Revision 0
March 30, 1984

Control Room Design Review

Special Studies Report

The South Texas Project

HOUSTON LIGHTING & POWER COMPANY

SPECIAL STUDIES
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Title

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 compietion of the CRDR, a decision was made by HL&P to redesign six of the ten main control panels. This redesign effort was required to accommodate design changes resulting from plant design evolution and Reg. Guide 1.97 requirements. Human engineering discrepancies determined in the CRDR have been or are in the process of correction.

The CRDR is described in the Program Plan document. It contains a detailed description of the plans for the majors task elements. Due to the control room redesign effort, a modified approach was required to complete and document the CRDR program. The following changes have been made in the CRDR Program Plan:

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 have been completed for the original design. The SFTA and the control room survey have been updated to validate any design revisions.

The following is a description of the documents covering this CRDR (see figure P-1):

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

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

C. Operating Experience Review (OER) 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 (SFTA) Report - Describes the methodology, results, conclusions and recommendations for the SFTA effort defined in the Program Plan.

E. Control Room Survey (CRS) 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 miscellaneous studies performed as part of the CRDR. This includes 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. SFTA Validation Report - Summarizes the second SFTA review based on relayed out panels and walk-through/talk-through validation.

J. OER Validation Report - Summarizes the review made by operators to determine if the redesigned panels corrected concerns reported in the OER Report and if any new problems were created.

K. CRS Validation Report - Summarizes the review made to determine if the category A and representative samples of the Category B HEDS are satisfactorily corrected and if any new problems were created.

L. 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.

Purpose

The Control Room Design Review of the main control room of the South Texas Project performed a number of studies to evaluate specialized aspects of the control room. These studies document investigations that provided specific solutions to certain problems. They are presented here to record, in one volume, the data, methods, and results, in order to retain the rationale used in certain areas of the design of the main control boards.

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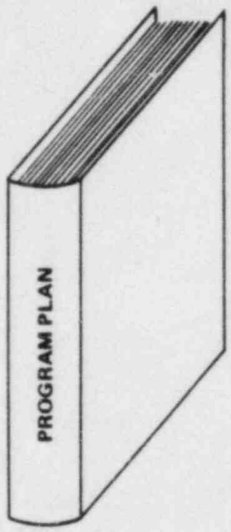
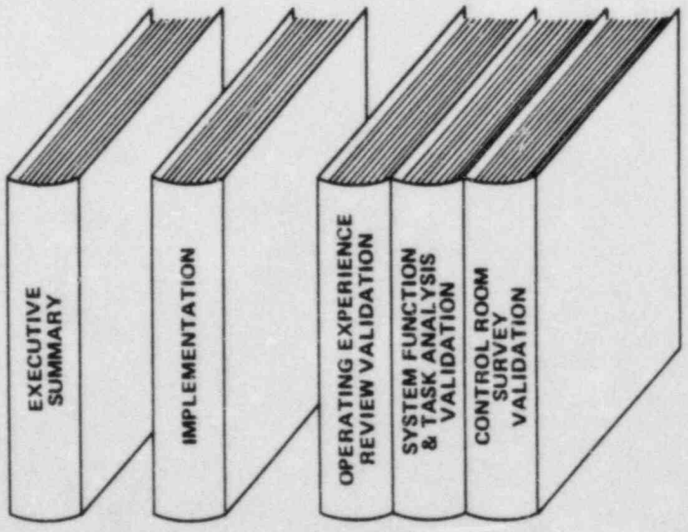


REVIEW & DESIGN SUPPORT

ASSESSMENT IMPLEMENTATION EFFECTIVENESS



STP CRDR MAJOR REPORTS
Figure P-1

HOUSTON
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AN ANTHROPOMETRIC ASSESSMENT

OF THE

SOUTH TEXAS PROJECT (STP)

STAND-UP

CONTROL PANELS

HOUSTON LIGHTING & POWER
BECHTEL POWER CORPORATION

5850P/0579P

ABSTRACT

Scope

Following is an anthropometric assessment of the standing control panels to be located in the STP control room. This assessment was performed during the first two weeks of the STP Control Room Design Review (CRDR). The sit-down design is incomplete and therefore, not addressed by this review. Five anthropometric variables were identified as those most pertinent to the dimensions of the standing operator. These variables as shown in Table 1 are standing height, eye height, shoulder height, functional reach, and extended functional reach.

Summary

With reference to visual factors, the STP stand-up control panels satisfy the general visual field guidelines contained in Section 6.1.2.2. of NUREG 0700. However, smaller operators may experience some difficulty in reading and interpreting the annunciator tiles. Additionally, the substantial head displacement required to read the annunciator tiles can lead to discomfort among smaller operators or those who wear bifocal lenses, especially if required for an extended time period. A more detailed assessment involving operators will be made of STP control panel visual factors during later phases of this CRDR.

The design adequacy of the STP control panels is clearly more questionable for operator reach. As presently configured, some STP panel segments contain controls that fall outside of the functional reach envelope of 90% of the female operator population and 30% of the male operator population. Use of the extended functional reach measure results in the controls falling outside of the reach envelope of only 20% of the female operator population and 5% of the male population. Neither of these measures accommodates the 5th percentile female thereby not conforming to the STP design goal in the Control Room Design Review Criteria Report.

To achieve this design goal of accommodating smaller (i.e. 5th-20th percentile) female operators, it likely will be necessary to reposition certain controls. To verify the need for control repositioning, it should be determined whether a representative lower percentile subject adequately can reach all controls on the STP mock-up. Any controls that cannot be reached by such a subject must be considered logical candidates for repositioning.

Conclusions

1. Based on the data reviewed for extended functional reach, the existing panel configuration will accommodate the 20th percentile female through 95th percentile male operator population. This is a more operationally realistic measure than functional reach.

2. Additional review of control reach is suggested using representative lower percentile subjects.

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Purpose

The purpose of this document is to provide data pertaining to the anthropometric "fit" of the South Texas Project (STP) stand-up control panels for the projected population of operators.

Definition and Benefits of Anthropometric Data

Anthropometry is the science of human body measurement. Its importance primarily is derived from its use in the design and evaluation of workplaces and workplace facilities such as chairs, desks, and control panels. The application of anthropometric data to the design of workplace facilities increases the likelihood that those facilities will be user-oriented (i.e., that the people who use the facilities to accomplish some specified objective(s) will be able to do so more safely, comfortably, and efficiently than otherwise possible). Two categories of anthropometric data are of use in the STP review - structural and functional. Structural data apply when control room operators are in a fixed (static) position. Functional data apply when operators are in motion (e.g., reaching to manipulate a control).

Generally, in the design of workplaces and associated facilities, there is a constraint imposed by the requirement to accommodate people whose physical measurements place them on the extremes of some anthropometric continuum. For example, the design should provide both for very small and very large people if such personnel are to be considered as potential users of the workplace. In the present case, the design of each STP control panel, the operator console, and other control room work surfaces should enable the operators to monitor all displays, detect and identify critical readings concerning plant status, and to reach and manipulate all controls as necessary. A cursory review of the STP control room mockup indicates that the present design of the control panels is such that smaller operators may experience difficulties in accomplishing the above functions. The exact extent of these difficulties can be assessed only after the mockup is completed and walkthroughs of several operational procedures have been conducted. However, analytic assessment can be made of the STP mockup panels on the basis of existing structural and

functional anthropometric data. The purpose of this brief document is to provide an overview of the design adequacy of STP standing control panels as they are presently mocked up with respect to anthropometric requirements set forth in Mil Std. 1472B (represented in Sections 6.1.2.1 - 6.1.2.3 of NUREG 0700), and to anthropometric data presented in Electric Power Research Institute (EPRI) Report No. NP-1918-SR (Parris & McConville, 1981), and in Woodson (1981). The Data Sources and Reference Data sections that follow contain a description of the rationale used to select these references.

Plant-Specific Concerns

Because the physical layout of the STP control panels appears to be more marginal for smaller than for larger operators, the relationships between maximum dimensions and lower percentiles of the potential operator population are of particular concern. For example, if those with short functional arm reach can reach and manipulate a control, those with longer arm reach likely could reach the control as well. In general, the major concern is with controls and displays that are positioned so high on the panel that small operators (e.g., those less than 5'-4" in height) cannot easily reach and manipulate the controls or see and read the displays. Moreover, controls and displays should not be so low on the panel that large operators have difficulty in using them safely and efficiently.

The sheer number of anthropometric variables of interest in the assessment of the STP mockup control panels makes it difficult (if not impossible) to accommodate the "average" operator. For instance, in taking 10 anthropometric measures of over 4000 adult males, Hertzberg (1960) found that not one of them fell within the average range (middle 30%) on all of the measures. Despite the myth of the "average man", however, there are legitimate reasons for providing workplace facilities on the basis of some composite measure that represents the average anthropometric dimensions of the targeted user population. Such is the case with regard to the STP control panels.

Limitations Of Anthropometric Data

Anthropometric data sometimes are used merely for population comparison purposes rather than for workplace design. Additionally, there is no complete assurance that all anthropometric measurements (especially functional ones involving reach) are obtained in

a completely standardized manner. Finally, some anthropometric data are based on physical measurements acquired up to two decades ago. It is reasonable to assume that such measurements might differ somewhat from those acquired more recently since age-constant body shape and size tend to change over time as a function of such factors as diet, exercise, and work requirements. Thus, precautions should be taken not to interpret the data too stringently. In spite of these limitations, the data serve as useful guidelines for assessing the "fit" of the panel mockup as presently configured to the potential STP control room operator population.

Data Sources

NUREG 0700 (Section 6.1.2.1) recommends that equipment dimensions accommodate the 5th to 95th percentile of the user population. Measurements of adult females define the 5th percentile while those of adult males define the 95th percentile. Since the STP control panels were considered potentially marginal for safe and efficient use by smaller operators, it was decided that the assessment of each anthropometric variable should be extended to multiple percentiles within both male and female subject populations. For instance, if the 5th percentile female operator (lower limit) cannot easily reach a control or clearly read an instrument, it is of interest for design modification purposes to determine whether the 10 rcentile female operator (or 5th percentile male operator) could do so. Such an assessment requires a more comprehensive anthropometric data base than that furnished in Exhibit 6.1-5 of NUREG 0700. Hence, it was necessary to obtain supplementary anthropometric data to accomplish such an assessment.

These data were taken from Appendix B of EPRI Report No. NP-1918-SR (Parris & McConville, 1981). Because the upper and lower values of data included in this latter document deviated no more than 4% from those in Exhibit 6.1-5 of NUREG 0700, the EPRI data[1] were used in their entirety for assessment purposes.Standing eye height data are not contained in the Parris and McConville (1981) document, so it was necessary to acquire these data from Woodson (1981).

(1) An advantage in using the EPRI data is that they were obtained on male power plant operators and maintenance personnel (N=1696). Because of the small size of the female power plant sample (N=63), the EPRI data base on females was generated from a 1968 Air Force survey.

Reference Data

Table 1 presents data for the anthropometric variables of concern. Following is a brief overview of the design adequacy of the STP control panels with respect to the Table 1 data. Of particular significance, for operator monitoring purposes, are the data pertaining to eye height. This variable serves as the reference point for defining the operator's line of sight as well as angles defining the visual field. For control purposes, shoulder height, functional reach, and extended functional reach are of prime concern.

Table 1. Standing Operator Anthropometric Measures

Sources - EPRI Report No. NP-1918-SR (Parris & McConville, 1981)
and
Woodson, 1981

Percentile	Standing Height		Eye Height		Shoulder Height		Functional Reach		Extended Functional Reach	
	M	F	M	F	M	F	M	F	M	F
5	66.4	60.0	60.8	55.5	54.0	48.4	29.4	26.6	32.6	29.9
10	67.3	60.7			54.8	49.1	30.0	27.2	33.3	30.6
25	68.9	62.1			56.3	50.3	30.9	28.1	34.4	31.7
50	70.7	63.8	64.7	60.3	58.0	51.9	31.9	29.2	35.6	32.9
75	72.3	65.4			59.5	53.4	33.0	30.2	36.8	34.3
90	73.7	66.9			60.8	54.8	34.0	31.1	38.0	35.6
95	74.5	67.8	68.6	65.3	61.5	55.6	34.6	31.7	38.7	36.3

M - Male
F - Female

Visual Assessment

Figure 1 depicts eye height and visual angles for the 5th percentile female and 95th percentile male operators of the STP standup control panels. Lines defining visual angles originate at the midpoints of the control panels. One inch has been added to the Table 1 eye height values for those two percentiles to accommodate shoe height. While NUREG 0700 guidelines are met by the angles depicted, it is apparent that the smaller operator might be expected to experience a moderate degree of difficulty in reading and interpreting the annunciators (located in the shaded portion of the control panel in Figure 1). The same problem exists for operators wearing bifocal lens regardless of their height. The exact degree of difficulty will depend on such factors as the actual distance of the operator from the annunciators, and the amount of time spent monitoring these displays relative to other STP control panel displays. There are approximately 1000 annunciator tiles on the STP control panels, various combinations of which may be lighted at any given time. The pattern of these lighted tiles warns the operator of deviant (or potentially deviant) system states. While these overall patterns can best be perceived from greater viewing distances, operators must verify information by reading the tiles from shorter distances. In general, relatively shorter viewing distances and greater scan times can be expected to increase the probability of neck tension, eye strain, visual fatigue, and headaches among shorter operators.

A more detailed analysis will be made of operator visual factors during later phases of the STP CRDR. This analysis will be conducted during the control room survey and/or verification phases.

Functional Reach Assessment

Figure 2 depicts shoulder height and functional reach[1] for the 5th percentile female and 95th percentile male operators of the STP stand-up control panels. As in Figure 1, one inch has been added to the Table 1 shoulder height dimension to accommodate shoe height.

(1) Functional reach is the distance from the back of the operator to the tip of the operator's fingers with the arm fully extended perpendicular to the vertical plane of the body (operator standing fully erect and fingers partially extended). This is the operator reach measure included in NUREG 0700.

NUREG 0700 (Section 6.1.2.2) states that all controls should be within reach of the 5th percentile female without stretching or using a stool or ladder. Additionally, Section 6.1.2.2 indicates that all controls should be within 25 inches of the front edge of the control panel. As can be seen in Figure 2, the STP control panels do not meet either of these guidelines. The functional reach of the 5th percentile female standing erect against the guardrail of the STP control panel results in her being unable to touch either Segment A or Segment B of the panel. Hence, given that standing position, it would not be possible for her to manipulate controls located in those segments of the panel. In fact, the 5th percentile male operator could not reach controls placed in Segment A and could reach Segment B controls only with some difficulty.

Since controls are to be located in Segments A and B of the STP control panel, the existing configuration satisfies the above NUREG 0700 guideline only for the 90th percentile female operator and approximately the 30th percentile male operator as shown in Figure 3. These percentiles are predicated on a required functional reach of approximately 31 inches, the distance from a vertical reference plane tangent with the outer edge of the guardrail to the Segment A panel surface.

Extended Functional Reach Assessment

NUREG 0700 (Section 6.1.2.2) guidelines require the operator to have both shoulders in line with the leading edge of the board when functional reach measurements are obtained. Strict adherence to this guideline does not permit even the slightest amount of forward lean or shoulder rotation by the operator for such measurements. Thus, functional reach is overly conservative for actual application in the control room.

Extended functional reach[(1)] is likely a more realistic measure of operator reach from an operational standpoint because operators frequently rotate their shoulders, bend, and/or lean to reach and manipulate controls during normal control room operations. Thus, extended functional reach shall be used as the reach criterion for STP control board review purposes.

(1) Extended functional reach is measured with the subject's right shoulder and arm extended as far forward as possible while keeping the left shoulder firmly against an imaginary wall.

Table 1 data (last column) indicate that for extended functional reach, the present STP control panel configuration will accommodate approximately the 20th percentile female operator and the 5th percentile male operator. Figure 4 depicts extended functional reach for these percentiles. Since there are approximately 200 controls located in Segments A and B (Figure 2) of the boards, some control repositioning will be necessary to accommodate 5th-20th percentile female operator extended functional reach.

Reach Height Limits

Of additional interest for operator reach purposes is the vertical location of Segment 'A' controls relative to operators' functional reach or extended functional reach. For a given (fixed) percentile operator with a given (fixed) functional reach or extended functional reach, controls located in Segment 'A' of the STP boards may or may not be reachable depending upon how far up on that segment such controls are located. This relationship as can be seen in Figures 3 and 4, is defined by the point at which the arc depicting the operators reach envelope no longer touches Segment 'A' of the panel. For present assessment purposes, this point is termed the reach height limit. Table 2 presents functional reach and extended functional reach height limit data for 5th through 95th percentile operators. Values in this table represent the distance from the lower edge of Segment 'A' to the arc departure point, and therefore define the upper limits for vertical location of controls.

Table 2. Standing Operator Reach Height Limits(1)

SEGMENT 'A' REACH HEIGHT LIMITS

	Functional Reach		Extended Functional Reach	
Percentile	M	F	M	F
5	*	*	8.9	*
10	*	*	11.6	*
25	*	*	15.4	7.1
50	10.3	*	19.0	13.3
75	15.5	*	22.0	17.9
90	19.1	*	24.6	21.4
95	20.9	12.4	25.9	23.1

M - Male
F - Female

(1)Table values reflect variations among operator shoulder heights and are distances from the lower edge of Segment 'A' to the point at which the arc defining the operators' reach envelope (Figures 3 and 4) no longer touches that segment of the panel surface. As such, these values define the upper limits for locating controls vertically on Segment 'A' given functional reach and extended functional reach measures. Asterisks (*) indicate that the reach envelope arc does not intersect any portion of the Segment 'A' panel surface for a given percentile operator.

Conclusions

1. Based on data reviewed for extended functional reach, the existing panel configuration will accomodate the 20th percentile female through 95th percentile male operator population. Extended functional reach is considered to be a more realistic, operationally relevant, measure than functional reach.

2. Further assessment of control reach is suggested using representative lower percentile subjects.

References

Guidelines for Control Room Design Reviews, NUREG 0700, U.S. Nuclear Regulatory Commission, Washington, D.C., September 1981.

Hertzberg, H. T., Some Contributions of Applied Physical Anthropology to Human Engineering, USAF, WADD, TR 60-19, January 1960.

Parris, H. L. & McConville, J. T., Anthropometric Data Base for Power Plant Design (EPRI NP-1918-SR) Electric Power Research Institute, July, 1981.

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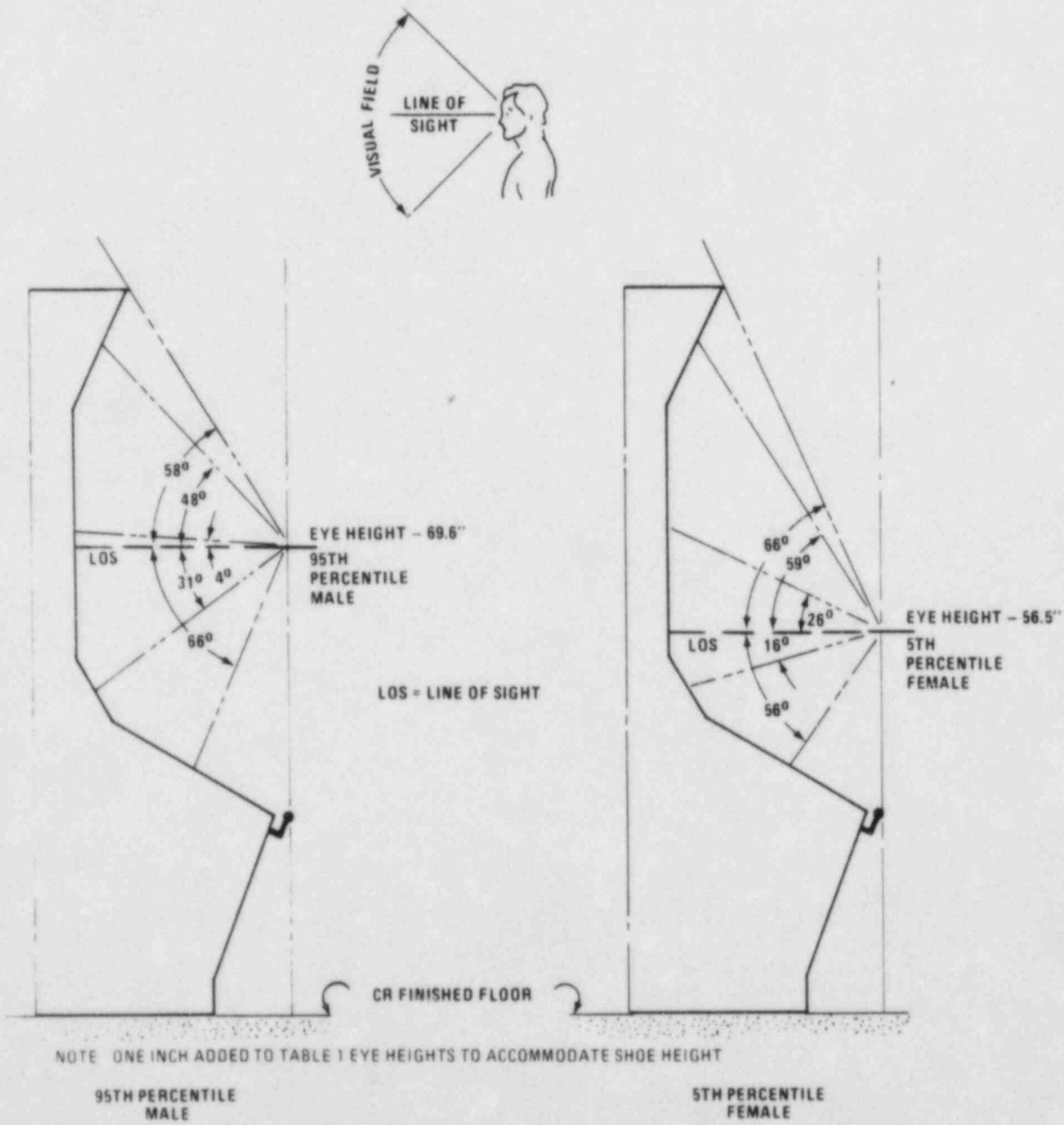
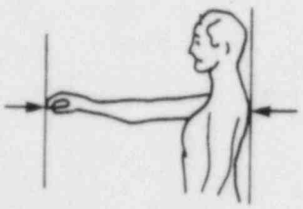
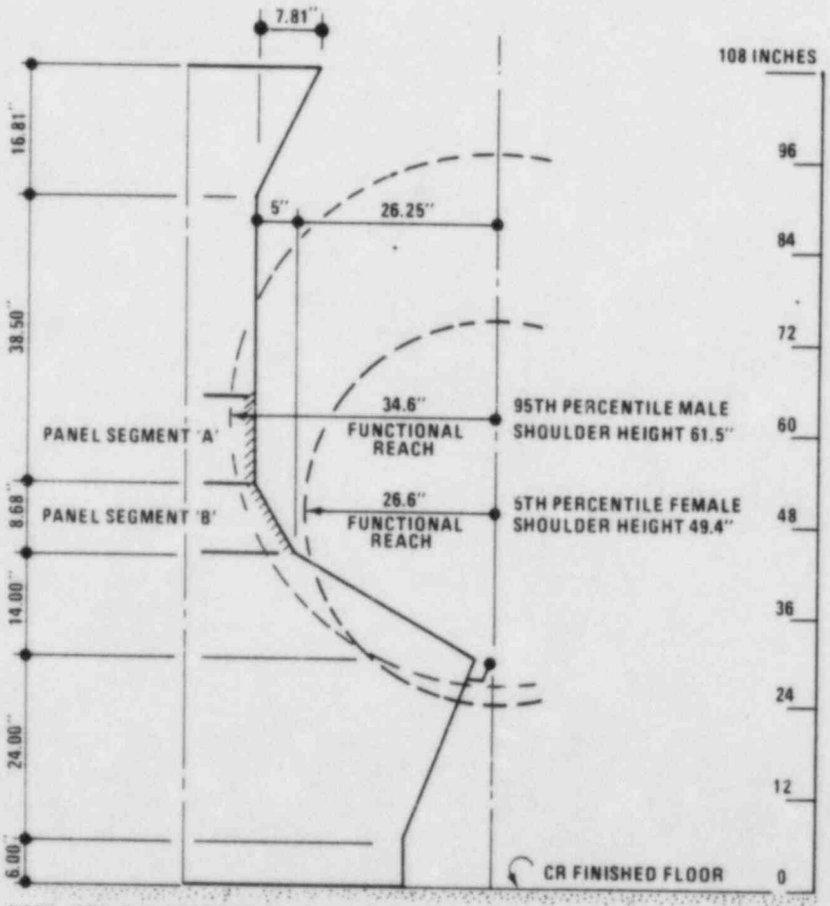


OPERATOR EYE HEIGHTS, LINES OF SIGHT (LOS), AND VISUAL ORIENTATIONS FOR SOUTH TEXAS PROJECT STAND-UP CONTROL PANELS

Figure 1

FUNCTIONAL REACH IS THE DISTANCE FROM THE BACK OF THE OPERATOR TO THE TIP OF THE OPERATOR'S FINGERTIPS WITH THE ARM FULLY EXTENDED PERPENDICULAR TO THE VERTICAL PLANE OF THE BODY (OPERATOR STANDING FULLY ERECT AND FINGERS PARTIALLY EXTENDED).



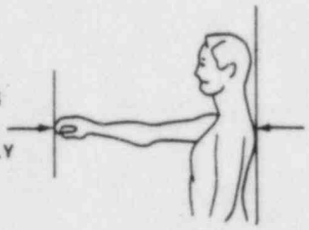


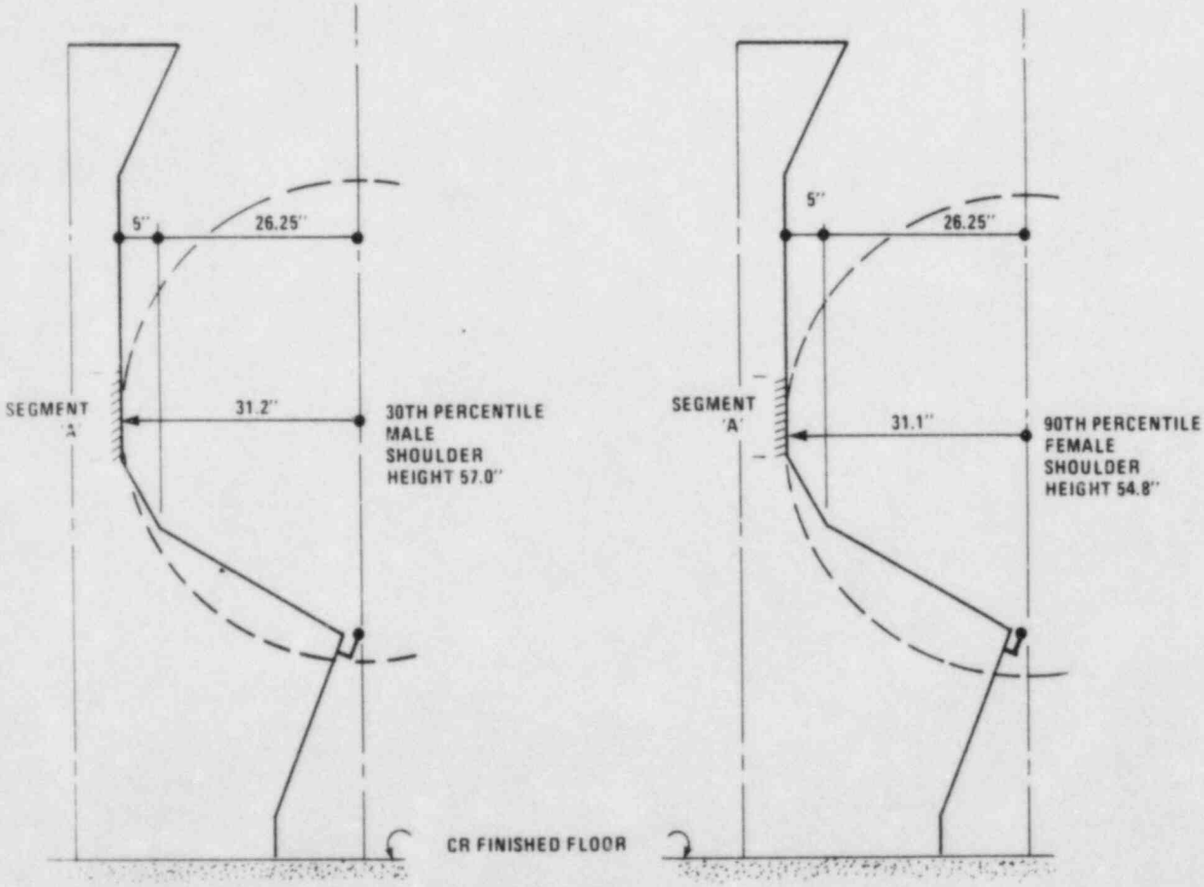
NOTE: ONE INCH ADDED TO TABLE 1 SHOULDER HEIGHTS TO ACCOMMODATE SHOE HEIGHT.

OPERATOR SHOULDER HEIGHTS AND FUNCTIONAL REACH PROFILES FOR SOUTH TEXAS PROJECT STAND-UP CONTROL PANELS

Figure 2

FUNCTIONAL REACH IS THE DISTANCE FROM THE BACK OF THE OPERATOR TO THE TIP OF THE OPERATOR'S FINGERTIPS WITH THE ARM FULLY EXTENDED PERPENDICULAR TO THE VERTICAL PLANE OF THE BODY (OPERATOR STANDING FULLY ERECT AND FINGERS PARTIALLY EXTENDED).





NOTE ONE INCH ADDED TO TABLE 1 SHOULDER HEIGHTS TO ACCOMMODATE SHOE HEIGHT.

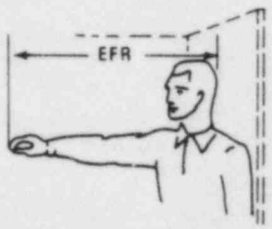
30TH PERCENTILE MALE

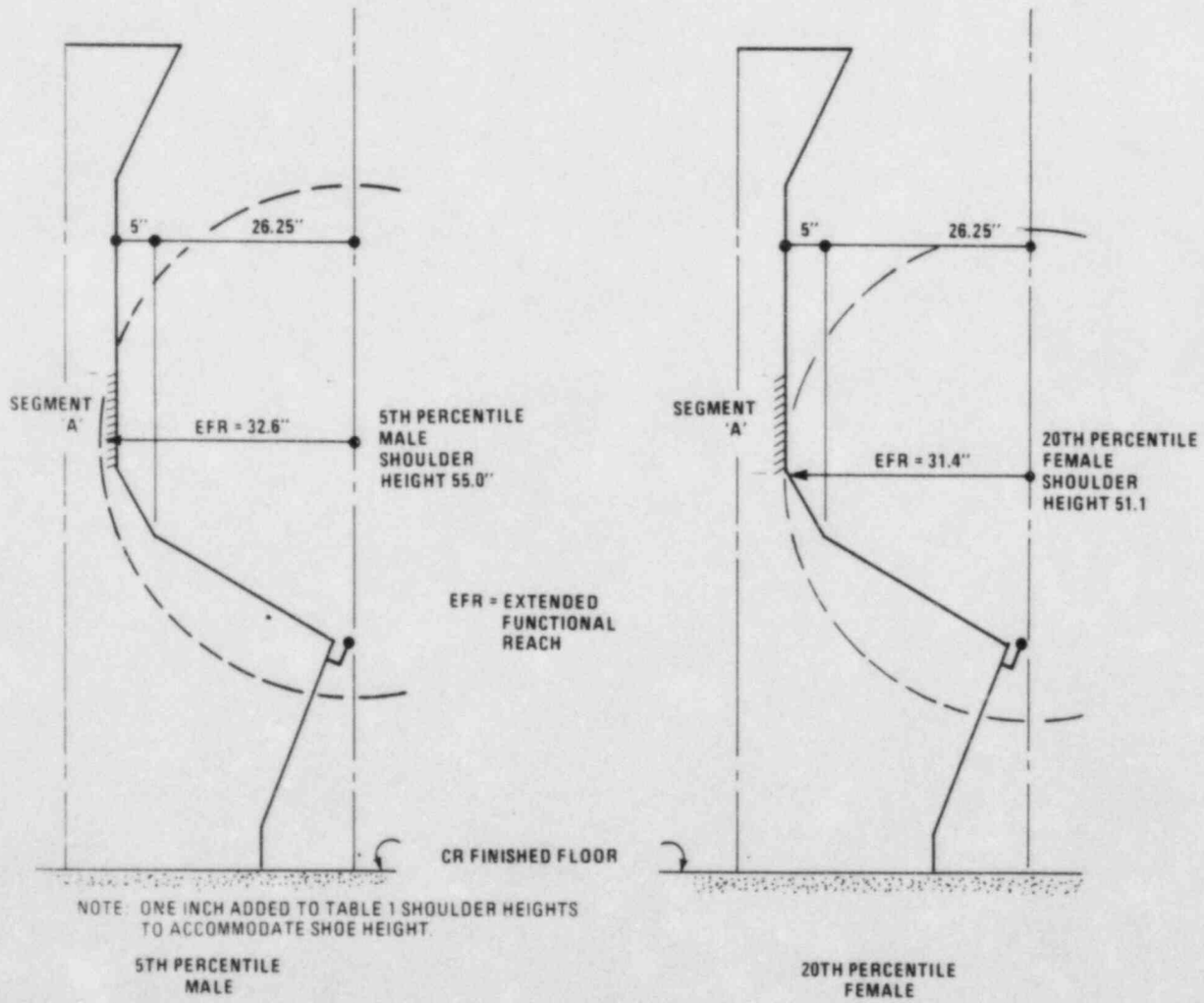
90TH PERCENTILE FEMALE

FUNCTIONAL REACH PROFILES AND CORRESPONDING OPERATOR PERCENTILES REQUIRED TO ACCESS SEGMENT 'A' OF SOUTH TEXAS PROJECT STAND-UP CONTROL PANELS

Figure 3

EXTENDED FUNCTIONAL REACH (EFR) IS MEASURED WITH THE SUBJECT'S RIGHT SHOULDER AND ARM EXTENDED AS FAR FORWARD AS POSSIBLE WHILE KEEPING THE LEFT SHOULDER FIRMLY AGAINST AN IMAGINARY WALL.





EXTENDED FUNCTIONAL REACH (EFR) PROFILES AND CORRESPONDING OPERATOR PERCENTILES REQUIRED TO ACCESS SEGMENT 'A' OF SOUTH TEXAS PROJECT STAND-UP CONTROL PANELS

Figure 4

LABELING STUDY

REPORT.

SOUTH TEXAS PROJECT

HOUSTON LIGHTING & POWER COMPANY

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1.0 INTRODUCTION

The labeling study was initiated as a result of the Control Room Survey observations on panel labeling. This survey, performed to the Criteria Report, highlighted: the need for hierarchial labeling and exact action verbage, inconsistencies in the use of abbreviations, nonconformance to engraving guidelines, and other violations of specifications.

The labeling study was conducted at the Bechtel-Houston office using the full scale mock-up. Figure 1-1 is a line drawing of the control room layout. Figure 1-2 is a photograph of the control room mock-up. This study was conducted according to the Labeling Design Guideline, Ref. 2, in compliance with the human factors criteria specified in the Criteria Report, Ref. 3. This report includes only the main control panels (CP) 001 thru 010.

The following outlines the major activities of this study.

1. Preparation and approval by the Project Review Team (PRT), of the Labeling Design Guide. See Program Plan, Ref. 1, for PRT in control room design review organization.

2. Review of mockup labeling against the Labeling Design Guide.

3. Formulation of higher level (system and subsystem) labels

4. Preparation of a reference set of panel component labels using format Figure 2-1 and 2-2 and top-down flow approach per Figure 2-3. The technique used produced an initial listing of labels with minimum verbage consistent with the higher level labels and maximum useage of abbreviations. Subsequent review with plant operators expanded the wording as required to facilitate quick comprehension of the label contents.

5. Prepare paper labels that represent the Design Guide engraving and size recommendations.

6. Review by plant operators of the mock-up and modification of label listings and mocked up labeling, in an interative process.

1.1 OBJECTIVE

The objective of this study was to develop control panel labeling that provides operational personnel with logical and functional descriptive information regarding the components mounted on it.

1.2 THE LABELING STUDY INCLUDED THE FOLLOWING TASKS:

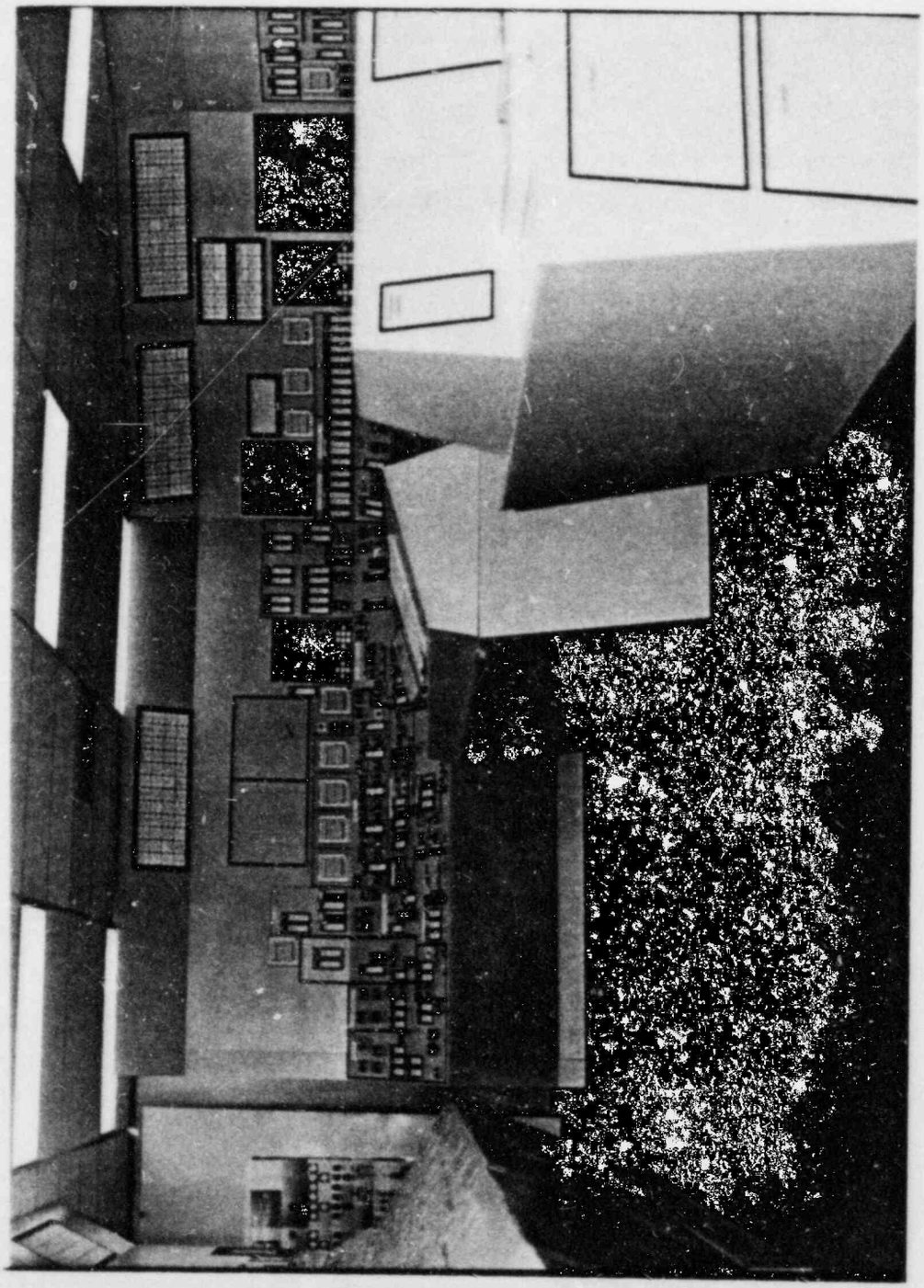
A. Develop a Labeling Design Guide (Ref. 2)

B. Develop a labeling format (Appendix A)

C. Develop a set of labels for each panel

D. Conduct operator review of proposed labels

E. Revise labels and document by panel



PHOTOGRAPH OF PANEL MOCK-UP
FIGURE 1-2

2.0 METHODOLOGY

2.1 LABELING DESIGN GUIDE

A labeling design guide, Ref. 1, was prepared, approved by the PRT, and used as the basis for this study. The design guide established character and label sizes as a function of a hierarchial scheme, i.e. for system, subsystem and component levels.

2.2 LABELING FORMAT

Three label format types were created to provide a standard for preparing and structuring the label content. Figure 2-1 shows the three label types.

Type I format was the most commonly used for identifying individual equipment components. Lines 1 and 2 were used to describe the equipment function and line 4 to provide the equipment number. Line 3 was used for components with two equipment numbers and is also available for adding information to assist operators,such as power supply bus designators.

Type II format was used for identifying hierarchial labels at either the system or subsystem level. A single line of print was normally used to identify a hierarchial level or to describe the component function.

Type III format was used in place of a Type II label when more than one line was necessary to identify subsystem hierarchy or a component function.

See Figure 2.2 for a sample of each of the label types.

Appendix A contains a sample of the formats used to produce new label listings for all labels on panels 001-010.

2.3 DEVELOP A SET OF LABELS FOR EACH PANEL

A top down approach was used to develop labels for each panel. Each equipment panel component label was affixed to its associated panel component on the mock-up of the control room panels, CP-001 thru CP-010 (Fig. 1-1). Each panel was surveyed separately using a top down approach, starting at the system level, and continuing downward to the subsystem and component groups and component level, see Figure 2-3. The underlying premise in label development was to assure rapid operator comprehension using minimum verbage.

The selection of words used to develop the label contents followed the criteria established in the Labeling Design Guide as follows:

A. Words employed shall express exactly what action is intended and shall have a commonly accepted meaning.

B. Uncommon technical terms shall be avoided.

C. Instructions shall be clear and direct.

D. Words shall be spelled correctly.

E. Abbreviations shall conform to Appendix L of the Criteria Document, Ref 3.

F. Words on labels shall be concise and still convey the intended meaning.

G. Labels shall be consistent within and across pieces of equipment in their words, acronymns, abbreviations, and part/system numbers.

The selection of character sizes and label sizes followed the Label Design Guide and are shown in Tables 2-1 and 2-2.

It should be noted that the panel identifier and control position indicator legend type sizes are not included in this labeling report. The rationale for excluding these legend types is as follows:

A. The panel identifier is used to provide information to non-operational personnel.

B. The control position indicator uses a complete word to identify the control action e.g., on, off, auto, open or close thus, the control action character size is all that needs to be identified.

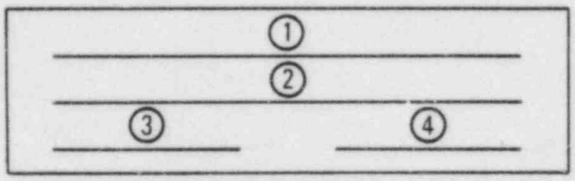
2.4 OPERATOR REVIEW OF PROPOSED LABELS

Several control room operators reviewed approximately 1900 proposed labels as shown on format sheets. Since the initial set of hierarchical labels utilized the minimum amount of label content, several iterations were necessary to achieve good comprehension with minimum verbage. A set of labels were prepared and mounted on the mock up with its associated panel components. Table 2-3 shows the distribution of labels produced for each panel. Figs 2-4 and 2-5 shows typical worksheets. Each sheet was reviewed and signed off by the reviewing operator and verified by Mr Rett Considine, the principal investigator.

2.5 REVISED LABELS AND LISTINGS

The mocked up panel labels were reviewed by plant operators, considering the hierarchial arrangement. A firm set of labels were agreed to and corrections made to the listings and to the mock up. The firm set of label work sheets were turned over to Bechtel engineering for production of engineering drawing required for panel fabrication.

LABEL TYPE I



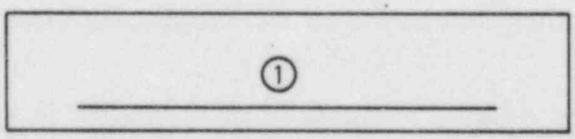
① ALWAYS CENTERED, IF THIS LINE IS USED

② GENERALLY CENTERED, MAY BE RIGHT AND LEFT JUSTIFIED FOR SEPARATE ITEMS RELATED TO ③ AND ④ RESPECTIVELY

③ ALWAYS LEFT JUSTIFIED

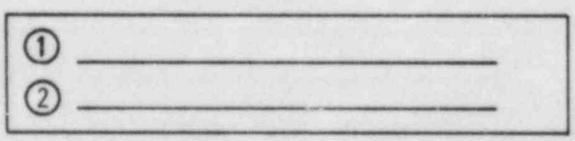
④ ALWAYS RIGHT JUSTIFIED

LABEL TYPE II



① ALWAYS CENTERED

LABEL TYPE III



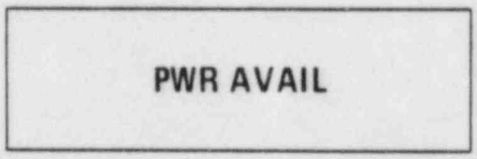
① ALWAYS CENTERED

② ALWAYS CENTERED

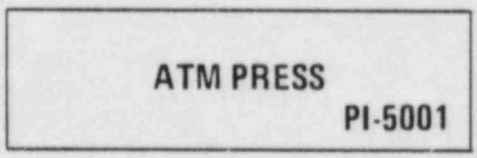
LABEL FORMAT TYPES
FIGURE 2-1

TYPE I

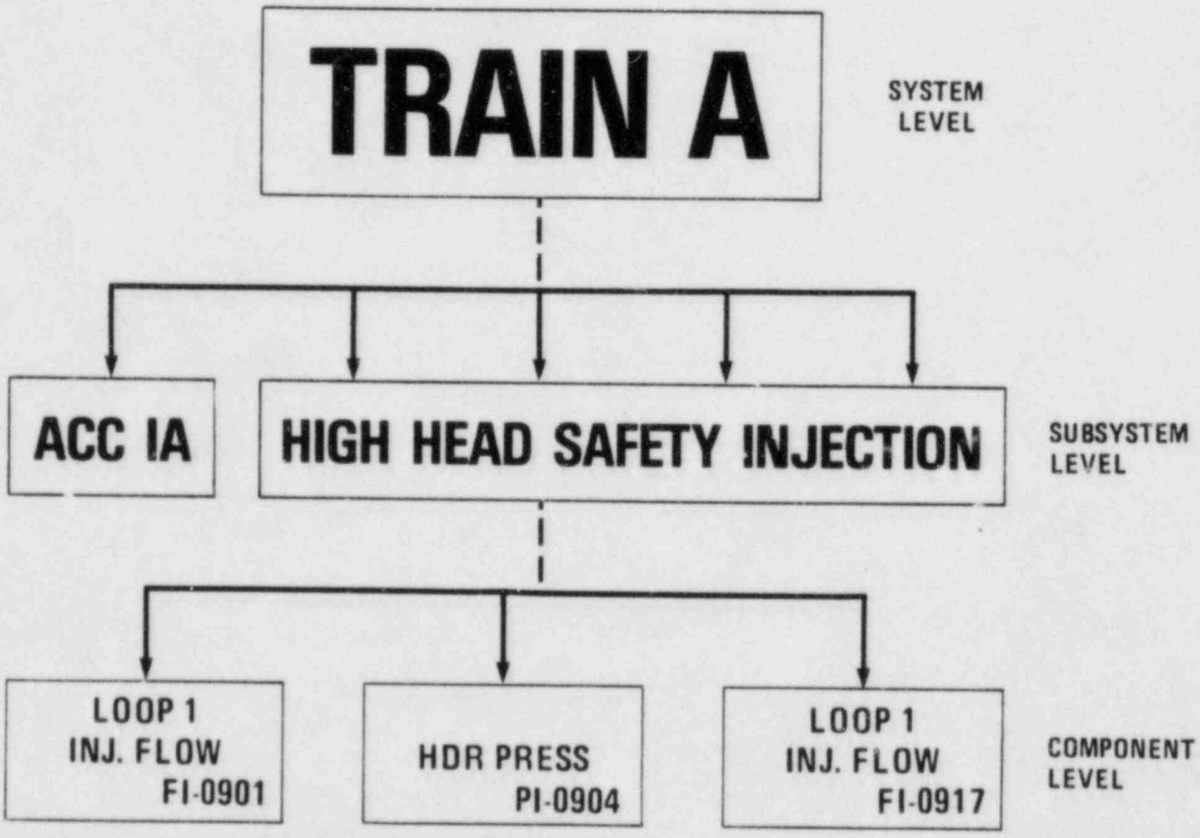
TYPE II



TYPE III



SAMPLE LABELS
FIGURE 2-2



TOP DOWN FLOW DIAGRAM FOR LABEL DEVELOPMENT
FIGURE 2-3

HOUSTON LIGHTING & POWER CO.

CONTROL ROOM DESIGN REVIEW

LABEL NAME	CHARACTER HEIGHT (INCHES)	BEZEL LENGTH (INCHES)	BEZEL WIDTH (INCHES)	TYPE	REMARKS
SPENT FUEL POOL PURIF.	0.14	2 1/2	3/4		
SI PUMPS SUCT HDR					
CHG PUMPS SUCT HDR					
LHSI HDR TRN A					
LHSI HDR TRN B					
LHSI HDR TRN C					
LOOP 3 Tc INJ VLV SI-0006B					
LOOP 3 Tc INJ VLV SI-0006C					

PANEL NUMBER 001 SHEET NO. 6 PREPARED BY _____ DATE _____

PANEL IDENTIFIER ESF (SI) CHECKED BY _____ DATE _____

DATA SHEET–LABELING

VERIFIED BY _____ DATE _____

TYPICAL LABEL SHEET
FIGURE 2-4

HOUSTON LIGHTING & POWER CO.

CONTROL ROOM DESIGN REVIEW

LABEL NAME	CHARACTER HEIGHT (INCHES)	BEZEL LENGTH (INCHES)	BEZEL WIDTH (INCHES)	TYPE	REMARKS
LEVEL LI-0933	0.14	2 1/4	3/4		Note Size Change
SUCT HDR ISOL VLV FV-xxxx		2 1/2			
SUCT HDR ISOL VLV FV					
HDR JOCKEY PUMP 1					
HDR JOCKEY PUMP 2					
SFP PURIF ISOL FV-3937					
SFP PURIF ISOL FV-3936					
LOOP 1 Tc INJ VLV SI-0006A					

PANEL NUMBER 001 SHEET NO. 5 PREPARED BY _____ DATE _____

PANEL IDENTIFIER ESF (SI) CHECKED BY _____ DATE _____

DATA SHEET–LABELING

VERIFIED BY _____ DATE _____

TYPICAL LABEL SHEET
FIGURE 2-5

TABLE 2-1

CHARACTER SIZES (INCHES)

Legend Type	Minimum Character Height	Stroke Width	Letter & Numeral Width	Character Spacing	Line Spacing	Space Between Labels
Panel Identifier	1.11	0.14	0.67	0.14	0.56	1.34
System Label	0.60	0.08	0.36	0.08	0.30	0.72
Subsystem Label	0.38	0.048	0.23	0.048	0.19	0.46
Component Label	0.14	0.02	0.08	0.02	0.07	0.16
Control Position Indicator	0.08	0.013	0.06	0.013	0.05	N.A.

TABLE 2-2

LABEL SIZES (INCHES) AND LINES PER LABEL

Label Category	Height	Length	Lines Per Label
System	1	As required	1 maximum
Subsystem	1 - 1.25*	As required	2 maximum
Component	0.75	2.25 - 2.50**	3 maximum

* 1.25 for two lines of print

** 2.25 = Level Indicator
2.50 = Valve Indicator

Note: All labels will utilize dark characters on a light background.

TABLE 2-3

LABEL QUANTITIES

Panel No.	Component Labels	Subsystem Labels	System Labels	Total Panel Labels
CP-001	174	11	4	189
2	313	38	2	353
3	163	25	6	194
4	209	28	3	240
5	126	24	1	151
6	209	55	5	269
7	67	15	1	83
8	209	16	2	227
9	36	8	1	45
10	135	48	1	184
Totals	1641	268	26	1935

3.0 SUMMARY OF RESULTS

The labeling study resulted in the correction of the control room survey discrepancies. Each panel received several layers of heirarchial labels that simplified the individual component labels. The study included significant operator participation.

The study produced a labeling guide that will become a permanent part of the criteria report to guide future labeling. Over 1900 labels were formulated. They were formulated, with the objectives of consistency, conformance to human factors recommendations for color contrast (change to light background and dark letters) and useage of standard abbreviations consistent with quick recognization of the label content.

4.0 REFERENCES

1. Houston Lighting & Power Company, "Control Room Design Review Program Plan," March 1983.

2. Houston Lighting & Power Company, "Control Room Design Review Labeling Design Guide," June 1983

3. Houston Lighting & Power Company, "Control Room Design Review Criteria Report," February 1983

4. NUREG-0700, "Guidelines for Control Room Design Review," September 1981

APPENDIX A

LABELING FORMATS

HOUSTON LIGHTING & POWER CO.

SOUTH TEXAS PROJECT

CONTROL ROOM DESIGN REVIEW

LABEL NAME	CHARACTER HEIGHT (INCHES)	BEZEL LENGTH (INCHES)	BEZEL WIDTH (INCHES)	TYPE	REMARKS

PANEL NUMBER _____ SHEET NO. _____ PREPARED BY _____ DATE _____

PANEL IDENTIFIER _____ CHECKED BY _____ DATE _____

DATA SHEET–LABELING

VERIFIED BY _____ DATE _____

HOUSTON LIGHTING & POWER CO.

CONTROL ROOM DESIGN REVIEW

LABEL NAME	CHARACTER HEIGHT (INCHES)	BEZEL LENGTH (INCHES)	BEZEL WIDTH (INCHES)	TYPE	REMARKS

PANEL NUMBER _____ SHEET NO. _____ PREPARED BY _____ DATE _____

PANEL IDENTIFIER _____ CHECKED BY _____ DATE _____

DATA SHEET–LABELING

VERIFIED BY _____ DATE _____

HOUSTON LIGHTING & POWER CO.

CONTROL ROOM DESIGN REVIEW

LABEL NAME	CHARACTER HEIGHT (INCHES)	BEZEL LENGTH (INCHES)	BEZEL WIDTH (INCHES)	TYPE	REMARKS

PANEL NUMBER _____ SHEET NO. _____ PREPARED BY _____ DATE _____

PANEL IDENTIFIER _____ CHECKED BY _____ DATE _____

DATA SHEET–LABELING

VERIFIED BY _____ DATE _____

CONTROL ROOM DESIGN REVIEW

DEMARCATION STUDY REPORT

SOUTH TEXAS PROJECT

Houston Lighting & Power Company

8.4/10173
2226W/0059W

DEMARCATION STUDY REPORT

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LIST OF FIGURES

1.0 INTRODUCTION

This report describes the demarcation study performed to correct discrepancies noted in the control room design review. These discrepancies indicated the need for distinguishing functional groupings of related controls and displays. This study was performed to the Demarcation Study Guide P-033, approved by the Project Review Team, April 25, 1983.

2.0 SUMMARY

The study recommends a demarcation technique that allows for the difference in the operator's demarcation needs depending on whether he is performing a task at the panel face or is surveying key parameters from the console area. It also recommends the change in base finish panel color from Sea Mist Green to Beige and the use of compatible colors for color shading specific areas of demarcation (pads).

3.0 OBJECTIVE

The objective of demarcation is to provide a technique for easy identification and differentiation of front panel surface mounted devices that are associated with a particular system, subsystem, or functional activity.

4.0 CRITERIA

The STP control room panels shall be demarcated using the following criteria:

1. The demarcation method shall facilitate easy identification and differentiation of major systems, subsystems, or major plant operational functions.

2. Demarcation shall be used to facilitate those operator actions that are performed at the panel surfaces. The demarcation techniques shall consider the fact that when the operator is performing operations, he is very close to the panel therefore bright colors or heavy lines should be avoided to minimize problems of recognition of panel information when viewing from a distance.

3. The selected demarcation scheme shall avoid or minimize additional confusion or noise in the form of the "Christmas tree" effect (multiple, strongly colored patches) or heavy demarcation lines.

4. The demarcation method shall be uniform (standardized) in its application for all panels.

5. The demarcation method shall accommodate and help to integrate the results of the labeling study.

6. Consideration shall be given to providing a scheme that will perform its function over a long period of time, i.e., it shall be a permanent system.

7. The method must recognize that in the life of the control panels layout changes are inevitable.

8. Consideration shall be given to treating individual panel device surfaces to achieve consistency with the overall demarcation scheme.

9. The application of demarcation material shall not detract from the asthestics of the overall control room.

5.0 METHODOLOGY

1. A Demarcation Study Task Group (DSTG) performed this study. The following individuals served on this task group:

   - o S. Luna* - TPT (chairman)
   - o R. Sabeh - TPT
   - o R. Considine - Bechtel
   - o T. Walsh - Bechtel
   - o B. Neil - HL&P Operations
   - * Alternate - Bob Arnold - TPT

2. The DSTG considered the techniques noted in EPRI NP-2411 "Human Engineering Guide for Enhancing Nuclear Control Rooms" in addition to schemes considered to be more appropriate for the STP control room configuration.

3. The DSTG evaluated the above techniques considering feedback secured from utilities that have experience with panels that have been demarcated.

4. The initial evaluation process reduced the number of candidate methods to two. (Color pads and demarcation lines).

5. Three 4-foot wide full scale front panel sections were used in the study. These were the same quality as the full scale mock-up. These mock-ups were laid out with identical arrangements of a typical board section.

6. The use of lines for demarcation places lines, typically block and 3/8 inch wide around devices or groups of devices. Where groups of devices are related to a specific function, all devices are located within the demarcation lines. Different colored demarcation lines or varying the line width can be used to cause a group of devices to appear related to one another, and if desired to appear to standout. Devices that standout are perceived as being more important.

   Demarcation lines should be applied in such a manner as to provide the operator with an easy reference to define control station boundaries; to associate related controls, or groups of controls and indicators; to highlight controls that perform a backup function; or to group related functional controls in crowded areas. Caution must be exercised to prevent an area from being visually cluttered, see figure 6-2.

7. The color pad technique selected for control panel demarcation places each device in the center of a large area of color. Where groups of devices are related to a specific function, all devices are located on a single pad. Color can be used to cause a group of devices to appear related to one another, and if desired, to appear to standout or to recede into the background. This is accomplished by using successively darker color shades to make an area stand out, or by using lighter colors to make a device or area recede. Devices that standout are precieved as being more important, and vice versa.

   The color pad technique is to be applied in such a manner as to provide the operator with an easy reference to define control station boundaries;

to associate related controls, or groups of controls and indicators; to highlight controls that perform a backup function; or to group related functional controls in crowded areas.

At the system level, this technique can separate systems from one another. Switches and other devices to be set apart can be mounted in an area of a darker shade than the panel background color. Where two systems are closely adjacent, a 1" strip of background color can effectively separate the two systems. In areas where systems are further apart, larger strips, or areas, of background color should appear to avoid a "stripped" appearance.

Within a system, some controls are of relatively more importance than others; are used more often; or are used together, such as a pump start switch and the associated discharge flow indicator. These controls are made to "stand out" of the panel, or to be obviously grouped together, by tying them together with a common color pad. The darker the color chosen, the more these controls will be brought to the attention of the operator. Grouping in this manner can also cue the operator to the next control in a sequence. When devices are seldom used, such as fill or test valves, the omission of demarcation removes the device from the operator's primary focus and the device recedes into the background.

On control panels containing many different subsystems, the use of color pads connects the devices together and guides the operator's attention through the course of action by using a different shade for each logical grouping. A preferred equipment alignment can be a single color shade, with any alternate flow path defined by a lighter shade.

On control panels that repeat patterns of controls, each grouping is outlined in a color shade darker than the panel background, with appropriate spacing between groups. Where controls and associated indicators are separated by intervening devices, the controls and indicators should be identical shades.

Each system has differing requirements and presents a unique problem in demarcation. The preferred method of application is to locate any trip or emergency functions in the darkest color area; to locate normal controls together in functional groups, in the next lighter shade; with the lightest shade being used for alternate lineups or controls. Any test, or peripheral, controls should be in areas of the basic panel background color. This technique assures that the most important or frequently used controls are easily identified, and that associated controls and indications are perceived as being together.

8. Five STP designated operators reviewed each mock-up. They noted the ease of locating devices as they would need to use them following procedures. They also noted their demarcation scheme preference.

9. The candidate demarcation methods were applied to these mock-ups.

3. The DSTG reviewed the merits of the originally selected panel finish color - Seamist Green. They elected to try the color pad demarcation scheme with both Seamist Green and compatible colors and with Beige or Grey and compatible colors to review the effects of color. The third panel would feature black demarcation lines.

4. The DSTG considered the demarcations schemes frequently used in the utility industry and decided to evaluate schemes in the following order:

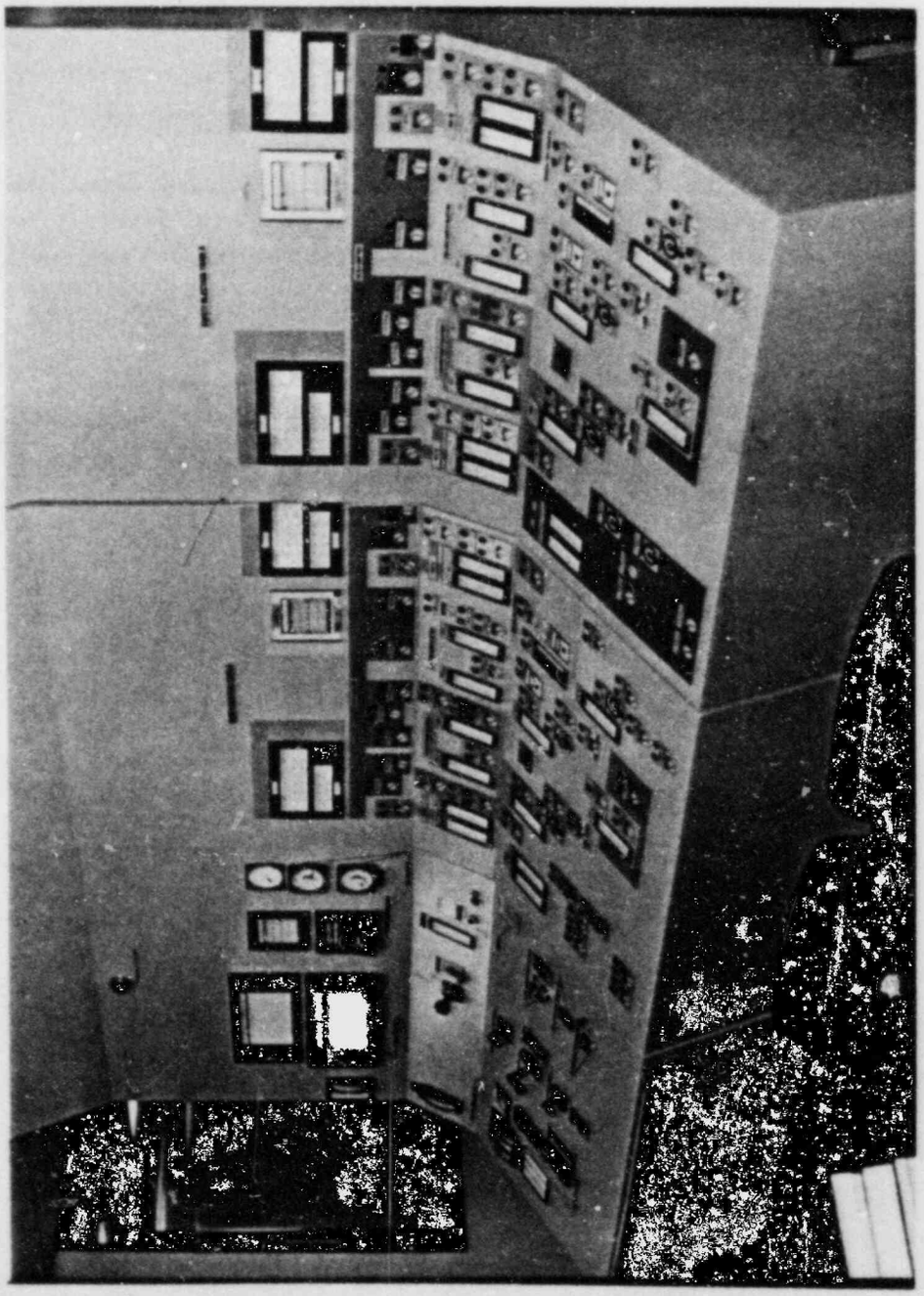
   - o Color shades (pads)
   - o Shape of color pads
   - o Labels, integration of the hierarchical labels
   - o Space
   - o Lines of demarcation (as a last resort)

   Three four-foot-wide panels were constructed to match the main mock-up panels. Each was laid out with part of Train "A" Safety Injection System (SI), part of the Refueling Water Storage Tank and Train "B" accumulator. The SI layout included the controls and indication for; check valve leak test, high head safety injection, low head safety injection, accumulator and residual heat removal.

5. The three set-ups were reviewed by the DSTG and five (5) plant designated operators. The operators reviewed the arrangements considering both emergency and normal operations. They viewed the panels from normal desk and operating positions. Fig. 6-1 shows a section of the main control board mock-up using demarcation lines. There was no preference shown by operations personnel or DSTG personnel for the panel demarced with black lines, this scheme was discarded. Fig. 6-2 shows one mock-up section done in green and another done in beige using the color pad technique. There was a very strong preference for the Beige scheme versus the Sea Mist scheme. Beige was recommended and approved for the color scheme.

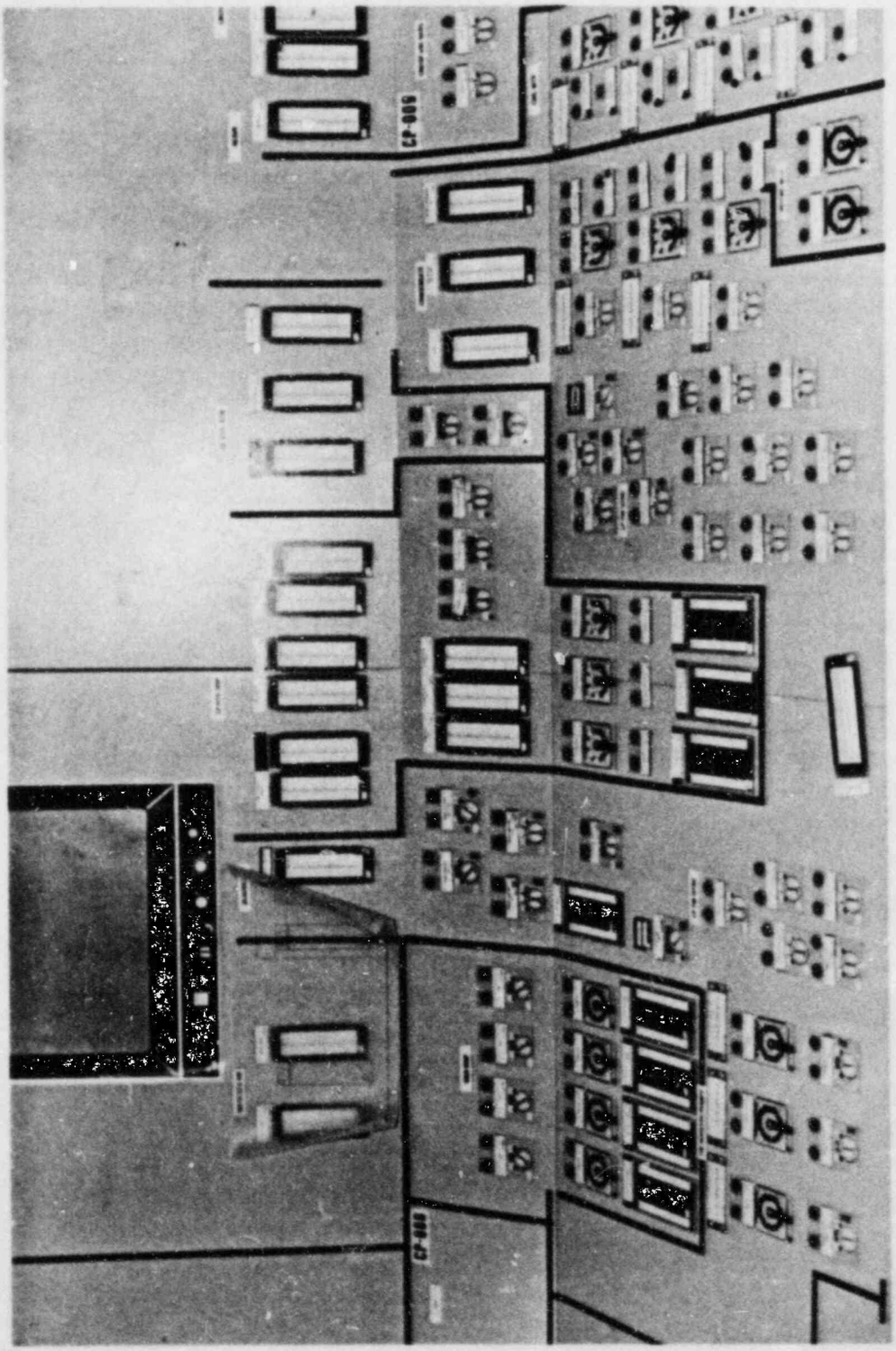
6. Color coordinated, three part sandwich labels will be used. The normal label edge bevel exposes the proper train color. The engraving will be filled with black.

7. A section of CP-008, feedwater and condensate was mocked up to provide an actual representation of the demarcation techniques and color scheme. The difference between line demarcation, Fig. 6-2, and demarcation using the color pad technique, Fig. 6-3.



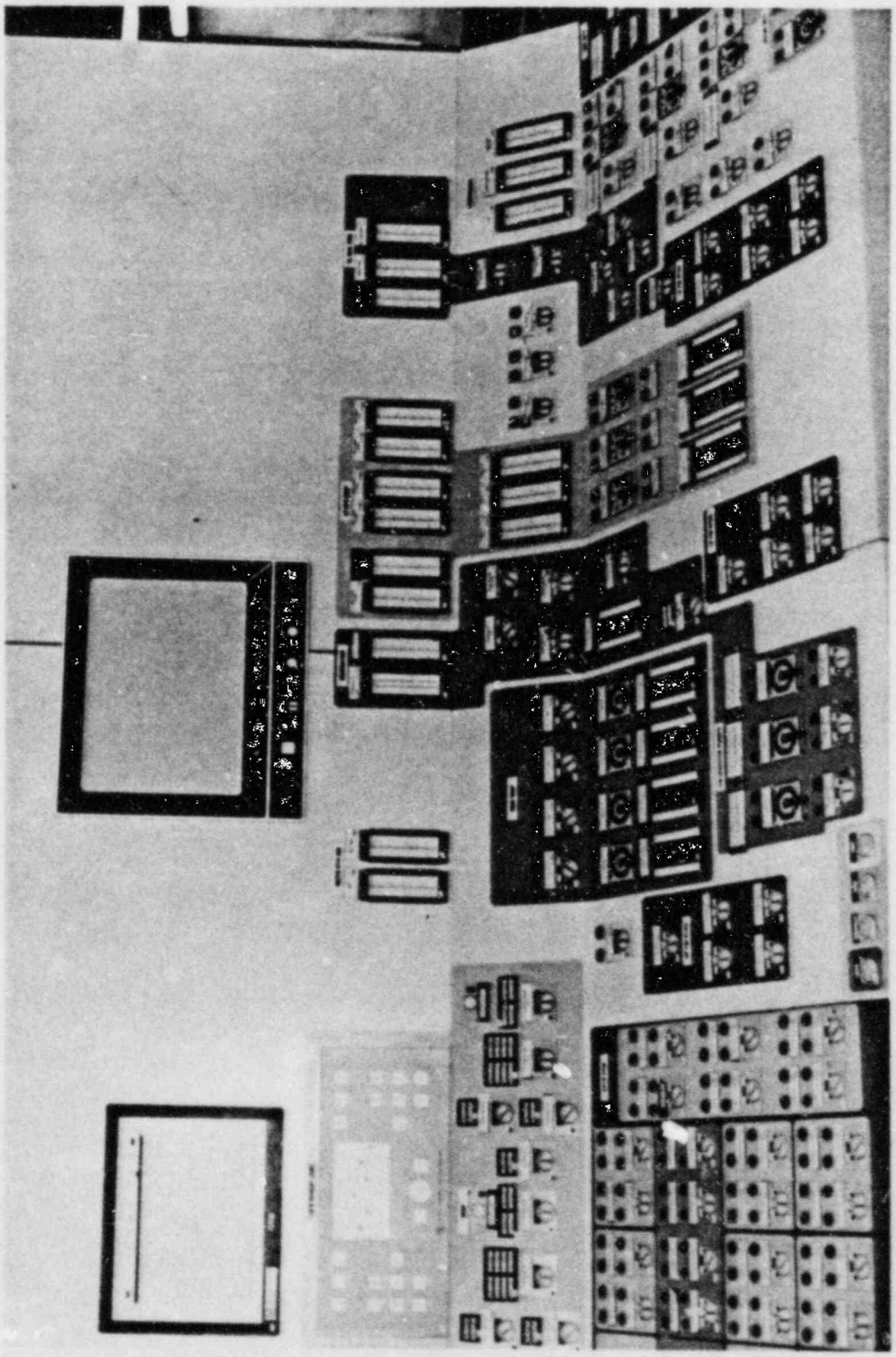
MOCK-UP BEIGE AND MOCK-UP SEA MIST GREEN
COLOR PAD TECHNIQUE

FIGURE 6-1



BLACK LINE DEMARCATION - PANEL 008

FIGURE 6-2



COLOR PAD TECHNIQUE - PANEL 008

FIGURE 6-3

7.0 RECOMMENDATIONS

The DSTG recommended the following:

1. All control room control panels shall be painted with Sherwin Williams (SW) BM 11-2 Beige paint.

2. The prime demarcation scheme shall be colored pads painted with SW paints: BM 13-4, or BM 13-5 or BM 13-7 which are three compatible colors and BM 13-8 which is a compatible color to use for highlighting.

3. The use of additional pastel color pads or light demarcation lines may be necessary in congested areas, but this practice is discouraged.

8.0 APPLICATION

The demarcation techniques have been applied to all of the control room panels that will be used for plant operations. These panels are:

CP-001	Engineered Safety Features
CP-002	Engineered Safety Features
CP-003	Engineered Safety Features
CP-004	Chemical and Volume Control
CP-005	Reactor Control
CP-006	Steam Generator Control
CP-007	Turbine Generator
CP-008	Feedwater and Condensate
CP-009	Circulating Water
CP-010	Electrical Power Distribution
CP-018	Recorders
CP-022	HVAC

8.1 GENERAL

There are several areas that are common to all of the control room panels. These have been demarcated identically on each panel.

The Bypass/Inoperable status indication system has lamp boxes associated with the safety systems. The lamp boxes have been demarcated to match the demarcation of their associated safety system. This is to permit a quicker recognition of the system where a potential problem would exist. The lamp test buttons have all been highlighted with S-W BM 13-4.

Special treatment has been given to the annunciator controls. All four of the pushbuttons have been surrounded with the medium demarcation color (S-W BM 13-5). The acknowledge pushbutton has also been highlighted with (S-W BM 13-8). The test pushbutton has also been surrounded with the lightest color (S-W BM 13-4). This demarcation is unique only to the annunciator system.

8.2 ENGINEERED SAFETY FEATURES

Control panels CP-001, CP-002 and CP-003 contain the controls for the Engineered Safety Features.

8.2.1 CP-001 Safety Injection

CP-001 contains the control instrumentation for the Safety Injection System (see Fig. 8-1). The Safety Injection System can be broken down into the following:

- o High head safety injection
- o Low head safety injection

- Systems that operationally tie into the safety injection system. They are:

  Residual heat removal

  RWST

  Accumulators

The equipment layout is a left-to-right, functional arrangement (this is consistent with the Criteria Report). There are three identical layouts, one for each train. During an emergency, the first subsystem of operational concern is the high head safety injection and the accumulators. These components are demarcated with the darkest of the demarcation colors (S-W BM 13-7). The low head safety injection is operationally the next system to be used. It has been demarcated with the medium demarcation color (S-W BM 13-5). The residual heat removal system is an integral part of the low head safety injection system and must have its controls in close proximity. Therefore, it has the same demarcation colors but can be differentiated by the use of hierarchical labeling, location of the control components, and the shape of the demarcation color patch.

There are three SI block/reset switches associated with the three trains. These have been highlighted using S-W BM 13-8.

The RWST is a passive system supplying water to the suction of all safety injection pumps. The control components have been demarcated with the lightest color (S-W BM 13-4). It is also arranged using mimic lines and hierarchical labeling.

The safety injection system and accumulators use a network of valves to determine if there is backleakage from the check valves where the system ties into the primary coolant loops. The control from these valves has been placed adjacent to the associated safety injection controls and demarcated to tie them together using the lightest color (SW BM 13-4). They are seldom used, only during startup, but because of the quantity (23 valves) and the required arrangement on the panel they have been demarcated. Mimic lines are not warranted.

8.2.2 CP-002 Cooling Water and Containment

CP-002 contains the control instrumentation for the cooling water systems and the containment (see Fig. 8-2). The cooling water systems consist of the following:

- Component Cooling Water, Trains A, B and C.
- Nuclear Service Cooling Water, Trains A, B and C.
- Traveling Screens and Screen Wash, Trains A, B and C.
- Component Cooling Water, common systems supply.

The control equipment for component cooling water, nuclear service cooling water and traveling screen are laid out in three identical arrangements, one for each train. (Part of the Train C layouts are actually on CP-001.)

The controls for the nuclear service cooling water and traveling screens are very simple and arranged in a functional layout. They have been demarcated with the lightest demarcation color (S-W BM 13-4).

The component cooling water system is a more complex system supplying cooling water to several different components.

It is laid out using mimics and demarcated to differenciate the pump, heat exchanger and associated controls, the control components for the reactor containment fan coolers, and the control components for the residual heat removal heat exchanger. The demarcation uses the medium color (S-W BM 13-5). Indication and control associated with the head tank are demarcated with the same color.

The Containment Systems consist of the following:

- Containment Sprays
- Reactor Containment Fan Coolers
- Sample Systems
- Hydrogen Recombiners

The control components for the containment sprays are laid out in three identical functional arrangements, one for each train. They are demarcated and tied together with the light color (S-W BM 13-4).

The control components for the Reactor Containment Fan Coolers are laid out in three near identical layouts. The Train C layout has power lockout controls for the cooling water valves. They are demarcated by their proximity to adjacent controls and the initial method of laying out the systems.

There are control components for controlling flows to three sample systems. The Primary Sample System and Post-Accident Sample System utilize a mimic layout and hierarchical labeling. There are two identical functional layouts for the Hydrogen Sample System. These are demarcated using the light color (S-W BM 13-4).

There are two identical layouts for the Hydrogen Recombiners. These are in close proximity to the Hydrogen Sample System controls and demarcated with the light color (S-W BM 13-4).

8.2.3 CP-003 ESF Electrical Distribution

CP-003 contains the control instrumentation for the ESF Electrical Distribution and some auxiliary electrical monitoring. The systems consist of:

- o ESF Diesel Generators, Trains A, B, and C
- o ESF Electrical Distribution, Trains A, B, and C
- o 125 Vdc ESF Monitoring, Channels I, II, II, and IV
- o DC Monitoring for 48Vdc, 125 Vdc and 250 Vdc non-ESF Buses

There are three identical layouts for the control components for the Diesel Generators. The layouts are integrated in with the ESF Electrical Distribution Systems. The diesel controls are demarcated with the medium color (S-W BM 13-5) with the emergency start and trip, and sequencer control push-buttons highlighted (S-W BM 13-8). There are two electrical feeds to each ESF bus that are controlled from CP-010 Electrical Power Distribution. Demarcation for these is coordinated with the demarcation on CP-010. It is the darkest demarcation (S-W BM 13-7).

The 125 Vdc ESF monitoring is demarcated using the lightest color (S-W BM 13-4) and hierarchical labeling.

DC monitoring for the 48 Vdc, 125 Vdc and 250 Vdc non-ESF buses is demarcated using the lightest color (S-W BM 13-4) and hierarchical labeling.

8.3 CHEMICAL AND VOLUME CONTROL

CP-004 contains control equipment for the Chemical and Volume Control System, Pressurizer and auxiliaries (see Fig. 8-4).

The Chemical and Volume Control System can be divided into the following subsystem:

- o Let down
- o Letdown Heat Exchanger
- o Volume Control Tank (VCT)
- o Charging
- o Boron Thermal Regeneration System (BTRS)
- o Reactor Makeup Water
- o Boric Acid
- o Reactor Coolant Pump Seals

The control components of the Chemical and Volume Control System are laid out using a combination of mimics, and functional arrangements. This was done to simplify the layout and still retain adequate intelligence inherent in the layout. The mimics show the flow path of the subsystems and terminate into a functional arrangement with demarcation. The areas that have functional arrangements generally have very complex piping systems, but only require relatively simple operating procedures.

The letdown subsystem utilizes a mimic and terminates at the Letdown Heat Exchanger and associated temperature and backpressure controls. It is demarcated with the medium color (SW-BM 13-5).

The flow path exits the Letdown Heat Exchanger demarcation using a mimic and terminates at the VCT or Boran Thermal Regeneration Subsystems (BTRS). The BTRS is demarcated utilizing hierarchical labels and two colors. The mode selector uses the darkest color (S-W BM 13-7), the borate/dilute controls are demarcated using the medium color (S-W BM 13-5). The two are tied together using the subsystem label. The BTRS chiller is normally operated in automatic. The control components for it are demarcated using the lightest color (S-W BM 13-4).

The Volume Control Tank is contained within the mimic flow; however, to make it more prominent on the panel, it has been demarcated with the medium color (S-W BM 13-5). The charging subsystem is laid out using a mimic.

The Reactor Makeup Water and Boric Acid Subsystems are laid out using a mimic. The pump and associated tank components are demarcated with the lightest color (S-W BM 13-4) to add clarity to the layout.

The Reactor Coolant Pump Seals consist of four identical layouts adjacent to each other. They have been seperated, and tied together using labels and the lightest demarcation color (S-W BM 13-4).

The Pressurizer System can be broken down into the following subsystems:

- Level and pressure, control and indication
- Pressure heaters
- Pressure relief
- Auxiliary indication

The Pressurizer System is a functional arrangement of control components entirely demarcated with the medium color (S-W BM 13-4). The more important subsystems are again demarcated with darker demarcation; the auxiliary indication is on the base demarcation color and slightly above normal eye level.

The level and pressure, control and indication are at eye level and demarcated to differentiate level and pressure using the dark color (S-W BM 13-7). They are also tied together using the label.

The backup heaters are demarcated using the dark color (S-W BM 13-7).

The Pressure Relief Subsystem is highlighted using S-W BM 13-8.

The Auxiliary Systems on CP-004 are:

- Containment Sumps
- Pressurizer Relief Tank
- Reactor Coolant Drain Tank
- Excess Letdown

The Containment Sumps are demarcated using the lightest color (S-W BM 13-4).

The Pressure Relief Tank and Reactor Drain Tanks utilize a mimic to show how the two are interrelated and controlled.

The Excess Letdown System utilizes a mimic to show its operation and the lightest demarcation (S-W BM 13-4).

8.4 REACTOR CONTROL

CP-005 contains control equipment for reactor control and protection. The reactor control equipment can be broken down into the following groups:

- o Reactor Coolant Loop indication and Control
- o Rod Control
- o Power Level

The reactor coolant loop indication and controls are arranged in four identical layouts, one for each reactor coolant loop. The layout has the loop temperature and flow indication and reactor coolant pump controls. They are functional layouts and demarcated with the medium color (S-W BM 13-5).

The rod control grouping consists of rod height indicators; rod speed, Tave, Tref and T error indication; and the rod control and rod bank selector switches. All of these are closely associated with rod control and are demarcated with the lightest color (S-W BM 13-4).

Indication and interlock switches associated with monitoring power level are demarcated using the medium color (S-W BM 13-5). The individual meter and switch groups associated with the Source Range, Intermediate Range, and Power Range are again demarcated using the darkest color (S-W BM 13-7).

The equipment used for protection is:

- o Reactor trip switches
- o SI actuation switches
- o CIA/CIB/CVI actuation switches
- o Pressurizer SI block/reset switches
- o Excess cooldown block/reset switches

Demarcation for the protection switches has been done by using the dark color (S-W BM 13-7) and highlighting the actuation and trip switches with S-W BM 13-8.

The boronometer and sample selector switch are demarcated with the lightest color (S-W BM 13-4) to tie the two together.

8.5 STEAM GENERATOR CONTROL

CP-006 contains the control equipment for steam generator control, and the main feedwater pumps control.

The steam generator controls can be broken down into the following groups:

- Main Steam Isolation Valve Control
- Feedwater Isolation Valve Control
- Steam Generator Level Control
- Auxiliary Feedwater
- Protection

There are four nearly identical layouts for steam generator controls. The entire area for each one is demarcated with the lightest color (S-W BM 13-4). Within this demarcation the Main Steam Isolation Valve, Feedwater Isolation Valve, and Steam Generator Level Controls are further demarcated using the medium color (S-W BM 13-5). The auxiliary feedwater controls are also in this area and are further demarcated with the darkest color (S-W BM 13-7).

The three feedwater pump inserts are painted with the medium demarcation color (S-W BM 13-5). Feedwater header indication is also demarcated with the medium color.

The equipment used for protection is:

- Steam Line Isolation Actuation
  SI Excess Cooldown
- Low Tave Feedwater Isolation

Demarcation for the protection switches has been done by using the dark color (S-W BM 13-7) and highlighting the actuation, block or reset switches with S-W BM 13-8.

8.6 TURBINE GENERATOR

CP-007 contains the control equipment for the turbine and generator. They can be broken down into the following systems:

- Turbine Control
- Generator Control
- Generator Hydrogen
- Turbine Lube Oil
- Turbine EHC Fluid
- Steam Pump
- Exhaust Hood Sprays
- Bearing Sprays

Turbine control consists of panel inserts. These are demarcated with the medium color (S-W BM 13-5).

The generator controls and metering, and hydrogen control are demarcated using the darkest color (S-W BM 13-7). The bearing sprays are located between the generator controls and the computer keyboards, their demarcation is caused by the equipment on either side of them.

The turbine EHC fluid system is demarcated to associate the fluid pressure meter and the pump controls, it is the medium color (S-W BM 13-5).

The turbine lube oil system control components are located below several interlock and selector switches. The demarcation applied for the lube oil system is the lightest color (S-W BM 13-4). It also helps form a line of demarcation for the interlock and selector switches.

The steam dump controls are demarcated because of the bends in the panel and with the use of hierarchical labels.

The Exhaust Hood Spray Controls are demarcated by the systems adjacent to them.

8.7 FEEDWATER AND CONDENSATE

CP-008 contains the control equipment for the Feedwater Condensate and associated systems (see Fig. 8-8).

They can be divided into the following subsystems:

- o Moisture Seperator Reheater (MSR)
- o Extraction Steam
- o MSR Drips
- o LP Heater Drips
- o Deaerator
- o Gland Seal Steam
- o Condensate
- o LP Feedwater Heaters (2 groups)
- o HP Feedwater Heaters

The MSR control panel and its vents and drains are tied together with demarcation using the lightest color (S-W BM 13-4).

The layout of the extraction steam controls required a complex demarcation using hierarchical labeling and the darkest color (S-W BM 13-7) to surround all of the controls. Controls for the feedwater heater pairs are demarcated with the lightest color (S-W BN 13-4), and the deaerator controls are demarcated using the medium color (SW BM 13-5).

The MSR drips and associated pump and level controls are demarcated using the medium color (S-W BM 13-5), as in the deaerator level controls and pumps, and the LP Feedwater Drips and Gland Steam System.

There are three areas demarcated with the darkest color (S-W BM 13-7) for controlling the condensate and feedwater flow through the high and low pressure feedwater heaters.

Demarcation for the condensate pumps and control is accomplished by the adjacent subsystem demarcation.

8.8 CIRCULATING WATER

CP-009 contains the control equipment for the circulating water system, the condenser and auxiliary cooling systems (see Fig. 8-8).

The circulating water pumps are demarcated using the darkest color (S-W BM 13-7). The condenser instrumentation is demarcated with the medium color (S-W BM 13-5).

The auxiliary cooling system consists of two subsystems. Each of the subsystems have been outlined using the lightest demarcation color (S-W BM 13-4). The control equipment for each subsystem are on the base color. They are also tied together using hierarchical labels.

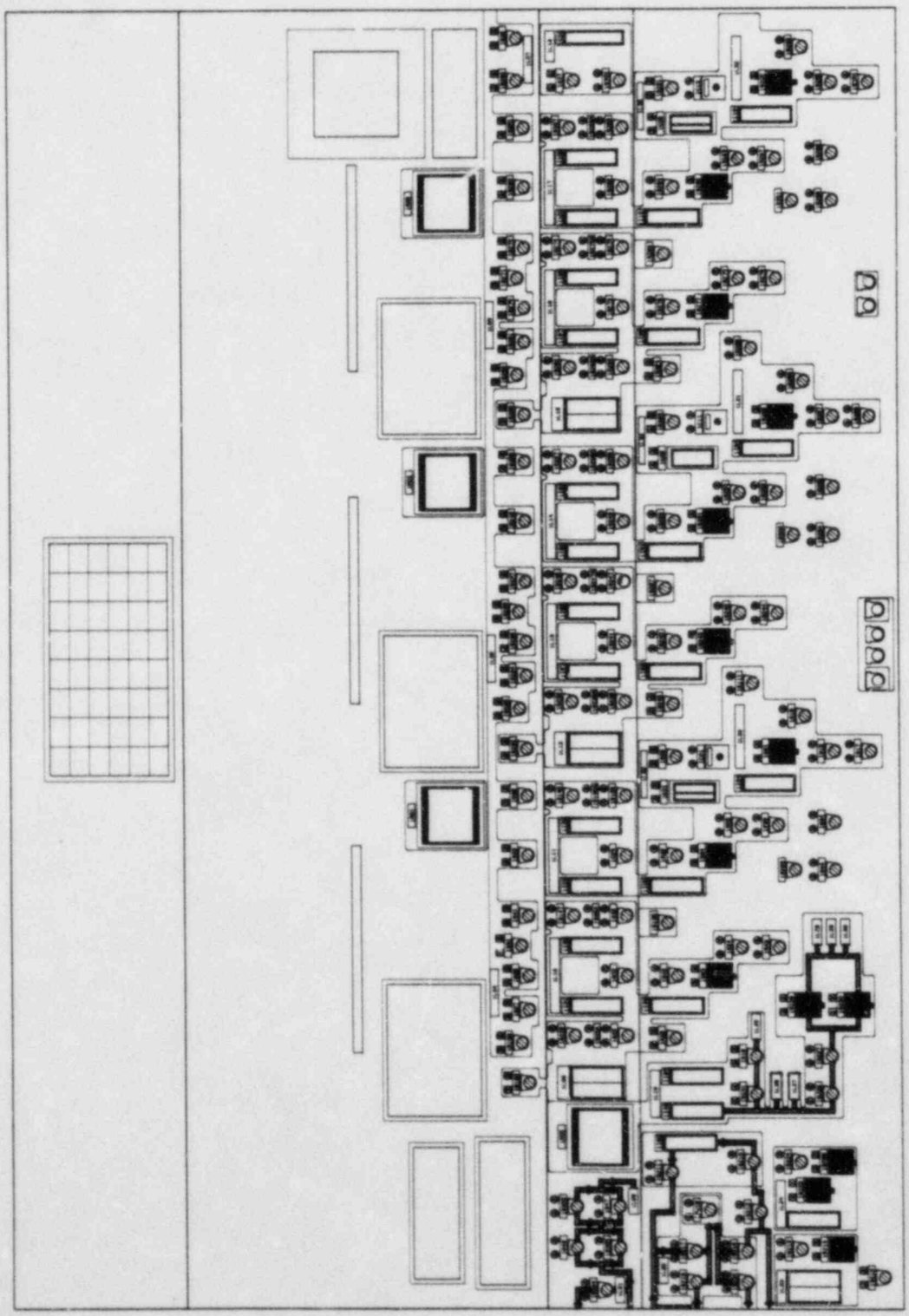
8.9 ELECTRICAL POWER DISTRIBUTION

CP-010 contains the control equipment for the electrical power distribution (see Fig. 8-9).

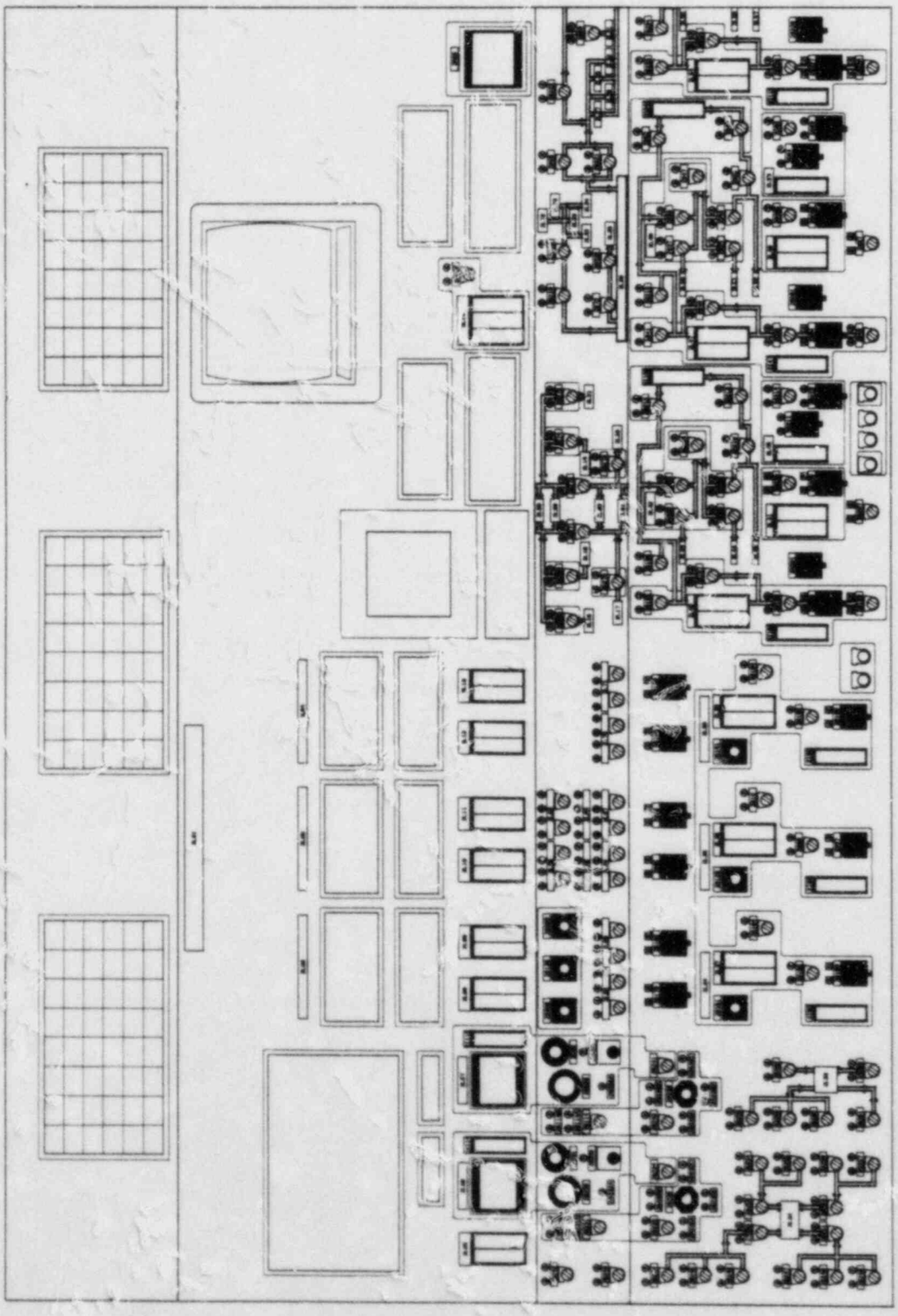
The control panel is laid out by the use of a mimic with breaker control inside the mimic, associated metering indication is located directly above the specific mimic section.

The darkest demarcation color (S-W BM 13-7) has been applied under the mimic and metering used for all ESF feeders.

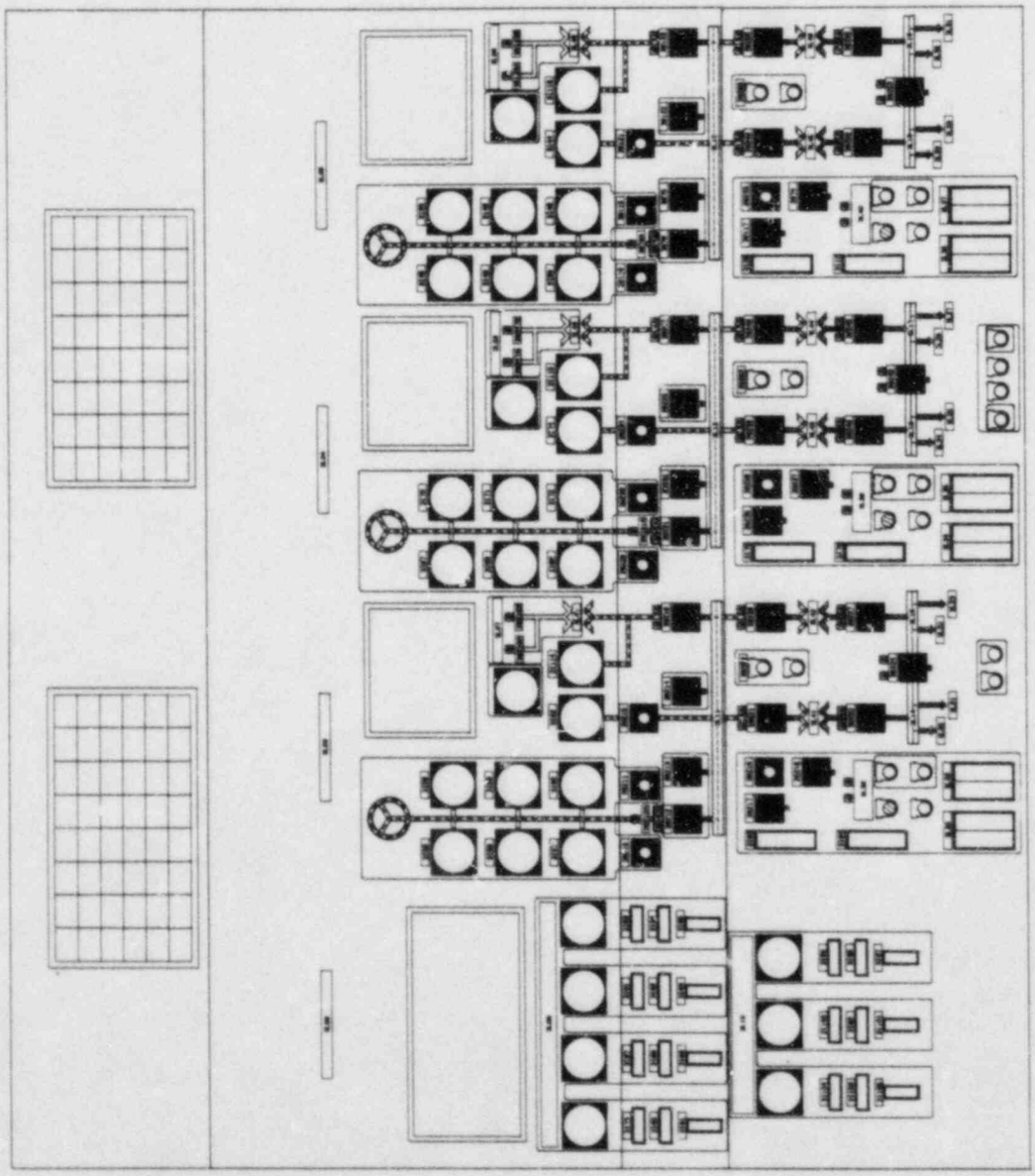
Each of the power distribution buses has been individually demarcated using the lightest color (S-W BM 13-4). The bus control and bus metering have been tied together by using the same color demarcation and hierarchical labeling. The metering is located directly above the bus control.



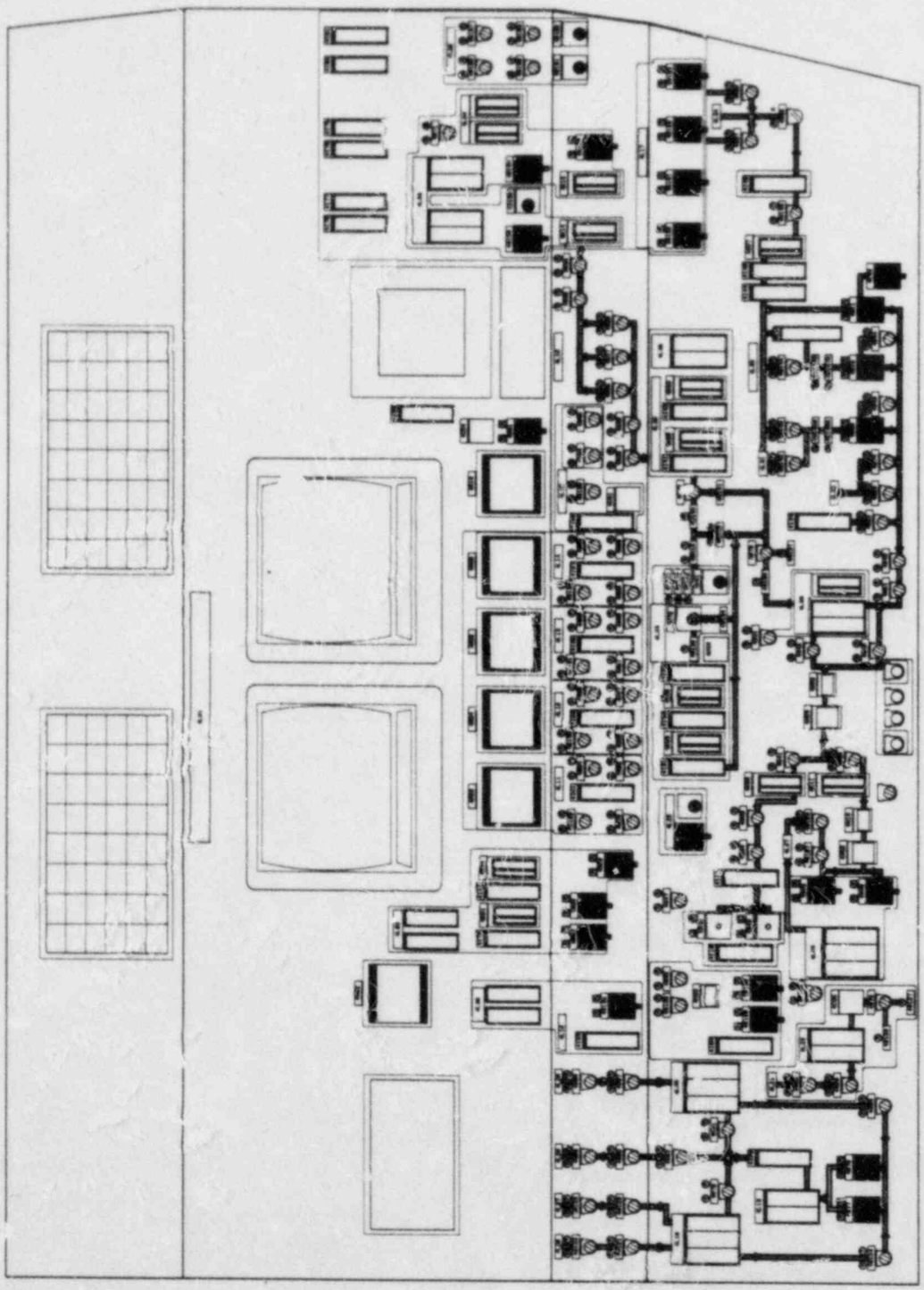
CP-001 – ENGINEERED SAFETY FEATURES
Figure 8-1



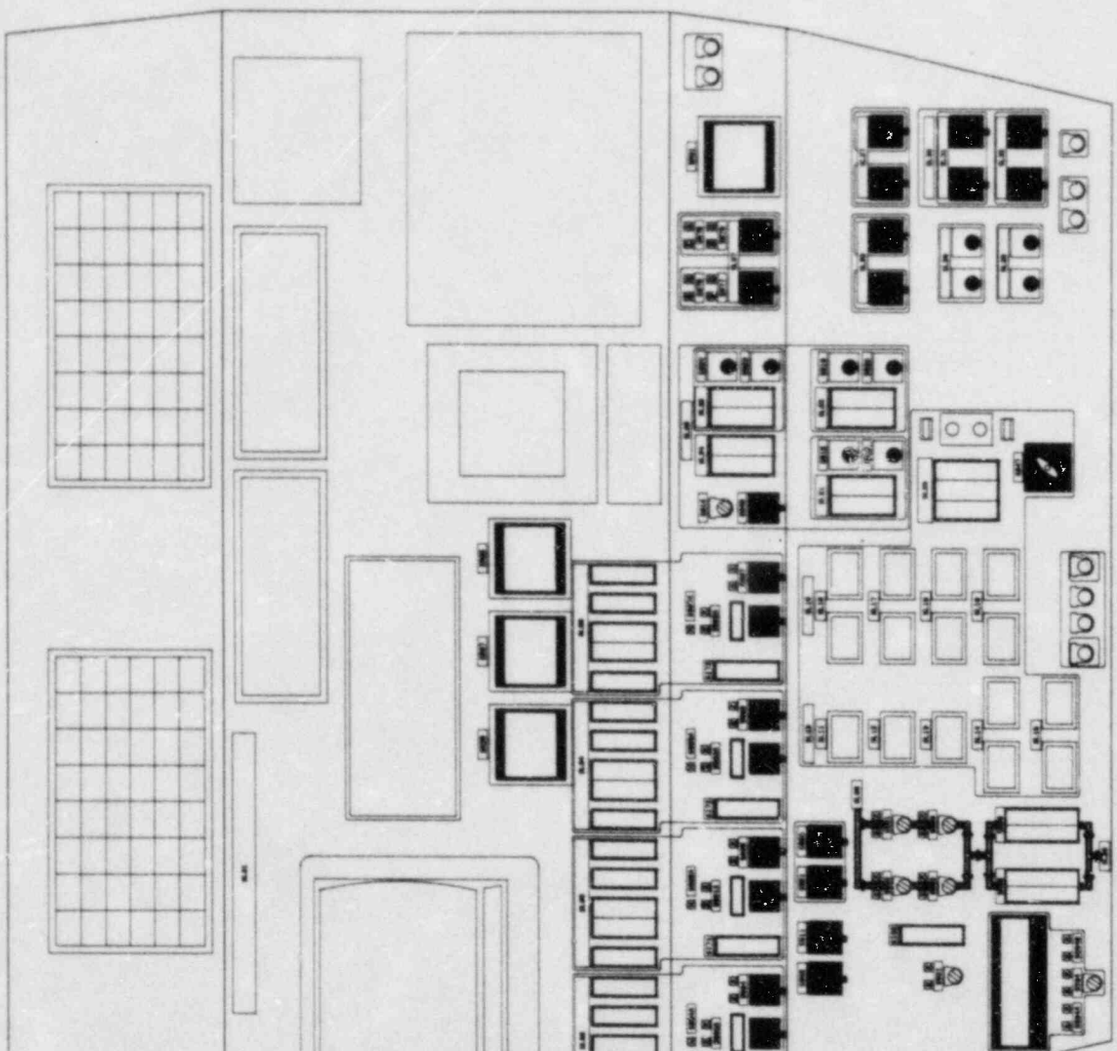
CP-002 – ENGINEERED SAFETY FEATURES
Figure 8-2



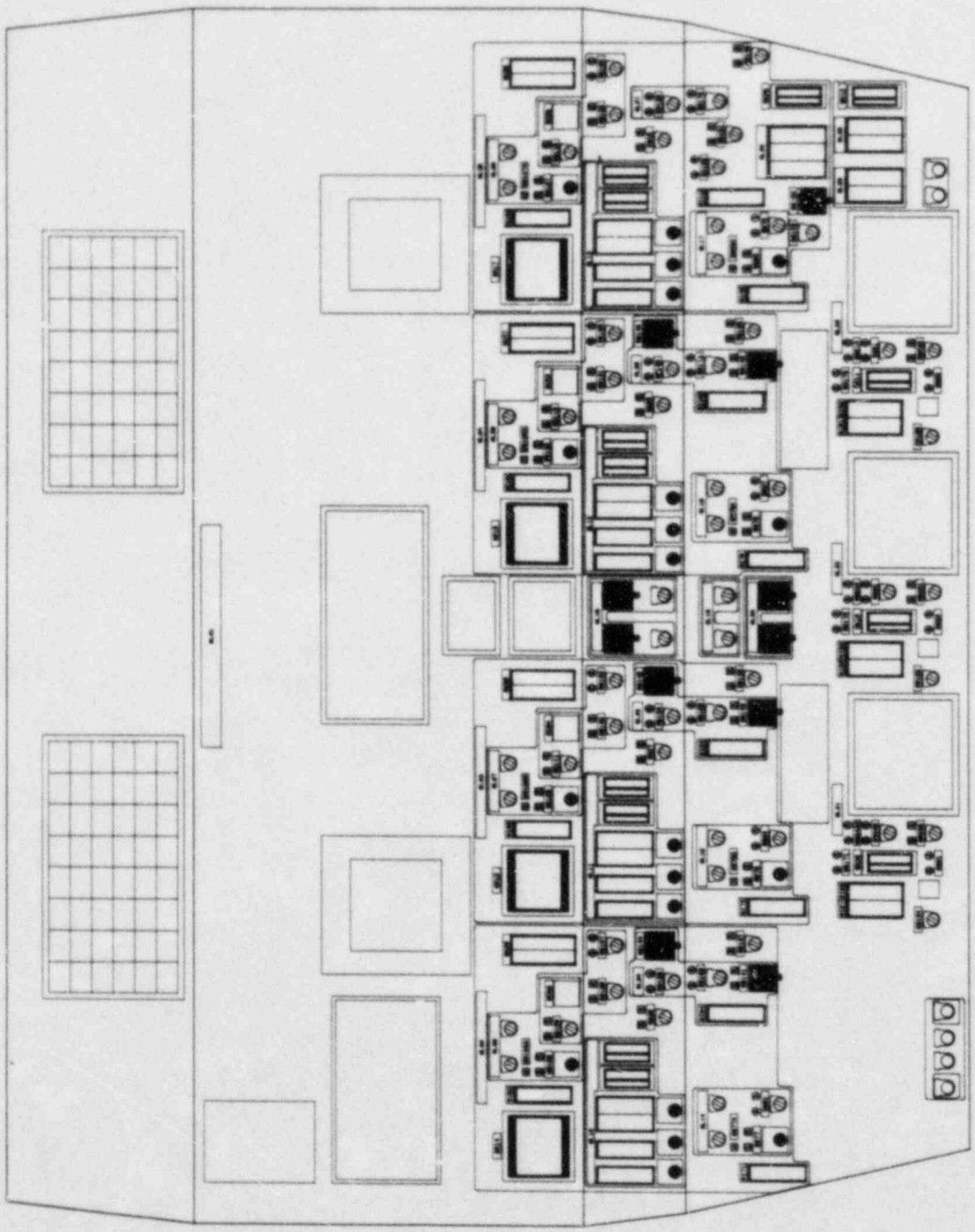
CP-003 – ENGINEERED SAFETY FEATURES
Figure 8-3



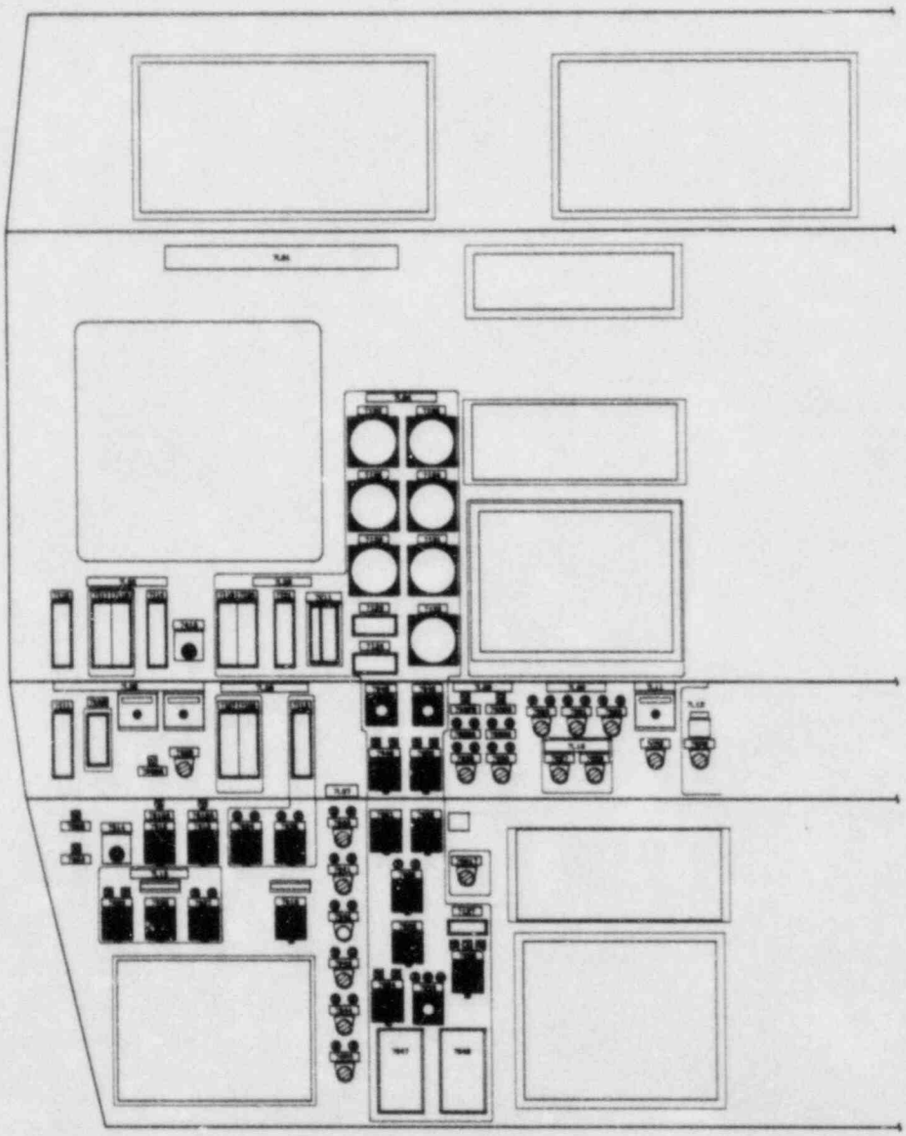
CP-004 – CHEMICAL AND VOLUME CONTROL
Figure 8-4



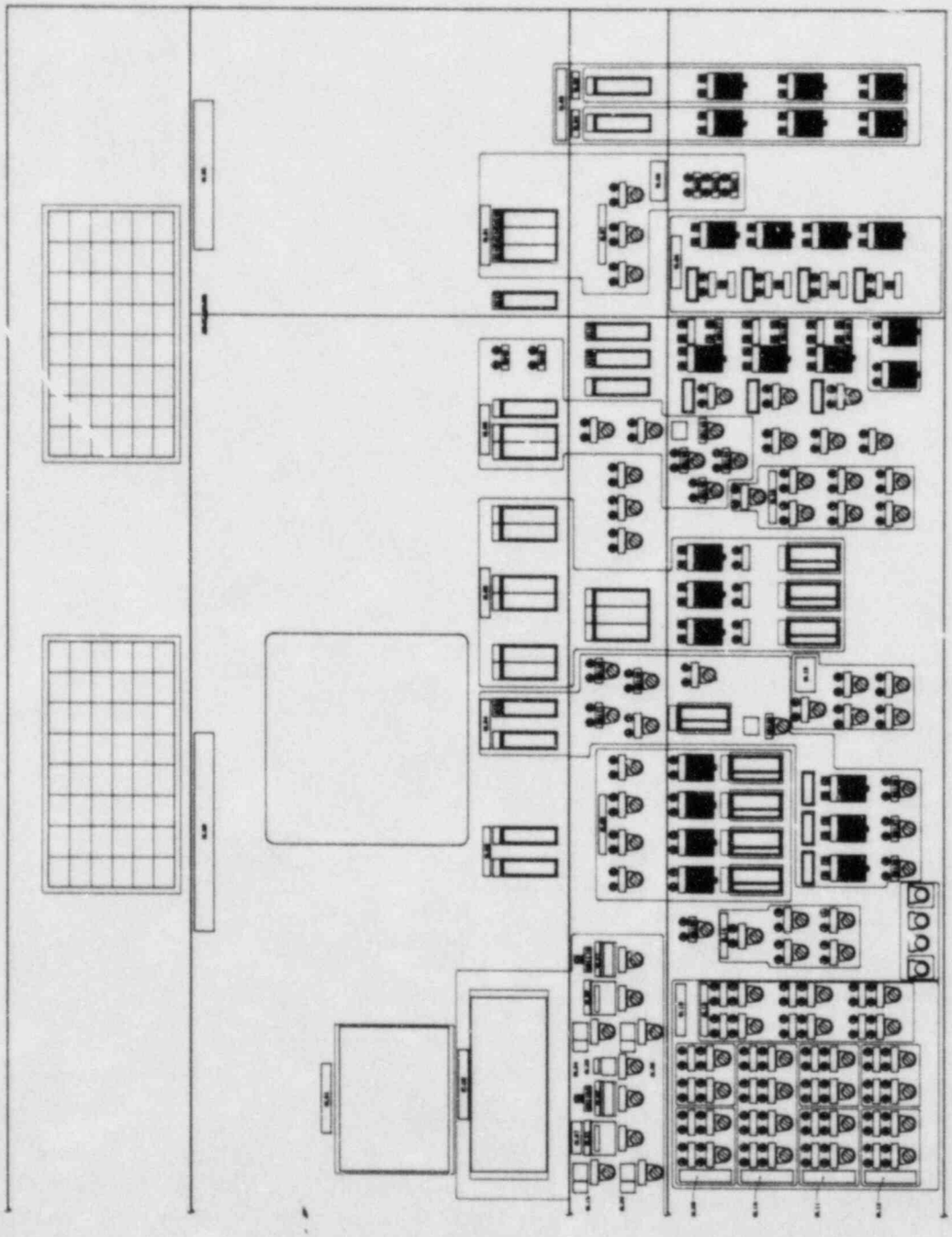
CP-005 – REACTOR CONTROL
Figure 8-5



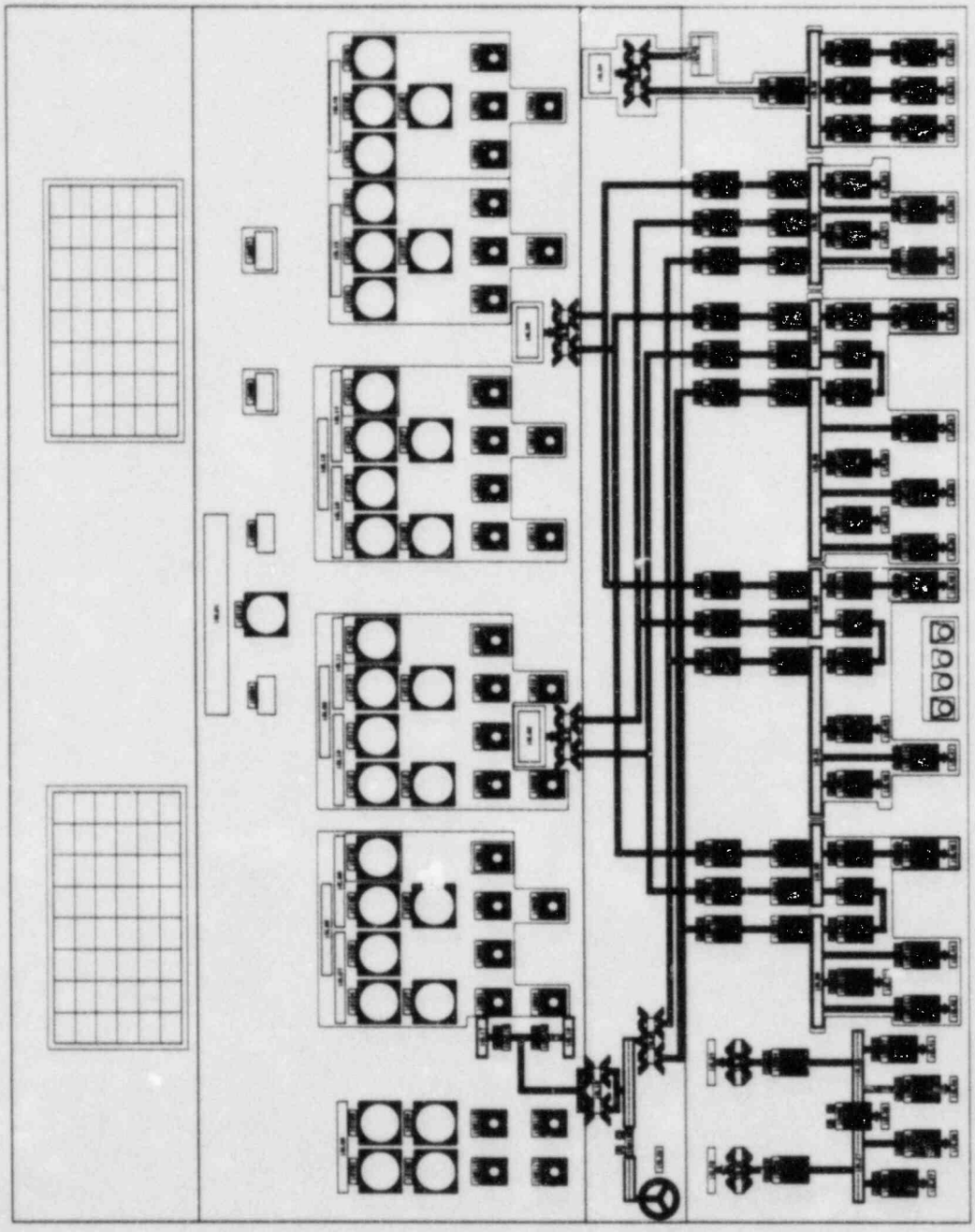
CP-006 – STEAM GENERATOR CONTROL
Figure 8-6



CP-007 – TURBINE GENERATOR
Figure 8-7



CP-008 – FEEDWATER AND CONDENSATE
CP-009 – CIRCULATING WATER
Figure 8-8



CP-010 – ELECTRICAL POWER DISTRIBUTION
Figure 8-9

METER SCALES

METER SCALES

1.0 INTRODUCTION

The guidelines concerning meter scales for the STP control room are located in NUREG-0700, section 6.5, and in the Criteria Report, Appendices F and G. The control room survey observed a number of human engineering discrepancies (HEDs) concerning the parameters of meters and scales, such as wrong progressions, no zone markings, too many and confusing graduations, graduation dimensions, and different type styles for both numerals and for units of measurement. The Project Review Team (PRT) recommended that the CRDR design review team examine the various methods of zone markings and prepare recommendations for these and for uniform progressions.

This report presents the results of the CRDR study to determine uniform meter parameters and provides examples for use as guidance in applying meter markings. The study was initiated as a result of the HEDs concerning meter parameters. The study results are recorded here to assure that the HED resolutions are incorporated into the control room design, and that future meter additions conform to established and uniform parameters.

2.0 RECOMMENDATIONS

2.1 ZONE MARKINGS

The CRDR team examined zone marking through the use of color coding, shape coding, and a combination of color and shape coding. Using shapes, such as circle, square or asterisk to denote the various operational zones, can be confusing. The coding recommended is color coding alone, see figure 1. The normal operating range is denoted by a green band; the cautionary process

parameter values by amber band(s); and the restricted or tripped values by red zone(s). The upper and lower limits of the red zones need not be extended to the meter limits. The edge between green and amber zones will indicate the alarm, or caution point(s) and the edge between amber and red zones will indicate the trip point or unsafe value.

Applying zone markings to every meter in the control room would reduce the effectiveness of the information presented. Many of the meters used in the control room measure parameters which either can assume a wide range of normal values, or have no trip values. Other meters have different "normal" ranges, depending on the operating mode of the plant. The meters that require zone markings will be identified by plant operations personnel after the plant setpoint list has been prepared and approved.

2.2 SCALE GRADUATIONS

The scale graduations recommended in NUREG-0700, section 6.5.1.5, and in the Criteria Report, Appendix F.4, are in progressions of 1's, 2's, 5's, or 10's. No mental calculations should be required of the operator, and there should be major and minor graduation marks for scales with up to four graduations between numerals. Table 1 is a list of recommended values for the most often used meter scales, showing the number of major divisions, with numerals, in column 3, and the total number of divisions in column 4.

Graduation lines should be as recommended in paragraph 6.5.1.5.b of NUREG 0700. A viewing distance of three feet, representing an operator position ten inches back from the control board edge, was used to size the meter markings. The line thickness is specified as 0.0125 inch; and line lengths as 0.4 inch for major, 0.28 inch for intermediate, and 0.17 inch for minor graduations.

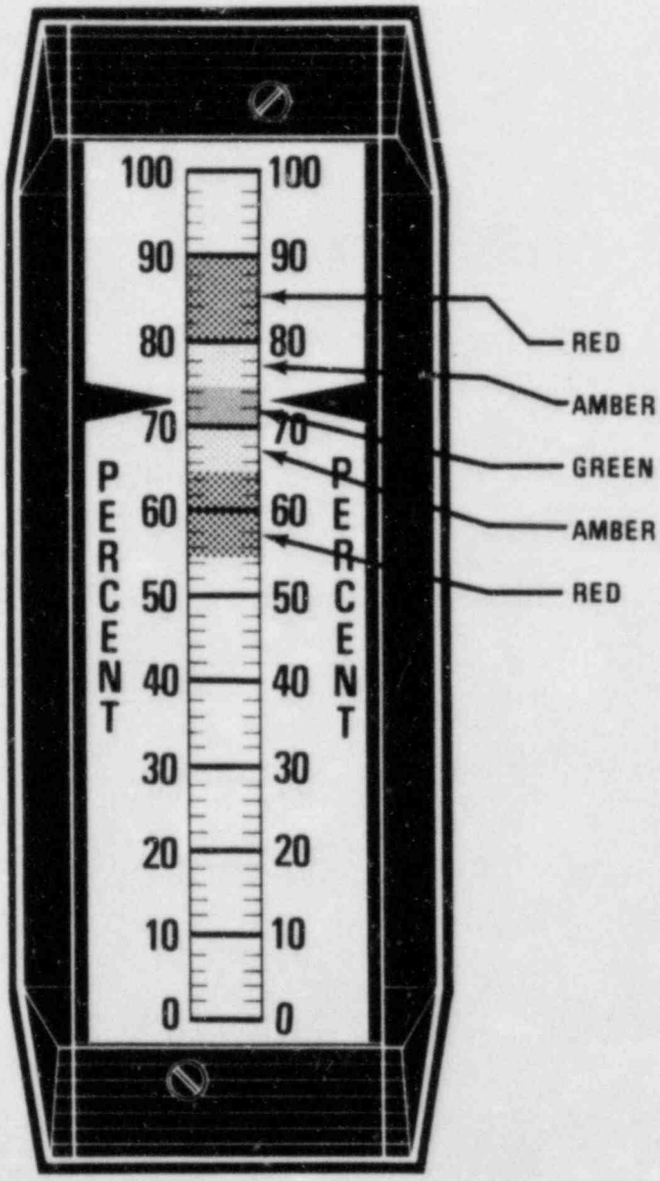
2.3 TYPE STYLE

The choice of type style to be used on meter scales is Helvetica, which is that used for labels on the control boards. This choice aids in achieving simplicity and uniformity in the control room, and meets the criteria that the type style should be simple, without serifs or flourishes. The type size recommended for both numerals and units on meters is 0.18 inch, which represents a viewing distance of 45 inches. Stroke width and the other font parameters should be in accord with the labeling study report.

TABLE 1

METER RANGES

RANGE		DIVISIONS	
MINIMUM	MAXIMUM	MAJOR	MINOR
0	4	4	20
0	12.5	5	25
0	30	6	30
0	60	6	60
0	100	10	100
0	150	6	30
0	200	10	40
0	300	6	30
0	400	8	40
0	600	6	60
0	800	8	40
0	1500	6	60
0	2500	5	50
50	150	10	40
50	100	5	50
-4	+4	8	16



ZONE MARKING EXAMPLE
Figure 1

RECORDER SURVEY

RECORDER FUNCTIONS

1.0 INTRODUCTION

The NRC audit of May 2, 1983 of the STP control room mockup resulted in a verbal comment concerning the recorders that remain on the main control boards.
The principal question addressed the suitability of the recorders to be used by the operators for real time indications. A functional survey was performed of the nineteen control board mounted recorders. No recorders are used for real time indication of high speed plant parameter transients.

2.0 DISCUSSION

The NRC audit team raised the question of the lack of a multi speed control on any of the STP recorders. The multi speed provides a method of advancing the paper to display the current value of the parameter if the operator needs to use this data immediately. Most recorders do not allow for reading the most recent values, as the pen track is obscured by the scale, glass, or other recorder parts.

It was agreed that the CRDR would review the recorders on a case-by-case basis to evaluate the useage of each recorder. A determination could then be made as to which recorders need a multi speed control. There are nineteen recorders on the revised main control boards. Two operators were asked to review each recorder for function. The data is recorded in the attached table.

Fifteen recorders are used for trending and historical records. Three record SG parameters during startup, shutdown and normal operation. Four record temperatures of the RHR heat exchanger during cooldown. One is used to record boric acid flow during blending operations, and four record seal water flow to the reactor coolant pumps. Two record pressurizer parameters (level and pressure), and one records generator megawatts. Of the other four, one each records ECW pond level, and auctioneered average temperature, and two are for recording computer trends.

3.0 CONCLUSION

None of these identified uses require that the operator have the capability to run out the recent records to see recent parameter values, and no revisions to the recorders are recommended.

TABLE 1.0

PANEL NO.	RECORDER TITLE	PURPOSE
001	RHR Hx 1C Inl/Outl Temp TK-0876	Provide for cooldown temp control
001	RHR Hx 1B Int/Outl Temp TK-0875	Provide for cooldown temp control
001	RHR Hx 1A Int/Outl Temp TK-0875	Provide for cooldown temp control
001	RWST Level LR-931	Provide for trend information
002	ECW Pond Level LR-6900	Provide for trend of historical record
004	BA Blend FR-0110	Record BA flow to the blending tank
004	RCP A Seal Flow FR-0156	Used for indication
004	RCP B Seal Flow FR-0157	Used for indication

PANEL NO.	RECORDER TITLE	PURPOSE
004	RCP C Seal Flow FR-0158	Used for indication
004	RCP D Seal Flow FR-0159	Used for indication
004	Computer Trend Recorder VDR-0761	Trend various paramaters
005	PRZR Lvl/Prgm LR-465	Check pressurizer level over an extended period, and verify established przr level
005	PRZR Press PR-455	Check przr level over on extended period, and verify established przr level
005	Auxtioneered Tavg TR-612	Trend
005	Computer Trend Recorder VDR-0760	Trend various parameters
006	SG-Rec VR-0551	Record SG parameters during startup, shutdown, and normal operations
006	SG-1B Rec VR-0552	Record SG parameters during startup, shutdown, and normal operations

PANEL NO.	RECORDER TITLE	PURPOSE
006	SG-1C Rec VR-0553	Record SG parameters during startup, shutdown, and normal operations
008	Generator Megawatts	Record generator load during all modes of operation

KNURLED KNOB POSITION INDICATOR

HOUSTON LIGHTING & POWER CO.

CONTROL ROOM DESIGN REVIEW

MEMORANDUM

7/21/83

To: Program Review Team
From: TPT (Sal Luna)

Subject: Knurled Knob Position Indicator

1.0 Summary

The knurled knob was chosen for the criteria report in an effort to reduce the number of changes required on the control panels. Subsequent evaluation by the Design Review Team (DRT) and the NRC Audit Team identified limitations with knurled knob handles for use on multiple detent position switch handles. This memorandum is in response to the NRC verbal comments of the Audit during the week of 2 May 1983.

2.0 Problem

The knurled detent positioning knob is planned for use on six of ten control room panels. The knurled knob handle has an arrow to identify switch position. Viewing the knob from any but the correct angle obscures the arrow position.

The lack of positive switch position information regarding the switch operating mode increases the probability of operator error in terms of speed and accuracy, i.e., misreading switch position, turning switch in the wrong direction or not enabling the operator to identify control setting from a distance.

3.0 Discussion

There are 71 multiple detent position knurled knob handle controls used on panels as follows:

Panel 002 = 7
003 = 15
005 = 1
006 = 14
007 = 5
010 = 29
Total = 71

Controls that may be set in any number of exact positions should use a rotary selector switch with lever or bar type handles. The Human Engineering Guide to Equipment Design by Van Cott and Kinkade recommended the use of lever type handles for positioning rotary switches that require discrete settings. This type of control action is required for the 71 knurled knob handle switches identified above.

Twelve selector switches are to be changed to Honeywell selector switches because of the electrical characteristics required for the circuitry. The handles of these switches comply with human factors requirements. It is therefore suggested that the remaining 59 selector switch handles be replaced with these same type of lever/bar handles. This will solve the human factors concern for:

- o Consistency
- o Rotary detent action
- o Obscuring the pointer position indication

4.0 Recommendation

Replace all knurled knob handles that require discrete detent position settings with lever/bar type handles.

Approval of this recommendation will minimize operator error, improve overall system performance and be in compliance with good human engineering practices.

DISTINGUISHING LEGEND PUSHBUTTON FROM LEGEND LIGHTS

HOUSTON LIGHTING & POWER CO.

CONTROL ROOM DESIGN REVIEW

MEMORANDUM

8/23/83

To: Project Review Team

From: Sal Luna (TPT) SL

Subject: Distinguishing Legend Pushbutton From Legend Lights

1.0 Summary

Eighteen Operators and Design Engineers were asked to make a preference between five different shape patterns to distinguish legend pushbuttons from legend lights.

Sixty-seven percent of those making a preference selected the Closed Corner Octogon (CCO) shape pattern.

A recommendation is made to utilize the "CCO" shape for distinguishing legend pushbuttons from legend lights.

2.0 Background

The Control Room Survey Report identified 8 legend pushbuttons that were not readily distinguishable from legend lights (sheet number 703, 464, 351-Appendix D, pages 53, 54, and 55). Disposition of this observation was to make legend lights distinguishable from pushbuttons by enhancement and assigned a Category C HED.

3.0 Objective

Conduct a study to determine preferences for a shape coding pattern that can be used to distinguish legend pushbuttons from legend lights.

4.7/08033
2922W/0085W

NAME

TITLE

SELECT PREFERENCE FOR DISTINGUISHING A CONTROL.

		NAME
☐		OPEN CORNER OCTOGON
☐		CLOSE CORNER OCTOGON
☐		DOTS ALONG EITHER SIDE
☐		DOT IN UPPER RIGHT CORNER
☐		PARENTHESES

SHAPE CODING PREFERENCE PATTERNS FOR
DISTINGUISHING LEGEND PUSH BUTTONS

Figure 1

4.0 Methodology

4.1 Data Collection - Five different shape patterns were selected as shown in Figure 1. Eighteen operators and design engineers were solicited for their shape coding pattern preference to be used for distinguishing legend pushbuttons. The sample of personnel solicited is shown in Table 1.

TABLE 1

Personnel Solicited For Preference

Specialty Type	Number
Operators	9
Design Engineers	9
Total	18

4.2 Data Analysis

Table 2 shows the distribution of preferences by each group.

TABLE 2

Preference Selection By Group

Control Shape Label	Operational Staff	Design Engineers	Total	Percent of Preference
Open Corner Octogon (OCO)	2	- 0 -	2	11
Closed Corner Octogon (OCO)	6	6	12	67
Dots Along Either Side (DAES)	- 0 -	- 0 -	- 0 -	- 0 -
Dot In Upper Right Hand Corner (DURC)	1	3	4	22
Parentheses (P)	- 0 -	- 0 -	- 0 -	- 0 -
Total	9	9	18	100

It can be seen that 12 of 18 individuals queried preferred the "Closed Corner Octogon" shape, twenty-two percent preferred a "Dot in the Upper Right Corner" (DURC) and eleven percent preferred the "Open Corner Octogon" (OCO) Shape.

4.3 Results

The high percentage for the "CCO" pattern clearly indicates this to be the preferred shape out of those used in this study.

5.0 Recommendation

The "CCO" pattern is the recommended shape to be used for distinguishing all legend pushbuttons.

ANNUNCIATOR

REVIEW

GUIDE

ANNUNCIATOR REVIEW GUIDE
TABLE OF CONTENTS

ANNUNCIATOR REVIEW GUIDE

1.0 SUMMARY

The Control Room Design Review Annunciator Review Guide establishes the basis and methodology for completion of the review of the annunciator system, including the Bypassed and Inoperable Status Lights.

The criteria and methodology set out in this guide will be used to determine the physical parameters, alarm message, and location of each alarmed point. The alarm printout and computer I/O will be revised to reflect changes made by this study.

2.0 OBJECTIVE

This guide will provide the basis for completion of the Annunciator Study. The remaining tasks are:

1. Firm up, from plant design requirements, what needs to be communicated to the operator as:

   - o Plant annunciator alarms
   - o Computer alarms
   - o Local panel annunciator alarms
   - o ESF by pass and inoperable status displays
   - o Other status indicators

2. Within each of the above major systems: where the message should be displayed and what audible signal, if required, should be used to alert the operator.

3. Prioritize each message

4. Firm up message display physical characteristics:

   - o Engraved plates or tile size
   - o Selection of lettering type
   - o Selection of letter size
   - o Usage of abbreviations
   - o Selection of numbers of lines per tile, maximum number of letters and spaces per line.
   - o Spacing within a tile and between:

     - Letter and characters

- Words (including abbreviations)
- Lines - single line, two lines or three lines

5. Design documentation formatting to effect integration of the annunciator systems

6. Final annunciator study report

3.0 CRITERIA

The annunciator study will be based on criteria developed by:

- o STP CRDR Criteria Report Rev. 1.
- o STP CRDR Labeling Guide
- o The contents of this guide, considering:

The list of points to be alarmed, including any new alarm points to be added. Combining alarm inputs to reduce the total number of alarms in the control room is necessary to reduce operator confusion. Where multiple inputs to a window are present, the computer is used to identify the source.

The Annunciator list will be reviewed for conformance with the list of accepable abbreviations in the Criteria Report, Appendix L. This review will assure that wording is consistent, and that the chosen wording can be fitted onto the tiles.

Priorities shall be assigned within the three categories identified in the Criteria Report, Section 8. Physical locations will be determined based upon priority, and the review team's recommendations as to the relative importance of a particular alarm, with the more important alarms being located higher in the tile array.

4.0 METHODOLOGY

4.1 The major annunciator study effort will be made by the Annunciator Study Task Group. (ASTG)

- Bob Arnold - TPT (Chairman)
- Ken Christian - HL&P Operations
- John Tedens - HL&P Operations
- Ashok Joshi - Bechtel Responsible Group Leader (Annunciator and Computer)
- Systems engineers and TPT Human Factors consultant as needed.

4.2 Organizational Meeting

An initial meeting will be held with PRT in attendance, to firm up:

- Order for review of systems
- Determine which systems engineer (including, if necessary, Westinghouse participation) and operations personnel will attend each of the systems review sessions
- Schedule for each systems review
- Review documents to be used
- Administrative rules

4.3 The ASTG will meet to cover the above scheduled meetings as follows:

- Review what has to be annunciated and why. Consider plant function and equipment protection needs (plant operations, plant safety, and plant availability).
- The system engineer should provide a general outline of what action the operator shall take in response to the alarm.

- The committee shall determine:
  - Where and how the annunciation should take place
  - The optimum message
  - The message priority
  - If the I/O Lists (Annunciator Computer or others) reflect the correct inputs and if modifications are necessary.
- Revise the Annunciator and Computer lists to incorporate the agreed changes. This list will be submitted to the PRT for approval.

4.4 The ASTG Chairman shall determine when to initiate the preparation of physical characteristics recommendations item 1.0 Para. 4 to the Human Factors engineer. These will be reviewed and accepted by the ASTG.

4.5 The documented results of the committee will be processed through the PRT.

4.6 TPT will prepare the final Annunciator Study Report

CONTROL ROOM DESIGN REVIEW
EVALUATION OF SPECIFIED
PARAMETERS
(Pressurizer, Reactor Coolant, Steam Generator)

EVALUATION OF PLANT PARAMETERS INDICATION

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LIST OF FIGURES

1.0 INTRODUCTION

Historically, the panel layouts for the Pressurizer, Reactor Coolant and Steam Generator Systems have been made with the inclusion of a wide variety and number of parameter indications. The problem of excessive panel instrumentation has been aggravated by the conflict between human factors requirements and the need for redundancy.

Very recently a seismically qualified IE display, part of the Qualified Display Processing System (QDPS), was made available to the panel layout engineer. Thus, the coordination of the panel layout with the SPDS design permits the removal of anomalous meter indications and enhances operator effectiveness.

2.0 OBJECTIVE

The objective of this evaluation is to reduce the anomalous meter indications for the Pressurizer, Reactor Coolant System and Steam Generators.

3.0 DISCUSSION

The evaluation encompassed 112 meters associated with the control and protection channels of 53 parameters. In the evaluation process it was determined that 61 meters should be deleted and 10 meters should be added.

The CRDR Criteria, Section 6.3.1.2 Information to be Displayed (NUREG-0700, Sect. 6.5.1.1) states "Efficient performance requires not only display of all needed information but also avoiding the display of extraneous information in the prime operating area." The design work undertaken in this study is based on the concept that only one indication of a parameter is needed for operating a system. The control channel was chosen for indication on the control panels instead of the protection channels because they relate to the day to day operation of the systems. When there is more than one control channel they will all be indicated. This will permit viewing the actual controlling variable when the alternate control channel is selected. Each of these cases is described in detail in Section 4.0 Recommendations.

The control panel mock-up has been laid out based on the results of this evaluation. A walk-through of the startup procedures, from shutdown to power, was performed to verify that only the instrumentation required to operate the plant was there and that the additional recommended instrumentation was needed. It was determined that the operator will be able to operate better, and respond quicker with fewer errors.

Where meters have been deleted, the signal has been sent to the Qualified Display Processing System (QDPS) for cross channel checking and on demand display.

The plant parameter indications that should be added are described below:

- o Four-Reactor Coolant Flow (auctioneered high)

  There are three channels for each of the four loops. The operator should have one channel of indication per loop. Auctioneered high was chosen so that accurate flow information would be available even if one channel should fail. Refer to Figure 3-1.

- o One - Tref

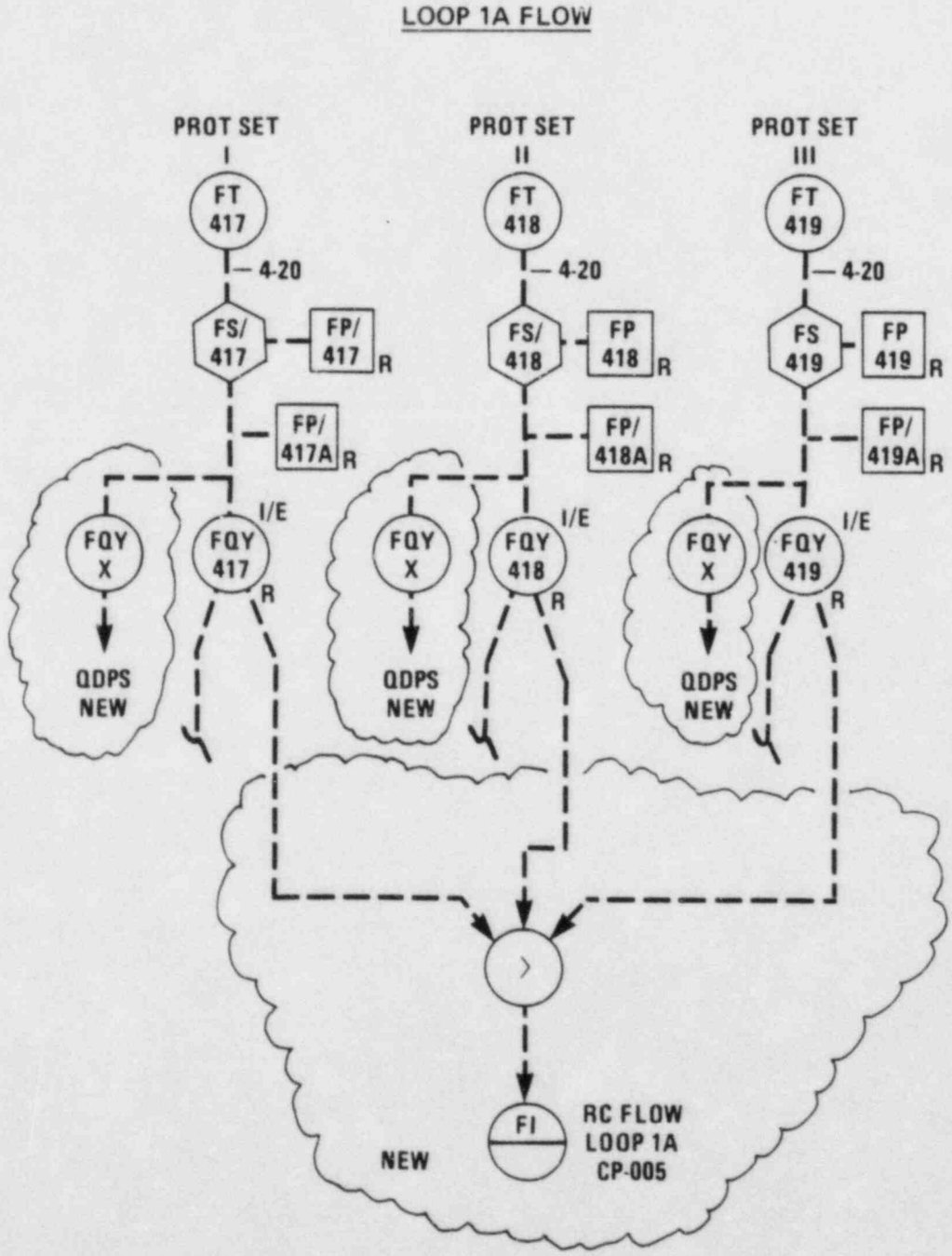
  Previously, there was no meter to indicate this parameter. It was only displayed on a recorder.

- o One - Tave (auctioneered low)

  Previously there was no meter to indicate this parameter. It is the parameter used for automatic rod control and should be displayed adjacent to Tref.

- o Four - T_h (narrow range)

  Indication for T_h and T_c should be presented on a dual meter with the same scale to make mental computations easier.



FUNCTIONAL DIAGRAM
AUCTIONEERED LOOP FLOW
Figure 3-1

4.0 RECOMMENDATIONS

This section describes the recommendations for indication on the control panels for the Pressurizer, Reactor Coolant and Steam Generator Systems; the rational for deleting the meters without loosing the intelligence previously provided by them; and the requirements for additional meters.

4.1 COOLANT PRESSURE

Pressurizer Pressure: There are four protection set control channels (see list below). These will be displayed in two dual meters on CP-004, as shown in Figure 4-1. There will be a selector switch mounted directly below the meters to select the controlling channel combination. All four channels will be sent to the QDPS for on demand display and cross channel checking.

Tag No.	Remarks
PI-455 PI-456 PI-457 PI-458	Pzr Press, display on two dual meters, send to QDPS for cross channel checking and on demand display

Ref: Westinghouse Process Control Block Diagram No. 8758D76, Sht. 15.

Reactor Coolant Pressure: One reactor coolant loop pressure channel will be displayed; PI-406A low range pressure, 0-700 psi. It is located with the Residual Heat Removal System (RHR) on CP-001. The operating procedure walk-through for cold plant startup demonstrated a need and the location. The remainder of the panel-mounted indicators have been deleted. All four channels are sent to the QDPS for cross channel checking and on demand display.

Tag No.	Remarks
PI-405, PI-406, PI-407	RC Press, delete meter, put into the QDPS for cross channel checking and on demand indication
PI-406A	RC Press, mount on CP-001 with RHR
PR-406	RC Press, no change, relocated to recorder panel

Ref: Westinghouse Process Control Block Diagram No. 8758D76, Sht. 3.

4.2 COOLANT FLOW

There are three protection set channels for each of the four loops. The CRDR Criteria, Section 6.3.1.2 Information to be Displayed (NUREG-0700, Sect. 6.5.1.1) states "Efficient performance requires not only display of all needed information but also avoiding the display of extraneous information in the prime operating area". To meet this all of the individual coolant flow meters have been removed. An indication of coolant flow for each loop is required when starting and running reactor coolant pumps. This should be the auctioneered high value from each loop. Figure 4-2 shows the control panel arrangement and how loop flow relates to the other control panel devices. All flow channels will be sent to the QDPS for cross channel checking and on demand display.

Tag No.		Remarks
FI-XXXX	Loop 1A	Auctioneered high RC flow, requires new circuitry and meter outputs, see sketch.
FI-XXXX	Loop 1B	
FI-XXXX	Loop 1C	
FI-XXXX	Loop 1D	

FI-417 FI-418 FI-419	Loop 1A Flow - delete meters, put into QDPS for cross channel checking and on demand indication
FI-427 FI-428 FI-429	Loop 1B Flow - delete meters, put into QDPS for cross channel checking and on demand indication
FI-437 FI-438 FI-439	Loop 1C Flow - delete meters, put into QDPS for cross channel checking and on demand indication
FI-447 FI-448 FI-449	Loop 1D Flow - delete meters, put into QDPS for cross channel checking and on demand indication

Ref: Westinghouse Process Control Block Diagram No. 8758D76, Sht. 5.

4.3 PRESSURIZER LEVEL

The level in the pressurizer is programmed to increase with power level (the signal is derived from Tave). There are four protection set channels of pressurizer level. Three of the four level signals are used for control, and 1 additional "cold calibrated" channel that is only accurate when the reactor is at cold shutdown.

The three control channels will be displayed continuously on CP-004. Program level and cold calibrated level will be displayed on one side of a dual meter with a selector switch below it to select which one is displayed. All pressurizer level indication will be displayed on two dual meters. Two selector switches will be mounted below the meters (1) control channel selector (2) program/cold calibrated level selector. Figure 4-1 shows the control panel layout.

All four protection set, pressurizer level signals will be sent to the QDPS for cross channel checking and on demand display.

Tag No.	Remarks
LI-0465 LI-0466 LI-0467	Pzr level - display on meters and send to QDPS for cross channel checking and on demand display.
LI-0468	Pzr level, delete meter, send to QDPS for cross channel checking and on demand display.
LI-0675	Pzr level, cold compensated, display on meter with selector switch, send to QDPS for on demand display.
LI-XXXX	Pzr program level, display on meter with selector switch, send to QDPS for on demand display.

Ref: Westinghouse Process Control Block Diagram No. 8758D76, Sht. 15 and 18.

4.4 LOOP TEMPERATURES

Tref: Presently, there is one recorder output. Another output for meter indication on CP-005 is required.

Tag No.	Remarks
TR-612	Tref, recorder located on CP-005
TI-XXXX	Tref, add meter

Ref: Westinghouse Process Control Block Diagram No. 8758D76, Sht. 11 and 14.

Tave: There is one protection set for each of the four loops. Each one is displayed on its own meter on CP-005, as shown in Figure 4-2. The output of each loop is fed to a high auctioneer (for alarms) and a low auctioneer (for recorder indication and control). An output from the low auctioneer is required for meter indication. This is used in the automatic rod control system and will be displayed on the panel adjacent to the rod controls.

Tag No.		Remarks
T1-412A	Loop 1A	Loop Tave
T1-422A	Loop 1B	
T1-432A	Loop 1C	
T1-442A	Loop 1D	
TR-612	Tave - Auct Hi and Tref	
TI-XXXX	Tave - Auct Low, add dual meter, with Tref	

Ref: Westinghouse Process Control Block Diagram No. 8758D76, Sht 8 and 11.

Cold Leg Temperature, T_c (Narrow Range): There are three protection set channels for each of the four loops. One T_c (NR) per loop is required to have meter indication on control panel CP-005, as shown in Figure 4-2. All protection set channels will be sent to the QDPS for cross channel checking and on demand display.

Tag No.		Remarks
TI-451A	Loop 1	T_c (NR) need to determine which should be meter indication
TI-451B		
TI-461A		
TI-461B		
TI-471A		
TI-471B		
TI-452A	Loop 2	T_c (NR) need to determine which should be meter indication
TI-452B		
TI-462A		
TI-462B		
TI-472A		
TI-472B		
TI-453A	Loop 3	T_c (NR) need to determine which should be meter indication
TI-453B		
TI-463A		
TI-463B		
TI-473A		
TI-473B		
TI-454A	Loop 4	T_c (NR) need to determine which should be meter indication
TI-454B		
TI-464A		
TI-464B		
TI-474A		
TI-474B		

Ref: Westinghouse Process Control Block Diagram No. 8758D76, Sht. 5.

Hot Leg Temperature, T_h (Narrow Range): There is no meter indication of this parameter. One meter indication per loop needs to be added. It should be on a dual meter with T_c (NR) as shown in Figure 4-2.

Tag No.		Remarks
TI-XXXX	Loop 1A	Add meter indication
TI-XXXX	Loop 1B	
TI-XXXX	Loop 1C	
TI-XXXX	Loop 1D	

Ref: Westinghouse Process Control Block Diagram No. 08758D76, Sht. 4.

Wide Range Temperatures, T_h and T_c: There is one protection set channel for T_h and one for T_c for each of the four loops. There is no need for meter indication of these parameters on the control panels; however, indication should be provided in the QDPS for plant heatups and cooldowns.

Tag No.		Remarks
TI-413	Loop 1A	T_h (WR) delete meters
TI-423	Loop 1B	
TI-433	Loop 1C	
TI-443	Loop 1D	
TI-414	Loop 1A	T_c (WR) delete meters
TI-424	Loop 1B	
TI-434	Loop 1C	
TI-444	Loop 1D	

TR-413	T_h (WR)---TI-413 & TI-423
TR-433	T_h (WR)---TI-433 & TI-443
TR-414	T_c (WR)---TI-414 & TI-424
TR-434	T_c (WR)---TI-434 & TI-444

Ref: Westinghouse Process Control Block Diagram No. 8758D76, Sht. 4.

4.5 STEAM GENERATORS

Programmed Level: The level in the steam generators is programmed to increase with power level (the signal is derived from turbine first stage pressure). There are two protection set channels that feed a single program level channel per steam generator. No change is required.

Tag No.		Remarks
LI-0551	S/G A	Program level indication
LI-0552	S/G B	
LI-0553	S/G C	
LI-0554	S/G D	

Ref: Westinghouse Process Control Block Diagram No. 8758D76, Sht. 24.

Steam Generator Levels (Narrow Range): There are four narrow range protection set channels for each steam generator. Two are used for level control signals through a selector switch. The switch will be mounted directly under a dual indicator that displays both control channel levels. The switch will be set up so that the handle points to the indication of the control channel in operation. Figure 4-3 shows the control panel arrangements and how steam generator level relates to the other control panel devices.

The other meter indications will be deleted. All channels are to be sent to the QDPS for cross channel checking and on demand display.

Tag No.	Remarks
LI-0571, LI-0519	SG 1A level control channels, display on a dual meter w/sel. sw. Send to QDPS for cross channel checking and on demand display.
LI-0517, LI-0518	S/G 1A protection set, send to QDPS for cross channel checking and on demand display, delete meters.
LI-0529, LI-0572	S/G 1B level control channels, display on a dual meter w/sel. sw. Send to QDPS for cross channel checking and on demand display.
LI-0527, LI-0528	S/G 1B protection set, send to QDPS for cross channel checking and on demand display, delete meters.
LI-0573, LI-0539	S/G 1C level control channels, display on a dual meter w/sel. sw. Send to QDPS for cross channel checking and on demand display.
LI-0537, LI-0538	S/G 1C protection set, send to QDPS for cross channel checking and on demand display, delete meters.
LI-0549, LI-0574	S/G 1D level control channels, display on a dual meter w/sel. sw. Send to QDPS for cross channel checking and on demand display.
LI-0547, LI-0548	S/G 1D protection set, send to QDPS for cross channel checking and on demand display, delete meters.

Ref: Westinghouse Process Control Block Diagram No. 8758D76, Sht. 23.

Steam Generator Level (Wide Range): There is one protection set channel for each steam generator. They are used for local indication and recording. Delete the meters and make the wide range level available on panel CP-006 via the QDPS displays.

Tag No.		Remarks
LI-501	SG 1A	Recorded on LR-501, send to QDPS for cross channel checking and on demand display, delete meters.
LI-502	SG 1B	
LI-503	SG 1C	Recorded on LR-503, send to QDPS for cross channel checking and on demand display, delete meters.
LI-504	SG 1D	

Ref: Westinghouse Process Control Block Diagram No. 8758D76, Sht. 6.

Steam Generator Pressure: There are three Westinghouse protection set channels and one channel for PORV control for each steam generator. Two of these channels are used for steam flow compensation. They have been chosen for display on the panel, CP-006. Steam generator pressure is used for comparison with feedwater pressure and for PORV control. Meter indication for the third protection set channel will be deleted. All channels are to be sent to the QDPS for cross channel checking and on demand display.

Tag No.	Remarks
PI-0514	S/G 1A pressure, send to QDPS for cross channel checking and on demand display. Display PI-0514 on a dual meter with and PI-0515. Display PI-7411 on the Auto/Man station for the PORV.
PI-0515	
PI-7411	

PI-0516	S/G 1A pressure, send to QDPS for cross channel checking and on demand display, delete meter.
PI-0524, PI-0525, PI-7421	S/G 1B pressure, send to QDPS for cross channel checking and on demand display. Display PI-0524 on a dual meter with and PI-0525. Display PI-7421 on the Auto/Man station for the PORV.
PI-0526	S/G 1B pressure, send to QDPS for cross channel checking and on demand display, delete meter.
PI-0534, PI-0535, PI-7431	S/G 1C pressure, send to QDPS for cross channel checking and on demand display. Display PI-0534 on a dual meter with and PI-0535. Display PI-7431 on the Auto/Man station for the PORV.
PI-0536	S/G 1C pressure, send to QDPS for cross channel checking and on demand display, delete meter.
PI-0544, PI-0545, PI-7441	S/G 1D pressure, send to QDPS for cross channel checking and on demand display. Display PI-0544 on a dual meter with and PI-0545. Display PI-7441 on the Auto/Man station for the PORV.
PI-0546	S/G 1D pressure, send to QDPS for cross channel checking and on demand display, delete meter.

Ref: Westinghouse Process Control Block Diagram No. 7858D76, Sht 21.

Steam Flow: There are two protection set channels for each steam generator. Both channels are used for steam generator level control through a selector switch. Both channels will be displayed continuously on a dual meter. The switch will be set up so that

the handle points to the indication of the control channel in operation. Figure 4-3 shows the control panel arrangement and how steam flow relates to the other control panel devices. All channels are sent to the QDPS for on demand display and cross channel checking.

Tag No.	Remarks
FI-0512 FI-0513	S/G 1A steam flow, display both channels on a dual meter, put control channel selector switch under meter. Send to QDPS for on demand display and cross channel checking.
FI-0522 FI-0523	S/G 1B steam flow, display both channels on a dual meter, put control channel selector switch under meter. Send to QDPS for on demand display and cross channel checking.
FI-0532 FI-0533	S/G 1C steam flow, display both channels on a dual meter, put control channel selector switch under meter. Send to QDPS for on demand display and cross channel checking.
FI-0542 FI-0543	S/G 1D steam flow, display both channels on a dual meter, put control channel selector switch under meter. Send to QDPS for on demand display and cross channel checking.

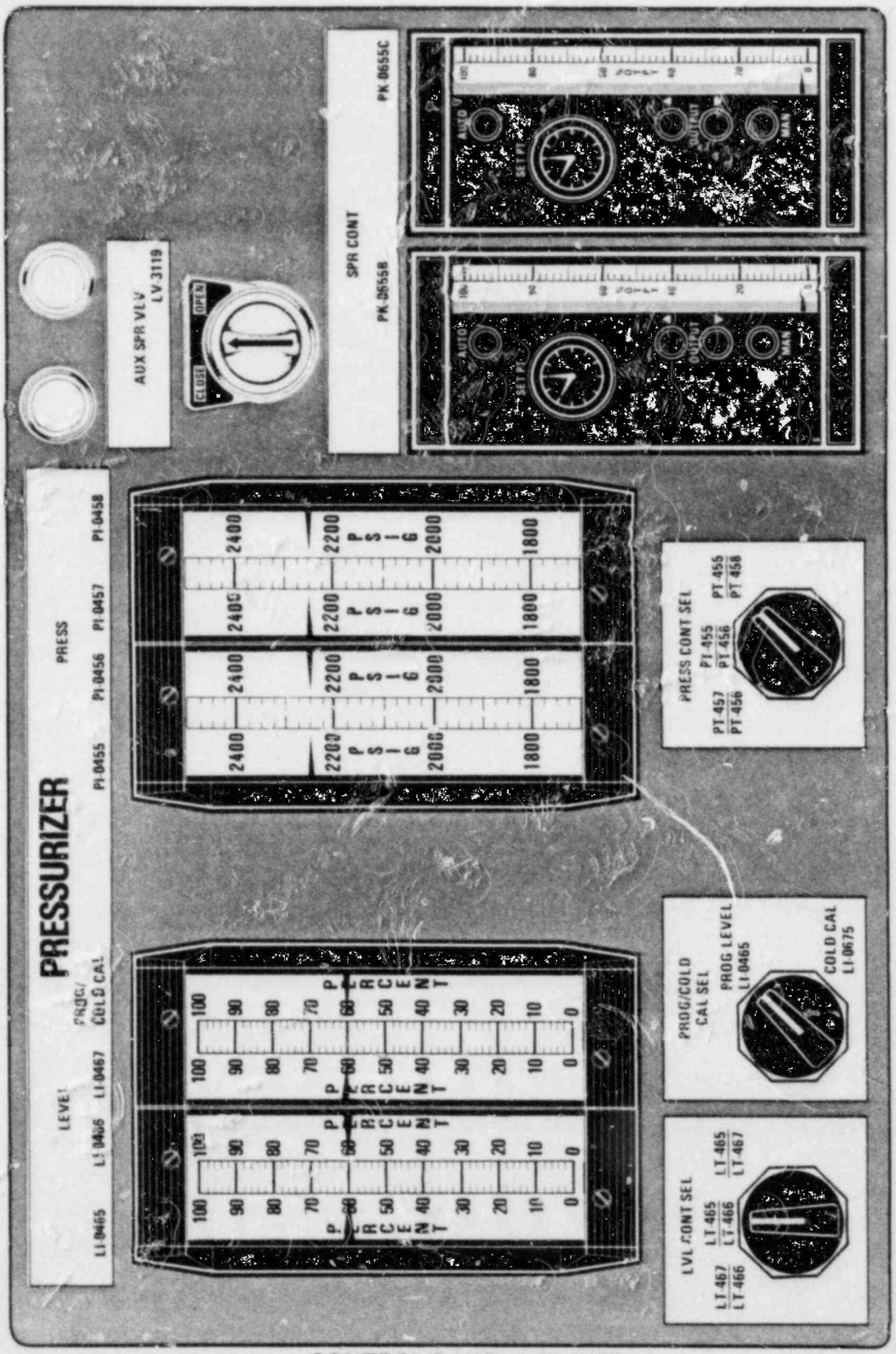
Ref: Westinghouse Process Control Block Diagram No. 8758D76, Sht. 22.

Feedwater Flow: There are three protection set channels for each steam generator. Two of these are used for steam generator level control through a selector switch. The two control channels are displayed continuously on a dual meter. The switch will be set up so that the handle points to the indication of the control channel in operation. Figure 4-3

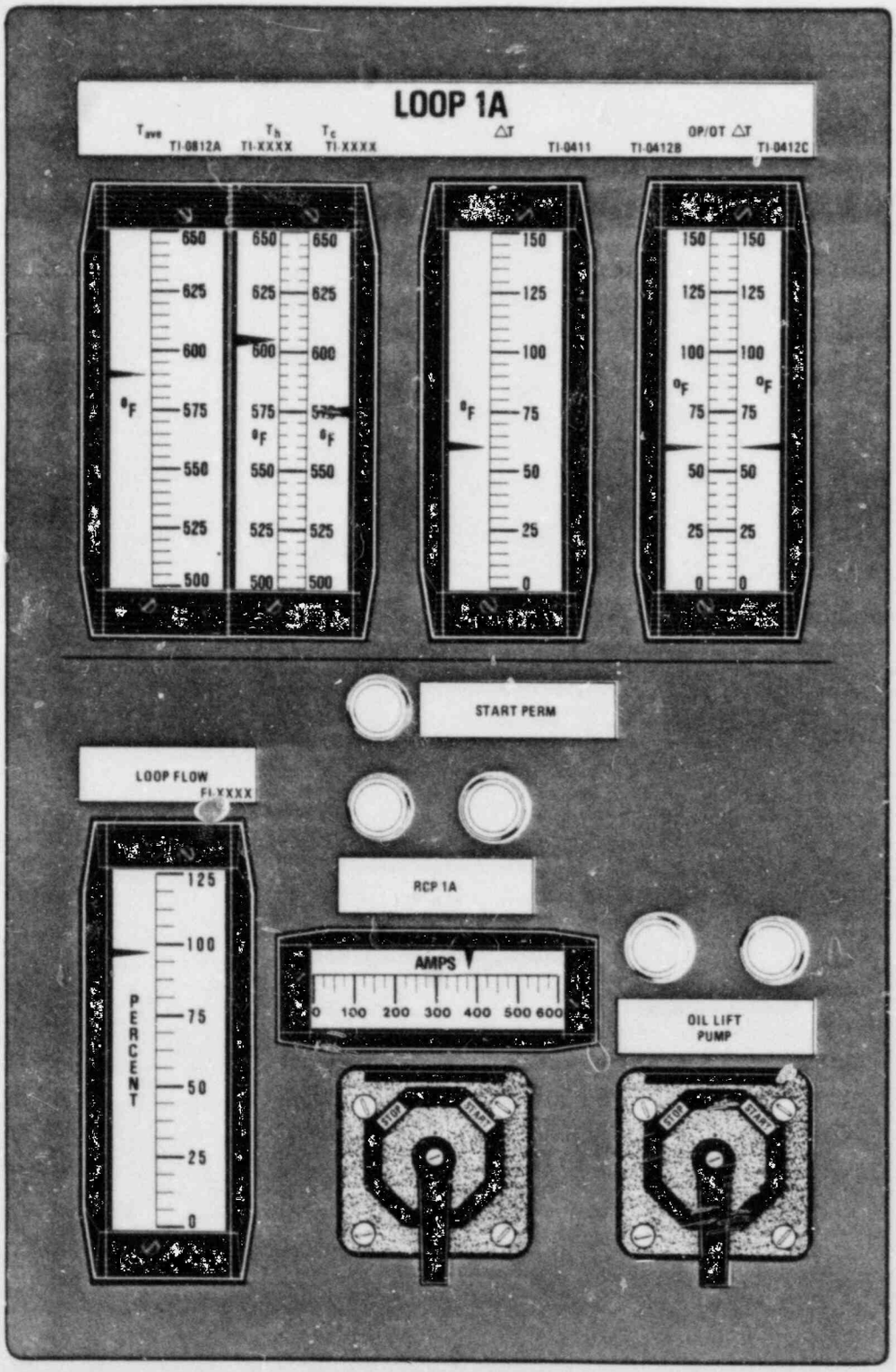
shows the control panel arrangement for feedwater flow and how it relates to other control panel devices. The third channel meter indication is to be deleted. All channels are to be sent to the QDPS for on demand display and cross channel checking.

Tag No.	Remarks
FI-0510 FI-0511	S/G 1A steam flow, display both channels on a dual meter, put control channel selector switch under meter. Send to QDPS for on demand display.
FI-0581	S/G 1A feed flow, send to QDPS for on demand display, delete meter.
FI-0520 FI-0521	S/G 1B steam flow, display both channels on a dual meter, put control channel selector switch under meter. Send to QDPS for on demand display and cross channel checking.
FI-0582	S/G 1B feed flow, send to QDPS for on demand display, delete meter.
FI-0530 FI-0531	S/G 1C steam flow, display both channels on a dual meter, put control channel selector switch under meter. Send to QDPS for on demand display.
FI-0583	S/G 1C feed flow, send to QDPS for on demand display, delete meter.
FI-0540 FI-0541	S/G 1D steam flow, display both channels on a dual meter, put control channel selector switch under meter. Send to QDPS for on demand display.
FI-0584	S/G 1D feed flow, send to QDPS for on demand display, delete meter.

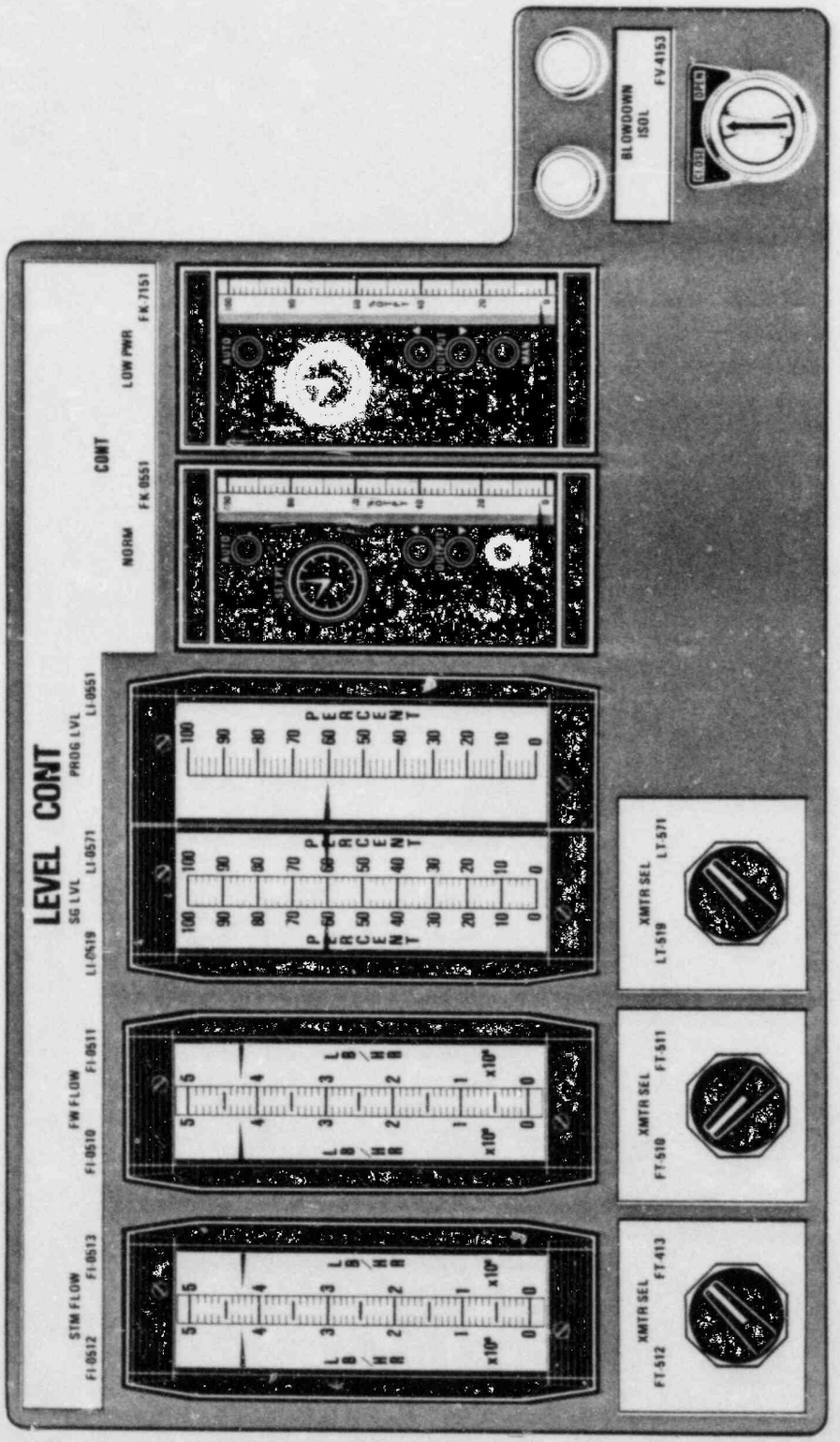
Ref: Westinghouse Process Control Block Diagram No. 8758D76, Sht 22.



CONTROL PANEL LAYOUT
PRESSURIZER
Figure 4-1



CONTROL PANEL LAYOUT
REACTOR COOLANT LOOP
Figure 4-2



CONTROL PANEL LAYOUT
STEAM GENERATOR LEVEL CONTROL
Figure 4-3

Control Room Design Review

Executive Summary

The South Texas Project

HOUSTON LIGHTING & POWER COMPANY