REV: 0
MARCH 28, 1983

Control Room Design Review

Implementation Plan Report

The South Texas Project

HOUSTON LIGHTING & POWER COMPANY

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ACRONYMS AND ABBREVIATIONS

AO	Auxiliary Operator
ASSOC	Associated
ASST	Assistant
AUX	Auxiliary
CAT	Category
CLO	Checklist Observation
CONT	Control
CR	Control Room
CRDR	Control Room Design Review
CRT	Cathode Ray Tube
CVCS	Chemical Volume Control System
EES	Emergency Event Sequences
EOF	Emergency Operating Facility
EPRI	Electric Power Research Institute
ESF	Engineered Safety Feature(s)
EST	Estimate(d)
EXPER	Experience
FW	Feedwater
HE	Human Engineering
HED	Human Engineering Discrepancy
HL&P	Houston Lighting and Power Company
HPSI	High Pressure Safety Injection
I&C	Instruments and Controls
INPO	Institute of Nuclear Power Operators
INSTR	Instrument
LDR	Leader
LOCA	Loss of Coolant Accident
LPSI	Low Pressure Safety Injection
M/M	Man/Machine
MCP	Main Control Panel
MON	Monitor

ACRONYMS AND ABBREVIATIONS (Cont.)

MW(e)	Megawatts (electric)
NOS	Numbers
NRC	Nuclear Regulatory Commission
OERT	Operating Experience Review Task Group
OSC	Operational Support Center
PORV	Power Operated Relief Valve
PRT	Project Review Team
PSAR	Preliminary Safety Analysis Report
RAS	Recirculation Actuation Signal
PZR	Pressurizer
RCB	Reactor Containment Building
RCP	Reactor Coolant Pump
RCS	Reactor Coolant System
RECIRC	Recirculating
REQ'D	Required
RO	Reactor Operator
RWST	Refueling Water Storage Tank
RX	Reactor
SBCS	Standby Cooling System
SG	Steam Generator
SIS	Safety Injection System
SOE	Selected Operational Event(s)
SPDS	Safety Parameter Display System
SRO	Senior Reactor Operator
SS	Subsystem
STAT	Systems Task Analysis Team
SUPVR	Supervisor
SW	Switch
SYS	System
TMI	Three-Mile Island
TSC	Technical Support Center

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PREFACE

The control room design review (CRDR) of the South Texas Project (STP) Nuclear Generating Station was started in September 1982. This review is being performed by Torrey Pines Technology for Houston Lighting & Power Company (HL&P) with Bechtel Energy Corporation (Bechtel) acting as agent.

Prior to completion of the CRDR, a decision was made by HL&P to redesign six of the ten main control panels. This redesign effort is required to accommodate design changes resulting from plant design evolution and Reg. Guide 1.97 requirements. Human engineering discrepancies determined in the CRDR for the six panels will be corrected in the redesign effort.

The CRDR is described in the Program Plan document. It contains a detailed description of the tasks to be performed and the reports documenting the overall results. Due to the control room redesign effort, a modified approach is required to complete and document the CRDR program. The following changes have been made in the CRDR:

A. The documentation program described in the Program Plan was changed to allow reporting of results on the individual CRDR tasks.

B. An Implementation Plan Report, was written to describe the background and reasons for the redesign effort. It outlines the approach to be used for implementing panel layout changes.

C. The tasks described in the Program Plan will be completed for the original design. The SFTA and the control room survey will be updated to validate any design revisions.

This report is one of several documents (See Figure 1) that describe the CRDR and the associated redesign effort on the STP control panels. The following is a description of these documents:

A. Program Plan - Defines the plan for performing the CRDR.

B. Criteria Report - Provides the basis for the CRDR and describes the interface between the control room and plant systems.

C. Operating Experience Review Report - Describes the review process results, conclusions and recommendations of the operating experience review (OER) task defined in the Program Plan.

D. System Function and Task Analysis Report - Describes the methodology, results, conclusions and recommendations for the SFTA effort defined in the Program Plan.

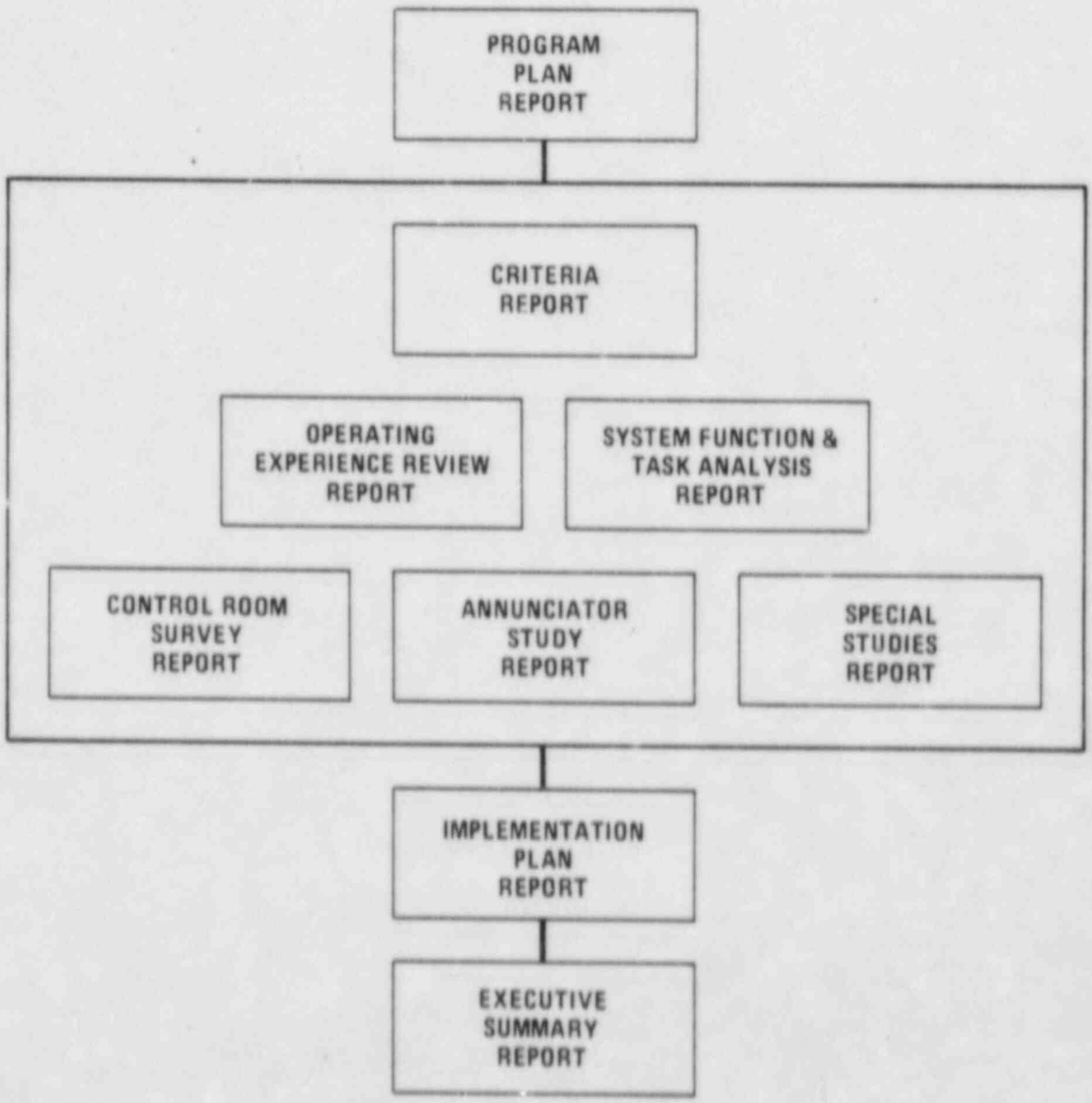
E. Control Room Survey Report - Describes the review process, results, conclusions and recommendations of the control room survey task defined in the Program Plan. This report also includes the final results and dispositions for the human factor observations obtained from the OER and the SFTA.

F. Annunciator Report - Describes the review process, results, conclusions and recommendation of the annunciator review task defined in the Program Plan.

G. Special Studies Report - Describes details of any miscellaneous studies performed as part of the CRDR. This will include the anthropometric study, the hierarchial labeling study and the demarcation study.

H. Implementation Plan Report - Summarizes the CRDR, the control room design changes, and the proposed methods of implementing the design changes.

I. Executive Summary - Summarizes the CRDR, results, conclusions and recommendations. Technical details are in the Operating Experience Review Report, the System Function and Task Analysis Report, the Control Room Survey Report, the Special Studies Report, and the Annunciator Report.



STP – MAJOR REPORTS

Figure 1

SUMMARY

This report details the implementation measures planned for the South Texas Project control room, the status and results of the control room design review (CRDR) through February 1983, and reviews the activities associated with the management team decision to make major panel design changes.

The CR DR process has progressed principally in conformance with the Generic Letter No. 82-33, "Supplement 1 to NUREG-0737- Requirements for Emergency Response Capability" and the Program Plan submitted to the NRC October 20, 1982. Through the control room review process, it became apparent that the status of engineering for the process systems, annunciator, and computer were undergoing revisions with a significant impact on the control panels. The human factors checklist observations, operator interviews, and system function and task analysis were also finding a number of observations that would have a significant impact on the control panels. Because of these factors the management team directed the DRT to review five alternatives as follow:

Alternative 1: Re-layout all panels with existing devices to meet all TMI, engineering, and human factors requirements.

Alternative 2: Leave everything "as-is" and use existing free space for the addition of new devices required by TMI and engineering requirements.

Alternative 3: Re-layout all panels with new miniature devices to provide space for other devices required to meet TMI and engineering requirements.

Alternative 4: Re-layout of the safety-related panels CP001 through CP006 with existing devices, modify the remaining panels CP007 through CP010, to resolve human engineering discrepancies and accomodate design evolution impacts.

Alternative 5: Re-design all panels on a modular concept using miniature devices and using a new and smaller foot-print.

Alternative 4 was selected on the basis of schedule. Bechtel placed a hold on the control boards ordered to the original panel layout and ordered new control boards based on a new layout to be completed by July 1983, with panel deliveries starting in January 1984.

The following outlines the status and work remaining in the major program elements covered in the following reports:

A. Criteria Report

This report includes all the NUREG-0700, Section 6 guidelines that have direct applicability to this plant. In addition, it includes definitive requirements for related subjects such as the Safety Parameter Display System (SPDS) and the annunciator system.

This report is completed, reviewed by the Project Review Team (PRT), and approved by the Management Team (MT). An additional revision is planned for the final program stage to make minor corrections and additions.

B. Operating Experience Review Report

This report covers the results of the operations personnel responses to questionnaires and interviews. The results provided excellent correlation with the observations noted in the control room survey, the annunciator review, and the system function and task analysis (SFTA).

The report is completed, reviewed by the PRT and approved by the MT. One more revision will be made during the final program to incorporate operations reaction to the implementation activities covered herein.

C. System Function and Task Analysis Report:

This report covers the SFTA of six plant events. The guidelines of NUREG 0700 were closely followed. The analysis of six events provided graphic evidence of the need to revise panel layouts; particularly those panels, for Engineered Safety Features (ESF). This activity constituted a major portion of the design review effort and promises to be a very useful tool in the redesign effort.

The report is completed, reviewed by the PRT and approved by the MT. An addendum to this report is planned to cover the pertinent implementation activities.

D. Control Room Survey Report

This report will include the results of the checklist observations, those processed into HEDs, and corrective actions planned with a schedule for such actions. It will contain a complete set of observations as processed through the PRT and MT.

All checklist forms have been completed for the original layouts of panels CP001 through CP010 and are in the review cycle.

It will be necessary to recheck several criteria for the revised panels. This work will proceed as each panel layout is developed.

E. Annunciator Study Report

This report will include the review results of the annunciator study. This will also include the plant computer alarm functions and the ESF Bypass and Inoperable Status.

To date, the study results indicate a need for finalization of the annunciator and I/O input definition. Rearrangement, size and location of window boxes and tiles will be done when the control panel arrangements are firmed-up.

A preliminary annunciator review report, covering the current status, is being reviewed by the PRT. The following work will be completed after the input/output (I/O) lists are updated and the new panel layouts are available: prioritization of alarms, recheck of appropriate checklist items, rearrangement of tiles and window boxes, and final allocation of alarms between the computer and main annunciator.

F. Special Studies Report

This report will cover expanded human factors studies as needed such as anthropometry, labeling, demarcation, and console-desk design.

The anthropometry study is completed. The ground rules for the labeling and demarcation are completed and the console conceptual design is completed. These will be completed concurrent with the planned main panel layout changes.

G. Executive Summary Report

This report represents the principal document for reporting the results of the CRDR. It includes an introduction, methodology, summary of the review tasks and evaluation results, and tabulations of the disposition of observations and corrective actions tied to plant schedule.

The outline for this report is completed. This report is in an early stage of preparation and is scheduled for completion by September 1983.

1.0 INTRODUCTION

A considerable number of design changes were required on the STP control panels as a result of Reg. Guide 1.97 requirements, engineering design requirements and the CRDR. This Implementation Plan Report describes the plans for implementing these design changes.

The following details are presented:

A. A comprehensive discussion of the control room design changes.

B. A summary of the CRDR work completed to date.

C. A discussion of the CRDR observations

D. A description of the engineering design changes.

E. A discussion of five implementation alternatives that were evaluated for presentation to the management review team.

1.1 OBJECTIVE

In September 1982, the CRDR of the South Texas Project (STP) Nuclear Generating Station was started. This review was intended to accomplish the following:

A. Determine whether the control room provides the system status information, control capabilities, feedback, and analytical aids necessary for control room operators to accomplish their functions effectively.

B. Identify characteristics of the existing control room instrumentation, controls, physical arrangements, and other equipment that may impact optimum operator performance.

C. Analyze and evaluate potential problems that could arise from this review.

D. Define and put into effect a plan of action that applies human factors principles to enhance operator effectiveness. Particular emphasis is to be placed on improvements affecting control room design and operator performance under abnormal or emergency conditions.

E. Integrate the CRDR review with other areas of human factors inquiries identified in the NRC Task Action Plan.

The CRDR was performed according to NUREG-0700 guidelines and in compliance with the NRC letter, "Supplement 1 to NUREG 0737 - Requirements for Emergency Response Capability (Generic Letter No. 82-33)."

2.0 IMPLEMENTATION

2.1 BACKGROUND

Approximately two months into the CRDR it was determined that a significant number of control panel changes would be required to resolve the HEDs. Also, Bechtel Engineering indicated that many other devices must be added to the panels. These additions were a result of normal design evolution and the changes required to satisfy Reg. Guide 1.97 requirements.

In November 1982, a MT meeting was held to review the changes required for the control panels. At this meeting, a decision was made to evaluate five possible alternatives for incorporating the required design changes. These alternatives are discussed in detail in Section 5.0.

Evaluation of the five alternatives were presented to the MT December 20, 1982. The MT decision was to proceed with Alternative 4, which consisted of a complete redesign of panels CP001 through CP006 and retention of panels CP007 through CP010 to the extent practicable. This decision was based on an evaluation of the feasibility, scheduling and licensing factors influencing each alternative.

Alternative 2, adding the new devices in spare spaces created by removing HVAC, etc., did not create enough space on panels CP005 and CP006, and was discarded. The use of new devices, as proposed in Alternatives 3 and 5 could not reliably meet scheduling requirements. Alternatives 1 and 4 ranked equally in most respects, however, Alternative 4 preserves the panels that have been constructed, and was judged the more desirable. A summary of the factors considered versus the relative impact of each is presented in Table 2.1-1.

The effect of a proposed change to the overall plant construction schedule was considered to be of primary importance by the MT. Bechtel engineering was directed to implement

Alternative 4. The CRDR, which was interrupted in order for the alternative studies to be performed, was resumed. At the time of this decision, major sections of the CRDR were not complete. Completion of these studies will assure that the revised layout satisfies the criteria established for the control panels by providing a means for checking the changes.

X DOES NOT MEET CRITERIA	RE-LAYOUT SAME HARDWARE	RESOLUTION OF HED'S	RE-LAYOUT NEW HARDWARE	RE-LAYOUT TO NRC REQMTS + RESOLVE HED'S	ALTERNATE FABRICATION TECHNIQUES
ALTERNATIVE / CRITERIA	1	2	3	4	5
RACEWAY DESIGN	X		X	X	X
PANEL DELIVERY			X		
ELEC DESIGN (LOGICS, EWD'S)			X		X
CABLE PULL			X		X
SAME PROFILE	X		X		X
SAME FOOTPRINT					X
CONSISTENT WITH CRDR PLAN					
EXPANSION	X	X		X	
LICENSABILITY/ HFE'S		X			
AVAILABILITY/HFE		X		X	

SUMMARY OF ALTERNATIVE EVALUATION
Table 2.1-1

2.2 IMPACT ON MAIN CONTROL PANELS

Alternative 4 provides the basis for implementing the changes identified by the CRDR and other requirements. The results and recommendations from the following sources are to be incorporated into the new design:

A. Design Evolution
B. Post TMI Changes
C. SFTA Results
D. Control Room Survey (HEDs)
E. Operating Experience Reviews
F. Annunciator Study

Changes in the plant design have required additional controls and displays. There are about 125 devices to be changed, affecting all control panels. Section 4.0 lists these devices by panel and by system. Post-TMI regulatory changes (Reg. Guide 1.97) involve the addition of about 100 devices, primarily for safety-related systems. These changes are also presented in Section 4.0.

Significant changes to the control panels would be required to accommodate the Reg. Guide 1.97 and the engineering design changes. It was determined that panels 005 and 006 did not have sufficient available free space to mount the new devices. On the other panels, the addition of new devices involved either moving existing devices to make a logical arrangement, or adding the new devices in existing space without regard to functional grouping. Relocation of the HVAC controls and the recorders to two new panels outside the primary control would result in enough gained area to accommodate the new identified devices, with adequate spare space.

The most significant observation obtained from the SFTA was excessive operator movement resulting from the train-oriented layout of panels 001, 002, and 003. Other observations included the charging and letdown system devices not arranged by function on CP004; the pressurizer and reactor devices not arranged by function on CP005; the

auxiliary feedwater control from CP006 and the ESF panels not grouped by task; and the PORV controls from panels 006 and 007 not grouped by task. Other SFTA observations related to the functional grouping of specific subsystems to conform with the sequences of actions the plant operators perform at each work station.

The results of the control room survey, the operating experience review, and the annunciator study have been detailed in separate reports. The discrepancies noted in those reports, in the form of checklists, are being resolved by the methodology described in the Program Plan and the resulting changes will be incorporated into the control board during the redesign effort.

The implementation of the recommendations of the above described studies requires a functional allocation of the available space, to properly orient the major segments of the plant controls in relation to function and frequency-of-use. The following paragraphs describe the proposed panel changes to accommodate the observations from all sources as described above.

2.2.1 ESF Panels - Proposed Changes

The original train-oriented layout of the ESF panels can be revised to a system-oriented layout as illustrated in Figure 2.2-1. Each of the areas identified in the figure has space allocated for the controls of the three ESF trains of that system. The electrical auxiliaries section on CP003 is part of the additions required by design evolution. Auxiliary feedwater controls are to be relocated to CP006 as indicated by operations and by the SFTA results. The indicators on CP002 used for post accident monitoring are located too high on the panel section for accurate operator viewing and were poorly located for use during an event. These can be integrated into the systems so that safety grade instrumentation is available at a work station when needed.

The location of ESF systems can be arranged, on the proposed allocation, as suggested by the SFTA, and modified by comments provided by HL&P operational staff.

2.2.2 Primary Coolant, Reactor and S/G Controls (CP004 through 006) - Proposed Changes

The proposed layout for panels CP004, 005, and 006 is illustrated in Figure 2.2-2. The controls for radiation monitoring are to be relocated to the operator's console and the recorder panel. The CRT and associated keyboard that were dedicated to radiation monitoring functions will be removed. The remaining devices will be shifted to the left, with no major revision in arrangement between systems. Changes within systems, to improve the functional grouping, will be made to satisfy the observations from the SFTA, the control room survey, and the operators. Also, the pressurizer functions will be moved to CP004 to provide added space on CP005.

The auxiliary feedwater controls will be moved from CP001, 002 and 003 to CP006, and the PORV and MSIV controls will be relocated from CP007 to CP006 to provide the operator with the necessary controls in a functional arrangement better suited for control under stressful conditions. Post accident monitoring instruments will be integrated into the system layouts for more convenient usage.

2.2.3 Secondary Plant and Electrical Distribution (CP007 through 010) - Proposed Changes

The proposed systems layout for panels CP007 through CP010 is illustrated in Figure 2.2-3. These panels have been completely constructed at the panel fabrication shop.

The objective of Alternate 4 is to make minimum changes to them. The HVAC controls on CP009 will be relocated to a new panel out of the primary control area, as will the three multi point recorders. The PORV and MSIV controls will be grouped with the steam generator controls on CP-006, and generator breaker controls added, as indicated by the SFTA results and the operators. This change eases operation during placing the turbine on-line. A full-flow deaerator will be added to CP008 as part of the identified design evolution changes.

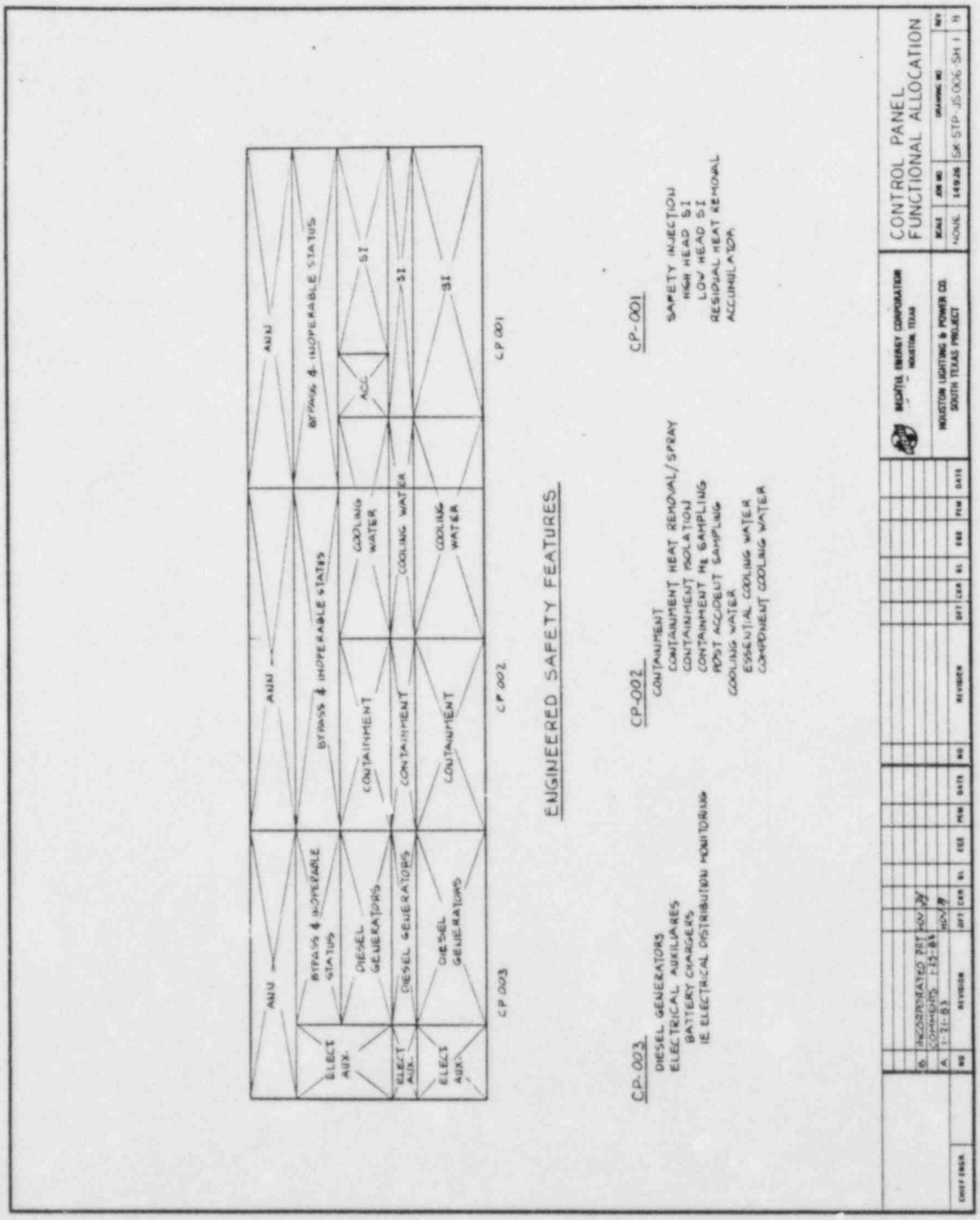


Figure 2.2-1

FUNCTIONAL ALLOCATION

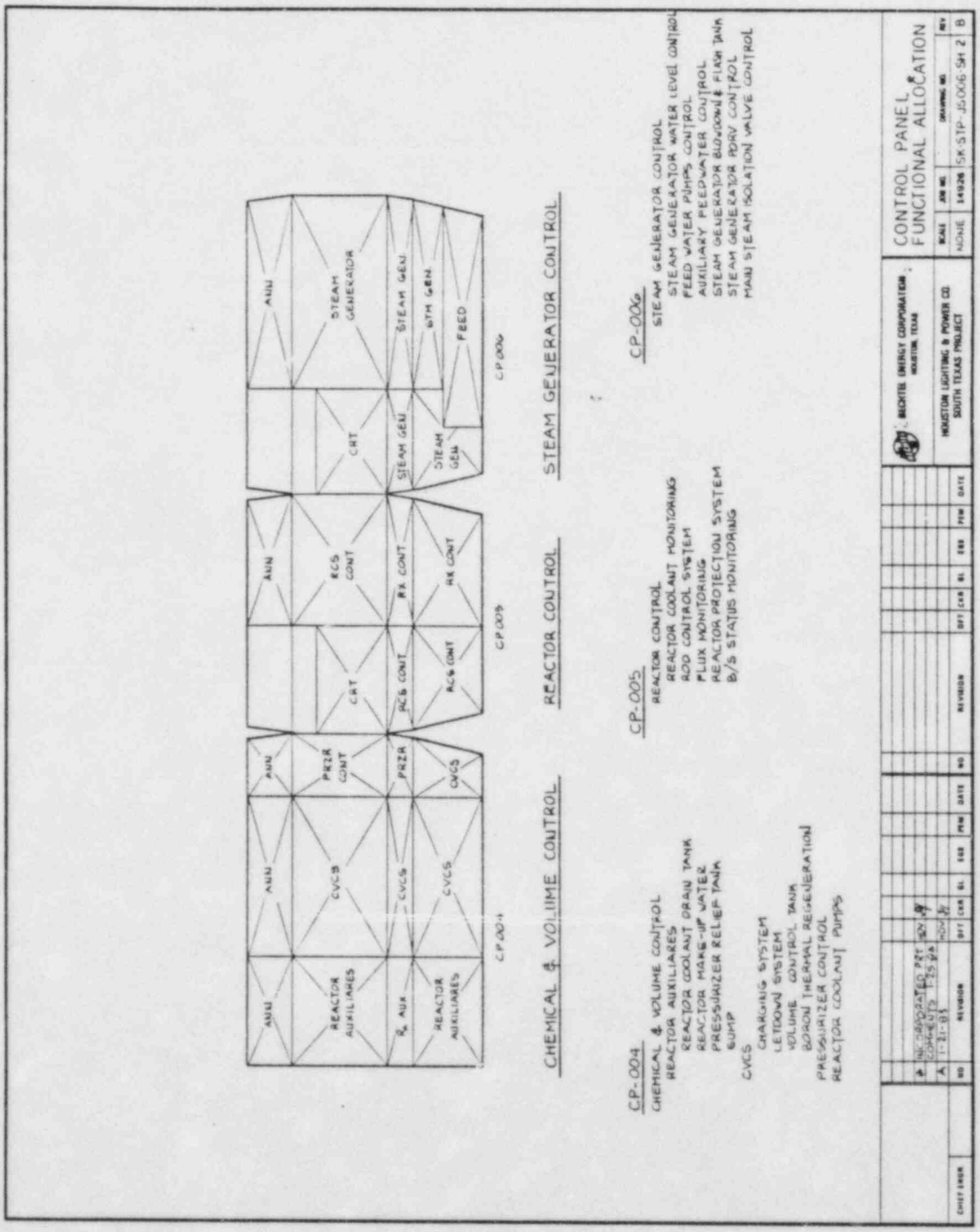


Figure 2.2-2

FUNCTIONAL ALLOCATION

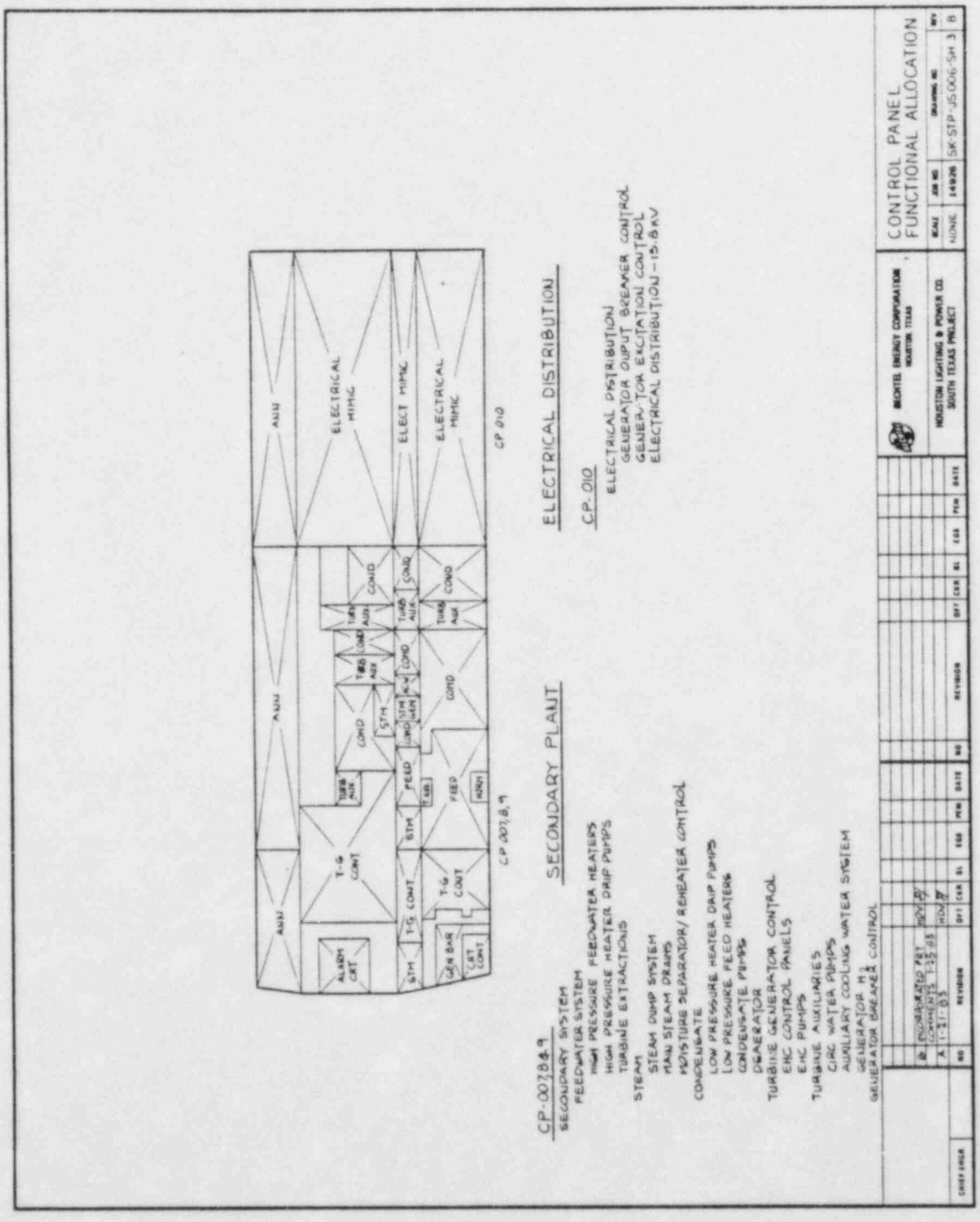


Figure 2.2-3

FUNCTIONAL ALLOCATION

2.3 ANNUNCIATORS AND PLANT COMPUTER

The Annunciator Report identified 17 recommendations for upgrading the usability of the annunciator and computer alarm systems. These are detailed in Section 3.9. The annunciator study is incomplete. Work is scheduled to resume after the control board layout is firmed up. The tasks remaining are:

A. Prioritize the alarms in the annunciator and computer systems

B. Complete the remaining checklist items that relate to hardware evaluation and final layout

C. Rearrange the individual alarm tiles.

2.4 OPERATOR'S/SUPERVISOR'S CONSOLES

These consoles were not a part of the mock-up; however, a conceptual arrangement is presented on sheet 5 of SK-STP-JS006 (Figure 2.4-1). As envisioned, there should be two consoles, one for each of the two operators. The back of one of them will have adequate work space for the supervisor. Plant operations normally consist of steady state conditions with the unit at base load and all control systems in automatic. The operator should be seated at a desk supervising operations. Yet he must have direct access to the controls to take immediate action in case of an unexpected transient. The supervisory console is a means of combining computer interface and communications functions that are the nucleus of total plant supervision. The video functions on the supervisory console must coordinate the SPDS, Regulatory Guide 1.97 requirements, and the plant computer. About 20 parameters should be continuously displayed. These are:

A. Average Core Power Level
B. Auctioneered Hot Leg Temperature
C. Average Primary Coolant Temperature

D. Auctioneered Cold Leg Temperature

E. Pressurizer Pressure and Level

F. Steam Generator Steam Flow (4 each)

G. Steam Generator Steam Water Level (4 each)

H. Steam Generator Feedwater Flow (4 each)

I. Turbine-Generator Megawatts

The communications center for the plant should be the supervisory console, with a telephone to the dispatcher, an intercom to health physics, radwaste, emergency shutdown, support facilities, and guard stations. A sound powered phone system serves as a backup. Alarms should be presented in a usable form, with prioritization to eliminate confusion. Fire detection, alarm, and system status should also be present here.

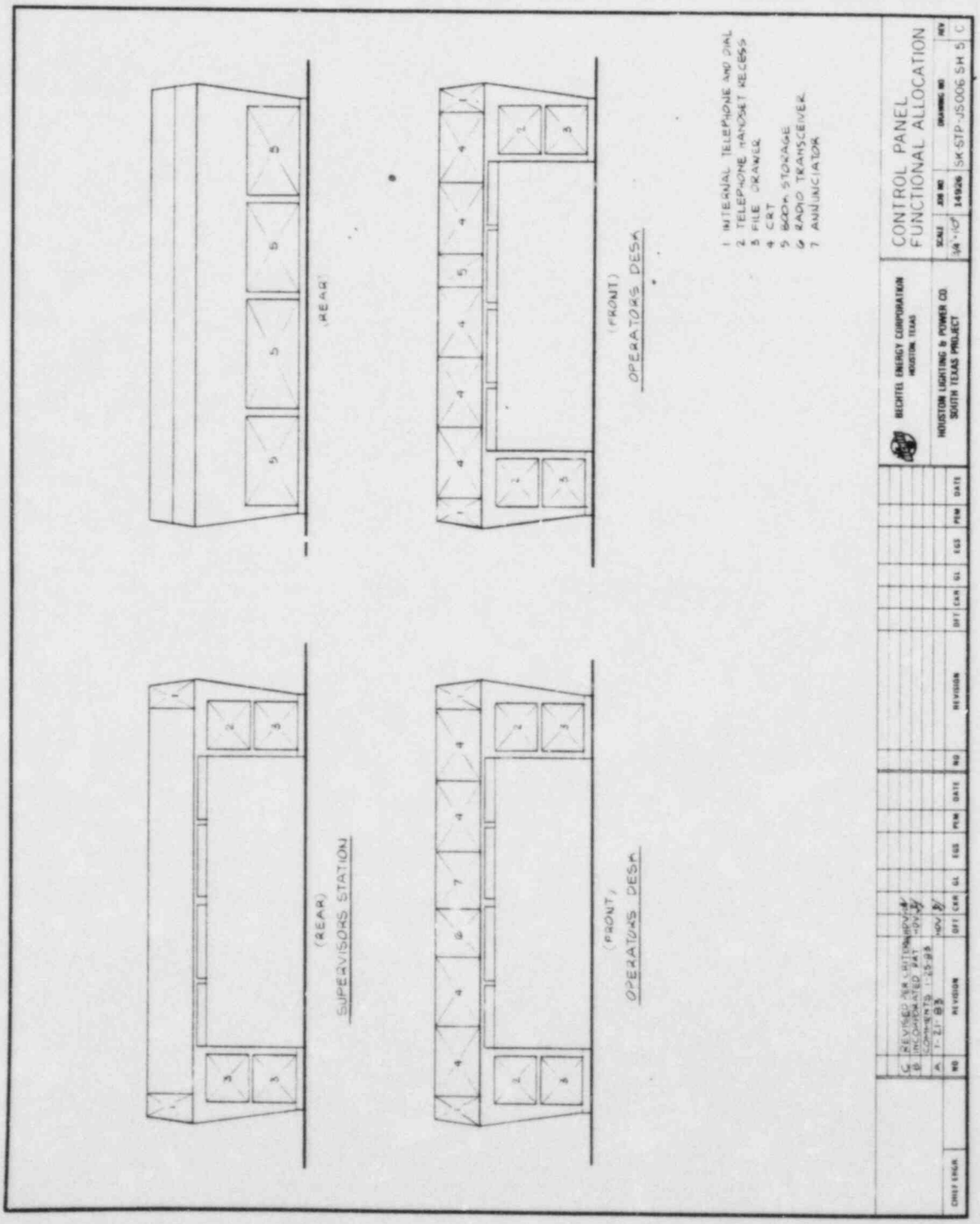


Figure 2.4-1

FUNCTIONAL ALLOCATION

2.5 ADDITIONAL STUDIES

The MT authorized two additional special studies, hierarchial labeling and demarcation. The relationships between labels for individual components, sub-systems, systems, and groups of systems are stated in NUREG-0700 in terms of viewing distance and ratios between classes of labels. A set of standard abbreviations for use on STP is given in the Criteria Report. The size of each class of label needs to be chosen, and character size, stroke width, separation, etc. determined. This study can be performed in parallel with control board layout, and is not a limiting factor in the panel delivery schedule.

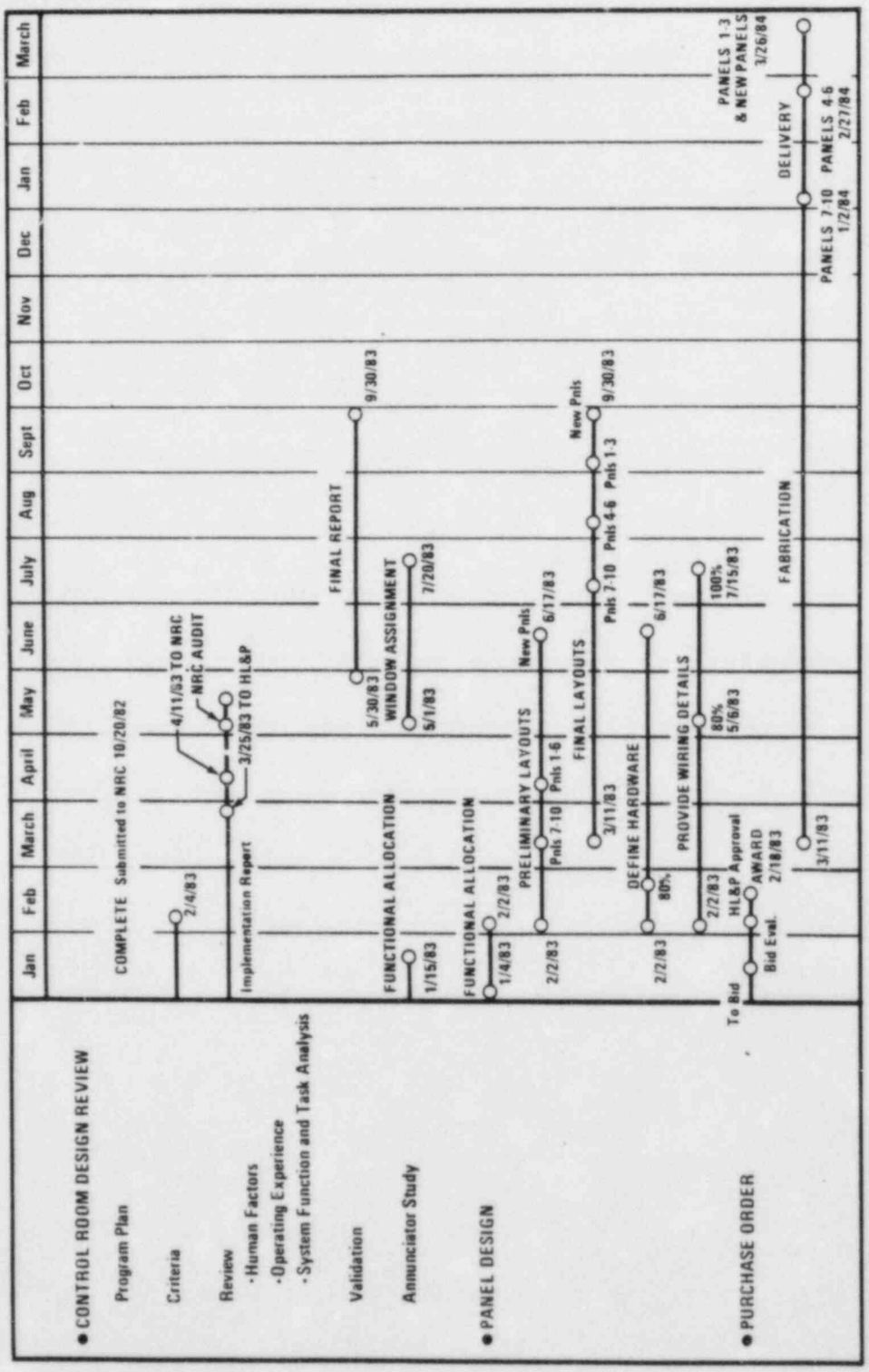
The present panel design uses demarcation on the ESF panels and on CP006 and uses mimics only on the electrical distribution panel. The Criteria Report identifies demarcation as a technique used to set apart groups of controls. Parameters such as size, color and quantity need to be selected and incorporated into the new design.

The functional allocation of control board space determines the relation between work stations. The location of systems within each work station, and of devices within each system is an ongoing effort. This design effort must integrate the functional requirements of a system, within the constraints of panel configuration (i.e. reach restraints of the vertical sections), and must incorporate the results of all the CRDR studies. These include both the SFTA results and the HEDs approved by the PRT.

2.6 SCHEDULE

A project schedule for completion of the CRDR, panel design, fabrication, test, and delivery that is consistent with the STP construction schedule was developed as illustrated in Figure 2.6-1. Construction requires approximately six months to complete, and is scheduled to start mid-July 1983, with main-frame design and construction preceding

this date. The detailed layout revision has started and will finish in mid-June. The final layout will be assessed by the CRDR team to verify compliance with criteria, and to assure that no new problems have been introduced into the design. This evaluation, with the annunciator/computer tasks described in Section 3.8, the special studies described in Section 2.5, and a validation walk-through with operations personnel, will complete the CRDR. The Executive Summary will document the results and summarize the overall program, and will be issued in October 1983.



CONTROL ROOM DESIGN REVIEW AND
CONTROL PANEL MILESTONES
Figure 2.6-1

3.0 CRDR SUMMARY

3.1 PROGRAM PLAN

The CRDR effort started with the development and documentation of a Program Plan. This plan was presented to the NRC at Bechtel, Houston on October 5, 1982 and the document was submitted to the NRC on October 20, 1982.

The Program Plan presented a brief description of the objectives of the CRDR, a plant description, a definition of the control room, and a description of the control room design/fabrication status. Also, the plan presented a detailed list of the tasks that were to be completed in the CRDR. These were as follows:

A. Preparation of control room design and review criteria which were to be included in the Criteria Report.

B. An operating experience review that includes a review of pertinent operating experience documents and an interview with control room operations personnel.

C. A systems function and task analysis (SFTA) of the control room complex during selected operational events.

D. An inventory of controls, instrumentation, displays and other equipment on the control room man/machine interfaces.

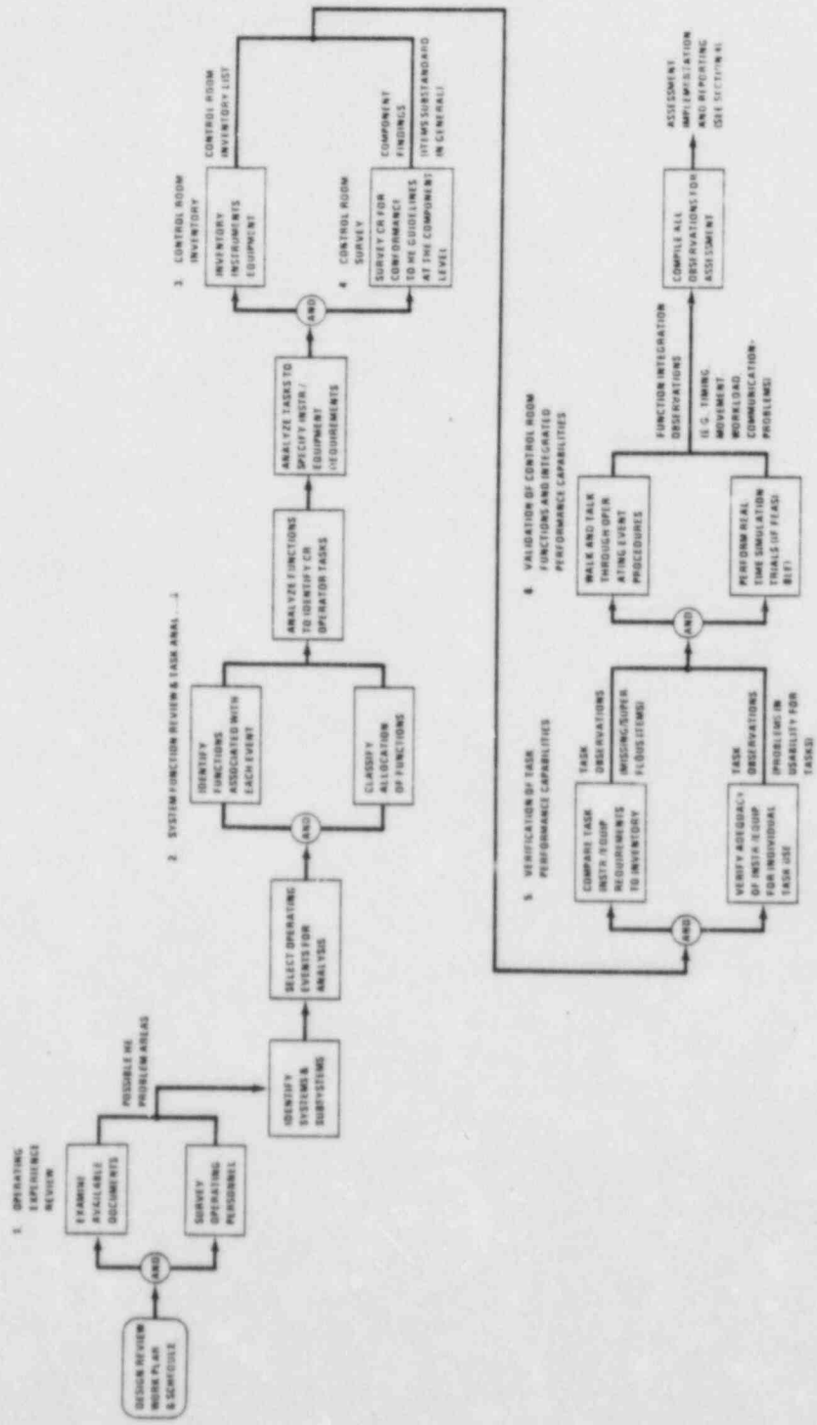
E. A control room survey of the full scale mock-up (located in the Bechtel-Houston engineering offices) with regard to the human factors criteria presented in the Criteria Report (and in NUREG-0700).

F. A verification of the availability of instruments and equipment needed to implement the tasks identified in the SFTA.

G. A validation of whether the control room operating crew can perform allocated functions within defined procedures using walk-through/ talk-through techniques on the mock-up.

H. A design review of the alarms of the main plant annunciator, plant computer and ESF bypass and inoperable status system.

An overview of the relationship of the above tasks (from NUREG-0700) is shown in Figure 3.1-1.



OVERVIEW OF CRDR PROCESSES
Figure 3.1-1

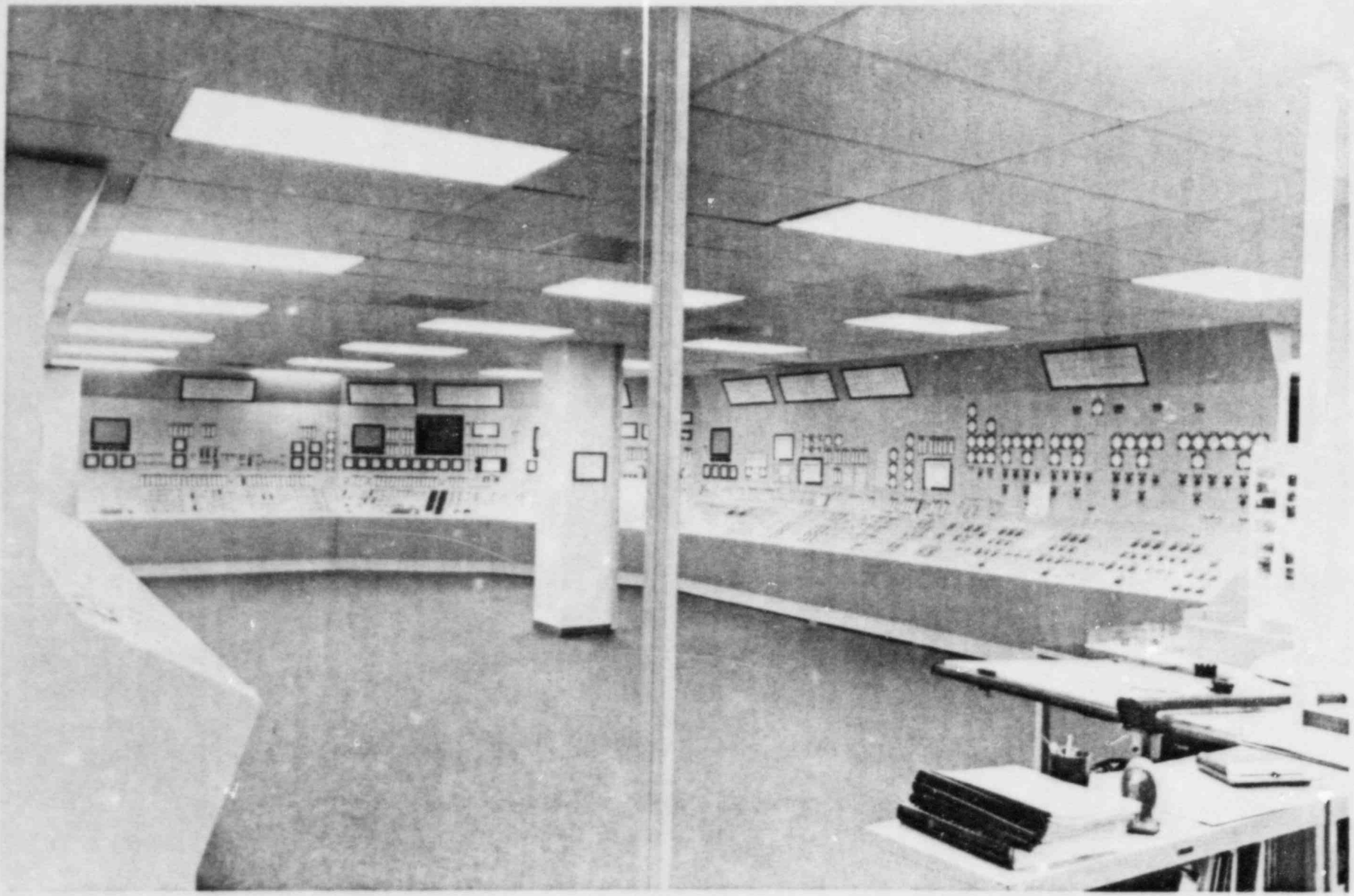
3.2 MOCK-UP

To aid in the CRDR, a full scale mock-up of the STP control room was fabricated in the Bechtel-Houston engineering offices. Figure 3.2-1 is a photo of the mock-up. It consists of full scale models of control panels 001 through 010. All the panel controls and displays are shown on the panel faces using reproductions of the equipment. All devices are shown in their proper locations and nameplates, labels, lines of demarcation, mimics, etc. are represented.

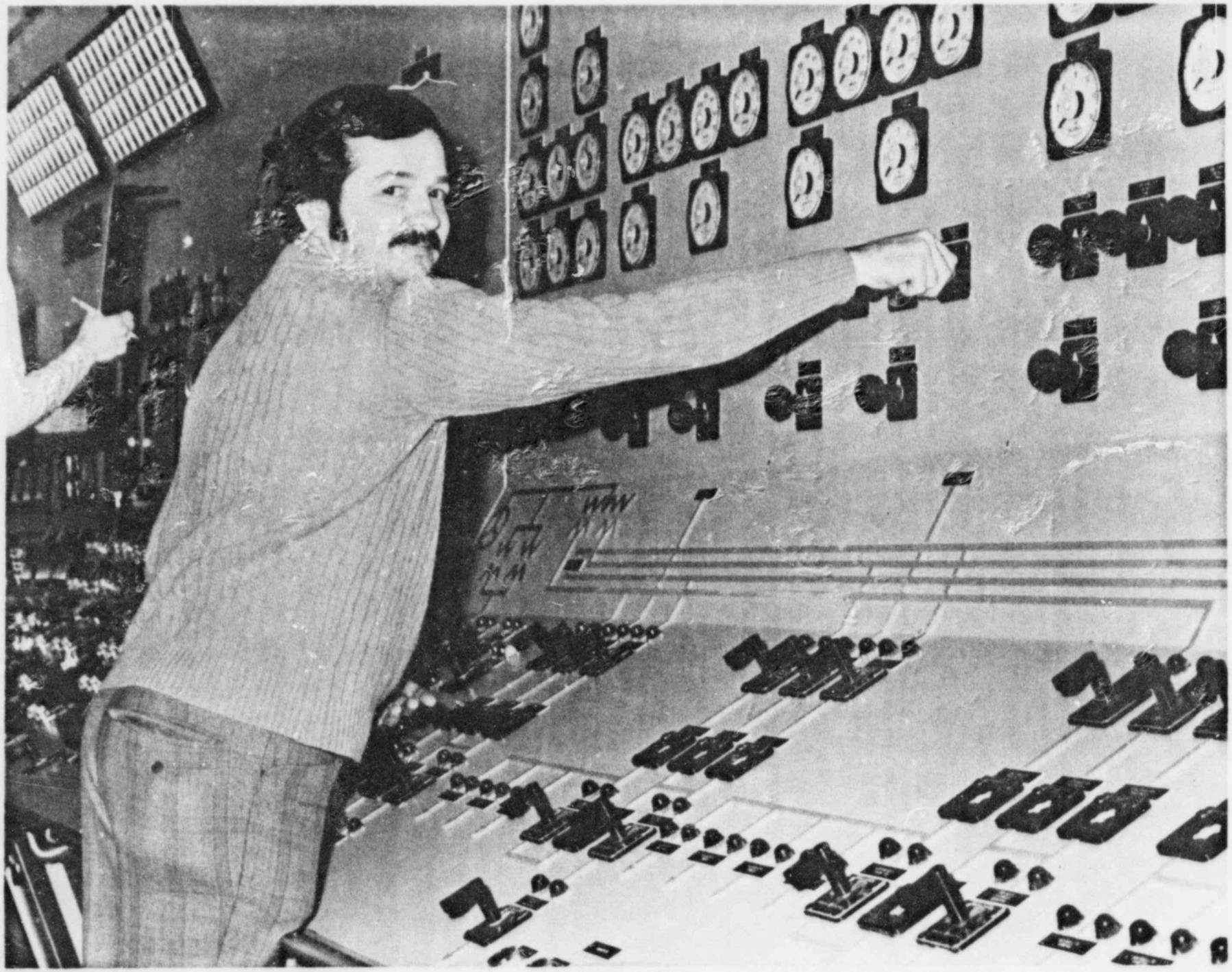
The mock-up was used in nearly all phases of the CRDR. In the control room survey most of the observations relating to visual displays, labels and location aids, panel layout, and control-display integration were obtained from a review of the mock-up. In the SFTA the functional and task related grouping of devices was evaluated on the mock-up. And in the operator experience review the interviews and questionnaires were based on walk-throughs of the startup Selected Operating Event (SOE) performed on the mock-up.

Certain human factors criteria could not be evaluated on the mock-up, such as communications, process computers and some of the control room workspace items. Hardware related criteria could not be evaluated on the mock-up. Most of these criteria were reviewed at the simulator (Figure 3.2-2) or computer facilities (Figure 3.2-3). A small number of criteria, such as sound level and control room illumination, will be reviewed at the plant when the control room is completed.

The mock-up will be used extensively in the panel redesign effort. All the control device reproductions on the mock-up are mounted on 1/8-inch acrylic backing plates to allow easy removal and relocation. Preliminary layouts of the control panels will be performed on the mock-up by rearranging the mock-up devices. As the redesign effort progresses the device layout on the mock-up can be easily revised to reflect the latest design. Eventually the equipment arrangement on the mock-up will be completely updated to show the final layout of all ten control panels. This version of the mock-up will then be used for the final CRDR.



STP CONTROL ROOM MOCK-UP
Figure 3.2-1



STP SIMULATOR
Figure 3.2-2

STP COMPUTER
Figure 3.2-3

3.3 CRITERIA REPORT

The Criteria Report was established to accomplish the following:

A. Provide the CRDR team with a basis for reviewing the control room. The criteria include the human factors guidelines specified in NUREG 0700, with minor modifications to account for plant specific features applicable to the STP.

B. Provide project personnel with a document that would integrate the plant systems and promote a unified and coordinated design with regard to the control room interface.

The Criteria Report is divided into two major parts. The first part, or the main body, contains criteria relevant to the control room design. The second part contains the human factors guidelines relevant to the various design criteria as well as appendices.

The main body describes the functions of the control room, the systems controlled from the control room, and the control room layout features. In addition, it defines design criteria for the following topics:

A. Main control panels
B. Human factors
C. Communications
D. Control room annunciation
E. Post-accident monitoring
F. Bypassed and inoperable status
G. Safety parameter display
H. Plant computer

The appendices describe the human factors guidelines appropriate to the topics covered in the main body of the document.

The initial draft of the report was prepared and submitted to the PRT early in the CRDR program. The document was reviewed by the PRT and comments were resolved. The document was submitted to the MRT January 20, 1983. The MRT comments were incorporated, and Rev. 0 of the document was formally issued February 4, 1983.

3.4 CONTROL ROOM INVENTORY

An inventory of the controls, instruments, displays, and other equipment on the control room panels was performed. The results served as a reference data base to verify that all the devices were properly represented on the control room mockup. In addition, the inventory provided a means to verify that all of the devices required by the SFTA (for those emergency events analyzed) were available in the control room.

The inventory consists of a computer listing that identifies all the devices on the control panels. The listing contains a unique component identification code, the panel number where installed, the nameplate engraving, and certain characteristics appropriate for the component. The inventory must be updated because several additions are required to meet the post-accident monitoring requirements defined in Reg. Guide 1.97. In addition, a number of additions have been identified by Bechtel engineering design disciplines. These inventory changes are undergoing a design review.

3.5 OPERATING EXPERIENCE REVIEW

The main purpose of the operating experience review (OER) was to identify human factors related concerns of the control room operations personnel. A second purpose was to identify problems associated with systems operability on those systems controlled from the control room. The latter information has been included with the SFTA and the control room survey as part of an overall and comprehensive CRDR effort.

Questionnaires and interview sheets were prepared considering the special knowledge and experience level of the operations personnel interviewed. The questionnaires were structured to secure basic information and to help prepare the operations personnel for interviews with the human factors consultants. Eleven operations personnel participated in the questionnaires and interviews; five were classified as senior reactor operators and six as reactor operators. One of the eleven participants was classified as the Reactor Operations Superintendent.

Applicable guidelines contained in NUREG 0700 were used to structure the questionnaire and interviews.

The content of the questionnaire fell into seven areas as follows:

A. Workspace
B. Controls
C. Displays
D. Annunciators
E. Labels/Location Aids
F. Process Computers
G. Panel Layout/Integration

The questionnaires were prepared and reviewed by TPT prior to the interviews. The interviews were held at the STP control room mock-up following a period of mock-up familiarization.

The OER results were evaluated and a report was submitted to the PRT January 14, 1983. This report is included in the transmittal covering this phase of the CRDR.

In the OER the control room operators expressed considerable concern over the human factors aspects of the control room layout. Concerns were expressed in all seven on the content areas noted above (workspace, controls, displays, etc.).

The operator's concerns are discussed in the OER report. These concerns were reviewed to confirm that they were covered by the control room survey. Thus, the CRDR observations discussed in Section 3.9 are reinforced by the OER results.

3.6 SYSTEM FUNCTION AND TASK ANALYSIS

The system function and task analysis (SFTA) represented a major effort within the overall CRDR program. The method of analysis and results of the analysis are described fully in the SFTA report. A summary of this work is presented below.

The SFTA was performed using the methodology described in NUREG 0700. The main elements of the analysis are:

A. Develop system background information according to the following:

1. Participate in a series of informal discussions in which the function and operation of the major systems and subsystems were described. Participants were the SFTA team members, Bechtel engineers from the various disciplines, and a Westinghouse representative.

2. Review STP plant documents such as the FSAR and the Westinghouse "Plant Information Package."

3. Prepare system background data sheets which include system descriptions and schematic process flow diagrams.

B. Select the operating events to be analyzed. This was accomplished by reviewing the emergency events given in the FSAR and selecting a number of events that encompass a broad use of the controls and operator task sequences. Six events were selected:

1. Normal startup from cold shutdown
2. Small break LOCA
3. Steamline break inside containment (loss of secondary coolant)
4. Steam generator tube rupture
5. Loss of all AC power
6. Turbine load rejection

C. Perform a SFTA for each selected operating event (SOE). This was accomplished by using the Westinghouse Owners Group "Emergency Response Guidelines" (ERGs) to the extent of their applicability to the STP plant. The basic analysis consisted of the following:

1. Prepare a functional sequence response for the event.

2. Expand the functional sequence into a list of specific operator tasks.

3. Prepare an operator decision - action diagram.

4. Summarize the results of the operator tasks in the form of illustrations which show the control room traffic from panel to panel and the operator activity sequence on each panel.

5. Evaluate the results from the viewpoint of the CRDR criteria document.

The SFTA was completed and the report was submitted to the PRT February 8, 1983. This report is part of the CRDR package transmitted to the NRC in preparation for an April 1983 NRC Review.

Numerous observations were made as a result of the SFTA. Those are discussed in Section 3.9.

3.7 CONTROL ROOM SURVEY

The control room survey represents the first level identification of potential human engineering discrepancies (HEDs). The human factors criteria presented in the Criteria Report were applied in the preparation of specific checklists, one set of checklists corresponding to each topic listed below, and a single checklist item for each human factors criterion. The checklist topics are:

A. Control room workspace
B. Communications
C. Annunciator warning system
D. Controls
E. Visual displays
F. Labels and location aids
G. Process computers
H. Panel layout
I. Control-display integration

The control room survey consists of a review of each control panel for compliance with each checklist criterion. The review was performed using the full size mock-up of the STP control room at the Bechtel engineering office, the computer located at the Westinghouse offices in Pittsbugh and the simulator located at the Gould plant in Long Island.

Each criterion was reviewed. If compliance was not met, an "observation" was noted and all the devices not in compliance were listed on the checklist. The number of criteria for the nine checklists is approximately 600. Since there are 10 control panels to be analyzed, approximately 6000 determinations were made. A computer program was developed with Bechtel to compile and catalog all of the information developed on the checklists.

The control room survey is almost complete, except for certain checklist criteria such as noise, illumination, and communication which will be performed after the control room is put into operation. The report on this task is scheduled to be issued in July 1983. The progress for each checklist, as of April 11, 1983, is indicated below:

A. Workspace checklist - 100% complete
B. Communication - 100% will be determined on the final control room
C. Annunciator Warning System - 100% complete
D. Controls checklist - 100% complete
E. Visual Displays - 100% complete
F. Labels and Location aids - 100% complete
G. Process Computers - 100% complete
H. Panel Layout - 100% complete
I. Control - display integration - 100% complete

The results from the survey completed thus far have produced a large number of observations. These observations which include recommendations by the Design Review Team, are being reviewed by the PRT. They will recommend dispositions based on the material in the Program Plan. Many of the observations are readily correctable, e.g., standardizing switch functions, labels and meter faces, or relocating a particular device to a new location. However, a significant number of observations relate to grouping devices by system, function, or task sequence, which affects the panel layout. These observations have broader consequences and result in relocating large numbers of devices.

Specific results and recommendations are given in Section 3.9.

3.8 ANNUNCIATOR STUDY

The purpose of the annunciator study was to perform a design review of the main plant annunciator, the plant computer alarm functions, and the ESF bypass and inoperable status system. In addition, the objective was to integrate these systems into a cohesive annunciation system considering human factors principles.

The review consisted of the following:

A. Review the available results of annunciator studies performed by the NRC and EPRI.
B. Develop criteria for the annunciator review, including prioritization and categorization of annunciator displays.
C. Prepare annunciator review checklists.
D. Perform an evaluation of the STP annunciator design based on the review criteria, and compile the observations and recommendations.

The annunciator study was not completed because the annunciator system design is not finalized. The development of criteria for the annunciator review was completed and checklists were prepared and completed on the original design. The design evaluation phase was initiated but a large fraction of the effort remains to be done. The remaining tasks are:

A. Review the latest annunciator and computer I/O lists.
B. Develop annunciator window assignments.
C. Prioritize the annunciator list.

The significant results of the annunciator study thus far are discussed in Section 3.9.

3.9 CRDR OBSERVATIONS

Although the CRDR is not yet completed several observations of potential HEDs were obtained from the initial review. The following sections discuss the observations from the major CRDR analyses.

3.9.1 SFTA Observations

An SFTA was performed for the following six operational events:

A. Small break loss of coolant accident (LOCA)
B. Steam line break
C. Steam generator tube rupture
D. Loss of offsite power (LOSP)
E. Plant startup
F. Turbine load rejection

This analysis included a functional review, a traffic flow analysis, and an operational sequence analysis of each event for ten control panels in the control room. These events were selected on the basis of criteria that provided a good cross section of operator actions for expected normal and emergency plant operating events.

The SFTA was based on human factor principles which specify that controls and displays should be placed within the control room at locations which promote efficient procedures, safe operation, and maximum operator awareness of the current system condition. There are three general principles that were considered in the arrangement of components:

A. Grouping by task sequence

B. Grouping by system function

C. Grouping by importance and frequency of use.

Grouping by tasks sequence is, from a human factors point of view, the first priority in any arrangement. Grouping by system function is considered second priority but ranks very high in importance.

The SFTA shows that the arrangement of devices on the control panels for tasks identified in the SFTA cause difficulty in performing the task and are not consistent from one system to another. The SFTA was developed from the Westinghouse Emergency Response Guidelines (ERG) which are symptom oriented. Based on these guidelines the operator must traverse from CP001, to CP002, to CP003, to CP001 26 times during the small break LOCA. The train-oriented layout of the ESF panels is the major factor in the large amount of operator travel along the ESF panels.

Following are some other SFTA observations:

A. During the turbine synchronization task the operator makes 13 trips between panels CP007 and 010. These panels are approximately 20 feet apart.

B. The diesel-generator controls and lights are located on 3 panels spanning 30 feet. During a loss of offsite power and other events, these devices must be checked for successful start and sequencing.

C. The three high-head, and three low-head, safety injection pumps controls are located on three panels spanning 30 feet. During the recovery operations from an event the controls must be attended to.

D. In the recovery operation for certain events, reset controls for each system must be attended to. These devices are located on panels that span 30 feet.

E. In the event of a steam generator tube rupture, the operator is required to "dump steam to maintain stable temperatures." The control for dumping steam is 20 feet away from the required temperature indicator.

F. In order to determine if reactor coolant system pressure is proper for shutting off the three low-head safety injection pumps, two operators must communicate across the width of the control room.

G. The following are system-to-system preferable layouts considerations as related to NUREG 0700 guidelines:

- Panel CP007 (turbine generator) and panel CP010 (electrical auxiliary power) should be located adjacent to each other and, if possible, panels 006 (steam generator) and CP007 should remain adjacent.

- Panels CP001, 002 and 003 (ESF) should be organized by systems to avoid many trips back and forth.

- Some consideration should be given to integrating functions on panels CP004 (CVCS) and 006. Startup shows 19 trips back and forth between these two panels.

A survey of six systems indicates that all controls required for each system are spread over several panels. For example, an operator must travel approximately 48 feet to address all the controls in the safety injection system, and 72 feet for the auxiliary feedwater system.

3.9.2 Control Room Survey Observations

The control room survey is not yet complete. However, there are a large number of observations that have been made thus far. These observations are being reviewed by the PRT for disposition. In addition to the observations derived from the SFTA, which are integrated with the control room survey checklists, the following types of observations were noted.

A. A large number of observations were noted due to lack of a consistent application of switch type vs function throughout the control room. Two hundred and forty six out of a total of 849 controls (about 29%) do not comply with established guidelines. Of this total the most significant contributors were cases where SBM switches (139 cases) and CR-2940 switches (51 cases) should have been used.

B. A number of observations concerning labels will require total relabeling of the control panels. A labeling specification will be written to incorporate pertinent human factors criteria.

Sample problems found with labels are:

1. Character height too small
2. Non-standard abbreviation or inconsistent use of abbreviations
3. Inconsistent engraving on simulator labels.

C. Many observations concerning the meter face scales will require adjustments or replacement of meter faces.

Sample problems found are:

1. Too many graduations between numerals
2. Graduation marks too short or narrow making the different size graduations hard to distinguish
3. Numerical progressions do not conform to criteria for progressing by 1's, 2's, 5's, or 10's or multiples of 10
4. Zone markings are not provided to indicate operating ranges.

D. Many related controls and display are not co-located.

E. Arrangements of similar equipment are not the same from panel-to-panel on the ESF panels.

F. No lamp test, dual-filament bulbs, or dual bulbs are provided for indicator lights associated with switches.

G. Legend lights on the status light boxes on CP001, 002, 003 and 005 are very hard to read. Legends contain too many words, lines of text and the engraving is too narrow.

H. Many systems are not functionally grouped. Due to the train separations, many systems are spread across many panels.

I. Controls on the vertical section of the control boards are hard to reach/access by small people.

J. No enhancement or demarcation techniques are evident on panels CP004, 005 and CP007 through 009.

3.9.2.1 Anthropometry Study

The anthropometry study discusses a number of observations related to the location of controls and displays. Some of these are outlined below:

A. Two hundred controls located above the lower panel surface do not accommodate 5-20th percentile operators using extended functional reach dimensions developed in the anthropometry study. These 200 controls are out of reach of 90% of the females and 30% of the males using functional reach dimensions in NUREG-0700.

B. The removal of the guard rail will decrease the number of out-of-reach components but then 49 controls will violate the criteria for maintaining a 3 inch clearance from the edge of the board.

C. Thirty-four strip charts located on the vertical panels of CP004, CP005, CP006 and CP007 will be very difficult to reach and observe by smaller operators. Operators could inadvertently activate components while leaning and stretching across these major control board surfaces.

D. The operators could accidentally actuate the computer keyboards on the control panels while leaning across CP005 and CP007 to manually access the strip charts. The distances of the three computer keyboards from the edge of the control panels are not standard. Inadvertent actuation of keys would be more likely on some keyboards.

3.9.3 Annunciator Review

An initial review of the main annunciator window boxes indicated the need for resizing window boxes, and organizing tiles considering system orientation. The following observations were noted:

A. Tiles per window box shall not exceed 50 (NUREG 0700): Most window boxes have room for 96 tiles. Most of these have 80 or more engraved tiles in place.

B. Inconsistency (location): RWST EMPTY tile is on top row, column 6 on CP003 and located at bottom row, column 10 on CP001 and CP002.

C. Repetitions: (above example) the RWST EMPTY tile is located on all three ESF panels.

D. Too small: The annunciators are half-size (i.e., about 3" x 1-1/2") and this results in difficulty in reading from some of the annunciator control positions.

E. Inconsistency (wording): On CP001 hydrogen is abbreviated "H", on CP007 hydrogen is abbreviated "H_2", and on CP005 hydraulic is abbreviated "HYD" (which can and has been misidentified as meaning hydrogen).

F. Hierarchy: Tiles not hierarchically located, e.g., on CP007, "Steam Generator 1A PORV in Local" is on top row of column 3 and "Main Cond. Vacuum Low - Turbine Trip" is on bottom row of column 3.

G. Vague meanings: On CP001, 002 and 003, RWST HI/LO is displayed. There is no indication of which condition is alarmed.

4.0 ENGINEERING DESIGN CHANGES

Approximately two months into the CRDR it was determined that many control panel changes would be required to resolve the potentially large number of HEDs. Also, the information presented in the systems lectures showed that many other devices must be added to the panels. These additions were a result of normal design evolution and the changes required to satisfy Reg. Guide 1.97 requirements. The following sections discuss these changes.

4.1 REGULATORY GUIDE 1.97 CHANGES

Regulatory Guide 1.97 specifies regulations for instrumentation to monitor plant variables and systems during and following an accident in LWR power plants. During accident situations, information is required to allow the operator to perform the following:

A. Perform safe plant shutdown using preplanned manual actions.
B. Determine what safety systems are functioning.
C. Determine potential for a gross breach of barriers to radioactivity release.

An assessment of these requirements for the STP control room was made by Bechtel. Appendix A presents the parameter requirements for Reg. Guide 1.97 which includes parameter, range, category, and other detailed information on the displays and controls that must be added or are already on the panels. There are about 100 of these changes.

4.2 DESIGN EVOLUTION

Several normal design changes have occurred since the control panels were originally designed. Based on a preliminary assessment, 175 additions or modifications were

identified for the ten control panels. The following presents a brief list of most of the changes for each control panel:

A. Chemical Volume Control System, CP004

1. There are four safety-grade design changes applicable to this system:

(a) Modification to the charging header of the centrifugal charging pumps. This involves the addition of two 1E valve controls.

(b) Upgrading the flow indicators on the seal injection lines. (Included in Reg. Guide 1.97)

(c) Upgrading the charging flow indicator (Included in Reg. Guide 1.97 instrumentation).

(d) Upgrading the RV Head vent to the pressurizer relief tank. This will require adding two 1E valve controls and associated indicator for the throttle valves.

B. Safety Injection and Residual Heat Removal Systems, CP001, 002, 003

1. Class 1E containment and containment sump level indication will be added (Included in Reg. Guide 1.97 instrumentation).

2. It is anticipated that extensive alarm modifications will be required for the accumulator discharge isolation valves.

3. Three solenoid operated accumulator vent valves will be added for safety grade cold shutdown. These valves will require 1E control switches and associated indication on CP001, 002, and 003.

4. Power lock outs are required for nine valves - low head safety injection (LHSI) isolation, high head safety injection (HHSI) hot leg isolation valves, and accumulator discharge isolation valve for each train to prevent spurious actuation from blocking a safety function which does not have a fully redundant backup. This will require adding nine switches and associated indication.

5. Several switches show different return to auto or normal positions than are shown on Westinghouse drawings. This will require review of the control circuits and coordination with Westinghouse to resolve the problems. In addition, a review is required to determine compliance with the Westinghouse system design documentation.

6. Two reset switches are required for reset of automatic switchover from RWST injection to sump recirculation.

7. Status indication will be added for three RHR heat exchanger isolation valves and for three bypass valves.

8. Requirements for safety grade cold shutdown RHR Heat Exchanger flow and temperature indications will require the addition of three Class 1E meters to CP004 and replacement of three nonclass 1E meters with Class 1E meters. (Included in Reg. Guide 1.97 Instrumentation).

C. Component Cooling Water (CCW) and Essential Cooling Water Subsystems, CP001, 002, and 003.

1. Changes are anticipated due to changing Westinghouse requirements on cooling the centrifugal changing pumps and the reactor coolant pumps and for cold shutdown/TMI requirements.

2. Changes are needed for all Train B power lockout for four valves submerged post-LOCA. This will add power lockout indication for these four valves.

3. Manual control action is needed for post-design basis accident (DBA) control of the spent fuel pool cooling water system. This involves the addition of two pump controls, and temperature and level indication or alarms.

4. Controls for the make-up valve to surge tank need to be added to CP003.

D. Reactor Coolant System, CP005

1. The RX vessel seal ΔP required during startup is currently not displayed in the control room.

2. The addition of Rx vessel level, core exit thermocouples, and subcooled margin monitoring to the main panel will require the addition of two Class 1E display systems. (Included in R.G. 1.97 instrumentation)

3. The pressurizer PORVs, block valves, and their controls and position indicators will be upgraded to Class 1E equipment to meet safety grade cold shutdown and TMI requirements.

4. Position indication for three pressurizer safety relief valves will be added. (Included in Reg. Guide 1.97 Instrumentation)

5. Back-up heater power supply upgrading for TMI will require upgrading two switches to Class 1E.

E. BOP Systems, CP005, 006, 007, 008, 009

1. Upgrade of the four existing steam generator PORVs to qualified safety grade active PORVs will require upgrade of the corresponding controllers to Class 1E on CP006 for safety grade cold shutdown.

2. Safety grade active throttle valves are required for the auxiliary feedwater system for safety grade cold shutdown. This will require the addition of jog valve controls on CP005.

3. The TMI review of the toxic gas exposure to the control room will result in the addition of several meters and alarms to CP001, 002, 003.

4. Upgrade four existing auxiliary feedwater flow indicators to Class 1E on CP001, 002, 003. (Included in R.G. 1.97 instrumentation)

5. Addition of four main stream line drain isolation valve controls and associated indication is required on CP008.

6. Addition of seven MSR drain valve controls and associated indication is required on CP008.

7. Addition of two valve controls and associated indication is required for the condensate polisher bypass and feedwater recirculation header block valves.1

8. Addition of three condenser air removal vacuum pumps and three vacuum breaker valves is required for CP008.

9. Addition of controls and displays associated with a full-flow deaerator. This will cause major revision to the layout of the feedwater panel.

F. Miscellaneous Systems

1. The addition of the post-accident sampling system will require addition of sampling system containment isolation valve controls on CP001, 002, 003. Twenty valve controls will be added including sample isolation valve controls for the normal sampling system.

2. Addition of six auxiliary cooling water pump controls is to be implemented on CP008.

G. Electrical Systems

1. Eight battery charger ammeters and eight voltmeters , four battery ammeters, four dc bus voltmeters and breaker status indication for 12 breakers will be added in response to an NRC question on the Class 1E dc system.

H. HVAC Systems

1. Three new essential chillers are being added. These will require new switches and associated indication to panels CP001, 002, and 003 for the chillers and the chilled water circulating pumps.

2. Four new RCFC and two new reactor cavity fans are being added to the RCB HVAC system. These will require new switches and associated indication.

3. Approximately 26 fan coil units are being added or modified for the MAB, EAB and FHB HVAC systems. All require control room controls and indication.

4. Three supply, air handling units and three return air fans are being added for the control room envelope essential HVAC system. All require control room controls and indication.

A summary of the above device additions, plus the Reg. Guide 1.97 changes, is shown in Table 4.1-1.

TABLE 4.1-1

Known Design Changes

CONTROL PANEL	DEVICE TYPE	REG. GUIDE 1.97	DESIGN EVOLUTION
CP001	CR-2940 switches	-	9
	Status lights	2	2
	SBM/SB-1 switches	-	21
	Vert. meters	17	4
	Round meters	-	0
	Alarms	-	2
CP002	CR-2940 switches	-	9
	CR-2940 buttons	-	-
	Status lights	-	6
	SBM/SB-1 switches	-	14
	Vert. meters	7	2
	Round meters	-	0
	Alarms	-	2
CP003	CR-2940 switches	-	16
	Status lights	-	2
	SBM/SB-1 switches	-	12
	Vert. meters	7	2
	Round meters	-	0
	Alarms	-	2
CP004	CR-2940 switches	-	4
	Status lights	28	4
	Vert. meters	4	1
	Plasma displays	0	-
	Chart recorder	1	-
	SBM		
CP005	CR-2940 switch	-	1
	status lights	2	-
	Vert. meter	11	-
	Plasma displays	2	
	SBM		

TABLE 4.1-1 (Cont'd)

Known Design Changes

CONTROL PANEL	DEVICE TYPE	REG GUIDE 1.97	DESIGN EVOLUTION
CP006	Status lights	27	-
	Vert. meters	7	-
	CR-2940		
	SBM		
CP007	CR-2940		
	SBM		
	Vert. meters		
CP008	CR-2940	-	16
	SBM/SB-1 switches	-	9
	Vert. meters	0	-
	Round meters		
CP009	SBM		
	Vert. meters		
CP010	SBM		
	Status lights	-	12
	Round meters	-	24
	CR-2940	-	-

4.3 OTHER PANEL CHANGES

Information was requested from the STP operational staff concerning equipment that could be removed from the panels, equipment that could be relocated from one panel to another, or equipment that could be revised. This information was reviewed and endorsed by project engineering. Following is a list of equipment recommended for removal and relocation:

A. CP001, 002, 003

1. Relocate HVAC switch control (2940s) for following areas to separate HVAC control panel:

   - o Control Room
   - o FHB
   - o CRDM
   - o Miscellaneous Containment
   - o Containment Purge

2. Relocate four MSIV above seat drain valves (2940s) to CP007

3. Relocate PAMS indicators to normal locations (CP004, 005, and 006) and integrate PAMS with SPDS.

B. CP004

1. Relocate radiation monitoring system including sample isolation valves to a radiation monitoring system panel or to the operator console.

2. Relocate CCP cubicle fan switches (2940s) to CCP area.

3. Relocate boric acid batch tank controls (2940s) and indicators (vertical meters) to BA batch tank area.

C. CP006

1. Remove four S/G setpoint indicators (vertical meters) from the panel (S/G level is not adjustable).

2. Relocate 23 PAMS indicators (vertical meters) to local areas and integrate PAMS with SPDS.

D. CP007

1. Relocate main steam temperature recorders to CP018 (Recorder Panel).

2. Relocate S/G PORV controls to CP006 and locate in respective S/G sections.

E. CP008

1. Remove condensate flow recorder and substitute indicator.

2. Relocate circulating water chlorine recorder to CP018.

3. Relocate generator megawatt recorder to CP018.

4. Remove all circular pump ammeters (G. E. DB40s) and substitute small vertical meters.

F. CP009

1. Remove all circular pump ammeters (G. E. DB40s) and substitute small vertical meters.

2. Relocate windspeed, wind direction, air temperature, and dewpoint indicators to the operator console.

3. Relocate generator frequency recorder to CP018.

4. Relocate MAB HVAC to back panel.

5.0 IMPLEMENTATION STUDIES

On November 22, 1982, a MT meeting was held to review the control panel design. At this time a decision was made to evaluate possible alternatives to resolve problems. Five design alternatives were defined for further study. These alternatives are as follows:

A. Alternative 1: Re-layout all 10 panels with existing devices to meet all TMI, engineering, and Human Factor requirements (NUREG 0700).

1. Create two additional panels to provide "spillover" necessary to re-layout the original panels.

2. Salvage presently purchased devices.

3. Only purchase devices to meet new requirements or if present device is unsuitable.

B. Alternative 2: Leave everything "as is" and use existing free space for the addition of new devices required by TMI and engineering requirements.

1. Two new panels are created.

2. Compromise on Human Engineering requirements.

C. Alternative 3: Re-layout all 10 panels with new miniature devices to provide space for new devices required to meet new TMI and engineering requirements.

1. No new panels are required.

2. Human engineering requirements are satisfied.

3. Many old devices are scrapped.

D. Alternative 4: Re-layout of panels CP001-006, with existing devices, modify existing panels CP007-010, and create two new panels.

1. Panels CP006-010 are completely fabricated; they will be modified only by adding new devices required by engineering. Human engineering will be comprised on these panels.

2. Panels CP001-006 will meet all TMI, engineering, and human factors requirements.

E. Alternative 5: Re-design all 10 panels on a modular concept using miniature devices and using a new and smaller footprint.

1. No new panels will be created.

2. All TMI, engineering, and human factor requirements will be met.

5.1 ALTERNATIVE 1: RE-LAYOUT ALL PANELS

5.1.1 Objective

Alternative 1 is defined as a complete new layout of the main control panels in order to resolve all potential HEDs and to include all known additional controls and

displays on the panels. The project ground rules for this alternative were defined as follows:

A. The existing hardware on the panels is to be retained to the maximum extent possible.

B. The panel footprint is to remain the same.

C. Panel delivery and plant construction schedule are to remain unchanged.

Given the project ground rules for Alternative 1, an analysis was made to determine the feasibility and schedule impact of this alternative. The specific objectives were:

A. Determine the panel surface area requirements necessary to accommodate the following hardware combinations:

1. All of the present devices are retained except for the changes required to meet NUREG 0700. In addition, the Engineering mandated changes to meet post TMI requirements and STP design criteria were added to the equipment on each panel.

2. Selected radiation monitoring equipment and HVAC equipment were assumed to be moved to separate auxiliary panels to provide additional space on the main panels. All of the Engineering mandated changes to meet post TMI requirements and STP design criteria were assumed to be added to the main panels as in 1. above.

3. This combination is similar to 2. above with an additional area allowance for expected future additions due to design evolution.

B. Determine the impact on panel delivery date.

C. Determine the schedule impact for releasing Elementary Wiring Diagrams.

D. Determine the schedule impact on construction. In particular, the cable pulling schedule is a critical path item and an adverse impact on it could have broad consequences.

5.1.2 Approach

The method used to derive the panel area requirements is an approximation consisting of three steps. The steps are:

A. The required devices for each panel are packed into the usable area without regard to functional grouping, but with strict adherence to the space requirements defined in Table 5.1-1 and to the acceptable zone locations for each device as defined in the table. This step produces an absolute minimum panel area required with close packing of all the devices.

B. Panels CP008 and CP009 were selected to produce a new layout for the devices including the additions defined by Engineering. The new layout was made with a conscientious effort to utilize the panel area as effectively as possible, but with the prime objective to provide grouping of the devices by subsystems. A schematic of the revised layout is illustrated in Figure 5.1-1. The revised layout produces a realistic, but minimum, panel area required.

C. A ratio of the area from B. to the area with close packing from A. above yields a multiplying factor to account for system layout by subsystem grouping. This ratio was then applied to all other panels as a constant. Since individual panels have a different makeup of devices between switches, meters, recorders, and panel inserts, it is essentially certain that the above ratio is not constant for each panel. In addition, the schematic layout for panels CP008 and CP009 do not account for functional grouping of devices according to system function and task analysis. Therefore, an additional allowance was included to account for this effect. This allowance is discussed further in the Section 5.1.4.

The impact on panel delivery schedule and on the construction schedule was derived by consensus of the project review team and engineering personnel with knowledge and experience in these areas.

5.1.3 Panel Layout Area Requirements

The panel surface area is dependent on the number and type of devices to be installed on the panel, and on the particular arrangement of the devices. Generally, the actual area occupied by the devices is significantly less than the usable area of the panel. Several bases were developed for the analysis. These are:

A. Each panel is divided into zones. The zones are:

Zone A. The angled surface which will contain only annunciator boxes.

Zone B. The vertical panel surface. The usable portion of this zone for meters is defined as the lower 18 inches. Because this zone is beyond the reach limits for a 5th percentile female, switches are excluded from this zone.

Zone C. This is the lower break area inclined approximately 60°. Meters and switches are permitted in this zone.

Zone D. The benchboard area. This has no restrictions on the type of device that can be installed.

B. In compliance with NUREG-0700, no devices can be installed within 3-inches of the outside edge of Zone D. Therefore, the usable area of Zone D excludes this area.

C. Structural angle iron restricts the installation of devices within 2-inches of the lateral edges of the panels. Therefore, this area was also excluded from the usable area.

D. A minimum space is required for each device to provide for labeling, visual separation, and to provide clearance between switches so they can be operated without interference with other devices. Table 5.1-1 identifies the dimensions and clearances used for each device.

E. For a change in switch type from CR-2940 to SBM the available free space on the panels is decreased. For the reverse change the free space area is increased. An evaluation of the net effect of these changes is shown in Table 5.1-2. The net result is a total decrease of 6.6 square feet of area for all 10 control panels.

5.1.4 Panel Area Correction for Functional Grouping

The calculations were performed using panels eight and nine as the base. The devices included on these panels were the existing devices plus the changes described in Section 4.

The results of the calculations showed that the panel area required for switches consumed nearly all of the area suitable for a switch location, i.e., zones D and C. Nevertheless, the area available is adequate, with suitable allowance for future design additions. Further, the revised layout, which includes grouping by subsystem as shown in Figure 5.1-1, also shows that the available area is adequate when panels eight and nine are considered together. The ratio of the consumed area with subsystem grouping to that of simple packing is 1.16. However, because the subsystem grouping does not include the process of optimizing the layout for functional sequence within the subsystems, some conservatism was added by adapting a ratio of 1.20 to derive the panel area requirements.

5.1.5 Panel Area Requirements, All Panels

Table 5.1-3 illustrates the incremental area changes required to accommodate the design changes discussed in Section 4 for each panel. The table shows eight columns. These are:

A. Area required for existing devices with close packing.

B. Incremental additional area to accommodate the control switch type changes.

C. Incremental additional area to accommodate known Engineering changes.

D. Incremental area change to accommodate the relocation of certain HVAC and radiation monitoring equipment to auxiliary panels.

E. Incremental area change to accommodate future additions of hardware to the panels.

F. Total panel area to accommodate all of the above effects with close packing.

G. Total panel areas required assuming area multipliers of 1.16 and 1.20 to provide for subsystem and functional grouping.

In addition, the table includes an intermediate summation of the areas grouped as follows:

A. One sum contains the summation of effects on panels 001, 002, and 003 since these panels are associated only with ESF systems, and the panels are physically detached from the other panels.

B. Another sum contains the summation of effects on panels 004 through 009. These panels are primarily associated with normal operating systems and form a contiguous surface for control devices.

C. The effects on panel 010 are listed separately since this panel contains mimics which require additional area allowance.

D. The last sum contains the summation of effects on all 10 panels.

5.1.6 Panel Area Available

Table 5.1-4 shows a comparison of the required versus available area for each panel. The required area is listed for both the minimum layout area ratio of 1.16 and the

desirable layout ratio of 1.20. The results show that the available area is not adequate for many of the panels, even for the minimum layout ratio of 1.16. The only panels which have an excess of available area are Panels CP003, 004, 009 and 010.

In order to accommodate all the known plus expected future changes, certain instruments will have to be located in the "B" zone outside the preferred viewing area (the preferred viewing area is defined as less than 18 inches above the bottom edge of Zone B. Table 5.1-4 shows the usable area for each panel when the allowable viewing zone is extended to 20 inches. The increase in total usable area is significant, about 14 ft^2. To achieve the desired layout ratio for the total area requirements of Panels CP004 through CP009, it is estimated that the Zone B usable height would have to be increased from 18 inches to 20.8 inches. This means that some instruments or displays will have to extend into the non-preferred viewing area. Instruments located outside the preferred viewing area will require scrutiny to assure that instrument readability is acceptable.

5.1.7 Licensing Impact

Since Alternative 1 involves complete new layout of all control panels to resolve potential HEDs there is not expected to be any significant licensing impact.

5.1.8 Schedule

Three schedules for Alternative 1 were prepared based on three different purchasing and review procedures. The following three methods were examined:

A. Normal purchasing and review procedures (See Figure 5.1-2 for schedule)

1. Bechtel writes detailed specification or B.M.
2. Bechtel issues for proposal

3. Panel vendors prepare proposal
4. Bechtel evaluates proposals
5. Bechtel awards P.O. on fixed price basis
6. Vendor prepares drawings and submits for approval
7. Bechtel reviews drawings and returns to vendor
8. Vendor does not start fabrication until drawings are approved
9. Each change is carefully documented and negotiated

B. Accelerated procedures (See Figure 5.1-3 for schedule)

1. Bechtel writes detailed specification, and during its preparation negotiates a P.O. with a single vendor with authorized overtime
2. Bechtel forwards to vendor preliminary sketches
3. Vendor starts drawings. based upon preliminary information and submits for approval
4. Bechtel reviews drawings
5. Vendor starts fabrication based on "informal" approval of drawings
6. Changes are incorporated on drawings during fabrication process without commercial negotiations

C. Minimize procedures with cost plus contrast (See Figure 5.1-4 for schedule)

1. Bechtel writes detailed specification and simultaneously negotiates a cost plus contract with panel vendor.
2. Bechtel forwards to vendor preliminary sketches.
3. Vendor starts drawings based upon preliminary information and submits for approval.

4. Bechtel reviews drawings.
5. Vendor starts fabrication based on "informal" approval of drawings.
6. Changes are incorporated on drawings during fabrication process without commercial negotiations.

5.1.9 Conclusions

It was determined that Alternative 1 can accommodate all the known engineering changes and the future design evolution changes. However, some instruments would be located outside the preferred viewing area and these must be reviewed from a human factors standpoint. No significant licensing impact is expected for this alternative.

Three schedules for different purchasing and review procedures were developed for the fabrication and delivery of the panels that ranged from a minimum period of 14 months to a maximum period of 22-1/2 months.

This alternative was not selected because it did not preserve panels CP007 through CP010 which were already constructed.

TABLE 5.1-1

Area and Clearance Allowance for Various Panel Devices

Device	Dimensions (ins) Horizontal and Vertical Actual		With Clearance		Area (in^2)
Large Recorder	17.	13.	18.	19.	342
Medium Recorder	17.75	9.0	19.	9.5	180.5
Small Recorder	7.0	8.0	7.5	8.5	63.8
Vertical Meter	1.5	7.0	2.75	8.5	23.37
Round Meter	4.25	4.25	4.25	4.25	18.06
Process Controller	3.25	6.5	3.75	6.75	25.31
Hand Controller	2.375	3.5	4.25	6.5	27.63
SBM Switch with Status Lights	2.625	5.0	4.25	6.5	27.63
CR-2940 Switch with Status Lights	2.625	3.75	3.375	5.0	16.87
Status Lights:					
Green-Red	2.625	1.875	3.25	2.0	6.5
2 Windows	1.875	1.5	2.0	1.5	3.0
3 Windows	1.875	2.0	2.0	2.0	4.0
4 Windows	1.875	2.5	2.0	3.5	7.0
12 Windows	3.5	3.5	4.0	4.0	16.0
CRT	19.25	17.75	20.	19.	380.
Keyboard	17.5	11.75	19.	13.	247.
Plasma Display	Unavailable		14.	11.	154.
EHC Panel	18.	15.	19.	16.	304.
EHC Display	18.	13.5	19.	15.5	294.5
SGFP Control	12.	11.	12.5	12.	150.
Reheat Temp Control	19.	8.75	20.	10.	200.
Emergency Trip	19.	8.75	20.	10.	200.

TABLE 5.1-2

Panel Changes to Conform to Switch Function

Panel Number	Number of Changes to SBM	Additional Area Req'd (ft^2)	Number of Changes to CR 2940	Reduction in Area Req'd (ft^2)	Net Additional Area Req'd (ft^2)
CP001	32	2.39	8	.60	1.79
CP002	33	2.46	8	.60	1.87
CP003	23	1.72	6	.45	1.27
CP004	20	1.49	1	.07	1.42
CP005	11	.82	11	.82	0
CP006	13	.97	4	.30	.67
CP007	3	.22	13	.97	.75
CP008	3	.22	0	0	.22
CP009	0	0	0	0	0
CP010	1	.07	0	0	.07
Totals	139	10.38	51	3.81	6.60

TABLE 5.1-3

Evolution of Panel Area Requirements

Areas, ft^2

Panel No.	Existing Area of Devices Close Pack	Additional Area to Correct Switches	Additional Area for Known Changes	Area Loss from Approved Deletions
CP001	34.29	1.79	9.81	-7.55
CP002	43.64	1.87	5.46	-10.41
CP003	25.68	1.27	6.12	-7.02
Sum 1-3	103.51	4.93	21.39	-24.98
CP004	39.40	1.42	1.90	-12.24
CP005	32.65	—	4.45	—
CP006	32.51	.67	2.09	-.14
CP007	22.70	-.75	—	-.89
CP008	27.00	.22	4.50	-2.51
CP009	6.50	—	—	-3.69
Sum 4-9	160.76	1.56	12.94	-19.47
CP010	25.20	.07	5.00	—
Sum 1-10	289.47	6.56	39.33	-24.98

Table 5.1-3 (Cont'd.)

Evolution of Panel Area Requirements

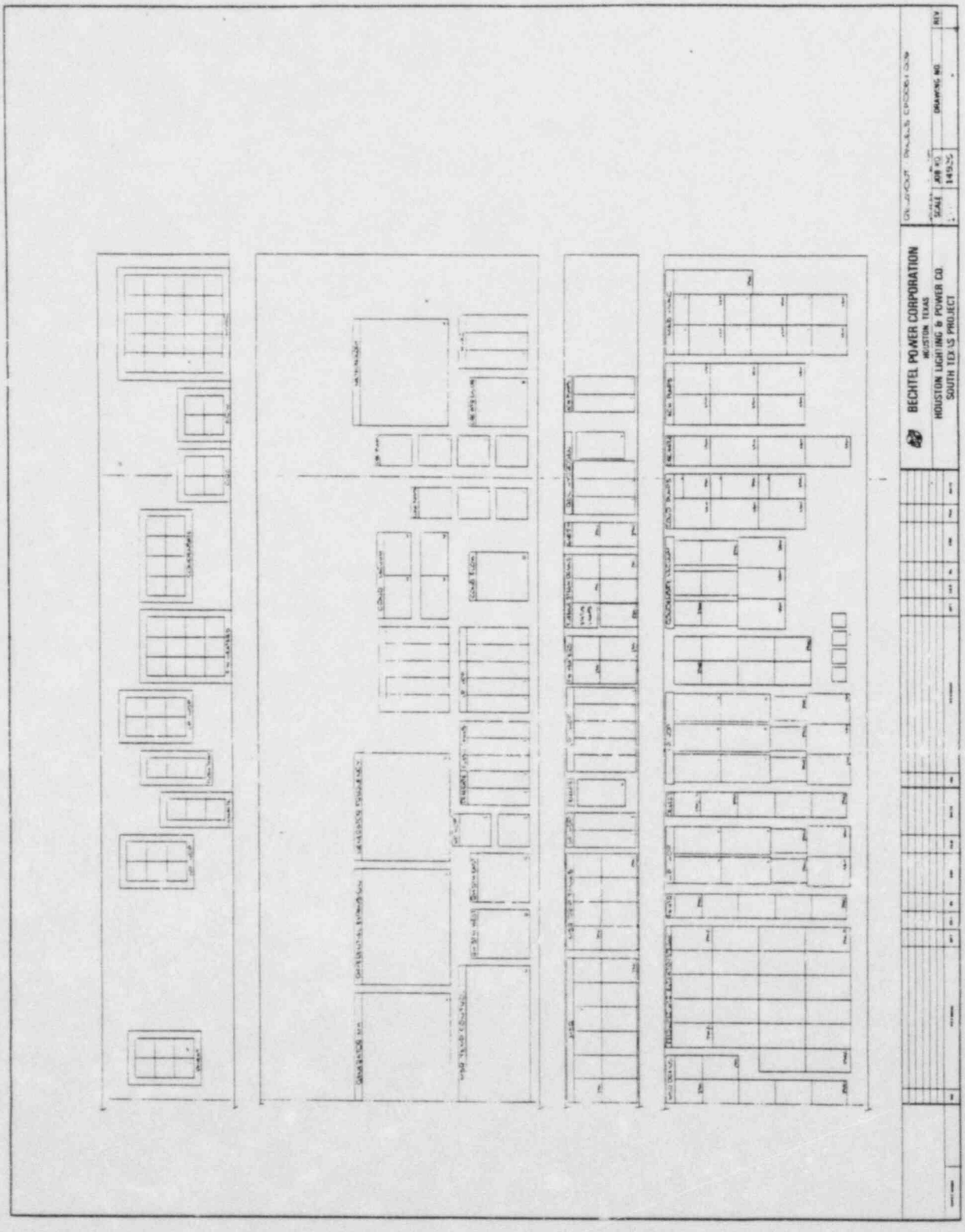
Areas, ft^2

Panel No.	Additional Area for Future Evolution	Total Area Required	Required Area w/ Layout Factor 1.16	Required Area w/ Layout Factor 1.20
CP001	4.25	42.59	49.40	51.11
CP002	4.47	45.03	52.23	54.04
CP003	3.34	29.39	34.09	35.27
Sum 1-3	12.06	117.01	135.7	140.04
CP004	3.09	33.57	38.94	40.28
CP005	2.58	39.68	46.03	47.62
CP006	2.85	37.98	44.06	45.58
CP007	1.04	22.10	25.64	26.52
CP008	2.30	31.51	36.55	37.81
CP009	.52	3.33	3.86	4.00
Sum 4-9	12.38	168.17	195.1	201.8
CP010	3.14	33.41	38.76	40.09
Sum 1-10	27.58	318.59	369.6	382.3

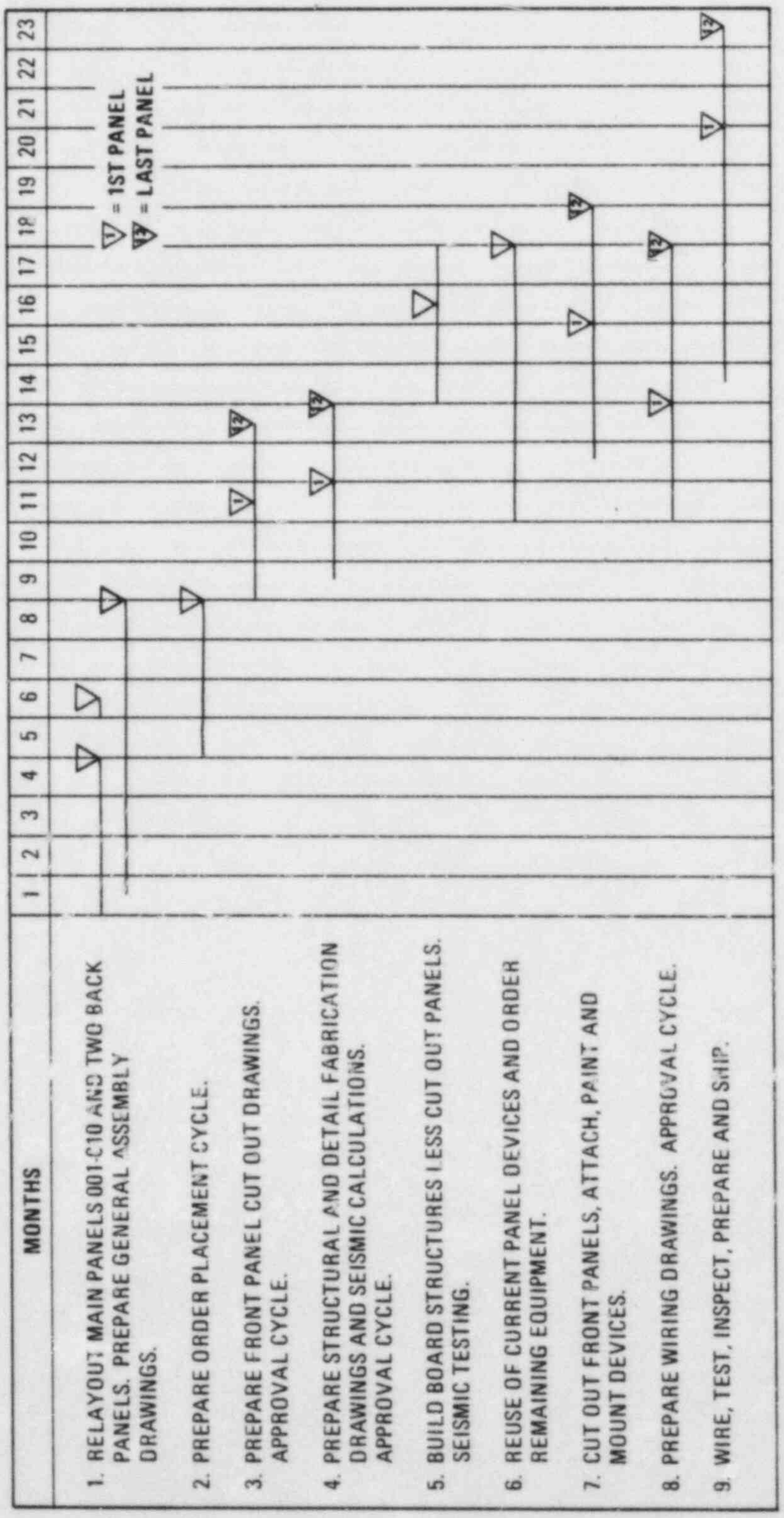
TABLE 5.1-4

Comparison of Required vs. Usable Panel Area

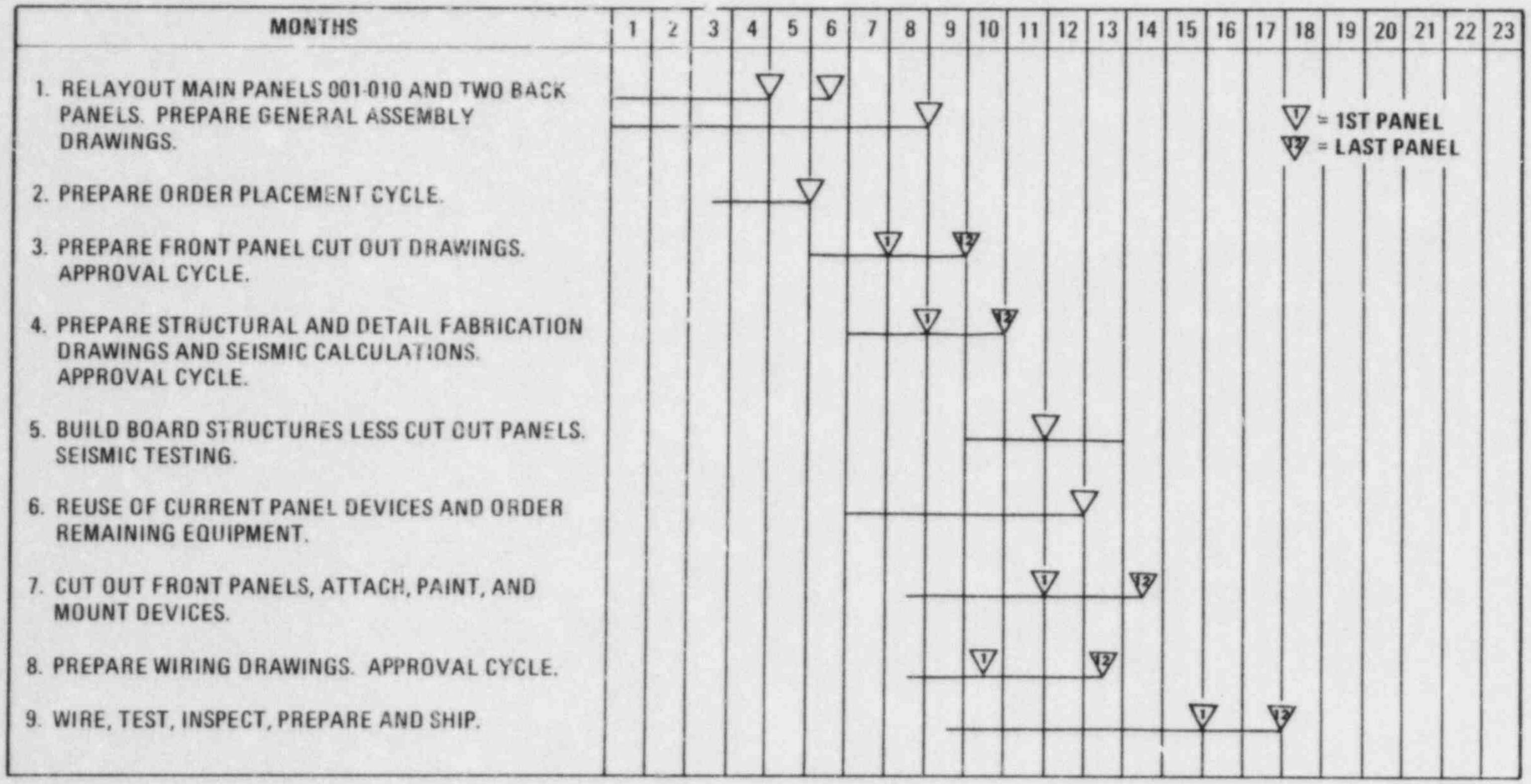
Panel Number	Required Area, ft^2 Layout Ratio 1.16	Required Area, ft^2 Layout Ratio 1.20	Usable Area, ft^2 Zone B=18"	Usable Area, ft^2 Zone B=20"
CP001	49.40	51.11	49.32	51.18
CP002	52.23	54.04	49.32	51.18
CP003	34.09	35.27	38.28	39.72
Sum 1-3	135.72	140.42	136.92	142.08
CP004	38.94	40.28	46.10	47.88
CP005	46.03	47.62	31.92	33.20
CP006	44.06	45.58	40.51	42.12
CP007	25.64	26.52	21.51	22.36
CP008	36.55	37.81	32.02	33.23
CP009	3.86	4.00	11.04	11.46
Sum 4-9	195.10	201.81	183.70	190.25
CP010	38.76	40.09	42.69	44.31
Sum 1-10	369.6	382.3	362.71	376.64



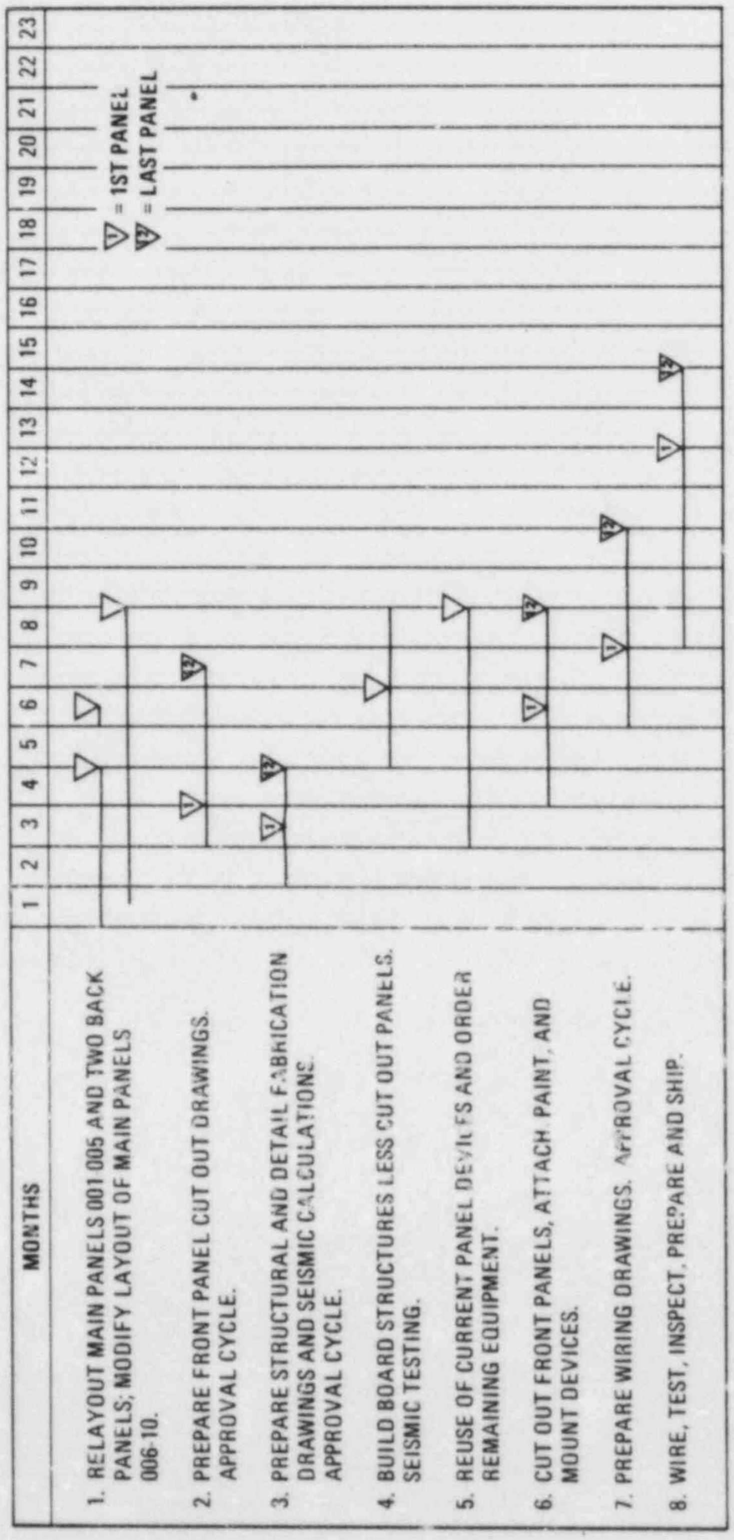
REVISED LAYOUT FOR ALTERNATIVE 1
Figure 5.1-1



SCHEDULE FOR ALTERNATIVE 1 – METHOD I
Figure 5.1-2



SCHEDULE FOR ALTERNATIVE 1 — METHOD II
Figure 5.1-3



SCHEDULE FOR ALTERNATIVE 1 – METHOD III
Figure 5.1-4

5.2 ALTERNATIVE 2: USE OF PRESENT LAYOUT

5.2.1 Approach

For Alternative 2, the present control panel design will be retained with any additional control panel changes integrated into this design. Changes that add devices to the control panels will require the placement of these devices in existing empty space on the panels. The technical feasibility of Alternative 2 is primarily based on whether available space exists on the panels to accommodate the presently known additions and any anticipated additions.

To evaluate the present control panel design for Alternative 2, the following procedure was used:

A. Control panel sketches were prepared to determine (on an approximate basis) if the available space on the panels could accommodate the known and anticipated hardware additions.

B. Paper diagrams of known hardware changes were added to the control room mockup to verify that sufficient free space exists on the control panels to accommodate the changes.

C. The approximate number of HEDs that will result from the present CRDR effort including the expected discrepancies arising from the known panel additions was determined.

D. Based on this projection of the expected number of HEDs, the approximate effort required to resolve these HEDs was determined. This included the manhours and schedule required to process the HEDs through the PRT and the MT as described in the Program Plan.

E. The licensing effort (meetings and correspondence) required to justify the HEDs that require partial or no correction was determined.

F. An estimate of cost and schedule required to revise and deliver the control panels was obtained.

5.2.2 Unused Usable Space (UUS)

A preliminary evaluation of the total available panel space was measured on the STP control room mock-up.

Table 5.2-1 presents measures of the panel space (in square feet) relative to the amount of space that is currently available for additional or relocated components.[1] This space, termed the unused usable space, is theoretical in nature and represents the measured panel surface area that does not presently contain control or display components. Since a number of variables will influence the actual panel space that becomes available for adding or relocating components, the UUS measure should be considered only an approximation. For instance, some UUS will accommodate certain components, but will not accommodate others (4" x 4" area would accommodate a pushbutton, but not a vertical meter).

The STP control panels presently contain some components (e.g. convex-face vertical meters) that are too high on the panel surface for efficient operator use. Thus, some UUS will need to be used for relocating these components for better accessibility. Additional UUS will be needed for functional demarcation of components by system and/or train.

[1] The reference area for all Table 5.2-1 measures includes the entire surface area of Segments C and D as well as the lower 18" of Segment B. Area above this reference area is not considered acceptable even for viewing purposes.

Finally, behind-the-panel engineering constraints likely will further reduce the UUS. In these respects, measured UUS will overestimate the actual space available for adding or relocating components. However, this overestimation may be offset by the removal of some components from the main panels as operational personnel have indicated for Alternative 1.

5.2.3 Results

Appendix B presents the panel diagrams showing the known device additions sketched into the available free spaces. Based on these sketches and the results of the mockup revisions, it was concluded that, with the exception of panels CP005 and 006, there was sufficient available space to accommodate the known design changes. Panels CP005 and 006 were able to accommodate most of the added devices but some of the vertical meters and the two plasma displays would not fit. In these cases, some rearrangement of the display devices could permit the addition of these devices.

As a result of a review of the sketches in Appendix B and the revised mockup it was decided that the panels were marginally acceptable with regard to available space for accommodating known design changes, but there is not sufficient space to fit any future design changes.

Potential revisions that would change the amount of space available for the addition of the known changes are:

A. Relocation to an auxiliary panel of some hardware as recommended by Operations and Engineering.

B. Removal or relocation of many of the strip chart recorders and possibly the CRT displays and associated keyboards.

5.2.4 Licensing Impact

Based on the CRDR which has been performed on the present control panels, many Human Engineering Discrepancies (HEDs) or observations have been found on the present panel design. The major HED category violations that have been discovered to date are:

A. Most of the ESF systems on panels CP001, 002 and 003 are not grouped according to task sequence.

B. Many of the control panels do not have the controls and display functional grouped (e.g., the Reactor Coolant System has 26 devices on panel CP004 and 37 devices on panel CP005).

C. The PAM displays on panel CP002 and CP006 do not satisfy the functional grouping requirements.

In addition, several discrepancies will arise when devices are added to existing board space for the known design changes. The discrepancies for these changes are expected to include:

A. Functional and task sequence grouping violations due to the placement of devices in available space instead of the proper functionally acceptable space.

B. Violation of several panel layout criteria such as separation, proximity and frequency of use criteria.

Based on the CRDR effort that has been completed to date, the number of observations were estimated to be approximately 330 (involving approximately 2350 devices). The projected number of observations for the completed CRDR was estimated to be 660 observations. Of these, it was estimated that 65% (429) will be recommended for correction and of the 429, 15% (64) will eventually be corrected. The remaining 365 will

require a written justification to the NRC to allow partial or no correction. The estimated effort required to justify these observations for Alternative 2 is approximately 1100 manhours total, assuming three hours per observation. A total period of from six to eight months will be required to resolve the licensing issues.

5.2.5 Schedule

Because of the high licensing risk associated with this alternative, a detailed schedule for completing the CRDR was not developed. The impact on the panel delivery date was judged to be unacceptable.

5.2.6 Conclusions

Alternative 2 was determined to be technically feasible for all the control panels except for panels CP005 and 006. For these two panels some rearrangement of display devices would be required to accommodate the known design changes.

Due to the requirement for a significant licensing effort to justify HEDs, the panel delivery date using Alternative 2 was judged to be unacceptable.

TABLE 5.2-1

STP CONTROL PANEL UNUSED USABLE SPACE (UUS)

PANELS	SEGMENTS	TOTAL SPACE	SPACE TAKEN (ft^2)	UUS	UUS AS % OF TOTAL SPACE
001	B	17.2	13.9	3.3	19
	C	9.3	7.2	2.1	22
	D	26.0	21.5	4.5	17
	TOTAL	52.5	42.6	9.9	19
002	B	17.2	14.7	2.5	12
	C	9.3	6.5	2.8	30
	D	26.0	20.6	5.4	20
	TOTAL	52.5	41.8	10.7	20
003	B	13.5	9.6	3.9	28
	C	7.5	5.7	1.8	24
	D	21.0	19.0	2.0	9
	TOTAL	42.0	34.3	7.7	18
004	B	16.4	13.3	3.1	19
	C	8.9	8.3	.6	6
	D	23.9	21.5	2.4	10
	TOTAL	49.2	43.1	6.1	12
005	B	12.0	12.0	0	0
	C	11.9	11.6	.3	3
	D	16.9	15.0	1.9	11
	TOTAL	40.8	38.6	2.2	5

TABLE 5.2-1 (Cont'd)

STP CONTROL PANEL UNUSED USABLE SPACE (UUS)

PANELS SPACE	SEGMENTS	TOTAL SPACE	SPACE TAKEN	UUS	UUS AS % OF TOTAL
		(ft^2)			
006	B	15.7	11.7	4.0	25
	C	8.0	6.9	1.1	14
	D	21.4	19.2	2.2	10
	TOTAL	45.1	37.8	7.3	16
007	B	8.0	6.6	1.4	18
	C	4.4	4.1	.3	7
	D	11.1	10.9	.2	2
	TOTAL	23.5	21.6	1.9	8
008	B	18.6	17.4	1.2	6
	C	10.3	9.4	.9	9
	D	28.9	24.5	4.4	15
	TOTAL	57.3	51.3	6.5	11
009	B	3.7	2.9	.8	21
	C	2.0	1.8	.2	10
	D	5.8	3.7	2.1	36
	TOTAL	11.5	8.4	3.1	27
010	B	14.8	10.8	4.0	27
	C	8.3	5.8	2.5	30
	D	23.1	17.9	5.2	22
	TOTAL	46.2	34.5	11.7	25

Mean UUS CP 001-010

As % of Total Space 15 %

5.3 ALTERNATIVE 3: RE-LAYOUT ALL 10 CONTROL BOARDS USING SMALLER HARDWARE

5.3.1 Approach

The five alternatives were generated in order to supply data on which to direct the implementation effort. At the time it was questionable, considering the known design changes, if all equipment could be fitted into the available usable space utilizing the hardware originally selected. Alternative 3 is a study to determine the flexibility to be gained by specifying smaller hardware, and the results are given here as a sub-set of Alternative 1.

5.3.2 New Hardware

The greatest gain in board area can be achieved by replacing the SBM switches with pistol-grip handles with some smaller type switch. Other equipment considered for replacement were rotary switches (CR2940 type), controllers, and vertical panel meters, but the area gained does not justify replacement of these devices.

The type of rotary switch presently used occupies an area small enough to allow for a relatively dense packing factor, and other types of rotary switches do not significantly reduce the area required.

The total number of controllers used is small, and any area gained by substituting new hardware is minimal.

The vertical panel meters used (6" scale) are convenient for easy operator viewing from a moderate distance, and allow for scale divisions to be chosen large enough to provide accurate reading and still cover a broad range of process excursions. Therefore, the equipment selected for evaluating Alternative 3 is the Electroswitch 20K line of switches. This equipment is readily available, is qualified for IEEE-323-1974, and contains enough variety to provide the configurations needed. The handle sizes available are detailed below:

HANDLE	DEPTH, in	DIAMETER, in
Pistol Grip	1.25"	1.68"
T-handle	1.0"	1.5"
Knurled	1.0"	1.13"

The escutchion dimensions for this switch line are 1.9 x 1.9 inches.

5.3.3 Re-layout

A typical subsystem, pressurizer control, was arranged (Fig. 5.3-1) using the dimensions of the new hardware, to obtain an envelope for comparison with the existing design. The re-layout was necessary because no additional area is gained by a direct one-for-one component substitution.

The existing pressurizer control layout requires approximately 904 square inches, and the rearrangement covers 748 square inches, for a reduction of 17% of board area.

5.3.4 Control Board Delivery

This alternative has the same impact on the control board delivery schedule as does Alternative No. 1. However, any further changes, either during panel fabrication or subsequent to plant startup, will be easier to accommodate because of the larger spare area obtainable with the smaller hardware.

5.3.5 Elementary Wiring Diagram (EWD) Schedule

Wiring diagrams, as well as all data bases, etc. will require more engineering effort to complete, as each drawing showing switch developments must be revised. The drawings associated with 847 switches will need revising.

5.3.6 Board Costs

Neither this change nor Alternative 1 allows for retention of any existing control board front skin. The re-layout task will be easier because of the additional flexibility available with the smaller hardware. Costs are increased over Alternative 1 by the costs associated with specifying and procuring the new hardware. These incremental costs were not developed.

5.3.7 Conclusions

Alternative 3 produces a 17% reduction in area required for equipment, should impact control board delivery dates no more than Alternative 1, increases board costs by the cost of the new hardware, and requires revisions of the EWDs, and logic diagrams and data bases to reflect the new hardware.

This alternative was not selected due to the possible schedule delays resulting from unreliable delivery dates for the new hardware.

5.4 ALTERNATIVE 4: RE-LAYOUT PANELS 1-6

5.4.1 Approach

For this option only those panels that control safety-related equipment, panels CP001 through 006, will be redesigned using the same type control/display devices that are used on the present panels. Panels CP007 through 010 are already fabricated; therefore, these panels must be modified to accommodate the design changes described under Alternative 2. Since this alternative is essentially a combination of Alternative 1 and Alternative 2, the evaluation approach is similar to that described for these alternatives. The evaluation of this concept used the same procedures described in previous sections for the respective alternatives.

5.4.2 Results

The analysis for Alternative 1 showed that sufficient area is available on panels CP001 through 006 for re-layout to resolve HEDs and to incorporate known and anticipated design changes.

For panels CP007 through 010, the evaluation performed for Alternative 2 showed that sufficient UUS was available to accommodate the known design changes but not sufficient UUS for the anticipated design changes. As indicated for Alternative 2 there are some potential revisions which would increase the available space.

5.4.3 Licensing Impact

With the addition of 25 new switches to panels CP008 and 009, it is anticipated that there will be an appreciable increase in the number of HEDs due to lack of functional grouping and integration of controls and displays. This result is the obvious outcome of adding a large number of new devices to the panels while restricting rearrangement of the existing devices to preserve functional grouping.

The licensing impact is uncertain in that the systems involved are not safety-related. Therefore, there is not an obvious precedent that can be compared with to judge the licensability.

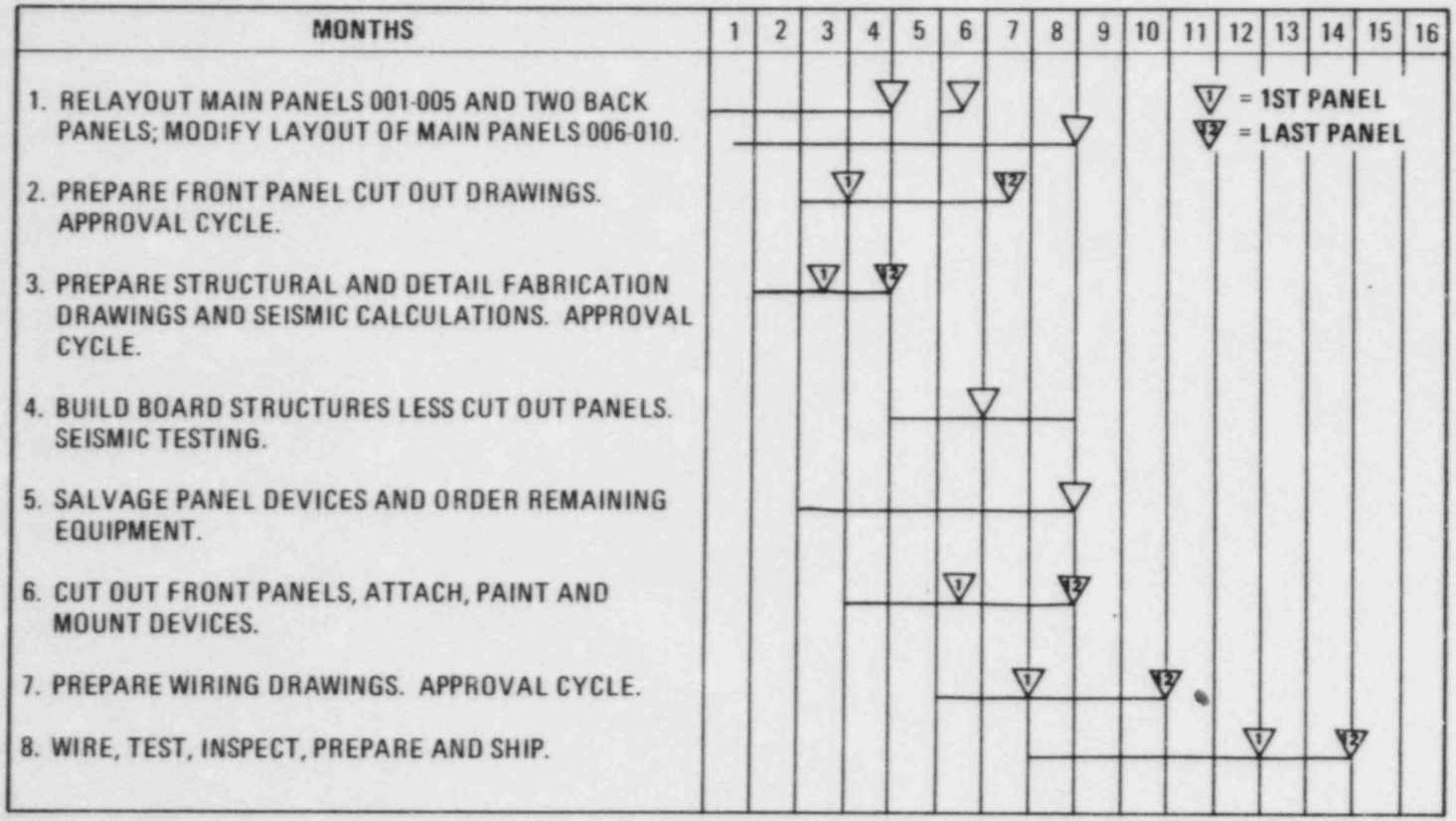
5.4.4 Schedule

An estimated schedule for the design, fabrication, and delivery of the control panels using Alternative 4 is presented in Figure 5.4-1.

5.4.5 Conclusions

The feasibility of Alternative 4 is based on the evaluations of Alternative 1 and Alternative 2. A re-layout of panels CP001 through CP006 was determined to be technically feasible based on the evaluation of Alternative 1. The revision of panels CP007 through CP010 was determined to be technically feasible based on the Alternative 2 evaluation. The licensing impact of the changes to panel CP007 through CP010 is uncertain.

Although Alternatives 1 and 4 were similar in most respects, Alternative 4 was selected because it preserves the panels (CP007 through CP010) that were already constructed.



SCHEDULE FOR ALTERNATIVE 4
Figure 5.4-1

5.5 ALTERNATIVE 5: REDESIGN ALL PANELS USING MODULAR CONCEPT AND NEW FOOTPRINT

5.5.1 Approach

Alternative 5 involves a complete redesign of the control panels using new components and a redesigned foot-print. The control panel profile would be redesigned for human factors considerations. Individual panels would be designed on a modular concept to provide flexibility for future changes and additions. As indicated in NUREG 0700 the results of the redesign should be increased availability by satisfying the following criteria.

A. The control room must be arranged with normal pant operations as the primary objective.

B. The control equipment must be laid out in a functional manner.

C. The design must be flexible to permit future changes and additions.

D. The design must allow for maintenance with the unit on line.

E. The design must be compatible with the engineering, construction and start-up schedules.

An evaluation of the functional requirements and preliminary system specifications for a design that satisfies the above criteria was performed.

The technical feasibilities of Alternative 5 is primarily based on availability of panel space for accommodating the panel equipment. The feasibility of Alternative 5 can be established on the basis of the results of the evaluations for Alternative 1.

This alternative involves a re-layout using the present devices.

A similar layout using miniature devices should provide considerably greater available area for placement of these devices. The following section discusses a feasibility evaluation of Alternative 5.

5.5.2. Results

Alternative 5 is similar to Alternative 1 with the exception that Alternative 5 uses miniature panel devices. The results for Alternative 1 showed that sufficient area is available to re-layout the present devices with a functional grouping. But, to achieve this some panels (CP001, 002, 005-008) require the placement of certain instruments outside the preferred viewing area. As indicated, Alternative 1 is marginally acceptable with some human factor review required regarding instrument readability.

For Alternative 3 a re-layout of pressurizer controls and displays on panel CP005 resulted in a 17% reduction in board area required through the use of miniature switches. Since the area falling outside the acceptable area for Alternative 1 was only about 5% (382.3 ft^2 required versus 362.7 ft^2 usable) it was concluded that miniature devices for Alternative 5 can be functional grouped with the acceptable area on the board.

5.5.3 Conclusions

Alternative 5 was determined to be a technically feasible method of redesigning the control panels to satisfy the TMI, engineering and human factors requirements. Since this option involves complete layout of all control panels to resolve potential HEDs there is not expected to be any significant licensing impact.

The schedule for designing and fabricating the control panels for this alternative is essentially the same as that shown in Section 5.1 for Alternative 1. These schedules must however be adjusted to reflect the availability of the new miniature hardware.

This alternative was not selected due to the impact on panel delivery schedule caused by possible unavailability of new miniature hardware.

APPENDIX A

PRELIMINARY ASSESSMENT OF CONTROL ROOM INSTRUMENTS TO MEET REGULATORY GUIDE 1.97

VARIABLE	RANGE/STATUS	TYPE/ CAT	QUAL ENV.	QUAL SEIS	NO. OF CHANNELS	DISPLAY	IMPLEMENTATION
1. RCS Pressure (Wide Range)	0-3000 psig	A1,B1,B2 C1,C2,D2	Yes	Yes	3/plant	3 indicators (2 1E and 1 non-1E), 2 channels recorded	Sensor - No change; Signal Processing - No change Display - No change.
2. Wide Range T_{Hot}	0-700°F	A1,B2	Yes	Yes	1/loop	1 1E indicator per loop, each loop recorded	Sensor - No change; Signal Processing - Add 1E processing for 2 new displays; Display - Add 2 1E indicators for loops 3 & 4. (Note 1)
3. Wide Range T_{Cold}	0-700°F	A1,B2	Yes	Yes	1/loop	1 1E indicator per loop, each loop recorded	Sensor - No change; Signal Processing - Add 1E processing for 2 new displays; Display - Add 2 1E indicators for loops 3 & 4. (Note 1)
4. Wide Range Steam Generator Level	0-100% of span	A1,B1,B2 B2, D2	Yes	Yes	1/Steam Generator	1 1E indicator per S/G loop, each loop recorded	Sensor - No change; Signal Processing - Add 1E processing for 4 new displays; Display - Add 4 1E indicators, 1 per loop.
5. Narrow Range Steam Generator Level	0-100% of span	A1,B1,B2,D2	Yes	Yes	4/Steam Generator	4 indicators (3 1E and 1 non-1E) per S/G loop, 2 points per loop recorded	Sensor - No change; Signal Processing - No change; Display - No change.
6. Pressurizer Level	0-100% of span	A1,B1,D2	Yes	Yes	4/plant	3 indicators (2 1E and 1 non-1E) per plant, 3 channels recorded	Sensor - No change; Signal Processing - No change; Display - No change.
7. Containment Pressure	-5 to 60 psig	A1,B1,B2 C1,C2,D2	Yes	Yes	4/plant	4 indicators (2 1E and 2 non 1E) per plant, 2 channels recorded	Sensor - Recalibrate sensor to -5 to 60 psig; Signal Processing - Recalibrate channels to -5 to 60 psig; Display - Recalibrate indicators.
8. Steamline Pressure	0-1400 psig	A1,B1,D2	Yes	Yes	3/loop	3 indicators (2 1E and 1 non-1E) per loop, 1 point per loop recorded	Sensor - No change; Signal Processing - No change Display - No change.
9. Refueling Water Storage Tank	0-100% of span	A1,D2	Yes	Yes	3/tank	3 indicators (2 1E and 1 non-1E) per tank, 1 channel recorded	Sensor - No change; Signal Processing - No change; Display - No change.
10. Containment Water Level (Wide Range)	0-600K gal	A1,B1,B2 C2,D2	Yes	Yes	3/plant	3 1E indicators per plant, 1 channel recorded	Sensor - Add 3 1E wide range transmitters; Signal Processing - Add 1E processing for 3 indicators; Display- Add 3 1E indicators and recording. (Note 1)

Note 1: Consideration being given to an integrated display system as part of the SPDS.

PRELIMINARY ASSESSMENT OF CONTROL ROOM INSTRUMENTS TO MEET REGULATORY GUIDE 1.97

VARIABLE	RANGE/STATUS	TYPE/ CAT	QUAL ENV.	QUAL SEIS	NO. OF CHANNELS	DISPLAY	IMPLEMENTATION
10. Containment Water Level (Narrow Range)	Later	A1,B1,B2 C2,D2	Yes	Yes	3/plant	3 1E indicators per plant, 1 channel recorded	Sensor - Add 3 1E narrow range transmitters, Signal Processing - Add 1E processing for 3 indicators; Display- Add 3 1E indicators and recording. (Note 1)
11. Condensate Storage Tank Level	0-100% of span	A1,D2	Yes	Yes	3/plant	3 1E indicators per plant, 1 channel recorded	Sensor - Replace 2 existing transmitters with 3 1E transmitters; Signal Processing - Add 1E processing for 3 new indicators; Display - Add 3 1E indicators and recording.
12. Auxiliary Feedwater Flow	0-110% of flow	A1,B1,D2	Yes	Yes	1/loop	1 1E indicator per loop, each loop recorded	Sensor - Replace existing transmitters with 4 1E transmitters; Signal Processing - Add 1E processing for 4 indicators; Display - Add 4 1E indicators and recording.
13. High Range Cont. Radiation Level	1-10^8 R/hr	A1,B1,B2 E2	Yes	Yes	2/plant (Note 2)	2 1E indicators per plant, 1 channel recorded	Sensor - Specify range to 1 - 10^8 R/hr; Signal Processing - No change; Display - Replace indicators and add recording. (Note 1)
14. Steam Generator Liquid Rad. Monitor	10^{-6} - 10^{-1} μCi/cc	A1,E2	Yes	Yes	1/plant	1 1E indicator per plant, 1 point recorded	Sensor - Add 1 1E monitor, Signal Processing - Add 1E processing to indication and incorporate into RMS computer; Display - Add 1 1E indicator and recording. (Note 1)
14. Steamline Rad. Monitor	Later	A1,E2	Yes	Yes	1/steamline	4 1E indicators per plant, 4 points recorded	Sensor - Add 4 1E monitors; Signal Processing - Add 1E processing to indication and incorporate into RMS computer; Display - Add 4 1E indicators and record all 4 points. (Note 1)
15. Core Exit Temperature	100-2200°F	A1,B1,C1	Yes	Yes	2/plant with 16 T/C per channel	2 1E redundant indicators per plant, record the average temp/channel	Sensor - Upgrade to 2 channels of at least 16 1E thermocouples; Signal Processing - Each channel to average T/C reading, provide 1E processing; Display- Add 2 1E indicators and recording. (Note 1)
16. RCS Subcooling	200°F subcooling to 35°F superheat	A2,B2	Yes	Yes	2/plant	2 1E channels indicated per plant	Sensor - Add 2 1E systems to determine RCS subcooling; Signal Processing - Add 1E processing for indication; Display - Provide separate 1E indication for two channels. (Note 1)

Note 1: Consideration being given to an integrated display system as part of the SPDS.

Note 2: Back-up variable to be determined.

PRELIMINARY ASSESSMENT OF CONTROL ROOM INSTRUMENTS TO MEET REGULATORY GUIDE 1.97

VARIABLE	RANGE/STATUS	TYPE/ CAT	QUAL ENV.	QUAL SEIS	NO. OF CHANNELS	DISPLAY	IMPLEMENTATION
17. Neutron Flux	10^{-8}% - 100% Full power	B1	Yes	Yes	2/plant	2 1E channels indicated per plant	Sensor - Add 2 1E fission chambers; Signal Processing - Add 1E processing for display; Display - Provide separate 1E indication for two channels. (Note 1)
18. Reactor Vessel Water Level	Later	B2,C2	Yes	Yes	2/plant	2 1E channels indicated per plant	Sensor - Add 2 1E channels, W-op or Ct - Heated Junction Thermocouple; Signal Processing - Add 1E processing for indication; Display - Provide separate 1E indication for two channels. (Note 1)
19. Containment Isolation Valve Status	Open/Closed	C2	Yes	Yes	1/valve	1 pair of lights per valve	Sensor - Add 1E limit switches for 4 main steam bypass valves, 14 primary sample valves and 6 PASS valves; Display - Add indication (1 pair of lights) for 14 primary sample valves and 6 PASS valves
20. Containment Hydrogen Concent.	0-10%	B1,C1	Yes	Yes	2/plant	2 1E indicators per plant, 1 channel recorded	Sensor - Recalibrate range to 0-10%; Signal Processing - No change; Display - Recalibrate range to 0-10%.
21. Cont. Pressure (Extended Range)	0-180 psig	C1,C2	Yes	Yes	2/plant	2 1E indicators per plant, 1 channel recorded	Sensor - Add 2 1E transmitters; Signal Processing - Add 1E processing for 2 indicators; Display - Add 2 1E indicators and recording. (Note 1)
22. RCS Pressure (Extended Range)	0-3500 psig	A1, B1 C1	Yes	Yes	2/plant	2 1E indicators per plant, 1 channel recorded	Sensor - Add 2 1E transmitters; Signal Processing - Add 1E processing for 2 indicators; Display - Add 2 1E indicators and recording.
23, 24. RCS Activity/ Sampling	N/A	C3	No	No	1 PASS/ plant	CRT	Sensor - Add a Post Accident Sampling System with computer for control and processing; Display - Add display by CRT.
25. Cont. or Plant Vent Rad. Level	Noble Gas: 10^{-6} - 10^{5} µCi/cc Part: 10^{-11} - 10^{2} µCi/cc Halogens: 10^{-11} - 10^{2} µCi/cc	C2,E2	Yes	Yes	1 combined monitor/ plant	CRT	Sensor - Replace existing equipment with monitoring to cover full range; Signal Processing - Provide KMS computer for signal processing; Display - Add indication via CRT.

A-3

PRELIMINARY ASSESSMENT OF CONTROL ROOM INSTRUMENTS TO MEET REGULATORY GUIDE 1.97

Note 1: Consideration being given to an integrated display system as part of the SPDS.

VARIABLE	RANGE/STATUS	TYPE/ CAT	QUAL ENV.	QUAL SEIS	NO. OF CHANNELS	DISPLAY	IMPLEMENTATION
26. Adjacent Bldg. Radiation Level	Vent: 10^{-6} - 10^{-1} μCi/cc Area: 10^{-1} - 10^{4} mR/hr	C2	Yes	Yes	2 vent mon. per plant 5 area mon. per plant	2 1E indicators, 1 per vent. mon. 1 channel recorded, CRT display for area monitors	Sensor - No change; Signal Processing - No change; Display - Add recording.
27. Site Environmental Radiation Level	N/A	C3,E3	No	No	N/A	N/A	Sensor - Portable sampling.
28. Pressurizer PORV Status	Open/Closed	D2	Yes	Yes	1/valve	1 pair of lights per valve, 2 valves per plant	Sensor - Add 2 1E valve position indicating devices; Signal Processing - Add 1E processing as required for sensors; Display - No change.
29. PORV Block Valve Status	Open/Closed	D2	Yes	Yes	1/valve	1 pair of lights per valve, 2 valves per plant	Sensor - No change. Display - No change.
30. Primary Safety Valve Status	Open/Closed	D2	Yes	Yes	1/valve	1 pair of lights per valve, 3 valves per plant	Sensor - Add 3 1E sensors, 1 for each valve; Signal Processing - Add 1E processing as required for sensors; Display - Add 3 pairs of lights for valve status.
31. Pressurizer Heater Breaker Position	Open/Closed	D2	Yes	Yes	1/bank (Note 3)	1 pair of lights per bank, 5 banks per pressurizer	Sensor - Add 2 1E sensors; Display - Add 2 pairs of lights for bank status.
32. Charging System Flow	0-500 gpm	D2	Yes	Yes	1/plant	1 1E indiator per plant	Sensor - Replace transmitter with 1 1E transmitter; Signal Processing - Add 1E processing for 1 indicator; Display - Replace existing indicator with 1 1E indicator.
33. Letdown Flow	0-500 gpm	D2	Yes	No	1/plant	1 indicator per plant	Sensor - No Change; Signal Processing - No change; Display - No change.
34. Volume Control Tank Level	0-100% of span	D2	Yes	No	2/plant	1 channel indicated per plant	Sensor - No Change; Signal Processing - No change; Display - No change.
35. CVCS Valve Status	Open/Closed	D2	Yes	Yes	1/valve	1 pair of lights per valve, 27 valves	Sensor - Add 14 1E limit switches, replacement for existing non-1E limit switches; Display - No change.

Note 3: Two channels are 1E and three channels are Non-1E.

VARIABLE	RANGE/STATUS	TYPE/ CAT	QUAL ENV.	QUAL SEIS	NO. OF CHANNELS	DISPLAY	IMPLEMENTATION
36. RCP Seal Injection Flow	0-20 gpm	D2	Yes	Yes	1/loop	1 1E indicator per loop, 1 channel per loop recorded	Sensor - Replace 4 existing transmitters w/4 1E transmitters; Signal Processing - Add 1E processing for 4 indicators; Display - Add 4 1E indicators.
37. S/G Atmospheric PORV Status	Open/Closed	D2	Yes	Yes	1/valve	1 pair of lights per valve, 4 valves per plant	Sensor - Replace 4 existing limit switches with 4 1E limit switches; Display - No change.
38. Main Steamline Isolation Valve Status	Open/Closed	B2,D2	Yes	Yes	1/valve	1 pair of lights per valve, 4 valves per plant	Sensor - Replace 4 existing limit switches with 4 1E limit switches; Display - No change.
38. Main Steamline Isolation Bypass Valve Status	Open/Closed	B2,D2	Yes	Yes	1/valve	1 pair of lights per valve, 4 valves per plant	Sensor - Replace 4 existing limit switches with 1E limit switches; Display - No change. (Note 4)
39. S/G Safety Valve Status	Open/Closed	D2	Yes	Yes	1/valve	1 pair of lights per valve, 20 valves per plant	Sensor - Add 20 1E sensors for valve status, 1 per valve; Signal Processing - Add 1E processing as required for senors; Display - Add 20 pairs of lights, 1 per valve.
40. Main Feedwater Control Valve	Open/Closed	D2	Yes	Yes	1/valve	1 pair of lights per valve, 4 valves per plant	Sensor - Replace 4 existing limit switches with 4 1E limit switches; Display - No change.
41. Main Feedwater Control Bypass Valve Status	Open/Closed	D2	Yes	Yes	1/valve	1 pair of lights per valve, 4 valves per plant	Sensor - Replace 4 existing limit switches with 4 1E limit switches; Display - No change.
42. Main Feedwater Isolation Valve Status	Open/Closed	D2	Yes	Yes	1/valve	1 pair of lights per valve, 4 valves per plant	Sensor - No change; Display - No change.
43. Main Feedwater Flow	0-110% of flow	D2	Yes	Yes	3/loop	3 1E indicators per loop, 1 channel recorded per loop	Sensor - No change; Signal Processing - No change; Display - No change.
44. S/G Blowdown Isolation Valve Status	Open/Closed	D2	Yes	Yes	1/valve	1 pair of lights per valve, 4 valves per plant	Sensor - No change; Display - No change.

Note 4: These implementation changes are previously covered by variable 19, containment isolation valve status.

VARIABLE	RANGE/STATUS	TYPE/ CAT	QUAL ENV.	QUAL SEIS	NO. OF CHANNELS	DISPLAY	IMPLEMENTATION
45. Total HHSI Flow	0-2000 gpm	D2	Yes	Yes	2/SI train	2 indicators per SI train	Sensor - Replace 6 transmitters with 6 1E transmitters; Signal Processing - Add 1E processing; Display - No change.
46. Total LHSI Flow	0-5000 gpm	D2	Yes	Yes	2/SI train	2 indicators per SI train	Sensor - Replace 6 transmitters with 6 1E transmitters; Signal Processing - Add 1E processing; Display - No change.
47. ECCS Accumulator Pressure	0-700 psig	D2	Yes	Yes	2/tank	2 indicators per tank, 3 tanks per plant	Sensor - Replace 1 transmitter per tank with 1 1E transmitter per tank. Signal Processing - Add 1E processing; Display - Add 3 1E indicators.
48. ECCS Valve Status	Open/Closed	D2	Yes	Yes	1/valve	1 pair of lights per valve, 45 valves	Sensor - Replace 3 limit switches with 3 1E limit switches and add 1 1E limit switch; Display - Add 2 pair of lights.
49. Auxiliary Feedwater Valve Status	Open/Closed	D2	Yes	Yes	1/valve	1 pair of lights per valve, 14 valves	Sensor - Add 1 1E limit switch; Display - No change.
50. Cont. Spray Flow	0-110% of flow	D2	Yes	No	1/train	1 indicator per train	Sensor - No change; Signal Processing - No change; Display - No change.
51. Cont. Spray System Valve Status	Open/Closed	D2	Yes	Yes	1/valve	1 pair of lights per valve, 9 valves	Sensor - No change; Display - No change.
52. Cont. Spray Pump Status	On/Off	D2	Yes	Yes	1/pump	1 pair of lights per pump, 3 pumps per plant	Sensor - No change; Display - No change.
53. RCB Fan Cooler Diff. Press.	3-4 in. water	D2	Yes	No	1/fan	1 indicator per fan	Sensor - Replace 6 existing switches with 6 1E switches; Signal Processing - Add 1E processing; Display - Add 6 indicators, 1 per fan.
54. CCW Header Pressure	0-150 psig	D2	Yes	Yes	1/header	3 indicators per plant	Sensor - Replace existing transmitters with 3 1E transmitters; Signal Processing - Add 1E processing; Display - No change.
55. CCW Header Temp.	0-250°F	D2	Yes	Yes	1/header	3 indicators per plant	Sensor - Replace 3 existing TE's with 1E temperature elements; Signal Processing - Add 1E processing; Display - No change.

VARIABLE	RANGE/STATUS	TYPE/ CAT	QUAL ENV.	QUAL SEIS	NO. OF CHANNELS	DISPLAY	IMPLEMENTATION
56. CCW Surge Tank Level	0-100% of span	D2	Yes	Yes	1/tank section	3 indicators per plant	Sensor - Replace existing transmitters with 3 1E transmitters; Signal Processing - Add 1E processing; Display - No change.
57. CCW Flow to ESF Components	0-110% of flow	D2	Yes	Yes	1/ESF component	9 indicators per plant	Sensor - Replace existing transmitters with 9 1E transmitters; Signal Processing - Add 1E processing; Display - No change.
58. CCW Valve Status	Open/Closed	D2	Yes	Yes	1/valve	1 pair of lights per valve, 68 valves	Sensor - Replace 4 limit switches with 4 1E limit switches; Display - No change.
59. ECW System Flow	0-110% of flow	D2	Yes	Yes	1/ESF component	1 indicator per major ESF component	Sensor - Add 1 1E sensor per major ESF component; Signal Processing - Add 1E processing; Display - Add 1 indicator per major ESF component.
60. ECW System Valve Status	Open/Closed	D2	Yes	Yes	1/valve	1 pair of lights per valve, 9 valves	Sensor - No change; Display - No change.
61. ESF Environment	Later	D2	Yes	Yes	Later	Non 1E indication or annunciation for each ESF area (to be determined)	Sensor - To be determined; Signal Processing - To be determined; Display - To be determined.
62. Standby Power and Emergency Source Status	Bus Specific	D2	Yes	Yes	1/bus	Non 1E indication and/or annunciation for each power source (to be determined)	Sensor - To be determined; Signal Processing - To be determined; Display - To be determined.
62. Other Energy sources important to safety (e.g. hydraulic, pneumatic, N_2)	Later	D2	Yes	Yes	1/source	Non 1E indication or annunciation for each source (to be determined)	Sensor - To be determined; Signal Processing - To be determined; Display - To be determined.
63. RHR Heat-exchanger Discharge Temperature	50-400°F	D2	Yes	Yes	1/heat exchanger	3 1E indicators, 1 per heat-exchanger, record each channel	Sensor - Replace 3 existing temperature elements with 3 1E TE; Signal Processing - Add 1E processing for indication; Display - Add 3 1E indicators, 1 per heat exchanger.
64. RHR Flow	0-110% of flow	D2	Yes	Yes	1/train	1 1E indicator per train	Sensor - Replace 3 existing transmitters with 3 1E transmitters; Signal Processing - Add 1E processing; Display - Replace 3 existing indicators with 3 1E indicators
65. RHR Valve Status	Open/Closed	D2	Yes	Yes	1/valve	1 pair of lights per valve, 11 valves	Sensor - No change. Display - No change.

VARIABLE	RANGE/STATUS	TYPE/ CAT	QUAL ENV.	QUAL SEIS	NO. OF CHANNELS	DISPLAY	IMPLEMENTATION
66. Reactor Trip Breaker Position	Open/Closed	D2	Yes	Yes	1/breaker	1 pair of lights per breaker, 4 breakers	Sensor - No change; Display - No change.
67. Turbine Stop Valve Position	Open/Closed	D2	No	No	1/valve	1 pair of lights per valve, 6 valves	Sensor - No change; Display - No change.
68. Turbine Throttle Valve Position	Open/Closed	D2	No	No	1/valve	1 pair of lights per valve, 4 valves	Sensor - No change; Display - No change.
69. Auxiliary Feedwater Motor Driven Pump Status	On/Off	D2	Yes	Yes	1/pump	1 pair of lights per pump, 3 motor driven pumps	Sensor - No change; Display - No change.
69. Auxiliary Feedwater Turbine Driven Pump Status	0-5000 rpm Open/Closed	D2 D2	Yes Yes	Yes Yes	1/pump 1/valve	1 turbine speed indicator, 1 pair of lights for each steam supply valve	Sensor - Replace turbine speed sensor with a 1E sensor; Signal Processing - Add 1E processing; Display - No change in panel design; 1 indicator for turbine speed yet to be purchased.
70. SI Pump Status	On/Off	D2	Yes	Yes	1/pump	1 pair of lights per pump, 6 pumps	Sensor - No change; Display - No change.
71. ECW Pump Status	On/Off	D2	Yes	Yes	1/pump	1 pair of lights per pump, 3 pumps	Sensor - No change; Display - No change.
72. CCW Pump Status	On/Off	D2	Yes	Yes	1/pump	1 pair of lights per pump, 3 pumps	Sensor - No change; Display - No change.
73. Control Room Radiation	10^{-6}-10^{-1} μCi/cc 10^{-1}-10^{4} mR/hr	E2	Yes Yes	Yes No	2/plant 1/plant	2 1E indicators, 1 per vent, Mon., 1 channel recorded, CRT on demand	Sensor - Recalibrate range of monitors; Signal Processing - Provide RMS computer for processing; Display - Add indication on CRT add recording for 1 vent. monitor.
74. Fuel Handling Building Area Radiation	10^{-1} - 10^{4}mR/hr	E2	Yes	No	10/plant	CRT on demand	Sensor - Recalibrate range of monitors; Signal Processing - Provide RMS computer for processing to Control Room indication; Display - Add Control Room indication via CRT.
75. Access Area Radiation	10^{-1} - 10^{4}R/hr	E2	Yes	No	8/plant	CRT on demand	Sensor - Add 8 area monitors to cover the indicated range; Signal Processing - Provide RMS computer for processing to indication; Display - Add Control Room indication via CRT.
76. Non-headered Effluent Radiogas Concentration	10^{-6} - 10^{3} μCi/cc	E2	No	No	1/plant	1 indicator per plant, 1 point recorded	Sensor - Add 2 monitors, 1 for condenser air ejector and 1 for gland seal exhaust; Signal Processing - Provide RMS computer for processing to indication; Display - Add Control Room indication via CRT.

VARIABLE	RANGE/STATUS	TYPE/ CAT	QUAL ENV.	QUAL SEIS	NO. OF CHANNELS	DISPLAY	IMPLEMENTATION
77. Concentration from Liquid Pathways	10^{-6} - 10^{-1} μCi/cc	E2	Yes	No	1/pathway 3/plant	CRT on demand	Sensor - No change; Signal Processing - Provide RMS computer for processing to indication; Display - Add Control Room indication via CRT.
78. FHB Vent Radiation	10^{-6} - 10^{-1} μCi/cc	E2	Yes	Yes	1/plant	2 IE indicators per plant	Sensor - No change; Signal Processing - No change; Display - No change.
79. Effluent Path Flow Rate	0-110% of design flow	E2	Yes	Yes	1/pathway	CRT on demand	Sensor - Add 1 Ie monitor for the common plant vent and a monitor for each of the following: Gland Seal Exhaust, Condensor Vacuum Pump, and 3 liquid pathways; Signal Processing - Provide RMS computer for processing to indication; Display - Provide Control Room indication via CRT.
80. Meterological Parameters	N/A	E3	No	No	15/plant	CRT on demand	Sensor - HL&P responsibility; Signal Processing - HL&P responsibility; Display - To be determined.
81. Control Rod Position Indication	0-258 steps	B3	No	No	1/rod	Digital Rod Position Indication	Sensor - No change; Signal Processing - No change; Display - No change.

APPENDIX B

PANEL DIAGRAMS SHOWING THE

KNOWN DEVICE ADDITIONS

HOUSTON LIGHTING & POWER CO.

SOUTH TEXAS PROJECT

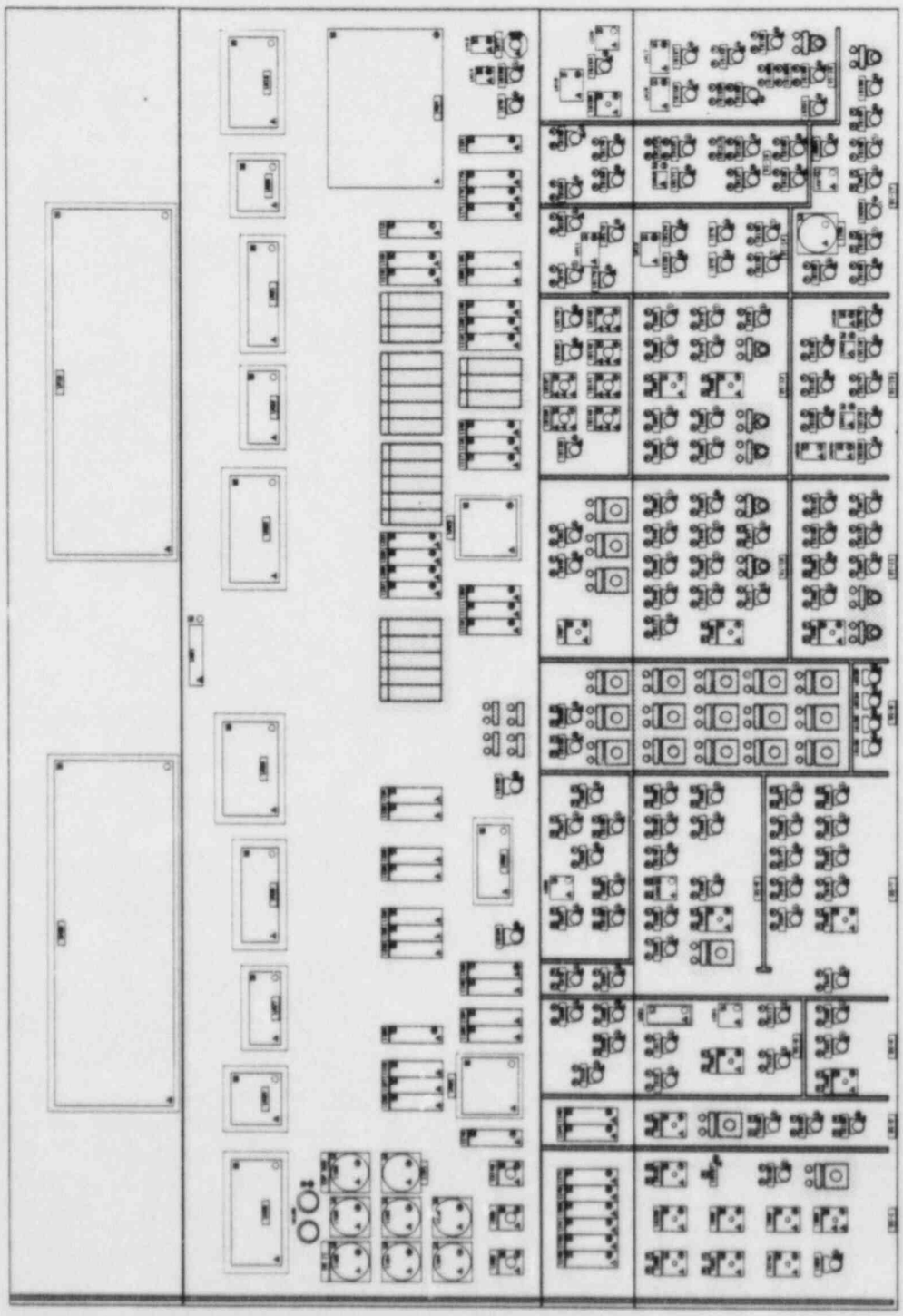
CONTROL ROOM DESIGN REVIEW

KNOWN CHANGES

Add 9 2940s
4 Status Lights
21 SBMs
21 Vertical Meters

ANTICIPATED CHANGES

16 2940s
4 SBMs
6 Vertical Meters
2 Round Meters



CP-001
ENGINEERED SAFETY FEATURES - TRAIN A

DEVICE ADDITIONS
ESF TRAIN A

HOUSTON LIGHTING & POWER CO.

SOUTH TEXAS PROJECT

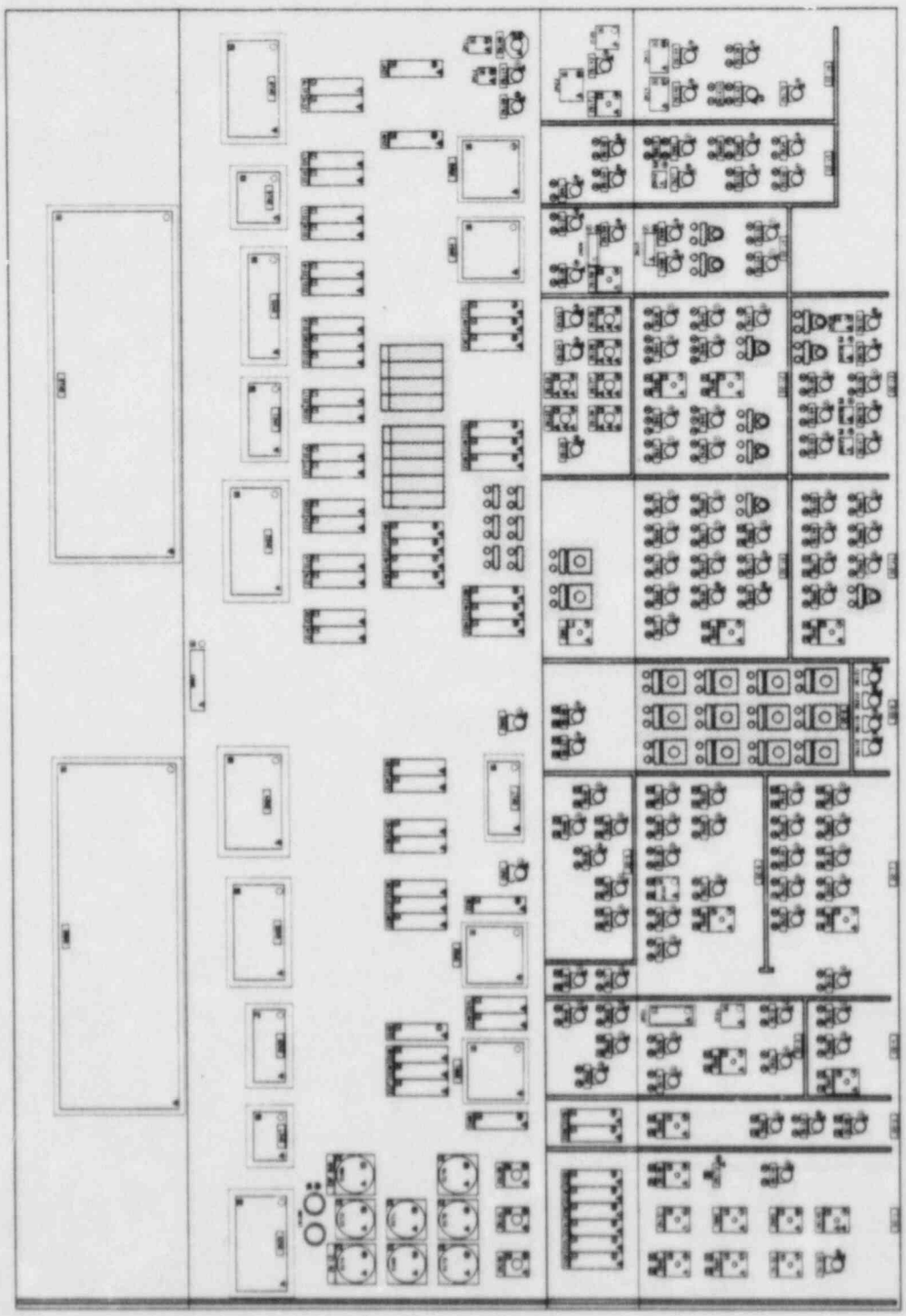
CONTROL ROOM DESIGN REVIEW

KNOWN CHANGES

Add 9 2940s
6 Status Lights
14 SBMs
9 Vertical Meters

ANTICIPATED CHANGES

16 2940 Switches
4 SBMs
8 Vertical Meters
1 Round Meter



CP-002
ENGINEERED SAFETY FEATURES - TRAIN B

DEVICE ADDITIONS
ESF TRAIN B

B-2

HOUSTON LIGHTING & POWER CO.

SOUTH TEXAS PROJECT

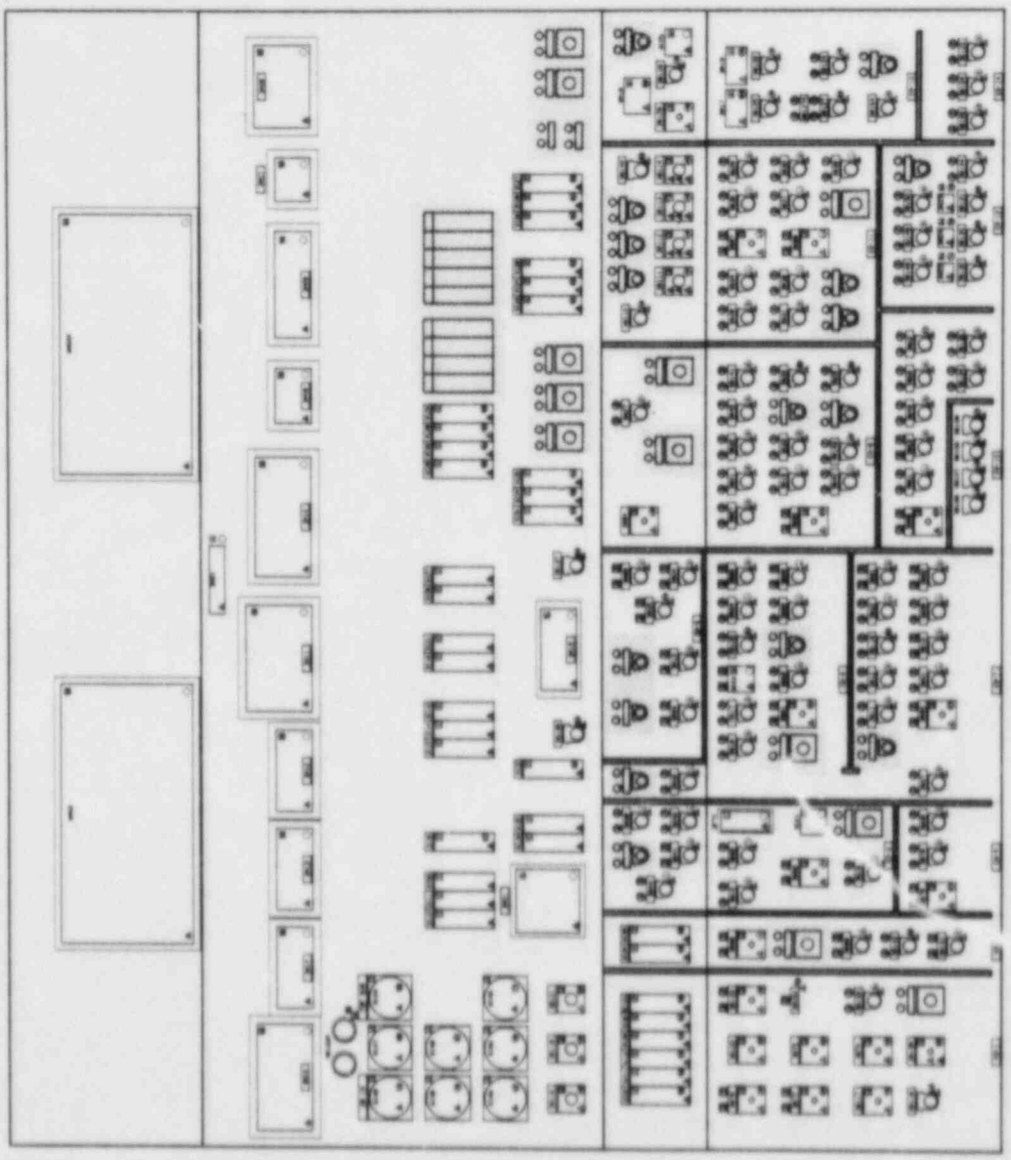
CONTROL ROOM DESIGN REVIEW

KNOWN CHANGES

Add	16	CR 2940s
	2	Status Lights
	12	SBMs
	9	Vertical Meters

ANTICIPATED CHANGES

Add	13	2940s
	3	SBMs
	5	Vertical Meters
	1	Round Meter



CP-003
ENGINEERED SAFETY FEATURES - TRAIN C

DEVICE ADDITIONS
ESF TRAIN C
B-3

HOUSTON LIGHTING & POWER CO.

SOUTH TEXAS PROJECT

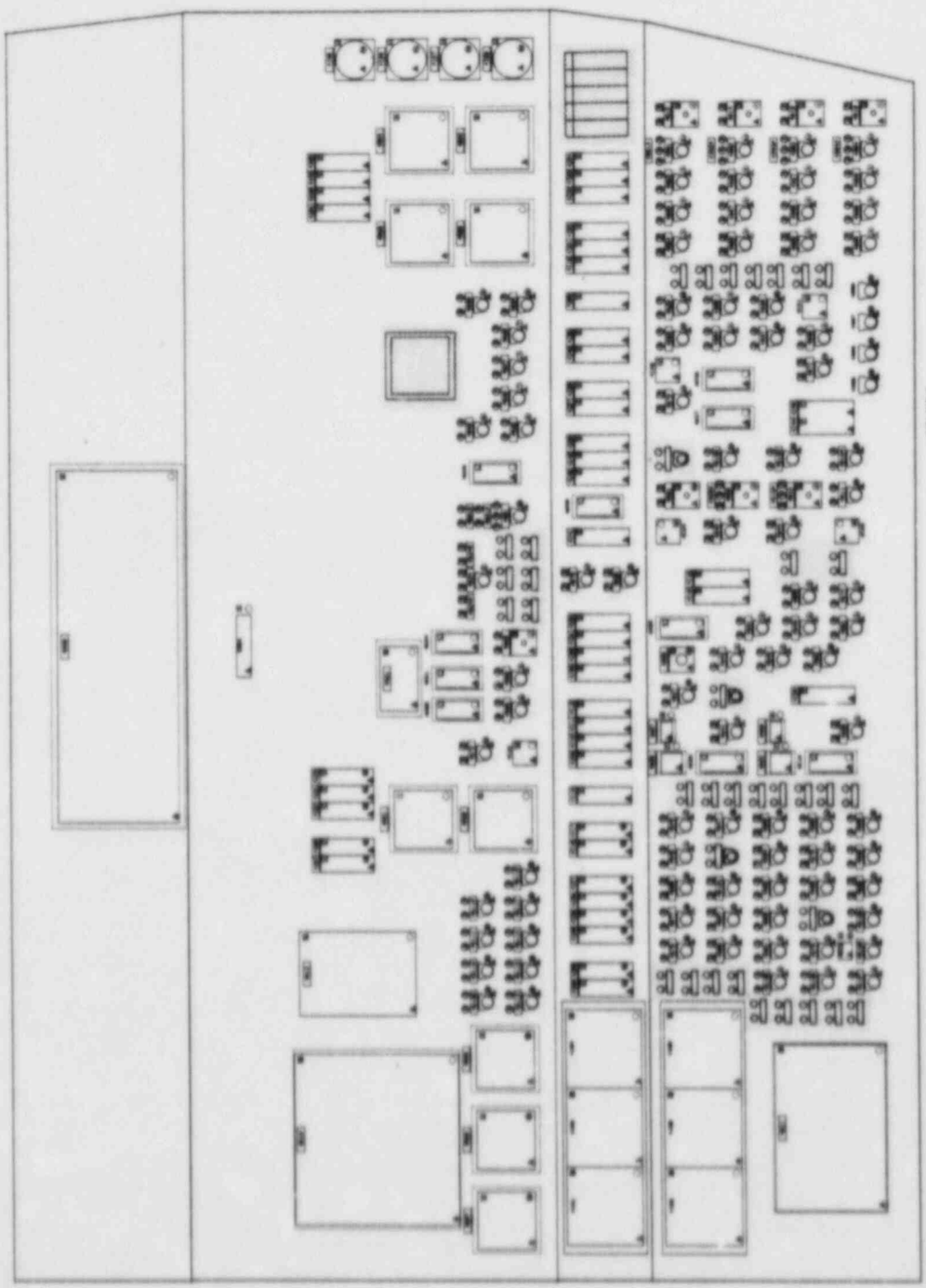
CONTROL ROOM DESIGN REVIEW

KNOWN CHANGES

Add	4	2940s
	32	Status Lights
	5	Vertical Meters
	1	Recorder

ANTICIPATED CHANGES

Add	14	2940s
	6	Vertical Meters
	1	SBM



CP-004
CHEMICAL AND VOLUME CONTROL SYSTEM

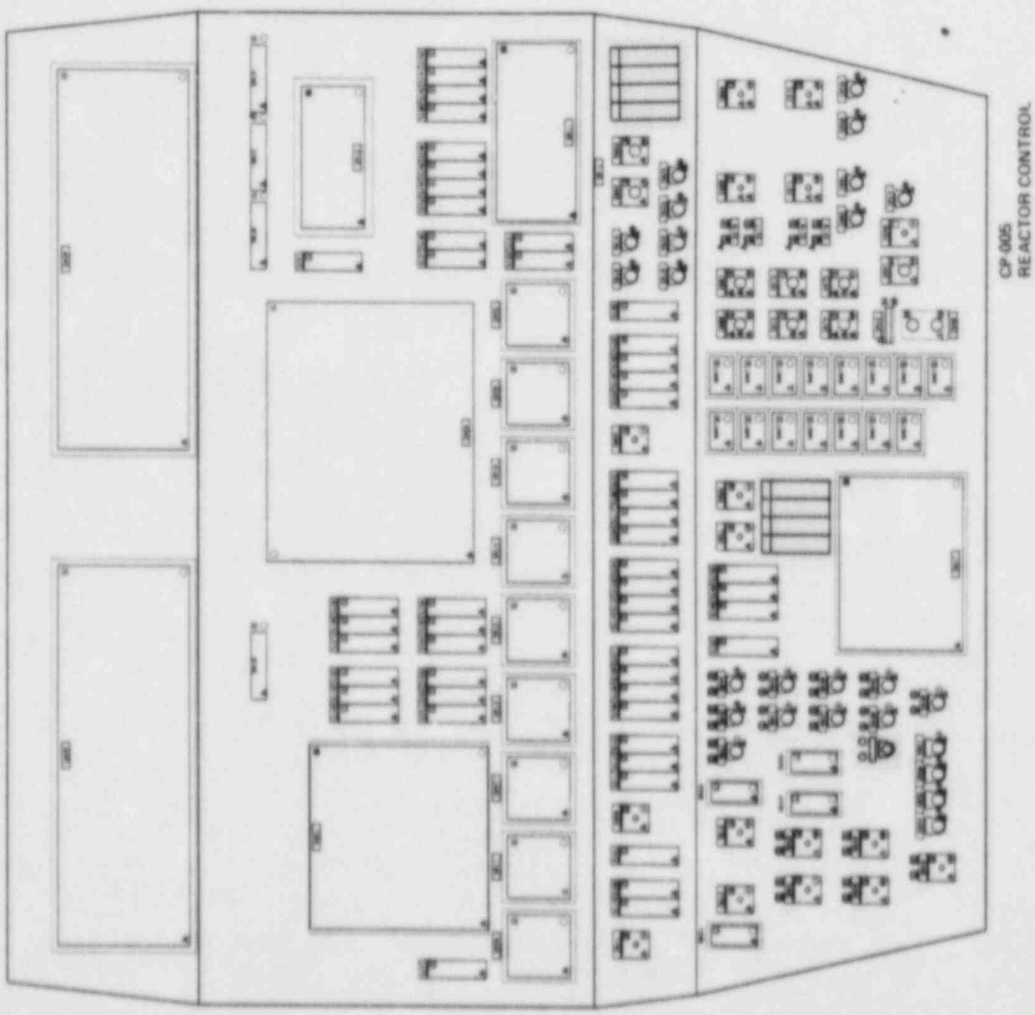
DEVICE ADDITIONS
CHEMICAL & VOLUME CONTROL

KNOWN CHANGES

Add	2	Status Lights
	1	2940
	11	Vertical Meters
	2	Plasma Displays (requires rearranging of recorders)

ANTICIPATED CHANGES

Add	4	2940s
	8	Vertical Meters
	3	SBMs



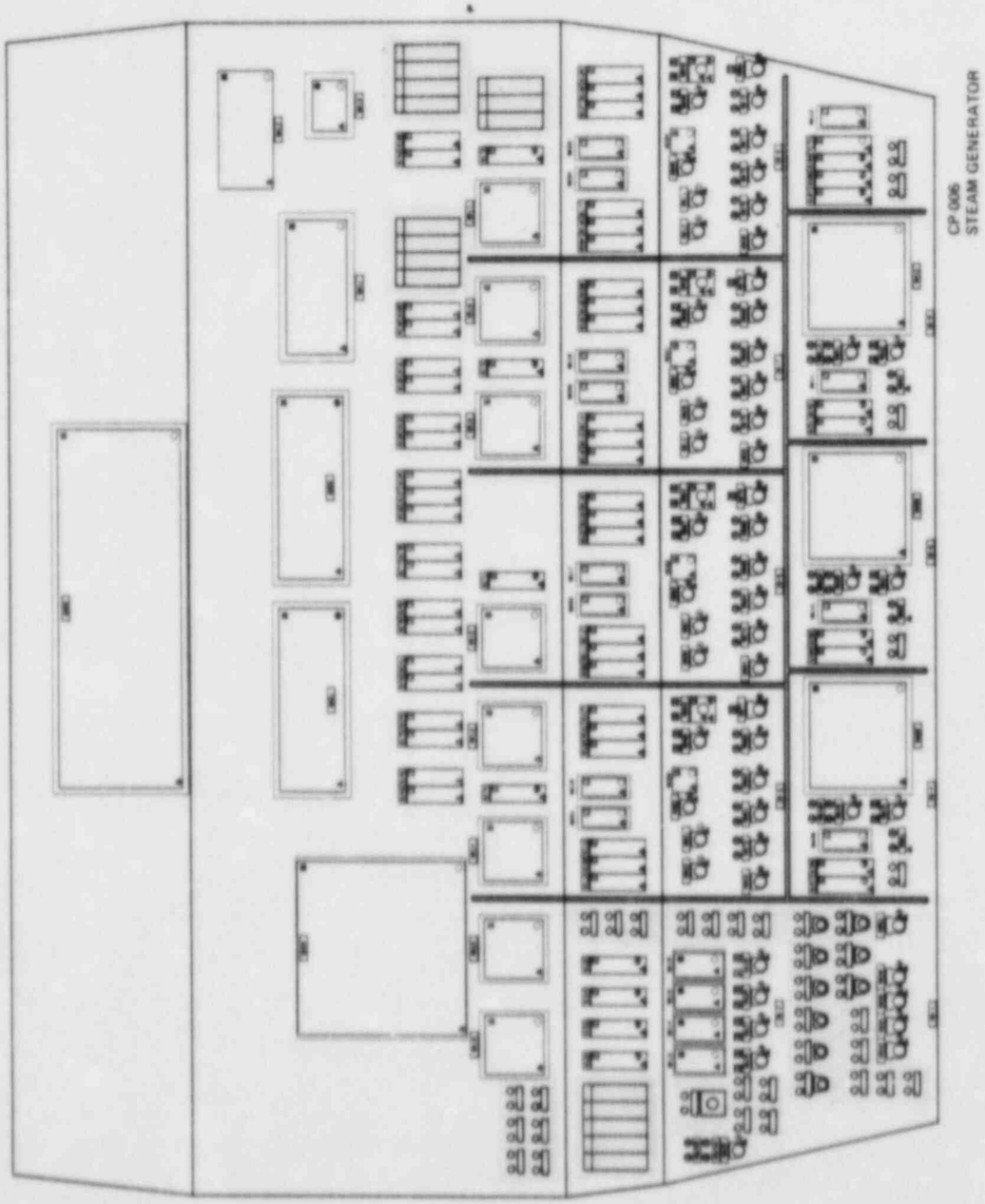
DEVICE ADDITIONS
REACTOR CONTROL

KNOWN CHANGES

Add	27	Status Lights
	16	Vertical Meters
	8	2940s
	1	SBM

ANTICIPATED CHANGES

Add	9	Vertical Meters
	8	2940s
	1	SBM



DEVICE ADDITIONS
STEAM GENERATOR

HOUSTON LIGHTING & POWER CO.

SOUTH TEXAS PROJECT

CONTROL ROOM DESIGN REVIEW

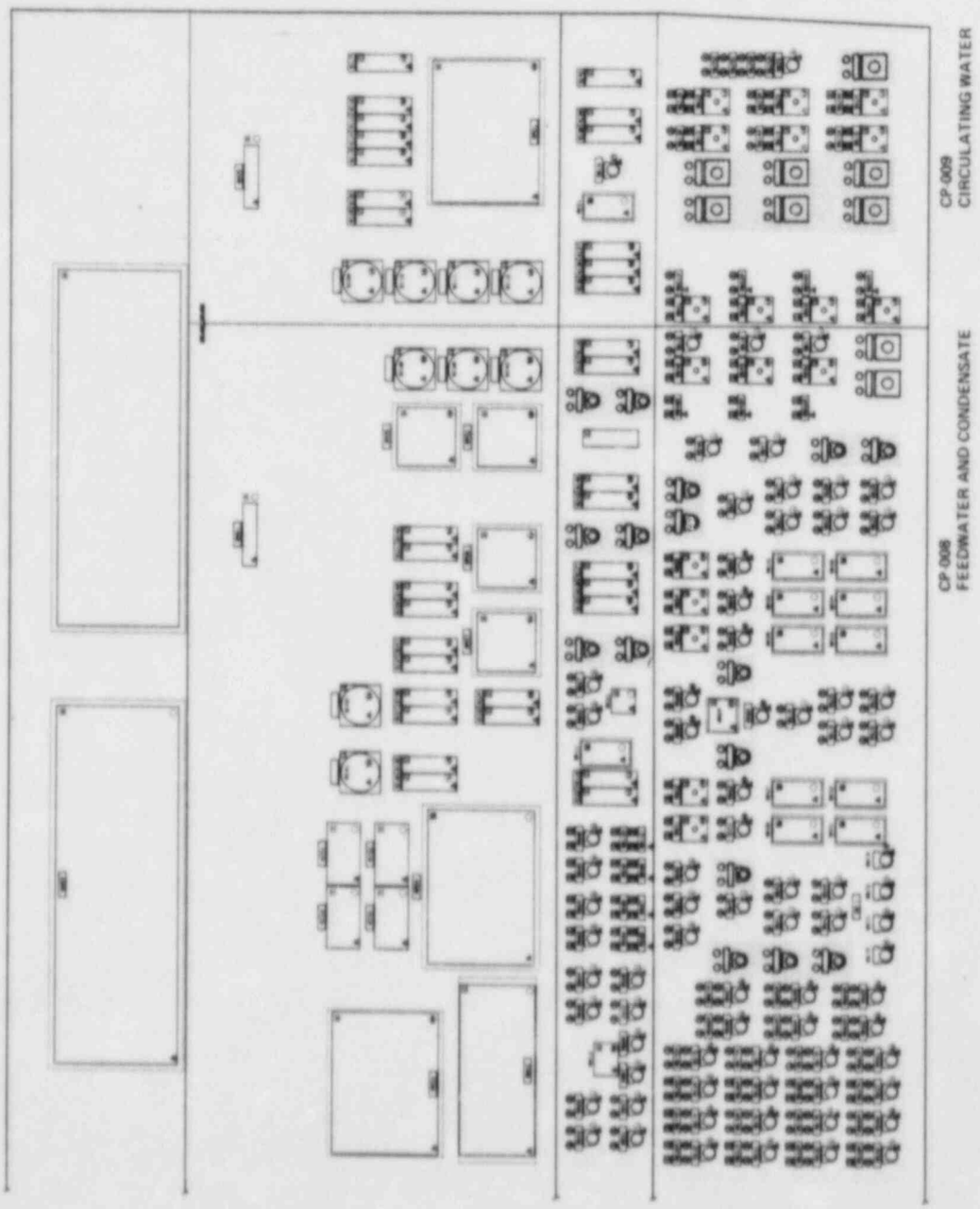
KNOWN CHANGES

Add 16 2940s
9 SBMs

ANTICIPATED CHANGES

Add 11 2940s
1 SBM
3 Vertical Meters
1 Round Meter } 8

1 SBM
2 Vertical Meters } 9



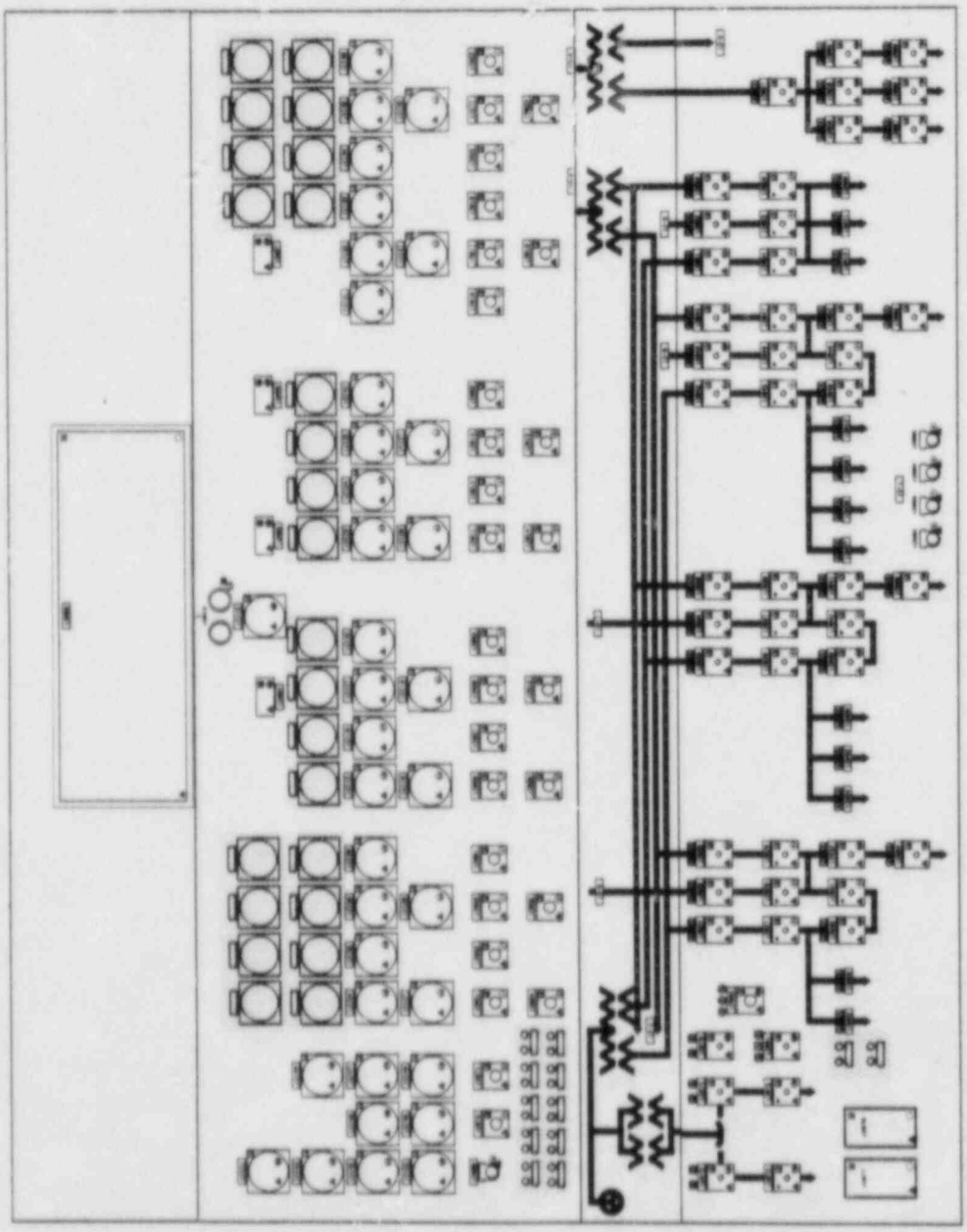
DEVICE ADDITIONS
FEEDWATER, CONDENSATE
AND CIRCULATING WATER

KNOWN CHANGES

Add 12 Status Lights
24 Round Meters

ANTICIPATED CHANGES

Add 11 SBMs
5 Round Meters
1 2940



CP-010
ELECTRICAL AUXILIARY POWER

DEVICE ADDITIONS
ELECTRICAL AUXILIARY POWER

Control Room Design Review

Special Studies Report

The South Texas Project

HOUSTON LIGHTING & POWER COMPANY