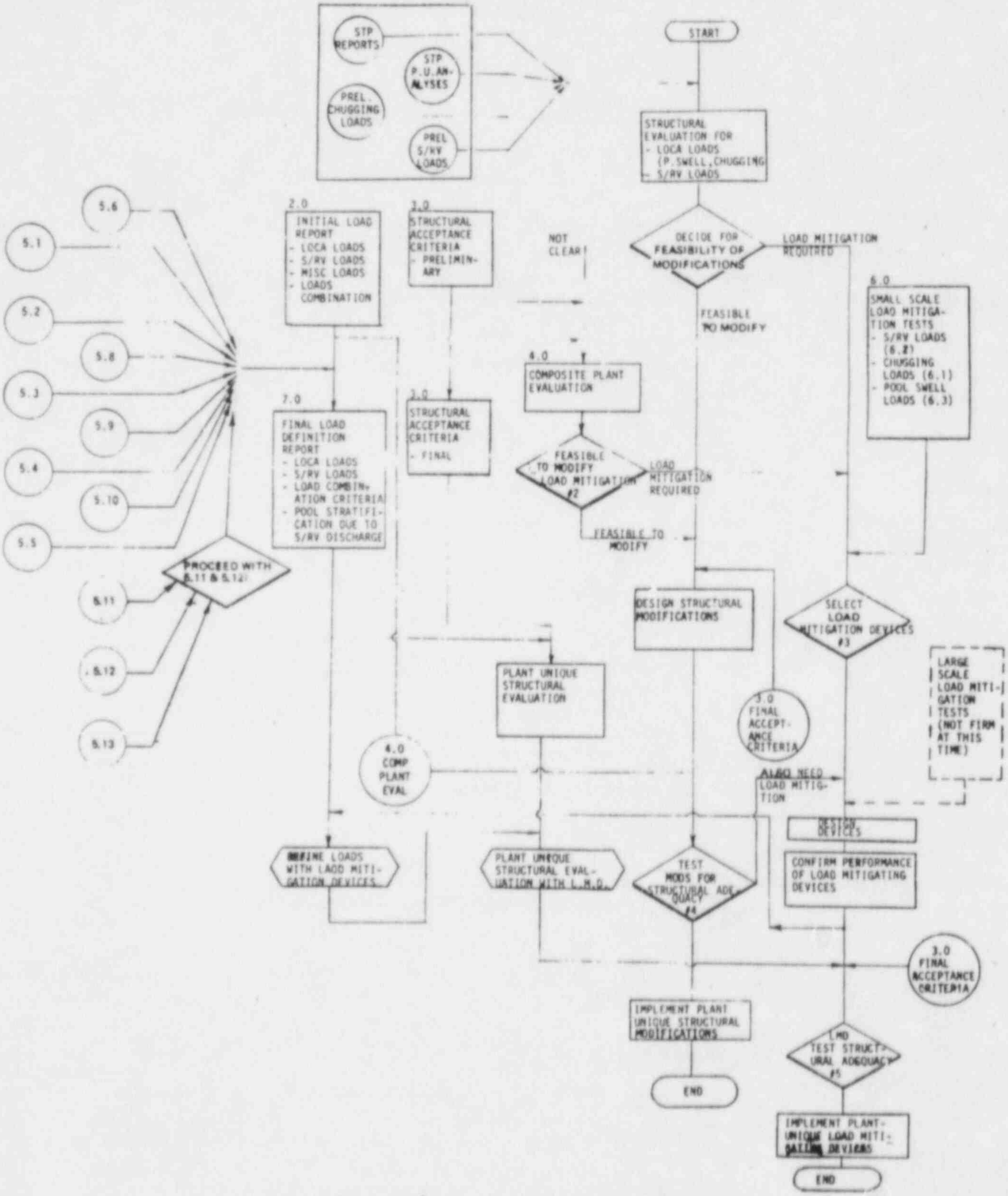

Figure 3-1. Program Logic Diagram

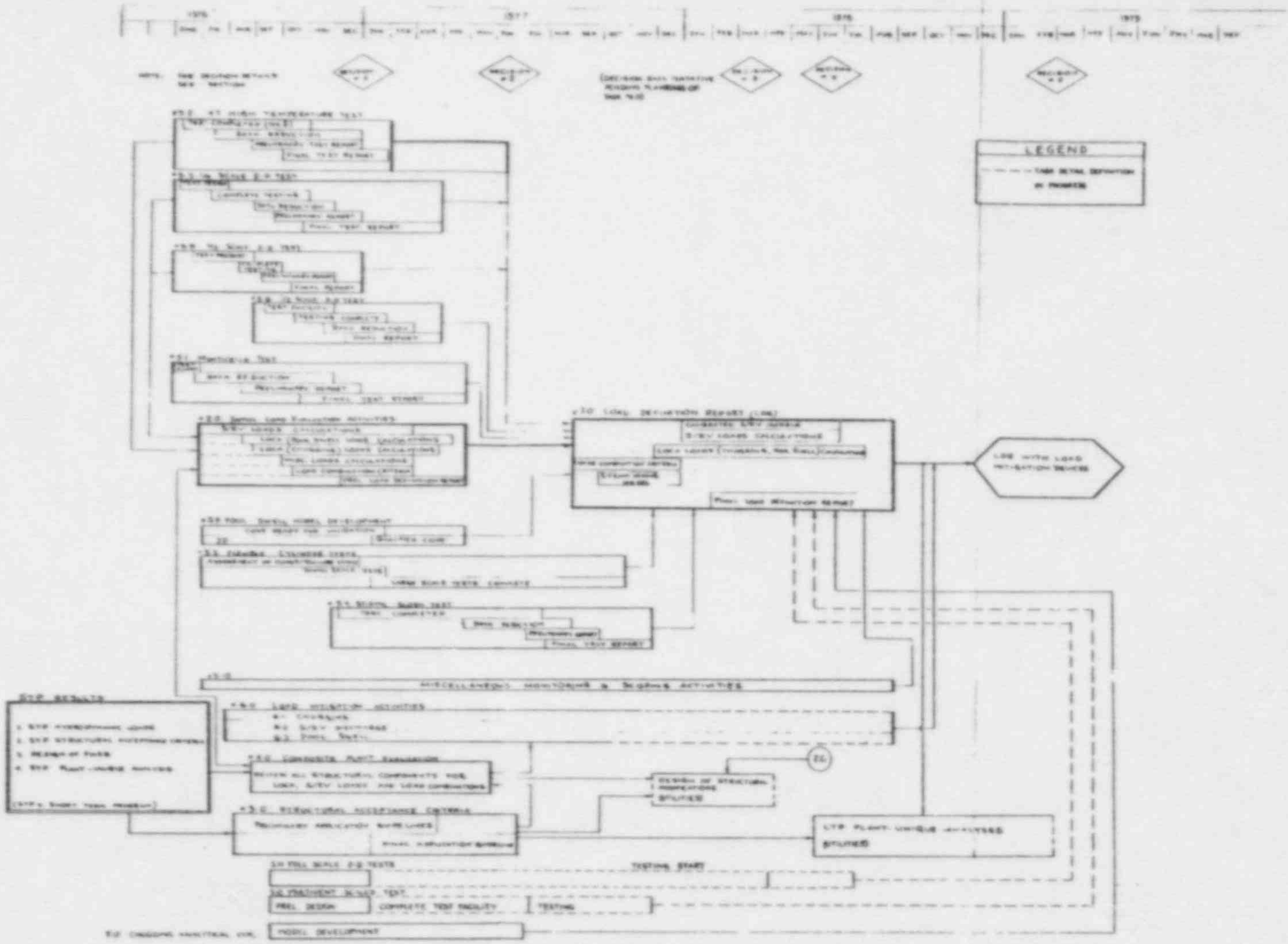

Figure 3-2. Activities Flow Network

Decision Point 1

For pool swell, SRV and chugging loads, it may become obvious early in the program that decisions on program direction can be made. Decision point 1 recognizes the need to evaluate this possibility. The decision point, based upon the current STP loads magnitude, STP plant-unique analyses, and preliminary structural acceptance criteria, may provide the following results:

(1) it will be feasible to design structural modifications; or

(2) load mitigating devices will be required; or

(3) present design is adequate but load definition must be justified.

Decision Date: January 1977

Tasks required to arrive at Decision Point 1 are:

(1) Plant-unique analyses for upward and downward load (STP reports)

(2) Composite plant structural evaluation for preliminary chugging loads (Task 4.0)

(3) Preliminary structural acceptance criteria established (Task 3.0)

(4) Preliminary load mitigation feasibility (Task 6.0 - Preliminary results as available)

Decision Point 2

If Decision 1 leads to the conclusion that structural modification feasibility is not clear, more effort leading to Decision 2 will establish if it will be feasible to design structural modifications, or if load perform structural modifications, then structural modifications will need to be evaluated against final design basis loads. Decision 4 will confirm whether these modifications are satisfactory against final loads or whether some load mitigation is needed.

Decision Date: Mid-1978

Tasks required to arrive at Decision 4 are:

(1) Tasks of Decision 3

(2) Final Load Definition Report (Task 7.0)

(3) Structural modification design (Utility task)

Decision Point 5

This decision point is a followup for Decision 3. Final specification of load mitigating devices for plant unique implementation will be made at Decision Point 5. Loads, incorporating the effect of selected (Decision 3) load mitigating devices, will be required before reaching Decision 5.

Decision Date: Early 1979

Tasks required to arrive at Decision Point are:

(1) Tasks of Decision 3

(2) Final Load Definition Report with load mitigating devices (Task 7.0)

(3) Composite Plant Structural Evaluation for S/RV loads (with mitigation) Task 4.0)

(4) Composite Plant Structural Evaluation for chugging loads (with mitigation) (Task 4.0)

(5) Structural modification design (Utility task)

mitigating devices will be required. The same decision point results as those for Decision 1 would be available.

Decision Date: Second Quarter of 1977

Tasks required to arrive at Decision point 2 are:

(1) Tasks of Decision 1

(2) Initial load evaluation activities (Task 2.0)

(3) Additional Composite Plant Evaluation (Task 4.0)

Decision Point 3

If Decision 1 or 2 leads to the result that load mitigating devices will be required. Decision 3 will be to select mitigating devices (for pool swell/chugging and SRV loads) for large-scale confirmatory tests.

Date of Decision: (Date reserved, pending detailed planning of Task 6.0)

Tasks required to arrive at Decision 3 are:

(1) Tasks of Decision 2

(2) Small-Scale chugging load mitigation tests (Task 6.1)

(3) Small-Scale S/RV load mitigation tests (Task 6.2)

(4) Small-Scale pool swell load mitigation tests (Task 6.3)

(5) Final structural acceptance criteria (Task 3.0)

Decision Point 4

If Decision 1 or 2 leads to the result that it will be feasible to

APPENDIX A

DETAILED DESCRIPTION OF ACTIVITIES

This appendix contains a detailed description of Mark I Containment Program Activities. The description includes objectives, work description, and targeted completion dated. It is to be noted, that completion dates shown in this Appendix are tentative because some program activities are still in the planning stages and their final work scope, schedules and manpower requirements are not yet defined in complete detail.

NUMBER: 1.0

TITLE: PROGRAM ACTION PLAN

DESCRIPTION: This document will provide an integrated source of information regarding the Mark I Program plan for communication to NRC, utility management, and all parties involved. It will define the Containment Program in terms of specific tasks, objectives and program descriptions. Also, it will show the integration of all the activities in terms of the loads that are to be documented in the final LDR.

TARGET DATE: October 1976

NUMBER: 2.0

TITLE: INITIAL LOAD EVALUATION ACTIVITIES

OBJECTIVES: The primary objective of Initial Load Evaluation Activities early in the program is to prepare a definition of loads (due to SRV and LOCA). Loads defined in this task will be made available for use by the utilities for preliminary structural evaluation activities. These loads will be based upon available (at the time of preparation) test data and analytical models. Activities required to produce this report are described in the following pages. An evaluation is currently in progress regarding the feasibility of reducing the time required for this task, in order to provide data for preliminary structural evaluations at the earliest possible date. The milestone dates in the following pages are, therefore, tentative.

NUMBER: 2.1

TITLE: SRV LOADS - METHODOLOGY

OBJECTIVE: Establish the degree of adequacy of current analytical models to predict SRV discharge characteristics and to calculate associated loads.

DESCRIPTION: Use and expand current analytical models for calculating loads on SRV lines, torus, and on submerged structures due to SRV discharge. The following phases of the SRV air-clearing transient will be represented to the maximum practicable extent: pipe clearing, bubble oscillation, asymmetric clearing of the ram head device by either bounding value load calculations or examination of Monticello test results, and superpositioning of loads due to multiple valve actions.

Target Date: January 1977 (Sec. 2.0 above).

NUMBER: 2.2

TITLE: SRV LOADS - PLANT DATA AND GROUPING

OBJECTIVES: Review plant geometric data received from owners and group Mark I plants to simplify the effect of calculating SRV loads. Identify where plant-unique analyses will be needed.

DESCRIPTION: Review the SRV discharge line geometry and valve characteristics and establish, if possible, groups of plants having sufficiently similar designs that SRV load calculations need only be performed for one plant in each group. The review will include an examination of the following parameters which influence the SRV pipe pressure and the torus wall loads produced by the SRV air clearing transient: reactor pressure, SRV flow capacity, SRV discharge line (DL) diameter and length, SRVDL submerged length, type of end fitting, and location of discharge point.

Target Date: November 1976 (Sec. 2.0, above).

NUMBER: 2.3

TITLE: SRV LOADS - CALCULATIONS

OBJECTIVE: Calculate preliminary hydrodynamic loads associated with SRV discharge phenomena.

DESCRIPTION: For the plant groupings identified by Activity 2.2, calculate the dynamic loads associated with SRV actuation. This will include: SRVDL pipe pressure, SRVDL pipe reaction loads during the expulsion of the SRVDL water leg, asymmetric loads on the SRVDL end fitting during water leg explusion and air bubble formation by either bounding value load calcuations or evaluation of Monticello test results, water jet loads on submerged structures, and loads on the torus and submerged structures due to air bubble oscillations. These loads will be calculated for the appropriate combination of first and subsequent valve activation, for single and multiple valve action cases. Error analysis and uncertainty evaluation will be done when calculating loads.

Target Date: February 1977 (Sec. 2.0, above).

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NUMBER: 2.4

TITLE: LOCA LOADS - PLANT GROUPING

OBJECTIVE: Review plant geometric data received from owners and group Mark I plants, if possible, to minimize the effort of calculating LOCA loads. Identify where plant-unique analyses will be needed.

DESCRIPTION: Review the containment geometry and establish if the LOCA loads calculated for a single reference plant can be considered applicable to all plants within 10 to 15%. The review will involve an examination of the following parameters: drywell, wetwell and suppression pool volumes; initial pressure, temperature and relative humidity in the drywell, wetwell and suppression pool; vent system flow area and flow loss characteristics; primary system break area; and details of the suppression pool and torus geometry.

Darget Date: December, 1976 (Sec. 2.0, above)

NUMBER: 2.5

TITLE: LOCA LOADS - CALCULATIONS

OBJECTIVE: Establish preliminary LOCA loads.

DESCRIPTION: Using current test data and analytical methods, the containment system hydrodynamic loads will be calculated for the following conditions: Design Basis Accident (DBA); an intermediate size liquid break (IBA) which actuates Automatic Depressurization System (ADS); and a small steam line break (SBA). Inventory (mass and energy downstream of the flow restrictions) effects on LOCA loads will be included in analytical models. Error analysis and uncertainty evaluations will be done when defining loads. One representative analysis will be included to demonstrate a comparison between the DBA and main stream line (MSL) break.

Target Date: April 1977 (Sec. 2.0, above).

NUMBER: 2.6

TITLE: MISCELLANEOUS LOADS - CALCULATIONS

OBJECTIVES: Identify potential asymmetrical loads in a bounding manner and seismic effects on pool.

DESCRIPTION: Using currently available analytical methods and data, the following containment system dynamic loads will be addressed:

1. Potential LOCA asymmetrical effects (in a bounding manner).

2. Evaluate seismic effects in the suppression pool - magnitude and frequency of loads induced by seismic slosh on the torus and internals. Error analysis and uncertainty evaluation will be made.

Target Date: February 1977 (Sec. 2.0, above).

NUMBER: 2.7

TITLE: LOAD COMBINATION CRITERIA

OBJECTIVE: Develop preliminary bar charts for loads showing time sequence.

DESCRIPTION: For the matrix of break types, discussed in Activity 2.5, bar charts for various containment structures will be developed. These bar charts will define the time period over which a particular loading condition exists and will thus define which of the loads need to be combined for the purposes of structural evaluation. Load combinations will be based on a mechanistic evaluation of the NSSS and containment response to a LOCA.

Target Date: January 1977 (Sec. 2.0, above)

NUMBER: 2.8

TITLE: REPORT PREPARATION

OBJECTIVE: To document the preliminary loads for use by the Utilities for initial structural evaluation.

DESCRIPTION: Document the loads to be used for initial evaluation activities.

Sufficient information and guidance will be given to assist the containment designer to apply these loads in evaluating various structures which form the containment system.

Target Date: April 1977 (Sec 2.0, above).

NUMBER: 3.0

TITLE: STRUCTURAL ACCEPTANCE CRITERIA

OBJECTIVES: To develop structural acceptance criteria for Mark I plants to which the structural evaluation and/or modifications will be made.

DESCRIPTION: Develop the structural acceptance criteria for Mark I Containments against which the results of plant unique structural evaluations will be compared. The scope of these criteria will be sufficiently broad to provide a basis for verifying the adequacy of the structure or the design of any modifications contemplated. Activities required to complete this task are described in the following pages.

NUMBER: 3.1

TITLE: EXISTING RULE SUMMARY

DESCRIPTION: Draft a summary of past and present rules for metal containments, linear supports and Class 2 piping. Identify specifications for and justification of a research program concerning short-term loads on columns, if necessary.

NUMBER: 3.2

TITLE: IDENTIFICATION OF NEEDED RESEARCH

DESCRIPTION: Review STP plant-unique analyses regarding research needs. Identify a research program, if deemed necessary.

NUMBER: 3.3

TITLE: COMPONENTS CLASSIFICATION

DESCRIPTION: Classify containment system components as vessels, piping and supports.

NUMBER: 3.4

TITLE: CATEGORIZATION

DESCRIPTION: Prepare a draft of guidelines for load combination categorization.

NUMBER: 3.5

TITLE: ALTERNATIVE CRITERIA

DESCRIPTION: Develop alternative acceptance criteria as applicable to Short term column buckling.

NUMBER: 3.6

TITLE: PRELIMINARY APPLICATION GUIDE

DESCRIPTION: Draft Application Guidelines incorporating Task 2.0, Initial Load Evaluation Activities, and Task 4.0, Composite Plant Evaluation, results.

NUMBER: 3.7

TITLE: FINAL APPLICATION GUIDE

DESCRIPTION: Establish Final Application Guidelines to provide that the Structural Acceptance Criteria are applied uniformly by those evaluating each of the specific containments for the utilities.

TARGET DATE: June 1977

NUMBER: 4.0

TITLE: COMPOSITE PLANT EVALUATION

OBJECTIVES: The primary objective of this activity is to establish how critical the loads are for the most critical components from the Mark I plant community. Then where applying loads results in not meeting anticipated acceptance criteria requirements, identify what is necessary to correct the situation by either (1) reduction of loads by some mitigation process, or (2) modifying the component structurally so that it is acceptable. Combinations of both of the above may be the optimum solution in some cases.

DESCRIPTION: Perform structural evaluation of a composite plant, using hydrodynamic loads - LOCA and SRV - and determine whether or not, plants would require structural modifications or load mitigation or combination of both. Activities required to perform the composite plant evaluation are described as follows:

TARGET DATE: May 1977

NUMBER: 4.1

TITLE: LOCA (Pool Swell) Loads Evaluation

DESCRIPTION: Review STP plant-unique analysis reports and determine the structural capability of the following components:

(1) Torus Support System
(2) Ring Girder
(3) Torus Shell
(4) Vent Header
(5) Vent Header Support Columns
(6) Downcomers
(7) Main Vents

(8) Vacuum Breakers

(9) SRV piping

(10) Miscellaneous components (e.g.,bellows, catwalks, spray header, air lines).

Demonstrate by using the preliminary structural acceptance criteria that:

(1) the composite plant can meet criteria as designed; or

(2) the plant can be made to meet criteria by a load mitigation of a specific amount; or

(3) structural modifications could be made so that plants meet criteria.

NUMBER: 4.2

TITLE: SRV LOADS EVALUATION

DESCRIPTION: The data obtained from the Monticello Test (Activity 5.1) will be used to evaluate acceptability of the torus shell for a 40-year plant life for the cycling loading imposed by anticipated SRV discharges. Using preliminary structural acceptance criteria, determine whether or not there is a need of structural modification or load mitigation.

NUMBER: 4.3

TITLE: CHUGGING LOADS EVALUATION

DESCRIPTION: All structural components are to be evaluated for the potential effects of end-of-LOCA chugging. The affected structural components are to include the torus shell, ring girder, downcomers, vent header support columns, ECSS suction strainers, SRV piping, etc. Using the preliminary structural acceptance criteria, determine whether or not the chugging loads will necessitate structural modification or load mitigation.

NUMBER: 4.4

TITLE: RELIEF VALVE DISCHARGE LINES EVALUATION

DESCRIPTION: The relief valve line configurations are to be reviewed to determine which are the critically routed and supported lines in the Mark I plants.

Representative lines are to be chosen for evaluation for the appropriate combination of pool swell and SRV blowdown loads including the effect of drag, if applicable.

Loads from the preliminary LDR will be used in the SRV line evaluation. The analyses results will be compared to the preliminary application guidelines defined in the structural acceptance criteria task of the program.

NUMBER: 4.5

TITLE: SUBMERGED STRUCTURES EVALUATION

DESCRIPTION: All structural components will be evaluated to determine the effects from drag loads from any of the possible sources. Among these components will be: Vent header column supports, downcomer, SRV line and support structure, screens, baffles, ECCS discharge lines, etc.

NUMBER: 4.6

TITLE: STRUCTURAL EVALUATION

DESCRIPTION: Using final structural acceptance criteria, components which are identified for the need of structural modifications and/or mitigating devices will be subjected to a reevaluation using the configuration modified for mitigated loads.

NUMBER: 5.0

TITLE: TESTING AND DATA CORRELATION

OBJECTIVE: The primary objective of this task is to provide an adequate technical data base to establish design basis loads from hydrodynamic effects of LOCA pool swell and chugging, and SRV discharge.

DESCRIPTION: Activities-Testing (in-plant tests, full/subscale) and Analyses - required to accomplish the above objective are described in sufficient details in the following pages.

NUMBER: 5.1

TITLE: MONTICELLO TEST

OBJECTIVES:

1. To measure pressures and temperatures in the torus and SRV piping associated with single, consecutive and multiple valve actuations. These measurements will be used to verify the analytical model to be used to predict the loads produced by SRV discharges through rams head.

2. To measure the structural response of the torus, SRV piping, supports and acceleration of the base mat and pedestal. These measurements will be used to evaluate the structural capability of the respective structural elements in conjunction with other loads acting simultaneously with the SRV loads.

DESCRIPTION: In-plant testing has been performed to provide sufficient SRV actuation (single, consecutive and multiple valve) data to refine an existing rams head analytical model for predicting loads on the torus, torus internals, and the safety relief valve lines. In addition, measurements of the structural response of the torus shell, supports, SRV lines and supports have been made for use in evaluating the structural capability of the affected components. Various activities included in this task are described as follows:

NUMBER: 5.1.1

TITLE: IN-PLANT TESTING

DESCRIPTION: Data measurements during the test include:

1. Containment Load Phenomena
   - Torus shell strains and displacements and accelerations
   - Pressure inside torus pool

- Torus pool temperatures
- Discharge air bubble formation

2. Relief Valve Line Pressure Phenomena Measurements of time-histories for:
   - Pressures inside the pipe
   - Temperatures inside the line
   - Water level rise in line
   - Vacuum breaker flow rates or position indicator with valve flow characteristics
   - SRV pipe strains and deflections
   - Rams head support strains, accelerations and deflections, to measure the reactions of the discharge loads

3. Soil/Structure Interactions
   Measurements of Acceleration time-histories at:
   - Torus basemat and torus supports
   - Pedestal

4. Reactor Steam Supply Condition
   Measurements of reactor steam supply condition through the plant process sensors are observed and recorded to avoid SCRAM.

TARGET DATE: June 1976 (Actual)

NUMBER: 5.1.2

TITLE: DATA REDUCTION

DESCRIPTION: Reducing the test data of about 10,000 traces for the 37 test runs recorded on PCM tapes and Wyle Analog tapes into time-history graphs and tabulations of phenomena and structural data including calculated principal stresses, etc.

TARGET DATE: November 1976

NUMBER: 5.1.3

TITLE: PRELIMINARY TEST REPORT

DESCRIPTION: The preliminary SRV test report will include the general test plan, identification of instrumentation and test results. Data on the phenomena, SRV piping and torus structural responses, and the effects of major parameters will be included.

TARGET DATE: December 1976

NUMBER: 5.1.4

TITLE: FINAL TEST REPORT

DESCRIPTION: This report will cover the test objectives, test matrix and limits, sensor and instrumentation system, test results, comparison of phenomena predictions with test data, discussion of effects of major parameters, summary and conclusions.

TARGET DATE: April 1977

NUMBER: 5.2

TITLE. 4T HIGH TEMPERATURE

OBJECTIVES: Use data to establish bounding values for Mark I downcomer loads and torus wall loads during low steam flow (chugging). Account for downcomer flexibility effects on chugging loads.

DESCRIPTION: These tests (Mark II) were performed to provide adequate data base to obtain bounding effects of elevated pool temperature on downcomer lateral loads and pool boundary loads resulting from chugging. These tests include: (1) three tests at two pool temperatures, and (2) measurements for the effect of vent system flexibility upon chugging loads.

TARGET DATES:

	DATE
Test Completed (Mark II)	July 1976
Data Reduction (Mark II)	September 1976
Loads for Mark I Application	December 1976

NUMBER: 5.3

TITLE: FLEXIBLE CYLINDER TESTS

OBJECTIVES: To quantify the influence of fluid-structure interaction for the pool swell impact loads upon the flexible vent header inside the Mark I torus. Also, use Test/Analytical results in quantifying this influence for other components, specifically the torus shell.

DESCRIPTION: Several alternative methods appear to be available for quantifying the fluid structure interaction effects. Different sub-activities involved in this activity are described as follows:

NUMBER: 5.3.1

TITLE: FLUID/STRUCTURE (F/S) INTERACTION ANALYSIS

DESCRIPTION: Access the importance of F/S interaction at the vent header by making calculations for rigid and flexible cylinders. This will utilize various F/S analysis techniques to determine the response of simple mathematical models of the vent header subjected to water impact; advance the state-of-the-art related to analysis of hydrodynamic impact loading of structures.

Target Date: December 1976

NUMBER: 5.3.2

TITLE: SMALL-SCALE TESTS

DESCRIPTION: Small-scale tests involving a series of drop tests will be designed and conducted to verify analytical calculations and to provide a confidence in quantifying fluid/structure interaction.

These tests, both for rigid and flexible cylinders, will be conducted for impact velocity ranging from about 6 to 30 fps.

Target Date: February 1977

NUMBER: 5.3.3

TITLE: LARGE-SCALE TESTS

DESCRIPTION: Based upon the review of small-scale test results, large-scale test will be designed and conducted to quantify such effects. This activity will involve the test planning, test execution, data interpretation and program documentation activities.

Target Date: October 1977

NUMBER: 5.4

TITLE: SEISMIC SLOSH TEST

OBJECTIVE:

1. To determine the slosh heights and its effect on the vent submergence in the Mark I suppression pool when a 1/30 scale torus model is subjected to simulated earthquake excitation.

2. To determine the impulsive and convective liquid pressure loads on the containment and drag loads on the critical internals due to sloshing.

DESCRIPTION: A 1/30 scale 3-D plastic model of the Mark I suppression tank with downcomers included will be designed and fabricated. Tubular sections will be cut from plastic tubing and bonded together to form the Mark I torus. Geometrically scaled smaller plastic tubing will be used to form the downcomers. The tank will be rigidly mounted on a flat plate seismic shaker. Instrumentation will be installed for determining liquid wave height and load measurements at critical locations. A typical earthquake acceleration/displacement time history (both horizontal and vertical) will be generated for driving the seismic simulator.

An analytical model will be developed to predict the wave profile and loads on the critical structures. The mathematical model will be verified with the small-scale test results. The mathematical model can then be used to calculate the slosh heights and loads for individual plants.

The test data will be recorded on analog tape. Excitation and response time histories will be plotted for ready comparison of results.

The results and findings will be documented in a report.

Target Date: **November 1977**

NUMBER: 5.5

TITLE: 1/4 SCALE 2-D TEST

OBJECTIVES:

1. To demonstrate the validity of the hydrodynamic scaling relationships for pool swell by direct comparison of 1/4 scale and 1/12 scale data.

2. To define the base case reference plant 2-D pool swell loads for use in developing plant-unique loads. This will include both, pressurized (drywell ΔP) and unpressurized (no ΔP) conditions for the reference plant.

3. To provide increased confidence in the sensitivity of pool swell loads to drywell pressurization (drywell ΔP).

DESCRIPTION: The program involves construction of a 2-D, 1/4 scale model of the Mark I torus. The facility is scaled to the reference plant geometry but has been designed in such a way that the internals can be readily modified to other geometries and test conditions. The first phase of the test program will provide pool swell data for the same conditions as were present in the 1/12 scale facility during the tests which were conducted in December 1975 and January 1976. Comparisons of the results (velocities, pressures, etc.) will be made and will permit an assessment of the accuracy of the fundamental scaling laws involved. The test results will also be used to confirm the reference plant pool swell velocity and torus upward and downward loads. This will be achieved by reproducing in the test facility the correctly scaled LOCA conditions for the reference plant. This will be done for both zero and positive drywell overpressure conditions. Any differences between the earlier 1/12 scale results and the 1/4 scale data will be evaluated.

Planning is in progress for a second phase of testing which will determine sensitivity of pool swell loads to various geometric and initial condition plant parameters.

Target Dates:

Tests Completed	November 1976
Preliminary Test Report	December 1976
Final Test Report	March 1977

NUMBER: 5.6

TITLE: 1/12 SCALE 3-D TESTS (EPRI)

OBJECTIVES: To establish 3-D effects on pool swell impact and drag loads on the vent system and net up and down loads on the torus. To quantify the load attenuation due to irregular spacing of downcomers, and to investigate the effects of asymmetric downcomer clearing and asymmetric vent flow.

DESCRIPTION: Three-dimensional pool swell effects on vent header impact loads, net up and down torus loads, asymmetric downcomer clearing and asymmetric vent flow will be quantified by performing dynamic tests on a 1/12 scale Mark I multiple downcomer model. These tests will quantify load attenuation due to irregular spacing of downcomers, as well as horizontal and vertical pool velocities for drag loads on submerged structures.

TARGET DATES:

Facility Completion	November 1976
Test Completion	January 1977
Final Report	March 1977

NUMBER: 5.8

TITLE: 1/12 SCALE 2-D TESTS

OBJECTIVES: To provide additional data base to verify scaling methods for direct comparison with 1/4 scale 2-D test and (5.5) results. To provide data enabling the investigation of the cause of the downward load anomaly observed between the December 1975 and January 1976 1/12 scale test series.

DESCRIPTION: An improved data base of 1/12 Scale Test results will be provided to aid in (1) understanding of anomalies between the December 1975 and January 1976 1/12 Scale Test runs; and (2) evaluation of scaling laws when compared against 1/4 Scale Test data. A series of about 32 runs will be made at both base conditions and drywell pressure differential. Control of initial conditions will be improved by consideration of air temperature and humidity conditions.

Also, the effects of structural flexibility on torus pressure forces will be investigated. A scoping investigation of the effect of structural flexibility on torus loads will be conducted.

A report which will serve as a basis for load development will be issued. Detailed loads development studies are to be included in 1/4 Scale Test (5.5).

TARGET DATES:

Test Completed	September 1976
Preliminary Report	November 1976
Final Report	December 1976

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NUMBER: 5.9

TITLE: POOL SWELL MODEL DEVELOPMENT

OBJECTIVE: Develop computer codes (2-D and 3-D) to simulate the pool swelling phenomena. Validate these codes against available test data and qualify them for plant-unique loads prediction.

DESCRIPTION: Both two- and three-dimensional computer codes will be developed to simulate the hydrodynamic response in the wetwell resulting from the postulated LOCA during the period from initial drywell pressurization and vent clearing to the point of bubble breakthrough. The models developed will be used: (1) to quantify horizontal and vertical pool velocities and accelerations for drag loads on submerged structures and impact on structures above the initial water level; (2) to define the load attenuation due to unequal spacing between downcomers; (3) to investigate the effects of asymmetric clearing; and (4) up and down loads on torus. These models will be verified against 1/12 scale 2-D, 1/4 scale 2-D and 1/12 scale 3-D test results.

TARGET DATES: April 1977

NUMBER: 5.10

TITLE: MISCELLANEOUS MONITORING AND SCOPING ACTIVITIES

OBJECTIVES: To monitor for any pertinent information of test and analytical activities going on outside of the present Mark I program.

DESCRIPTION: Pressure suppression efforts going on in other organizations and facilities (e.g., 3-D tests at Livermore, LOFT program at Idaho, GE Licensee Full Scale 3-D tests, Marviken tests, and others if any) may yield information of use to the Mark I Program. Knowledgeable personnel will be assigned to monitor the reports, establish contacts, and made periodic visits as required. Review reports will be issued as and when required depending upon the significance of the finding.

TARGET DATE: Continuous support (dependent on progress on monitored activities).

NUMBER: 5.11

TITLE: FULL-SCALE 2-D LOAD DEFINITION TEST PROGRAM

OBJECTIVES: To obtain "single cell' chugging loads

DESCRIPTION: A facility will be constructed for conducting tests in a 2-D full-scale Mark I torus configuration. The tests will be conducted for the purpose of defining basic single cell chugging loads associated with a postulated LOCA. Parameters that will be investigated include initial pool temperature, over pressure, submergence, steam mass flow rate, temperature stratification. The facility will permit testing of load mitigation devices if needed.

Some alternatives to the above approach will also be considered including in-plant tests or other means to determine if a schedule or cost benefit will result. If the alternative approaches yield data changes pertinent to the load definition, the full-scale test facility may not be necessary.

TARGET DATE: Program in definition and proposal phase. Preliminary design in progress.

NUMBER: 5.12

TITLE: SCALED MULTIVENT TEST

OBJECTIVE: To determine effective multiplier effect of multivent configuration.

DESCRIPTION: It is planned that a multivent facility will be configured as a test tank with multiple cells and removable partitions in order to maintain vent area/pool area constant as the number of vents is increased. The test will include data acquisition of multiple vent effects and attenuation. Some parameters to be investigated are submergence, vent area/pool area and pool temperature. It is planned that two scales of vent diameter will be investigated in order to obtain scaling effects. Alternate approaches will be considered to shorten the schedule that may have some increase in technical risk. Changes that will be considered are one scale only, rigid walls only and number of vents.

TARGET DATE: Program in definition and proposal phase. Preliminary design in progress.

NUMBER: 5.13

TITLE: CHUGGING ANALYTICAL EVALUATION

OBJECTIVE: To provide a basic analytical understanding of fluid phenomena related to chugging loads and the combination of various loads, and to understand chugging fluid/structure interaction effects. Results of this task will be incorporated into evaluation of Tasks 5.11 and 5.12.

DESCRIPTION: An effort will be initiated to develop an analytical understanding of chugging phenomena based on "first principles". Consultants available from both industry and university environments will be unified into a task force for this purpose. This work will support the test programs by providing a rigorous insight into the physical basis of chugging, which in turn will be used to develop appropriate data reduction, correlation, and perhaps even scaling law guidelines.

Among the other areas to be developed in this task are included: development of analytical models to predict chugging loads on multivent facilities; detailed review and correlation of all available test data, including determination of fluid/structures interaction effects from GE 4T tests; and analytical determination of combined loads using "Monte Carlo" methods.

TARGET DATE: Program in definition and proposal phase.

NUMBER: 6.0

TITLE: LOAD MITIGATION TESTING

The primary objective of this activity is to provide quantitative evaluation of different mitigating devices (for LOCA and SRV Loads) in small-scale for identifying potential devices for further confirmation and subsequent plant unique implementation.

This activity is divided into three subactivities which are described in the following pages.

NUMBER: 6.1

TITLE: CHUGGING LAND MITIGATION TESTING (SMALL-SCALE)

DESCRIPTION: Basic studies will be performed to screen various concepts identified as possible methods to mitigate the hydrodynamic loads resulting from "chugging" at the exit of the downcomers during a postulated LOCA. Perforated vents, staggered vents, and other discharge device concepts will be considered. Vent mass flow rate, submergence, and pool temperature will be varied during these tests. Sufficient geometric variations will be made for the purpose of extrapolating to full scale. Studies will also be performed to establish a multiple vent chugging data base under controlled testing conditions.

TARGET DATES: Open pool screening tests complete December 1976
Detailed planning for accelerated load mitigation task in progress; target dates available 12/1/76.

NUMBERS: 6.2

TITLE: SAFETY/RELIEF VALVE LOAD MITIGATION TESTING

DESCRIPTION: Basic studies will be performed to screen various concepts identified as possible methods to mitigate the hydrodynamic loads resulting from SRV discharge into the suppression pool. These tests would rank the various relief valve load mitigation candidates.

TARGET DATES: Detailed planning for accelerated load mitigation task in progress; target dates available 12/1/76.

NUMBER: 6.3

TITLE: POOL SWELL MITIGATION TESTING

DESCRIPTION: Basic studies will be performed to screen various concepts identified as possible methods to mitigate the hydrodynamic loads resulting from the pool swell during a postulated LOCA. Flow visualization tests of promising ideas will be conducted to determine qualitatively which configurations have the potential for pool swell load reduction. The tests will be conducted in such a way as to permit comparison of the relative reduction over straight down vents. Various ideas such as special nozzles, perforated pipes or spargers will be tested. Should one of these tests show enough reduction to warrant its potential application to the containment, tests will be necessary for demonstration purposes.

TARGET DATES: Open pool screening tests complete — September 1976

Final screening test report — December 1976

Detailed planning for accelerated load mitigation task in progress. Target dates to be available available 12/1/76.

NUMBER: 7.0

TITLE: LOAD DEFINITION REPORT - FINAL

OBJECTIVES: Document pressure suppression hydrodynamic loads for the use of the utilities to perform plant-unique analysis.

DESCRIPTION: Test data and analytical models generated by the Long Term Program Activities will be used to refine loads to a practicable confidence level for the use by the utilities for the evaluation of their plants. In defining loads, test data including an error and uncertainty analysis and analytical models properly validated against test data will be used. For plants having some unique features, realistic but yet conservative loads will be defined.

This activity is divided into six subactivities which are described as follows:

NUMBER: 6.3

TITLE: POOL SWELL MITIGATION TESTING

DESCRIPTION: Basic studies will be performed to screen various concepts identified as possible methods to mitigate the hydrodynamic loads resulting from the pool swell during a postulated LOCA. Flow visualization tests of promising ideas will be conducted to determine qualitatively which configurations have the potential for pool swell load reduction. The tests will be conducted in such a way as to permit comparison of the relative reduction over straight down vents. Various ideas such as special nozzles, perforated pipes or spargers will be tested. Should one of these tests show enough reduction to warrant its potential application to the containment, tests will be necessary for demonstration purposes.

TARGET DATES: Open pool screening tests complete September 1976

Final screening test report December 1976

Detailed planning for accelerated load mitigation task in progress. Target dates to be available available 12/1/76.

NUMBER: 7.0

TITLE: LOAD DEFINITION REPORT - FINAL

OBJECTIVES: Document pressure suppression hydrodynamic loads for the use of the utilities to perform plant-unique analysis.

DESCRIPTION: Test data and analytical models generated by the Long Term Program Activities will be used to refine loads to a practicable confidence level for the use by the utilities for the evaluation of their plants. In defining loads, test data including an error and uncertainty analysis and analytical models properly validated against test data will be used. For plants having some unique features, realistic but yet conservative loads will be defined.

This activity is divided into six subactivities which are described as follows:

NUMBER: 7.1

TITLE: SRV LOADS - MODEL DEVELOPMENT/VERIFICATION

DESCRIPTION: Verify or refine analytical models for calculating SRV discharge loads on discharge lines and torus submerged structures using Monticello Test Data (Task 5.1). These models will be confirmed with Monticello test data over the range of expected parameter variation. A Topical Report will be prepared containing a description of the analytical models and verification of models using Monticello Test data Also, parametric studies for the parameters such as air volume, submergence, length of water leg, spacing of ramshead, distance from ramshead to the point of interest, reactor pressure, and pool temperature will be included.

TARGET DATE: June 1978

NUMBER: 7.2

TITLE: S/RV LOADS - CALCULATIONS

DESCRIPTION: Plant unique S/RV loads for all the affected structures discharge lines, torus shell, and submerged structures - will be calculated. An error analysis will be performed and uncertainties for S/RV loads will be evaluated. The loads will be calculated for each plant, or group of similar plants, considering plant parameters and using the output of subactivity. 7.1.

Differences between Test Data base and individual plant conditions will be discussed. These loads will be justified by reference to documents (output of subtask 7.1) that describe the analytical models, and test data used in the development of the loads.

TARGET DATE: June 1978

NUMBER: 7.3

TITLE: LOCA LOADS - CALCULATIONS

DESCRIPTION: Using plant-unique geometry and data available from various tests, loads will be established for the drywell, vents, bellows, vent header, downcomers, submerged structures and the torus for different sized line breaks. Differences between Test Data base and individual plant conditions, if any, will be discussed. This activity is similar to the work described in Subactivity 2.5. The various analytical and experimental items in the Long Term Program will have provided improved methods and extended data base for specification of the LOCA loads.

TARGET DATE: July 1978

NUMBER: 7.4

TITLE: LOAD COMBINATION CRITERIA

DESCRIPTION: The analytical and experimental work performed during the execution of the Long-Term Program will provide additional insight into the time-phasing relationships between the various LOCA and S/RV loading conditions. Using this information, the bar charts (subactivity 2.7) developed for the Preliminary Load Definition Report, will be reviewed and amended as necessary to form the final definition of load combinations. This final definition will be based on a mechanistic evaluation of the NSSS and Containment response to a LOCA. There will be a series of bar charts covering all significant structures.

TARGET DATE: December 1977

NUMBER: 7.5

TITLE: RELIEF VALVE STEAM DISCHARGE MIXING MODEL

DESCRIPTION: An analytical model for predicting thermal mixing in the suppression pool during relief valve discharge will be developed. This model will be capable of predicting pool temperature distribution resulting from a stuck-open relief valve, vessel isolation, and vessel automatic depressurization. In addition, the model will be used to confirm the adequacy of the pool-temperature monitoring system.

TARGET DATE: December 1977

NUMBER: 7.6

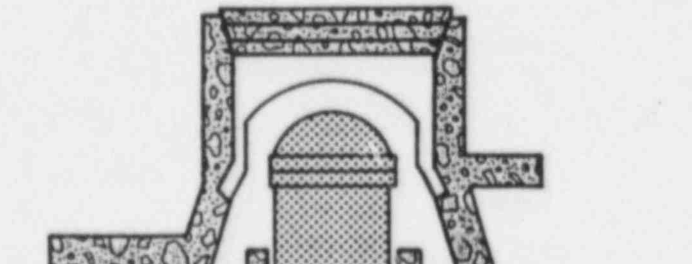
TITLE: REPORT PREPARATION

DESCRIPTION: This subactivity will document the final design basis loads for all Mark I plants. This will include the coordination and integration of all the hydrodynamic loading information generated by the Long Term Program Activities into a single coherent document using preliminary load definition activities (# 2.0) as a basis. It will define reasonably conservative loads for the use of the Mark I utilities to evaluate their plants.

TARGET DATE: August 1978

In-Plant SRV Test

La Salle County



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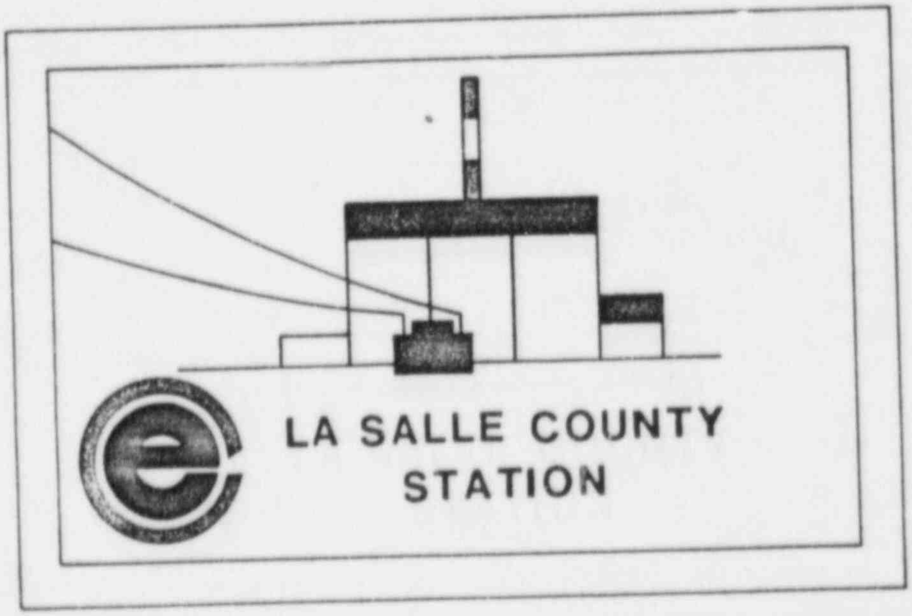
La Salle County 1

In-Plant SRV Test Plan



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October 27, 1980

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FIGURES

Figures 1 through 19 including 1A, 1B, 12A, 13A, 14A, 15A, and 15B

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FIGURES

APPENDICES

I. OBJECTIVES

The objectives of the LaSalle County Unit 1 In-Plant SRV Test are to provide test data that: (1) will be utilized to confirm that the containment can safely accommodate all hydrodynamic loads and thermal effects associated with SRV actuation; and (2) will be utilized to demonstrate adequate plant design margins for these SRV loads. In addition to the In-Plant SRV Test results, it is intended that all appropriate information available from the generic Mark II Program, from the Karlstein Test Group (KTG), and from the Kraftwerk Union AG (KWU) information package also be used to support the LaSalle County plant licensing activities and schedule.

It is intended that the In-Plant SRV Test results will be used to address licensing issues relative to SRV actuation. The current issues are:

A. Submerged structural loads resulting from SRV actuation.

B. Containment boundary loads resulting from SRV actuation.

C. Thermal mixing of the suppression pool water during an extended SRV blowdown.

D. SRV response spectra for mechanical components in reactor building.

These issues will be addressed for both first and subsequent SRV actuation conditions.

It is anticipated that the licensing issues identified above will be resolved by: (1) confirming that the actual measured SRV induced mechanical/structural response of selected components in the reactor building can be accommodated; (2) confirming that the actual measured SRV hydrodynamic loads and thermal effects in the suppression pool can be accommodated; and (3) confirming that the SRV design basis loads provide an adequate safety margin by analytically extending the actual in-plant test results to the most severe design basis conditions. In order to accomplish the latter objective, the in-plant test data will be utilized to predict the most severe design basis SRV response postulated during plant operation. This experimental/analytical approach provides a method to compare the most severe actual SRV responses with the design basis responses and will demonstrate that plant safety margin.

II. SCHEDULE

Figure II-1 is the schedule developed to address those activities associated with testing activities. These activities are concerned primarily with the SRV test preparations and preliminary analysis and the subsequent acquisition of data from SRV actuations as described in Paragraph III.C, Test Matrix.

The schedule uses the LaSalle County - Unit 1 fuel load date as the primary reference date for activities associated with the In-Plant SRV Test.

The scheduled items on Figure II-1 will encompass the following:

A. Pre-Test Activities - This will include the procurement of instrumentation, design, and installation of sensor mounting brackets, design of downcomer penetration and installation, issuance of revised test plan, final engineering evaluation and guidelines for testing parameters.

B. Equipment Installation - This will involve the actual installation of sensors and data acquisition station.

C. Test Procedure - This activity will include the preparation, review, and approval of a step-by-step method for performance in the In-Plant SRV Test.

D. Conduct of Test - The implementation of the test procedure at LaSalle County Station.

ACTIVITY

INTERMITTENT ACTIVITY

FIGURE II-1
LA SALLE COUNTY STATION
UNIT 1
SRV TEST PROGRAM ACTIVITIES

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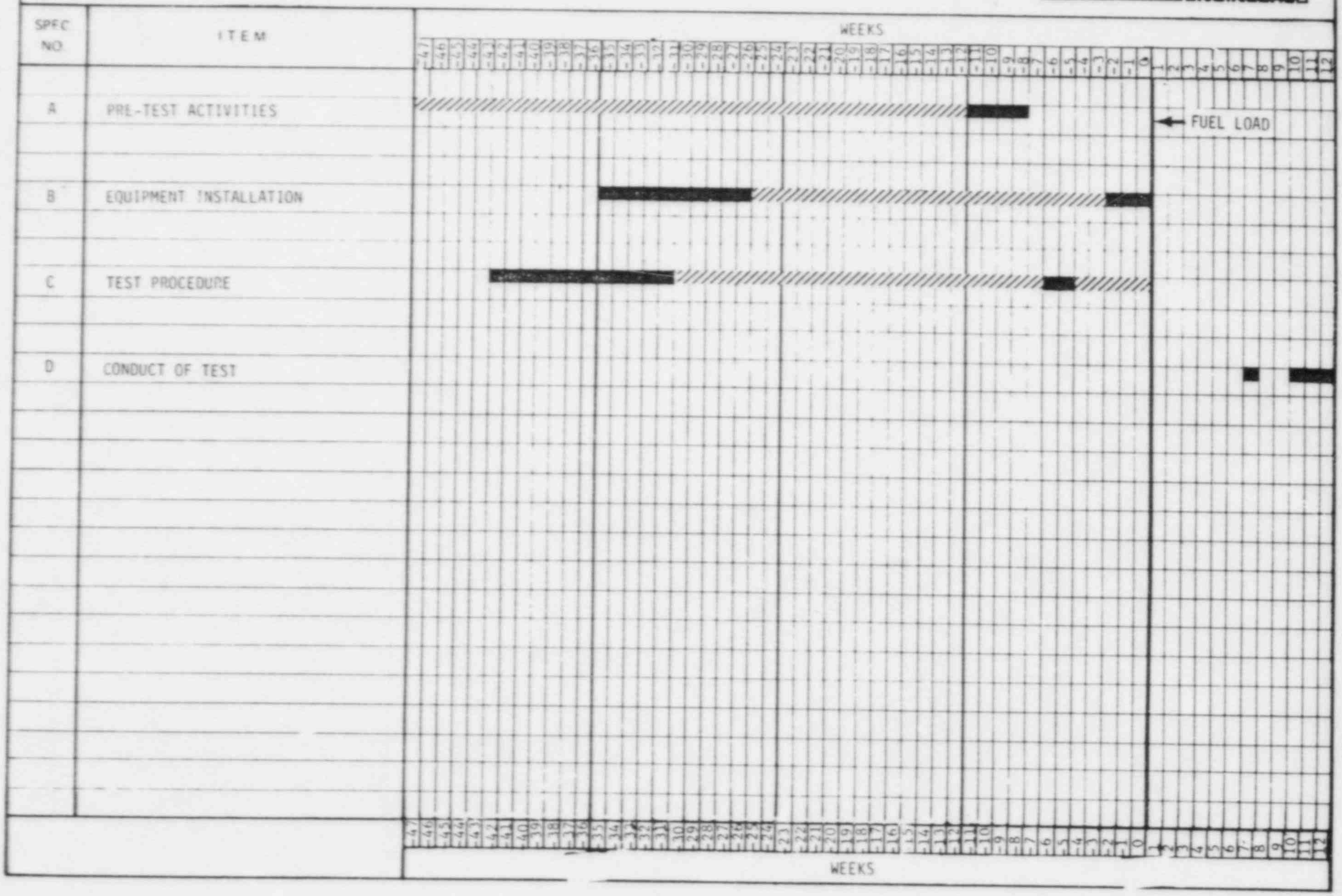

III. SCOPE

A. Test Conditions

1. During the performance of this test, the reactor temperature and pressure will be maintained within allowable operational and test limits. The prescribed reactor tolerances will be within 2% of the nominal operating values, with the reactor at or less than 60% power. These test tolerances have been established for statistical considerations and have been applied to all applicable initial plant conditions. To assure repeatability of data, the following initial conditions, in addition to those previously discussed, will be within allowable test tolerances prior to an SRV/ADS valve actuation: suppression pool water level, suppression pool water temperature, and discharge pipe temperature.

2. An air bleed system is included in each of the five SRV discharge lines in the test program. The bleed system consists of a double solenoid valve tapped into each line in the drywell. These valves are individually operated from remote controls. Position indication lights give an indication of the solenoid valves being energized open or deenergized closed. On loss of control power the valves fail closed.

The purpose of the air bleed system is to return the suppressed discharge line water level to a level approximately that of the suppression pool. The air bleed system is used prior to each cold pipe discharge to provide a statistically constant parameter for data analysis. The air bleed system is not used prior to hct pipe or second pop SRV lifts. (See Figure 19.)

B. Quencher Selection Criteria

1. Quenchers located at azimuths 210°, 230°, 252°, 264°, and 170° will be selected for testing. The selection is based on the following criteria (see Figure 16):

   a. Maximum Structural Response - It is anticipated that the structural response of containment structures due to SRV discharges will be small. Therefore, the location selected for monitoring accelerations should be on the containment wall rather that on the buttresses. There are three buttresses, located at azimuths 60°, 180°, and 300°. Thus, the suppression pool is divided into three potential sectors, separated by these buttresses.

b. Representative Structures - The sector selected for testing must represent a typical structural element with a minimum amount of discontinuities such as large penetrations, concentrated masses, etc. This would provide a favorable condition for comparing test data and analytically-derived "expected values."

c. Proper Mixes of SRV Line Volumes - The ideal combination of line selection is to include those lines with the largest and smallest volumes, and other lines with intermediate volumes. This would allow the evaluation of effects of line volumes on pool pressure variations. If the above condition could not be met, the alternative is to include the largest line volume in the test sector and to select the best available line combination, based on the existing SRV line arrangement.

d. Close Proximity to Electrical Penetrations - To minimize noise levels in the signal conductors, the shortest distance from the sensors to the available electrical penetration is preferred.

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e. Submerged Structural Loads and Thermal Mixing - The orientation of the tested quenchers should facilitate determination of multiple discharge load combinations, pool thermal mixing, and submerged structure loading characteristics.

f. The SRV discharge line volume ranges from 80.05 ft^3 (smallest) to 122.2 ft^3 (largest). The arithmetic average of all line volumes is 100.2 ft^3.

The five SRV discharge lines selected for this test have the volumes 91.2 ft^3, 103.5 ft^3, 107.0 ft^3, 114.5 ft^3, and 122.2 ft^3. Thus, the largest volume line is one of the test lines. The smallest volume test line deviates from the smallest volume line in the plant by only 12.60%.

C. Test Matrix

The test matrix is based on actuations of SRV valves with quenchers located adjacent to each other (Az. 210°, 230°, 252°, and 264°). In addition to these four valves, the SRV quencher at Az. 170° shall be tested in a single-valve-actuation mode. (Refer to Figure 16 and Appendix A.) Combinations of valve actuations shall be used to cover a variety of loading conditions and consequent structural responses that will provide test data to confirm the methods used for summing dynamic SRV loads. A classification of the type of tests to be conducted is as follows:

1. <u>One SRV Actuation Test (SRV-1)</u>

   This test will be conducted by actuating a single SRV for a nominal 15 second duration of discharge time. This test is designated as SRV-1 in the Test Matrix. The test will include both the cold and hot initial pipe temperature in order to investigate first and subsequent SRV actuation conditions. The cold pipe actuation data is used to form the statistical basis for all other SRV Test actuations.

2. <u>Consecutive SRV Actuation Test (SRV-C)</u>

   This test will be conducted by actuating a single SRV consecutively for a given duration of discharge time for each actuation. This test is designated as SRV-C in the Test Matrix. The time interval between two consecutive actuations will be varied to determine the effects of the reflood transient on the maximum SRV loads resulting from subsequent actuation.

This procedure will cover the range of time intervals during which peak reflood height would occur in the line. A review of the KTG test data was also made to determine the range of time intervals to be considered in this test. The test will be repeated at least five times at the maximum loading condition measured in this test.

3. Two SRV Actuation Test (SRV-2)

This test will be conducted by actuating two adjacent SRV's for a given duration discharge time. This test is designated as SRV-2 in the Test Matrix. The test will include both the cold and hot initial pipe conditions.

The valves will be actuated manually and their lift times will be recorded automatically on the sequential recording annunciator typewriter in the Reactor Control Room.

The Sargent & Lundy (S&L) analytical model will be used to evaluate the effects of differences in line length and volume, which in turn affect the bubble entry times into the pool.

Since the time of valve actuation and the geometric characteristics of the line will be available from the test data, the analytical model can be used to determine the vent clearing time, and hence the bubble entry times into the pool. This information can then be utilized to determine the appropriate pressure-time histories in the pool. An evaluation would then be made with the measured pressures traces to demonstrate that the analytical model prediction bounds the measured test results. The same S&L analytical model will be used to conservatively predict the loading conditions at the LaSalle design conditions. This S&L analytical model predicts loading conditions at design conditions which are bounded by the LaSalle Design Basis.

4. Four SRV Actuation Test (SRV-4)

This test will be conducted by actuating four SRV's simultaneously for a given duration of discharge time. This test is designated as SRV-4 in the Test Matrix.

The valves will be actuated manually and their lift times will be recorded automatically on the sequential recording annunciator typewriter in the Reactor Control Room.

The Sargent & Lundy (S&L) analytical model will be used to evaluate the effects of differences in line length and volume, which in turn affect the bubble entry times into the pool.

Since the time of valve actuation and the geometric characteristics of the line will be available from the test data, the analytical model can be used to determine the vent clearing time, and hence the bubble entry times into the pool. This information can then be utilized to determine the appropriate pressure-time histories in the pool. An evaluation would then be made with the measured pressures traces to demonstrate that the analytical model prediction bounds the measured test results. The same S&L analytical model will be used to conservatively predict the loading conditions at the LaSalle design conditions. This S&L analytical model predicts loading conditions at design conditions which are bounded by the LaSalle Design Basis.

5. <u>Sequential SRV Actuation Test (SRV-S)</u>

This test will be conducted by actuating four SRV's in sequence (rather than simultaneously as in the previous case) for a nominal 15 second duration of discharge time and at a one second opening time interval. The sequencing for the sequential valve actuation case will be accomplished manually with time interval equal to the time period of the first cycle of the lowest set-point air bubble in the Resonant Sequential Symmetric Discharge load case. This test is designated as SRV-S in the Test Matrix.

The purpose of this test is to provide data which can be used to verify the conservatism of the loads due to bubble phasing.

Analyses of bubble phasing and its effects will be examined by using the S&L analytical models already available. Since the valve opening time and the associated geometric characteristics for each line are known, the analytical models can be used to predict the line clearing transient and determine the time at which individual bubbles arrive in the pool. The analytical model then can predict the wall pressure histories at any location in the suppression pool for the test condition. The same analytical model is also used to predict loads at the design conditions which are bounded by the LaSalle Design Basis. With this type of analyses, in conjunction with the measured data, an evaluation of the effects of phasing can be obtained for both test and design conditions.

6. Extended SRV Blowdown Test (SRV-E)

This test will be conducted to simulate the initial phases of the suppression pool temperature transient resulting from a postulated stuck-open safety relief valve (SORV). This test is designated as SRV-E in the Test Matrix. The purpose of this test is to demonstrate: (1) adequate normal thermal mixing of the suppression pool water; and (2) adequate performance of the installed temperature monitoring system during an extended SRV blowdown due to SORV.

7. Leaky Valve Test (SRV-L)

This test will be conducted to simulate a leaky relief valve seat preceding an SRV actuation. The discharge pipe will be hot but unlike SRV-1 Hot Pipe, will not necessarily be purged of air. Leaky valve test will be simulated by introducing steam into the SRV discharge line before actuation of the valve. Provision has been made to introduce steam into the line over any desired time period. This test is designated as SRV-L in the Test Matrix.

Appendix A shows the Test Matrix for this program. The reactor will be maintained at normal operating temperature and pressure. The entire test will be performed with the reactor at or less than 60% power. It is anticipated that after a series of tests, the hot SRV/ADS line will require about three or four hours to restore pipe temperature to within allowable test tolerances for a "Cold Pipe" test.

Therefore, during the actual testing program, sequencing of the tests shall be optimized to reduce the total time required for completion of the entire test program.

Tests which will be used to evaluate thermal effects, hydrodynamic loading and response shall be repeated at least five times to ensure that a statistically significant result is obtained, and to demonstrate repeatability of the results.

The tests used to evaluate relative responses shall be performed a maximum of three times. The Test Matrix (Appendix A) details the types of various tests to be performed.

D. Sensor Requirements

1. General

Four basic types of instruments were selected to measure the test data: Accelerometers, Pressure Sensors, Temperature Sensors, and Strain Gauges. These instruments are further divided by monitoring ranges and environmental conditions as described below.

2. Accelerometers

Thirty-eight (38) accelerometers will be used in the tests. The accelerometers are divided into three categories by environment: Containment Drywell, Containment Wetwell, and Outside Containment.

The Endevco 7717-200 will be used in the Containment Drywell; the Endevco 7717-M2A will be used in the Containment Wetwell; and the Endevco 7704-100 will be used at all locations outside of the containment. Technical data on these accelerometers is provided in Appendix B.

Accelerometer locations are listed in Table 1 and shown on Figures 1, 1A, and 1B.

3. Pressure Sensors

Fifty-two (52) pressure sensors will be used in the tests. The pressure sensors are divided into four groups based on pressure range to be monitored.

The high pressure sensors are used to monitor SRV discharge line pressures at several locations. The medium and low pressure sensors are used in the suppression pool to measure the pressure transient caused by the SRV discharge. One low pressure sensor capable of withstanding a high overpressure will be used to monitor reflood transient pressure.

Four ranges of the CEC 1000 were selected to furnish all but one of the required pressure signals. A Validyne AP-78 will be used to measure low pressure fluctuations in discharge piping after an SRV list. Pressure sensor locations are listed in Table 2 and shown on Figures 10, 11, 12, 12A, 13, and 13A.

4. Temperature Sensors

Forty-eight (48) temperature sensors will be used in the tests. Two categories of RTD's are used due to the differences in mounting methods required.

The Medtherm PTF-XXX-10356 will be used in all locations listed in Table 3 and shown on Figures 14, 14A, 15, and 15A except for T42, T43, T46, and T47. These sensors are Medtherm PRT-XXX-10387 surface mounted RTD's. (XXX is the sheath length in feet.)

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5. Strain Gages

Fifty (50) uniaxial strain gages will be used in the tests. Although all the strain gages are of the weldable type, three different categories of strain gages are used due to different temperature compensation requirements of the metal on which they are mounted (Table 4 notes).

The Ailtec MG-125/20-01HG-150-6S uniaxial strain gage was selected to be installed in ¼ bridge, ½ bridge, and rosette configurations.

Strain gage locations are listed in Table 4 and shown on Figures 3, 5, 6, 7, 8, and 9.

E. Signal Conditioning System

1. General

A 208-channel signal conditioning system will be required for the SRV test program. Strain gages and pressure sensors will be conditioned with the Vishay 2100 signal conditioning/amplifier system. The temperature sensors will be conditioned with the AGM Electronic, Inc. Model EIA-4003 RTD Signal Conditioner. The Endevco accelerometers will be conditioned by the charge amplifier, Endevco 2721AM4 or by Endevco 4479.1M3/2652M11.

2. Vishay System

The Vishay 2100 will be used to condition strain gages and pressure sensors. (See Appendix C for system specifications.) This system features independently variable excitation for each channel (1-12V DC) and will accept quarter-, half-, and full-bridge inputs as well as DC signals from other than bridge sources. Internal to each amplifier channel are 120-ohm and 350-ohm bridge completion components for quarter- and half-bridge gages, as well as internal shunt calibration resistors to simulate ±1000 microstrain. Each channel has a bridge balance network that will offset a ±3000 microstrain imbalance, and an always active LED null indicator and balance resistors to compensate for line resistance.

The 2100 system has a signal output from 0 to 10V DC up to 100 ma with a frequency response of 5 KHz. All signal and power outputs are current-limited for short circuit protection.

After transducer hook-up, normal setup procedure for the Vishay 2100 system involves only offset balancing and output gain adjustment. This system will accommodate any common data collection or monitoring equipment.

3. Endevco 2721AM4 AC Charge Amplifier

The Endevco 2721AM4 amplifier (See Appendix D) will be used to condition Endevco accelerometer sensors. This amplifier is an all solid state, wideband instrument designed for use with piezo-electric transducers. The output voltage of the charge amplifier is proportional to the electric charge generated by the connected transducer. As a result, changes in cable length between transducer and amplifier will not affect system sensitivity, system low frequency response, or the temperature response of the transducer.

A ten-turn potentiometer on the front panel allows insertion of specific transducer sensitivity. The five-position rotary switch provides five steps of calibrated gain resulting in system sensitivity (transducer plus amplifier).

4. Endevco 4479.1M3/2652M11 Charge Converter Signal Conditioner

The Model 2652M11 is a charge-to-voltage converter designed for use with piezo-electric transducers. The Model 4479.1M3 Plug-In Mode Card is a signal conditioner for use with the Model 4470 Signal

Conditioner module and provides power to, and conditions the signal from the Model 2652M11. (See Appendix D and Figure 17.)

The charge converter, located near the transducer, converts the electrical charge generated by the transducer to a low impedance voltage signal. The output is essentially unaffected by the length of the cable on changes in cable capacitance between transducer and driver.

A calibrated dial is provided to set in transducer sensitivity. Full scale output ± 2.5 volts peak is obtained for input measurements of 0.1, 0.3, 1.0, 3. and 30g.

5. AGM Electronic, Inc., Model EIA-4003, RTD Signal Conditioner

The Medtherm EIA-4003 RTD Signal Conditioner provides a filtered, regulated, rectified power supply to individual RTDs.

The EIA-4003 amplifies, linearizes, and isolates the output signal from the RTD and provides an output signal to the Q.S.I. 721 or Oscillograph Recorders.

For conditioner specifications, See Appendix E.

F. Data Acquisition and Monitoring System

1. Data Acquisition System

The digital data acquisition and recording system is the Q.S.I. Model 721. A block diagram of the Q.S.I. 721 along with the other Data Acquisition System and Playback (DARPS) equipment is shown in Figure 17.

All signal inputs to the system are processed, formatted, and written in IBM compatible form on digital magnetic tape. The tapes so generated may then be processed on any computer system (supporting industry standard magnetic tapes) for data reduction, analysis, and reformatting to any desired standard. See Appendix E for System Performance Characteristics. Internally, the System consists of four main subsystems: (1) an analog multiplexer; (2) precision analog-to-digital converter; (3) high speed digital magnetic tape recorder; and (4) electronic control logic. Several factors contribute to the unusually high accuracy and throughput of this system. The analog-to-digital converter is a precision, 12-bit (11 bits plus sign) unit, with crystal referenced sampling rate. The resulting low sample interval jitter eliminates the wow and flutter problems of analog recorders. The digital magnetic tape unit is a high-speed (125 ips), very high density (6250 BPI Group Code Recording [GCR]) device. This enables an extremely high data throughput for the system. The GCR technique provides for a very low error rate by correcting many recording errors on-the-fly. Finally, semiconductor memory is used to buffer data flow through the system. This allows data acquisition and recording functions to proceed independently, for the highest possible system throughput (up to ¼ million samples/sec.).

The system provides for on-the-spot playback of recorded data, with reconversion to analog form. It is also possible to speed up or slow down the playback over a 1000:1 range, with no loss of accuracy. Time data retrieved from the tape are locked to the signal data and thus track and speed up or slow down.

2. Data Monitoring System

a. General

The analog monitoring system will consist of a number of conventional analog instruments (oscillographs, X-Y recorders, spectrum analyzers, FM magnetic tape, etc.). The monitoring system has four functions:

(1) real-time monitoring of signals;
(2) display medium for after-the-run quick-look replay of digitally-recorded signals; (3) redundant recording of any specially selected critical signals; and (4) system operational check/calibration.

One FM magnetic tape recorder will be provided for analog recording of dynamic data from seven selected accelerometer channels. In addition, up to 47 selected channels will be recorded on oscillograph recorders for real-time verification of data.

This "quick-look" data will be provided as follows:

Sensor Type	No. of Sensors	Time History	Resp. Spec.	Freq. Spec.
Accelerometer	7	X	X	X
Pressure Sensor	14	X		X
Temp. Sensor	11	X		
Strain Gage	8	X		X

b. FM Recorder

The FM magnetic tape recorder will be a Bell and Howell Model 4010. During recording of the test data, a transport speed of 3-3/4 ips will be used so that a response of 0-1250 Hz will be obtained. This recorder will be calibrated for full scale equal to $\pm 40\%$ deviation of the center frequency. Data from accelerometer channels will then be played back into a spectrum analyzer with an X-Y plotter in order to obtain response spectrum plots.

c. Oscillograph Recorder

Up to 47 selected channels of test data will be presented in real-time through the use of light beam oscillograph recorders. Honeywell Model 1508 recorders, with M-1000, M-1600, or M-400-350 galvanometers are used for this application. This equipment will provide for the recording of data over the frequency range of DC to 200 Hz and will allow test personnel to validate incoming data before proceeding onto the next test phase.

d. Response Spectrum Analyzer

An MRAD Model 282S or equivalent spectrum analyzer will be used to present the "quick-look" accelerometer data required. The data will be analyzed at one-sixth octave intervals over a frequency range of 1 Hz to 100 Hz.

G. Processing and Reduction of Recorded Data

1. General

The following processing and reduction tasks will be performed on the recorded, digitized data, and will be written in IBM EBCDIC format.

- The digitized data will be converted to engineering units and recorded in IBM EBCDIC format with appropriate header information on 1600 BPI magnetic tapes.
- Microfiche records will be prepared of the digitized engineering unit data.
- All digital tapes used will be certified to be free from parity errors.
- The data will be reduced and plotted and will be recorded on digital tape in IBM EDCDIC format.

2. Data Reduction

To perform the required data processing and reduction, we are presently considering the existing general purpose Wyle computer program ADARS (Advanced Data Analysis and Reduction Software). ADARS provides the framework for coordinating various data files on disc. ADARS has an operator interface which allows the user to select a wide variety of processing and display options to meet his analysis requirements.

ADARS will perform all the necessary steps to process the raw digitized data tape and produce the required plots of reduced data. The major tasks involved in this process include: building a data base of pertinent channel information, demultiplexing the digitized data, conversion of the data to the proper engineering units and producing the analysis plots.

3. Basic Analysis Parameters

The data, which is to be acquired at 1000 samples per second, per channel, will be filtered at 200 Hz and then decimated to 500 samples per second. The list below summarizes the major parameters of the acquired data:

- Acquisition rate of 1000 samples per second per channel.
- Frequency components of data up to 200 Hz.
- Typical test time will be a nominal 15 seconds for most tests.
- Data recorded in multiplexed 16-bit integer A/D counts.

- All data from each test run will be recorded on one magnetic tape.

4. Computer System Description

The ADARS computer program is operational on Wyle Interdata 8/32 system. The Interdata 8/32 is a 32-bit computer with 256 Kilobytes of 300 nanosecond main memory. The system includes a high performance single and double precision floating point processor to speed calculations.

The primary peripherals of the Interdata 8/32 system include:

- 16-channel, 12-bit analog-to-digital converter
- 8-channel, 12-bit digital-to-analog converter
- 67 Megabyte disc memory
- 300 Megabyte disc memory
- Two, 800/1600 BPI, 75 ips tape drives
- 400 cpm card reader
- 600 lpm line printer
- Two interactive terminals
- Tektronix 4014 Graphic Terminal

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- Versatec 1200A printer/plotter/hardcopy unit

The interdata is supplied with a full complement of software, including a real-time multiprogramming operating system, time sharing, an optimizing FORTRAN compiler, and full disc file management facilities. These capabilities provide full support for all the ADARS activities.

5. Data Processing and Reduction Approach

The data processing and reduction that will be performed are described in a step-by-step manner. Descriptions of steps that are not directly related to final requirements are included to show the logical process of the steps performed. The processing steps are:

(1) Build a data base on disc containing the pertinent channel information, including gage sensitivity, gage type, engineering units and plot labels.

(2) Demultiplex the data to tape and copy it to disc for processing.

(3) Remove any unwanted transducer bias or drift from the data.

(4) Convert the data to its proper engineering unit form.

(5) Low pass digitally filter the data to remove any unwanted noise. The cutoff point and rate are user selectable.

(6) Decimate the data down from 1000 samples per second.

(7) Copy the filtered and decimated data as described in (5) and (6) above to magnetic tape in IBM EBCDIC format in 4000 character records (fifty 80-character card images) in the tape format and file structure.

(8) Prepare microfiche records of the data described in (7) above. 42 power 4" x 6" microfiche cards with 208 pages per sheet will be prepared using computer output to microfiche (COM) techniques.

(9) Plot the following time history data in engineering units:

- Accelerometer data
- Pressure sensor data
- Temperature data

- Uniaxial stress data (computed from strain gage data)

(10) Plot the Fourier spectrum magnitude and phase for the following:

- Pressure Sensor Data
- Accelerometer Data
- Uniaxial Strain Gage Data

(11) Plot the response spectra for the following:

- Accelerometer Data

(12) Copy the reduced data Items (9), (10), and (11) above to magnetic tape in IBM EBCDIC format.

All digital magnetic tapes used on this project will be new and certified by the manufacturers to be free from parity errors.

H. Test Documents

The In-Plant SRV Test procedure provides a methodical approach which will ensure repeatability of data, plant safety and optimize the time spent performing this test.

The step-by-step format of the procedure addresses the critical plant conditions applicable to this test.

The precautions and induced conditions are within allowable operating tolerances as specified in the LaSalle County Technical Specification.

As an added precaution, "Quick-Look" data will be evaluated at the completion of each uniquely different test section, to ensure response levels are within design limitations. This evaluation will be completed prior to proceeding with the next test section.

I. Implementation

Implementation of the In-Plant SRV Test program requires a multi-organization, multi-discipline effort.

Commonwealth Edison Company (CECo), as the licensee, provides overall program direction. CECo operations and technical/engineering staffs will provide input to test document preparation and assist in conduct of the test (test performance and data collection).

Sargent & Lundy, as the plant designer, will provide program definition and requirements, testing requirements and acceptance criteria for the test. Sargent & Lundy will also prepare all necessary testing documents, provide test administration, specify sensor types and locations, and conduct any associated analysis.

Wyle Laboratories, as the contractor, will install test equipment and sensors. The field installation and test team will operate the data acquisition station. They are experienced with this type of testing and have performed similar tests in the past.

SARGENT & LUNDY ENGINEERS

TABLES

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ENGINEERS

TABLES

General Notes to Tables 1-4

Tables 1 through 4 refer to six environmental conditions that are defined as follows:

Environment E1	Wetwell
Fluid	Water
Pressure	100 psia
Temperature	50°F-150°F
Relative Humidity	NA
Radiation	50R/hr.γ

Environment E2	Drywell
Fluid	Air
Pressure	15.4 psig
Temperature	135°F
Relative Humidity	90%
Radiation	50R/Hr. γ ; 1.4 x 10^5 n/cm^2 sec.

Environment E3	SRV Discharge Line
Fluid	Air/Water/Steam
Pressure	650 psia
Temperature	500°F
Relative Humidity	NA
Radiation	*50R/Hr. γ

Environment E4

Fluid
Pressure
Temperature
Relative Humidity
Radiation

Sensor will be in the SRV discharge line (E3) and the "outside" of the sensor and its cabling will be exposed to conditions in wetwell (E1).

*Note
Discharge Line in the drywell experiences 50 R/Hr. γ ; 1.4 x 10^5 n/cm^2 sec.

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Environment E5

Fluid Pressure Temperature Relative Humidity Radiation	Sensor will be in the SRV discharge line (E3) and the "outside" of the sensor and the cabling will be exposed to conditions in the drywell (E2).

Environment E6

Fluid	Air
Pressure	15.4 psig
Temperature	120°F
Relative Humidity	60%
Radiation	Negligible

SARGENT & LUNDY ENGINEERS

LA SALLE COUNTY - 1
COMMONWEALTH EDISON COMPANY
PROJECT NO. 5835-00

TABLE 1

ACCELEROMETER DATA

REV 4

SENSOR NUMBER	SENSOR LOCATION AZIMUTH (DEG)	ELEV. (FT-IN)	RADIUS (FT-IN)	EXPECTED RESPONSE (G)	EXPECTED FREQUENCY RANGE (HZ)	ACCURACY (± % F.S.)	ENVIRON-MENT	DIRECTION	NOTES
A1	46	804'-0	22'-7	0.005-1.0	1-50	1	E2	R	1
A2	46	804'-0	22'-7	0.005-1.0	1-50	1	E2	T	1
A3	106	804'-0	22'-7	0.005-1.0	1-50	1	E2	R	1
A4	106	804'-0	22'-7	0.005-1.0	1-50	1	E2	T	1
A5	226	804'-0	22'-7	0.005-1.0	1-50	1	E2	R	1
A6	226	804'-0	22'-7	0.005-1.0	1-50	1	E2	T	1
A7	46	755'-3	14'-11½	0.005-1.0	1-50	1	E2	R	
A8	46	755'-3	14'-11½	0.005-1.0	1-50	1	E2	V	
A9	106	755'-3	14'-11½	0.005-1.0	1-50	1	E2	R	
A10	106	755'-3	14'-11½	0.005-1.0	1-50	1	E2	V	
A11	226	755'-3	14'-11½	0.005-1.0	1-50	1	E2	R	
A12	226	755'-3	14'-11½	0.005-1.0	1-50	1	E2	V	
A13	46	736'-7	14'-11½	0.005-1.0	1-50	1	E2	R	2
A14	46	736'-7	14'-11½	0.005-1.0	1-50	1	E2	V	2
A15	106	736'-7	14'-11½	0.005-1.0	1-50	1	E2	R	2
A16	106	736'-7	14'-11½	0.005-1.0	1-50	1	E2	V	2
A17	226	736'-7	14'-11½	0.005-1.0	1-50	1	E2	R	2
A18	226	736'-7	14'-11½	0.005-1.0	1-50	1	E2	V	2
A19	226	764'-6	41'-0	0.005-1.0	1-50	1	E6	R	6
A20	226	764'-6	41'-0	0.005-1.0	1-50	1	E6	V	6
A21	236	740'-0	48'-0	0.005-1.0	1-50	1	E6	R	3,6
A22	236	740'-0	48'-0	0.005-1.0	1-50	1	E6	V	3,6
A23	226	699'-10	47'-4	0.005-1.0	1-50	1	E6	R	6
A24	226	699'-10	47'-4	0.005-1.0	1-50	1	E6	V	6
A25	226	673'-4	47'-4	0.005-1.0	1-50	1	E6	R	4,6
A26	226	673'-4	47'-4	0.005-1.0	1-50	1	E6	V	4,6

TABLE 1

ACCELEROMETER DATA

REV 4

SENSOR NUMBER	SENSOR LOCATION			EXPECTED RESPONSE (G)	EXPECTED FREQUENCY RANGE (HZ)	ACCURACY (± % F.S.)	ENVIRON-MENT	DIRECTION	NOTES
	AZIMUTH (DEG)	ELEV. (FT-IN)	RADIUS (FT-IN)						
A27	See Notes	740'-0	104'-0	0.005-1.0	1-50	1	E6	V	3,5,6
A28	See Notes	673'-4	104'-0	0.005-1.0	1-50	1	E6	V	3,5,6
A29	226	673'-4	14'-11½	0.005-1.0	1-50	1	E1	R	4
A30	226	673'-4	14'-11½	0.005-1.0	1-50	1	E1	V	4
A31	230	699'-10	29'-9	0.1-30	1-100	1	E1	R	
A32	230	699'-10	29'-9	0.1-30	1-100	1	E1	T	
A33	230	736'-7½	29'-9	0.005-1.0	1-100	1	E2	V	
A34	230	688'-4	29'-9	0.1-30	1-100	1	E1	R	
A35	230	688'-4	29'-9	0.1-30	1-100	1	E1	T	
A36	226	804'-0	22'-5	0.005-1.0	1-100	1	E2	V	
A37	174	688'-10	32'-9	0.10-50	1-100	1	E1	R	
A38	174	688'-10	32'-9	0.10-50	1-100	1	E1	T	

TABLE 1
ACCELEROMETER DATA

NOTES

(1) Sensors are to be located on the Gusset Plate connecting the legs of the Stabilizer Truss.

(2) Sensors are to be located on the Drywell Floor near the Reactor Support.

(3) Sensors are to be located on the Slab.

(4) Sensors are to be located on the Basemat.

(5) Sensors are to be located near the Intersection of Column Rows 8.9 and A.

(6) Sensor has no Conductors passing through the Containment.

GENERAL NOTES

Location	Sensor No.	Function
Stabilizer Truss	A1 through A6	To record the horizontal responses at the interface point with G.E.
Reactor Support	A7 through A12	These sensors are coordinated with sensors A1 through A6 to record both the horizontal and vertical responses at the top of the reactor support.
Drywell Floor/ Pedestal Interface	A13 through A18	These sensors are coordinated with sensors A1 through A6 to record both the horizontal and vertical responses at the top of the reactor support.
Containment Wall	A19 through A26	To record the containment responses at important locations. They are also required to determine the vertical attenuation through the containment.

SARGENT & LUNDY ENGINEERS

TABLE 1
ACCELEROMETER DATA

GENERAL NOTES

Location	Sensor No.	Function
Corner of Reactor Building	A27 and A28	To determine the attenuation of the horizontal responses across the reactor building slabs when compared to sensors A21 and A25, respectively.
Bottom of Reactor Support	A29 and A30	To record the reactor support horizontal and vertical responses at the basemat. When A23 and A30 are compared with sensors A11, A12, A17 and A18, the amplification of the responses can be determined.
Column (Az. 230°, Radius 29'-9")	A31 through A35	To record the horizontal and vertical acceleration responses of the suppression pool column. These sensors are needed to correlate the acceleration response with the pressure measured by sensors P18 through P21 and P27 through P30.
Top of Support Column	A36	To record the vertical responses at the top of the sacrificial shield. This sensor is provided to show the vertical amplification of the acceleration response in the sacrificial shield when compared to sensor A8.
Downcomer (Az. 174°, Radius 32'-9")	A37 and A38	To record the horizontal acceleration responses of the instrumented downcomer. These sensors are needed to correlate the acceleration response with the pressure measured by sensors P37 through P44.

SARGENT & LUNDY ENGINEERS

LA SALLE COUNTY - 1
COMMONWEALTH EDISON COMPANY
PROJECT NO. 5835-00

TABLE 2

PRESSURE SENSOR DATA

REV 4

SENSOR NUMBER	SENSOR LOCATION			EXPECTED RESPONSE (PSIA)	EXPECTED FREQUENCY RANGE (HZ)	ACCURACY (± % F.S.)	ENVIRON. MENT	NOTES
	AZIMUTH (DEG)	ELEV. (FT-IN)	RADIUS (FT-IN)					
P1	260.90	673'-5	36'-11½	3-46	0-100	0.5	E1	
P2	246.40	673'-8	36'-10½	3-46	0-100	0.5	E1	
P3	233.14	673'-5	36'-6	3-46	0-100	0.5	E1	
P4	220	673'-8	37'-1½	3-46	0-100	0.5	E1	
P5	200	673'-8	35'-7	3-46	0-100	0.5	E1	
P6	173.14	673'-5	36'-5½	3-46	0-100	0.5	E1	
P7	166.86	673'-5	36'-5½	3-46	0-100	0.5	E1	
P8	258.90	673'-8	20'-8½	3-46	0-100	0.5	E1	
P9	246.41	673'-5	21'-0	3-46	0-100	0.5	E1	
P10	214.57	673'-5	20'-7½	3-46	0-100	0.5	E1	
P11	201.21	673'-5	20'-10	3-46	0-100	0.5	E1	
P12	264	681'-2	43'-4	3-46	0-100	0.5	E1	
P13	246.46	676'-10	43'-4	3-46	0-100	0.5	E1	
P14	229	681'-2	43'-4	3-46	0-100	0.5	E1	
P15	161.67	676'-10	43'-4	3-46	0-100	0.5	E1	
P16	250	676'-10	14'-11½	3-46	0-100	0.5	E1	
P17	210	676-10	14'-11½	3-46	0-100	0.5	E1	
P18	230	676'-10	29'-9	3-46	0-100	0.5	E1	
P19	226.42	676'-10	28'-0	3-46	0-100	0.5	E1	
P20	230	676'-10	26'-3	3-46	0-100	0.5	E1	
P21	233.58	676'-10	28'-0	3-46	0-100	0.5	E1	
P22	268.67	684'-3	43'-4	3-46	0-100	0.5	E1	
P23	258.90	685'-5¾	43'-4	3-46	0-100	0.5	E1	
P24	234.67	684'-3	43'-4	3-46	0-100	0.5	E1	
P25	250	691'-0	14'-11½	3-46	0-100	0.5	E1	
P26	210	688'-1½	14'-11½	3-46	0-100	0.5	E1	

TABLE 2

PRESSURE SENSOR DATA

SENSOR NUMBER	SENSOR LOCATION			EXPECTED RESPONSE (PSIA)	EXPECTED FREQUENCY RANGE (HZ)	ACCURACY (± % F.S.)	ENVIRON. MENT	NOTES
	AZIMUTH (DEG)	ELEV. (FT-IN)	RADIUS (FT-IN)					
P27	230	688'-4	29'-9	3-46	0-100	0.5	E1	
P28	226.42	688'-4	28'-0	3-46	0-100	0.5	E1	
P29	230	688'-4	26'-3	3-46	0-100	0.5	E1	
P30	233.58	688'-4	28'-0	3-46	0-100	0.5	E1	
P31	—	—	—	14-650	0-200	0.5	E5	1
P32	—	—	—	14-650	0-200	0.5	E5	1
P33	—	—	—	14-650	0-200	0.5	E4	2
P34	—	—	—	14-650	0-200	0.5	E4	2
P35	170	700'-10	36'-6	13-660	0-200	0.5	E4	
P36	170	700'-10	36'-6	13-660	0-200	0.5	E4	
P37	174	694'-10	32'-9	3-46	0-200	0.5	E1	
P38	174	694'-10	32'-9	3-46	0-200	0.5	E1	
P39	174	694'-10	32'-9	3-46	0-200	0.5	E1	
P40	174	694'-10	32'-9	3-46	0-200	0.5	E1	
P41	174	689'-10	32'-9	3-46	0-200	0.5	E1	
P42	174	689'-10	32'-9	3-46	0-200	0.5	E1	
P43	174	689'-10	32'-9	3-46	0-200	0.5	E1	
P44	174	689'-10	32'-9	3-46	0-200	0.5	E1	
P45	—	—	—	14-650	0-200	0.5	E5	1
P46	—	—	—	14-650	0-200	0.5	E5	1
P47	—	—	—	14-650	0-200	0.5	E4	2
P48	—	—	—	14-650	0-200	0.5	E4	2
P49	228.66	682'-7	43'-4	3-46	0-200	0.5	E1	
P50	228.33	699'-6½	43'-4	3-46	0-200	0.5	E1	
P51	350	673'-5	33'-10	3-20	0-200	0.5	E1	
P52	170	—	36'-6	3-15	0-200	0.5	E5	3

TABLE 2
PRESSURE SENSOR DATA

NOTES

(1) Sensors P31, P45, and P32, P46 are located downstream of Safety/Relief Valve and inside Pipes 1MS04BR-12 and 1MS04BM-12, respectively (see Figure 13).

(2) Sensors P33, P47, and P34, P48 are mounted in the center of the Quencher Device for Pipes 1MS04BR-12 and 1MS04BM-12, respectively (see Figure 13).

(3) Sensor P52 shall have, as a minimum, a sensitivity of ± 1 in. of H_2O at 90°F and be capable of withstanding the conditions of Environment E5.

GENERAL NOTES

Location	Sensor No.	Function
Basemat	P1 through P11	Measurement of pressure-time history on the basemat surface for the determination of load on basemat. P1 and P6 are also used to obtain circumferential pressure attenuation along with P51.
Outer Pool Boundary Wall	P12, P13, P14, P15, P22, P23, P24	Measurement of pressure-time history on the outer wall surface for the determination of pool boundary loads. P14 and P24 are also used to obtain vertical pressure attenuation along with P49 and P50.
Inner Pool Boundary Wall	P16, P17, P25 P26	Measurement of pressure-time history on the inner wall surface for the determination of pool boundary loads.

SARGENT & LUNDY ENGINEERS

TABLE 2
PRESSURE SENSOR DATA

GENERAL NOTES

Location	Sensor No.	Function
Column (Az. 230°, Radius 29'-9")	P18, P19, P20, P21, P27, P28, P29, P30	Measurement of pressure-time history on the column for the determination of submerged structures load. These sensors will be worked in conjunction with sensors A31, A32 and A33 to correlate between the pressure measured and the acceleration response on the column.
T-Quencher (1MS04BR-12)	P33 and P47	Measurement of pressure-time history inside the T-quencher sphere for the determination of quencher load and the condition of steam during the blowdown transient.
T-Quencher (1MS04BM-12)	P34 and P48	Measurement of pressure-time history inside the T-quencher sphere for the determination of quencher load and the condition of steam during the blowdown transient.
Downcomer (Az. 174°, Radius 32'-9")	P37, P38, P39, P40, P41, P42, P43, P44	Measurement of pressure-time history on the downcomer surface for the determination of submerged structures load. These sensors will be worked in with sensors A34, A35, A37 and A38 and sensors S31 through S34 to correlate between the pressure measured and the acceleration response on the downcomer.
SRV Discharge Line (1MS04BR-12)	P31 and P45	Measurement of pressure-time history inside the SRV discharge line for the determination of back-pressure downstream of the safety relief valve.

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TABLE 2
PRESSURE SENSOR DATA

GENERAL NOTES

Location	Sensor No.	Function
SRV Discharge Line (1MS04BM-12)	P32 and P46	Measurement of pressure-time history inside the SRV discharge line for the determination of back-pressure downstream of the safety relief valve.
SRV Discharge Line (1MS04BM-12)	P35 and P36	Measurement of pressure-time history inside the SRV discharge line above the normal water level for comparison with analytic model predictions and for accurate calculation of discharge line rigid restraint loads.
Suppression Pool	P49 through P51	Measure pressure attenuation within the suppression pool.
SRV Discharge Line (1MS04BM-12)	P52	Measurement of low pressure transient of the discharge line.

TABLE 3

TEMPERATURE SENSOR DATA

SENSOR NUMBER	SENSOR LOCATION			EXPECTED RESPONSE	EXPECTED FREQUENCY RANGE	ACCURACY	ENVIRON. MENT	NOTES
	AZIMUTH (DEG)	ELEV. (FT-IN)	RADIUS (FT-IN)	(°F)	(HZ)	(± °F)		
T27	210	687'-1½	14'-11½	50-200	0-100	0.5	E1	
T28	90	684'-0	14'-11½	50-200	0-100	0.5	E1	
T29	0	684'-0	14'-11½	50-200	0-100	0.5	E1	
T30	0	685'-6	43'-4	50-200	0-100	0.5	E1	
T31	87.66	685'-5¾	43'-4	50-200	0-100	0.5	E1	
T32	252		21	50-200	0-100	0.5	E1	
T33	230		37	50-200	0-100	0.5	E1	
T34	—	—	—	60-500	0-200	0.5	E5	1
T35	—	—	—	60-500	0-200	0.5	E5	1
T36	—	—	—	60-500	0-200	0.5	E4	2
T37	—	—	—	60-500	0-200	0.5	E4	2
T38	—	—	—	60-500	0-200	0.5	E5	1
T39	—	—	—	60-500	0-200	0.5	E5	1
T40	—	—	—	60-500	0-200	0.5	E4	2
T41	—	—	—	60-500	0-200	0.5	E4	2
T42	—	—	—	60-500	0-200	0.5	E2	3
T43	—	—	—	60-500	0-200	0.5	E2	3
T44	—	726'-6	—	60-500	0-200	0.5	E4	4
T45	—	728'-3	—	60-500	0-200	0.5	E4	4
T46	—	726'-6	—	60-500	0-200	0.5	E1	5
T47	—	728'-3	—	60-500	0-200	0.5	E1	5
T48	228.33	699'-0	43'-4	50-200	0-100	0.5	E1	

TABLE 3
TEMPERATURE SENSOR DATA

NOTES

(1) Sensors T34, T38, and T35, T39 are located downstream on Safety/Relief Valve and inside Pipes 1MS04BR-12 and 1MS04BM-12, respectively and measure fluid temperature (see Figure 15).

(2) Sensors T36, T40, and T37, T41 are mounted in the center of the Quencher Device for Pipes 1MS04BR-12 and 1MS04BM-12, respectively and measure fluid temperature (see Figure 15).

GENERAL NOTES

Location	Sensor No.	Function
Suppression Pool	T1 through T33 and T48	Measurement of temperature-time history at various locations in the suppression pool to determine the degree of thermal mixing during an SRV blowdown. T2, T6, T7 and T23 are used in conjunction with permanent sensor 1TE-CM057G to measure therm stratification in the suppression pool.
SRV Discharge Line (1MS04BM-12)	T35 and T39	Measurement of fluid temperature-time history inside the SRV discharge line downstream of the safety relief valve.
SRV Discharge Line (1MS04BM-12)	T35 and T39	Measurement of fluid temperature-time history inside the SRV discharge line downstream of the safety relief valve.
T-Quencher (1MS04BR-12)	T36 and T40	Measurement of fluid temperature-time history inside the T-Quencher sphere for determination of quencher load and the condition of steam during the blowdown transient.

SARGENT & LUNDY ENGINEERS

TABLE 3
TEMPERATURE SENSOR DATA

GENERAL NOTES

Location	Sensor No.	Function
T-Quencher (1MS04BM-12)	T37 and T41	Measurement of temperature-time history inside the T-quencher sphere for the determination of quencher load and the condition of steam during the blowdown transient.
SRV Discharge Line (1MS04BR-12)	T42, T46	Measure pipe external surface temperature.
	T44	Measure pipe internal surface temperature.
SRV Discharge Line (1MS04BM-12)	T43, T47	Measure pipe external surface temperature.
	T45	Measure pipe internal surface temperature.

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TABLE 4

STRAIN GAUGE DATA

REV 4

SENSOR NUMBER	SENSOR LOCATION			EXPECTED RESPONSE (IN/IN)	EXPECTED FREQUENCY RANGE (HZ) *	ACCURACY (± % F.S.)	ENVIRON. MENT	NOTES
	AZIMUTH (DEG)	ELEV. (FT-IN)	RADIUS (FT-IN)					
S1	170	692'-9/16	36'-6	.0001-.002	0-100	3	E1	1,7,8
S2	170	692'-9/16	36'-6	.0001-.002	0-100	3	E1	1,7,8
S3	170	692'-9/16	36'-6	.0001-.002	0-100	3	E1	1,7,8
S4	170	692'-9/16	36'-6	.0001-.002	0-100	3	E1	1,7,8
S5	170	716'-10	36'-6	.0001-.002	0-100	3	E1	1,7,8
S6	170	716'-10	36'-6	.0001-.002	0-100	3	E1	1,7,8
S7	170	716'-10	36'-6	.0001-.002	0-100	3	E1	1,7,8
S8	170	716'-10	36'-6	.0001-.002	0-100	3	E1	1,8
S9	170	676'-9 1/4	36'-6	.0001-.002	0-100	3	E1	1,9
S10	170	676'-9 1/4	36'-6	.0001-.002	0-100	3	E1	1,9
S11	170	676'-9 1/4	36'-6	.0001-.002	0-100	3	E1	1,9
S12	170	676'-9 1/4	36'-6	.0001-.002	0-100	3	E1	1,9
S13	170	676'-9 1/4	36'-6	.0001-.002	0-100	3	E1	1,9
S14	170	676'-9 1/4	36'-6	.0001-.002	0-100	3	E1	1,9
S15	170	676'-9 1/4	36'-6	.0001-.002	0-100	3	E1	1,9
S16	170	676'-9 1/4	36'-6	.0001-.002	0-100	3	E1	1,9
S17	170	676'-9 1/4	36'-6	.0001-.002	0-100	3	E1	1,9
S18	170	676'-9 1/4	36'-6	.0001-.002	0-100	3	E1	1,9
S19	170	676'-9 1/4	36'-6	.0001-.002	0-100	3	E1	1,9
S20	170	676'-9 1/4	36'-6	.0001-.002	0-100	3	E1	1,9
S21	170	676'-9 1/4	36'-6	.0001-.002	0-100	3	E1	1,9
S22	170	676'-9 1/4	36'-6	.0001-.002	0-100	3	E1	1,9
S23	170	674'-7	36'-6	.0001-.002	0-100	3	E1	9
S24	170	674'-7	36'-6	.0001-.002	0-100	3	E1	2,9
S25	170	674'-7	36'-6	.0001-.002	0-100	3	E1	2,9
S26	170	674'-7	36'-6	.0001-.002	0-100	3	E1	9

TABLE 4

STRAIN GAUGE DATA

REV 4

SENSOR NUMBER	SENSOR LOCATION			EXPECTED RESPONSE (IN/IN)	EXPECTED FREQUENCY RANGE (HZ)	ACCURACY (± % F.S.)	ENVIRONMENT	NOTES
	AZIMUTH (DEG)	ELEV. (FT-IN)	RADIUS (FT-IN)					
S27	170	674'-7	36'-6	.0001-.001	0-100	3	E1	2,9
S28	170	674'-7	36'-6	.0001-.001	0-100	3	E1	2,9
S29	170	674'-7	36'-6	.0001-.001	0-100	3	E1	2,9
S30	170	674'-7	36'-6	.0001-.001	0-100	3	E1	2,9
S31	174	—	32'-9	.0001-.001	0-100	3	E1	6,7,10
S32	174	—	32'-9	.0001-.001	0-100	3	E1	6,7,10
S33	174	—	32'-9	.0001-.001	0-100	3	E1	6,7,10
S34	174	—	32'-9	.0001-.001	0-100	3	E1	6,7,10
S35	246	—	23'-3	.0001-.001	0-100	3	E1	6,7,10
S36	246	—	23'-3	.0001-.001	0-100	3	E1	6,7,10
S37	246	—	23'-3	.0001-.001	0-100	3	E1	6,7,10
S38	246	—	23'-3	.0001-.001	0-100	3	E1	6,7,10
S39	250	681'-2	43'-4	.0001-.001	0-100	3	E1	2,9
S40	250	681'-2	43'-4	.0001-.001	0-100	3	E1	2,9
S41	250	681'-2	43'-4	.0001-.001	0-100	3	E1	2,7,9
S42	250	681'-2	43'-4	.0001-.001	0-100	3	E1	2,7,9
S43	250	681'-2	43'-4	.0001-.001	0-100	3	E1	9
S44	250	681'-2	43'-4	.0001-.001	0-100	3	E1	9
S45	230	681'-2	43'-4	~.0001	1-50	3	E1	10
S46	230	681'-2	43'-4	~.0001	1-50	3	E1	10
S47	230	681'-2	43'-4	~.0001	1-50	3	E1	3,10
S48	230	681'-2	43'-4	~.0001	1-50	3	E1	3,10
S49	230	681'-2	43'-4	~.0001	1-50	3	E1	4,10
S50	230	681'-2	43'-4	~.0001	1-50	3	E1	5,10

TABLE 4
STRAIN GAUGE DATA

NOTES

(1) Gauges on SRV Discharge Pipe/Quencher may experience temperature up to 500°F.

(2) The following sets of Strain Gauges should be arranged in a Rectangular Rosette Pattern: (S25, S27, S28), (S24, S29, S30) and (S39, S43, S44).

(3) These are redundant sensors to S45 and S46.

(4) Sensor is centered between stiffeners and oriented along the short direction.

(5) Sensor is centered on the stiffener opposite sensor S49 and aligned with the long direction.

(6) Sensor elevation is shown in Figure 5.

(7) The following sets of Strain Gauges should be wired in a half-bridge fashion in order that their signals add on a bending moment and subtract on elongation.

(S1, S2); (S3, S4); (S5, S6); (S7, S8); (S31, S32); (S33, S34); (S35, S36); (S37, S38); (S41, S42).

(8) Strain gauge mounted on SA-106 - Grade B steel.

(9) Strain gauge mounted on SA-358 - Grade 316L steel.

(10) Strain gauges mounted on SA-240-TP-304 stainless steel.

GENERAL NOTES

Location	Sensor No.	Function
SRV Discharge Line 1MS04BM-12 (Discharge line having largest air volume)	S1, S2, S3, S4, S5, S6, S7, S8	Measurement of bending strains in radial and tangential planes. For determining bending stresses resulting from self-imposed SRV discharge loads. Placement of strain gauges is based on expected locations of maximum stress.

SARGENT & LUNDY
ENGINEERS

TABLE 4
STRAIN GAUGE DATA

GENERAL NOTES

Location	Sensor No.	Function
Quencher Assembly and Support (Quencher corresponding to SRV discharge line 1MS04BM-12)	S9, S10, S11, S12, S15, S16, S17, S18	Measurement of quencher arm bending strains in two mutually perpendicular planes, parallel to the arms longitudinal axis. For determining bending stresses resulting from self-imposed SRV discharge loads.
Quencher Assembly and Support (Quencher corresponding to SRV discharge line 1MS04BM-12)	S13, S14, S19, S20, S21, S22	Measurement of hoop strains in quencher arms and sphere for determining approximations of thermal transient and pressure stresses.
Quencher Assembly and Support (Quencher corresponding to SRV discharge line 1MS04BM-12)	S23, S24, S25, S26	Measurement of bending strains in the quencher support in the radial and tangential planes. For determining bending stresses resulting from self-imposed SRV discharge loads.
Quencher Assembly and Support (Quencher corresponding to SRV discharge line 1MS04BM-12)	S27, S28, S29, S30	To be combined with S24 and S25 to form two rectangular rosettes. The strain rosette will be used to calculate support torsional stresses resulting from self-imposed discharge loads.
Downcomer (Az. 147°, Radius 32'-9" Az. 246°, Radius 23'-3")	S31, S32, S33, S34 S35, S36, S37, S38	Measurement of bending strains in radial and tangential planes. For comparison with stresses calculated from analytically predicted submerged structure loadings. Placement of strain gauges is based on expected locations of maximum stress.

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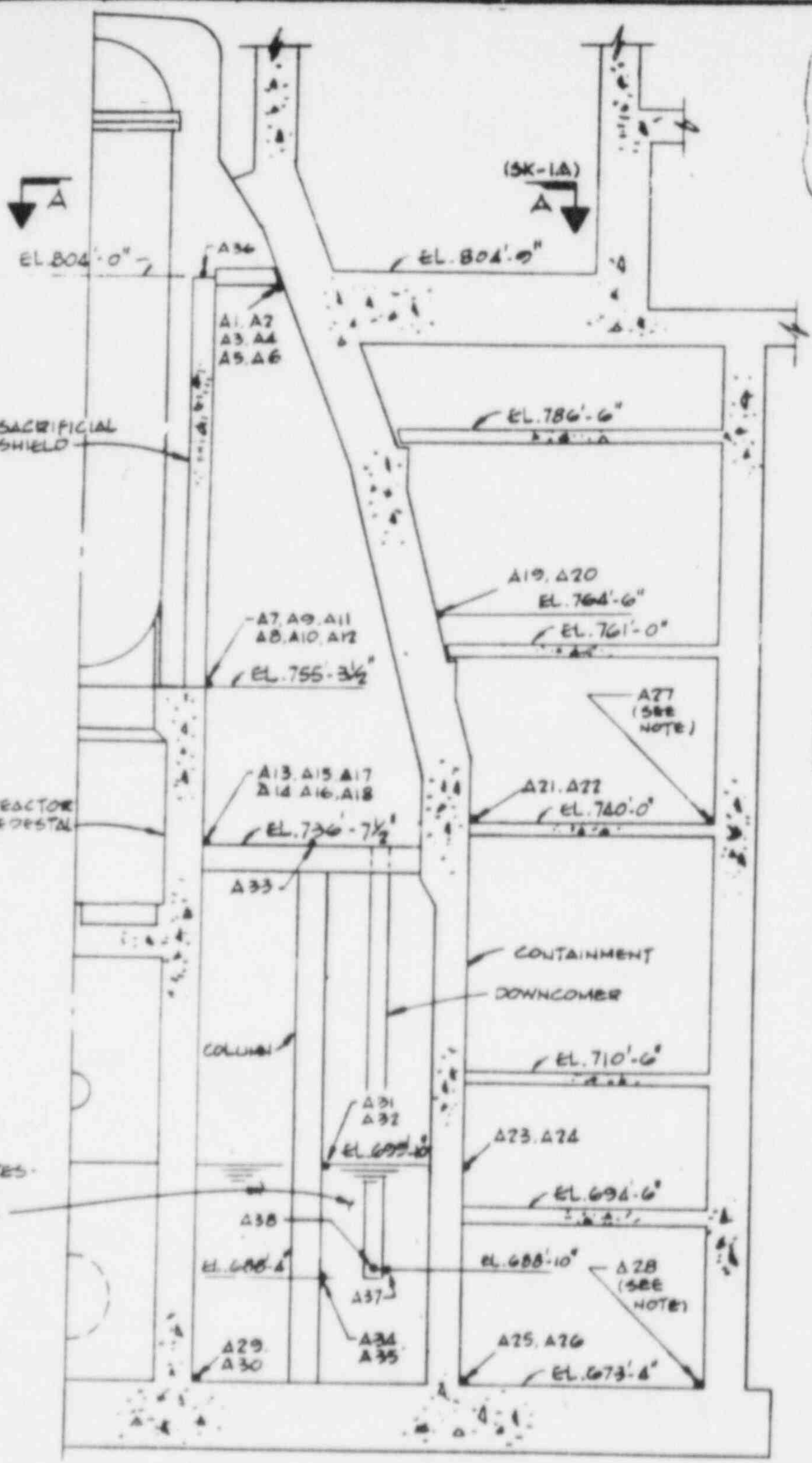
TABLE 4
STRAIN GAUGE DATA

GENERAL NOTES

Location	Sensor No.	Function
RHR Suction Line (Az. 250°, Radius 43'-4")	S39, S40, S41, S42	Measurement of bending strains in and out of the plane of the elbow. For comparison with stresses calculated from analytically predicted submerged structure loadings.
RHR Suction Line (Az. 250°, Radius 43'-4")	S43 and S44	To be combined with S39 to form a rectangular rosette for calculating torsional stresses. For comparison with stresses calculated from analytically predicted submerged structure loadings.
Containment Wall Liner	S45 and S46	To record the strain responses in the containment wall most likely to experience a net suction pressure loading, if any.
Containment Wall Liner	S47 and S48	Backup sensors to S45 and S46.
Basemat Liner	S49 and S50	To record the strain responses in the basemat liner and liner stiffeners. They are located in an area most likely to experience a net uplift pressure loading, if any.

FIGURES

SARGENT & LUNDY
ENGINEERS



NOTE:

Accelerometers A27 and A28 are located at intersection of Column row "8.9" and "A" at elevation as shown. (Far south east corner of Reactor Building.) For all remainings Accelerometer Radial Locations see Section A-A on SK-1A

D

FIGURE - 1

ACCELEROMETER LOCATIONS

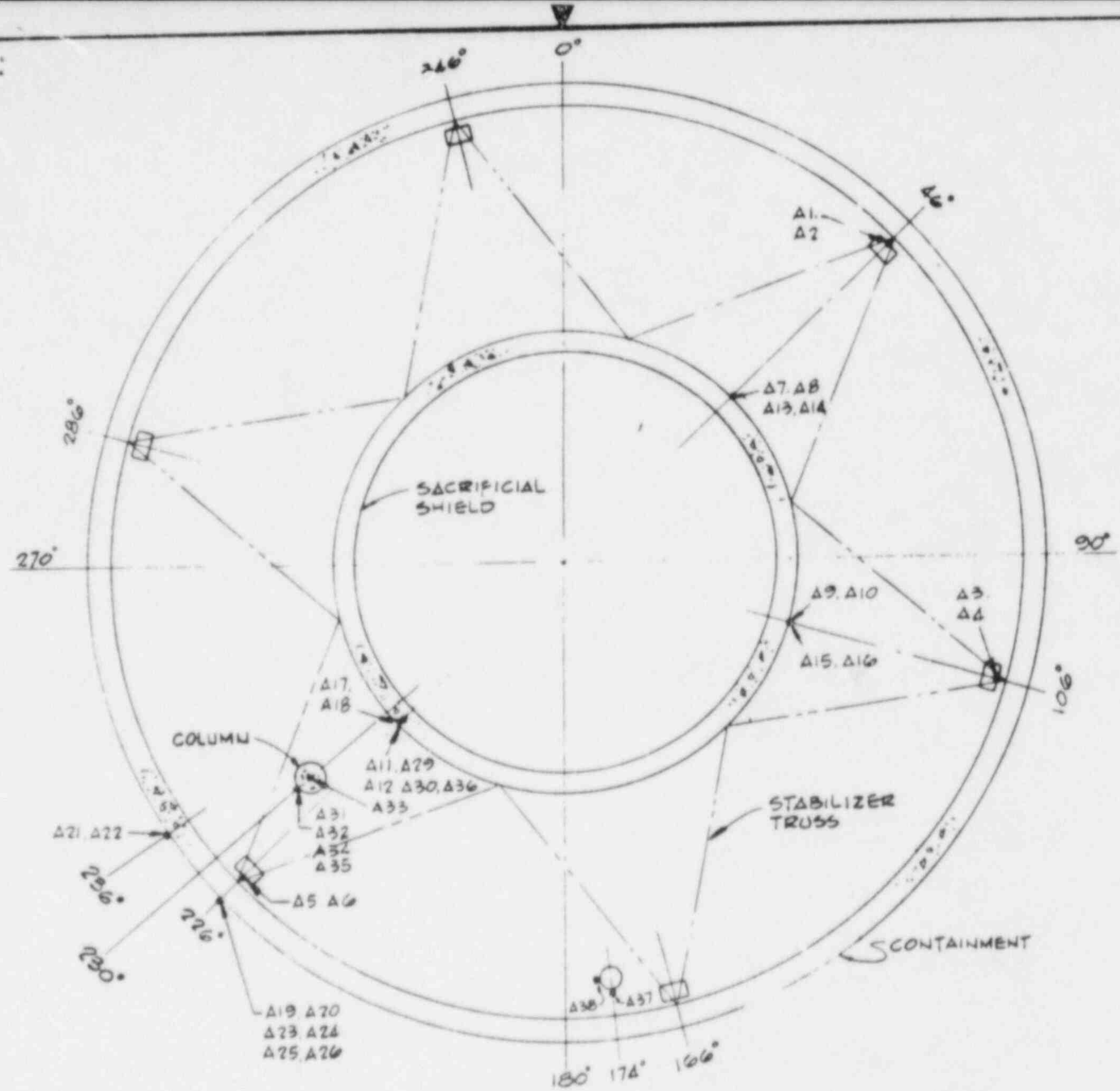
REV	DATE	PREPARED
A	11-15-78	[illegible]
B	4-16-79	[illegible]
C	6-5-79	[illegible]
D	10-10-79	[illegible]

SCALE: NONE

IN-PLANT SRV TEST PROGRAM
LASALLE COUNTY STATION
UNIT 1
COMMONWEALTH EDISON CO.
CHICAGO, ILLINOIS

SK-1

REV. D



D

FIGURE - 1A

ACCELEROMETER LOCATIONS SECTION A-A

REV	DATE REL'D	PREPARED	REVIEWED	APPROVED	PURPOSE
A	11-15-78	[illegible]			
B	2-16-79	[illegible]			
C	6-5-79	[illegible]			
D	10-10-79	[illegible]			

SCALE: NONE
PROJECT NUMBER: 5835-00

IN PLANT SRV
TEST PROGRAM
LA SALLE COUNTY STATION
UNIT 1
COMMONWEALTH EDISON CO.
CHICAGO, ILLINOIS

SARGENT & LUNDY
ENGINEERS

DRAWING NO. SK-1A
REV. D

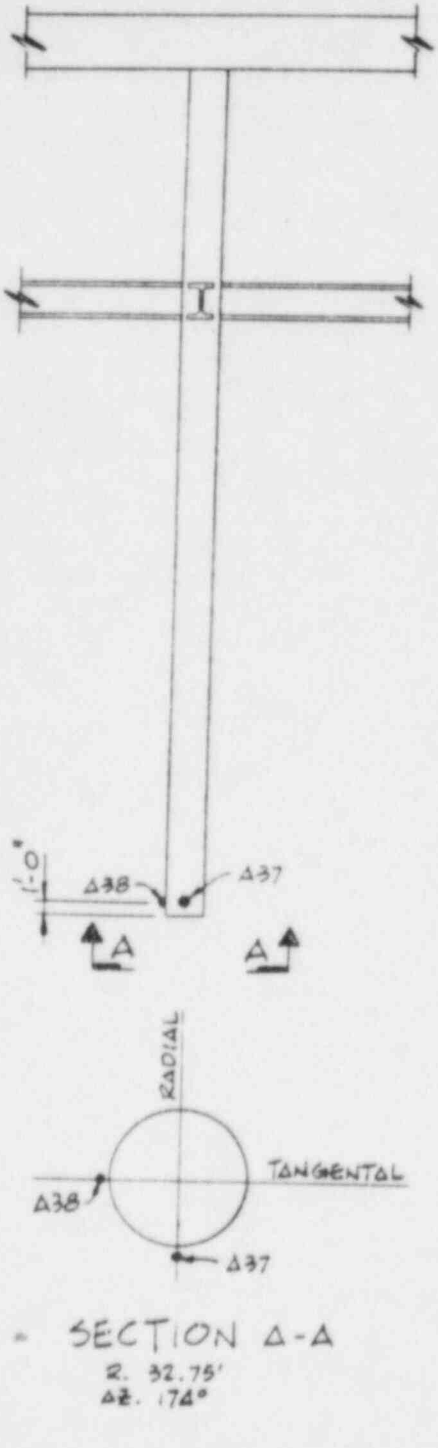


FIGURE-1B

DOWNCOMER ACCELEROMETER LOCATIONS

REV	DATE REL'D	PREPARED	REVIEWED	APPROVED	PURPOSE	SCALE
A	10-10-79	[illegible]				NONE
						PROJECT NUMBER 5855-06

IN-PLANT SRV TEST PROGRAM
LA SALLE COUNTY STATION
UNIT 1
COMMONWEALTH EDISON CO.
CHICAGO, ILLINOIS

SARGENT & LUNDY

DRAWING NO. SK-1B REV A

DELETED

B

FIGURE · 2

SENSOR LOCATIONS IN WET WELL AND SRV LINES

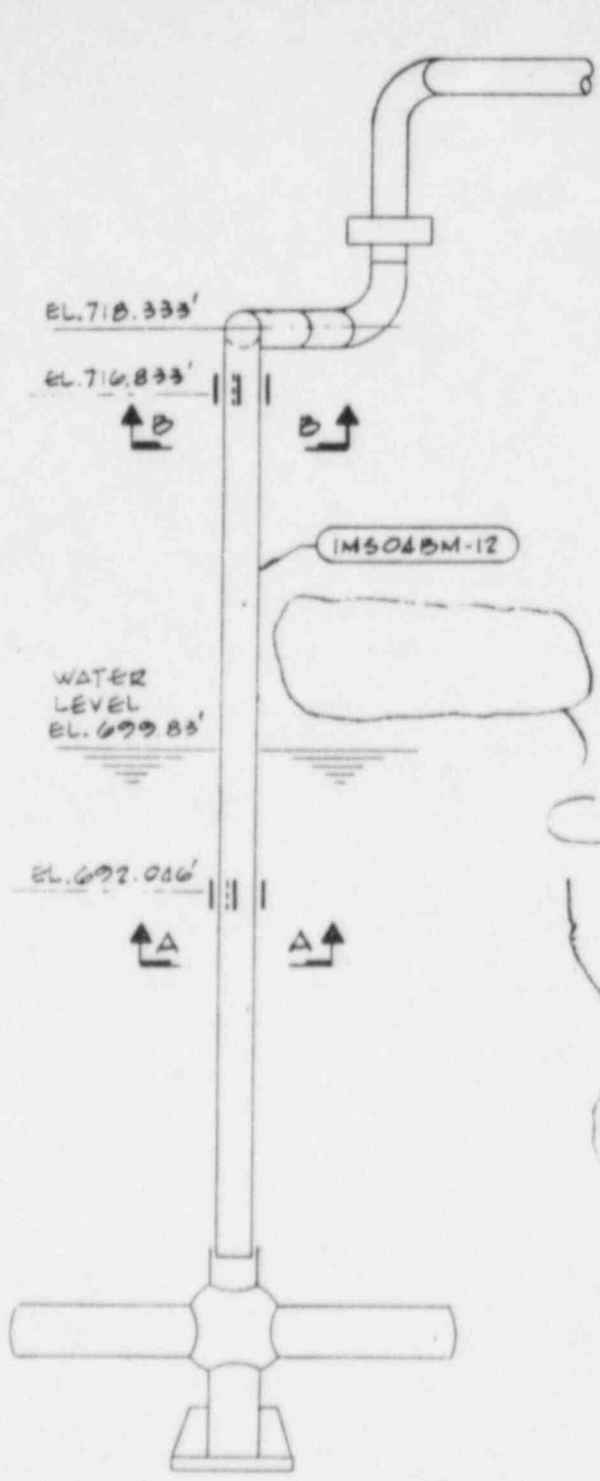
A	11-15-78	[illegible]
B	5-4-79	[illegible]

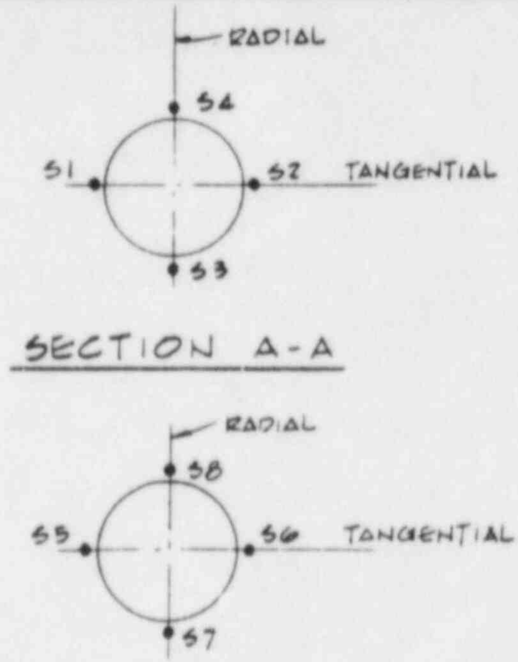
SCALE: NONE

5835-00

IN-PLANT SRV TEST PROGRAM
LA SALLE COUNTY STATION
UNIT 1
COMMONWEALTH EDISON CO.
CHICAGO, ILLINOIS

SK-2 B





SECTION A-A

SECTION B-B

NOTES:

STRAIN GAGES ARE REQUIRED AT TWO LOCATIONS: 2 PAIRS OF DIAMETRICALLY OPPOSED STRAIN GAUGES ORIENTATED PARALLEL TO THE LONGITUDINAL AXIS OF THE DISCHARGE PIPE. THE GAUGES SHOULD BE AT LEAST 2" AWAY FROM ANY WELDS.

FIGURE 3

STRAIN GAUGE ON SRV DISCHARGE LINE

REV	DATE				
B	2-15-79				
C	10-10-79				REDRAWN

SCALE NONE

IN-PLANT SRV TEST PROGRAM
LA SALLE COUNTY STATION
UNIT 1
COMMONWEALTH EDISON CO.
CHICAGO, ILLINOIS

SK-3 C

DELETED

FIGURE - 4

SENSORS ON SRV BRANCH CONNECTION

REV	DATE	PREPARED	REVIEWED	APPROVED	PURPOSE
A	11-15-78	[illegible]			
B	5-4-79	[illegible]			

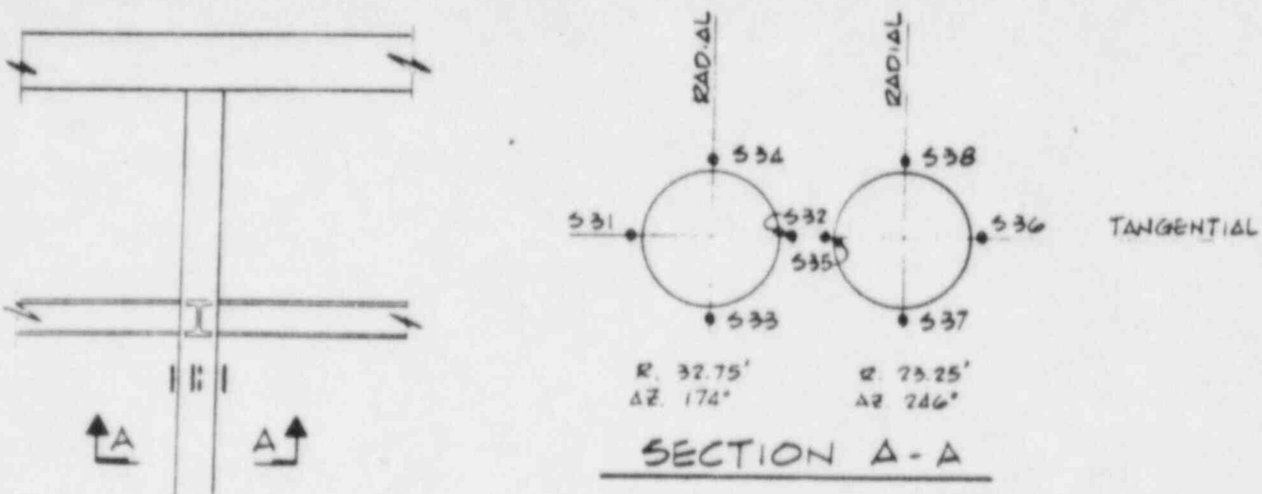
SCALE NONE

PROJECT NUMBER 5835.30

IN-PLANT SRV TEST PROGRAM
LA SALLE COUNTY STATION UNIT 1
COMMONWEALTH EDISON CO.
CHICAGO, ILLINOIS

SARGENT & LUNDY

DRAWING NO. SK-4 REV B



SECTION A-A

NOTES:

1. THE INSTRUMENTED DOWNCOMERS ARE LOCATED AT: RADIUS: 32.75' AZ: 174°
   RADIUS: 23.25' AZ: 246°
2. DIAMETRICALLY OPPOSED GAUGES SHOULD BE CONNECTED TO MEASURE BENDING STRAIN.
3. STRAIN GAUGES SHOULD BE LOCATED 6" BELOW THE BOTTOM OF THE BRACING, AND AT LEAST 2" AWAY FROM ANY WELDS.

D

FIGURE-5

DOWNCOMER STRAIN GAUGE

D

REV	DATE			PURPOSE
B	2-15-79			REDRAWN
C	2-2-			
D	10-10-79			

SCALE: NONE

5895-00

IN-PLANT SRV TEST PROGRAM
LA SALLE COUNTY STATION
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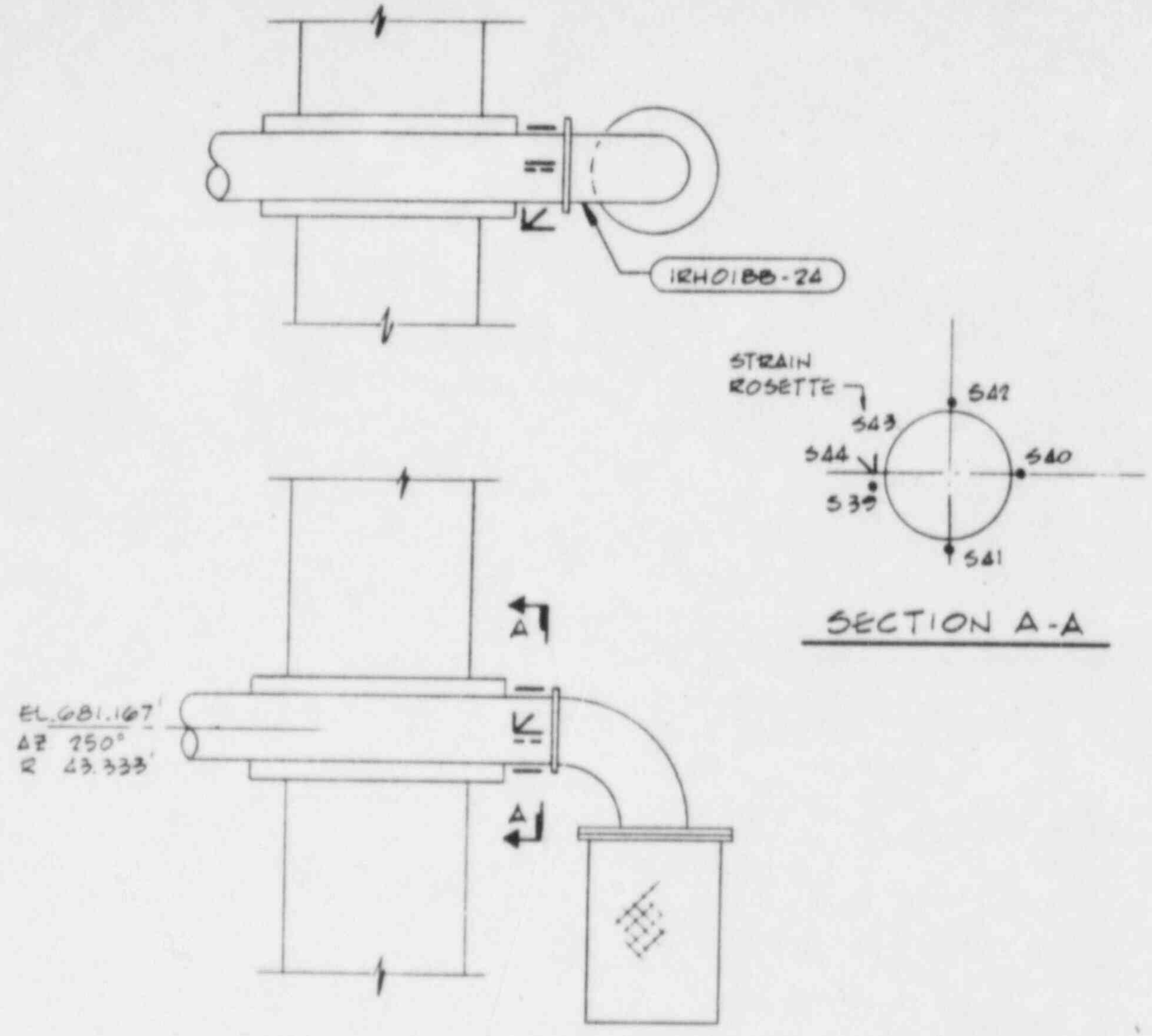
CHICAGO, ILLINOIS

SK-5 D



NOTES:

1. THREE STRAIN GAUGES ARE ARRANGED TO FORM A RECTANGULAR ROSETTE, WITH ONE GAUGE PARALLEL TO THE LONGITUDINAL AXIS OF THE PIPE AND ONE GAUGE ORIENTATED ALONG THE CIRCUMFERENCE OF THE PIPE, 3 ADDITIONAL GAUGES ARE ORIENTATED PARALLEL TO THE PIPE'S LONGITUDINAL AXIS AT 90° INTERVALS.
2. GAUGES SHOULD BE LOCATED AT LEAST 2" AWAY FROM ANY WELDS.
3. ANGLES BETWEEN TWO ADJACENT GAUGES OF A STRAIN ROSETTE SHOULD BE 45°

FIGURE 6

STRAIN GAUGE ON RHR SUCTION LINE

REV.	DATE	PREPARED	REVIEWED	APPROVED	PURPOSE
B	2-15-79	[illegible]			REDRAWN

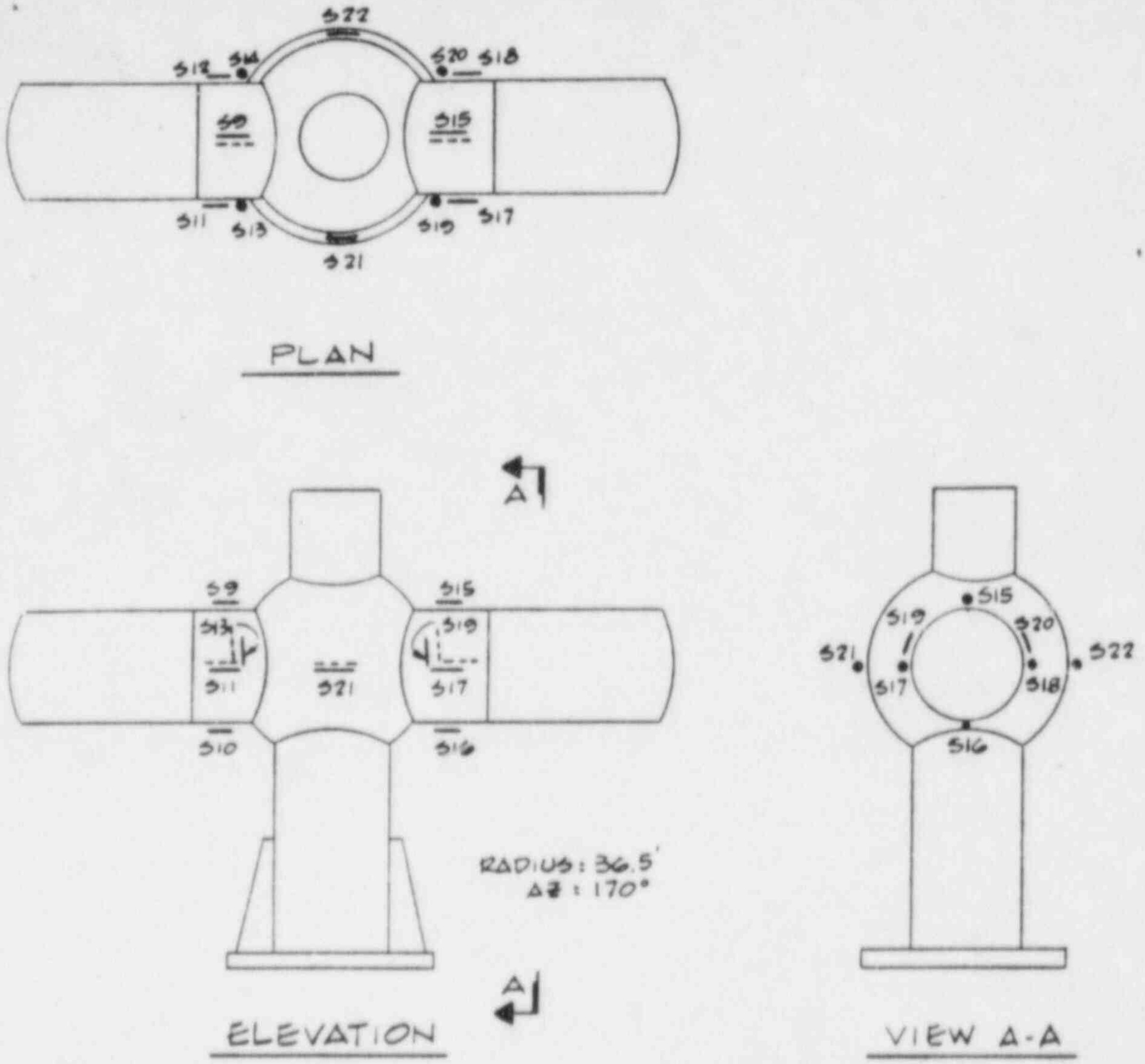
SCALE: NONE

3834-00

IN-PLANT SRV TEST PROGRAM
LA SALLE COUNTY STATION
UNIT 1
COMMONWEALTH EDISON CO.
CHICAGO, ILLINOIS

SARGENT & LUNDY ENGINEERS

SK-6 B



NOTES:

1. EACH ARM HAS 2 PAIRS OF DIAMETRICALLY OPPOSED STRAIN GAUGES ORIENTATED PARALLEL TO THE ARM'S LONGITUDINAL AXIS WITH ONE PAIR IN AND ONE PAIR OUT OF THE PLANE OF THE QUENCHER ARM AND SUPPORT.
2. EACH ARM ALSO HAS 1 PAIR OF DIAMETRICALLY OPPOSED GAUGES ORIENTATED ALONG THE CIRCUMFERENCE OF THE ARM AND IN THE PLANE OF THE ARM AND SUPPORT.
3. TWO GAUGES 180° APART ARE LOCATED ON THE SPHERE SURFACE, ORIENTATED PARALLEL TO THE LONGITUDINAL AXIS OF THE ARMS.
4. STRAIN GAUGES SHOULD BE LOCATED AT LEAST 2" AWAY FROM ANY WELDS.

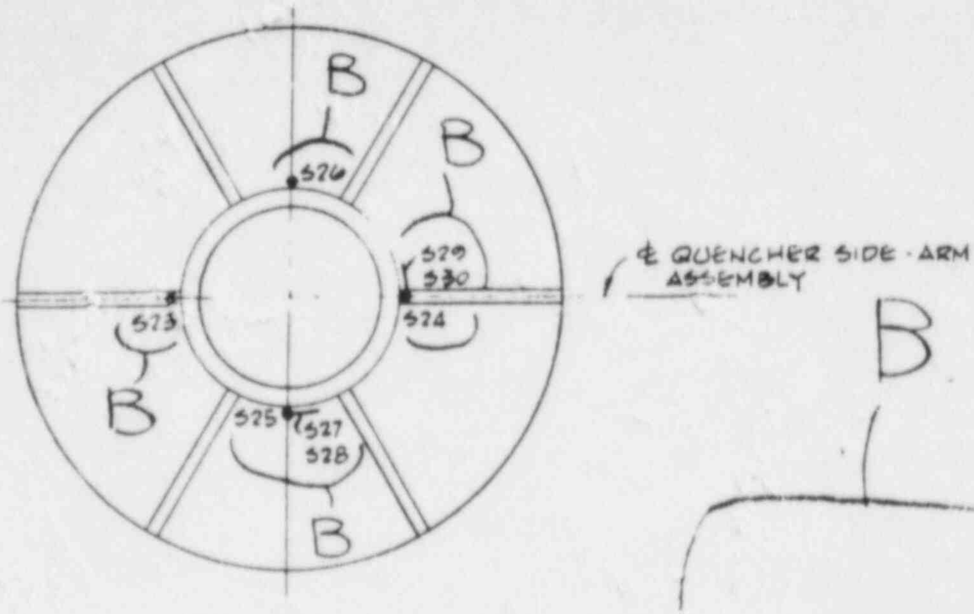
FIGURE-7

STRAIN GAUGES ON QUENCHER ASSEMBLY

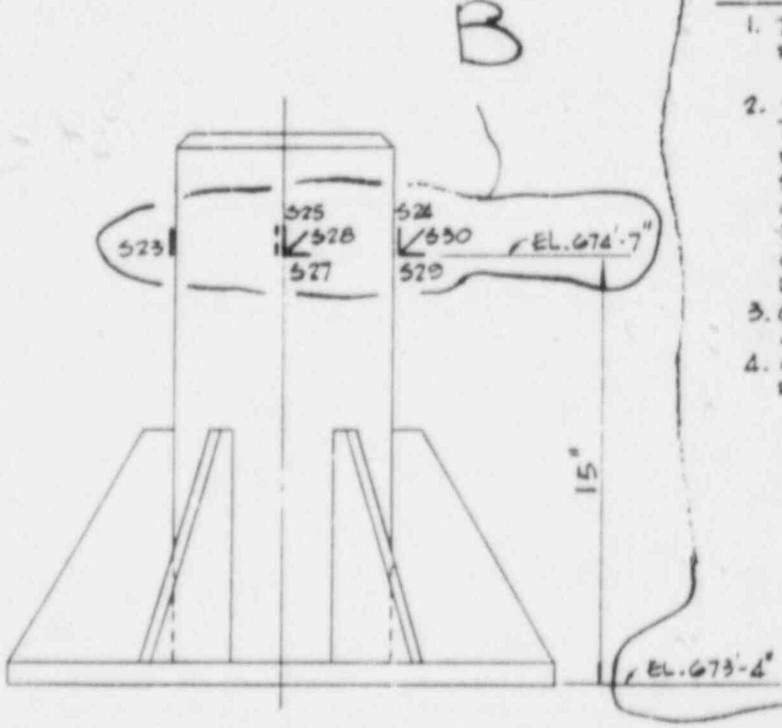
REV.	DATE	PREPARED	REVIEWED	APPROVED	REVISION	SCALE
B	2-15-79	[illegible]			REDRAWN	NONE
						3833.00

IN-PLANT SRV TEST PROGRAM
LASALLE COUNTY STATION UNIT 1
COMMONWEALTH EDISON CO
CHICAGO, ILLINOIS

SK-7 B



B



B

NOTES:

1. THE QUENCHER LOCATION IS LOCATED AT:
   RADIUS: 36.5'
   AZ: 170°
2. 2 SETS OF 3 STRAIN GAUGES ARE ARRANGED TO FORM RECTANGULAR ROSETTES, EACH ROSETTE HAVING 1 GAUGE PARALLEL TO THE SUPPORT'S LONGITUDINAL AXIS AND 1 GAUGE ORIENTATED ALONG THE CIRCUMFERENCE OF THE SUPPORT. 2 ADDITIONAL GAUGES ARE ORIENTATED PARALLEL TO THE SUPPORT'S LONGITUDINAL AXIS AT 90° INTERVALS.
3. GAUGES SHALL BE LOCATED AT LEAST 3" AWAY FROM ANY WELDS.
4. ANGLES BETWEEN TWO GAUGES OF A STRAIN ROSETTE SHOULD BE 45°.

FIGURE - 8

STRAIN GAUGES ON QUENCHER SUPPORT

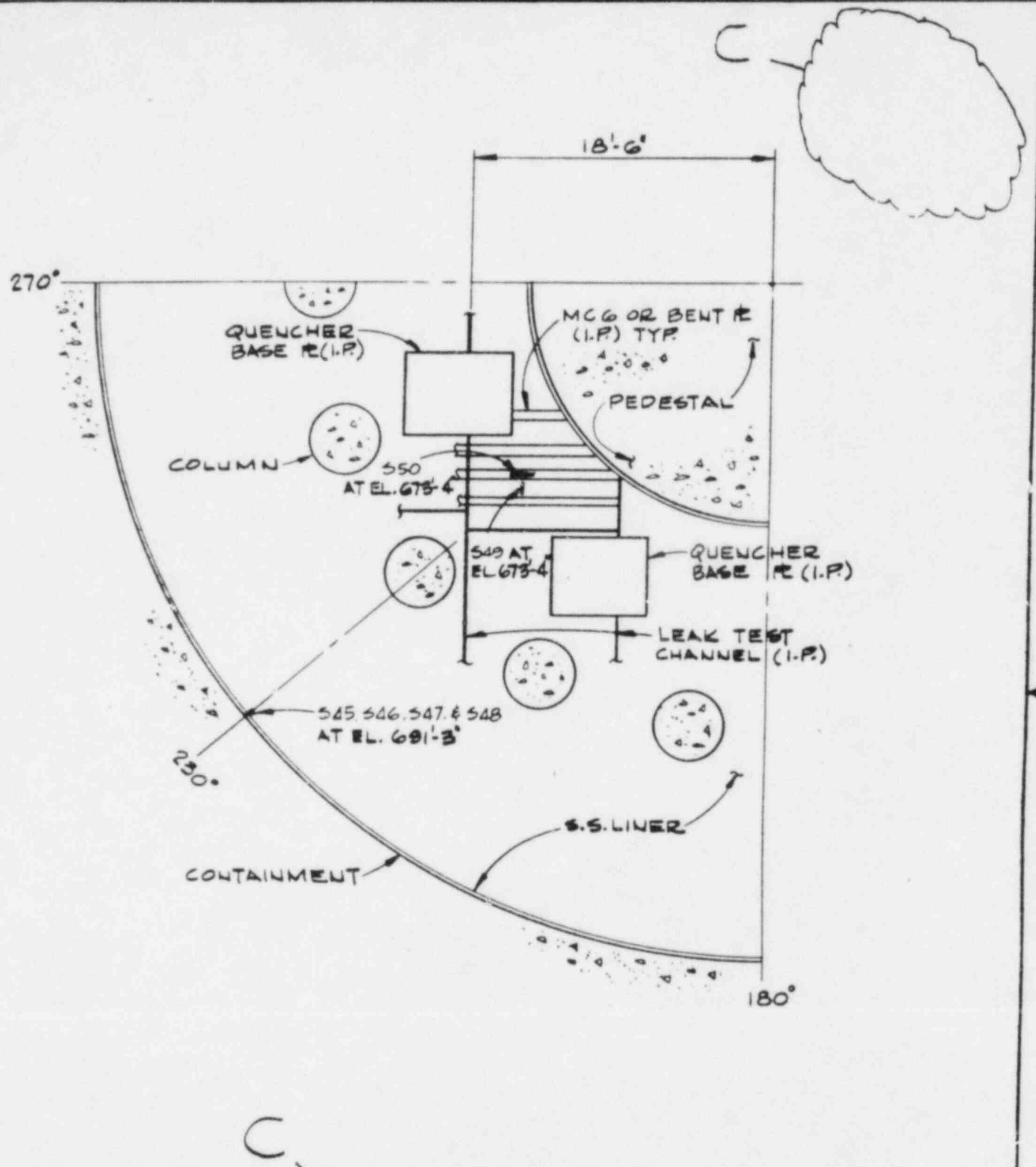
REV	DATE	PREPARED	REVIEWED	APPROVED	PURPOSE
A	11-15-78	[illegible]			
B	1-15-79	[illegible]			

SCALE: NONE

5815-00

IN-PLANT SRV TEST PROGRAM
LASALLE COUNTY STATION
UNIT 1
COMMONWEALTH EDISON CO
CHICAGO, ILLINOIS

SK-8 B



C

FIGURE - 9

STRAIN GAUGES ON CONTAINMENT LINER

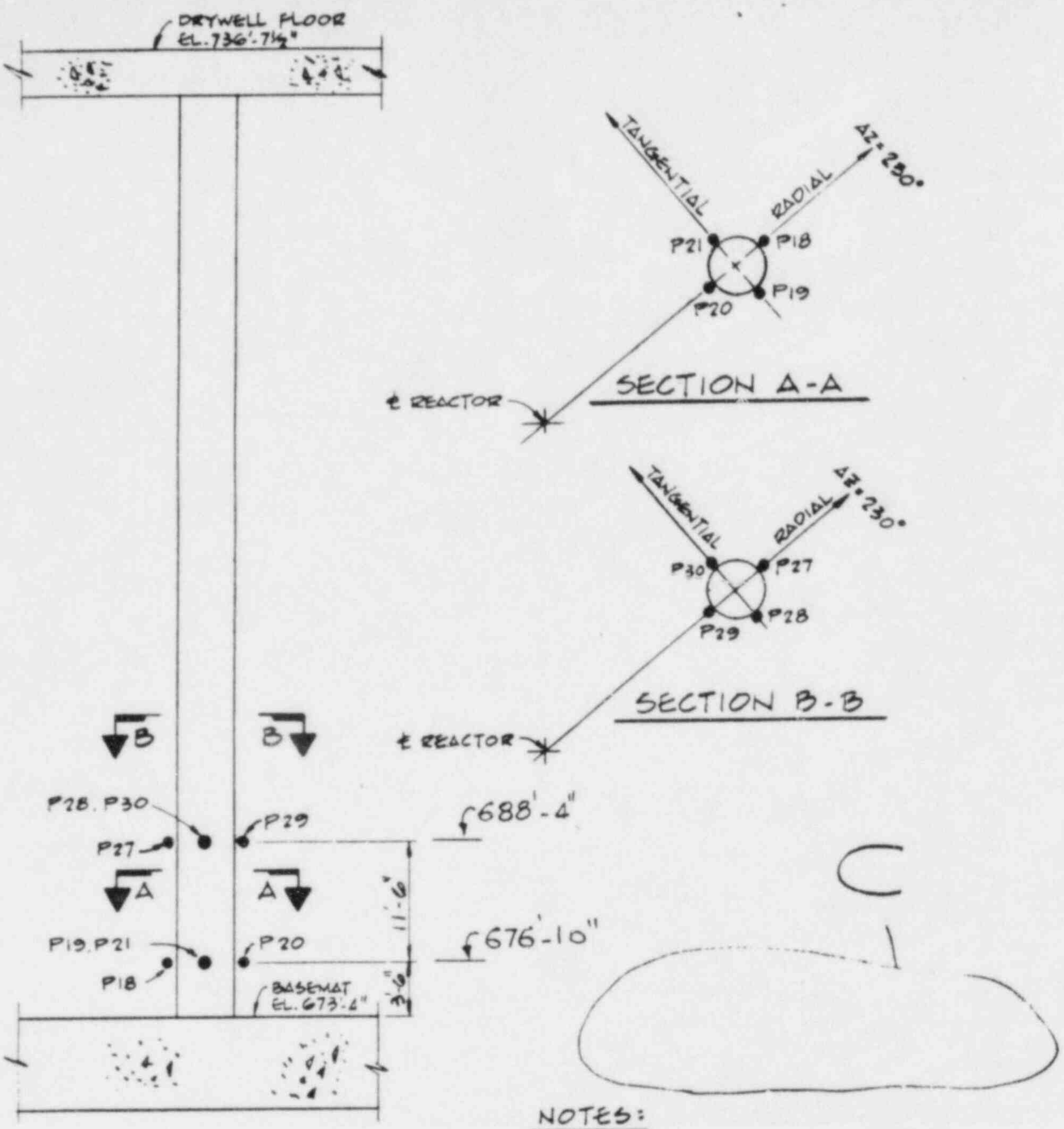
REV.	DATE	PREPARED	REVIEWED	APPROVED	PURPOSE
A	11-15-78	[illegible]			
B	2-12-79	[illegible]			
C	10-5-79	[illegible]			

SCALE NONE

PROJECT NUMBER 5838-00

IN PLANT SRV TEST PROGRAM
LASALLE COUNTY STATION UNIT 1
COMMONWEALTH EDISON CO.
CHICAGO, ILLINOIS

DRAWING NO. SK-9 REV. C



NOTES:

1. COLUMN IS LOCATED AT 230° AZ.
2. 4 PRESSURE SENSORS ARE LOCATED AT EACH LEVEL AND SPACED 90° APART.

FIGURE - 10

PRESSURE SENSOR LOCATIONS ON COLUMN

REV	DATE	PREPARED	REVIEWED	APPROVED	PURPOSE
A	11-15-78	[illegible]			
B	2-15-79	[illegible]			
C	10-10-79	[illegible]			

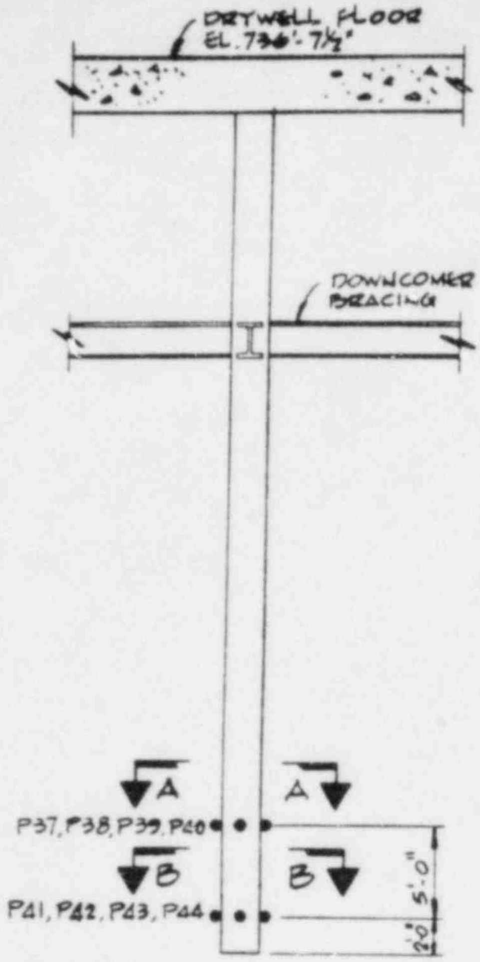
SCALE NONE

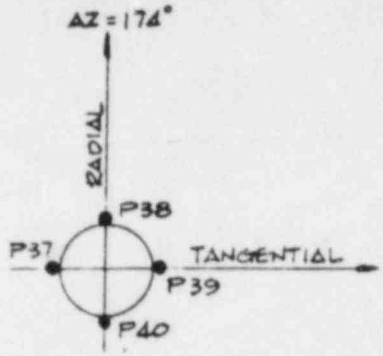
PROJECT 5435-00

IN-PLANT SRV TEST PROGRAM
LaSALLE COUNTY STATION UNIT 1
COMMONWEALTH EDISON CO.
CHICAGO, ILLINOIS

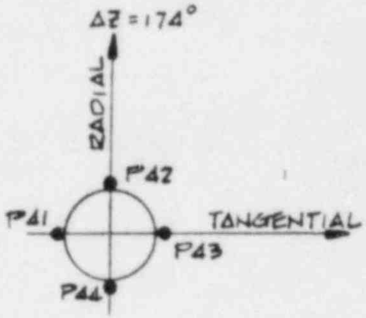
SARGENT & LUNDY

SK-10 C





SECTION A-A



SECTION B-B

1. DOWNCOMER IS LOCATED AT
   AZIMUTH = 174°
   RADIUS = 32'-9"
2. 4 PRESSURE SENSORS ARE LOCATED AT EACH LEVEL AND SPACED 90° APART.

FIGURE - 11

PRESSURE SENSOR LOCATIONS ON DOWNCOMER

REV.	DATE	PREPARED	REVIEWED	APPROVED	PURPOSE
A	11-15-78				
B	12-12-78				
C	10-10-79				

SCALE: NONE

PROJECT NUMBER: 5485-00

IN-PLANT SRV TEST PROGRAM
LaSALLE COUNTY STATION
UNIT 1
COMMONWEALTH EDISON CO.
CHICAGO, ILLINOIS

SARGENT & LUNDY

DRAWING NO. SK-11

REV. C

FORM 806 2, 6, 8

2-CC 4

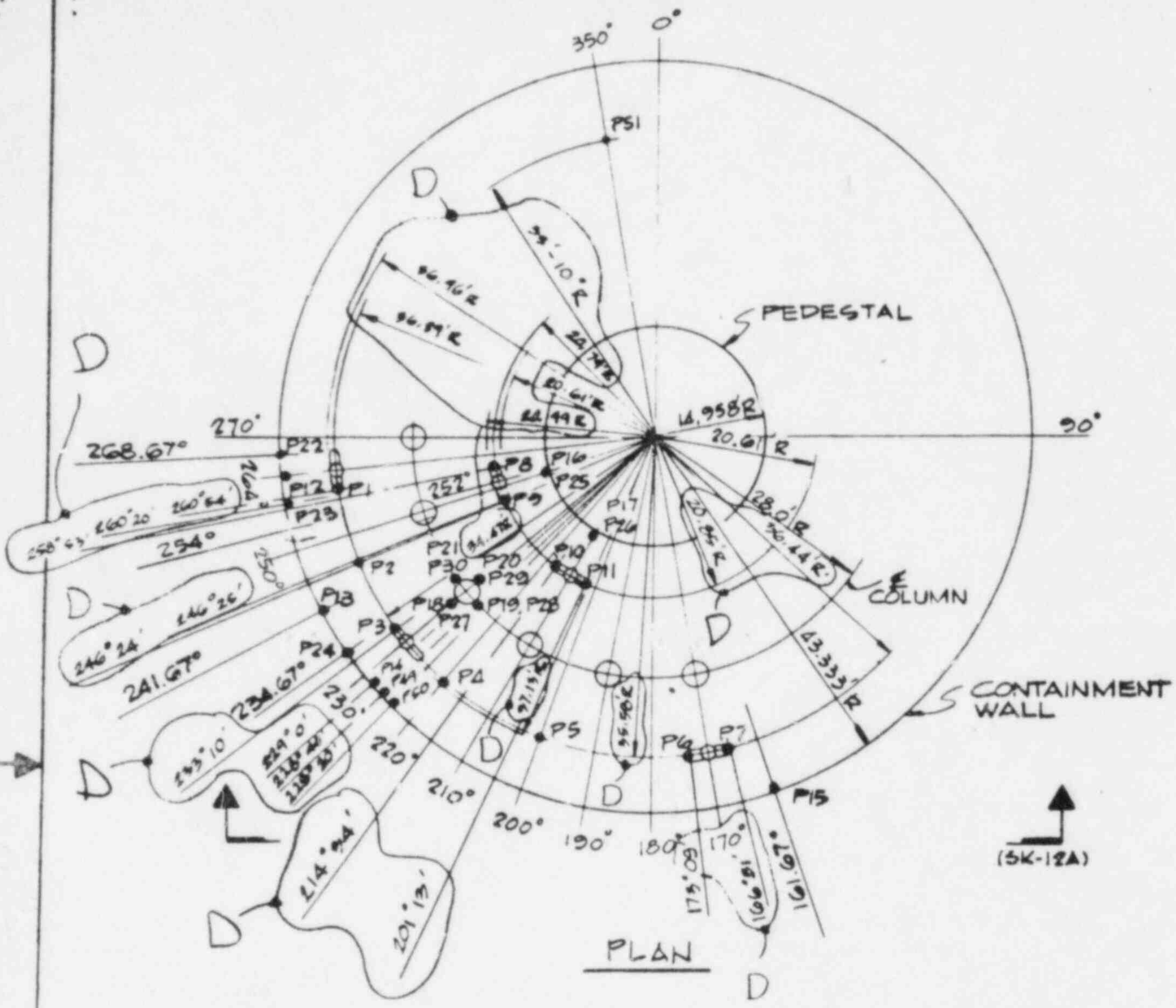


FIGURE - 12

PRESSURE SENSOR LOCATIONS IN SUPPRESSION POOL

IN-PLANT SRV TEST PROGRAM

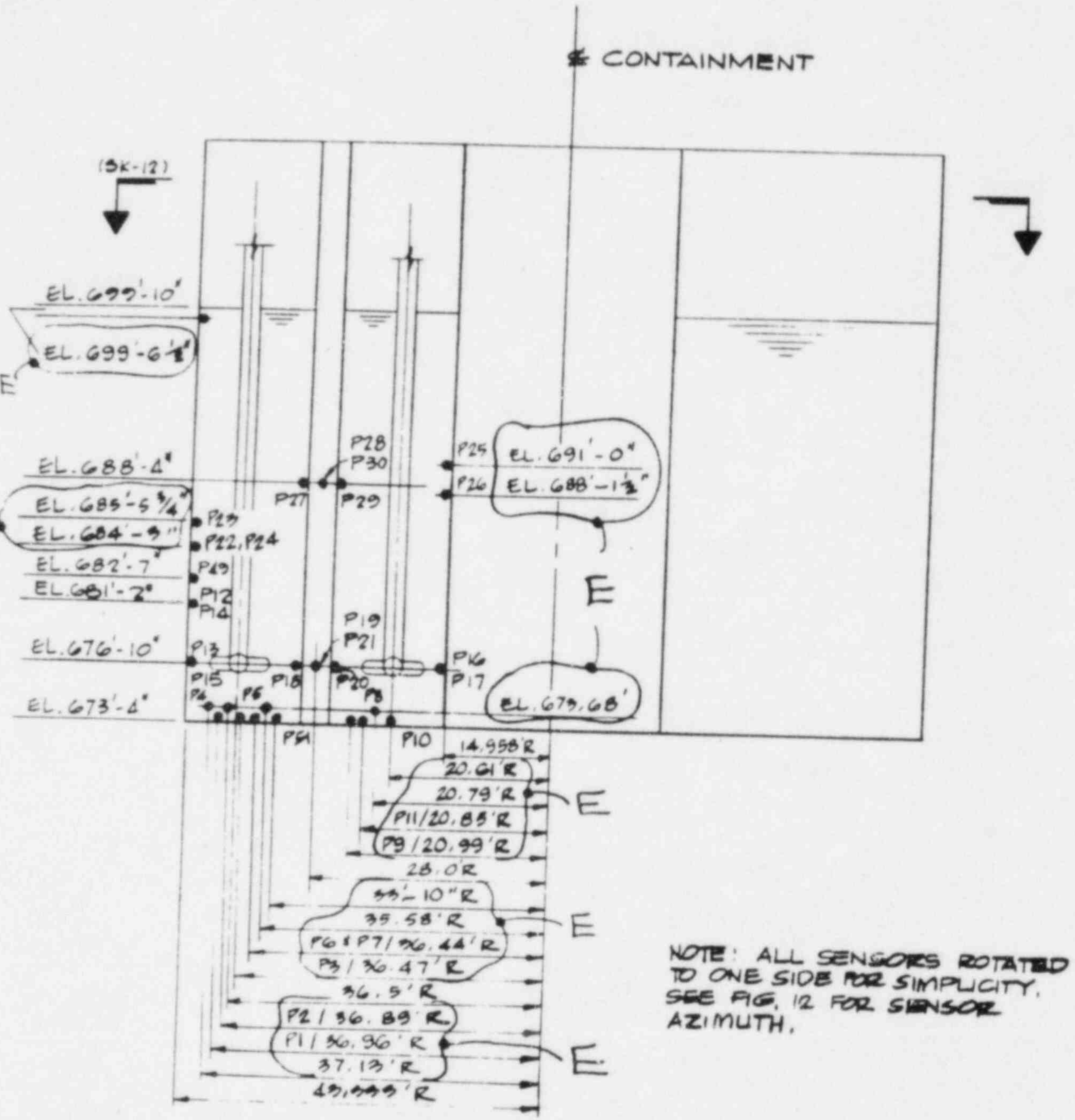
LASALLE COUNTY STATION UNIT 1

COMMONWEALTH EDISON CO.

CHICAGO, ILLINOIS

SK-12

D



NOTE: ALL SENSORS ROTATED TO ONE SIDE FOR SIMPLICITY. SEE FIG. 12 FOR SENSOR AZIMUTH.

ELEVATION
FIGURE-12A

PRESSURE SENSOR LOCATIONS IN SUPPRESSION POOL

REV.	DATE	PREPARED
A	2-13-79	
B	6-5-79	
C	10-10-79	
D	4-9-80	
E		

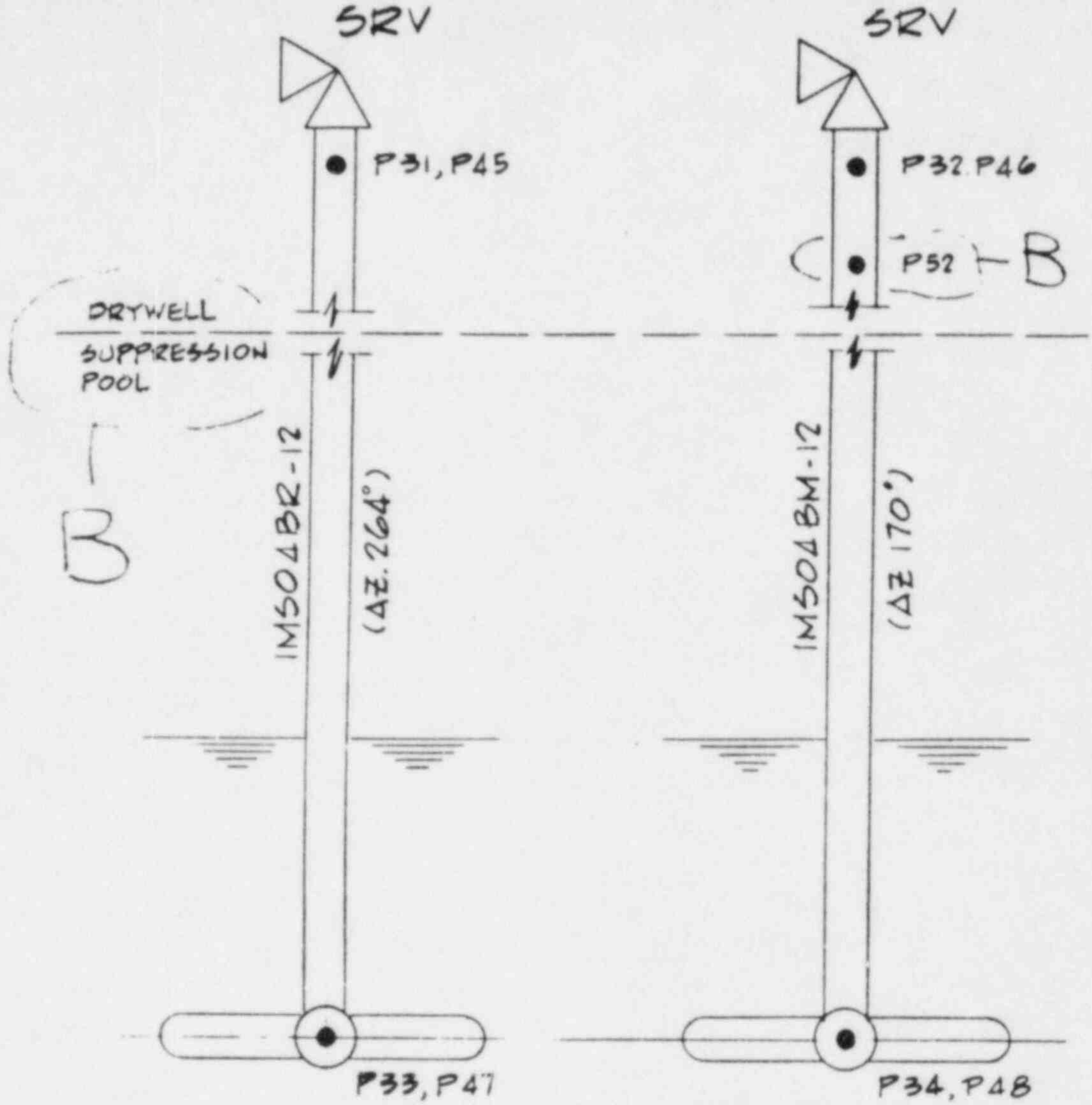
SCALE: NONE

PROJECT NUMBER: 5838-00

IN-PLANT SRV TEST PROGRAM
LASALLE COUNTY STATION UNIT 1
COMMONWEALTH EDISON CO
CHICAGO ILLINOIS

SARGENT & LUNDY

DRAWING NO. SK-12A REV. E



NOTE:
P45, P46, P47 & P48 ARE REDUNDANT PRESSURE SENSORS.

FIGURE-13

PRESSURE SENSOR LOCATIONS IN SRV DISCHARGE LINES

REV.	DATE REL'D	PREPARED	REVIEWED	APPROVED	PURPOSE	SCALE
A	2-15-79	[illegible]				NONE
B	10-10-79	[illegible]				

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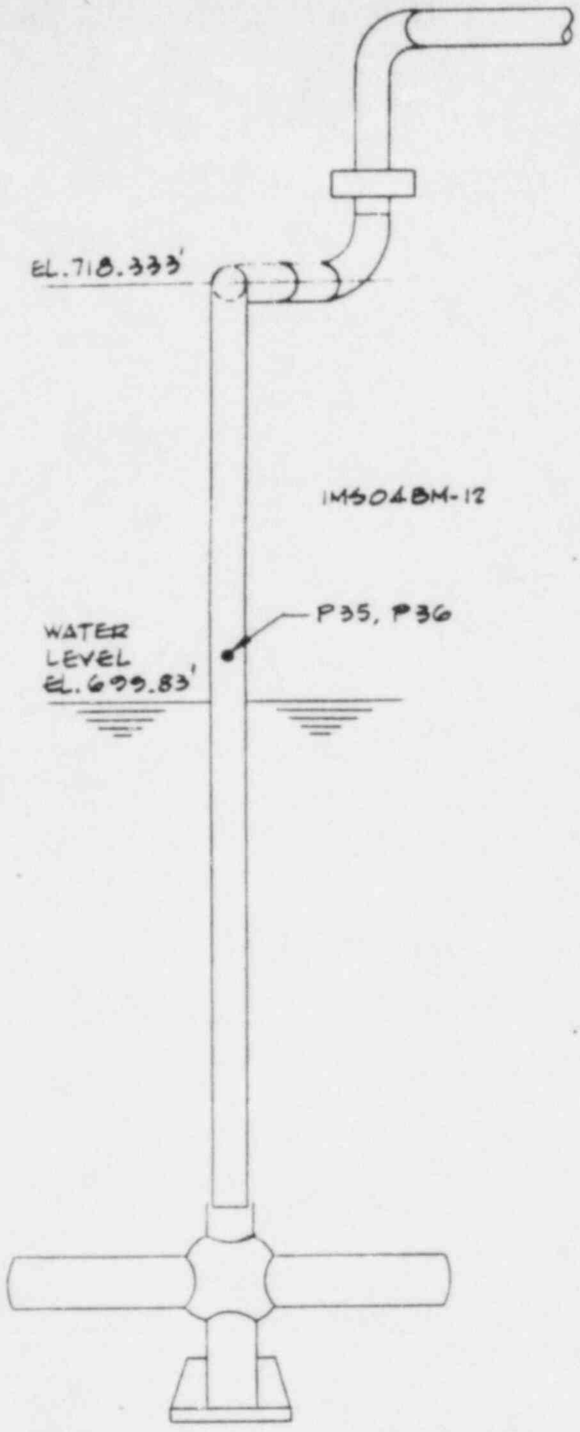
LASALLE COUNTY STATION
UNIT 1
COMMONWEALTH EDISON CO.
CHICAGO, ILLINOIS

SK-13 B



NOTES:

1. TWO PRESSURE TRANSDUCERS ARE LOCATED IN THE DISCHARGE PIPE ONE FOOT ABOVE NORMAL LEVEL (ONE TRANSDUCER IS FOR REDUNDANCY). (MOUNT AT LEAST 90° APART TO PREVENT INTERFERENCE)

FIGURE 13A

PRESSURE SENSORS ON SRV DISCHARGE LINE

DRAWING RELEASE RECORD								
REV	DATE REL'D	PREPARED	REVIEWED	APPROVED	PURPOSE	SCALE NONE / PROJECT NUMBER 5835-00	IN-PLANT SRV TEST PROGRAM LA SALLE COUNTY STATION UNIT 1 COMMONWEALTH EDISON CO. CHICAGO, ILLINOIS	SARGENT & LUNDY CHICAGO / DRAWING NO. SK-13A / REV. A / SHEET — OF —
A	10-10-79							

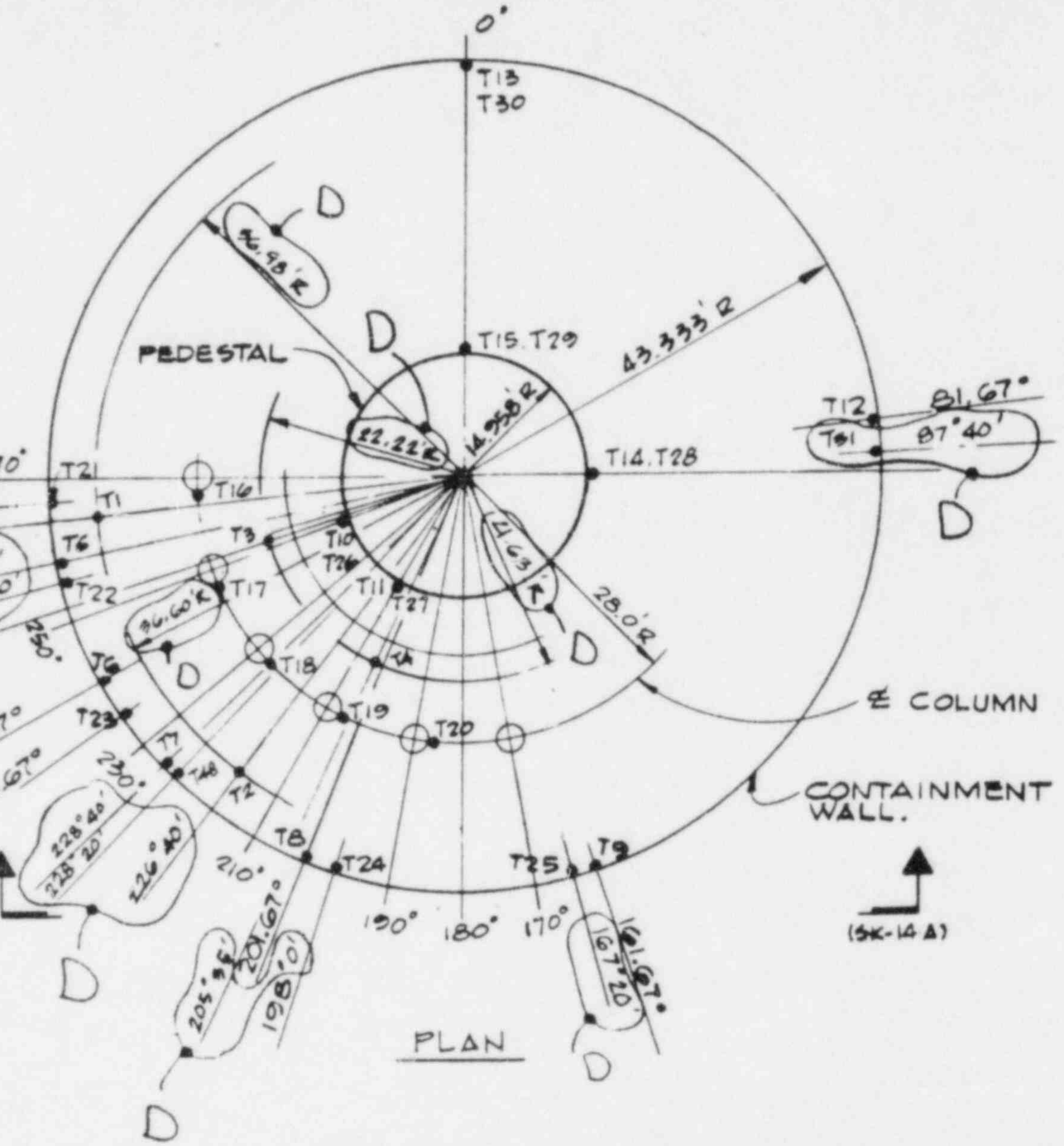


FIGURE - 14

TEMPERATURE SENSOR LOCATIONS IN SUPPRESSION POOL

REV.	DATE	PREPARED	REVIEWED	APPROVED	PURPOSE
A	2-15-79				
B	6-8-79				
C	4-9-80				
D	10-27-80				

SCALE: NONE

IN-PLANT SRV TEST PROGRAM
LA SALLE COUNTY STATION
UNIT 1
COMMONWEALTH EDISON CO.
CHICAGO, ILLINOIS

SK-14 REV. D

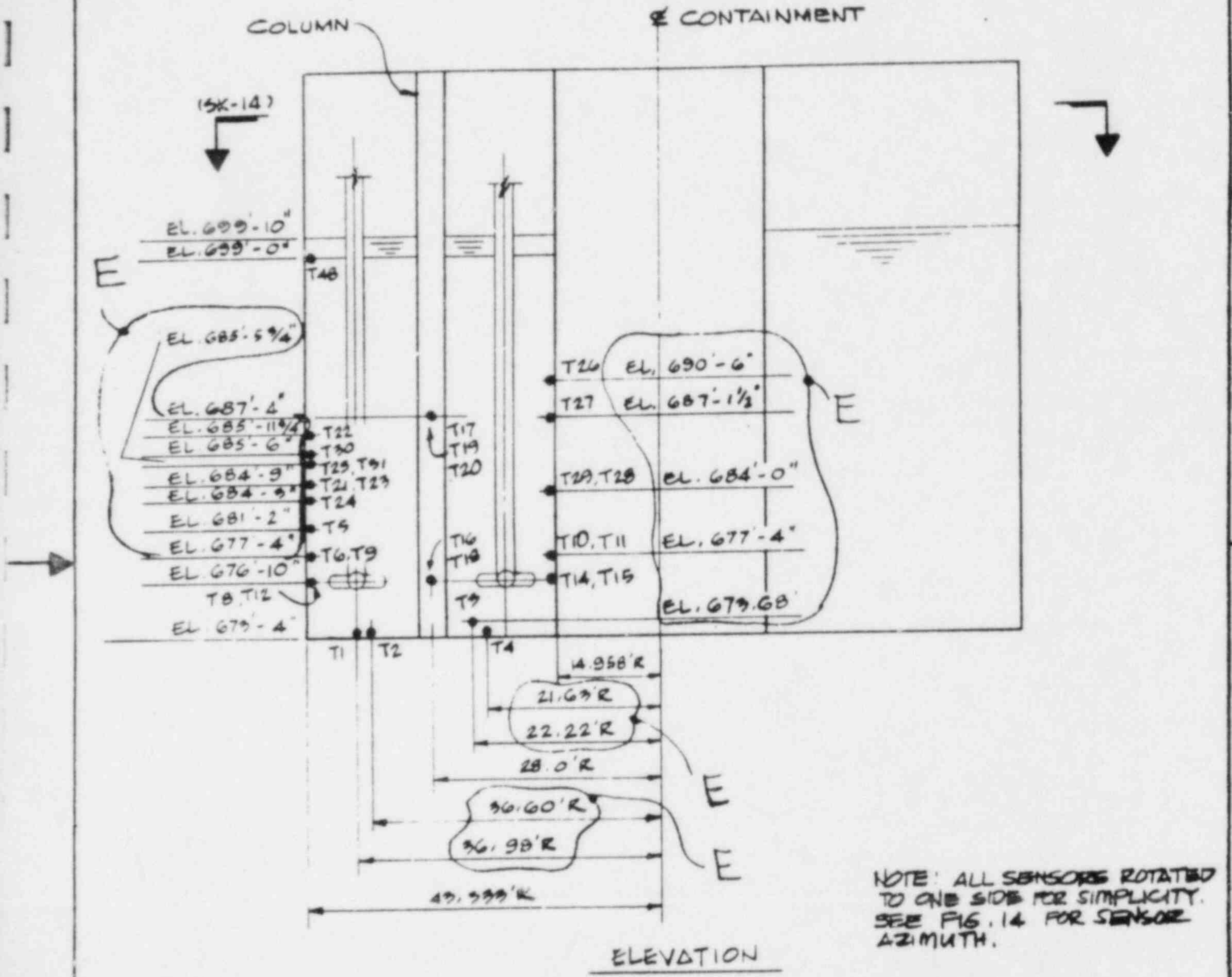


FIGURE-14A

TEMPERATURE SENSOR LOCATIONS IN SUPPRESSION POOL

REV	DATE REL'D	PREPARED	REVIEWED	APPROVED	PURPOSE
A	2-15-79	[illegible]			
B	6-6-79	[illegible]			
C	3-27-79	A.B.K.			
D	[illegible]	[illegible]			
E	10-[illegible]	[illegible]			

SCALE: NONE

PROJECT NUMBER: 5835-00

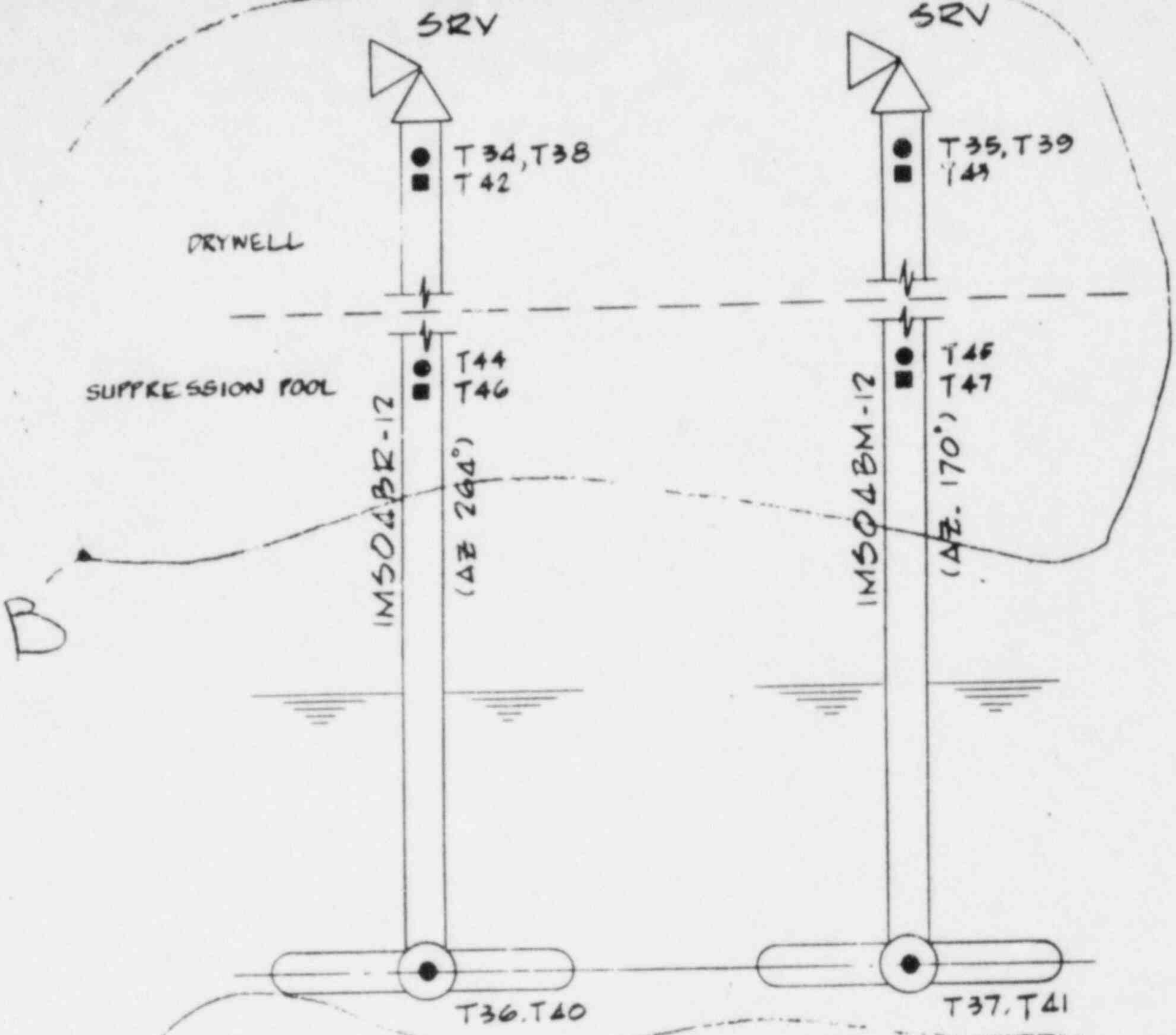
IN-PLANT SRV TEST PROGRAM
LA SALLE COUNTY STATION
UNIT 1
COMMONWEALTH EDISON CO.
CHICAGO, ILLINOIS

SARGENT & LUNDY

DRAWING NO. SK-14A REV. E

FORM SD6 2.4.8

2-CC4



NOTE:
1) T38, T39, T40 & T41 ARE REDUNDANT TEMPERATURE SENSORS.
2) T42 IS MOUNTED ADJACENT TO T34, T43 IS MOUNTED ADJACENT TO T35.
3) T44 & T45 MEASURE INSIDE WALL TEMPERATURE.
4) T46 IS MOUNTED ADJACENT TO T44 & T47 IS MOUNTED ADJACENT TO T45.
5) T42, T46, T43 & T47 MEASURE OUTSIDE WALL TEMPERATURE.

B

FIGURE - 15

TEMPERATURE SENSOR LOCATIONS IN SRV LINES

REV	DATE	PREPARED		
A	2-15-79			
B	10-22-80			

SCALE: NONE

IN-PLANT SRV TEST PROGRAM
LaSALLE COUNTY STATION
UNIT 1
COMMONWEALTH EDISON CO.
CHICAGO ILLINOIS

SK-15 B

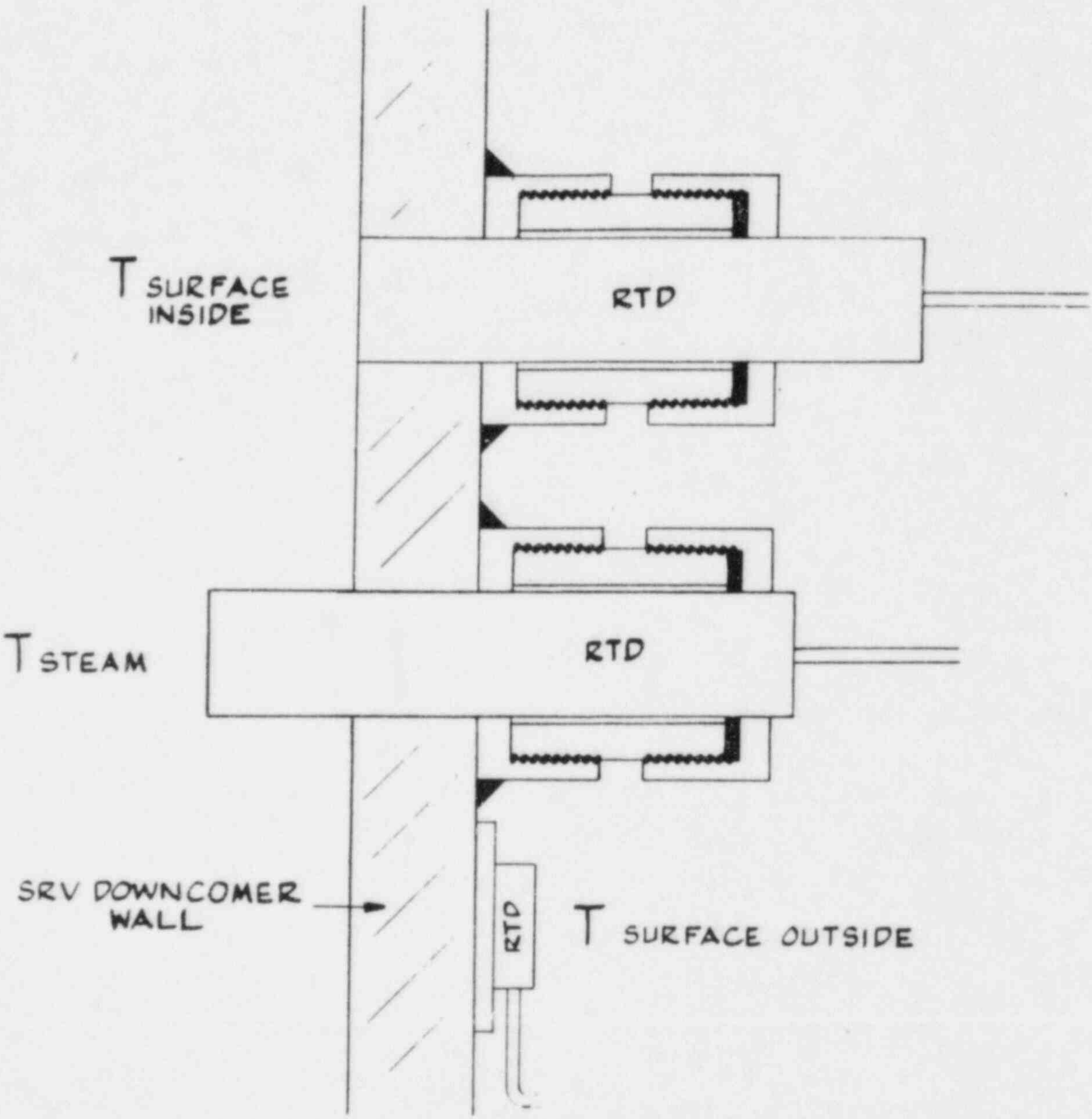


FIGURE 15A

TEMPERATURE SENSOR MOUNTING
ON SRV DISCHARGE LINES

IN-PLANT SRV TEST PROGRAM
LaSalle County Station
Unit 1
Commonwealth Edison Co
Chicago Illinois

SARGENT & LUNDY

DRAWING NO SK-15A REV A

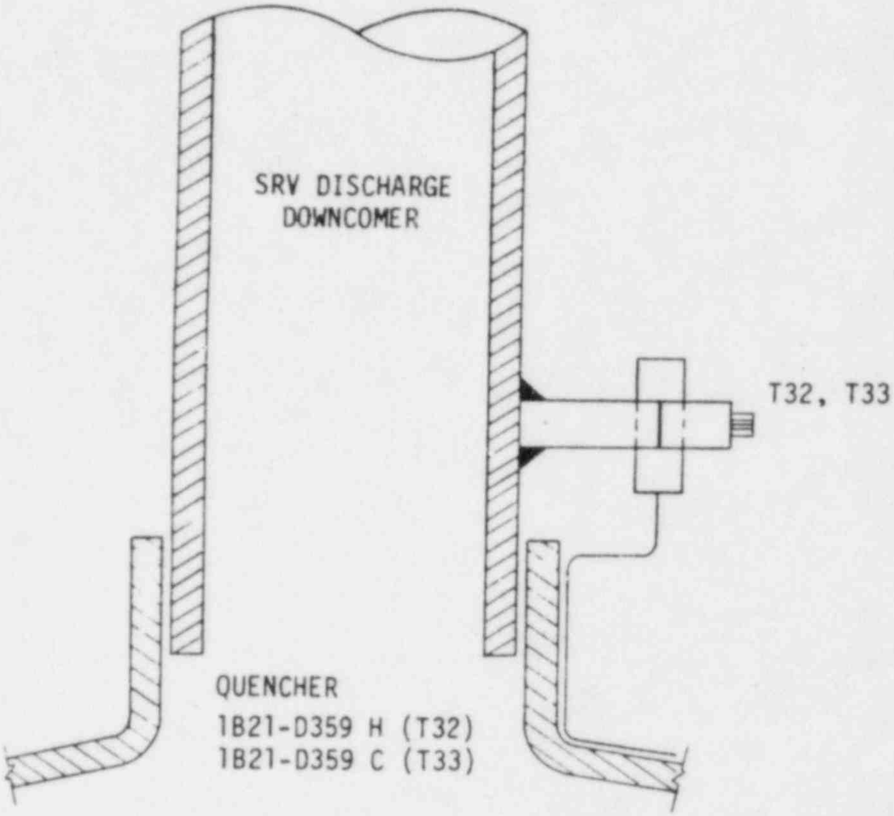


FIGURE 15B

SRV DOWNCOMER LOCAL TEMPERATURE SENSORS

DRAWING RELEASE RECORD

REV.	DATE REL'D	PREPARED	REVIEWED	APPROVED	PURPOSE
A	10-20-80				

SCALE NONE

PROJECT NUMBER

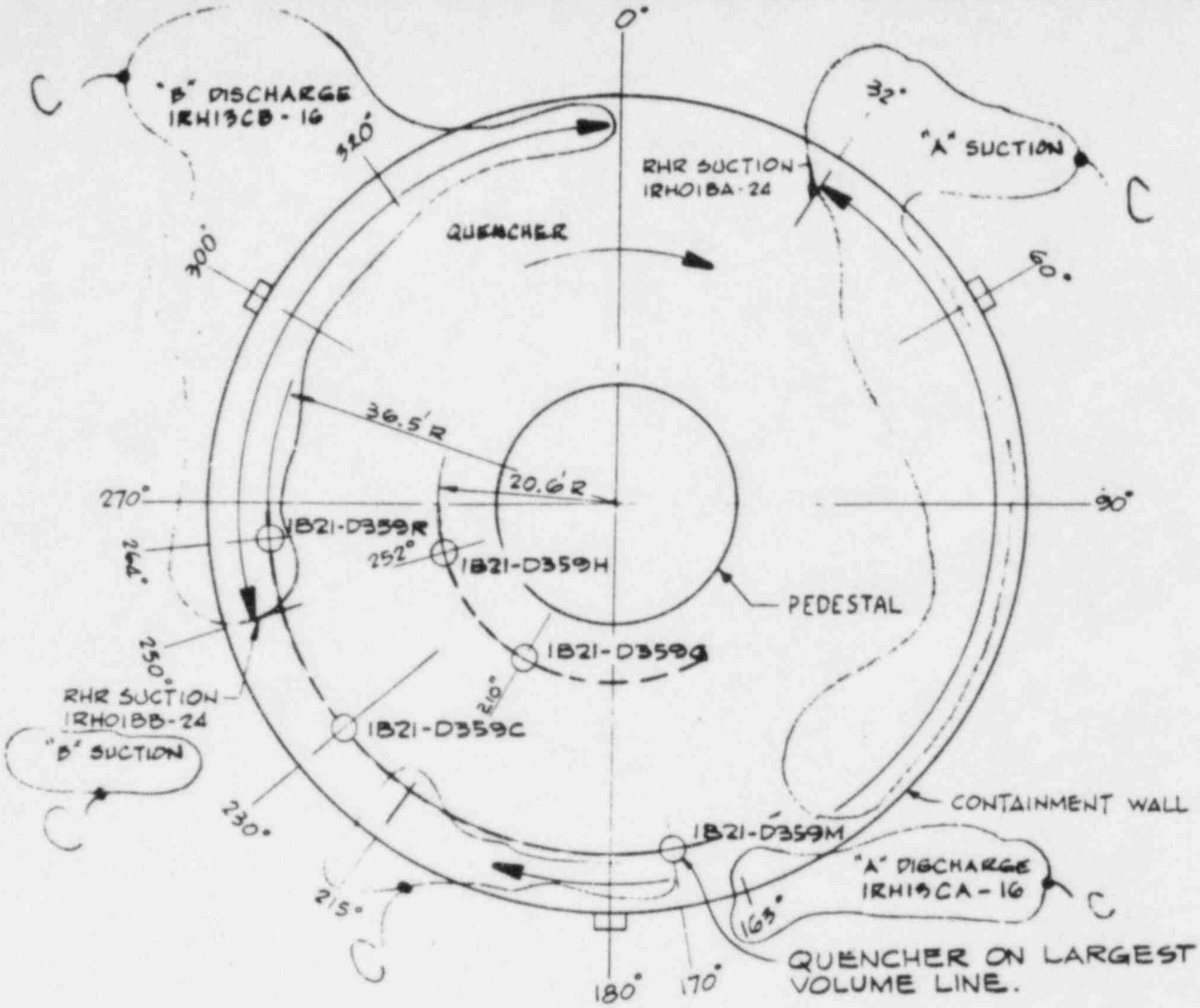
IN-PLANT SRV
TEST PROGRAM
LaSalle County Station
Unit 1
Commonwealth Edison Co
Chicago Illinois

SARGENT & LUNDY

DRAWING NO. SK-15B

REV A

SHEET OF



PLAN

FIGURE-16

IDENTIFICATION OF SRV LINES

REV.	DATE REL'D	PREPARED	REVIEWED	APPROVED	PURPOSE
A	10-10-79				
B	4-21-80				
C	10-31-80				

SCALE: NONE

PROJECT NUMBER: 5835-07

IN-PLANT SRV TEST PROGRAM
LA SALLE COUNTY STATION
UNIT 1
COMMONWEALTH EDISON CO.
CHICAGO, ILLINOIS

SARGENT & LUNDY

DRAWING NO. SK-16 REV. C

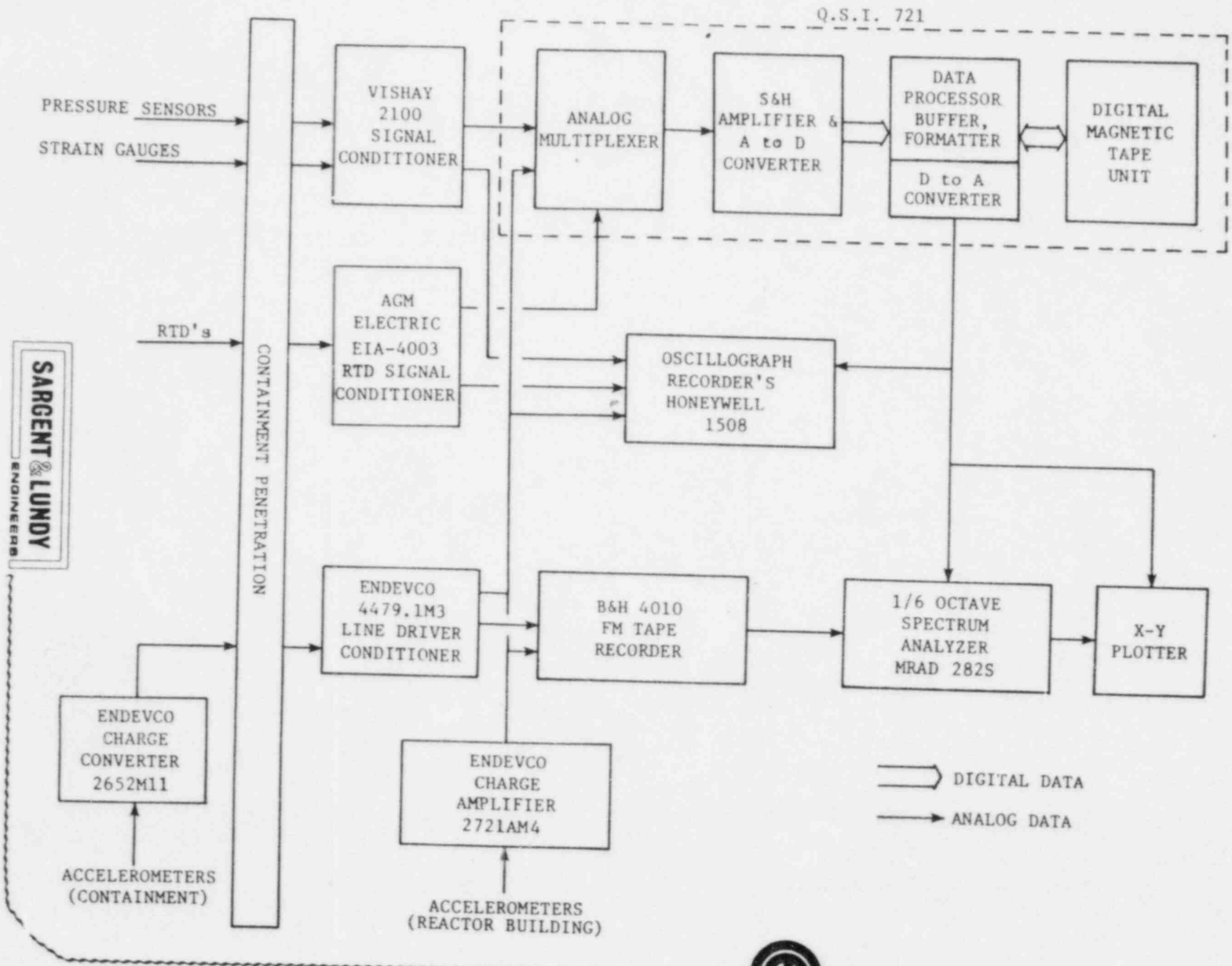


FIGURE 17
Data Acquisition, Recording and Playback System (DARPS)

Revision 4

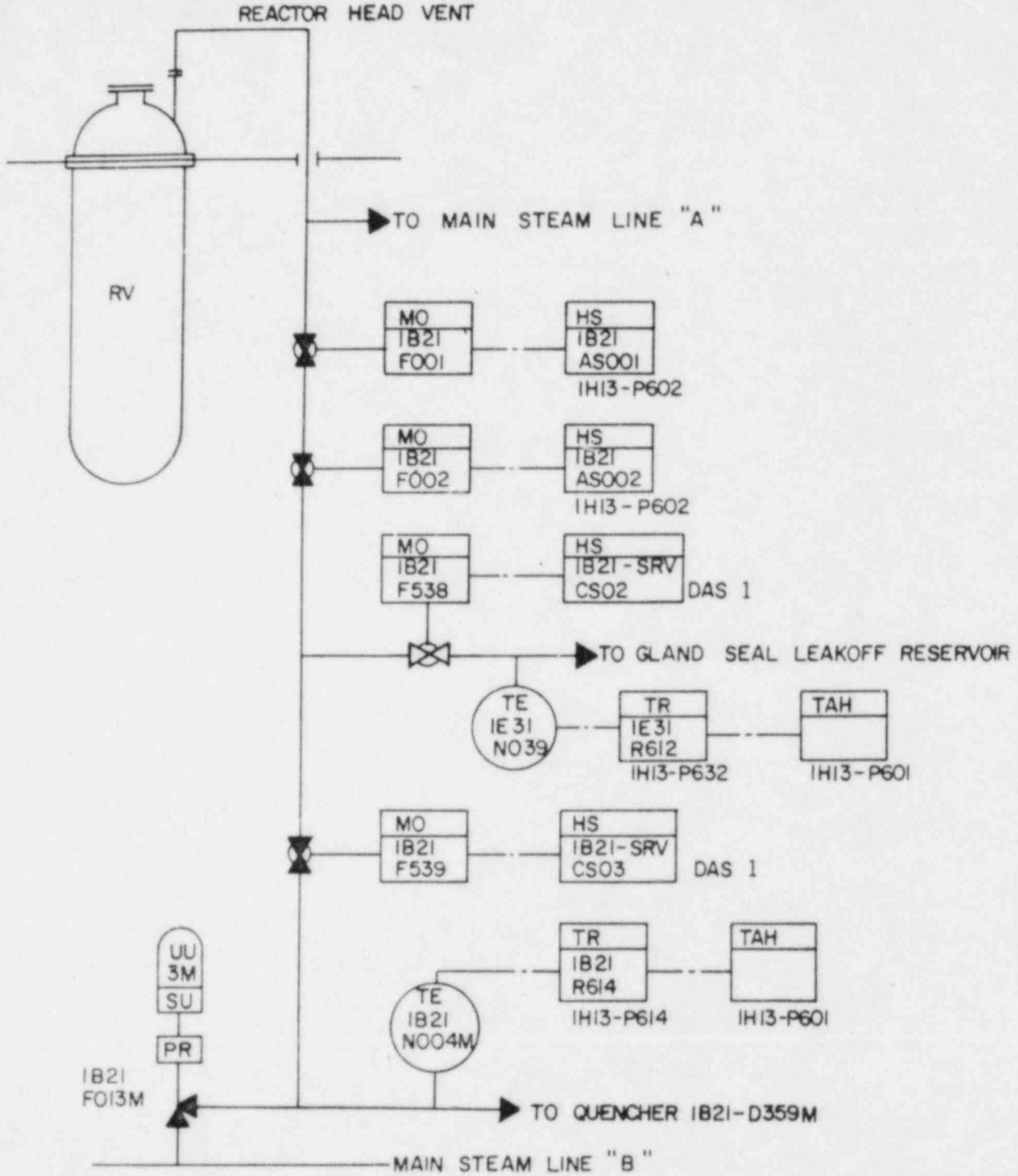


FIGURE 18

LEAKY VALVE TEST SETUP

DRAWING RELEASE RECORD

REV.	DATE REL'D	PREPARED	REVIEWED	APPROVED	PURPOSE
A	2-11-80	[illegible]			

SCALE

PROJECT NUMBER 5883500

IN-PLANT SRV TEST PROGRAM
LASALLE COUNTY STATION UNIT 1
COMMONWEALTH EDISON CO
CHICAGO, ILLINOIS

SARGENT & LUNDY

DRAWING NO. SK-18 REV. A

SHEET OF

FORM GDS 2.0.5

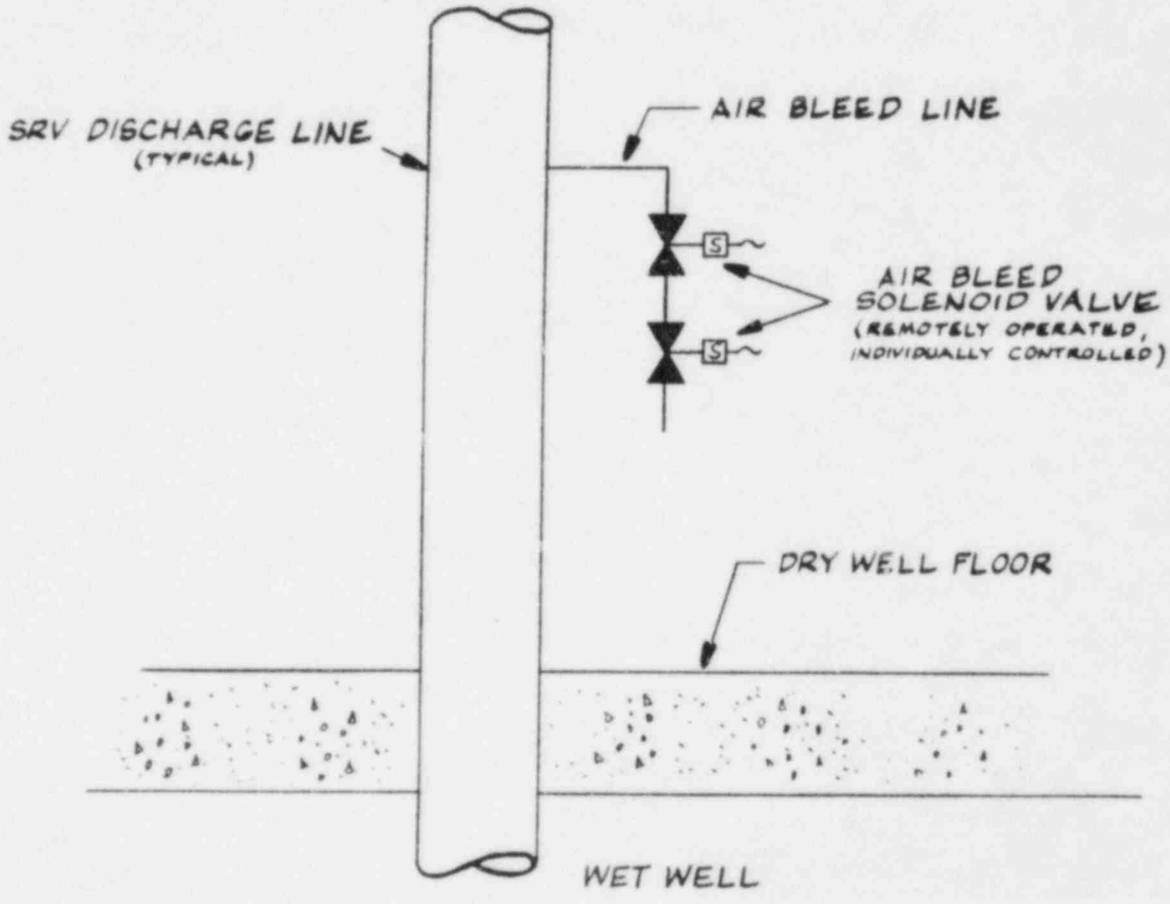


FIGURE 19

AIR BLEED SYSTEM

DRAWING RELEASE RECORD

REV.	DATE	DRAWN	REVIEWED	APPROVED	PURPOSE
A	9-5-80	[illegible]			

SCALE
FILM
PROJECT
NUMBER

IN-PLANT SRV
TEST PROGRAM
LASALLE COUNTY
STATION UNIT 1
COMMONWEALTH EDISON CO.
CHICAGO, ILLINOIS

SARGENT & LUNDY
ENGINEERS

DRAWING NO. SK-19
REV. A
SHEET OF

APPENDICIES

SARGENT & LUNDY
ENGINEERS

APPENDIX A

TEST MATRIX

Type of Test	Valve(s) Actuated	Initial Water Leg	Initial Pipe Temp.	Initial Pool Temp.	Nominal** Discharge Duration (sec)
SRV-1	C	NWL+	CP, HP	NT	15
SRV-1	G	NWL+	CP, HP	NT	15
SRV-1	H	NWL+	CP, HP	NT	15
SRV-1	M	NWL+	CP, HP	NT	15
SRV-1	R	NWL+	CP, HP	NT	15
SRV-C	C	NWL*	CP*	NT	15
SRV-C	G	NWL*	CP*	NT	15.
SRV-C	M	NWL*	CP*	NT	15
SRV-2	C,H	NWL+	CP, HP	NT	15
SRV-2	C,R	NWL+	CP, HP	NT	15
SRV-2	C,R	NWL+	CP/HP	NT	15
SRV-2	C,G	NWL+	CP, HP	NT	15
SRV-4	C,G,H,R	NWL	CP	NT	15
SRV-S	C,G,H,R	NWL	CP	NT	15
SRV-E	C	NWL	CP	NT	600
SRV-E	H	NWL	CP	NT	600
SRV-L	M	---	HP	NT	15

NOTES: The number of times each type of test should be repeated is to be determined from statistical considerations.

* = After first actuation temperature and water level change.
** = 15-second nominal time can be 5 to 20 seconds actual; extended blowdown may be limited by plant limits.
\+ = Cold pipe only

The SRV Discharge Quenchers of valves M, G, C, H, and R are located at 170°, 210°, 230°, 252°, and 264°, respectively.

SRV-1 = One valve actuation
SRV-C = Consecutive valve actuations
SRV-2 = Two valve actuation
SRV-4 = Four valve actuation
SRV-S = Sequential valve actuation
SRV-E = Extended valve blowdown
SRV-L = Leaky valve simulation

CP = Cold Pipe
HP = Hot Pipe
CP/HP = One Hot & One Cold Pipe
NWL = Normal Water Level
NT = Normal Pool Temperature

APPENDIX B

Specifications for Sensors

- Accelerometer Specifications: (Endevco 7704-100 Accelerometer) (used outside containment)

- Charge Sensitivity		
Nominal:	pC/g	100
Minimum:	pC/g	90
- Frequency Response (±5% charge deviation):	Hz	1 to 5000
- Mounted Resonant Frequency		
Nominal:	Hz	20,000
- Transverse Sensitivity		
Maximum:	%	3
- Temperature Response (±5% charge deviation):	°F	-65 to 500
- Amplitude Linearity	%	Sensitivity increases 1% per 250 g's.

- Accelerometer Specifications: (Endevco 7717-200 Accelerometer) (used in Containment Drywell)

- Charge Sensitivity		
Nominal:	pC/g	200
Minimum:	pC/g	180
- Frequency Response (±5% charge deviation):	Hz	1 to 4000
- Mounted Resonance Frequency	Hz	17,000

- Transverse Sensitivity @ Approx. 15 Hz:	%	3 max.
- Temperature Response (±5% charge deviation):	°F	-65 to 572
- Amplitude Linearity:		Sensitivity increase approx. 1% per 250 g.

Accelerometer Specifications: (Endevco 7717-M2A Accelerometer) (used in Containment Wetwell)

- Charge Sensitivity		
Nominal:	pC/g	200
Minimum:	pC/g	180
- Frequency Response (±5% charge deviation):	Hz	1 to 3000
- Mounted Resonance Frequency:	Hz	17,000
- Transverse Sensitivity @ Approx. 15 Hz:	%	3 max.
- Temperature Response (±5% charge deviation):	°F	-65 to 572
- Amplitude Linearity:		Sensitivity increase approx. 1% per 250 g.

RTD Specifications: (Medtherm PTF-XXX-10356) (used in all applications except pipe outside surface temperature measurement)

- Type:	Platinum thin resistance thermometer on ceramic substrate.

- Resistance: 100 ohms at 0°C, 138.50 ohms at 100°C.
- Temperature Range: 50° - 600°F
- Pressure Range: 0 - 1500 psig
- Reference Time: 5 milliseconds
- Accuracy: ± 0.5°F

• RTD Specifications: (Medtherm PRT-XXX-10387) (used for pipe outside surface temperature measurement)

- Type: Platinum Resistance Thermometer
- Resistance: 100 ohms at 0°C, 138.5 ohms at 100°C
- Temperature Range: 50°F to 600°F
- Pressure Range: 0 - 700 psig
- Response Time: 1 second typical

• Strain Gauge Specifications: (Ailtech MG125)

- Element Type: A
- Resistance: 120 ± 5 ohms
- Gauge Factor: 1.7 ± 3%
- Gauge Factor Change with Temperature: -1%/100°F
- Pressure Rating: 0 - 2500 psig

Pressure Sensor Specifications: (CEC 1000)
(used for ranges 0-100, 0-300, 0-50 psig)

PRESSURE RATING:

- Proof Pressure:	200% of rated pressure, not to exceed 7,500 psi, will not cause changes in performance beyond the specified tolerances.
- Burst Pressure:	300% of rated pressure, not to exceed 10,000 psi, will not cause rupture of the sensing element or case.

ELECTRICAL CHARACTERISTICS:

- Excitation:	10 Vdc rated; 15 Vdc maximum
- Full range output:	30 mV minimum
- Residual unbalance:	within ±2%, FRO
- Bridge Resistance:	300 to 500 ohms
- Combined Linearity, Hysteresis and non-repeatability:	±0.25% FRO, BSL
- Insulation Resistance:	500 megohms or greater at 45 Vdc.
- Breakdown Voltage:	100 Vdc or pk ac between case and any terminal without damage.
- Connections:	6-pin Bendix PTIH-10-6P, or equivalent.

- Shunt Calibration:	Provisions for single-arm, external shunt calibration.

MECHANICAL CHARACTERISTICS:

- Mounting Isolation:	Double case isolation provides assurance that the sensing element will be unaffected by external stresses.
- Sensing Element:	4 active arm bridge using sputtered elements.

ENVIRONMENTAL PERFORMANCE:

- Temperature:	
Operating Range:	-65° to +300°F
Compensated Range:	-65° to +250°F
Thermal Zero Shift:	±0.005 FRO/°F over the compensated temp. range.
Thermal Sens. Shift:	±0.005/°F over the compensated temp. range.
Thermal Zero Stability:	0.15% FRO over the compensated temp. range.
Thermal Sensitivity Stability:	0.10% FRO over the compensated temp. range.
- Vibration:	Qualification Level of 35 g. pk; 5-2000 Hz Max. 1/2" D.A. Less than 0.003% FRO/g

- Shock: Qualification level of 100 g. 11 msec, half sine wave without damage.

- Humidity: Per MIL-E-5272C Proc. 1.

- Altitude: Insensitive to external case pressure variations within the range of 0 to 25 psia.

- Performance Stability: $\pm 0.1\%$ FRO for a minimum of 4 hours when subjected to any combination of constant temperature and pressure within the specified limits.

Pressure Sensor Specifications: (CEC 1000-04 Sputtered Thin Film High Temperature Pressure Transducer) (used for 0-1000 psig range)

PRESSURE RATING:

- Proof Pressure: 0 to 100 psi and above are available in psis. 200% of rated pressure or 15,000 psi (whichever is less) will not cause changes in performance beyond specified tolerances.

- Burst Pressure: 300% of rated pressure or 20,000 psi (whichever is less) will not cause rupture of the sensing element or case.

ELECTRICAL CHARACTERISTICS:

- Excitation: 10 Vdc rated; 15 Vdc maximum

- Full Range Output:	30 mV nominal.
- Residual Unbalance:	within ±5%, FRO.
- Bridge Resistance:	300 to 500 ohms.
- Combined Linearity, Hysteresis and non-repeatability:	±0.25% FRO, BSL.
- Insulation Resistance:	100 megohms or greater at 45 Vdc.
- Connections:	6-pin Bendix PCIH-10-6P (101), or equivalent.
- Shunt Calibration:	Provisions for single-arm, external shunt calibration.

MECHANICAL CHARACTERISTICS:

- Mounting Isolation:	Double case isolation provides assurance that the sensing element will be unaffected by external stresses.
- Sensing Element:	4 active-arm bridge using sputtered elements.

ENVIRONMENTAL PERFORMANCE:

- Temperature:

Operating Range:	-65 to +450°F.
Compensated Range:	+75 to +400 °F.
Thermal Zero Shift:	±0.01% FRO/°F over the compensated temp. range.

Thermal Sens. Shift:	±0.01% FRO/°F over the compensated temp. range.
Thermal Zero Stability:	0.25% FRO over the compensated temp. range.
Thermal Sens. Stability:	0.15% FRO over the compensated temp. range.
- Vibration:	At 35g peak from 10 to 2000 Hz (1/2" D.A. max.) the output shall not exceed 0.04% FRO/g for 15 psi units decreasing logarithmically to .003% FRO/g for 1000 psi units and above.
- Natural Frequency:	50 kHz at 5000 psi, decreasing logarithmically to 5kHz at 15 psi.
- Shock:	100g, 11 msec, half sine wave without damage.
- Humidity:	Per MIL-E-5272C, Procedure 1.

Pressure Sensor Specifications: (Validyne AP-78-44-1590) (used for low pressure measurement after high pressure spike)

- Pressure Range:	20-32 PSIA
- Linearity:	±0.5% FS best straight line
- Hysteresis:	0.5% pressure excursion
- Overpressure:	
Differential:	200% FS up to 6000 psi maximum

Absolute:	20 PSIA or 200% FS whichever is greater, up to 6000 PSI maximum
- Differential	
Line Pressure:	5000 psig operating
Line Pressure Effect:	Less than 1% FS Zero shift/ 1000 psig
- Output:	40mV/V full-scale (typical)
- Inductance:	20mH nominal, each coil
- Zero Balance:	Within 5mV/V
- Excitation:	Rated: 5V RMS, 3 kHz
- Pressure Media:	Corrosive liquids and gases compatible with 410 CRES and Inconel
- Temperature	
Operating:	-65°F to +250°F
Compensated:	0°F to +160°F
- Thermal Zero Shift:	1 psi and above, 0.02%, (typ) FS/°F Below 1 psi, 0.04% (typical) FS/°F
- Thermal Sensitivity Shift:	0.04%/°F (typical)
- Pressure Connection:	0.125" O.D. by 1" stainless steel tubing
- Electrical Connection:	8-inch wire leads

APPENDIX C

Specifications for Vishay System

- Bridge Completion:	1/4 bridge completion network per channel
- Bridge Balance Range:	3000 micro-inches/inch
- Calibration:	Internal calibration of ±1%
- Amp Gain:	100 to 2000 continuous or steps of 100, 500, 1000, and 2000
- Input:	Differential
- Input Impedance:	25 megohms differential or common mode
- Output:	±10V maximum
- Linearity:	±0.05% to DC
- Stability	0.5% after 15 minutes

APPENDIX D

Specifications for Charge Amplifier

ENDEVCO Model 2721AM4 and

Charge Converter Signal Conditioner Endevco

Model 4479.1M3/2652M11

2721AM4

INPUT

INPUT CONNECTION	Single-ended with one side connected to circuit common; restricted for use with capacitive devices.
SOURCE IMPEDANCE	1 kΩ minimum shunt resistance; 30,000 pF maximum shunt capacitance.
MAXIMUM INPUT	30,000 pC pk without overload
SLEW RATE	1,000 pC/μs maximum

OUTPUT

OUTPUT CONNECTION	Single-ended with one side connected to circuit common.
LINEAR OUTPUT VOLTAGE	± 10 V, maximum
LINEAR OUTPUT CURRENT	± 2 mA, maximum
OUTPUT IMPEDANCE	$10\Omega \pm 10\%$
RESIDUAL NOISE	Nc <0.03 pC rms +00.008 pC rms per 1,000 pF of source capacitance, referred to input.

$$Nr = \frac{100}{\sqrt{RS}} \text{ pC rms (typical)}$$

where $Rs \leq 100$ kΩ

$$\text{Noise} = \sqrt{Nc^2 + Nr^2}$$

TRANSFER

SYSTEM SENSITIVITY	Amplifier gain is continuously adjustable to allow for indicated calibrated system sensitivity for transducers with sensitivities of 1 to 100 pC/g.
INDICATED RANGES	1, 3, 10, 30, 100 mV/g for 1 to 11 pC/g; 10, 30, 100, 300, 1,000 mV/g for 10 to 110 pC/g.
GAIN ACCURACY	±1% of actual gain for source impedance ≥10 kΩ and/or ≤10,000 pF
GAIN STABILITY	±200 ppm/°F, maximum
FREQUENCY RESPONSE 2721AM4	±5%, 1Hz, with source, impedance ≥300 kΩ

ENVIRONMENTAL

TEMPERATURE	0°C to 75°C (32°F to 167°F)
HUMIDITY	95% relative humidity, maximum

4479.1M3/2652M11

ELECTRICAL

INPUT CHARACTERISTICS (2652M11)	
Input Connection	Single-Ended
Source Impedance	Capacitive devices only. Shunt resistance 25 MΩ minimum.
Source Capacitance	10,000 pF, maximum
OUTPUT CHARACTERISTICS (2652M11)	
Output Connection	Single-Ended
Output Impedance	5 ohms nominal, when used with 4479.1.

Maximum Capacitance between 2652M11 and 4479.1M3	To meet all specifications, C = K/fµF, where f is maximum frequency of interest and K = 130,000 for 1 pC full scale, K = 3,000 for 100 pC full scale, K = 85 for 3,000 pC full scale. Worst case: 8500 pF maximum at 10,000 Hz and 3,000 pC pk input signal.
INPUT CHARACTERISTICS (4479.1M3)	
Input Connection	Single-Ended
Input Resistance	1000 ohms in series with 390 µF
OUTPUT CHARACTERISTICS (4479.1M3 Card)	
Output Connection	Single-Ended
Linear Output Volt	±2.5 V pk, Full Scale
Linear Output Current	±2.5 mA pk, maximum
Output Impedance	50 ohms, maximum, in series with 200 µF.
POWER (R40)	+30 V dc from 4470 set by program resistor on mode card.
TRANSFER CHARACTERISTICS (2652M11 and 4479.1M3) Full Scale Ranges for Sensitivities:	
10 to 100 pC/g	0.1, 0.3, 1.3, 10, 30g
Actual Gain	0.8 to 2500 mV/pC
System Accuracy	±3% of F.S., any range at +24°C (+75°F) and source capacitance of 1000 pF, maximum.
Gain Stability	Better than 0.5% per 1000 pF source capacitance. Better than 2%, -10°C to +65°C (+15°F to +150°F). Gain decreases approximately 1% for every 10 ohms cable resistance.
Frequency Response	±5%, 1Hz to 10,000 Hz
Linearity	±0.5% of reading from best straight line.
Total Harmonic Distortion	0.2%, maximum
Residual Noise	Less than the total of 0.0075 pC rms plus 0.0025 pC rms per 1000 pF source capacitance referred to input plus 0.5mV rms referred to output.

PHYSICAL

MODE CARD (4479.1M3)	Designed for plugging into from panel of 4470 Module.

CONNECTORS (2652M11)	
Input (J1)	Coaxial, 10-32 thread, Microdot S-50 Series or equivalent.
Output	Solder terminals.
MOUNTING (2652M11)	Converter mounts in 13/16" hole. Washer and 11/16" x 28" nut supplied.
CONTROLS (on Mode Card)	
Sensitivity (R30)	Ten turn potentiometer, with calibrated turns dial.
Full Scale (S1)	Six position rotary switch.
ENVIRONMENTAL	
OPERATING TEMPERATURE (2652M11)	-54°C to +85°C (-65°F to +185°F)

APPENDIX E

Q.S.I. System Performance Characteristics

Record Electronics

- Analog Input Channels:	Expandable to 256 channels in 16 channel blocks.
- Digital Input Channels:	Expandable to 32 channels up to 16-bit parallel with handshake transfer.
- Frequency Response Range:	200 Hz
- Throughput Rate:	1000 samples/sec/channel
- Recording Capacity:	Up to 145 Megabytes per reel.
- Analog Input Impedance:	10 Megohms
- Conversion Method:	Successive approximation with S/H input amplifier.
- Conversion Code:	2's complement binary
- Conversion Resolution:	12 bits including sign
- Dynamic Range:	66 dB
- Conversion Accuracy:	0.01% F.S., + 1/2 LSB
- Input Level-Analog:	±5 FS, ±15V FS maximum overvoltage protected.
- Digital:	Standard TTL Logic Levels
- Time Code Data:	Days, hours, minutes, and seconds may be entered into tape records as required.
- Header Data:	Manually entered by operator via front panel keyboard.
- Power:	1800 W, 110V AC, ±10%, 50-60 Hz.

Playback Electronics

- Number of Output Channels:	One (expandable up to eight channels)

- Throughput Rate:	Up to 250,000 samples per second.
- Speed-Up Factor:	Up to 1000:1 and beyond limited only by throughput rate.
- Conversion Code:	2's complement binary
- Conversions Resolution:	12 bits including sign
- Setting Time:	3 microsec to 1/2 LSB
- Slew Rate Output Voltage:	20V/second standard for ±5V FS; other ranges optional
- Output Current:	± 5 ma
- Output Filter:	4-pole active Bessel, Butterworth or Tschebychev optional
- Conversion Accuracy:	±0.05% FS ± LSB at 25°C
- Temperature Coefficient:	20 ppm/°C
- Time Code Data:	Days, hours, minutes, and seconds may be read from tape records and displayed.

Tape Transport Characteristics

- Format:	IBM compatible
- Number of Tracks:	9-track
- Density:	6250 BPI, GCR
- Record Length:	4096 bytes
- Tape Speed:	125 ips

APPENDIX F

Specification for RTD Signal Conditioner

- Analog/digital integrated circuit design.
- 117V AC 60 Hz or 24V DC ±10% regulation.
- Nominal ambient temperature range −20°F/120°F.
- Calibration accuracy ±0.10%.
- Linearity/repeatability ±0.10%.
- Temperature sensitivity ±0.0025%/°F.
- Line voltage sensitivity ±0.0001%/1% line change.
- Signal isolation from dc power source is standard.
- Optional input to output signal isolation is 1kVp-p.
- Extremely high common/normal mode rejection.
- Digital circuit resolution, 10 bit minimum.
- Zero droop sample-hold and ramp generator circuits.
- Output circuits.

  Current (automatic ΔR loop correction)

  1/5mADC into 0-2400 Ωstd., 0-5000 Ωopt.,
  4/20mADC into 0-600 Ωstd., 0-1500 Ωopt.,
  10/50mADC into 0-300 Ωstd., 0-600 Ωopt.

  Voltage (nominally zero source impedance).

  0 to 10 mADC into load.

  Control Relay, 10 Amp contacts, resistive.

  Pulse, any V or I, source or sink.

- Input impedances.

  1/5mA is 200 Ω, 4/20mA is 50 Ω, 10/50mA is 20Ω.
  V and mV is greater than 10 megohm.